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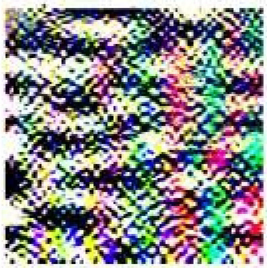

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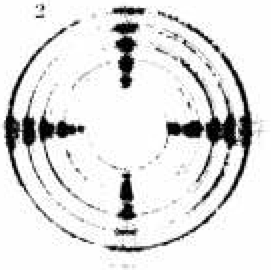

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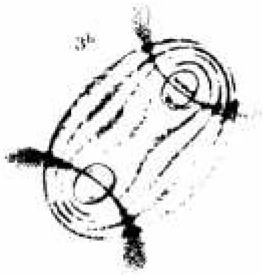

Monoclinic — Inclined Dispersion

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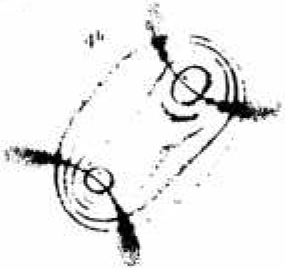

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6

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r DRUMKKMD, PR[KTEIt. I

PREFACE.

The remarkable advance in the Science of MJn«raIogy, during the years that have elapsed since this Text-Book was first issued in 1877, has made it necessary, in the preparation of a new edition, to rewrite the whole as well as to add much new matter and many new illuetrations,

The work being designed chiefly to meet the wants of class or private instruction, this object has at once determined the choice of topics discussed, the order and fullness of treatment and the method of presentation.

In the chapter on Crystallography, the different types of crystal forms are described under the now accepted thirty-two groups classed according to their symmetry. The names given to these groups are based, so fat as possible, upon the characteristic form of each, and are intended also to suggest the terms formerly applied in accordance with the principles of hemihedrism. The order adopted is that which alone seems suited to the demands of the elementary student, the special and mathematically simple groups of the isometric system being described first. Especial prominence is given to the " normal group" under the successive systemB, that is, to the group which is relatively of most common occurrence and which shows the highest degree of symmetry. The methods of Miller are followed as regards the indices of the different forms and the mathematical calculations.

In the chapters on Physical and Chemical Mineralogy, the plan of the former edition is retained of presenting somewhat fully the elementary principles of the §cience upon which the mineral characters depend; this is particularly true in the department of Optics. The effort has been made to give the student the means of becoming practically familiar with all the modem methods of investigation now commonly applied. Especial attention is, therefore, given to the optical properties of crystals as revealed by the microscope. Further, frequent references are introduced to important papers on the different subjects discussed, in order to direct the student's attention to the original literature.

The Descriptive part of the volume is essentially an abridgment of the Sixth Edition of Dana's System of Mineralogy, prepared by the author (1893). To this work (and future Appendices) the student is, therefore, referred for fuller descriptions of the crystallographic and optical properties of species, for

analyses, lists of localities, etc.; also for the anthoritiea for data here quoted. Id certain directions, however, the work has been expanded when the interests of the student have seemed to demand it; for example, in the statement of the characters of the varions isomorphous groups. Attention is also called to the paragraph headed " ms." in the description of each commoD species, in which are given the distinguishing characters, particularly those which serve to separate it from other species with which it might be easily confounded.

The list of American localities of minerals, which appeared as an Appendix in the earlier edition, haa beea omitted, since in its present expanded form it requires more apace than could well be given to it; further, its reproduction here is unnecessary since it is accessible to all interested not only in the System of Mineralogy but also in separate form. A full topical Index iias been added, besides the usual Index of Species.

The obligations of the present volume to well-known works of other authors—particularly to those of Groth and Rosenbnsch—are too obvious lu require special mention. The author must, however, express his gratitude to his colleague. Prof. L. Y. Firsson, who has given him material aid in the part of the work dealing with the optical properties of minerals as examined under the microscope. He is also indebted to Prof. S. L. Penfield of New Haveu and to Prof. H. A. Miers of Oxford, England, for varioai Talnable SQggestions.

Hew Havkm, Goito., Aug. 1, 1808.

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APPENDIX B.

Tabids to bb Ubed m tbe Dbtebhinatioii of Mutebals..

Geherai. Ikdex

Ikdex to SPEcms

INTRODUCTION.

1. Thb scienob of Mineralooy treats of those inorganic epeciea called mineral*, irhich together in rock masses or in isolated form make np the material nf the cruat of the earth, and of other bodies in '.he univerae so far as it is possible to study them in the form of meteorites.

S. Definition of a Mineral. — A Mineral is a bndy produced by the processes of inortiaiiic nature, hncing a definite chemical composition and, if forrmi tinder fnvorable conditions, a certain characteristic molecular structure which is erhibUed in Us crystalline form and other physical properties.

This definition calls for some further explanation.

First of all, a mineral must be a homogeneous substance, even when minutely examined by the microscope; further, it must have a definite chemical composition, capable of being expressed by a chemical formula. Tims, mnch basalt appears to be homogeneous to the eye, but when examined tinder the microscope in thin sections it is seen to be made up of different substances, each having characters of its own.
•■^■AgaiTl,"ObFi*y««lJ,"or'voleanic , glnss, thongb it may be essentially homogeneous, has mit ajleftnite composition \ <f. corresponding to a specific chemical formula, and ia hft^ce classed as a roclc, ' ^ ■ not as a mineral species. Further, several substances, ast^hylyte, hyalome- j -(J lane, etc., which at one time pitssed as minerals, have S&«n relegated to \ jwtrology, becanse it has been shown that they are only local fol^s of basalt, J retuiiiiiig.aH~&ppai«iilJ;Ju><noi;«ndeOA fot:in-dti« to-rapid cooling. ^ ^. -^

Again, a mineral has in all cases a definite molecvlar struulnrf, unless th« conditions of formation have been such as to prevent this, which is rarely tnie. This molecular structure, as will be shown later, manifests itself in the physical characters and especially in the external crystalline form.

It is customary, as a matter of convenience, to limit the name mineral to those compounds which have been formed by the processes of nature alone, while conipoun<ls made in the laboratory or the smelting-furnace are at most called artificial minerals. Further, mineral substances which have been produced through the agency of organic life are not included among minerals, us the pearl of an oyster, the opal-silica (tabasheer) secreted by the bamboo, etc. Finally, mineral species are, as a rule, limited to solid substnncea/ the only liquids included oeing metallic mercury and water. Petroleum, op mineral oil, is not properly a homogeneons snbstance, consisting rather of several hydrocarbon compounds; it is nence not a mineral species.

It is obvious from tne above that minerals, in the somewhat restricted sense nsualty adopted, conetitnte only a port of what is often called tha Uineral Kingdom.

3. Soop« of Kineralogy.—In the following pages, the general enbject of Mineralogy is treated under the following heada:

(1) Grystallography, —This comprises a discussion of crystals in general and especially of the crystalline forms of mineral species,

(2) Physical Mineralogy. —This includes a diacussion of the physical ohar&cters of minerals, that is, those depending upon cohesion and elasticity, density, light, heat, electricity, and so on.

(3) Chemical Mineralogy. —Under this head are presented briefly the gen< eral principles of chemistry as applied to mineral species; their characters as chemical compounds are described, also the methods of inyestigating them from the chemical side by the blowpipe and other means.

(4) Descriptive Mineralogy, —This includes the classification of minerals and the description of each species with its varieties, especially in its relations to closely allied species, as regards crystalline form, physical and chemical characters, occurrence in nature, and other points.

4. Literature.—Reference is made to the Introduction to the Sixth Edition of Dana's System of Mineralogy, pp. xlv-lxi, for an extended list of independent works on Mineralogy np to 1892; the names are also given of the many scientific periodicals which contain original memoirs on miueralogtcal subjects. For the convenience of the student the titles of a few works, mostly of a general character, are given here. Further references to the literature of Mineralogy are introduced through the first half of this work, particularly at the end of the sections dealing with special subjects.

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e given Id pp. ll-)xi of Daits's System of Uiner-

Qeneral MineraUtgj/.

Of the man; works, a knowledge of wliicli ts Deeded bj oae wbo wlghes a full acqutlnt-uice wilh tb« historical develupmcLt of Hloeralogy, the following are parlicularlf Important. Very early works iucliide those of Theopbiastua, Flloy, Liuufeus, Wallerlus, CtODstedt, Werner, Bergmaim, KlaprotU.

Within iLe uineteenth century: HaOy's Treaiise, 1801, 1882: Jameaon, 1816, 1830; Werner'a Letztea Mineral-SjBlem, 1B17: ClenTClniid'a Mlnemlogy, 1818, 1833; Leoohard'a Haiidbuth, 1821, 1830; Holis's Min.. 1832; Haldiuger's Iranslutlou of Midia. 18:>4; Drdt-haiipl'a Charaktcrlitlk, 1«20, 1833, 1833; Beudaiil's TreatUi'. 1834, 18S2; Phillips's Hlu., I8'.>3. 1837; Sheptrd's HIn , 1833-8S. and later editloiiit; tod Eobell's OruDdzClge. I»88; MohssHiii.,18ii9; Brellhaupt'sMin.. 18^8-1847; Hnldioger's HnndbiLcli, 184S; NniimauD'a Hiu.. 1846 and later; Hauamimii-s Haiulbucli, 1B4T; Dafr^uoy's Hlu.. 1844-1847 <alM 1856-1859); Brooke & Miller, 1852; J. D. Dana's System of 1887, 1844, 1800, 1854, IWi.

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Abbbetiatioks.

Lm pi. Plane of the optic asea. B. Hardness.

Ix. Bxt. Acute biaectrix (p. 208). Ob*. Observatloos oo occurrence, etc.

Jx,. Oljtuse bisectrii (p. 808). O.F. Oxidizing Flame (p. 2B7).

J.B, Before llie Blowpipe (p. fl66).' Pyr. Pyrogoosiica or blowpipe And

Jomp. CompoalLion. allied characters.

as. Differences, or distinctive char O, Ratio, Oxygen Ratio (p. 249),

ftciets. R.P. Reducing FUme (p. 357),

V. SpeciUc Gravity. Var. Varieties.

The sign A is used to Indicate the angle betneeo two faces of a crystal, as

»(100 A 110) = 44'30'.

*See the bibliography given by RoseDbuecb.

PART L CRY8TALLoGEAPHT,

GENERAL MORPHOLOGICAL RELATIONS OF CRYSTALS.

ft. Crystallograpliy.—The subject of Grystallograph; inclndee the description of the characters of crystals in general; of the various forma of crjatals and their division into groups and Byetoms; of the methods of studying crystals, incinding the determination of the mathematical relations of their faces, and the measuremeDt of the angles between them; finally, a description of com-poaod or twin crystals, of irregularities in crystals, of crystalline aggregates, and of pBendomorphouB crystals.

Allied to Crystallograpny is the subject of Cryatallogeny, which describes the methods ol making crystals which may be applied in the laboratory, and discusses the theories of their origin in nature. This department is only briefly toDched upon in Che present work.

6. Definition of a Crystal—^ crystal* is the regular polyhedral form, bounded by smooth gurfacsg, which is assumed by a chemical compound, under the action of its intermolecitlar forces, when passing, under suitable conditions, from the slate of a liquid or gas to thai of a solid.

As expressed in the foregoing definition, a crystal is characterized, first, by its definite internal molecular structure, and, second, by its external form. A crystal ie the normal form of a mineral species, as of all solid chemical compounds ; but the conditions suitable for the formation of a crystal of ideal perfection in symmetry of form and smoothness of surface are never realized. Farther, many species usually occur not in distinct cry^als, but in mussive form, and in some exceptional coses the definite molecular structure is absent.

7. Moleonlar Stmoture in Oeneral—By definite molecular structure is meant the special arrangement which the physical units, called molecvles,\ assume under the action of the forces exerted between them during the formation of the solid. Some remarks are given in a later article (p. 18 et see/.) in regard to

* In ils ori^nal aisiiiflcatloD ibe term eryttal v. ich tlie ancient pblloeophers believed to be wite)-

wbich tlie ancient philosopher t«rm, from Ko^araXXoi, iee.

f Tbe relation between at<>mt. chtmieal mdeeulet, stid pkptieal moleeulei is explained noder the chapter on Cliemlcal Minenlogy. The molecules here spokeu of are the pbysical molecules.

the kinds of molecalar arrangement theoretically possible, and their relation to

the Bjmmetry of the differeiit groups and systems of crystals.

The definite molecular structure ia the essential character of a crystal, and the eiternal form is only one wf the ways, although the most im])ortaiit, in which this structure is manifested. Thus it is found that all similar directious in a crystal, or a fragment of a crystal, have like physical characters,* as of elasticity, cohesion, action on light, etc. This is clearly shown liy the cleavage, or uatural tendency to fracture in certain directions, yielding more or less smooth surfaces; as the cubic cleavage of galena, or the rhomhohedral cleavage of calcite. It is evident, therefore, that a small crystal diffei-s from a large one only in size, and that a fragment of a crystal is itself essentiully a crystal in all its physical relations, though showing no crystalline faces.

Further, the external form without the corresponding molecular structure does not make a solid a crystal. A model of glass or wood, on the one hand, is not a crystal, though having its external form, heoause there is no relation between form and structure. Also, an octahedron of malachite, having the form of the crystal of cuprite from which it lias been derived by chemical alteration, is not a crystal of malachite.

On the other hand, if the natural esternal faces are wanting, the solid is not called a crystal. A cleavage octahedron of fiuorite and a cleavage rhom-ttofaedron of calcite are not properly crystals, because the surfaces have been yielded by fracture and not by the natural molecular growth of the crystal.

8. Cryitalline and Amorphooi.—When a mineral snows no external crystalline form, it is said to be massive. It may, however, have a definite molecnlar structure, and then it is said to be crystalline. If this structure, as shown bv , the cleavage, or by optical meana, is tne same in all parallel directions thron^h the mass, it is described as a single individual. If it varies from grain to grain, or fiber to fiber, it is said to be a crystalline aggregate,] since it is in fact made up of a multitude of individuals.

Thus in a granular mass of galena or calcite, it may be possible to separate the fragments from one another, each with its characteristic cubic, or rhom-bohedr^, cleavage. Even if the individuals are so small that they cannot be separated, yet the cleavage, and hence the crystalline structure, may be evident from the spangling of a freshly broken surface, as with fine-grained statuary marble. Or, again, this aggregate structure may be so fine that the crystalline structure can only be^esolved by optical methods with the aid of the microscope. In all these cases, the structure is said to be crystalline.

If optical means show a more or less distinct crystalline structure, which, however, cannot be resolved into individuals, the mass is said to be crypto-crystalline ; this is true of some massive varieties of auartz.

If the definite molecular structure is entirely wanting, and all directions in the mass are sensibly the same, the substance is said to be amorphous. This is true of a piece of glass, and nearly so of opal. The amorphous state is rare among minerals.

* Thia BHbjecl is furlber elucidaied in the chapter devoted to Physical Mineralogy, wliere it fs aUi) shown that, witb respect to ninny, but not all, of the physical characlers. the 4»>averae ot this proposjiiou U true, viz., that unlike directions lu a crystal have in general unlllie properties.

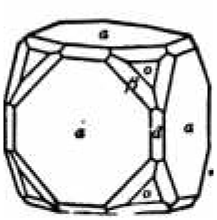
t The coDslJeralloo of the various forms Of cryMalliue aggregates is postponed to the end o(the preseot cliapter.

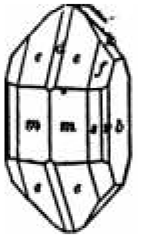
cnfln there ia a tendency to go over into tlie cryBtalllDe condition by molecular resrrango. menl. A iranspurent amorphooB cmag of »reeuic Irloxide (Ai^,o,). (onned by fuBion, bwimes omque and crystallini! after n time. Similarly ihe -leel ijtams of a railroad bridge miiv cniiliially become crystalline unii tlius liwe soine-'of iheir original MrenRih because of tht molecular rearrange me nl m.ide possible by iLe vlbmlioug caused by ihe frequent Jar ol tJMSsinii iraine Tbe microscopic study of rocks reveals many cases In which an analogoui t-liim}:e in molecular structure baa takeu place iu a bolid mase, as caused, for example, by great pri-s^ure.

9. Biternal Form.—A crystal ia bonnd«d by smooth plane surfaces, called fiices or planes,* showing in their arrangement a certain characteristic symmetry, and related to eacTi other by definite mathematical laws.

Thus, without inquiring, at the moment, into the exact meaning of the term eymmetry as applied to crystals, and the kinds of symmetry possible, which will be explained iu detail later, it is apparent that the accompanying figjires, 1-3, show the external form spoken of. They represent, therefore, certain definite types. ^

1.





Zircon.

ChryBollte.

10. Variation of Form and Surfkoe.—Actual crystals deviaw, within certain limits, from the ideal forms.

First, there may bo variation in the size of like faces, thne producing what are defined later as distorted foi-vis. In the second place, the faces are rarely ■ absolntely smooth and brilliant; commonly they lack perfect polish, and they niaj even be rough or more or less covered with fine parallel lines (called atriations), or show minute elevations, depressions or other 4.

peculiarities. Both the above subjects are discussed in detail in -.^\\. another place. yy* \ i\

It miiy be noted in passing that tbe characters of natural f r -A

fiices, just alluded to, in general make it easy to distinguish between them and a face artificially ground, on the one hand, like the facet of a cut gom; or, on the other hand, the splintery , uneven surface yielded by cleavage, "

11. Constancy of Angle in the Same Species.—The crystals of any species are essentially constant in the angle of inclination vj_^j_j between like faces, wlierever they are found, and whether prod- X,^ 1^,^ ucts of nature or of the laboratory. These angles, therefore, ^>t< form one of the distinguishing characters of a species. Apatite.

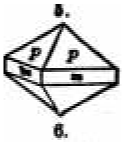
Thus, in Fig. 4, of apatite, the angle between the adjacent faces x and

as wbere the direction, rather than the definite

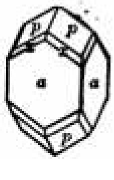
m (130° 18') is the eame for any two like faces, similarlj situated with refer* ence to each other. Further, this angle is constaDt for the species, differing bat little on crystals from different localities. Moreover, the angles between all the faces ou cryBtals of the same species (cf. Figs. 5-9 of zircon below) are more or less closely connected together by certain definite mathematical laws.

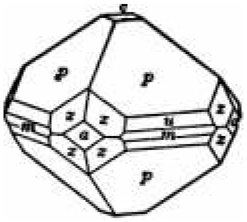
12. Diversity of Ponn, or Habit. —While in the crystals of a given species there is constancy of angle between like faces, the forms of the crystals may be exceedingly diverse. The accompanying figures (5-9) are examples of a few of the forms of the species zircon. 'I here is hardly any limit to the number of faces which may occur, and as their relative size changes, the habit, as it is called, may vary indefinitely. Yet for the crystals of each species, the angles between like faces are essentially constant.

5.



6.





Crystals of Kircon.

13. Diversity of Si». —Crystals occur of all sizes, from the merest microscopic point to a yard or more in diameter. It is important to understand, however, that in a minute crystal the development is as complete as with a large one. Indeed the highest perfection of form and transparency is found only in crystals of small size.

A siugle crystal ot quartz, now nl Milan, is three and a quarter feet long and five and a bsir ia c ire urn Fere nee, and its weight Is eslimaled at el^ht hundred and seven ly pounds. A siugle cavity in a vein o[quartz near the Tiefen Glacier, in 8wit?:erland, discovered In 18ST. afTorded smoky quartz cryalftls wei);hiag in the aggregnte about 20,000 pounds; a considerable number of the single crys'iils Imviiiit a weight of 300 ti> 350 pounds, or even more. A gigantic lieryl from Acworth, New Hampshire, measured tour feet in length and two and a half in cireumference : another, from Oraftoo. was over four feet long, and thlriy-two incites in one of its diameters, and weighed about two and a lialf ions,

14. Symmetry in General —The faces of a crystal are arranged according to certain laws of symmetry, and this symmetry is the natural basis of the division of crystals mto groups and systems. The symmetry may be defined relatively to (1) a plane ^ symmetTy, (3) an axis of sj/mmeiry,aad (3) a center of si/mnieiry.

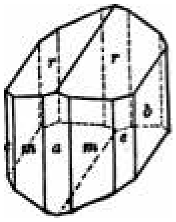
These different kinds of symmetry may, or may not, be combined in the same crystal. It will be shown later that there is one group the crystals of which have neither center, axis, nor plane of symmetry; another where there is only c center of symmetry. On the other band, some groups have all these elements of symmetry represented.

16. Flanes of Symmetry.—A solid is said to be geometrically * symmetrical with reference to a plane of symmetry when for .each face, ^q

edge, or solid angle there is another similar face, edge, or angle which has a like position with reference to this plane. Thus it is obvions that the crystal of amphibole, shown in Fig. 10, is symmetrical with reference to a central plane of symmetry, parallel to the face b, passing vertically tiiroiigh the edge formed by the faces r, r and through the middle of the face a.

In the ideal cryatal this Bymmetry is right symmetry v. the geometrical sense, where every point on the one side of the plane of symmetry has a corresponding point at equal distances on the other side, measured on a line normal to it. In other words, in the ideal geometrical symmetry, one half of the crystal ia the exact mirror-image of the other half.

A crystal may have aa many as nine planes of symmetry, three of one set and six of another, as ia illustrated hy the cube f (Fig. H). Here the planes of the first set pass through the crystal parallel to the cubic faces; they are shown in Fig. \'Z. The planes of the second set join the opposite cubic edges. On the other band, some crystals have no plane of symmetry.



AnipuilKjIe.

16. Axes of Symmetry.—If a solid can be revolved through a certain number of degrees about some line as an axis, with the result that it again occupies precisely the same position in space as at first, it is said to have an asis of svmmetry. There are four different kinds of axes of symmetry among crystals; tliey are defined according to the angular revolution needed m each case, that is, by the number of times which the crystal repeats itself in a complete revolution of 360°.

{n),A crystal is said to have an axis of binary, or twofold, symmetry when a revolution of 180° produces the result named above; in other words, when it repeats itself twice in a complete revolution. This is true of tlie crystal shown in Fig. 13 with respect to the vertical axis (and indeed each of the horizontal axes also).

(6) A crystal has an axis of trigonal, or threefold, symmetry when a revolution of 120° is needed ; that is, when it repeats itself three times in a complete revolution. The vertical axis of the crystal shown in Fig. 14 is an axis of trigonal symmetry.

• The relation belween the Ideal geomelrical symmetry and the actual crystallognphlo ■ymmeiry is discuMed Id Art. IB.

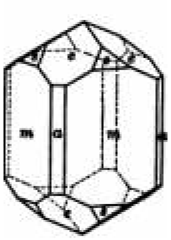
I This Is the cube o[Ihe normal group oF tbe Isometric system.

(c) A crystal has un osis of tetragonal, or loarfold, symmetrT when a revolution of 90' is called for; in other words, when it repeats itself four times

^

W

16.



Tellnrlntn. Kiitlle.

The vertical axis in t

Mimetite. 3 crystal shown in Fig. 15 ia

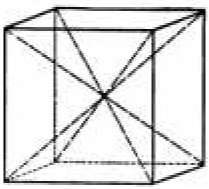
FolycrsM.

in a complete revolntion. such an axis.

(d) Finally, a crystal has an axis of hexagonal, or sixfold, symmetry when H revolution of 60° ia called for; in other words, when it repeats itself six times . in a complete revolution, Tliia ia illustrated by Fig. 16.

Tlie cube * lllustrfttes three of [lie four passible klods of symmelry with respect 10 Hies of eymmetry. It has six axe» of binnry symmetry joining \he middle pniata of opposite edges (Fig. 17). It bBB four axes of trigonal symmetry, joinioE tlie iipposite solid angles (Fig. 18). It bas, flD&lly, three axes of tetragonal symmetry jdaing ilie middle poiots of op^te fftces (Fig. 19).

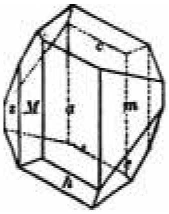
18.



17. CentST of Symmetry.—Most crystals, besides planes and axes of sym* metry, have also a center of symmetry. On the other hand, a crystal, though possessing neither plaue nor axis of symmetry, may yet be 20.

symmetrical with reference to a point, its center. This last ia tnie of the triclinic crystal shown in Fig. 20, in which it follows that every face, edge, and solid angle hns a face, edge, and angle similar to it in the opposite half of the crystal.

Tliere is auolber mellio 1 of viewiii); tlie i^ymmetry in Ihia ja^t cnse, wliicli is adopled by some nuiliors. If ilie crystal lie thought of as I dividtd Into two similar halves by a plane pitiallel to auy one of its \ faces, and one half be revnlverl 181)° about an nsis uormal 10 this face, this half would be brought mto n posltloD in which it would be the mirror-image of the remaining half. This symmeliyla hence described as eomp<mnd i}/mjiielrj/•Kith reference to un axis of binary aymmelry and a plime uormal to it, both taken together. This method is not followed bere since, though bBviug cci'lum tlieoteiical advantages. It is likely to confuse the student meethig the pioblemH of crysinllogmphy tor the lirsl lime.



ml.lyg,ii

* This is agnlu the cube of llie uormal group of (he isometric system.

=:i,:cc ..Google

GBNBBAL MOBPHOUWICAI, EELAT10N3 OP'CRYSTALS.

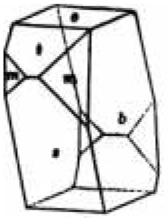
U

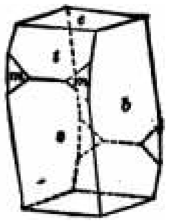
18. Belktios of Oeometiioal to CryiUllognphio Symmotry.— Since the ■yminetr; in the arrangement of the faces of a crystal is an expression of the internal molecular stmcttire, which in SI. 22.

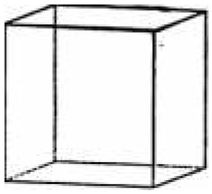
general is itlike in all parallel directions, the relative size of the faces and their distance from the plane or axia of symmetry are of no moment, their angular position alone is essential. Hence Fig. 21 has aa truly a vertical plane of symmetry (parallel to b) as Fig. "Z'i if the faces have exactly the same angular position as in that, although the strict geometrical definition * could not be applied to it.

Also in a normal cube (Fig. 33) the Heulandite.

three central planes parallel to each pair of cubic faces are like planes of symmetry, as stated in Art. 16, But a crystal is still cirstallograpnically a cube, though dcTiating widely from the requiremeuts of the strict geometrical definition, as shown in Figs. 34, S5, if only it can be proved, «.;. by cleavage, the





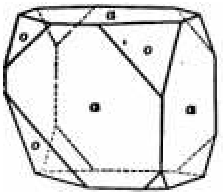


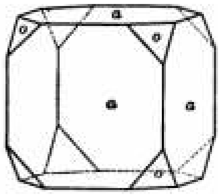
pbysical nature of the faces, or by optical means, that the three pairs of faces are like faces, independently of their size, or, in other words, that the molefohir structure is the same in the three directions normal to them.

Further, in the case of a normal cube, a face of an octahedron on any solid angle requires, as explained beyond, similar faces on the other angles. It is a«_ fl7. not necessary, however, that

these eight faces should he of equal size, for in the crystal-logrnpliiG sense Fig, 26 is jis trulv symmetrica] with reference to the planes named as Fig. 27. 19. On 'the other hand, the molecular and hence the crys-tallographic symmetry is not always that which the geometrical form would suggest. Thus, deferring for the moment the consideration of peeudo-symmetry, an illustration of the fact stated is afforded by the cube.

* It Is to be noted tbat the pei-apecllve Sgurca of crjsUls always show the geomelrimlly Ideal form. In which like faces, edges, and nnglc^s have thn aame shape, size, nud posiCiou. In other words, the ideal crysriil Is iiniforinly represented as having the symmetry called for by the strict geometrical deflnitloa.





It has already beeo implied and-will be fnll; explained later that whik the cube of the normal group of tbe isometric syatem naB the symmetry described ia ArtB. 15,16, a cube of the same geometrical form bnt beloogiug molectilarly. for example, to the tetrahedral group, bas no planes of symmetry patallel to the faces, only the sii diagonal planes ; further, though tbe four axes shown in Fig. 18 are still axes of trigonal symmetry, the cubic aies (Fig. 19) are axes of binary symmetry only, and there are no axes of symmetry corresponding to those represented in Fig. 17. Other more complex cases will be described later.

Further, a crystal having interfacial angles of 90° is not necessarily a cube; iu other words, the angular relations of the faces do not show in this case whether the figure is bounded by six like faces; or whether only two are alike and the third unlike; or. flnuily, whether there are three pairs of unlike faces. The question must be decided, in sncb eases, by the molecular structure as incticated by the physical nature of the surfaces, by the cleavage, or by otiier physical characters, as [lyro-electricity, those connected with light phenomena, etc.

Still again, tbe student will learn later that the decision reached in regard to the symmetry to which a crystal belongs, based upon the disiribulion of the faces, is only preliminary and approximate, and before being finally accepted it must be confirmed, first, by accurate measurements, and,second, by a minute study of the physical characters as just insisted upon.

The method baseil upon tbe pliysical cbni-aclcrs. wblch ci^CB moat coni'lustve resiill* aiid admits of the widest applicui luii. is llie skillful elchl'iig of tbe surracij of the crytml by some appropriate Bolveut. By ihls means tberc are, \a general. pnHliiced upon ii minute depressiiina Ibe shape of whicli alwnya coufornis to Ihe Bjniiiietry m the arrangemeut of the moleciiies. This process, which is la pun eawmially one involving tlie dissection of the tnok'Cuiar strncliire, is more imrticulariy diacusBed In tbe chapter ou Pliysical Miiienilopy.

20. Fseado-Bymmetry.^The crystals of certain species approximate closely in angle, and therefore in apparent symmetry, to the requirements of a system higher in symmetry than that to which they actually belong: they are then said to exhibit pseudo-si/mnietrt/. Numerous examples are given under the dWerent systems. Thus tbe micas have been shown to be truly nionoclinic in crystallization, thongh in angle they seem to be in some cases rbombo-hedriij, in others ortborhombic.

It,will he shown later that compound, or twin, crystals may also simulate by their regular grouping a higlier grade of symmetry than that which belongs to tbe single crystal. Such crystals also exhibit pseudo-symmetry and are specifically called mimetic. Thus aragonite is an example of an ortborhombic species, whose crystals often imitate by twinning those of tlie hexagonal system.* Again, a highly complex twinned crystal of the nionoclinic species, phillipsite, may have nearly tne form of a rhombic dodecahedron of the isometric system. This kind of pseudo-symmetry also occurs among the groups of a single system, since a crystal belonging to a group of low symmetry may oy twinning gain tbe geometrical symmetry of the corresponding form of the normul group. This is illustrated by a twinned crystal of scbeelite like that figured (Fig. 378) in the chapter on twin crystals.

Pseudo-symmetry of still another kind, where there is an imitation of tlie syipmetry of another system of lower grade, is particularly common in crystals of the isometric system (e.g., gold, copper). The result is reached in

* The terms pteudo-hexagonal, elc, used Iu this an J similar cases explain themselves.

Bncn cases b; an aboormal development or "distortion" in the direction of certain axes of Bynimetry. This subject is discussed and illustrated on • later page.

21. Fowible Oroaps of Symmetry.—The theoretical consideration of the different kinds of symmetry possible among crystals built up of like molecales, as explained in Arts. 30-32, has led to the conclusion tbat there are thirty-two (32) types in all, difleriiig with respect to the combination of the different symmetry elements just described. Of these thirty-two natural groups umong crystals baaed upon their symmetry, seven groups include by far tue larger number of crystallized minerals. Besides these, some thirteen or fourteen others are distinctly represented, though several of these are of rare occurrence. Further, eight or nine others, making in all twenty-nine or thirty, are known among crystallized salts made in the laboratoiy. The characters of each of the thirty-two groups are given under the discussion of the several crystalline systems.

' 22. Cryatallographic Axes.—In the description of the form of a crystal, especially as regards the position of its faces, it is found convenient to a^time, after the methods of analytical geometry, definite lengths of certain lines passing throueh the center of the ideal crystal, as a basis of reference, (See further Art. 38 et teq.)

These lines are called the cryatallographic axes. Their direction is to a greater or less extent fixed by the symmetry of the crystals, for an axis of symmetry is in almost all cases* a possible crystallographic axis. Further, their unit lengths are fixed sometimes by the symmetry, sometimes by the faces assumed as fundamental, i.e., the itnit forms in the sense defined later. The dotted lines'shown in Fig. 19 are the crystallographic axes to which the cnbic faces are referred.

23. Syatema of Crystallization.^The thirty-two possible crystalline groups, distinguished from one another by their symmetry, are classified in this work under six systems, each characterized by the relative lengths and inclinations of the assumed crystallographic axes. These are as follows:

I. Isometric System. Three equal axes at right angles to each other.

II. Tetragonal System. Three axes at right angles to each other, two of them —the lateral axes—equal, the third—the vertical axis—longer or shorter.

III. Hexagon'AL Sxsteu. Four axes, three equal lateral axes in one plane intersecting at angles of 60°, and a vertical axis at right angles to this plane and longer or shorter.

IV. Orthorhombic System. Three axes at right angles to each other, but all of different lengths.

V. MoNOCLiNic System. Three axes unequal in length, and having one of their intersections oblique, the two other intersections equal to 90°.

VI. Triclinic System. Three unequal axes with mutually oblique intersections.

The sysleins of cTyBlalHziillou have been vnriously nnmed by different aiilhors. as follows:

laoMETRtc. Tettytlar i>f Sfohs nnd HBi<linger: lurmetrie of HniismBnn; Tetteral of N*umai)ii; Segitlar of Weiss bhiI Rose; Cubic at Dufrenoy. Miller, Des Cloizeaux; Monomairie of thu eiirlier ediiioos of Dhds's System of Hi.iernlo^y.

• Excepllons nre found in llie isiimelric sysloni, wliere tlie axes must uecpssnrily be the ues of teii«g;onn1 Bymmetry (Pig. 19). and cuuDot l)e those of biuary or trlgoual symmetn (Figs. 17. 18).

Tbtraookal. Pyramidal ot Mobn; Viergliedrige, or Zam-vnd-eituitige, of Wefw; Tetragonal ul NuumiLUU: Monodimttne uf Hsuaoitiuu; Q^adratie of rtiD Kubtll; Dtmetrio of unrly edilioiig of Dulb's Syateiu.

Hexagonal. Wiomboh«dral til Mnlis; Seclisgliedrige, or Drai-und-eiaangt of Weiss; HM-igonul ui Naiimuiiaj Monolrititetric of Huusoiuun.

OtcTHORHOUBic. PHtmatit. or OrUiotype, of HuUs; Bin-vndtimixige •>(Weiis;

Trimetric »f earlier edilious of Dana's Byalem.

Mu<40CLiNio. HemiprUmatie uud IJatniorihotypt of Moha; Zimi andeinfilitdrigt cif We.w: Moiu/ciiiio/iedral of Naumuua; Clinorltombk of v. E'lbtill. Hiiuaiiiiiiiii, Des CloiKi.-iiiix: ^uffi'tM of Haidlnger: 06%u« of Miller: JfunMjfTnmefnc uf GrotL (l^Tti).

TiuCLIMC. T'efarto-priimaffe of Mobs; Ein-vnd-eingliedrige of We >«; Trieliiuiliedr-il of ^allmlLt1l1; Clinor/iomboidat ot t. Kobell: JnortAte of Uuidiotjer aud Milkr; ^rKnC/iK. ' or Ihabl;/ Oblique, of Dea Cloizeaiix; Atummetric, uf Urolli (187G},

Aa remarked liiter, some uulhors prefer lo divide the tliirtyiwo Bjinmetry groups luto «ec<n systems, referriuK tbe to-calied rliomboliedral forms 10 tlirec etiuul axes witli equal oblique iulersectioBs; this is the tr^nal tytlimi of Qrolli (189tt).

24. Each one of the six systems, as will be underBtood from Art. 21, embraces several groups differing among themaeives in tlieir Bymuietiy, One of these groups is conveniently called the normal group, since it is in general the common une, and since further it exhibits the highest degree of symmetry possible for the given system, while the others are lower iu grade of aymnietry.

It is important to note that the gronps comprised within a given system are at once essentially connected together by their common optical characters, and iu general separated * from those of the other systems in the same way.

In the paragraphs immediately following, a synopsis is given of the symmetry of the normal group of each of the ditfei-ent Bystems, and also that of one subordinate group of the hexagonal system, which is of so great importance that it is also often conveniently treated as a snb-system even when, as in this work, the forms are referred to the same axes as those of the strictly hexagonal type—a nsage not adopted by all autbors.

25. Symmetry of the Syitenu.—With respect to the symmetry of the form, which finds practical expression, as before stated, in tbe axial relations, the normal groups under the different systems are characterized as follows.

I. Isometric System. Three like axial f planes of symmetry (principal planes) parallel to the cubic faces, and fixing by their intersection the crystallographic axes; six like diagonal planes of symmetry, passing through each opposite pair of cubic edges, and hence parallel to the faces of the rhombic dodecanedron.

Further, three like axes of tetragonal symmetry, the cubic or crystallo-graphic axes; four like axes of trigonal symmetry, the octahedral axes; and six like axes of binary symmetry, the dodecahedral axes. There is also obviously a center ot symmetry.J Tliese relations are illustrated by Fig. 28; also by Fig. 41; further by Figs. 70 to 110.

*Cr)'sIals of the tetragonal and hexagoaal systems are alike in being optimally uiinxinl; bul I he rrystals of all the other systems have disiinguisliini; optical nliarac'ws.

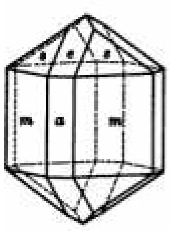
f Two iiisiies of symmetry are said lo be like when tiicy divide tlie Idenl crystal into lialves wliicb ai*e identical to each other; otherwise, they are said to be wnlika. Axes of symmetry nre nisn like or unlike. If n plane of symmetry includes Iwo ot tbe crystailo-Rriiphic iixes, it is called an arial plane of symmetry. If the plane includes two or more llkt axes "f symmetry. It is called a prtTteipnlplane of symmetry; also an nxis of symmetry in wliicli two or more like plaoes ot symmetry miet is a principal axil of symmetry.

{In describing the symmetry of the difTereot gioups, here and later, the center of symmetry is ordiDsrlly not mentioned when its presence or absence Is obvious.

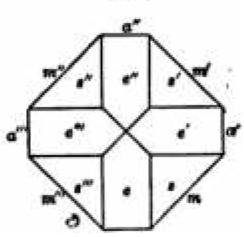
II. Tetbagonal SyaTEU. Three axial planes of symmetry: ot these two ■n like planes intersecting at 90° in a line which is the vertical crystallo-graphic axis, and the third plane (a principal plane) ia normal to them and

yk^^

29.



30.



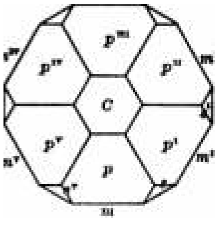
hence contains the lateral axes. There are also two diagonal planes ot symmetry, intersecting in the vertical axis and meeting the two axial planes at angles of 45°.

Fnrtber, there is one axis of tetragonal symmetry, a principal axis; this is the vertical crystallographic axis. There are also in a plane normal to this four axes 'ot binary symmetry—like two and two—those of each pair at right angles to each other. Fig,-29 shows a typicHl tetragonal crystal, and Fig. 30 a basal projeccion of it, that is, a projection on the principal plane of symmetry normal to the vertical axis. See also Fig. 42 and Figs. 149-lTl.

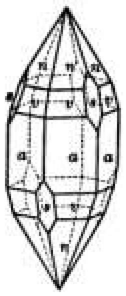
lir. Hexagonal System. In the Hexagonal Division there are four axial planes of symmetry; of these three are like planes meeting at angles of 6ii", their intersection-line being the vertical crystallographic axis; the fonrth lilaiie (a principal plane) is at right angles to these. There are also three ctiier diagonal planes of symmetry meeting the three of the first set in the vertical axis, and making with them angles of 30°.

^^^^

BeryL



33.



Beryl.

Corundum.

Further, there is one principal axis of hexagonal symmetry; this is the vertical crystallographic axis; at right angles to it there are also six binary axes. The last are in two sets of three each. Fig. 31 shows a typicw hexagonal crystal, and Fig. 32 a basal projection of the same. See also Pig. 43 and Figs. 195-209.

.dbyGooglc

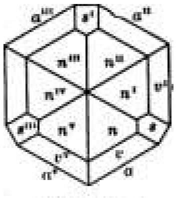
CBYSTA.LLOGBA.PHT.

STSteiD there are three

lo 'i the vertical axis.

In the Trigonal or Rhombohedral Division of this s like planes of symmetry intersecting at angles of (Further, the forme belonging here have a vertical principal aiis of trigonal symmetry, and three horizontal axes of binary symmetry, diagonal in position to the crystal!ographic axes. Fig. 33 shows a typical rhombohedral crjst^, and Fig. 34 a basal projection. See also Figs. 326-252.

34. 36. 36.



Corundum.

Chrysolite. I System. Three unlike plat

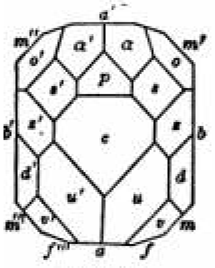
Clii'ysolfte.

IV. Obthqrhombic System. Three unlike planes of symmetry meeting at 90°, and fixing by tbeir intersection-lines the position of the cryatallo-graphic axes. Fnrtber, three unlike axes of binary symmetry coinciding with the last-named axes. Fig. 'ij shows a typical orthorhom hie crystal, and Fig. 36 a basal projection. See also Fig. 44 and Figs. 2T.J-303.

V, MoNOCLisic Sy8TEM. One plane of symmetry which contains two of the crystallographic axes. Also one axis of binary symmetry, normal to this plane and coinciding with the third cry stall ographic axis. See Figs. 37-39; also Fig 45 and Figs, 312-327,

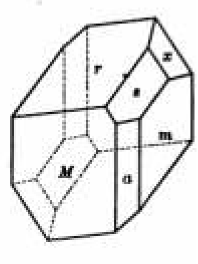
Pyroxene.

39.



Pyroxene.

40.



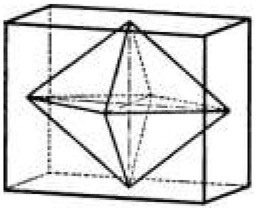
Axinite.

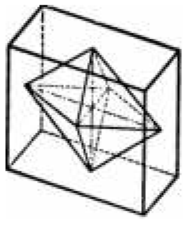
VI. Triclinic System. No plane and no axis of symmetry, hut symmetry solely with respect to the central point. Fig. 40 and Fig. 46 show typical triclinie crystals. See also Figs. 333-341,

26. The relations of the normal groups of the different systems are further illustrated both as regards the cryetallographic axes and symmetry by the accompanying figures, 41-46. The exterior form is here that bounded by faces each of which is parallel to a plane through two of the crystallographic axes indicated by the central broken lines. Further, there is shown, within this, the combination of faces each of which joins the extremities of the unit lengths of the axes.

The full understanding of the aubject will not be gained ootil after a Btudjr of the forms of each system in deuil. Keverthelesa the student will do well to make himself familiar at the outset with the fundamental relation! here illustrated.

41. *a. 43.





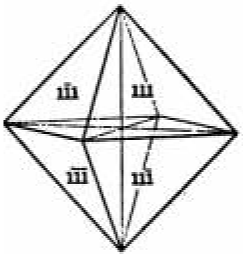
It will be shown later that the symmetry of the different groups can be most clearly and easily exhibited by the nse of the spherical projection explained in Art. 39 ei aeq.

VI. Mod«li—Ulaas (or trnn'parcDt cellulotd) modeli lllustratiDg the dlSeTciit systema, haviDg ilie forms si)own in Figs. 41-46. will be very useful to the-sluilent. especially in Jeamiii^' liie fimdiLmeutsI relatione as regards Bjmmetry. They bIioiiIiI fhow williin tli« crjBtallozriipbic axes, and by colored tht'eads or wires Ibe outlines of one or more Mmple forms. Moiie 3* of wood are alBO made in great varielv and perfection of form; tLese are iudispeusable to llie Mudent In mastering the principles of cryMalloi^rapliy.

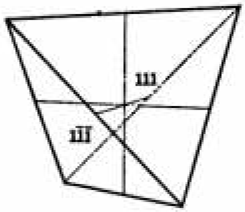
38. So-called Holohedral and Hemihedral Forms.—It will appear later that each crystal form t of the normal group in a given system embraces «// the faces which have a like geometrical position with reference to the crystallo-grapliic axes; such a form is said to be holohedrnl (from oAos an<t eSpn, face). On tbo other hand, under the groups of lower symmetry, a certain form, while necessarily having all the faces which the symmetry allows, may yet have but half as many as the corresponding form of the normal group; these half-faced forms are sometimes called on this account hemihedral, Fiirthermore, it will be seen that, in such cases, to the given holohedral form there correspond two similar and complementary hemihedral forms, called respectively plus and minus (or right and left), which together embrace all of its faces.

A siugle example will help to make tbe above Statement Intelligible. In the normal group o(tlie laumeiiic a^etem, [lie octaliedroii (FIk- 47) is a "holohedral" form nitb all the possible faceH—eight m iiumber—which tire alike in that Ibey meet the axes at ei^ual dlBtauces. In ihe teli-abedral group of the anme syalem. tbe forms are referred to the same crystallograpbic axes, but the symmetry defined Ic Art. 19 laud mure fully later) culls for but four similar fucea baHug the position described. These yield a four-fnced. or " iieuii-bedrHl," tonn, the tetrahedroD. Figures 48 aad 49 show tbe plus and minus i«t»iicdrou, which togeiUer, tt will be Been, embrace all tbe faces of the octahedron, Fig. 47·

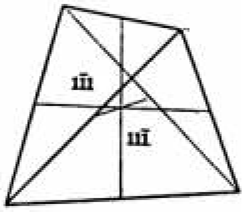
47.



48.



49.



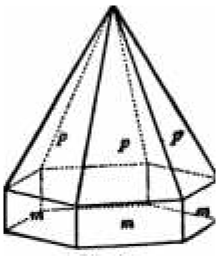
Id certain groups of still lower syrometr; a given crystal form may hare bat one-quarter of the faces belonging to the corresponding normal form, and, after the same method, sach a form is sometimes called tetarlohtdral.

The development of the variouB possible kinds of hemihedral (and tetarto-hedralj forms under a given STstem has played a prominent part in the crjstal-lograpny of the past, but it leads to mncn complexity and is distinctly leas simple than the direct statement of the symmetry in each case. The latter method ia systematically followed in this work, and the snbject of hemihedrism is dismissed with the brief (and incomplete) statements of this and the following par^raphs.

29. Hemimorphio Forms.—In several of the systems, forms occur under the groups of lower symmetry than that of the normal group which are characterized by this: that there is no transverse plane of symmetry, but the faces present are only those belonging to one extremity of an axis of symmetry (and cryst^lo-grapbic axis). Such forms are conveniently called hemt-morp/iic forms. A simple example under the hexagonal system is gjven in Fig. 50. It is obvioQS that hemi-morphic forms have no center of symmetry.

30. Molecnlar Networks.—Much light has recently been thrown upon the relations existing between the \ different types of cryatala, on the one hand, and of these I to tbe physical properties of crystals, on the other, by the consideration of the various possible methods of grouping of the molecules of which the crystals are supposed to be built up. This subject, very early treated by Hauy and others (including J. D. Dana), was discussed at length by Frankenheim and later by Bravats. More recently it has been extended and elaborated by Sohncke, Wulff, Schfiufliess, Fedorow, Barlow, and others.*

All solid bodies, as stated in Art. 7, are believed to be made up of definite



Zincite.

physical iiiiitB, called the physical, or crjBtal, molecules. Of the form of the molecules

• Bee tbe literature (ulluwlng Art. 83.

nothing is definitely known, and though theory has something to say about their size, it is enough here to understand that they are tilmoet infinitely small, BO small that the surface of a solid— e.g. of a crystal—may appear to the touch and to the eye, even when assisted by a powerful microscope, us perfectly smooth.

The molecules are further believed to be not in contact but separated from one another—if in contact, it would be impossible to explain the motion to which the sensible heat of the body is due, or the transmission of radiation (radiant heat and light) through the mass by the wave motion of the ether, which is believed to penetrate the body.

When a body passes from the state of a liquid or a gas to that of a solid, under such conditions as to allow perfectly free action to the forces acting between the molecules, the result is a crystal of some definite type as regards symmetry. The simplest hypothesis which can be made assumes that the form of the crystal is determined by the way in which the molecules group themselves together in a position of equilibrium under the action of the inter-molecular forces.

As, however, the forces between the molecules vary in magnitude and direction from one type of crystal to another, the resultant grouping of the molecules must also vary, particularly as regards the distance between them and the angles between the planes in which they lie. This may be simply represented by a series of geometrical diagrams, showing the hypothetical groupings of points which are strictly to be regarded as the centers of gravity of the molecules themselves. Such a grouping is named a network, or point-system, and it is said to be regular when it is the same for all parallel lines and planes, however they be taken. For the fundamental observed fact, true in all simple crystals, that they have like physical properties in all parallel directions, leads to the conclusion that the grouping of the molecules must be the same about each one of them (or at least about each unit group of them), and further the same in all parallel lines and planes.

61. B3.

The subject may be illustrated by Figs. 51, 52 for two typical cases, which are easily understood. In Fig. 51 the most special case is represented where the points are grouped at equal distances, in planes at right angles to each other. The structure in this case obviously corresponds in symmetry to the oabe described in Arts. IS and 16, or, in other words, to the normal group of the isometric system. Again, in Fig. 53, the general case is shown where the molecules are unequally grouped in the three directions, and. further these directions are oblique. The symmetry is here that of the normal group of the trie! inic system.

If, in each of these cases, the figure be bounded by the simplest posaible arrangement of eight points, the result is an eltmentary parallelopiped, which obviously defines the molecular structure of the whole. In the grouping of these parallelopipeds together, as described, it is obvious that in whatever direction a line be drawn through them, the points (molecules) will be spaced alike along it, and the groaping about any one of these points will be the same as about any other.

31. Certain important conclusions can be deduced from a consideration of such regular molecular networks as have been spoken of, which will be enumerated here though it is impossible to attempt a full explanation.

(I) The promiuent crystalline faces must be such as include the largest □umber of points, that is, those in which the poiuts are nearest together.

Thus in Fig. 53, which represents a section of a network conforming in symmetry to the structure of a normal orthorhombic crystal, the common crystal-lin« faces would be expected to be those having the position ib, aa, mm, then

"j-'v , ..,\

II, nn, and so on. This is found to he true in the study of crystals, for the common forms are, In nearly all cases, those whose position bears some simple relation to the assumed axes; forms whose position is complex are usually present only as small faces on the simple predominating forms, that is, as modifications of them. So-called vicinal forms, that is, forms taking the place

of the simple fundamental forms to which thej approzimftte Terj closely in an go lar position, are exceptional.

(3) When a rariety of faces occur on the same crystal, the numerical relation existing hetween them (that which fixes their position) must be rational and, as stated in (1), a simple numerical ratio is to be expected in the common cases. This, as explained later, is found by experience to be a fundamental law of all crystals. Thus in Fig. 53, starting with a face meeting the section in turn, II wonid be a common face, and for it the ratio is l:i! in the directions b and a; nn would be also common with the ratio 3:1.

(3) If a crystal shows the natural easy fracture, called cleavage, dne to a minimum of cohesion, the cleaTage sarface must be a surface of relatively greiit molecular crowding, that is, one of the common or fundamental faces. I'his follows (and thus gives a partial, though not complete, espiauatiou of cleav-^e) since it admits of easy proof that that plane in which the points are closeat together is farthest separated from the next molecular

plane. Thus Jn Fig. 53 compare the distance separating two adjoining planes parallel to bb or aa; then two parallel to mm, ll, nn, etc. Illustrations of the above will be found under the special discussion of the subject of cleavage.

S2. Kindt of Jlolecolar Groapings.—The discussion on the basis just deeeribed shows that there are fourteen possible types of arrangement of the molecules. These agree as to their symmetry with the seven groups defiued iti Art. 25 as representing respectively 6*.

the normal groups of the six systems a bo

with also that of the trigonal (or ^-o-' ~ o •■-fclli^ •^^S^---^ the rhombohedral) division of the \\ y [FNXjirT iW^'^^v" hexagonal system. Of the fourteen, i i ■*'

three groupings belong to the iso- Lo

metric system (these nre shown, for * '

sake of illustration, in Fig. 54, a,b,c, from Groth); two to the tetragonal; one each to the hexagonal and the rhombohedral; fonr to the orthorhombic system; two to the iiioiioclinic, and one to the triclinic.

In its simplest form, as above outlined, the theory fails to explain the existence of the groups under the several systems of a symmetry lower than that of the normal group. It has been shown, however, by Sohncke and later by Fedorow, Schoiiflies and Barlow, that the theory admits of extension. The idea supposed by Sohncke is this: that, instead of the simple form shown, the network may consist of a double system, one of which may he conceived of as having a position relative to the other (1) as if pushed to one side, or (2) as if rotated about an axis, or finally (Z) as if both rotated as in (3) and displaced as in (1). The complexity of the subject inakes it impossible to develop it here. It must suffice to say that with this extension Sohncke concludes that there are 65 possible groups. This number has been further extended to 2.30 by the otliei- authors named, but it still remains true that these fall into 33 distinct types as regards symmetry, and thns all the observed groups of forms among crystals, described under the several systems, have a theoretical explanation.

Literature. —A complete understanding of this subject can only be gained by a careful study of the many papers devoted to it, a partial list of which is added below. Further references particularly to the early literature are given in Sohncke's work (see below). An excellent and very clear summary of the whole subject is given by Groth in the third edition of bis Fbysikalische KrystallograpEie, 1S9&.

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Wiilfiiig. For title see p. 3.

GENERAL MATHEMATICAL RELATIONS OF CRYSTALS.

33. Axial Batio, Axial Plane.—The crystallographic axes have been defined

{Art. 22) as certain lines, usually determined by the symmetry, which ^re used

in the description of the faces of crvBtala, and in the determination of tbeir

position and angalar inclination, with these ohjects in view, certain lengths

55. of these axes are assumed as nnits to which the

occurring faces are referred.

The axes are, in general, lettered a, b, c, to correspond to the scheme in Fig, 55. To aid the memory, the letters may he furtner distinguished; as i (vertical axis); d, 5^ (shorter and longer lateral axes), etc.

If two of the axes are equal, they are designated a, a, d; if three, a, a,ij. In one system, the hexagonal, there arc four axes, lettered a, a, a, i.

Further, in the systems other than the isometric, one of the lateral axes is taken as the unit to which the other axes are referred; hence the lengths of the axes express strictly the axial ratio. Thus for sulphur (orthorhombic, see Fig. 57) the axial ratio ie

d:l% 6 = 0-8131 : 1 : 1-9034. For rntild (tetragonal) it is

a: i = 1: 0*64415, or, simply, 6 = 0-64415.

Tbe plane of any two of the axes ia called an axial plane, and the space iDcliided by the three asi&l planes ia an octant, since the total apace about the center is thus divided by the three axes into eight parts. In the hexagonal system, however, where there are three lateral axes, the space about the center ia divided into 12 parts, or sectnnts.

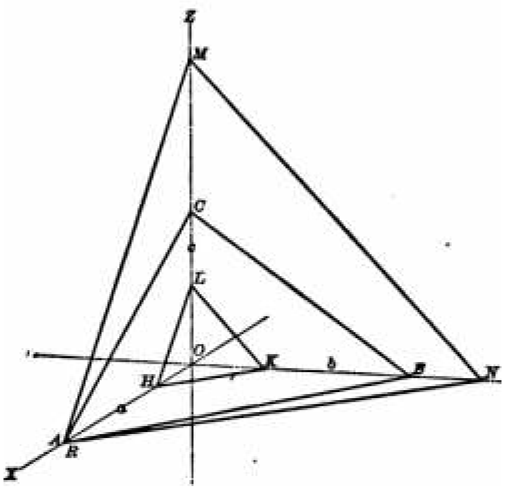
34. Paramatart, Symbol.— The parameters ot a plane are its intercepts on tlie asaumed axes. The symbol expresses, often in abbreviated form, the relation of these intercepts to certain lengths of the axes taken as unite,

For example, in Fig. 56 let the linea OX, OF, OZhe taken as the directions of the crystallographic axea, and let OA, OB, OC represent the unit h-iigths, designated (always in tbe aame order) by the letters a, b, c. Then the piirameters for the plane (1) HKL are OH, OK, OL; for the plane (2) RNM iliey are OR, OA, OM. But in terms of the nnit lengths these ars, resi)ectively,

(1) J-" • I' • r- " <^) '" • I' ■ -"■

These two expressions are identical, since the two planea HKL, MNR are parallel and hence cryatallographically the same, Obvionely each of the above expressions may be changed into the other by multiplying (or dividing) by 4,

56.



It will be noted that in (1) the numerators of the fractional nambers expressing the relation to the axes are all nnity; while in (3) the nnmber referring to one of the lateral axes (n) is made nnity. The significance of this distinction will appear at once.

The general expression for any plane referred to these axes, written after the same method, will be

(1) r,'-

or (2) la : nb : mc

Here in (1) the munbere, or indices, hkl (in the case above, 433) constitnte the symbol after the method of Miller (1839; earlier developed aj Whewell and Orasfimann).

The second form (2) ie the symbol essentially as early written by Weiss. This last was contracted by Kanmann to mPn imOn in the isometric system), the axes bein^ omitted from the ezpresBion and the order reversed; the same with the omission of the P (or o), m-n, is adopted in Dana's System of Mineralogy, in the last edition (1S92) of which work, however, the Miller symbols are given the preference.

In the hexagonal system there are assumed fonr axes, three of them lateral axes. Corresponding to this, in the symbols after the method of Miller as adapted by Bravais, there are fonr indices, hkit. The relation of these to the axes is the same as in the other cases, as explained under the hexagonal system.

The following are other examples of planes with the symbols written after the two methods given. It will be seen that the respective expressions under (1) and (2) are identical.

HlUor** SfinbaL Muimum'i BrmboL

: j-« 821 or la: WsSe 2Por2

: le 818 " lo : S* : Ic i>8orl.2

la:<t>b:2o 3i^» or

la: 2b:a>o ooPSoi

If the axial values are measured behind for the axis a, to the left for J, or below for c, they are called negative, and a minus sign is placed over the corresponding number of the Miller symbols; as.

' 1 ■

It is soraetimPB slaieii that Nanmann"s armbols are the more ewy of comprelienaioD b«csii5e more readily referred to the aiee. and tbU is In a measure true. If the Bludeut, however, wlllsccuatom hhiiBelf m thick of the Miller symbols iu the form given above, that ie, always us the deiiominfttors of the fractional values ot the axes whose numerators am unity, he will never have any trouble in seeing the position of a given plane relatively to the axes. He must remember that the order is always that given ftbo?e. A, k. and (referring respectively lo the axes a, b, and e-, moreover, he will note that a zero, 0, alw^iB roeaus that ihe given plane is parallel to the mis to whicli it refers, since t- = cd.

With the symbols of Naumann, the m, written first, always refers to the vertical axti, while the n, which follows, and is always greater than unity, refers to one of the ialeral axes. tUe other being made unity. To which lateral axis the n belongs is often indicated by a mark over the n (n, or n, or n), or attached to the Pas explained under the different syBtema. When m = 1, it Is omitted before the Por 0 (but not so when the Pis dropped); --' = I. it Is omitted in all c- -

.dbyGoOglc

Of Ihete the BjmboU of 'WelsB are easenllally thone alreaiiy given (under 2. p, 28) which, ■bbreriated {anci inrerted In order), were adopted by Nnuamnu, The ajmbols of Ury bsTe been eiteusivel]' used by the Freuch school of ininerulogista, A. \ery full ezplanatlos of til the different systems, 08 of that receutly devised by himself, la given in GoldBchmldt'i jDilez (IBH6-1B9I). Transformatlun eoualtons for the important cases, are giveu by Orolb

(Pbye. Kryet.J,Mallard (Criec, vol. 1), Lfebisch (Kryst.), and others ; see p. 2.

35. Law of Bfttional Indioei.—The study of oryetala has eBt&blisbed the general law tliilt the ratios between the intercepts on the axes for any face OD a crystal to those of any other face can always be expressed by rational nambera. These ratios may be 1:2, 2:1, 2:3, 1:0 (as :1), etc., but never 1:4^2, etc. Hence the values of hkl in the Miller ey mho la must always be either io?iole numbers or zero, and similarly the m and n of Naumann's sytnbolft may be whole numbers or fractious, or infinity.

If the form whose intercepts on the ases a, b, c determine their assumed nnit leuKths—the unit form as it is called—is well chosen, these numerical Tolues of the indices are in most cases very simple. In the Miller symbols, 0 and the numbers from 1 to 6 are most common.

The above law, which has been established as the reeuU of experience, ia fact follows from the consideration of the molecular structure as hinted at in an earlier paragraph (Art. 31).

Tlie law of rational indices Qnda an illustration later under the isometric system. It It staled there that three ot the five regular solids of geometry, viz., ibe cube, oclahedron, ud the regular triangular pyramid (crystalloijrapbiciilly tlie tetnihedron) all occur nmotig crystals; the regular pentagonal dodecaliedroii and icosahedrou, on the contrary, are im-p(i«sil)le forms. This is true bicauec theraiiua oF tbelrinleiceptsou tbeaxes forsucli forms

would be irrational; thus for the regular dodecabedron the rallo wiiuld be 1 : „ -■

Tliereare. it is true, two forma respecii-ely Iwelve-sided and twenty-sided wlilcb approximate to these regiiliir solids, but tlieiv fiices in Ibe tlrsl case are not nil regular peulagons, ■nil Id the second tbey are nut all regular triangles. In the latter cose ft will be seen that lite tweuty fiices iu fact belong to two distinct forms, eight of one and twelve of tlie other.

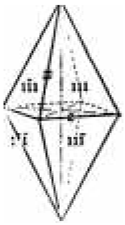
36. Form.—A form in crystallography includes all the faces which have a like position relative to the planes, or axes, of symmetry. The full menniiig of tliie will be appreciated after a study of the several

mcems. It will be seen that in the most general case, that of a form having the symbol (hkl), whose planes meet the assumed unit axes at unequal lengtlis, there must be forty-eight like (aces in the isometric system * (see Fig. 101), twenty-four in the hexagonal (Fig. 301), sixteen in the tetragonal (Fig. 166), eight in the orthorhombic (Fig. 57), four in the monoclinic, and two iti the triclinic. In the first four Byatems the faces named yield an enclosed solid, and hence the form is called a closed form; in the remaining two systems this is not true, and such forms in these and other casei! are called open forma. Fig. 275 shows a crystal boundci by three pairs of unlike faces; each pair is hence an open form.

Figs. 58-61 show open forms.

The unit or fundamental form is one where parameters correspond to the assumed unit lengths of the axes. Fig. ^7 shows the unit pyramiii of sulphur whose symbol is (111); it has eight similar faces, the position of which determines the ratio of the axes given iu Art. 33.

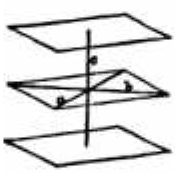
* The normal group is referred lo In each case.



The foriDB In the laometrfc system liave special iDdivfdusl nnmes, given later. In U19 otber systems certaiu general oaroes are e[nplnye<l wliicli may be briefly mentioned here. A form whose faces are parallel to two of the axes* Is called a jtinaeoid (from xiVag, & boiird. It Is shonii In Fig. 58. One whose faces are parallel to the vertical axis but meet both the lateral axes is called a pritm, as Fig. 6B. If tbe faoea arc parallel to one lateral axis only. It U a dome (Figs. 60, 61). If tbe faces meet all ibe axes, the form is h pyramid (Fig 57); tl'is uHiiie is given even If tLere ia only one face belonglug to tbe form.

Ill Fig. 6S. a (100), b (010). e (001) are pinacoids; m (110). ((120) nre lirUmsi d (101), also A (Oil). 1(021) are domes; all Ibese ure open forms. Finally, «(111). / (121) are pyramids, an<l in this case they are closed forms. The relation existing Id each of Ihew cases between the symbol and the position of the facts to the axes should be carefully studied.

68.



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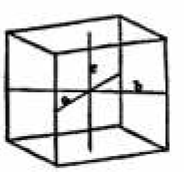

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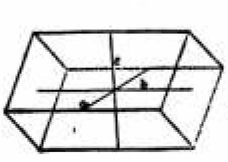
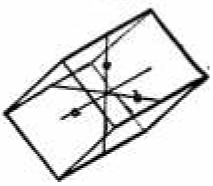


61.



(0«)

As sbowD Id the'above ctises, tbe symbol of ^form is usually Included in parentheses, u (111), (100); or It may be in brackets [111] or J 111)■. If Ibe symbol is written without pai'cntbesla, as 111. it usually refers to a single face of Ibe form ouly. Note also that witb the Miller symbols, each face of a given form has its own iudividual symbol.

37. Zone, —A zone includea a serieB of faces on a crystal whose intersection-lines are

mutually parallel to each other and to a common line drawn through the center of the crystal, called the zoue-azia. This parallelism means simply that the parameters of the given faces have a constant ratio for two of the axes. Some simple numerical relation exists, in every case, between all the faces in a zone, which is expressed by the zonal equation. The faces a, m, s, b (Fig. 62) are in n zone; also, b, k, Ii, c, etc.

If a face of a crystal falls simultaneouijly in two zones, it follows that ita eynibol is fixed and can be determined from the two zonal equations, without the measurement of angles. Further, it can be proved tliat the face corresponding to the intersection of two zones is always a possible crystal face, that is, one having rational values for tbe indices which define its position.

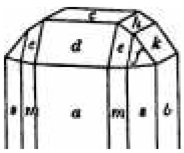
In many cases the zonal relation is obvious at sight, but it can always be determined, as shown in Arts. 43, 44, by an easy calculation.

38. Horizoatal Frojeotioni. —In addition to the usual perspective figures of crystals, projections on the basal plane (or more generally the plane normal to the prismalic zone) are very conveniently nsed, Tliese give in fact a map of the crystal as viewed from above looking in the direction of tbe axis of the prismatic zone. Figs. 30, 32, 34 give simple examples; also Fig. 63 a projection of Fig. 62, both repeated from p, 16. In these the successive faces may be indicated by accents, as in Fig. 63, passing around in the

, prism and (101) a

QENBBAL MATHEMAIICAI. BBLAT1oN8 OF CRTTSTAIA

On the cooatrac-



[\2W

direction of the axes a, b, a', that ia, counter-clock wise, tion of these projections see the 6a.

Appendix A.

39. Spherical Fr<ijeetiona.— Tlie Btiidv of actanl crystiils, ^Kirticiilarij as regards the aiignliir and zonal relations of tiieir fiices, is much facilitated bv the nse of the aphericil pro-jtclion. In this the position of eanh face is represented bj point called its po}e, when? normal drawn to it from the center and produced nneete the surface of the 8(>here. The

eymboh aftur Miller are immediately connected with this projection, and by means of it all ordinary calculations can be performed m a very simple manner. Fig. 65 shows a spherical projection of the orthorhom* bic crystal. Fig. 62. '

IF tlie ceuter of n crysliil, Ibnt \n, Uie point of inlerseclion of tlie crystal Wrap lite axes, Ik Inken ns the center of a apliere, auii uormiils be drawn from it lo iLe successive , fiLCBS of tbe crysiiil, ibe iwliils. wLeru thi-y

^* meet tlie surface of tlie apliere, will be. as

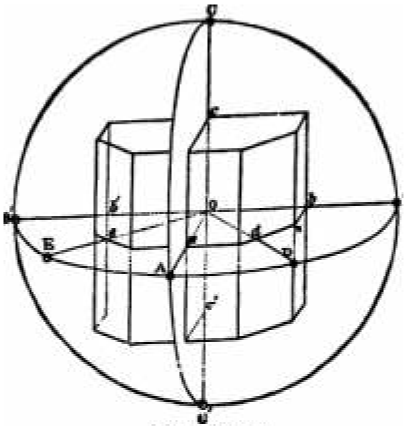
before ileOned, tbe polet of tlie Ti-speclive fnci'B. For txiimple. iu T\s. 64, tlie common renter of llie crystal iind spbere is iit O, tlie normal to tbe fiice I mecla tbu surfnce of ilie spbere at B, of 6' at B'. of d aud e nl D and £ respeciiTcly. aud so on. These poles evidenlly deiennine tbe posilion of Ibe fnre Id encli case.

]1 is obvious that Ibe pole of tlie fiice b' (OiO) opposite 6(010) will belli llie opposite I exlrimltyoflliediamilerofIbi'sphere,and si> in Keneral for (120) iiDd (120', etc. It is seen niso that nil the |M)K-s, or normal points, of fiices Iti llie snme tone, tbat is, fiicis whose inlerseclion lines are parnllel, nre in tbe samu greni circle, fin- inslnnce B(010),J)(110i. .^(100). «(110). and soon. It Is cusiomiiry In tbe use of tbe spbere lo regnnl It ns projected upon a borizonlal plane, usually tlini nonnni to tbe prismatic zone, so tlial. as in Fig. 65. tbe poles of the prismatic fnces lie in Ibe ctrcumfereiice of tbe circle, nnd those of llie other facei^ within it. Tbe eye lieing supposed to be situattd at the opposite extremity of i lie dfnmeter of Ibe spbere normal to tbis plane, tbe great cirtlea tben appear ellber us nrci of circles, or as stratglu lines, ie.. iliumelers.

It will be further obvious from Pig. 84 tbut tie are IID, between the |ioIes of b nod d, m«a8urea an ingle at Ihs center (BOD), wljich Is the tuppUmeiil of the aclual Interior angle bad lii;iween Ibu two faces ; niul tliia Is true ia general.

40. ConitrnBtion of ths Spharloal Projsntion.—Since iu tbe method ordinarily followed the pok-a of the prismatic faces lie in Ibe circumference of tbe circle, Iheir posilion Is fixed at uuce by the iiegles laid off, e.g. from 100, with a protractor. Further, the distances of the poles of all faces measured from Ihe center of the cii-cle (which, when the vertical axis is at right angles to those in tbe lateral plane, Is the pole of the hose 001) are proponlonal lo tbe langentt of half Uu nngU». For example, to construct tbe spherical proJect16n of Fig. 83. first draw lUfi circle, and lay off on the eircumferenre, from a po nt taken as 100, Ihe angular distances characteristic of Ihls species (i-brysoliie):

am. 100 a HO = 34" 58'; at, 100 a 120 = 48* 68'; oi, 100 A 010 = 90°.



After Brezina.

Th« rosltioa of Ihe poles of the f&cea a (100). m (110), «(120). h (010) are Ilius flxed. Tbe poles of tbe otber faces of these forms are obviously flxeil. a', m\ »', i', m'', *'', m''. <'', by .. tlie symntclry. Again, to And tbe ''''*■ pole of d (101), wiiicli lies an tbe gruiit circle, or zone, a (100), e (001). a' <iOO) (for whicb k = Hr. mdcv d (001) A d (101) = sr ittr, tbe ilUtauce cd Is pTupDrliODul to tb<> Itiugeut of llfil'' tS3) or 25° 4tit', tbia Is. U.4t» of ■ be radius eu. Simik.ly for A|Olt> nod k(Vril) nu Ibe zoix-circle c (001), 6 (010), Httice cA (001 A I'l 11 = 80' a8i' aud e4 (001 a Oiil) = 49'' 88'', tbe dls- ' tsDces are proimnloiiiil Id tht laugi-iits of balf IbeBf niiglin re-peclively. So 9LO06 also from the aiigleH ct (001 a 111) = 51' 16' iwd if (001 A 121) = S9' 50*' ibc distances on the OorreapoDdJur

ione-cireU-8, e (001) m (110) aud e

(OUl) 1(120), may be delermined. In

priicilce, liowever, tbese Inst steps are

Huiieci ssiiry ; since If tlie circular arc

through b (010). d (101). 6" (010) Is

drawn, it elves the zone-circle for all

Ibe fiices for which A = (; similarly

^ ... thai through a (100). h (Oil), a! (lOO)

"* ^ give tbe zone circle for the plaues for

which k = l, while thnl through a

(100), J; (031), a' (100) gives tliu zone-circle for the planes having jt = 3i. The tutersecUoo-

poluts belweeu tiiese last arcs and ihut first drawn Axes Ibe)>o£itioDSof «(lll),/(12l),

pnch of which sutisties the two relutious. Further, through these same poinis must i>ass

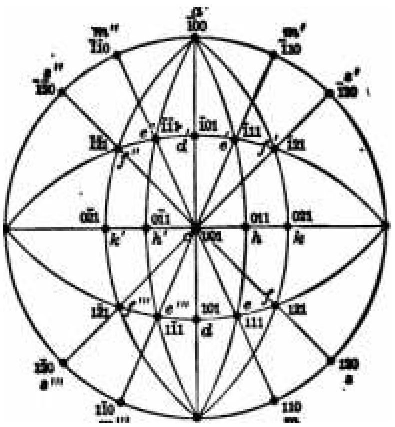
Iliezone.circlee(001), in (110). for which ft = t, mid c (001). * (120). for which t = 2A, tbua

giving a check ' ....

It is< Ihe intersection of either n

100, 031, iOO 010, 401. OiO 001. 480, OOi. In geaernl any fnce. hkl. iniisl lie In the three zoue-clrcles

100. OW. Too. 010. AW. OiO, 001, AAO, OOl.



41. AnglM between Face*.—Tlie angles most conveniently used with the Miller symbols, and those given in this work, are the normal angles, that is, the titigles between the poles or normals to the faces, nieadure<I on arcs of great circles joining the poles as shown on the spherical projection, Thsse normal angles are the supplements of the actual interfncial angles, aa has been eiplaineil.

The relnlinns between these normnl Hngli'°. forexninple id a given zone, is much simpler than those existing lietween the HCtual tmerfncial HDKles. Thus ii i; alwiijs true thai, fur a series of fiicea in the snme zone, the nurmnl aogle between two cod Taces Is equal to tbe sum of the angles of faces falling between. Thus (KIgs. 62. (W) Ihe nonnul angle of ab (IOO A 010) is the sum of am (100 A HO), m«(110 a 130), and lA(130 a OIO). This relation holds true in all the sysietus.

Furthermore. It will be seen that, supposing acn' (Fig- 65) s plane of symmetry as in tbe ortliorhomhicsystera, Ihe angle 100 Alio. oram(Fig. 62], tahalf the angle 110 A llOimm'"] Similarly 010 a 120 (6t) is half the angle 120 a 120 (m') ; again. 100 a 111 (ne) is tbe complement of half the angle 111 A 111 (aa)aDd 010 a 111(&:) tbe complement of half Ihe angle 111 a 111 (*^') ■

Here, as throughout this work, the slgD A Is used to represent the angle between two faces, usually designated by letten.

4S. Um of the 8plLsrlc»l FrDJeotion to Exhibit the SymmetTy.—The aym-metry of any one of the crystalline groups may be readily exhibited by the help of the spheric&l projection, following the notatiou introduced by Gadolin (1871, eee p. 22).

The axes of binaiy, trigonal, tetragonal, hexagonal eyminetry are represented

respectively by the following signs: ^A^#. Further, a plane of Bymnieiry is represented by a full line (zone-circle), while a dotted line indicates that the plane of symmetry is wanting. The position of the crystal]ographie axes is shown by arrows at the estremiLiea of the lines. The pole of a face in the npiKjr half of the crystal (above the plane of projection) is represented by a crosa; one below by a circle. K two like faces fall in a vertical zone a double sign is need, a cross within the circle. Figs. 69,111,136, etc., eive jllustrations. 43. Qener&l Bel&tlona between Planet m the Same Zone.—It may be demonstrated that if on a crystal two faces P {kkl) and B (pgr) lie in the same zone, then the follovring equation must hold good :

Ma COS XQ + vb cos YQ + wc coa ZQ = o,

where a = kr — Ig, v = Ip — kr, w = hq — kp.

The letters n, v, w are called the symbol of the zone or great circle PR. Every face ixyz) of this zone must satisfy the equation

■ax + \y 4 W2 = o.

If now (avw) be the symbol of one zone, and (efg) of another intersecting it, then the'point of intersection will always be the pole of a possible crystal face. Its indices {hkt) must obviously satisfy two equations similar to (1). These indices are bence equal to

A = gv — f w, * = ew — gu, i = f a — ev.

The application of this principle is extremely simple, and its importance caunot be overestimated.

Tlie zone-symbolB can be always oblulned by nrrengiug tbe symbnls of the two faccB la oHer. repeating tbe first two iodices nnd then mu 111 ply log accordiog to the foltowiug scheme:

I

xx:

HcDce \i = kr-lq\ ^ = lp-!ir: w = ft? - tp.

44 BxftKVlM tf Zoom knd Zonal Bvlatloni.—The followiog are cases in which the zoaal equiilinn ta eeer nt once. In Fig. 62. p. 27. the faces a (100). m (110), .(130). 6(010), form a vcrlicbl zone w!lh mutually parallel lulerspoLinDs, since the^ are alike lii poaltiou In so far ns (liis: that they are all parnflel lo the vertical axis ; that la, for all faces lu Ihia zone It must bo true that 1 = o.

AiMln tbe facef a (1001. d (101), e (001) are In zone, all hoini; parallel to n lateral axis i; hence for tl.em nml all others in this zone i = o Also fr (010), * (031), A (Oil), <! (001) are ID a zone, all belnit imrallel lo the axis a, bo thni /. = o

Also the faw '(181). «(1»). <* (lOU. ^" ("!)./" HSl) are in a zone, since they have a common ratio foi I In nxesiTC With them, obviously, h = l.

The faces e |iyt) « (111), m (110) are nlso in a zone, and agaiu « (001). /(121), a (120), thoiieh intereedlTiiB tin not happen lobe made between caiid «ln tbe one case, and c and fin ihe other r..r each of tlie«e zones it is true tlmt there^s a common ratio of the laleral nxes. rhat Is, of I M k in the symbols. For the Aral U may he shown that A = i; for the second, that ak:^k

1

.XX.X

u = 3, v = i. w = 0: .■.Zh-k = <i.oiU = k.

The symbol of a ftice tj^lDK M ODce id two zones, as atated above, must satisfy Ibe zonal equation of each; these symbols are heuce eiisily obtained either by combialtig the equs-tluua or by a scheme of muliipiicatidu like iliut giTeu above.

" mole, in Fig. 66, of sulphur, ihe face lettered x is in the zone (1) with 6(010) aud

0 in zo ' ' ' "' "

«(113), also !i

e (2) with p (111) ttiid n (Oil). These zones give, respectively :

(1) 0 1 0 0 1 (2) 1 1 1 1

XXX XXX

1 1 S 1 1 0 110 1

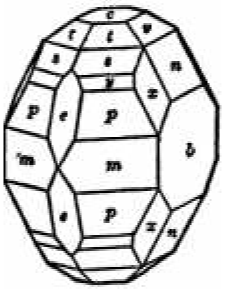
u = 8, v = 0, w=i. <! = 0. /=i. g = l.

Hence for (1) the zonal rqualEon iaSh = l; for (2) k = l. Com-biDJDg these, nc obtain A =-1. k = 3.i^3. The symbol of the face x is, therefore, 1S8. _Thes)ime result is given by rauliiplyiaRihe zonal Indices Oil, 801, together after the same method, tbus:

0 i 1 0 I

■ XXX

66.



Sulphur.

ıgain, x = 183.

This method of cftlculalion belongs to all the diSereut s^lems. In the bexngorial svstem, in nhlch there are four indices, one of the three referrmg to the lateral axes (usually the third) is omitted when the zoual relations are applied. Bee Art. 160.

46. Methodfl of CBloiilatii>ii.—In general the angles between the poles can be calculated by the methods of spherical trieonometrj from the triangles shown in the sphere of projection (Fig. 65)—which for the most part are right-angled. Certain fundamental relations connect the axes with the elemeotal angles of the projection ; the most important of these are dven nnder the individual systems. Somo general relations only are explained here.

46. Relation between the Indicea of a Plane and the Angle made by it with the Axes.—When the assumed axes are at right angles to each other they coincide with the normals to the pinacoid faces (100, 010, 001), and consequently meet the spherical 67.

surface at their poles. When the axial angles are not 90°, this is no longer true. In all cases, however, the following relation holds good between the cosines of the an^es made by a plane, HEL, with the axes:

^-cobPX-

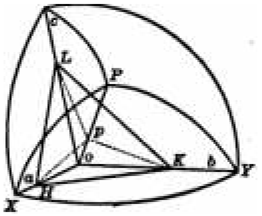
Qjj-COBl-A,

This is equivalent to

oK~

cosPY;

= cos PZ.



- cos PX = T cos FY = 7 COB PZ.

This equation la f andameutal, and soveral of the relations giTea beyond are deduced from it.

. . etlie AIbo if ibe plaue E

OH -a. OK == 6, OL = e. Tbeq the lineB HK, HL, EL give also the intersections of Ibe planes 110, 101, Oil on ' tbe three azlal planes, and ihelr poles arc bence at ihe points fixed by Donuala to ihese lioL-s drawn from O. It wUl be obvious from this flgure, then, tbat Ibe follonlog relaUoDH bold true:

tan (100 A 110) = -^;

t&u (001 A 101) = -;

tan (001 A Oil) = |. TbeK values are often used later.

47. Cotangent and Tangent Kelatlona.—If the angles between the poles ot three faces in a zone are known, the augle between any one ot them and the pole of a fourtii face can be calculated by a formula called the cotangent for-niula. Conversely, if the angular position of thia fourth face ia given, the ratio. of its indices can be calculated.

Let P. Q, S. R be tlie poles of four faces in a zoqp, taken Id such an older " tbat PQ < PR, aod let the indtcea of these faces be respectively : P Q R S

hkl pqr vtte xj/t Tbeii it may be proved tbat

If one of tbese fractloDS reduces lo an iodelermlnote form, —, then one of

<bc others must be taken in Its place.

Tbis formula Is chiefly used In tbe moDoclinic sad tricllnlc systems; and some special 0B3e~ nre referred to under those Kyalems.

Tiie cotangent reliilion becomes much simplified for a rectangular zone, that is, a zone between a pinacold nml a face in the zonu oF tbe other plnacoids at right angles to it. Thus if Pa, P6, Po, Qa, Q6, Qe represent respcctlTely tbe ftugies between two faces in the saute rectongulsr sotie, viz., F [likl) and Q t^qr) and Ibe pu^scolds a (100), b (OlO). o (010), tbe foUuwlng relations bold good :

A Ian Pa k I

tan Qa   q   r

$$\frac{k}{q} \cdot \frac{\tan Pb}{\tan Qb} = \frac{l}{r};$$

$$\frac{k}{q} = \frac{l}{r} \cdot \frac{\tan Pc}{\tan Qc}$$

* In the application of this principle it is eaBenlial (hat the planes should be taken In the proper iirder, as shown above ; to accomplish this It ia often_ necessary to use tbe Indices and con-eaponding angles, not of (UO, but tbe face opposite (hkCi, etc.

the above equatloos for I .

ftnd pgO, or domes MH and jiOr or Qkl &ud Ojr, between two plnacold pWes, we astc

tan (100 A hkQ) _kp Uq (100 A pqO) ~ A- q' tau (001 A AOQ ft r^ tan (001 A pOr) i ' p' tao (001 A 0*0 _ * r Un (001 A 0?r) ~ i ■ 3 ■

These equations are the ones ordinarily employed to determine the ajmbol of utj priamatlc plane or dome.

The most common sna impoibint applicslion of this tangent principle is where the posEilons of the unit faces 110, 101, Oil are known, iheu the relation becomes

tan (100 A fttO) _ * tan (OIQ a hkO) _ h

tan (100 A HO) ft' °' tan (010 a 110) ~ i'

tan (001 A AOf) _ A ttn (001 a Okl) _ k

•*^**' tan (001A 101) I' tan (001 A Oil) ~ r

Sles between the base, 001, and 102. 208, S03, SOI, etc., aro le tangent of the angle between 001 and 101. Again, the

tangent of the angle 100 A 130 Is twice th^ tangent of 100 A HO [here t = 3], and one-half the tangent of 010 A HO.

4S. Formnlaa fOr Spherloal TriuiglM.—For convenience, some of the more Important formulas for the solution of spberical trianvles are here added.

In right-angled spherical triauglt

shi ^ = -A-f, sin B

sin b

tan 6 „ r. *»"»

cos J = -—J, cos £ = -—-=.

tan A tan A

In oblique-angled spherical triangles familiar reiaiions are (1) fiin J : sin £ = sin a: sin

Bill b ein ecmA; A + aSn A col B; C+sEn Bain Ccma.

Id CB)cu1alion it is often mor especlall; arraneed tor logaritbmi to mathematlcarformulaa.

L ISOMETRIC SYSTEM.

49. The Isohetbic System embracea all the forma which are referred to three equal axes at right angles to each other. Each of these axes is designated' bj the letter a.

There are five groups here included, of which the normal group,* posseaaing the highest degree of symmetry for the system and, indeed, for all crystitls, is bv far the most important. Two of the other groups, the pyritohedral and tetrahedral groups, also have numerous representatives among minerals.

1. NORMAL GROUP (1). GALENA TYPE.

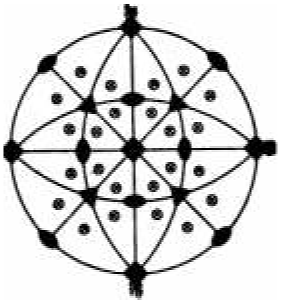
50. Bynunetry.—Of each of the types of solids enumerated in the following table, aa belonging to this group, aa of all their combinations, it is true t that there are three like principal pianea of symmetry, whose intersections fix the jHwition of the cvystallographic axes (aee Fig. 12, p. 9). There are also aix other auxiliary planes of symmetry ; these are situated diagonally to the others, each two equally inclined (45°) to the adjucent planes of chief symmetry, that is, to the axial planes.

Further, the crystals of this group have three principal axes of tetragonal symmetry, the cubic or crystallographic axes ; four axes of trigonal symmetry, liie octahedral axes ; six axes of binary symmetry, the dodecauedral axes (see Art. 16, ^o the following paragraph). I'hese axes are shown in Figa. 17,18, 19, p. 10.

The accompanying spherical projection (Fig. („ with the principlea explained in Art. 42, shows the distribution of the facea of the general form, hkl, and hence repreaenta clearly the sj'mmetry of the group. Compare also the projection given latef, fig. 110, p. 41.

51. Forms.—The various possible forms belonging to this group, and possessing the symmetry defined, may be grouped under seven typea of solids.* These are enumerated in the following table, commencing with the most simple. The symbols are given in accordance with both the systems of Miller and Naumann; also the full expression showing the eeneral position of the planes with relation to the axes. The last, however, are reduced to the form, corresponding to (2) in Art. 34, which shows how the Naumann symbols are

if constrnoted in accordance



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* li U c&llec] ttoTTnal, as before suited, sioce It Is the most commoD and heace by Tar tbe most Importanl group uoiler Ihv Bjstcm ; also, more fundamentally, because ilie forms liere iucluilvd |)osseas the bigbcst grade or symmetry possible in tlie syBtem. There are Ave torms in ibis system, each geomelrtcally a cube, but only that of this normal poup ttctually lias tlie full aymmelry ns regania molecular structure wbir.ti its ^ometrical shape sucgcsta. If s crystal Is said to belong to the isometric system, without further qualiQcntton, it is to he uudersiood that it Is Included here. Similar remarks apply to the normal groupa of the Wiier ay SI ems.

t The ivmmetry of the normal groups of the different syslems has been already briefly explained lo Art. SB.

Uflier. NatiinMin.

i. Onbe (100) aiooaiooo « 0» or t-»

5. Octahedron (Ill) a:a:a 0 or 1

3. Dodecahedron (110) a: a ; oo a as 0 or t

4. Tetrfthezahedron (AitO) o : na : co a <» On or t'-n

B8, (310) t-3; (310) t-2; (3S0) i-|, etc

6. TriBOotahedron (hhl) a; a: ma mO or m

w, (331) 3; (221) 2; (333) j, eto.

6. TrapezohedroD (A//) a : ma : ma mOm or m-m

as, (311) 3-3; (211) %■%; (332) f-f, etc.

7. Hexoctabedron {hkl) a:na:ma mOn or m-n

as, (421) 4-2; (321) 3-), etc. In thegeoeral expreisioD of Miller's ^robola, A > Jt > t. In tlioaa of Naumiuin, « > 1, AtteolioD is called to the letters nnlfonnly used In this work a&d In Duut'a SjrMem ol Hloerslog; (1893) to dealgiute certalD of the isometric forms.* Tbey are:

Cube: a. ,

OctsbedrOD: o.

DodecatiedroD: d.

.TeiraheialiedronB: o = 310. ^2; / = 81D. i-8; g = 9S6.i^i A = 410,^.

Trisocuiliedrons: ; = 231, 2; q = S&\. 8; r = 832, 4; p = 411, 4.

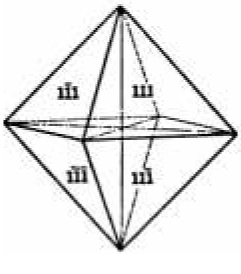
Trupezohedroos: m = 311, 8-3; n = 211, %2; fl = &£, |-(-

HexocuihedrODS: ■ = 321, 8-|; (= 421, i-2.

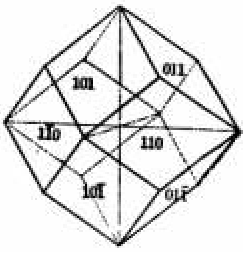
63. Cube.—The cube, whose general symbol is (100), ia shown in Fig. 70. It is bounded by six similar faces, each parallel to two of the axes. Each face is a square, and the interfacial angles are all 90°. The faces of the cube are parallel to the principal or axial planes of symmetry. The lines joining the opposite solid angles of the cube are called the octahedral or trigonal inter-axes ; those joining the middle points of opposite edges are the dodecahedral interaxes (see Figs. 17, 18, p. 10).

53. Octahedron.—The octahedron, shown in Fig. 71, has the general symbol (111). It is bounded by eight similar faces, each meeting the three axes at

71.



72.



equal distances. Each face is an equilateral triangle with plane angles of 60". The normal interfacial angle, (111 A 11!), is 70° 31' 44".

54. Dodeoahedron.—The rhombic tlodecahedron, shown in Fig. 72, has the general symbol (110). It is bounded by tweWe faces, each of which meets two

* Tlie usage followed here (ss also in the other systems) Is in most cases tltat of Miller

of the axes at equal distances and is parallel to the third axis. Sach face is a rhomb with plane angles of 70}° and 109^°. The real or interior interfacial angle is 120°, or the angle between two adjacent poles, that is, the normal interfacial angle, is GO". The faces of the dodecahedron are parallel to the six auxiliary, or diagonal, planes of symmetry.

It will be remembered that, while the forms described are designated respectively by the symbola (100), (111), and (110), each face of any one of the forms has its own symbol. ThuB for the cube the six faces have the symbols

100, 010, 001, ioo, olo, ooL

For the octahedron the Bymbols of the eight faces are :

Above 111, ill, ill. 111;

Below III, ill. III, 111. For the dodecahedron, the symbols of the twelve faces are :

110, 110, iio, lio,

101, lOl, lOl, 101,

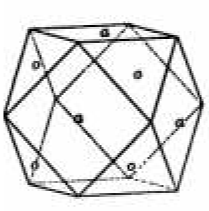
oil, oil, oil, oil.

These should be carefully studied with reference to the figures (and to models), and also to the Epherical projection (Fig. 110). The stndent should become thoronghly familiar with these individual symbols and the relations to the axes which they express, so that he can give at once the symbol of any face required.

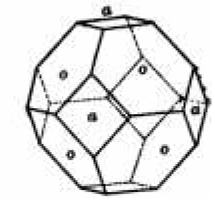
65. Combinatioiu of the Cube, Octahedron, and Dodecahedron.—Figs. 73,74, 75 represent combinations of the cube and octahedron ; Figs. 76, 79, of the cnbe and dodecahedron ; Figs. 77, 78, of the octahedron and dodecahedron ; finally, Figs. 80,81 show combinations of the three forms. The predominating

ff"WS A

74.



75.



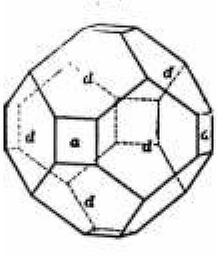
form, as the cube in Fig. 73, the octahedron in Fig 75, etc., is ueudly said tw be modified by the faces of the other forms. In Fig. 74 the cube and octahedron are said to be " in equilibrium,-" since the faces of the octahedron meet at the middle points of the edges of the cube.

It should be carefully noticed, further, that the octahedral faces replace the solid angles of the cube, as regular triangles equally inclined to the adjacent cubic faces, aa shown in Fig. 73. Again, the square cubic faces replace the six solid angles of the octahedron, being equally inclined to the adjacent octahe* dral faces (Fig. 75). The faces of the dodecahedron truncate * the twelve

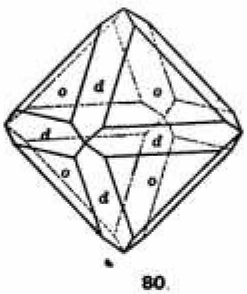
1 ODly when tbe modifjlog face makes equal

fiimilar edges of the cube, as shown in Fig. 79. They also trnncate the twelte edges of the octahedron (Fie. 77). Further, in Fig. 76 the cubic faces replace tlie six letiahedral solid angTes of the dodecahedron, while the octahedral races i-ephtce its eight trihedral solid angles (Fig. 78).

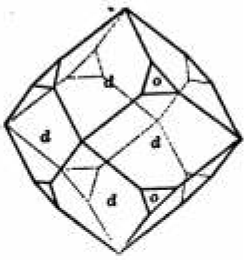
76.



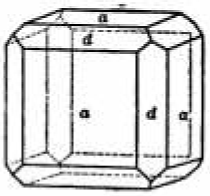
77.



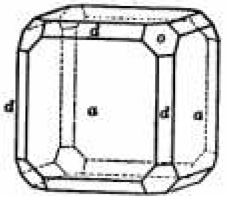
78.



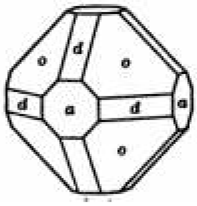
79.



80.



81.



The normal interfacial angles for adjacent faces are as follows : Cube on octahedron, m, 100 A 111 = 54° 44' 8".

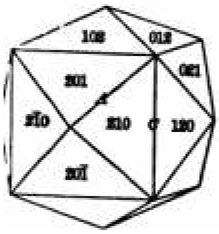
Cube on dodecahedron, ad, 100 A 110 — 45' 0' 0".

Octahedron on dodecahedron, od, 111 A 110 — 35" 15' 52", t6. As eiplaioed iu Art. K, actual cryslniB always deviate move or Icsa vlde^f from the ideal aollds SgunHl, Id cmiFcqueuce of tbe uDetjiinl ilevclnpnieat of like faces. Such ciyslalB. lliere(ore, do uot sHtiafy the geometrical defliiillon of right symmelry relatively to tLe Ibrce priDcipal Hiid the six auxiliary planes meutiooed ou p. 33. hill they do tiouform to the couditions of cryslnllognipliic aymmelry, refiiiiriog like angular paaJIJou for simlluT faces. AgaJu. it will be uoted that in a coinbiuatioD form many of Ihe faces do uot actually meet the axes wlthiu th't cryslal, as, for example, the octabedral face o iu Piij. 73. It ia sllll true, however, that thi^ face would meet the axes at equal dlslances If produced: and since the tMxial ratio is the esseolial point in the case nf each form, and the itcltial ltngt/i» oF the axes are of no iinpiiriaiice. it is uot iiecemiry that the faces of the differi'iit fiiniisi n a crystal should lie referred to llie same actual iixial leugths. Tlie above remarks wl 1 be seen to apply also to all the other forms and combinatioua of forms described Iti the pages fullowiog.

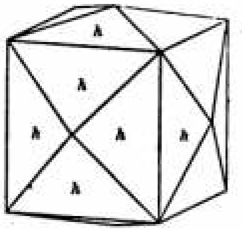
67. Tetrahexahedron.—The tetraheiahedron (Figs, 82, 83, 84) is bounded by tweuty-four faces, each of which is an iaosceles triangle. Four of these faces together occupy the position of one face of the cube (hexahedron) whence the name commonly iipplied to this form. The general symbol is (hkO), hence each face is parallel to one of the axes while it meets the other two axes at unequal distances. There are two kinds of edges, lettered A and C in Fig, 83 ; the interfncial angle of either edge is sufficient to determine the symbol of a given form (see below). The angles of some of the conamon forms are given on a later page (p. 42).

There may be an indefinite onmber of tetrahezahedrons, as the th< iDtercepts of the two axes, and heuce of h to i: Taries ; for exaiii]F (310), (210), (320), etc. The form (aiOl is shown in Fig. 82 ; (410) in , and (530) in Fig. 84, All the tetranezanedrons fall in a zone with a cu-j and a dodecahedral face. Ae b increases relatively to i: the form ap|ii'<

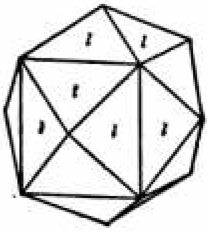
82.



83.

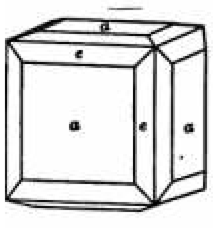


84.

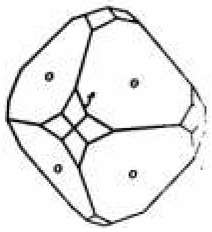


the cnbe (in which h:i= x : 1 or 1:0), while as it diminisbes and becomes more and more nearly equal to h in valae it approached toward the dodecahedron ; for which A = A. Compare Fig. 83 and Fig. 84; also Fig. 110. The special symbols belonging to each face of the tetrahexahedron should be carn-folly noted.

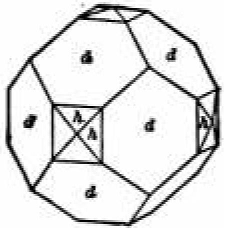
85.



86.



87.



The faces of the tetrahezahedron bevel * the twelve similar edges of the cube, as in Fig. 85; they replace the solid angles of the octahedron by four faces inclined on the edges (Fie. 86), and also the tetrahedral solid angles of the dodecahedron by four faces inclined on the faces (Fig. 87).

58. TrisootahedroE.—The trisoctahedron (Fig. 88). or, more definitely, the trigonal trisoctahedron, is bounded by twenty-four similar faces; each of these is an isosceles triangle, and three together occupy the position of an octahedral face, whence the common name. Further, to distinguish it from the trapezo-hedron or tetragonal trisoctahedron, it is sometimes called the trigonal trisoctahedron. There are two kinds of edges, lettered A and B in Fig. 88, and the interfacial angle corresponding to either is sufficient for the determination of the special symbol.

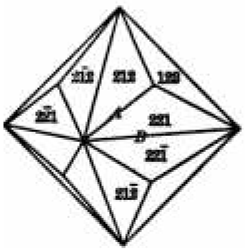
* The word bmtl (b used when two Ilka fnces replsce the edge of a form aad hence are lucliaed at equal angles to Its adjacent similar faces.

.dbyGooglc

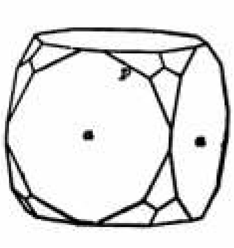
t CBT8TALL06RAPHT,

The general symbol ia (hhl); common forme are (231), (331), etc E«cl>

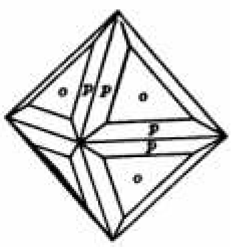
88.



89.



90.



face of the trisoctahedron meets two of the axes at a distance less than unity

and the third at the unit length, or (which is an identical

expression *) it meet« two of the axes at the unit length

and the third at a distance greater than unity. The

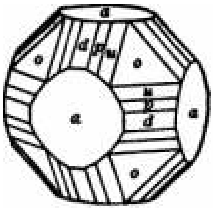
symbols belon^ng to each face should he carefully noted.

The normal luterfacial angles for some of the more

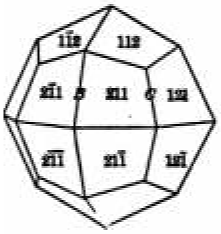
common forms are given on a later page.

69. Trapezohedrtm.—The trapezohedron f {Figs. 92, 93) is bounded by twenty-four similar faces, each of them a quadrilateral or trapezium. It also bears in appearance a certain relation to the octahedron, whence the name, sometimes employed, of tetragonal trisoctahedron. There are two kinds of edges, lettered B and C, in Fig. 92. The Oaiena.

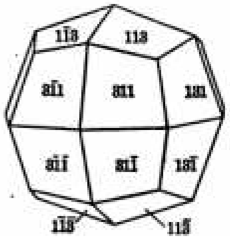
general symbol is hll; common forms are (311), (311), (333), etc. Of the faces, each cuts an axis at a distance less than unity, and the other two at the unit length, or (again, an identical expression) one of them intersects an axis at the



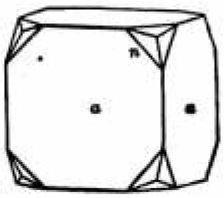
92.



93.



94.



nnit length and the other two at distances greater than unity. The symbols belonging to each face should be carefully noted. The normal interfacial

" Since ia:ib:ie=la:lb:2o. The studeut should read again carefully the explana-lionsiD Art. U.

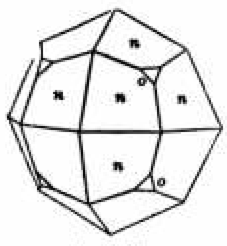
t It will be seen laler tbnl tbe name fooes are irapeztuma, conspicuoualy t trapezobedrou.

.dbyGooglc

ftnglee for some of tha common forma are given on a litter page. Another name for this form is icositetrahedron.

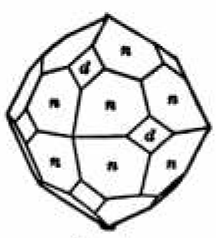
60. Tbd combinationB of these forms vith the cnbe, octahedron, etc., should be carefully studied. It will be seen (Fig. 89) that the faces of the trisocta-hedron replace the solid angles of the cube as three faces equally inclined on the edges. The faces of the trapezohedron appear ae three equal trianglea eqa^y inclined to the cu.\tio/acea (Fig. 94).

95.



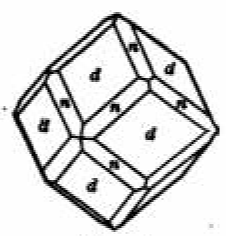
Analcite.

96.



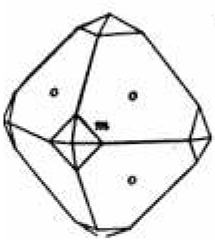
Garnet.

97.

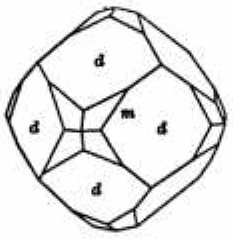


Garnet.

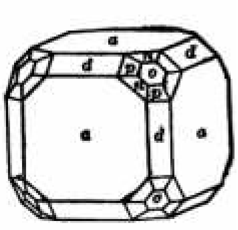
98.



99.



100.



Spinet

Magnetite.

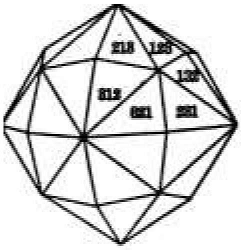
AmKlgam.

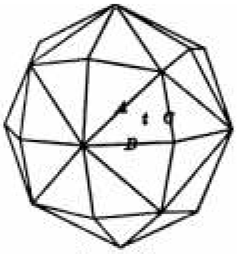
Again, the faces of the trisoctahedron bevel the edges of the octahedron (Fig. 90, also Fig 91, with p (2^1) and m (554)), while those of the trapezo-hedrao are triangles inclined to the faces at the extremitiee of the cubic axes (Fig. 98), Still again, the faces of the trapezohedron (211) trnncato the edges of the dodecahedron (110), as shown in Fig, 97; this can be proved to follow at once from the zonal relations (Arts. 43, ii), cf. also Fig. 110. The position of the faces of the form (311), in combination with o, is shown in Fig. 98; with '/ in Fig. 99. Fig, 100 shows both the trisoctahedron p (221) and the trapezohedron n (211) with a. o, and d.

It shonid be added that the trapezohedron n (211) is a common form both alone and in combination; m (311) is common in combination. The trisoctahedron alone is rarely met with, though in combination (Figs. 90, 91, 100) it is not uncommon.

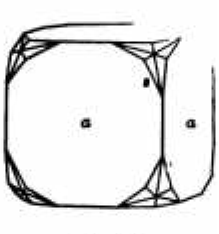
61. HexootahedroD,—The hexoctahedron. Figs. 101,102, is the general form in this system ; it is bounded by forty-eight similar faces, each of which is a scalene triangle, and each intersects the three axes at unequal distances. The general symbol is (kkl); common forms are (321). shown in Fig. 101, and (4'^1), in Fig. 103. Tlie symbols of the individual faces, as shown in Fig. 101 and more fully in the projection (Fig. 110), shonid be carefully studied.

The bexoctahedroD has three kinilB of edges lettered A, B, C (longer, middle, shorter) in Fig. 103; the aoglesof two of these edges are needed to fix the K^mbol unless the zonal relations can be made use of. In Fig. 104 the faces of the hexoctahedron berel the dodecahedral edges, and hence for this



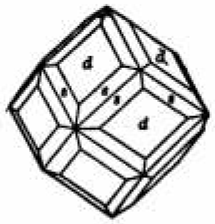


t = (421).

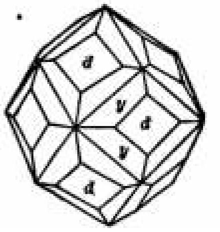


Fluorite.

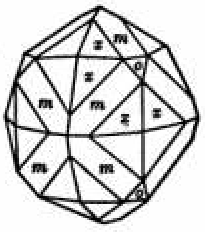
104.



105.

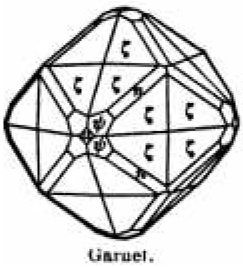


106.



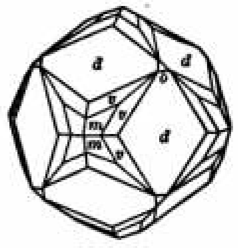
form h = i:-\-l; the form t haa the special symbol (321). The hezocta^ hedron alone is a very rare form, bat it is seen in combination vith the cube (Fig. 103, Anorite) as six small faces i-eplacing each solid angle. Fig. 104 is common with garnet; Fig. 105 shows a combination observed in native copper (y = 18 ■ 10 ■ 5), and Fig. 106 with native gold (.1;= 18-10-1). The angles of some common hexoctahedrons are given on p. 42.

107.



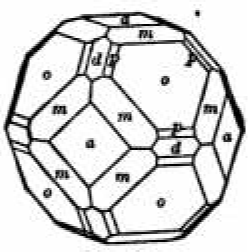
Garnet.

108.



Magnetite.

109.



Microlite.

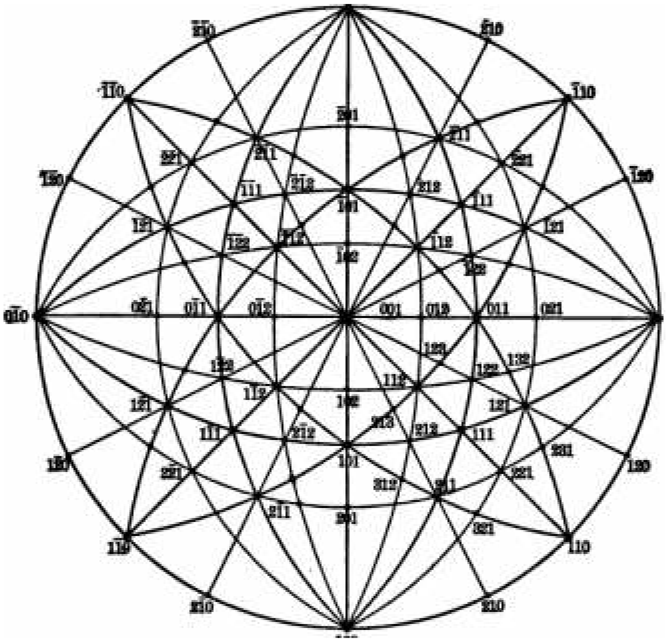
62. Some fnrther ezsmplee of isometric forma are given in Figs. 107, 108, 109. In Fig. 107, ^ is the trapezohedron (723); C is the hexoctahedron

(64 ■ 63-1), this last being called a ricmo//orm, since it deviatea but sliglitly in angular position from the aimple form ordinarily occurring (d, 110): hence the complex indices. In Fig, 108, v is the hexoctahedron (531). In Fig. 109, m = (311),/) = (221), etc.

63. Fundo-tymmetry in the Iwmetrio Brrtem.—Isometric forms, by development in the direction of one of the cubic asee, simulate tetragonal forms. ^ More common, and of greater interest, are forms simulating those of .-bombohedral symmetry by extension, or

flattening, in the direction of an octahedral axis. Both these cases are illustrated Uter. OonTersely, certain rhombohedral forms resemble an isometric octahedron in angle and complex twinning.

64. Spherioal Projeotioo.—The spherical projeotion, Fig. 110, shows the



poeitions of the poles of the faces of the cube (100), octahedron (111), and dodecahedron (110); also the tetrahexahedron (210). the trisoctahedron (321), the trapezohedron (211), and the heioctuhedron (321).

The student ahouW Btudy this pmjeclion carefuUv. noting the armmetry iiiailied hy the lone-circlBs lOO. 001. 100, and 100, 010. 100; nlso by 110, 001, 110; 110, 001. IlO ; 010. 101. OlO; 010. iOl.Olll. Note further tbat Hie faces of a given form are BymmetricaltyiliBlril^ nleil about a cubit face, as 001; a dodecaheiirnl face, as 101 ; an octabedral face, as 111.

Mote further the symbols thai belong to the Individual faces of each form, cumpariag the projection wllti the figures wbich precede.

FiDftllT, nota tte promlaent wnM rf pian«,- for example, the wme between two cnMc faees including a dodecnbedral face and tbe faces of all possible letrabeKshedrona. Again. the zones from a cubic face {as 001) througb an octahedral (ace (h* lll)pu»»iug tlirougb Ibe trisoctsbedrooe, as 118, 112, 228, and the trapezoliedrons 883. 3S1, 8BI. etc. Also the son* from one dodecaheilml face, as 110, to another, as 101, passing through 331, all, 812, etc. Ai the same lime compare these zones with the same Eonea uown on the flguies alteftdr described.

66. Angle* of Common Iiometrie Formi.* Atkahexahbdronb,

Edge A Edge C

Cf. Fig. 88. 810 A 201, etc 310 A 120, et 1» 46 61 65(

86 001

410, v4 810, i-S 080, »4 810. i 8 680, H

sao, ^

480, H 640. f-f

Tbibootahbdbohs.

821,8 602,1 831,8 773.1 441.4 Tbafezohsdbon b .

Cf. Fig. 82. 411,4-4 733.1-1 811, S-8 032, t-l 811. 2-2 822. H

80 37

86 031

48 40

40 11)

00 181

03 36}

Edge A ai A 312. etc. 17 201 27 16 88 331 87 01{ 40 S» 48 201

03 17| 4fl 2S{

Angle on a (100, *-.) 14 3)

811 A ail, etc 27 16 80 43J 85 Of 40 40 48 111

23 S71 16 161 12 40f

EdgeB 31 A 32l. et 50 28| se 0«| 81 80} 36 811 23 00|

55 00}

50 28)

48 301

S3 831

19 45

80 07(83 411 86 S31

Angle on a (100, U) GO 14} 48 11 47 71 46 801 46 71 45 52

Angle on a (100. i-i) 19 28} 28 0 25 14} 39 3»} 30 15(48 18(

Angle on *(U1,1)

40 83} 48 6}

41 28 80 14 87 37 36 481 86 4} SO 461

Angle on 0 (111, 1) 10 11 10 47^ 19 28} 83 0 23 601 25 141

Angle on 0(111.1> 86 16} S3 44 30 39} 36 141 19 38} tl 86}

Hbxootahbdrons.

Cf. Fig. 102. 431. 4-3 18-10-5. V-l 18-I0-1,18-1 881,0-1 SSI, 8-1 488, »4 481, 4-f

Edge A 821 A 312, etc. J 17 45} 19 121 85 67} 27 SO} 81 47} 16 0}

Edge B

20 121

37 17}

0 83}

IB 87}

.81 0}

48 86}

33 87}

I, etc. 321 A 331, etc.

85 57

80 06

81 61} 27 801 31 47} 10 0} 16 601

Angle on o (100. i-i) 39 13}

81 50} 39 101

82 18} 86 42 43 1} 88 10}

o(111.1)

28 61

35 57}

35 411

28 83}

23 12}

15 13}

' A fuller list is glyen in the Introduction to Dana'a System of MInentlog;, pp, zx-xzliL

8. PYRITOHEDRAL GEOTJP (2). PYRITE TYPE.

66. Typical Pormi and Symmctry.^The typical forms of the pyritohedral group are the pyritohedron, or pentagonal dodecahedron. Figs. 113, 113, and the diploid, or dyakis-dodecahedron, Fig. 118. The symmetry of these forms, as of the group as a whole, is as follows: There are but three

111. planes of symmetry; these are parallel to the

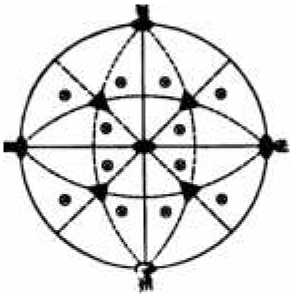
cubic faces and coincide with the planes of the cabic axes. The three crjBtallographic axes are axes of binary symmetry only; there are also four axes of trigonal symmetry coinciding with the octahedral axes.

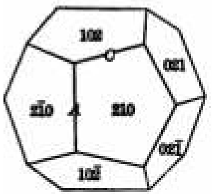
The spherical projection in Fig, 111 shows the 'distnbution of the faces of the geuei'al form (hkl) and thus exhibits the symmetry of the group. Thjs should be carefully compaied with the corresponding projection (Fig. 69) for the normal group, so that the lower grade of symmetry here present be thoroughly understood. In studying the forms described and illustrated in the following pages, this matter of symmetry, especially in relation to that of the normal group, should be continually before the mind.

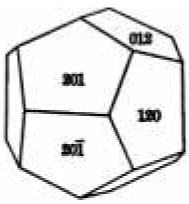
It will be observed that the faces of both the pyritohedron (Fig. 113) and the diploid (Fig. 118) are arranged in parallel pairs, and on this account these forms have been sometimes called parallel hemthedrong. Further, those authors who prefer to describe these forms as cases of hemibedrism call this type parallel-faced hemihedrism or pentagonal hemihedrism.

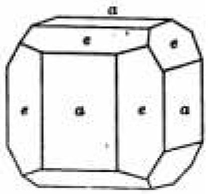
67. Pyritohedron.—The pyritohedron (Fig. 112) is bo named because it is a typical form with the common species, pyrite. It is a solid bounded by twelve faces, each of which is a pentagon, but with one edge {A, Fig. 112) longer than the other four similar edges (C). It is often called a pentagonal dodecahedron, and indeed it resembles closely the regular dodecahedron of geometry, in which the faces are regular pentagons. This latter form is, nowever, as already noted (Art. Sti), an impossible form in crystallography.

lis. 113. 114.







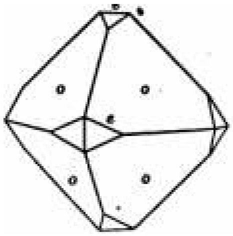


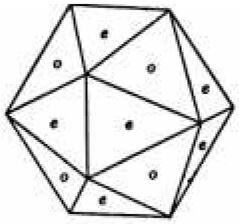
The general symbol ia (kkO) or like that of the tetrahexahedron of the normal group. Hence each face is parallel to one of the axes and meets the other two axes at unequal distances. Common forms are (410), (310), (210), (320), etc Besides the ^Iu« pyritohedron, as (210), there is also the comple-

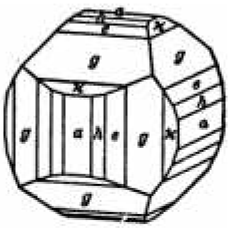
mentary minus form* shown in Fig. 113; the eymbol is here (ISO). Other oomiiiOL forma are (250), (230), (130), etc.

The plaB and minns pyritohedroos together embrace twenty-fotir faces, haying the same position ae the twenty-four like faces of the tetrabexahedron of the normal gronp.

68. CombiSAtioat.— The faces of the pyritohedron replace the edges of the





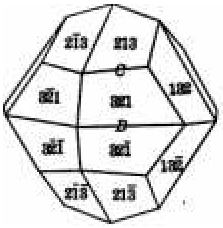


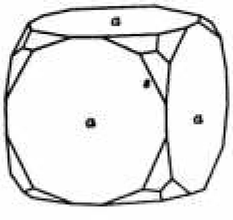
cube, but make unequal angles with two adjacent cubic faces; on the other hand, when the pyritohedron is modified by the cube, its faces truncate the longer edges of the pentagons. Cf. Fig. 114.

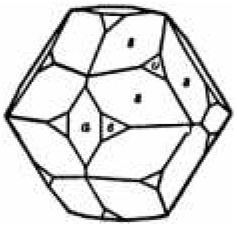
Fig. 115 shows ^ne combination of the pyritohedron and octahedron, and in Fig. 116 these two forms are eqjially developed. The resulting combin»tion bears a close similarity to the icosahedron, or regular twenty-facc^d solid, of geometry (see Art. 35). Here, however, of the twenty faces, the eigiit octahedral are equilateral triangles, the twelve others belonging to the pyritohedron are isosceles triaugles. Fig. 117 shows a nnmber of pyritohedroTia with the cube (a), namely, A (410), e (310), ff (320), and the minns form K (4.50).

69. Diploid. —The diploid is bounded by twenty-fonr similar faces, each meeting the axes at unequal distances; its general symbol is hence (M/), and common forms are (321), (421), etc. The form (321) is shown in Fig. 118;

118. 119. . 120

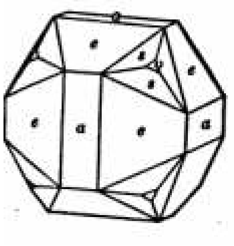




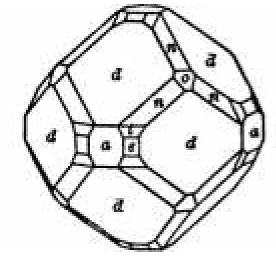


the symbols of its faces, aa given, should be carefully studied. As seen in the figure, the faces are quadrilaterals or trapeziums; moreover, they are grou]ied in pairs, hence the common name diploid. It is also called a dyakis-dodecahedron.

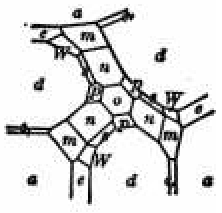
The complementary minus form bears to Fig. 118 the same relation as the minus to the plus pyritohedron. Its faces have the symbols 313, 231,123, in the front octant, and similarly with the proper negative signs iti the others. Tlie pliia and minus forms together obviously embrace ail the faces of the lieioctahedroD of the normal group.



Pyrile.



Pyrile.



Pyrite.

In Pig. 119 the plus diploid is shown in combination with the cube. Here the three faces mplace each of ite solid ungles. This combination form rcHembles that of Fie;. 89, bnt the three faces are here uneqnally inclined upon two adjacent cubic faces. Other ronibinations of the diploid witli the cube, octahedron, and pyritohedron are given in Figs. 120 and 131.

70. Other Pornu.—If the pyritohedral type of symmetry be applied to planes each parallel to two of the axes, it is seen that this symmetry calls for six of these, and the resulting form ia obviously a cube. Tliis cube cannot be

ja4 distinguisned geometrically from the cube of the normal

group, but it has its own characteristic molecular sym-

' ' raetry. Corresponding to this it is common to find cubes of pyrite with fine lines (striationa) parallel to the alternate edges, as indicated in Fig. 124. These are due to the partial development of pyritohedral faces (210). On a normal cube sncb striations, if present, must be parallel to both sets of edges on each cubic face. Similarly to the cube, the remaining forms of this pyritohedral group, namely, (111), (llf), (Jihl), (hll), have the same geometrical form, respectively, as the octahedron, dodecahedron, the trisoctahedrons and trajwzohedrons of the normal group. In molecular stnicture, however, these forms are distinct, each having the symmetry described in Art 66.

71. Other combinations of pyritohedral forms are shown in Figs. 132, 123, both of the species pyrite. Fig. 123 is dodecahedral in habit, with the diploid t {«]), the trapezohedron » (211), also a (100), o (Hi), e (310). In Fig. 133, a single angle of a pynte crystal is represented with a (100), o (111), d (HO); the two pyritohedrons e (210) and e, (120); the tnsoctahedron y (221); the trapezohedrons « (311). H((311); the diploids a (321) ff'(851).

This species illustrates well the complexity that may be observed among the crystals of a given mineral. Not only is there wide variation in habit, but the occurring forms are also very numerous. Thns some thirty-five pyritohedrons (-{-and —) have been noted and a like number of diploids; also five trisoctahedrons and eleven trapezohedrons.

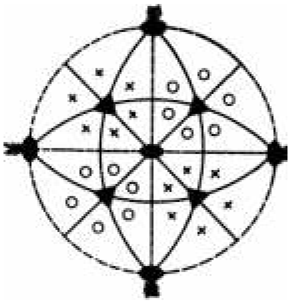
72. AaglM. —The following tables contain the angles of some common forms:

Pr&ITOHEDBOKB.

3. TBTRAHEDRAL GROUP (3). TETRAHEDRITE TYPE.

73. Typical Forms and Symmetry.—The typical form of this gronp, and that from which it derives its name, is the tetrahedron, shown in Figs. 126, 137. There are also three other distinct forms, shown in Figs. 133,134, 1.S5.

The symmetry of these forms is that which is characteristic of the entire



X planes of symmetry, parallel faces of a rhomhic dodeca-

136. group. There are si

respectively to the

hedron, but no planes of symmetry parallel to the cubic faces. Ihe three cubic axes are axes of binary symmetry only, and the four octahedral axes are axes of trigonal symmetry. There is no center of symmetry. f The spherical projection (Fig. 1251 showR the distribution of the faces of the genei'al form (hkl) and thus exhibits the symmetry of the gronp. It will be Been at once that the like faces are all grouped in the nlternale octants, and this will be seen to be characteristic of all the forms peculiar to this group. The relation between

the symmetry here described and that of the normal gronp must be cnrefnlly

studied.

In distinction from the pyritohedral forms whose faces were in parallel

pairs, the faces of the tetranedron and the analogous solids are inclined to>

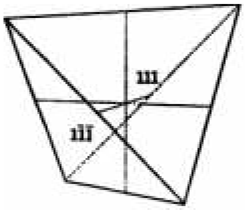
each other, and hence they are sometimes Bjmken of as inclined hemiAedron», and the type of 80-called bemihedriem here illustrated is thea called inclined or tetrahedr&l hemihedriam.

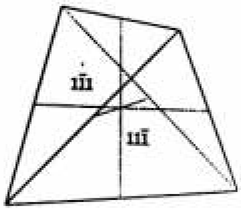
74. Tetrahedron.—The tetrahedron,* as its name indicates, is a fonr^fooed solid, bounded by planes meeting the axes at equal distances. Its general symbol is (111), and tlie_ four faces of the plus form (Fig. 126) have the symbols 111, ill. 111, HI. 'I'heae are four of the faces of the ootahedron of the normal group (Fig. 71), and those fonr which belong to the alternate octants as required by the symmetry already defined.

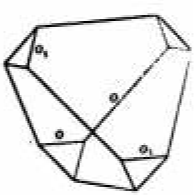
Each of the four faces of the tetrahedron is an equilateral triangle; the (normal) interfaci^ angle is 109° 29' 16". The tetrahedron is the regular triangular pyramid of geometry, but crystallographically it must be so placed that the axes join the middle points of opposite edges, and one axis is TerticaL

IM.

138.

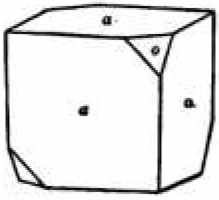




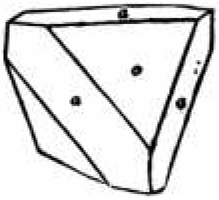


There are two possible tetrahedrons: thepZu« tetrahedron (111), designated by the letter o, wliich has already been described, and the minvs tetrahedron, having the 8ame_geometrical form and symmetry, but the symbols of its four faces jire 111, 111, 111, 111. This second form is shown in Fig. 127; it is nsually designated by the letter o,. 'l.'hese two forms are, as stated above, identical in geometrical shape, but they may be distingaished in many cases by the tests which serve to reveal the molecular structure, particularly the etch in,^-figures. It is probable that the plus and minus tetrahedrons of

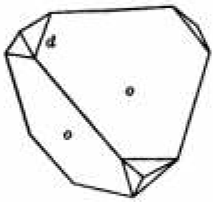
129.



180.



131.



sphalerite (see that species) have a constant difference in this particular, which makes it possible to distinguish them on crystals from different localities and of different habit.

If both tetrahedrons are present together, the form in Fig. 138 results. This is geometrically an octanedron when they are eqnally developed, ■ but

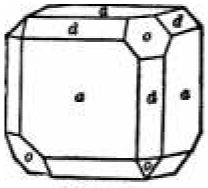
'TliiB is nae of Out five regulnr Biiliils of geometry, which include also (lie cube, octabedro'. the regular pentagoiial dodecahedron, and the fcoBshedroD; tte last two are Impowible forma among CTTStals.

.dbyGooglc

crystallogmphically it is always only a combination of two anlike forms, the plus and minus tetrahedrons, which can be diBtinguished as already noted.

The tetrahedron in combination with the cube replaces the alternate solid angles as in Fig. 129. The cube modifying the tetrahedron truncates itg edges as shown in Fig. lilO. The normal angle between adjacent cubic and tetrahedral faces is 54° 44'. In Fig. 131 the dodecahedron is shown modifying the pins tetrahedron, while in Fig. I'd'i the cube ia the predominating form with the plus and minus tetrahedrons and dodecahedron.

76. Other Typical Forms. —There are three other dis-} tinct types of solids iu this gronp, having the general J-/ 3jmbola{hkl),{hll),&ud{hi:I). Thefirst of these is shown ■^^"^ in Fig. 133, here the symbol is (221). There are twelve faces, each » quadrilateral, belonging to this form, distributed as determined by the tetrahedral type of symmetry. They correspond to twelve of the faces of the trisoctahedron, namely, all those falling inalternate octants, This type of solid is sometimes called a tetragonai tristetra-hedro'n, or a deltoid dodecahedron. It does not occnr alone among crystals, but its faces are observed modifying other forms.

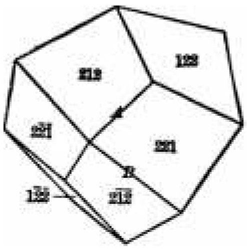


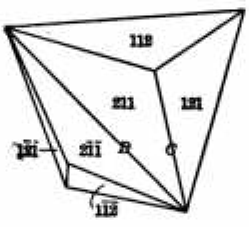
Boracite.

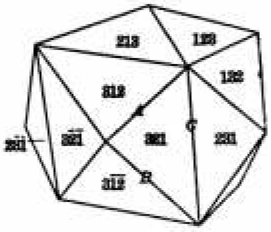
133.

134.

136.





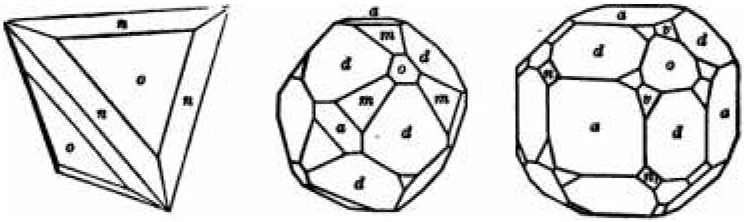


There is also a complementary minuti form, corresponding to the plus form, related to it in precisely the same way as the minus to the plus tetrahedron. Its tVFelve faces are those of the trisoctahedron which belong to the other set of. alternate octants.

Another form, shown in Fig. 134, has the general symbol (hll), here (211); it i» bounded by twelve like triangular faces, distributed after the type demanded by tetrahedral symmetry, and corresponding consequently to the faces of the alternate octants of the form {hlJ) —the tnipezohedron—of the normal group. This type of solid is sometimes called a trigonal tristetra-hedron or tngondodecahedon.* It is observed both alone and in combination; it is much more common than the form {!ihl). There is here again a complementary minus form. Fig. 136 shows the plus form h (2U) with the plus tetnihedron, and Fig. 137, the form m (311) with a (100), o (111), and d (110). In Pig. 138, the minus form w, (211) is present.

*It is tri be noted tbst the tetniiKiiiRl Iristetrahedron bas facea which tvsemble Ibose of the Inipeznliedron (Celra^oDal trisoctahedron), although it Is relnled not l<i tbb but to the trlKortnhedron <lrieoiiFil trjeoctnbedron). On ibe other hand, the faces of the trigonal tris-tetmhedrou reseinble those of the triaociabedron. tbougtar in fact related to tbe trapezo-

Tho fourth independent type of solids in this ^onp is ahown in Fig. 135. It has the general symbol {hxl), here (33L), and is bounded by twenty-four faces distributed according bo tetrahedral symmetry, that is, embracing all the faces of the alternate octants of the forty-eight-faced hexoctahedron. This form iB_sometimes called a Jiexakistetrahedron, The complementary minus form {hkl) embraces the remaining faces of the hezoctahedron. Ibe plus ,136. 137. 138.



Sphalerite.

hexakistetrahedron, i> (531), is shown in Fig. 138 with the cube, octahedron, and dodecahedron, also the minus trigonal tristetrahedrou n (^II).

76. If the tetrahedral symmetry be applied in the case of planes each parallel to the two axes, it will be seen that there must be six such faces. They form a cube similar in geometrical appearance to the cube both of the normal and pyritohedral groups, but differing in its molecular structure, as can be readily proved, for example, by pyroelectricity. Similarly in the case of the planes having the symbol (110), there must be twelve faces forming a rhombic dodecahedron bearing the same relation to the like geometrical form of the normal group. The same is true again of the planes having the position expressed by the general symbol (hkO); there must be twenty-four of them and they together form a tetrahexahedron.

In this group, therefore, there are also seven types of forms, but only four of them are geometrically distinct from £he corresponding forms of the normal gronp.

77. Angles.—The following tables contain the angles of some common, forms:

TKT&AOOKAI, TXIBTKTItAHKDBONS.

iCoogIc

o BTBTALLOOaAPHr.

Hbxakibtetba bed bods.

Jl^geA EdgeB Edge C

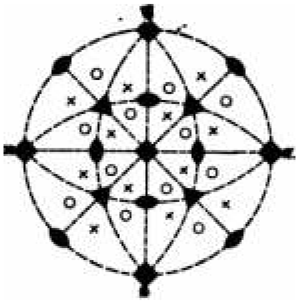
Cr. Fig. 185. 821 A 812, etc 8S1 A 8i2, eto. 891 a 281, etc

6ai 27' 89f' 6r 7i' 27" 891'

dil 21 47i e» 41 21 47i

482 10 si 83 4i 10 o)

481 82 l4 67 22f IS oo|



4. PLAGIHEDBAL GROUP (4). CUPRITE TYPE.

78. Typical Fomu and Symmetry.— The fourth group under the Uometrio system ia called the plagiliedral or gyroidal 139.

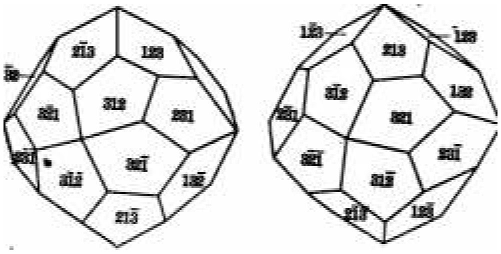
group because the faces of the general form {hicl) are arranged in spiral order. This ia shown on the spheric^ projection. Fig. 139, and also in Figs. 140,141, which represent the single typical form ol the group. These two complementary solids together embrace all the faces of the heioctahedron. They are distinguished from one another by being called respectively right-handed and left-handed pentagonal icositetra-hcdrons. The other forms of the group are geometrically like those of the normal group.

The symmetry characteristic of the group in general is as follows :

There are no planes of symmetry and no center of symmetry. There are, however, three axes of quaternary symmetry normal to the cubic faces, four axes of trigonal symmetry normal to the octahedral faces, and six axes of binary symmetry normal to the faces of the dodecahedron. ^ In other words, it has all the s of symmetry of the normal group while without planes or center of symmetry.

79. It is to be noted that the two forms shown in Figs. 140,141 are alike geometrically, hut are not superpcaable; in other words, they are related to one another as is a right- to a left-hand glove. They are hence said to be enantiomorpjious, and, as explained elsewhere, the crystals belonging here may be expected to show circular light polarization. It will be seen thai the complementary plus and minus forms of the preceding groups, unlike those here, may be superposed by being rotated 90" about one of the crystallographic axea. This distinction between plus and minus forms, and between rignt- and left-handed enantiomorphous forme, exists also in the case of the groups of Beveral of the other systems.

This group is rare among minerals; it is represented by cuprite, sal



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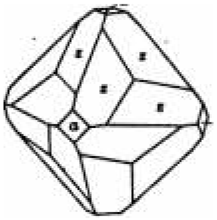
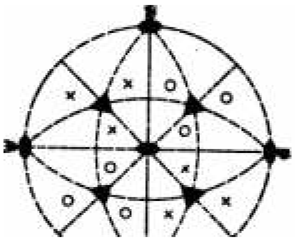
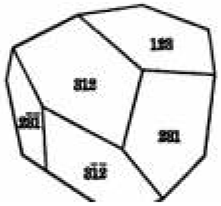
ammoniac, sylvite, and halite. It is neually shown by the distribution of the snrall rnoUifyiDg faces, or by the form of the etchine 1«L

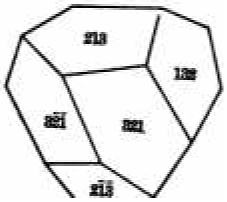
figures. Fig. 14a shows a crystal of cuprite from Cornwall (I'mtt) with the form a (13-10-13).

5. TETARTOHEDEAL GROUP (5). ULLMAN-NITE TYPE. SO. Symmetrr and Typical Forms.—The fifth remaining possible group under the isometric system is illustrated by Fig. 144, which represents the twelve-faced solid corresponding to the general symbol (/ikl). The dis-tribation of its faces is ahown in the projection, Fig, 143. This form is sometimes called a tetrahedral-pentugonal dodecahedron. It is seen to have one-fourth as many faces as the form {kkl) in the normal group, hence there are four similar solids which together embrace all the faces of the hexoctahedron. These four solids, which are distinguished as right-handed (+ and —) and left-handed (-|- and —), are enantiomorphous, lilfe those of Figs. 140 and 141, and hence the suits crystallizing here may be expected to alio show circolar polarization. The remaining forms of the group are







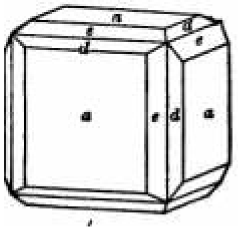


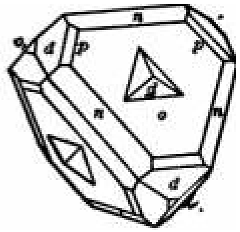
v^.

(besides the cnbe and rhombic dodecahedron) the tetrahedrons, the pyrito. hedrons, the tetragonal aod trigonal tristetrahedrong; geometrically they 14G 147. are like the solids oj the

same names already described. This group has plane of symmetry and / no center of symmetry. There are three axes of binary symmetry normal to the cubic faces, and four axes of trigonal symmetry normal to the faces of tha tetrahedron.

This group is illnstrated by artificial crystals of barinm nitrate, strontium nitrate, sodium chlorate, etc. Further, the species nllmanuite, which showa sometimes pyritohedral (Fig. 146) and again tetrahedral forma (Fig. 147), both having the same composition, must be regarded as belonging here.





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Hatbekatical Rxi^tiohi or thb Isomitbic Btbtxm. tl. Host of the problems arislog Id ihe Isometric tyttem cau be solved at ouce br tbe rigbtrADgled triftugies iu the aphere oF projection (Fig. 110, p. 41; without tho tue of an7 formulas.

It win be remembered tbat the uokIss between a cubic face, rs 100. and Uie adjacent face of a tetrabexaheUrou, SIO, 310, 82Q, etc, can be obtained at once, since the laugeul U

112 k

this angle is equal to g, ^ -„, or in geoeral —.

tan (AW A 100) = ^.

Since all tbe forms of a ffiTen symbol under dlSerent spedee have the same angles, the tables of angles already given are very useful.

Tbese and similar angles may be calculated Immediately from tbe spbere, or often more simply by the formulas ^iven i[i tbe following article.

19. Formulas.—(1) Tne dUtanre of tbe pole of any face P{l>tl) from the cubic faces ii given by tbe fulloning equations. Here Pa Is tbe distance between (&U) and (100); Pb is the distance between {fikt) and (010): aud Pc that between (hkl) and (001).

Tbese eqiiatioos admit of much simplification in the various special cases, for (AiO), (Mi), etc.:

*' .IW ** in '*

"™ "^"^ f'(A' + i* + i') (p- + J. + r')

(8) The calculation of the supplement luterfnclal or normal angles for the several form* may be accompllBlieil as follows:

I'riiectahedron.—Tbe angles A nnd B are, as before, the supplements of the iDter-facial angles of tbe edges lettered as in Fig. 88.

For the t«tragonal-tri*lttrali«droti (Fig. IBS), cos

Trapm>?iedr(m (Fig. S2). B and C are tbe supplement angles of tbe edges u lettered in !ie figure.

Tot the trigonal-trUtetra/udTon (Fig. IM), COS TitrahemhedTon (Fig, 82).

A' + A"' ™^ ^ ~ A' + f •

Forthe pyrilohtdron (Fig. 113). cos A = ^^; cos C = j^^.

&xcetafudtvn (Fig. 102).

A' + atf _ A' + A* - f _, p _ 2hk + l'

'^ h^ + k' + i" *"" h' + k' + i" ""- - A» + 4" + (*■

For the Ji4!cakiilefraAtdtvn (Pig. 186). cos B = ..^"'L^f^., .

11. TETRAGONAL SYSTEM.

83. The Tetragonal Ststeh includes all the forms which are referred to three rectan^lar aiea of which the two lateral axes are equal to each other and the third, the vertical axis, is either shorter or longer. The lateral axea are deaignated by the letter a ; the vertical asis bj i (see Fig. 149) The leugtb of the vertical axia expresses properly the axial ratio of a : 3, a being nniformly taken as equal to unity.

Seven groups are embraced in this system. Of these the normal group is common and important among minerals; two others have several representatives, and another a single one only. It may be noted that in four of the groups the vertical axis is an axis of tetragonal symmetry; in the remaining three it is an AXIS of binary symmetry only.

1. NORMAL GROUP (6). ZIRCON TYPE.

;iug to the normal group of the tetragon^ principal plane of symmetry, the plane

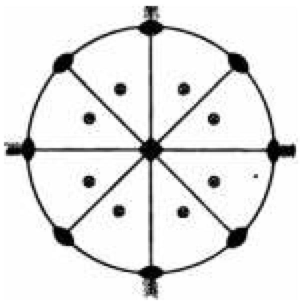
i«6.

84. STmmetry.—The forma system (of. Figs. 149 to 171) hi of the lateral axes it, a; further, at right ang] to this, and meeting each other at angles of 45° in the vertical axis, rf, two pairs of planes of symmetry, like two-and-two. One of these sets, the axial planes, pass through the cryBtallograpbic axes, a, a, and are hence parallel to the faces lettered a ; the others are diagonal to them, or parallel to the faces m.

Further, the vertical axis, i!, is a principal a of tetragonal symmetry; there are also fonr axes of binary symmetry, like two-and-two ; one set coincides with the lateral axes a, a; the others are diagonal to thero.

i'he distribution of the faces of the general form, hkl, belonging to this group, is shown in the spherical projection. Fig. 148.

86. Forms.—The various possible forms under the normal group of this system are as follows:



Miller. ..(0:.I)

..(100) ..(110)

1. Base or basal pinacoid

2. Diametral prism, or prism)

of the second order \

3. Unit prism, or prism)

of the first order j" - ■ ■ ■

4. Ditetragonal prism (hkO)

as. (310) /-3; (210) t.2; (320) i-J, etc.

5. Pyramids of the diametral) ,,,,,

or second order \ ' '

as, (203) l-i; e (101) It"; (201) 2-i, etc.

,ab,GoOgIc

CBYeTALLOQRAPHT.

Hlller. Naiim-nii

6. Pyramids of the cnit,) ,;^j» a:a:mc mP o. m

or first order, [^ '

as, (223) I; (111) 1; (221) 2, etc.

7. Ditetragonal pyramids, 1 ,j^^„ a-.na'.mc mPn or m-n

or Zirconoids,) * '

aa, (421) 4-3; (331) S-J; (133) 1-3, etc.

66. Basal Pinaooid or Base.—The hose is that form which includes the two similar faces which are parallel to the plane of the lateral aiea. These faces have the eymbola 001 and 001 respectiTely ; it is an " open form," as they do not inclose a space, consequently this form can occur only in combiniition with other forms. Cf. Figs. 149-152, etc. This form ia iilwajfe lettered c in this work.

87. Prinna.—Prisms, in systems other than the isometric, have been defined to be forma

whose faces are parallel to the vertical axis {S) of the crystal, while they meet the two lateral axes ; in this system the four-faced form whose planes are parallel both to the vertical and a lateral axis is also called a prism. There are hence three types of prisma here included,

88 Diametral Priam,—The diametral prism shown * in combination with the base in Fig. 149 includes the four faces which are parallel at once to the vertical and to a lateral axis; it has, therefore, the general symbol (100). It is a square prism, that is, the angle between any two adjacent faces is 00°.

The diametral prism is often called the prism of the second order; it is uniformly designated "by the letter a, and its faces, taken in order, have the aymbols 100, GIO, iOO, 010.

It will be seen that the combination of this form with the base is the analogue of the cnbe of the isometric system. It has four similar vertical edges and eight similar lateral edges. It has also eight similar solid angles. 149. IBO. IBl. ISfl.

4=^—

89. Unit Priun.—The unit prism includes the four faces which, while parallel to the vertical axis, meet the lateral axes at equal distances; its

* 111 Figs. 149-152 tbe di men Pilous ot the form are mnde lo cbrre^piiid lo iLp ntsiimed leiiglli i>r tlie verliciil axis (here i~ 1-78 as in octahedrile) used iu Fig. 156. It must be anted, however, thnt in the case ot actnai crfHtais oF these fnnn<<. while the tetragonal sy:Lineiry U usually Indicaled by the unlike pliyslcal character of Uie fnce e aa compared wllb the fiLCea a, m. etc., in tbe verlloil priamatic zone, no inference can be drawn as to the reiiitlve lengtb of the verttciU axis. Thla iMt cnn be determined only when a pyramid U present: It Is fixed for the spedea when a particular pyramid U cboKD u fundameutal or unit form, as ezplained later.

general symbol ia conseqaently (110). Like the preceding form, it is a square prisBi, with interfacial angles of 90°. It is shown iu combinatiun with the oaae iu Fig. 150. It is ofteu called the prism of the first order, aud is uniformly designated by the letter vi. The symbols of its faces, taken in order, are 110, 110, 110, 110.

The faces of the unit prism truncate the edges of the diametral prism and vice vena. When both are equally developed, as in Fig. 151, the result is a regular eight-sided prism, which, howcTer, it mast be remembered, is a com-binatiou of two distinct forms.

It is evident that the two prisms described do not differ geometrically from one another, and farthermore, in a given case, the symmetry of this group allows either to be made the unit, and the other the diametral, prism according to the position assumed for the lateral axes. If on crystals of a given species both forms occur together equally developed (or, on the other hand,, separately on different crystals) and without other faces than the base, there is no means of telling them apart unless by minor characteristics, as striations or other marking on the surface, etchings, etc.

90. Ditetragon&l Prism.—The ditetragonal prism is the form which ia bounded by eight similar faces, each one of which is parallel to the vertical aiis while meeting the two lateral axes at unequal distances. It has the general symbol HttO). It ia shown in Fig. 152, where (hkO) = (210). The successive faces We here the symbols 310, 120, l20, 5lO, 3lo, I30, l20, 210.

In Pig. 164 a combination is shown of this form (y = 310) with the diametral prism, the edges of which it bevels. In Fig. 168 it bevela {h = 310) the edges of the unit prism m. In Fig. 169 it ia combined ({ = 310) with both the square prisms.

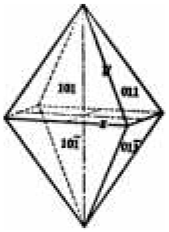
91. Pyramids.—There are three types of pyramids in this group, corresponding, respectively, to the three prisms which have just been described. As already stated, the name pyramid is given (in systems other than the isometric) to a form whose planes meet all three of trie axes; in this system the form whose planes meet the axis i and one lateral axis while parallel to the other is also a pyramid. The pyramids of this group are strictly double pyramids.

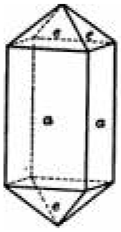
92. Diametral Pyramid.—The diametral pyramid, or pyramid of the second order, is the form. Fig Ib'A, whose faces are parallel to one of the lateral axes, while meeting the other two axes. The general symbol is {hOPf. These faces replace the basal edges of the diametral prism (Fig. 154), and the solid angles of the unit prism (cf. Fig. 155). It is a square pyramid (also called a sqnare octahedron), since its basal section is a square, and the inter-facial sngles over the four terminal edges, above and below, are equal. The successive faces of the form (101) are as follows: Above 101, Oil, 101, Oil; below 101, Oil, 101,011.

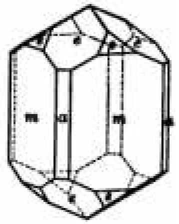
If the ratio of the intercepts on the lateral and vertical axes ia the assumed axial ratio of the species, the symbol is (101), and tlie form is designated by the letter e. This ratio can be deduced from the measurement of either one of the interfacial angles [y or z) over the terminal or basal edges, as explained later. In the case of a given species, a number of diametral pyramids may occur, varying in the ratio of the axes n and i. Hence there is possible an indefinite number of such forms whose symbols may be, for example, (104), (103), (103), (101), (302), (201), (301), etc. Those mentioned first come nearest to the base (001), those last to the diametral prism (100); the base is therefore the limit of these pyramids (hOl) when A = 0, and the diametral

priBm (100) when & = oo and I = 1; or, what is the same thing, when h = I and I = 0. Fig. 165 sbowa the three diametral pyramids u (105), e (101), q (30L).

1S3. 164. 166.







Rutlle. 93. Unit Pyramid.—A unit pyramid, or pyramid of the first order, is a form whoBe eight similar faces intersect the two lateral axes at equal distances and also intersect the verticai axis. It has the general symbol (hhl). Like the diametral pyramid, it ia a square pyramid (or square octahedron) with equal interfacial angles over the terminal edges, aud the faces replace the lateral, or basal, edges of the unit prism. If the ratio of the vertical to

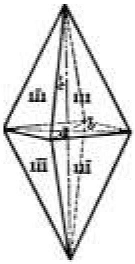
the lateral axis for a given unit pyramid is the assumed axial ratio for the species, the form is called the/wndrtmew/w/ form, and it has the symbol (111) asjn Fig. 156. Its faces mentioned in order as before are: Above 111, 111, 111, 111; below 111, 111, 111, 111.

166.

167.

168.

199.



(4^ /^

^ ^

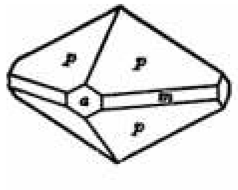
zircon. Zircon. Apopbyllite

Obviously the angles of the unit pyramid, and hence its geometrical aspect, vary widely with the length of the vertical axis. For Fig. 166 (octa-hedrite) i = 1-78; for Fig. 161 p = (111) and (f = o 64.

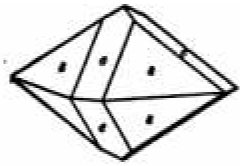
For a given species there may be a number of unit pyramids, varying in position according to tho ratio of the vertical to the lateral axis. Their symbols, passing from the base (001) to the unit prism (110), may thus be (115), (113), (323), (Ul), (332), (291), (441), etc. In the general symbol of these forms iAhJ), as h diminishes, the form approximates more and more nearl3' to the base (001), for which A ■= o; as/t increases, the form passes toward the unit prism, for which h = <x> ifZ = 1, that is, for which A = 1 if Z = o. In Fig. 158 two pyramids of this order are shown, p (HI) and « (331).

The faoee of the nnit pyramids replace the terminal edges of the unit priBtn (Figa. 157, 160) and the solid angles of the di&metral prism (Fig. 159).

^^isir::?'

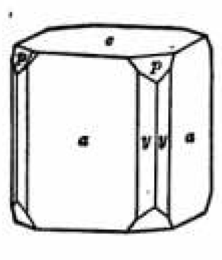


Vesuvianite.

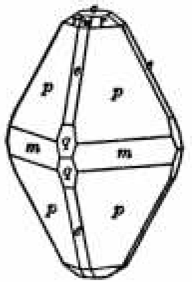


Cassiterite.

164.



165.



A.popby1tile,

Oclabedrite.

The application of the zonal relations proves that a dinmetral pyramid tmiicating the pyramidal edges of a given nnit pyramid has the same ratio as it has for /* to I. Tliua (101) truncates the terminal edge of (Ul); (201) of (tl\), etc Again, if a unit pyramid truncates the pyramidal edges of a given diatnetral pyramid, its ratio for /»to I is hnlf that of the other ^rm; that ia, {U3) truncates the pyramidal edges of (lOl); (HI) of (201), etc. These relations are exhibited by Fig. 165, and the basal and splierical projections (Pigs. 170, 171) corresponding to it. Here e (101) and « (105) truncate the terminal edges of p (111) and r (115), respectively, vhile p (111) truncates the edges of y (201).

94. Ditetragonal Fyramid, or Ziroonoid.—The ditetra^onal pt/ramid, or double eight-aided pyramid, is the form each of whose sixteen similar faces meeta tlie three axes at unequal distances. This is the most general case of the symbol (Jikl), where A, k, I are all unequal and no one is equal to 0, That there are sixteen faces in a single form is evident. Thus, for example, for the form (213) the face 212 is similar to 122, the two lateral axes being eqnal (not, however, to 231). Hence there are two like faces in each octant. Similarly the symbols of all the faces in the successive octants are> therefore, u follows:

Above 212 122 122 5l2 T52 152 l22 2T8 Belovr 213 125 I.-S 3l3 513 132 l53 3l8

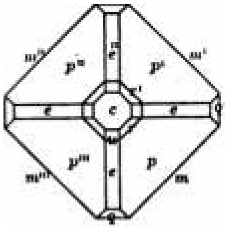
Ttiia form ia common with the specieB zircon, and ie hence often called a zirconoid. It is shown in Fig. 166. It, is not observed alone, tliough soiiie-times, as in Figs l(iT (x = 311) and lo8 {z = 321), it is the predominating form. In Fig, 169 two zirconoidg occur, namely, I (313) and z (3'Jl). Uf. also FigB. 6, 8, 9 of zircon on p. 8.

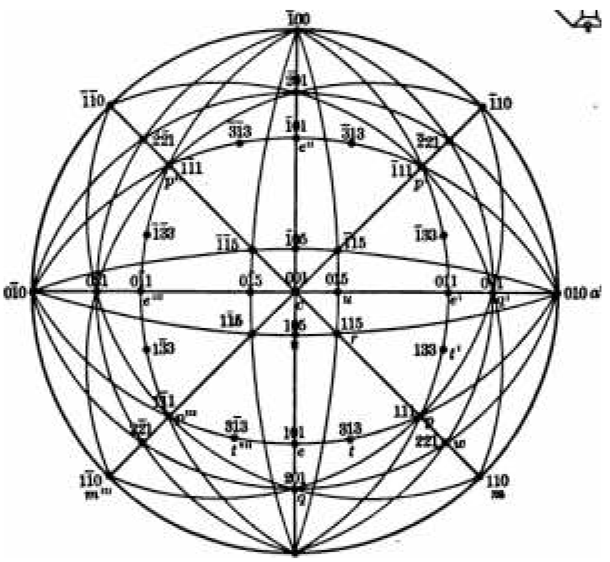
186. 147. l«S. 169.

ZIrcoD. CiiMllerilc. Ruttle

96. In addition to the perspective figures already given, a basal projection (Fig 170) is added of the crystal of octahedrite j^q.

already referred to (Fig. 165); also a spherical projection oE tiie same (Fig. Itl) with the faces of the form (313) aJded. These exhibit well the general relations of this normal group of the tetragonal system. The symmetry here is to be noted, first, with respect to the similar zones 100, 001, Too and 010, 001, OiO; also, second, that of the other pair of similar zones, 110, 001, !Io, and lIO, 001, IlO.





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TBTRAOONAL 8YBTBH.

2. HEMIMOKPHIC GROUP (7).

96. Bynunetiy, —This group differs from the normsl group onlj in having 172, no platie of symmetry through ttie plaue of the

trausverse axes; hence the formB are heminior' phic as defined in Art. 29. It iB not known to be represented among minerals, and ie sufficiently illustrated by the spherical projection (Fig. 1T2). Here the two basal planer are distinct forms, 001 and 001; the prisma do not differ geometri--|« cally from those of the normal group, though dis tinguished by their molecular structure; further, the pjramids are no longer double pyramids, but each form is representea by one half of FigB. 163, 156, 166 (cf Fig. 50, p 18). There are hence six distinct pyramidal forms, corresponding to B upper and lover halves of the unit pyramid, the diagonal pyramid and the ditetragonal pyramid.

3. PYRAMIDAL GROUP (8). SCHEELITE TYPE.

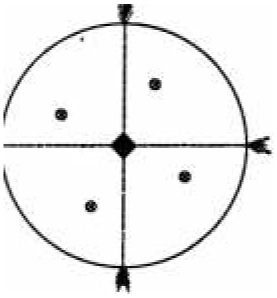
97. Typical Forms and Bymmfltry. —The forms here included have one plaue of symmetry only, that of the transverse axes, and one axis of tetragonal symmetry (the vertical axis) normal to it. The distinct forms are the tetragonal prism (hkG) and pyramid (hkl) of the third order, shown in Figs. 174, 175,

The distribution of the fucea of the general form (hkl) on the spherical projection. Fig, 173, pxhibits the symmetry of the group. Comparing i this, as well as the figures immediately following, *! wiih those of the normal group, it is seen that this group differs from it in the absence of the vertical planes of symmetry and the horizontal axes of symmetry. Further, half the faces, belonging to each octant, of the normal form {likt) shown in Fig. 166 only are present, and these are the faces situated in a vertical zone, from 001 to OOl.

98. Prism and Pyramid of the Third Order.—The typical forms of the group, as above stated, are a square prism and a square pyramid, which are distinjruished respectively from the square prisms a (100) and m (110), shown in Figs. 14!) and 150, and from the square pyramids [Ml) and (hhl) of Figs. 153 and 156 by the name "third order."

There are two complementary forms in each case, designated lefl and right, which toother include all the faces of the ditetragonal prism (Fig. 152) and ditetragonal pyramid (Fig. 166) ot the normal group

The faces of the two complementary prisms, as (210), are: Left: 210, l30, 3iO, 150. Right: 120, 510, I30, 2lO.

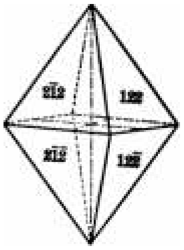


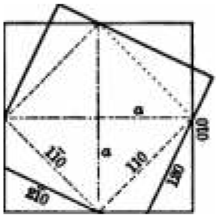
The faces of the correspondiDg pyramids, as (SIS), are:

Uft: Right.

above 313, l33, 3l3, iSS; below 2l2, l22, 313, l33. above ISS, 3lS, IS2, 2lS; below 1S3, 3l3, 133, 2l3.

Fig. 176 gives a transverse section of th« priamaa (100) and m (110), also the prism of the third series (ISO). Fig. 175 shows the right pyratnid (1S3) corresponding to the same prism.

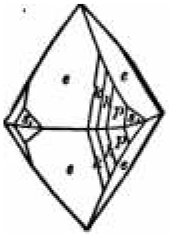


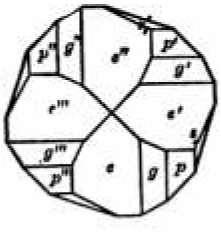


99. Other Forma.—The other forms of this gronp, that is, the base c (001); the other square prisms, a (100) and m (110): also the square pyramids (AO/)

and (hhl) are geometrically lilce the corresponding forms of the normal group already described.

100. To this group belouga the important species echeelite; also the isomorphoua species stolzite and poweilite, unless it be that they are rather to be classed with wulfenite (p. 61). Fig- 1T7 shows a typical crystal of scheelite, and Fig. ITS a basal section of one similar; these illustrate well the charac-





^^

S'ySLS I'P^.i (?.3,, ,^v^, .. m. Ifig.

Here the forms are e (101), p (111), and the third-h (313), g (212), s, (131). Fig. 179 represents a meionite crystal with r (111) and the third-order pyramid z (311) See also Pies. 181, 182, in which the third-order pnam is shown.

The forms of this gronp are sometimeB described (see Art. 28) a pyramidal hemtkedrism ; hence the name here given.

a showing

.dbyGooglc

-TSTRAOOMAL STSTEU.

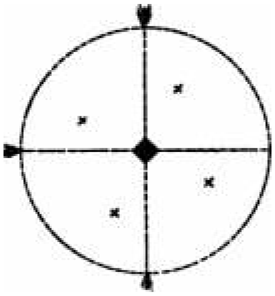
i. PYHAMIDAL-HEMIMORPHIC GROUP (9). WULFENITE TYPE.

101. Bymnctry. —The foarth group of the tetragonal Bystem is closely J30 related to the group just descrihed. It has the

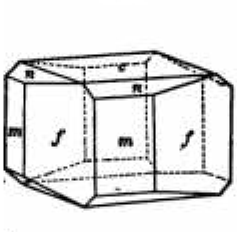
same vertical azia o(tetragonal symmetry, but there is no transverse plaue of Hyinoietry. The forms are, therefore, heinimorphic iu tbe distribution of the faces (cf. Fig. iUO). The specie* wulfeuite of the Scheelite Qroup among mineral species probably belongs here, altliougli the orys

rtals do not always show the diflerence between the pyramidal faces, above and below, which would characterize distinct complementary forms. Figs. 181, 183 could, therefore, serve as illustrations of tbe preceding group, but in Fig. 183 a characteristic distinction is exhibited. In tbeae figures the forms are u (102), e (101), n (111); also/ (230), A (210). t (432), x (311).

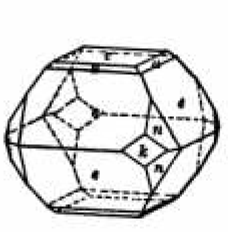
183.



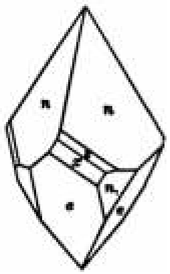
181.



182.



183.



Figs. 181-188. Wulfenlie. 5. SPHENOIDAL GROUP (10). CHALCOPYRITE TYPE.

The typical forms of this gronp are " ^ • ' '" thej

102. Typical Forma and STmmetry.

the sphenoid {Fig. 185) and the tetragonal scalenohedron (Fig. 186).

and all the combinations of this group are 184.

characterized by the presence of two vertical

planes of symmetry; these are diagonal to the

crystal I ographic axes and intersect at angles of

90' in tlie vertical axis, which ie an axis of binary

symmetry only. Further, the two horizontd

This symmetry is exhibited in the distrihution o(the faces of tbe general form (hkl) in tbe spherical projection (Fig. 184). It ia seen here that the faces are present in the alterDute octants only, and it will he remembered that tliis same statement was made of the tetrahedral group under the isometric system. There is hence a close analogy between these

,ab,GoOgIc

two groups. The eymmetry of this group should be carefully compared with that of the first and third groupe of this systetn already described.

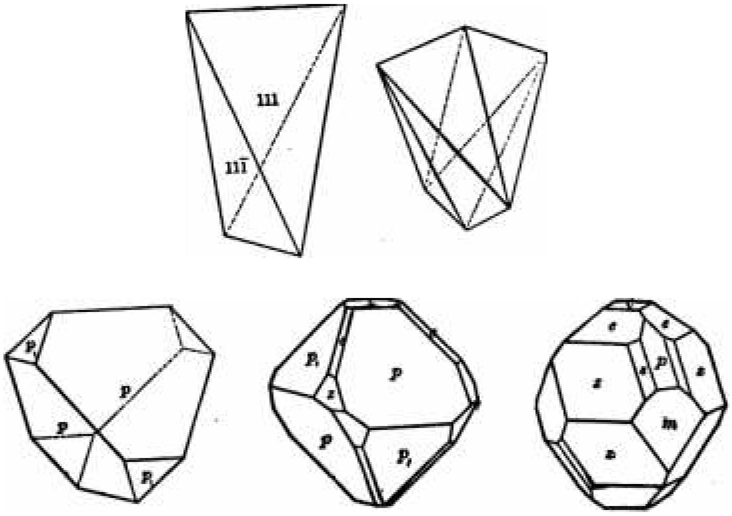
103. Sphenoid.—The sphenoid, shown in Fig. 185, is a four-faced solid, resembling a tetrahedron, but each face is an isosceles fnot an equilateral) triangle. The genera! symbol of the plus unit sphenoia is (111), and the faces have the symbols: 111, III, III, ill. The complemeiitary minus sphenoid has the symbol (ill), and these two forms include all the faces of the unit pyramid (111) ofthe normal group. When they occur together, if equally developed, the resulting solid, though having two unlike sets of faces, cannot be distinguished geometrically from the square pyramid (111).

In the species chalcopyrite, which belongs to this gi"oup, the deviation in angle and iu asial ratio from the isometric system is very small, and hence the unit sphenoid cannot by the eye be distinguished from a tetrahedron (compare Fig. 187 with Fig. 128, p. 47). For this species t - 0-D85 (instead of 1, as in the isometric system), and the normal sphenoidal angle is 108° 40', instead of 109° 28', the angle of the tetrahedron. Hence a crystal with both the plus and minus sphenoids equally developed closely resembles a regular octahedron.

In Fig 1H8 the diametral pyramids e (101) and z (201) are also present, also the base c (001).

' 104. Tetragonal Scalenohedron.—The sphenoidal symmetry yields another distinct type of form, that shown in Fig, 186. It is bounded by eight similar ,eK ia« scalene triangles, and hence is called a tetragonal scalenohedron; the general symbol is (Jikl). The faces of the complementary plus and minus forms embrace all the faces of the ditetragonal pyramid This form appears in combination in chalcopyrite, but is not observed independently. In Fig. 189 the form s (531) IS the plus tetragonal scalenohedron.

106, Other Forms.—The other forma of the group, namely, the two square prisms, the ditetragonal prism, and the two square pyramids {hhl) and {hol), are geometrically like those of the normal group. The lower symmetry in the molecular structure is only revealed by special investigation, as by etching.



Figs. 187-189, CbaJcopyriie.,

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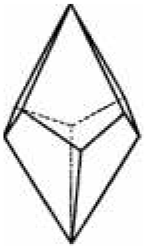
6. TRAPEZOHEDRAL GROUP (11).

106. The trapezohedral sroiip is uualogous to the plagihedral gronp under tlie iaometric systtim; it ie cTiaracterized by the absence of any plane or center oC symmetry: the vertical axis, however, is an axis of tetragonal symmetry, and pterpeiidiciilar to this there are four axes of binary synimetrj. The distribution of the faces of the general form (/ikl) is shovn in the spherical projection,



nder this system

Fig. 190, and Fig. 191 gives the resulting solid, a tetragonal Irapezohedron. The complementary right- and left-handed forma embrace all the faces of the ditetragonal pyramid of the normal group. These two forms are ^antiomor-phona, and the salts belonging to this group show circular polarization. Phosgenite (p. 364) probably belongs to this group (Ooldscbmidt).

7. TETAUTOHEDRAL GROUP (12).

107. Symmetry.—The seventh and last possible group has no plane nor center of symmetry, but the vertical axis is an axis of binary symmetry. The distribution of the faces of the general form

{likl) is shown on the sphere of projection (Fig. 192), and the solid resulting is a splieiioid of the third order. There are also three other posijible forms complementary to thi*. and the four are respectiveiy diatingniBhed us right (-}- and —) and left (-|- and —), These four together embrace all the sixteen faces of the ditetragonal pynimid. The other characteristic forms of this group are tne prism of the third order IhtOj, the phis and minus sphenoids of the first order (111), and also those of the second order (101). This group has no known representative.

Matrekatical Rklationb o

£ TBTB AGONAL StBTEH.

in. CQkOiw at Asm. —It nppi'iLra from tlie (llacnssion of the symmetry of tlie fevea groups of this gyBlcm tlial with all nf theoi the position of the verljcnl axis U 6xed, Id groups 1, 8, hnwcvei, where tliere are two sets of verticnl plikue»^ of symmelry. cither set msij be made tbe sxIbI planes and tlie other the iMagonnI pInacE. Tht choice belweeti tliese two posalb]« pcnllions of rbe lateral axes (s i^iiided paiKciiliirly by tbe habit of tbe occurring cryalala tind the relalloDS of tbe given species to others of similar form.

100. D*t*nnliifttion of tko AxUl B&tlo, lU.—The followiug raUtloos terre to connect le B^ial laiio. ibu is, tlie kngtL of llie vertical axis i, wheu a = 1, wiili ibe fuodainiiutal

uglee lUOl /\ 101} uud (001 a 111):

tan (001 A HI) X l^=i-

For faces in tbe uuoe rectangular zone the taugent principle applies. The ii ,ut cases (ct. Fig. 171) are:

tan (001 A hOl j _ i. tan (001 A 101) ' i '

tan (001 A Oil)" t' tau (001 A h/U) _ h taolOOl A 111) I' For the prisms

lan (010 A IW) = p "' ^^ (*» A MO) = p

110. Othei Calenlatlona.—It will be noted thai In the spherical projectloii (Fig. 171) all those spherical Irian glee htc right-augled which are formed by greut c)ivle3{dlHineters) whicb meet the prismatic zone-circle 100, 010. 100, 010. Again, ali thoae formed by great circles drnwn between 100 aiirt iOO. or 010 and 010, Hud crossing respectively the zouecircles 100. 001. 100. or 010, 001, 010. Also, all thoae formed by great cjrcles drawn between 110 and ilO and crossing the louecircl^: 110, 001, 110, or between 110 and 111) and crossing the BiuecirclellO, 001, ilO.

These spherical Ivinngles may hence be readily used to ciilculnte any iingles desired; for example, tbe angles between Hie iwie of any fticr, us hkl (say 1)21 ■, iind Ibe piuacoids 1(H), 010. 001. The iBrmiuai angles (r and f. Fig. 166) of tbe diletrngouiil pj-ramid, 218 A 813 (or 313 A 813, elc). mid 213 A 122 (ilr 813 a 133, etc.), can also be obialnert in the Bame wiiy. The zonal relations give the symbols of tbe poles on tbe znnes 001. 100 and 001, 110 for tlie given cose. For example. Ibe zone-circle 110, 813, 133. 110 meeU ilO, 001, 110 at tbe pole 223. nud tbe calculated aiigl: 313 a 223 is half tbe angle SIS a 133. If a large number of similar angles are to be calculated, it is more convenient to use a formula, as Ihnt giveo below.

111. Formiilas.—It is sometimes ronvcnienl to have Ihe uormal interfacial angle* expressed directly in terms of ihe axis i iind tbe indices h, k, and I. Thus:

(1) The dislancoa .if the pole of any face P(/(W) from the plnaoolds a (100) = Po, b (010) = Pft. 6 (001) = P< ore given by the following equalionBi

"■•'•■' AV+'w + i' "■"•" W + W + I' º""" >V + W + i» These may also be expressed In the form

u..p, = i!^; ,.„,pi = 551+i; „■?.. >■•' + '■'■ .

(2) For the distance between the poles of nnf two faces (hkl), (pgr). we bave In ^" cos PQ = hpc' + He^lr

VtC" + *•)«' + "J[(P' + 9'>' + '■'1 The almve equations lakes simpler form for special cases often occurring; forexatnple, for hkl and ihe angle ot the edge y of Pig. 166.

119. Frismstie Anglss.—The angles for the commonly occurring diietragonal prisms aro as follows:

Angle on Angle on Angle un

m (110, /) a (100, t-i") m (110. 7>

SO" 67J' S30. i-\ SO" 571' 14' ^'

ae 34. 820.1-1 38 4li 11 IS]

IS 20 480. j-i S6 52} 6 71

m. HEXAGONAL SYSTEM.

113. The Hexagonal Stbtem includee all the forme vhicb are referred to four axes, three equal lateral axes in a common plane intereecting at angles of 60°, and a fourth, vertical axis, at right angles to them.

Two sections are here included, each embracing a number of distinct groups related among themBelves. Thej are called the Hexagonal Division und tlie Trigonal (or Rkombohedral) Division. The symmetry of the former,, about the vertical axis, belougs to the hexagoual type, that of the latter to the trigonal type.

Miller (18&2> referred *X\ the rorins of ihe hexaeoriBl ayBtcm to tliree eqtiil axes pant11e> In llie fucea of Ibe finiilainental rbombubedroii, and heuce loUrsccling nt equal augles, uot 90°. Tbis metbod (furthet expUiui'd !□ An. IBt) lias tLe disitdvantiLge of fiiHiu): lo brlDK out the relutloDsbfp between llie noruinl bexa^ouiil mid telragoaiil types, botb cliaracterizea by a prioclpnl tixh of Bymtnelry, whlcli (on the system liere ailopled) Is Ibe vertical crystal I ograpblc ails. It furtljer gives diSerent aymbols 10 faceR wbicb nre crysiallo-grapbicnlly ideoiical. It ia more uaturn) to employ the ibree rbombiiherfral avea for trigonal forms ooly. as ilonu b^ Orolh (IBM}, wlio iDcliidca tbese gioups iu a Trigonal Sgifcm; but tliis also hna some diaadvaningcs.

114. Qroupi.—There are fire possible groups in the Hexagonal Division., Of these the normal grotip ia much the most important, and two others are also of importance among crystalliied minerals.

In the Trigonal Division there are seven groups; of these the rhombo-hedral group or that of the Oalcite Type is by far the most common, and three others are also of importtiiice.

119. Axes and Bymboli.—The position of the four axes taken is shown in Fig. 193; the three Utcral axes are called n, and the vertical axis is i. Further, when it is desirable to distinguish ,_,

between the lateral nxes they may be designated «,, fl,, a,. The general position of any plane on the method of Brnvais (who adapted the system of Miller to this system) may be expressed in a manner analogous to that applicable in the other systems, viz.:

1111,

r- ■■ A''' = !"• '■ r-

The corresponding indices for a given plane are then h, k, i, I; these always refer to the axes named in the above scheme:

It is found convenient to consider the axis d, ns negative in front and positive behind, hence the general symbol ia hkll Further, as following from the angular relation of the three lateral axes, it can be readily shown to be always true that the algebraic sum of the indices k, k, J, is equal to zero:

A + 4 -I- V = o.

The general expression for any plane in accordance Tith the system of Nsnmonn is

na : pa %-— a : t

Here it is alvays true that p = ■ ___ . The ahortened form for the abOTe ezpreesion as adopted by Kaumano ie mPn.

(1) ^a.: la,:-

TliU is equinlent (ftfter multlplyiag by 8) to

u.ii

Here «> B 8, n >~ a • >ixl ^^ value oF p Is 8. The qrmbol la hence writtea 8P|, or 8-1.

194.

A. Hexagonal Division.

1. NORMAL GROUP (13). BERYL TYPE.

116. Symmetry.—Crystith btiloiip;iiig to the normal group of the Hexagoual Division have one principal plane of Bymmetry, the plane of the lateral axes ; alao, normal to this and meeting in the vertical axiB at angles of 30°, six other

f)lanes of Hymmetry, like three-and-three. Those of one set pass through the ateral axes a, a, a (Figs. 195, 198) aud are —

• hence parallel to the faces of the form (lOlO) lettered m, as in Fig. 208. The others are diagonal to the first set (Figs. 196, I9ti) and are parallel to the faces of the form (1130) lettered </, Fig. 208.

Further, these crystals have one principal axis of heiagonal, or sixfold, symmetry, the vertical cry stenographic axis ; also six horizontal axes of binary symmetry; three of these coincide with the lateral crystallograplitc axes, the others are diagonal to them, Tlie symmetry of this group is exhibited in the accompanying spherical projection, Fig. 194, and by the fijfiires ill the following pages from 195 to 209.

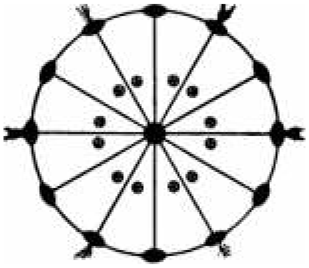
I'he analogy between this group and the normal group of the tetragonal system is obvious at once and will he better appreciated as greater familiarity is gained with the individual forms and their combinations.

117. Forms.—The possible forms in this group are as follows :

Hlller-Bravats.

1. Base (0001) oo

2. Unit prism, or prism) of the first order f



.(lOlO)

, Diagonal prism, or prism) /iiSm of the second order \\^^^}

OI'otO.c mP or I,m

ZaiZai

: CO e OS i'2 or t-3, a

Hllller-BnTdB NaumauD.

4. Dihexagonal prism {hkiO) na :pa : — a -.aic <aPn or t-n

as, (2l30) {a : 3a : - a : «) c oo Z' j or t-}

5. Pyramids of the unit, 1 i},{xT,n „.„„. „.„„ ™p„, „

oi firet order f *'" ('*'^'"* a:^a:-a:mc mPorm

M, (lOll) a-.-na: -a:c P or 1; also 203l (a :qd o : - a :2c) 2P or2

as, (1122) an : 2fl : - « :c i^ or 1-2

as, (2 l3l) ia:3a:~a: 3c SPi or 3-(

In the above h > k, and A + k = - i.

118 Baao —The base, or baetil pinacoid, includes the two faces, 0001 and OOOl, parallel to the plane of the lateral axes It is uniformly designated by tlie letter c; see Figs. 19£*e(seq.

119. Prisms. Unit Prism.—There are three types of prisms, or forms in which the faces are parallel to the vertical aiia.

The unit prism, or priam of the first order, Fig. 195, includes six faces, eacli one of which is parallel Co the vertical axis and meets two adjacent lateral sie^ at equal distances, while it is parallel to the third lateral axis. It has hence the general symbol (lOlO) and is uniformly designated by the letter m; its six faces, taiien in order (see Figs. 195 and 309), are;

lOlO, OlTO, IlOO, lOlO, OllO, lIOO.

120. Diagonal Priim.—The diagonal prism, or prism of the second order. Fig 19C. hap six faces, each one of which is parallel to the vertical axis, and meets the three lateral axes, the two alternate at the unit distance, the other It one-half this distance; or, which is the same thing, it meets the last-named axis at the unit distance, the dthers at double this distance.* The general symboL is (llSO) and it is uniformly designated by the letter a; the six faces (see Figs 196 and 309) in order are :

Il5o. I2lo, 3110, nsO, I5lo, 2llo.

The unit prism and the diagonal prism are not to be distinguished geo* metrically, each being a regular hexagonal prism with normal interfacial angles of 60^. They are related to each other in the same way as the two square prisma tn (110) and o (IOC) of the tetragonal system.

Tite relation in position between the unit prism (and pyramids) on the one band and the diagonal prism (and pyramids) on the other will be understood bettei frorr. Fig. 198. representing a cross-section parallel to the base c.

12L Dihexagonal Tritm.—Thedihexngonalprism,'ffig. 197, is a twelve-sided prism bounded bj twelve faces, each one of which is parallel to the vertical axis, aud also meets two adjacent lateral axes at unequal distances the ratio of wliich always lie.- between 1 :1 and 1 . 2 (see 2 p. 66) This prism has two unlike edges, lettered z and y, as shown in Fig. 197. The general symbol is (hkiti), and the faces of a given form, as (:^l30), are: ,'

2l30, 1250, l:i50, 53l0 52iO, 3120, iSiSO 1330. 1320, 25l0 3211, 3lS0.

* Since lOi: la, - — ia, : coi h eaiiWr.lent

eaiiWr.lei

^Aioglc

CBYSTALLOO RAPBT.

I>i

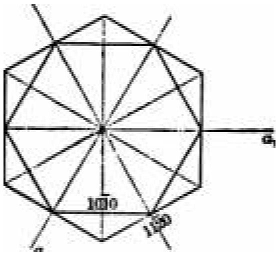
122. Pyramids. Unit Pyramida,—Correaponding to the three types ol prisms just mentioned, there are three types of pyramids.

A unit pyramid, or pyramiU of the first order. Fig. 199, is a form bounded hy twelve similar triangular faces—six above and six below—which have tha same position relative to the lateral axeB as 183.

the faces of the unit prism, while thej also intersect the_vertical axis The general symbol is hence (liO/il). The faces of a given form, as (1011), are :

Above lOll, Olll, IlOl, 1011, OTll, 1101.

Below lOll, Olil, IlOl, Ion, oTll, 1101. On a given species there may be a number ~ of unit pyramids, differing in the ratio ol the lateral to the vertical axis, and thus forming a zone between the base (0001) and the faces of the nnit prism (lOlO). Their symbols, passing from the base (0001) to the unit prism (lOlO), would be, for example, 1014,10T2, 3033, 10ll,*3052, 205l, etc. In Fig. 202, the faces o and s are unit pyramids and they have the symbols respectively (lOll)and (203l), here(!= 1-014. In Fig. 205,p is the uiiit pyramid (1011);



here i = 0'50. As shown in these cases the faces of the unit pyramids replace the edges of the nnit prism. On the other hand, they replace the solid angles of the diagonal prism a (1120) as shown in Fig. 20J.

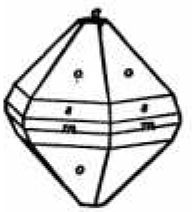
123. Diagonal Pyramidi. — The diagonal pyramid, or pyramid ol the Kcond order (Fig. 2UU), is a double six-sided pyramid iucluding the twelve umilar faces which have the same position relative to the lateral axes as the faces of the diagonal prism, und^whlch also intersect the vertical axis. They have the general symbol (ft ' A ■ 'J,h ■ I). The symbols of the faces of the form (1122) are:

Above 1133, I2T2, 2112, I!22, l5l2, 2112. Below 1153, ViU, 2llS, TT23, l3lS, 2115.

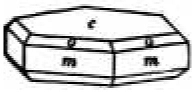
The faces of the diagonal pyramid replace the edges between the faces of the di^onal prism and the base. Further, tliey replace the solid angles of the unit prism vi (lOlO). There may be on a single crystal a number oi diagonal pvramids forming a zone between the base c (0001) and the faces of the diagonal

ffism a (ll50), as, naming them in order: ll34, ll52, 22l3, ll2l, etc In ig 205, 0, s are the diagonal pyramids (ll32) and (ll3l).

202.



' 203.



^^^^

BaDkrit& ' CoDDfllllte. Beryl

124. Sibezagonal Pyramid.— The dihexagonalpyramid. Fig. 201, is a double twelve-sided pyramid, having the twenty-four similar faces embraced under the general symbol {hkU). It is bounded by twenty-four similar faces, each meeting the vertical axis and having a ratio for the intercepts on two adjacent lateral axes between 1 :1 and 1 :2 (cf. the general

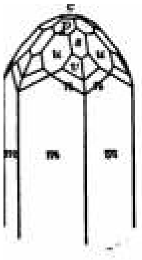
symbol (2) given in Art. 115). Thns the form (^l3l) includes the following twelve faces in the upper half of the crystal:

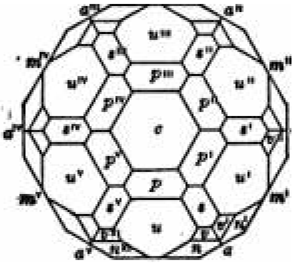
21.^1, 12.^1, I33l, 3311, 3311, 3121, ' Sl3l, 1531, 1321, 2311, 3Sll, 3!3l.

And similarly below with / (here I) negative, 2l3I, etc. The dihexagonal pyramid is often called a bert/llnid because a common form with the species beryl, lu Fig 206. w is the beryltoid (11 •3-i5-3).

125 Combinations.—Fig. 20? of beryl shows a combination of the base <;(000l) and prism m (lo!0) with the unit pyramids ji (lOTl) and « (203l); the diagonal pyramid s (ll3l) and the berylloids v (213l) and n (3lil). Both the last forms lie in a zone between in and s, for which it is true that k~ I.

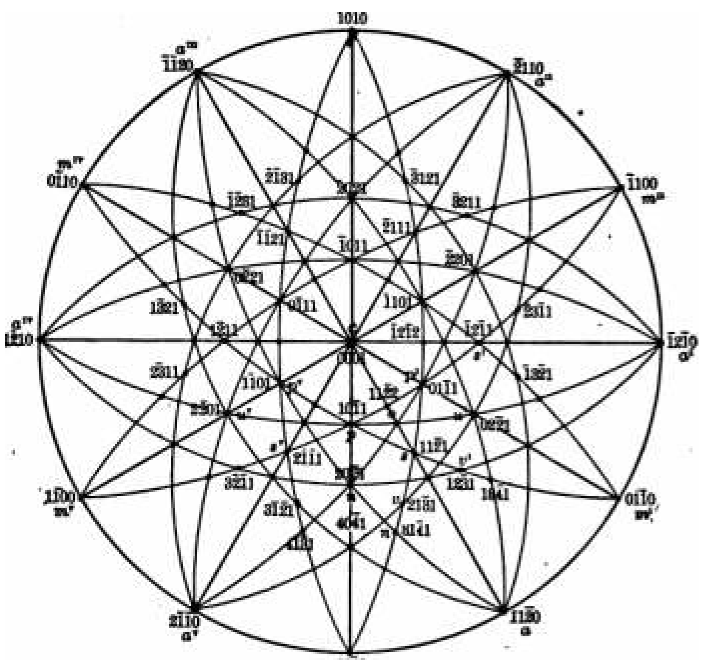
The basal projection of a similar crystal shown in Fig. 208 is very instru'" ae exhibiting the symmetry of the normal hexagonal group. This is uIm





Conoelllle. BeryL Beryl.

of the spherical proJAction in Fig. 209 of a like crystal with also the torm 0 (11S2).

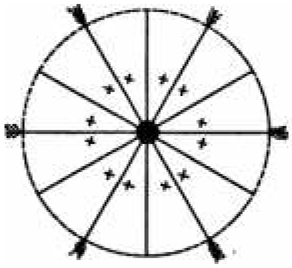


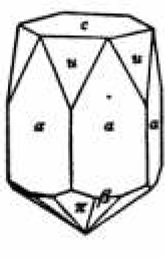
2. HEMIMORPHIC GROUP (U) lODYRITE TYPE.

126. Symmetry,—This group differs from the uormal group only in having 10 tranaverae plane of princip^ eymmelry and no horizontal axee of binary symmetry. It has, hoverer, tne same two sets of plaiiea of sjmnietry meeting 2iQ 211. at angles of 30° iu the vertical aziij which is an axis of iiei agonal By mm e try There ie no center of symmetry. The symmetry is exhibited in the spherical projection, Fig. 210.

127 Fonni. — The forms belonging to this group are the two l»isa1 planes, 0001 and OOOl, here distinct forms, the plus (upper) and minus (lower) pyramids of each of lodyriie. the three types; also the three prisme, which last do not differ geometrically from the prisms of the norma! group. An example of this group is found in iodyrite, or ailver iodide, Fig- 211; here m = (4051), t = (40l5), /3 ^ (9-9l8'50). Greenockite anil wurtzite, also aincite

(Fig 50, p. 18) are classed here, but there is some reason for belicTing that these species belong, with tourmaline, to the corresponding group nnder the trigonal (rhombohedral) division.



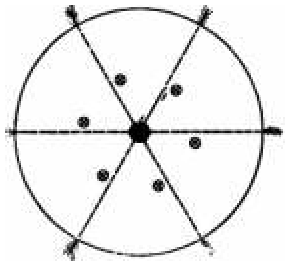


3 PYRAMIDAL GROUP (15). APATITE TYPE.

128. Typical Forms and Symmetry.—This gronp is important beoanse it includes the common species of the Apatite Group, apatite, pyromorphite, mimetite, vanadinite. The typical form is the 213. heiaffonal prism (AAiO) and the hexagonal pyramid [hkil), each designated as of the third order. These forms are shown in Figs. 313 and 214. They and the other forms of the group have only one plane of symmetry, the plane of the horizontal aies, and also one axis of hexagonal symmetry (the vertical axis).

The symmetry is exhibited in the spherical projection (Fig. 212). It is seen here, as in the figures of crystals given, that, like the pyramidal group nnder the tetragonal system, the faces of the general form {hkil) present are half those belonging to each sectant, and further that those above and below fall in same vertical zone.

129. Priam and Pyramid of the Third Order.—The prism of the third order (Fig. 313) has six like faces embraced under the general symbol (hklO), and the form is a regular hexagonal prism with angles of 60°, not to be distinguished



geometrically, if alone, from the other hexagonal prisms; cf. Figs. 195, 196, p. €8 The bIx faces of the right-handed form (2l3o) have the aymboU 2l5o, l33o, 3^10, 513o, l3ao, 33lo. The faces of the complementaiy left-lmoded form have the symbols:

123o, 33lO, 3l2o, T-33o, 23lO, 3l3o. TIieRe two forma together embrace all the faces of the dihexagonal prism

(Fig. jy;).

riu pyi'iiniiJ is also & regular liexagonal pyramid of the third order, and in iU- rclulioiis to the other hexagonal pyramids of the group (Figs. t99,ti0o) it is analoguiib to the aquiiie pyramid of the third order met wjlli in the correspond-iog group of the tetiugoual system (see Art. 98). The faces of the right* handed form (^l33) are :

Above 2133, !333, 3213, 5133, l323, 32l3.

Below 21113, 1323, 5213, 3133, 1323, 3313.

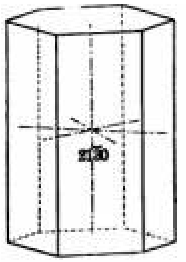
There is also a com piemen tar; left-handed form, which with this embraces

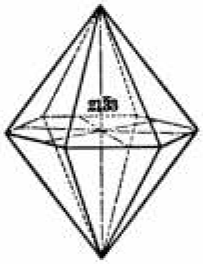
all the faces of the dihexagonal pyramid. The cross section of Fi^. 215 shows

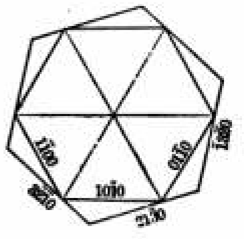
in outline the position ot the unit prism, and also that of the right-handed

prism of the third ordei.

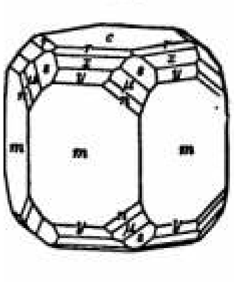
213. 314. ai6.

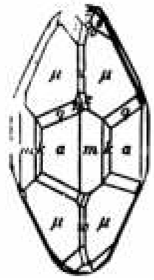


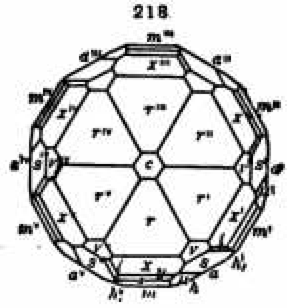




216. 217. 218







Apaiite. Apatite. A|iHiie.

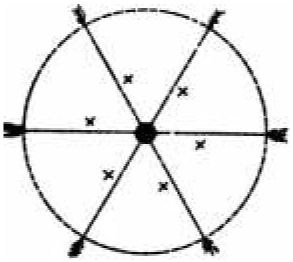
The prism and pyramid just described do not often appear on crystals as predominating forms, though this is sometimes the case; for example, Fig. 217 shows a crystal of apatite in which the prominent pyramid /j is a pyramid of the third order (2131). Commonly tiiese faces are present modifying other fundamental forms, and their character is obvious from their position relatively, for example, to the unit prism m (lOlO).

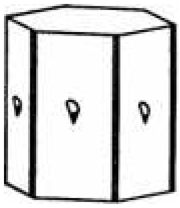
130. Other Fonoa. —The remaiuing forms of the group are geometrically like tbose of (lie nurmal group, viz., lli« base (UOUI) ; the uuit prism (lulUj ; the diagonal prism (ll3o); the unit pyramids (hOhl); and the diagonal pyramids (h-ff-ilfl). That their molecular structure ia the same is readily proved, for example by etching. In this way it was shown that pyromorphite ■lid miuiecite belong in che same group with apatite (Baumhauer), though jsrystals with the typical forms have not been observed.

131. Typicul crystals of apatite are given in Figs. 316,217, and S18 (a basal section). They sliow the third-order prisms A (ilSUj, h (2l3o), h, (1^30), and the third order pyramids, right, M (^l3l), « (SlJl), q (437l), o CAlii), left, t (123-.i); also the unit pyramids r (lOia), x (lOll), y (2u3l), z (So5l); the diagonal pyramids v (LlS'.i), a (ll3l); finally, the prisms m (lOlU), a (llSO), and the base c (0001).

4. PYRAMIDAL-HEMIMOEPHIC GROUP (16). NEPHELITE TYPE. 133. Symmetry.—A fourth group under the hexagoiial system, the pyra-midal-kemimorphic group, is like that just described, except that the forms are iiemimorphic. The single horizontal plane of symmetry is absent, but the vertical axis is still an axis of hexagonal symmetry. This symmetry is shown in the spherical projection of Fig. 219, The typical form would be like the upper half of Fig. 214 of the pyramid of the third order. The species nephehte is shown by the character of the etching-figures (Fig. 220, Groth after Baumhauer) to belong here.

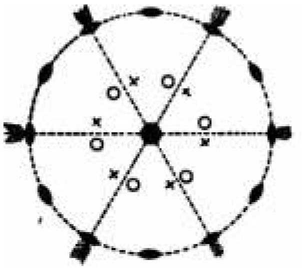
319. aao.

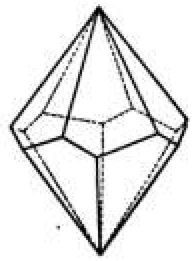




Nephellte. 5. TRAPEZOHEDRAL GROUP (17). 133. STmmetry. —The last group of this division ia the trnpezohedral group. Vt has no plane of symmetry, bat the vertical axis is an axis of hexagonal

aai. 223.





Bjmmetry, and there are, further, six horizontal axes of binary sjmmetrj. There is no center of symmetry. The distribution of the faces of the typiciil form (hkil) is shown in the spnerical projection (Fig. 321). The Cypicitl forinE. the right and left hexagonal trapezohedroua (see Fig. 222), are etiautioniorphoua, and the few cryatallized salts fulling in this group show circular polarization. The symbols of the right form {-llfi) are as follows :

Above 2153. 133;!, 3313, 5l33, 1^23, 3213.

Below 1235, S313, 3l25, 1533, 33l3, 3l33.

B. Trigonal or Rhombohedral Division.

134. Oeneral Character.—As stated on p. 65, the groups of this division are characterized bv a vertical axis of trigonal, or threefold, symmetrT. There are seven groups Iiere included of which the group of the Caloite I'ype is by far the most important.

13&. Trigonotype Qroup.—The first group (18), that which has strictly the — nighest grade of symmetry, has

no known representatives among crystals, natural or artificial. It has, besides the vertical axis of trigonal symmetry, three horizontal axes of binary symmetry. There are four planes of aym-metry, one horizontal, and three others intersecting at angles of 60° in a rertical axis. The characteristic forms are the trigonal priamnnd pyramid and ditrigonal prism and pvramid. The symmetry is exhibited in Fig. 223. The typical form (Fig. 224) is a double ditrigonal pyramid with terminal edges alike in alternate sets of three each. This form may be compared to a scalenohedron twinned about the vertical axis.

2. RHOMBOHEDRAL GROUP (19). CALCITE TYPE.

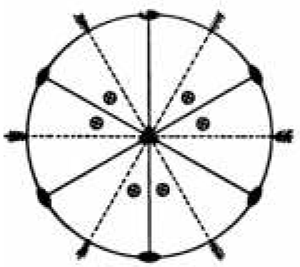
136. Typical Forma and Symmetry. —The typical forms of the rhombohedral (jroup are the rhombohedron (Fig. 226) and the scalenohedrjon (Fig. 242). These forms, with the spherical projection. Figs. 236.

225 and 252, illustrate the symmetry characteristic of the group. By comparing Fig. 253

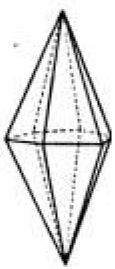
with Fig. 209, p. 70, It will be seen that all the faces in half the sectants are present. This group is hence analogons to the tetrahedral group of the isometric system, and the sphenoidal group of the tetragonal system.

In this group there are three planes of symmetry only; these are diagonal to the crystallographic axes and intersect at angles of 60° in the vertical crystallographic axis. This axis is with these forms an axis of trigonal symmetry; there are, further, three horizontal axes of binary symmetry. Compare Fig. 235, also Fig. 226 ei seq.

223.



224.



,ab,GoOgIc

137. Rhombohedxon.—GeometrioallT described, the rhombohedron is a solid boiiiiiit'i bj' sii like faces, each a rhomb. It has six like lateral edges forming a zi^'Siig liue about the crystal, aud six like terminal edges, three above and tiiret! Ill alternate poeition below. The vertical axis joius the two trihedral ^)lid angles, and the lateral axes join the middle points of the opposite sides, aa shown in Fig. 226.

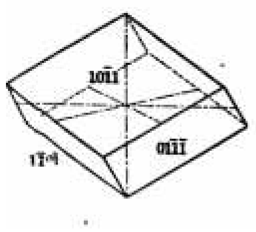
Ttiu general symbol of the rhomhohedron le {IMkl), and the successive faces of the uiut form (lOll) have the symbols :

Above, lOll, IlOl, Olll; below, OlII, lOl!, llol.

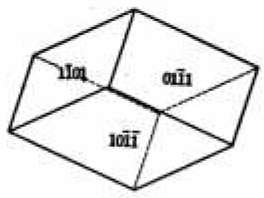
The geometrical shape of the rhomhohedron varies widely as the angles change, aud consequently the relative length of the vertical asis i (expressed in terms of the lateral asea, a = 1), Ah the vertical axis diminishes, the rhombohedrons become more and more obtuse or flattened; and as it increases they become more and more acute. A cube placed with an octahedral axis TerticttI is obviously the limiting case between the obtuse and acute forms where the iuterfacial angle is 90". In Fig. 336 of calcite the normal rhombohedral angle is 74° 55' and b — 0-854, while for Fig. 228 of hematite this angle \% 94° and h = 1-366. Further, Figs. 239-334 show other rhombohedrons of calcite, namely, e (OliS), o (0554). / (032l), jtf(40ll), and v (13-0-IB ■ 1), p (16'0-I5-1), here the vertical axes are in the ratio of i, f, 2, 4, 13,16, to that of the fundamental (cleavage) rhomhohedron of Fig. 226, whose angle determines the value of i.

22fi. 227.

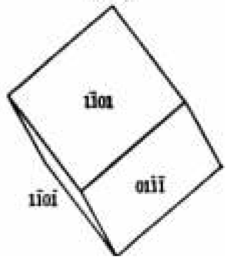
226.



227.



228.



13B. Flos and Miniu Bhombohedrons.—To every plus rhomhohedron there may be an inverse and complementary form, identical geometrically, but bounded by faces falling in the alternate sectant^. Thus the minus form of the unit rhomhohedron (Olll) shown in Fig. 237 has the faces:

Above, Dili, Ion, ITOI; below, IlOl, oTlI, lOTT.

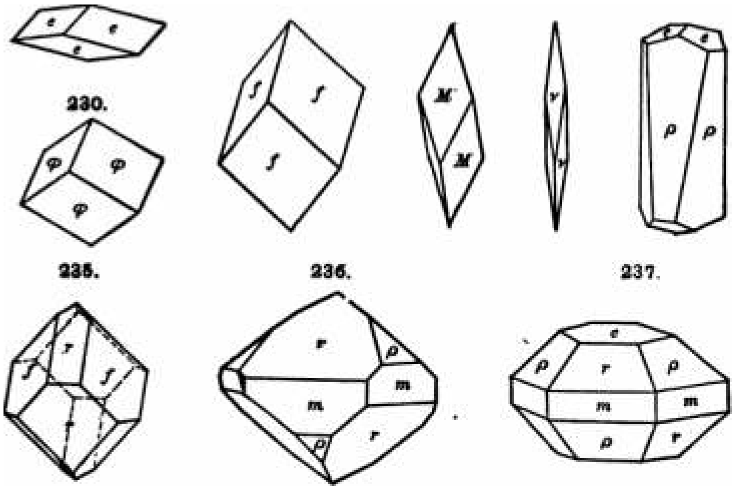
The position of these in the spherical projection (Fig. 252) should he carefullv studied; see also Fig. 262, Of the figures already referred to. Figs, i-iS, 238. 233, 333 are plus, and Figs. 237, 229, 230, 231 minus, rhombohedrons; Pig. 234 shows both forms.

It will be seen that the two complementary plus and minus rhonibohedrone of sriven axial length, that is, of given angle, e.g., lOTl (+ E) and Olll (— 7?), together embrace all the like fanes of the double sis-sided pyramid. When thesp two rhombohedrons are equally developed the form is geometrically identical with this pyramid. This is illustrated by Fig. 237 of gmelinite r (lOTl), p (Olll) and by Figs. 266, 267, p. 83, of quartz, r (lOll), z (Olil).*

.dbyGooglc

Id each case the form, wbich is geometricall; an hexagonal pyramid (in Fig. 237 with c and m), ia in fact a cornbiDatiOn of the two unit rhombohedrons, pins and minus. Commonly a diHerence in size between the two forms may be observBd, as in Figs. 336 and 363, where the form taken as the plus rhombo-hedron predomiaatea. But even if this distinction cannot be eatablisbed, the two rhombohedrons can always be distinguished bj etching, or, ae in the case of quartz, by pyro-electrical phenomena.

329. 231. 332. 333. 334.



PigB. 329-235, Calciie Figs. 286, 387. Qmellnite. 139 Of tbe two series, or zones, of rhombohedrons the faces of the piua rhombohedrons replace the edges between the base (0001) and the unit prism (lOlO). Also the laces of the minus rhombohedrons replace the alternate ed^s of the same forms, that is, the edges between (0001) and (OllO), (compare Figs. 236. 237, etc.). Fig. 338 ahowB the rhombohedron in combination with &e 338. 340. 341.

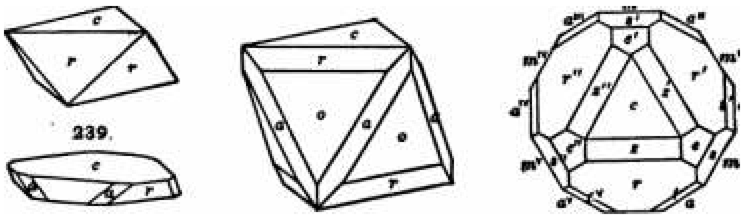


Fig* 296. 239. Hematite. Coqiilmblte. Eudlslyte.

base Fig. 239 the same with the prism n(lli50). When tbe angle between the two forme happens to approximate to 70 32' the crystal simulates the aspect of a regular octahedron. This is illnstrated by Fig. 240; here co = 69° 42%

also 00 = 71° 33', and the crystal resembles closely as octahedroD with truncated edges (of. Fig 77, p. 36).

140. There is a very simple relation betwesD the plus and minus rbombo-hedroDs which it is important to remember. The form of oue series which traucates the terminal edges of a given form of the other has half the length of the vertical axis, and this ratio ih expressed iu the values of the indices

of the two forma Thus (0112), or — 5 R, truncates the terminal edges of the plus nnit rhombobedroa (lOll), or R; (lt.'T4), or + -R, truncates the

terminal edges of (OlIS), or — ^R, 10l5 of (2035). Again (lOll), or + Jt, truncates the edges of (025l), 01 — 2R; (4041), or + 4R, of 022l, or - 3B, etc. This is illustrated by Fig. 235 with the forms r (lOll) and/{023l). Also in Fig. 241 a basal projection, z (10T4) truncates the edges of e (Oll2), e{0l!'>)otr(10ll); r (lIUl) of s (023l).

141. Soalenohedron.—Tbe scalenohedroti, sliown in Fig, 242, is the general form for this group corresponding to the symbol hkll It is a 342, solid, bounded by twelve faces, each a scalene triangle. It bos

roughly the shape of a double six-sided pyramid, hut there are two Bets of terminal edges, one more obtuse than the other, and the lateral edges form a zigzag edge around like that of the rhombohedron. Like the rhomboiiedronG. the scalene-hedrnns may i>e cither plus or minus according as to whether the faces are symmetrical to the zone-circle 1010,0001, or to Olio, 0001- The former plus forme correspond in position to tlie plus i-hombohedrons and conversely.

The plus scaJenohedron (2l5l), Fig. 242) has the following EvniLola for the several faces:

Above 2l3l, 33ll, 5311, 1331, 1321, 3l5l.

Below 1231. I32I, 5131, 3T3i, 254l, 3511. g^,^„^l^^j„„

For the complementary minus scalenohedron (123l) the symbols of tha faces are:

Above 1331, I32l, 3l21, 5T31, 23ll, 33!l.

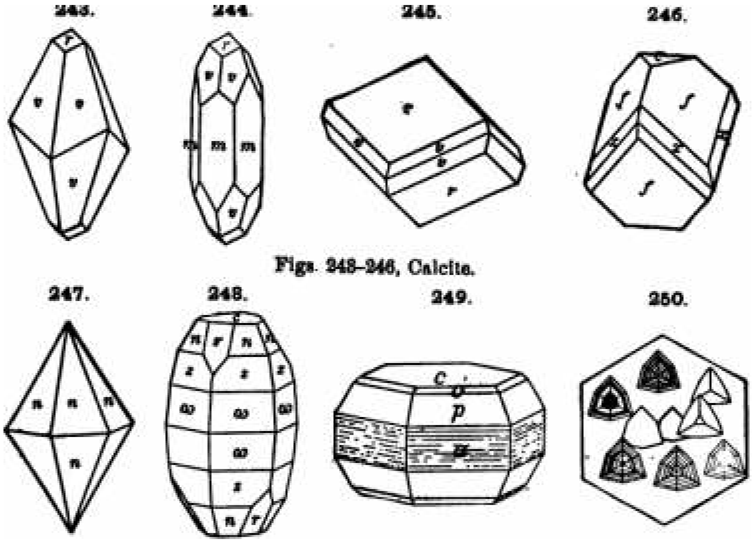
Below 2311, 3211, I23I, l33l, 3l2I, 2l31.

142. BaUtion of B«al«iioh*droii« to Blioubolitdroiii.—It was noted above that the scaleao-

hi'ilrnu iu general bas a eeriea of ziji^g laienil eilses lik« Hie rbomboljedrflu. It i% ol>vIou(, fiirtlier Ibiil for every rlioinbolieilrou tbei-e will be 11 series or zone of Bcaleiiuiivdron* Wvitif{ tlie »amt lateral edges. Tbih is sbowu fii Fig. 245, where tbe sfuleiiuljedroD t[3l81) hevcU the lateral eili;eB of 1b<' fuudumemat rbumboliedron r<10il), tlie same would be true of the sfaieiiobedroii (325l). elc Furtiier, Iti Fig. 246. the minus sciili-no-hi'dron X 1941) levels (lie lateral edges of llie miriui rlionib<)hcdroii/r0321) The ri-1nt!nn (if llie iiidieea whioh must exist iii lliess cnsis miiv be siiowii 10 lie, fur example, for lbs rhnml)ohe.lron r (toil], A = ft + i; ngiin for/(0-:2l), h-\-%l = k. elc. f^ee niso tbe pro j-ctiiHi Pii;. 2K.

Fnr'hiT. Ibe pncllion of tbe scalenoliedroo may lie deflnwi with reference In lis parent rWiiibolipdrnu. For example, in Fig. 245 the soilenolieilron n (2l3l) lin« tlii-ee times the veriici.l nxisofthe imll rlinmlmhedron r (lOlli Apain in Fig 346 r(1S4I)has twice the venical axis of /(0221). Hence the lysleni of symbnls devised by Naiimnnii to express Ibis n-latioii. written In general mRnor (in Dnno's System m-), wbere the n expresses tbe midiiple value ol the vertical aile corresponiiing to the rborabolieilron mR. The symbol

Of • la on this system R8 or 1«. and of * - 3R,. or - 2". If niPn U the symbol of a scaleno-aeOTOD on ihe beiagoosl type uid m,Rn, that referred hi thU way, ft tnay be ahown that



Figs. S47 348, Coruodum.

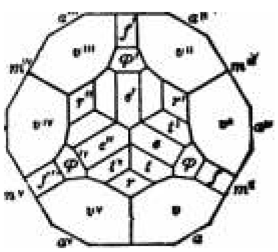
Figs. 24S, eOO, Spaagolite.*

g forniB of the normal group of the 251.

143. Other Forms.—The i

Tbomhohedral difisiou are geometrically like those of the correBponding group of the hexagonal syatem—viz., the base c (0001); the prisma vt (lOlO), a (Il30), (//XriO); also the diagonal pyramids,'ae (U5l). Some of these forma are flhown in the accompanyiug figiirsB. For further illustrations reference may be made to typical rhomhohedral species, as ralcite, hematite, etc. ' With respect to the diagonal pyramid, it is interesting to note that if it occurs alone (as in Fig. 247, n = 2243) it is impossible to say, on geometrical grounds, whether it has the trigonal symmetry of the rhomhohedral type or the hexagonal symmetry of the hexagonal type. In the ~ latter ease, the form might be made a unit pyramid by exchanging the axial and diagonal planes of symmetry. The true symmetry, however, is often indicated, as with corundum, by the occurrence on other crystals of rhomhohedral faces, as r (lOTl) in Fig. 248 (here i = 2241, a> = 14-14-58-3). Even if these are absent {Fig. 249), the etchiiig-figiires (Fig. 250) will often serve to reveal the true trigonal molecular symmetry; here o = (ll24), p = (1122).

144. A basal projection of a somewhat complex crystal of calcite is given in Pig. 251, and ,■* spherical projection for the same species in Fig. 3.72; both

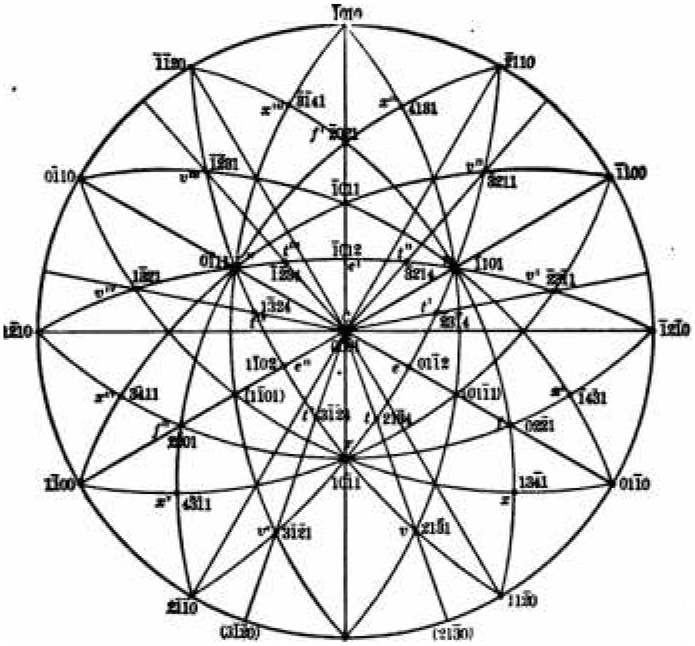


show well the symmetry in the distribution of the faces. Here the forma are:

prisma, a (ll30), m (lOlO); rhombohedruns, plus, r (lOll), mistia « (OlIS),

^ (0554),/{0i!2l)j acalenohedrona, plus, v (2l3l), t (2134), minus, «(l3il).

363.

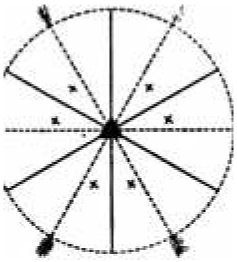


3. RHOMBOHEDKAL-HEMIMORPniC GROUP (20). TOURMALINE TYPE. 146. Symmetry.—A number of prominent rhombohedral species, i tourmaline, pyrargyrite, pronstite, belong to a heminiorphic group nnder this

2B3.

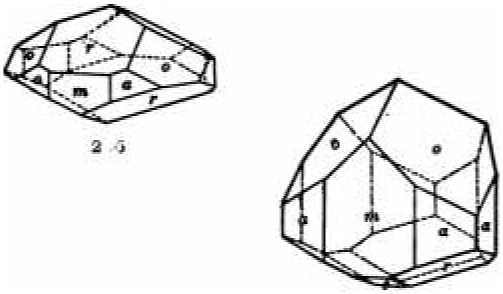
division. For them the sj-mmetry in the grouping of the faces differs at the two extremities of the vertical axis. The forms have the three diagonal planes of symmetry meeting at angles of CO" in the vertical aiis, whieli is an aiig of trigoual symmetry. There are, however, no horizontal axes of symmetry, as in the rhombo-hedral grnnp, and there is no center of symmetry. Cf. Fig. 25.1.

146. Typio^ Forms. — In this group the basal planes (0001) and (OOOl) are distinct forms. The other characteristic forms are the two trigonal prisms7«(lOlO) and w), (01 iO) of the nnit aeries; also the four trigonal unit pyramids, corresponding respectively



to the three upper and three lower faces of a plus rhombofaedron, and the three upper and three lower faces of the miiius rhombohedrou; also the belliimorphic diagonal hexagonal pyramid; finally, the four ditrigoual pyramids, corresponding to the upper and lower faces respectively of the plus and minus scalenohedroQS. Figs. 254-357 illustrate these forms. Fig. 25f> is a basal section with r, (OlII) and e, (lOlS) below.

264. 266. 367.



Ilgs. 2S4-257, TourmallDe, m(lu!l)), '". (liiiO), a (im), & (4lfio), r (lOll), o(O1!Sl), <,(10i2), tt(825i). 2(1282).

4. TRI-RHOMBOHEDRAL GROUP (21). PHENACITE TYPE.

147. Symmetry.—This gi'oup, illustrated by the species dioptase, pheoacite, willemiCe, dolomite, ilmentte, etc., is an impor 253

taut one. I^t is characterized by the absence of ^ _. .*-,.._ ^.

al] planes of symmetry, bnt the vertical axis is ,?^," "".*^-.

Btill an aiis of trigonal symmetry, and there is _/' \ _,■"

a center of symmetry. Cf. Fig. 258, /' \o /

148. Typical Forma.—The distinctive forms / \ /' ',

of the group are the rhombohedron of the second ^ .1 ^ i^

order and the hexagonal prism and rhombo \ / \ O ;

hedron, each of the third order. The group is \ o/ ^,^ _/

thus characterized by three distinct rhombohe \ / \

drons (each -|- and —), and hence the name "••,^." \ ,.•'

given to it. ^■-- --^

The complementary plus and minus rhombo-hedrona of the second order together embrace all the faces of the diagonal pyramid of the normal group. For example, in a given case the faces for the plus and minus forms are;

Plus (above) ll32. i5ll2, lSl2; (below) 12T3, TT23, 2liS, Minus (above) !2l3, 1122, 2ll2; (below) Sll3, l5l5, 1133.

The rhombohedron of the third order baa the general symbol (hkil), and the sjmbolG of the six like faces of the plus right-hunded form (3l3l) are: Abo?e 2l3l, 3211, lS21; below 1351, 3l3l, 35II.

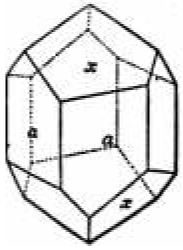
There are three other complementary rhombohedrons, diatingiiUheiJ respectively as])lua left-hauded {ai3l), minus right-handed (l32l), and mimis left-handed (l!i,1l). These four sets of faces make np the twenty-four like faces ol the diheiagonal pyramid of Fig. 201. In Pig. 259 {drawn in the reverse position) the minus right-handed form (l3S2) is shown.

The complementary right and left hexagoual prisms of the third order embrace all the faces of the dihesagonal prism (i^ig. 197). The faces in a given case (2l3o) have the symbols:

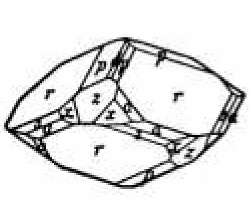
Right 2130, 1350, 3210, SI30, l320, 32lo, Left 1230, 53lO, 3120, 1230, 2310, 3l20.

148. The remaining forme are geometrically like those of the rhombobedral group, viz.: Base c (0001); unit prism wt (lOlO); diagonal prism a (llSO); rbombohedrona of the first order, sa (lOll) and (Olll), etc.

259.



260.



160. The forma of this group a species phenacite, with whicn the n

) best illustrated by the crystals of the nns right rhombohedron x (1322) is not

infrequently the predominating form, as in Fig. 359. The true position of this rnombohedron is shown by its relation to the prisms m (lOlU) and a (llSO). A more complex crystal of the same species* is given in Fig. 260, and a basal projection (in norma] position) is shown in Fig. 261. The faces present are: rhombohedrons, first order, plus, r (loll). minus, z (Olll), d (0112); second order, right, p (US3), left, p, (2!l3), oAmi) ; third order, plus right, s (2l3l), minus left, x, (1232), minus right, x (1333),

In order to make clearer the relation of the faces of the different types of forms under this group. Fig. 262 is added. Here the zones of the plus and minus rhombohedrons of the first order are indicated, also the plus and minus eectante corresponding to each.

The following scheme may also be helpful in connection with Fig. 262. It shows the distribution of the faces of the four rhombohedrons of the third order (-J- r, -\-1, — r, — I) relatively to the faces of the unit hexagonal prism (lOlO).

Phbmacitb Ttpk.

6. TRAPEZOHEDEAL GKOUP (

QUARTZ TYPE.

\ '"

151. Synuaetry.—This group includes, among minerals, the species qnartz and cinnabar. The forms have no plane of symmetry and no center of sym* metry; the vertical axis is, however, an axis of ^** trigonal symmetry, and there are also three

horizontal axes of binary symmetry, coincidine^ in direction with the crystallograpnic axes; ci. Fig. 263.

158. Typical Forms. — The characteristic form of the group is the tri^nal trapezohedron shown in Fjg. 264. This is the general form corresponding to the symbol (hkil), the faces being distributed as indicated in the accompany> ing spherical projection (Fig. 263). There are fonr such trapezohedrons, two plus, called respectively rignt-handed (Fig, 2ti4) and left-handed (Fig, 265), and two similar minus forms, also right- and left-handed (see the scheme given in Art, 164). It is obvions that the two forms of Figs. 264, 265 are enantiomorphous, and circular polarization is a striking character of the species belonging to the group as elsewhere discussed.

The symbols of the six faces belonging to each of these will be evident on

* Dnwn with tbe zone of minus rhombohedrons Id froot to better show the modlfjliig facet. Fig. 200 i> similar. ■

■•/ V

,ab,GoOgIc

cODSnltisg Figs. 263 and SOS, p. 70. The complementarT pins forms (r and T) of a given symbol include the twelve faces of a plus scslenobedron, while the faces of all fonr include the twenty-lonr facfj of the dihexagonttl pyramid.

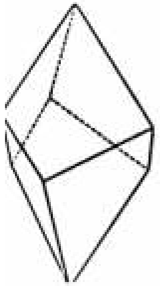
Corresponding to these trapezohedrons there are two ditrigonal prisms, respectively rights and left-handed, aa (2l30) and (ZWi).

The remaining characteristic forms are the right- and left-handed trigonal prism \ s(ll3u) and a(2llo); also the right- and left-handed trigonal pyramid, as (llSS) and (2ll2). They include respectively the faces of the hexagonal prism of the second order (llSO) ftnd those of the corresponding pyramid (ll52); these are shown in Figs. 196 and 200.

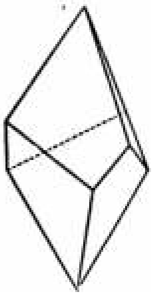
153. Other Form*.—The other forms of the gronp are geometrically like those of the normal jrvoup. They are the base c (0001), the hexagonal unit prism m (lolo), and the pins and minus rhombohedrons as (lOll) and (Olll). Thf!se cttiinot be distingnisfaed geometrically from the liormal forms.

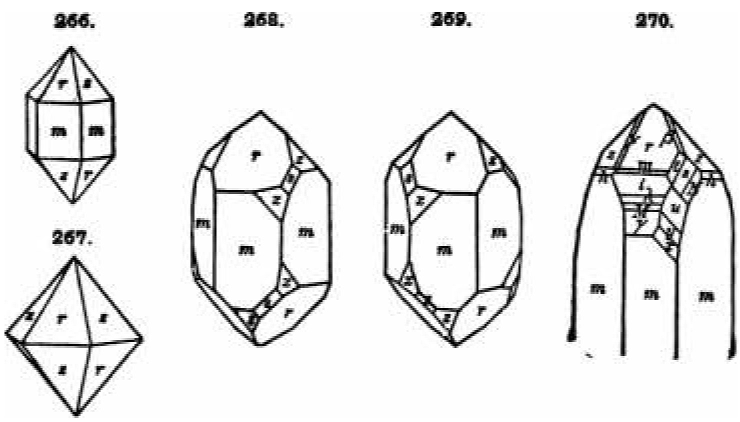
IftC ninstrationi.—The forms of this group are best shown in the species qnartz. As already remarked (p. 75), simple crystalB often appear to be of normal hest^onal symmetry, the rhombohedrons r (lOll) and x lOlIl) being eqnally developed (Figa. 26t), 367). In many cases, however, a difference in molecular character_between them can be observed, and more commonly one rhombohedron, r (1011), predominates ; the distinction can always be made ont hy etching. Some crystalB, like Fig. 268, show as modifying faces the right trigonal pyramid s(ll3l), with a right plus trapezehedron, as ^ (515l). Sitch crystals are called right-handed and rotate the plane of polarization of light transmitted in the direction ot the vertical axis to the right, A crystal, like

264.



265.





FtgR. 366-370, QuarlB.

Fig. 269, with the lefl trigonal pyramid s (2 1) and one or more left trapezo-faedrons, as x (OlSl), is ciuled left-handed, and aa regards light has the opposite

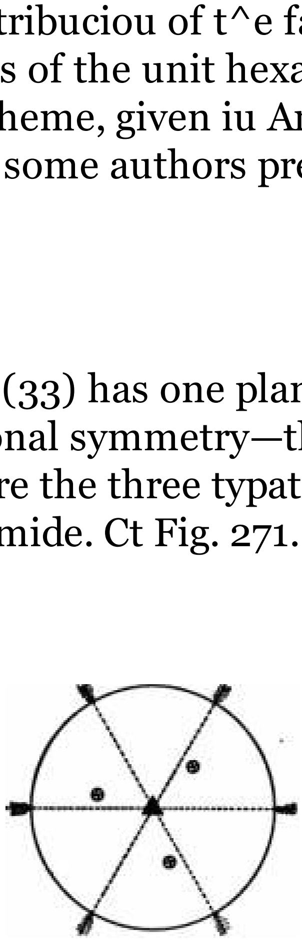
character to that of Fig. 368. Fig. '^TO shows a more complex right-banded cryBtal with ser^ral plus and minus rhombohedrons, several ^ua rigot trapezo-bedrons and the minus left trapezohedron, N.

The following scheme shows the distribuciou of t^e faces of the four trape-Eoliedrons (-{-r, -j- I, — r, — I) relatively to the faces of the unit hexagonal prism (1010) ; it is to be compared with the correspondiug scheme, given iu Art. 160, of crystals of the phenacite type. In the case of the minus forms some authors prefer to make the faces ai5I, I23l, etc., right, and 3l3I, i33l, etc., left.

QoARTZ Type.

1B5. Other Oronpt.—The next group (33) has one plane of synimetry—that of the horizontal axes, and one axis of trigonal symmetry—the vertical axis. There is no center of symmetry. Its characteristic forms are the three typat of trigonal prisms and the three corresponding types of trigonal pyramide. Ct Fig. 271.

271. 273.



\A

\ / X #• •*

group (34) has no plane of symmetry and no center of symmetry, ical axis is an axis of trigonal symmetry. The forms are all henii-e prisms trigonal prisms, and the pyramids hemimorphic trigonal r<i 1?:™ or-o Neither of these groups is known to be represented

The last o-. but the vertical morphic, the pyramids. Cf. Fig among crystals.

Hatheu ATicAL Relations ot ths Hbzaoonai. SysTBif.

ISe. OholM of Axil.—The position of tlie vertical cryBtnllographic osIh Is flxed in all tbe groups of ihie system since it colnciilea with the axis of hexagonal symmetry Iu the hexagonal dlvlBiun and that of trleoual symmetry in tbe rhombohedral division. The three lateral axes are also fixed in alreclion except in the normal group and the subordinate hemimorphic ^roiip of the hexagonal division ; Iu these there Is a choice of two poelilona according to which of the two sets of vertlcnl plnnes of symmetry Is taken as the axial set.

157. Azlal and Angular Elamsnti.—The hiIhI element Is the length of Ibe vertical axis, i. Id terms of a lateral ails, a; in other words, the axial lailo ot a:i. A single measured

maltcj mil; be taken as tbe

Tbeau^uUrelemeiitiausiially taken as tbeaagk between the biisee (0001) and tbe unit p;niniul (lOli), thai is, 0001 a lull.

Tbe KlfttiuD between this aogle aod tbe axis t is given by tbe formula

tan (0001 A 1011) X ^V'S = h. Tue vertical axis is also easllj obtained from tbe unli diagonal pynmid, dnce

lau (0001 A ll2a) = i. These lelatlons become geoeral by writing tbum as follows:

lau (0001 A hOhH X ^1^3 = jXi; tan (0001 A hh-2hti =^xi.

In general It is easy to obtiiia niiy reiiuireil angle I'einifeii tbe poles of two faces on tbe spberlcat projeclion eillier by tbe iiee of tlie InngeiU (or ci>liui^eQt) relation, or by tba BulutiMi of split-ncal IriaoL'les, or by die appUcat ou of liolli metliods. lu practice most of the triangles iiseil in culculntiOD nre risljt-augU-rl.

168. Taageat and CoUngant B«IaUon* —The tangent relation holds good in any zod« from e (0001) to a lace iu tbe pristnullc zone. For example:

.n(OQQl A a-a-27lt) _Z>i

tan(0001 A lOTi) I' tan (0001 A 1132)

& siroplifled form; for example, for a

cot(10iOAAKO) = ?^/jj

cot (Il50 A hklO) = ■^^f'8.

The sum of the angles (1010 a UiO) and (llSO A hkm) Is equal to 80*.

Purllier, the last equations can be written In a more general form, applying to any pjTamicI (fikU) in a zone, first between lOlO and a face In the zone 0001 to OUO. where tbe angle between lOlO and this face Is known; or again, for tbe same pyramid, in a zone between 1120 and a face In the zone 0001 to 1010, the angle between 11^ and this face being given. For example (ef. Fig. 209, p. 70). If the first-men^oned zoneia lOiOAAiiOlll and ilie second is 112O'AiI:U-1011. then

cot (lOlO A AMI) = cot (lOiO A Olll). — 't -*.

Also simllBrly for other zones,

cot (lOTO A hm = cot {lOiO A

= cot(IOiO A 3(fil).^^,etc

uiii(10il A Olll) = sliiCf'i, wberoUuiEs^ ud la general

Uo i (MM A OAU) = an H^, where Un S. = j^

^) For a Hagonal pi/ramid, u (llSz),

9 Bfc i(l]S2 A I3l2) = aln £, and Un f = &.

(8) For a rtonioAadnm

rin l(10!l A ilOl) = sin af/}. where a = (0001 A lOll);

Id general

aln i (AOAt A AAOO = du a.V), where a, = (0001 A MJU).

160. Zonal Belatiou.—The zoDal equatioDs, deacribed b Arts. 4S, 44. apply here aa in other STstemB, only ibatit Is to be noted that one of the indices leferriDE to the lateral axes, preferably the third, (is to be dropped in the calculations and only tlie other three em-'- -- ■ "''' - .-"— ' -• ■'. g lu which the faces (Am), (pgrl) lie are

XXX

where u = JH — jl, v = (p — Ai. yi = hq — kp.

For example ^ig. 216), the face u lies In tlie zone mt, 1010 ' 1131 and also in the sone m'y. OliO-aOai. For tlie first zone tlie values obtained are ; ii = 0, v = 1, w = 1; hence for any face in tbia sone the relaliou k = t holds true, Biniilsrly for the second lone « = 1. / = 0, ff = — 8, or ft = 2i. TUerirfore the symbol ot the given face is given either hy the scheme

0 i 1 0 i

3 1 1

or from the two eqnalions k = t and A = 21. The face m has, therefore, the symbol 2l9l, doce further i = - (h + k).

161. Formnlss.—The following formulas are sometimea useful:

(1) The distances (see Fig- 200) of the pole of any face (Aitnf) from the polea of the faces (lOlO), (OlIO). (ilOO), and (WOl) are given by the following equations:

cos PA = cos (flKO (lOiO) - . Hk + 2h)

t/ac + ii'ik' + *» + **)■ = cos (ftiu) (Olio) = "'^ + "^

CM PO 3 CM (AM) (0001)

' yw + i»(h} + *• + AA) '

_ ZU + W{hq + p* + 3ftp + a*j>

" ^[W + W>(A' + *• + hk)\ [W + 4i'(p' + g* + pj)] •

of ue normal Angles for tbe several forms Id the ajatetr.. Tliey are as follows: (a) HMogonai Pyramid (AOU). Fig. 190:

owX{termln«l)--^jr^^jjip-; 00. Z (Iwal) =-g^r^p^j^ip.

^ JHagotuipyramid{hh-Sh-l). Fig. 900;

<».T (termini)-^^^;, oo. Z (b«.l) = ^^. (M«):

oo. X(.e« Fig. Ml) - 8f* + 4i'(A' + ^ + AA) -

v, » «... «• + 2i'l3A' + 2AA - A«) oo. T (see Pig. »1) = gji + 4J'(A-+ A* + AA) '

,^ ,. 4i'(A* + A* + AA) - 8i»

W^Zd^-l) = 8/+4i'(A' + A' + AA) -

(<) /MbinvonaJ Pritm (AAiO), Fig. 1S7:

_ , , „ A* 4- A" + 4AA ,., ,. SA* + aAA - *

«-^<"''' - 2tA'VAA*) <»«T«Hagonal)= g^^.^.^^^^ .

(A AlMMMbibvn (1oll)i

lU* — SA'i* CO. X (terminal) ■ g^-j-jpjj-.

oo.x («e Pig. 942) - Bf+^-ty + y + M) -

■B-, » n^n. 8'" + 2*'(3A' 4- 2At - A*) Oo.T(..eng.M8)- 8i. + 4^.(,. + y + a^; .

«>iZ(bua]) = «qr4j.(ft. + *> + AA) •

IBS. AaglM.—The angles for aome commonl}' occurring priama are given in Uu follow tug (able:

m(10iO. i)

BlSO *4 8* 6r

4l50 H 10 58t

8140 ^1 18 54

S2T0 t-i 16 0

SlSO f-l IB 6}

8250 <-t 38 24{

G4d0 H ^ IS)

IBS. Th* &hamboh*dnl 8jit«ta ^ KUlai.—The following projection (Fig. 2TS) It added

lo order Co show the relatlua oF llie forma in the lieiagonal Hysiem aa referred by

373, Miller to three equal oblique iixea psrallel

lo the faces of the fuudameutal rhombo-

hedron. The forms are ns followa :

TLe faces having IL>- iudlces 100, 010, 001 are those of ibe (plus) fundamental rhomhohedrou. while ibe face 111 la the base The facea 331, 133, 312 are ihoa« of the mJDUB fuudameutal rhombohedroii; with 100, 010, 001 they form the unit hexFiKooal pymmid.

The facea of Ihe hexagoual unit prfam, m (lOTO). h»ve the eymboU 211, 112, isi. §11, ii2, 121. Those of Llie secomi, or diagonal, hexagonal prism, a (1120), have the aymbols 101, Oil, 110, 101, Oil,

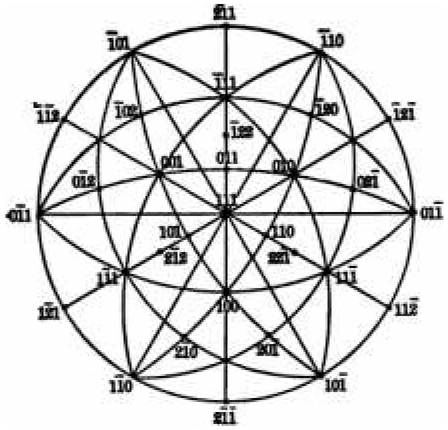
lio.

The diheragnnnl pynimid embraces. like the simple hexngouat pyramid, two forma (AW) and {^g): of iliese ihe symbol (hkl) hence beloujcB lo tlie plus scalenolie-droii, and [ffg) lo the mltius. Id ibis as in other cases it la Irue thnt t = 2li + Vi — l. /=2A-* + 2i,ff-- A J-24+2i. For example, Ihe facea 210, 301, 021, 130, i02, "OiS (Kg. 978) belong Ju the Rhombohedral DiviBioo of thia system to the Bcalenohedroii (2l9l). The complemeulary minus scalenobedron woidd have Ibe faces 6S4, etc. The tweniy-four faces of these two forms taken together would embrace all the faces of tbe dibezagonal pyramid of the Hexagonal Division (2l3l). Gf. Fig. 20B. p. 70, and Fig. 853, p. 79, with Fie. 373 given here.

Similarly the dlbexagoijal priam Includea tbe ais faces ot tbe form (AM), and the remaining six of the form (e/0|.

It is seen at once that the Indices fdveD above are those of the [aometric system, where the cube cori-esponds toarhombobedron of 90'; tbe projection of Fig. 110, p. 41, is brought into relation with the above if an octahedral axis is placed vertical.

The iuconveulence of having tbe faces of tbe same form (a.g., the diheiagonal prism nr pyrnmid ot beryl) represented by two seta of indices Is obvious, and this method, inlniducefl by HilliT. is now seldom employed. This objection, however, disappears if tbe axes iini) indices described are used for rhombohedritt forms oaly. that is, for forms belonging to thn groups which Hre rlisracterlzed by a vertical axis of trigonal symmetry. Tills is the method adopted by Oroth (18ofi). It is believed by the author, however, that ibe mutual relalloiis of all tbe groups or both dlvialons of the hexagonal ayatem among tbemselvi's (as also to tbe groups of the tetrngooal aystem), both morphological and physical, are Oest brought out Dy keeping throughout the same axes, namely, tboee of Ftg. 198, An. lU.



IV. ORTHORHOMBIC SYSTEM.

164. The Obthokhombic Ststeh inclDdes all the forms which are referred to three uueqiial axes at right angles to each other.

Of these axes the shorter lateral axis, or brachy-axis,* is represented by the letter a, the longer lateral tixis, or macro-axis, hy h, and the vertical axis bj 6 (cf. fig. 2T5). In the statement of the axial ratio 5 is uniformly taken as the Doit.

1. KOEMAL GROUP (25). BAKITE TYPE.

165. Symmetry.—The forms of the normal group of the orthorhombio system are characterized by three unlike planes 374.

of symmetry, lit right angles to each other, and fDrther, coincident with their intersection-lines, there are three axes of binary symmetry, which directions are also those of the crystallogniphic axes. These axes are consequently fised in position by the aymmetry, but any one of them may be made the vertical axis. -*

The symmetry of the group is oxliibited in the accompanying spherical projection. Fig. tJT4. This should be compared with Fig. 69 (p. 33) and Fig. 148 (p. 53), representing the symmetry of the normal groups of the isometric and tetragonal Eystems respectively. It will he seen that while normal isometric crystals are developed nlike in the three axial directions, those of the tetragonal type have a like development only in the direction of the two lateral axes, and those of the orthorhomhic type are unlike in the three axial directions. Compare also Figs. 70 (p. 34), 149 {p. 54), and 276 (p. 90).

166. Forms.—The varions forms possible in this group are as follows:

Miller. Naumaou.

3. Base or opinacoid (001) a>S ■.'Xihd OP or 0, c

(Unit prism (IIO) d:!>:<x>i ooPori, m

4. \ Macropriams. .,{hkO) ?t>k d -.nh: asi ooPm or t-n, as (210) t-S (Brachypri8m8..(AtO) h<k nS-.h-.ooi qoPm or t-n, as (120) t-5

5. Macrodomes (hOl) ti-.txilimi mPoo or m-;, as (201) 3 I

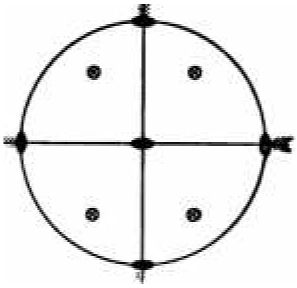
6. Brachydomes {Okl) a>d:h:mi mPS> or m-l, as (021) 2-i

(Unit pyritmids {hhl) &il\ mi mP or m, as (221) 2

(111) &:l:i Porl

Maon)pyramid8(Sii) A>i d : nh -.mi mPhor m-H,as(211)2-2

Brftchypyramids(Aii)7*<A nd:h:mi mPTiOv ni-n,aB(121)2-^



Id f-Deral, IIS defined a

I form wbosc (hcm are purallel to two of il pluQe; u prirm is one whosf fiiCiB an: pHrahbl tii tLe verlicul uxin. Iiul iiilercucl llie iwo lateral axes; udome* is one whuBc faces niv jmrallel 10 t>ue uf ilie la'eml Bies, but latersect lu the vertical axis. A dome is suiiibtiiueBCHlledii Aortcontu^ pritm: a iiyroniid is a form whose facea mtei ul) tilt iLitv «xl-b.

These lenns are used in the aboTe seuKe Dot ouly In Uie oriliui'|]oiiib:c system, but al-o

111 ibe tuuDOcliuic iLud triclinic syaiema ; In iLe last encL funii rctisist ui iwu pliines oo.y.

167. Finaooidi.^—The macropinacoid includes two faces, eacli of which ts parallel both to the macro-axis i and to the Tertical axis d; their symbols are respectively 100 and 100. This form is uniformly designated by the letter a, and is conTenietitly and briefly called the a-piiiacoid.

The irachypinacoid includes two faces, each of which is parallel both to the brachy-azia a and to the vertical axis i ; they have the symbols 010 and OlO. This form is designated by the letter b; it is called the b-pinucoid.

The base or basal pinauoid includes the two faces parallel to the plane of the lateral axes, and having the eynibols 001 and OOl. This form is designated by the letter c; it ia called the c-pinacoid.

Each one of these three piuacoids is au open-forni,f but together they make the so-called diametral prism, shown in Fig. 275, a solid wnich is the analogne of the cube of the isometric system. Geometrically it cannot be distingnished from the cube, but it diflera in having the symtnetry unlike in the three axial directions; practically this may be shown by the unlike physical character of the faces, a, b, c, for example as to luster, striations, etc.; or, again, by the cleavage. Further, it is proved at once by optical properties. This diametral prism, as just stated, has thi'ee pairs of unlil^e faces. It has ' three kinds of edges, four in each set, parallel respectively to the aiea a, i, and d ; it has, further, eight similar solid angles. In Fig. 275 the dimensions are arbitrarily made to correspond to the relative lengths of the axes, but the student will understand, that s crystal of this shape gives no suggestions as to these values.

188, PriBmi.—The pi'iam.-s proper incliuie ti.ose forniB whose faces are parallel to the vertical axis, while they intersect both the lateral axesj their general symbol is, therefore, {hkO). These all belong to one type of rhombic prism, in which the interfacial angles corresponding to the two unlike vertical edges have different values.

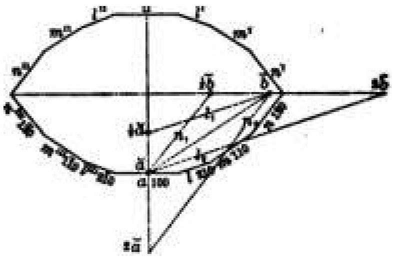
The unit prism, (110), is that form whose faces intersect the lateral axes in lengths having a ratio corresponding to the accepted axial ratio of £:h for the

i;iveQ species; in other words, the angle of this unit prism fixes the uoit engths of the lateral axes. This form is shown in combination with the basal

* From the Latio domut, becaute rewmbllug the root of a bouse ; ct, Flgi. STV, 280.

pinacoid in Fig. 276; it is uniformly deeignated by the letter m. The tonr ocea of the onit prism have the symbols 110, IlO, ilo, llo.

The macTOpTisms lie betwuen the macropinacoid, a (100), and the unit prism m (110), and conaequently for them the ratio of h to k is greater than 1:1; in other words, the ratio of the intercepts on the axes i and & is greater than that for the unit prism. Common forms have the symbola (410), (310), (210), (320), (430), etc., given in order from 100 toward 110; cf. the spherical projection of Fig, 3u3, The face / of Fig, 277 is the macroprism (310); for this form the axial intercepts (see the basal projection, Fig. 278) are in the ratio of ^& : Xl, or Id: %h; a similar relation holds for the other forms (410), etc.



The bracht/prisms lie between the onit prism and the brachypinacoid b (010), and conseqnently for them the ratio of the first two indices is less than 1:1, or tlie ratio of the intercepts on B, & is leea than that of the nnit prism. Common forms are (340), (230), (120), (130), given in order from 110 towjird 010. For the form « (120), shown in Figs. 377, 278, the axial intercepts are in the ratio of Ifi-.^h, or 2d:l. Other examples of these prisms are given later {see Figs. 296-299).

Ill NanmniiD's Bjmbola the Dumber n, the multiple of llie lateral tula, is always made greater [biiD unity. Hence wliile the uiHcruprbnj, t, of Pig. S!77 lias Ilie lull symbol i:ib:-at. or btiedy 00 P5 (or i-2), the brnchypriaiii is irrillen &i ; 6 ; a)4, or-el's (or *-g), inslenl of tlie eqiiivHltHt form a: \h: aai. In i)tbi.-r wiirds, wiiL lUu macruiinrms (aud macTopyramida) ike value of the bi-acby axis U made equal to unity, while witL tUe bracliy* prisms (and brtieliypyramids) tbe macro-aiia is taken as Ibe unit.

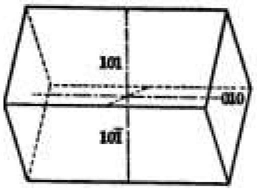
169. HacTodomei, Bnohydomet.—The tnacrodomes are forma whose faces are parallel to the macro-axis, J, while they intersect the vertical axis d &nd the lateral axis a; hence the genarnl symbol is (kOl). The angle of the unit macroiiome, (101), fixes the ratio of the axes (i:d. This form is shown in Fig. 279 combined (since it is an open form) with the brachypinacoid.

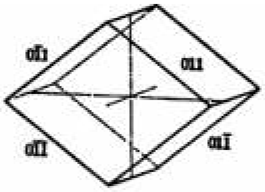
In the macrodorae zone between the base c (001) and the raacropinacoid a (100) there may be a large number of macrodomes having the svmbols, taken in the order named, (103), (lOi), (303), (101), (302), (201), (301), etc Cf. Fisrs. 298 and 302 described later.

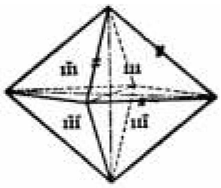
The irachydotnes are forms whose faces are parallel to the brachy-axis, S, while they intersect the other axes i and h\ their general symbol is [Okl). The angle of the unit brachydome, (Oil), which is shown with a (100) in Fig. SHO, determines the ratio of the axes h:i.

Tbe brachydome zone between c(OOl) and 4(010) includes the forms (013), (012), (023), (Oil), (032), (021), (031), etc. Cf. Figs. 298 and 302.

Both sets of domes are often epokea of as horizontal prigma. The propriety of tliis expresBion is obvious, since th^ are in fact prisms in geometrical form; further, the choice of position for the axes which makes them domes, iast^d of prisms ic the narrower sense, is more or less arbitrary, as already explained elsewherfl.







170. Pyramids. —The pyramids in this system all belong to one type, the double rhovbicpyramid, bounded by eight faces, each a scalene triangle. This form has three kinds of edges, X, Y, Z (Fig. 281; cf. also Fig. 290), each set with a different interfacial angle; two of these angles suffice to determine the axial ratio. The symbol for this, the general form for the system, is [hkl).

The pyramids fall into three groups corresponding respectively to the three prisma just described, namely, unit pyramids, macro pyramids, and bracby pyramids.

The unit pyramids are characterized by tlie fact that their intercepts on the lateral ases have the same ratio as those of the nnit prism; that is, the assumed axial ratio {a:h) for the given species. For them, therefore, the general symbol becomes {hhl).

For different nnit pyramids on crystals of the same species the vertical axes may have diiferent lengths bearing usually some simple numerical ratio to each other (and always commensurate), and these form a zone of faces lying between the base c (001) and tlie unit prism m (110). This zone, for example as shown in the basal projection of a sulphur crystal given in Fig. 302, includes the forms V^ (119), m (117), / (115), o (114). 5 (H3), y (112), ju (lU).

Cf. als

I Fig. 66, p. 30, of the same species, and the spherical projection, """" I of this zone /* — k, and the

Fig. 303. In the symbol of all of the

lengths of the vertical axes are hence, in the example given, \, \, -J, \, j, 1 of the vertical axis i of the pyramid ;i (Fig. 290), which in this species ii taken as the unit pyramid. The axial ratio for snlpliur is given on p. 22.

The macropyrnmids and hrnchypyrmniil" are related to each otlier and to the unit pyramids, as were the mncroprisms and brachyprisms to themselves and to the unit prism. Further, each vertical zone of niacropyramids (or brachypvramids), having a common ratio for tiie lateral axes (or of A: it in the symtiol), belongs to a particular macroprism (or brachyprism) characterized by the same ratio. Thus the macropyramids (314), (213), (212), (421), etc, all belong in a common vertical zone between the base (001) and the prism (210). Similarly the brachypyramids (123), (122), (121), (241), etc., fall in a common vertical zone between (001) and (120). Cf. Fig. 299, where « and o are the brachy pyramids (134), (131), falling in the same vertical zone as the brachyprism (f(130). See also the basal projection. Fig. 303, and the cpfaencal projection, Fig. 303, both of sulphur, noting the relation of the

macropyramid (315) to the macroprism (310) and tlie brachypynunids (135),

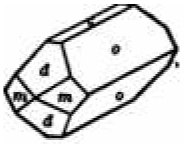
(133), (131) to the brachypriBm (130).

171. Illastiationi.~The following figares of bai-ite (282-289) give excellent illustrstiona of cryBtala of a typical orthorhombic Bpeciea, aud show also bow the habit of one and tbe same species may vary. The axial ratio for this species is gijea on p. 96. Here d is tbe macrodome (103) aud o the unit brachydome (911); m is, as always, the anit prism (110). Figs. 2SS-2S5 and

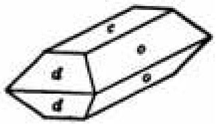
383. 3B3. flS4. 28B.

d

^^



289.

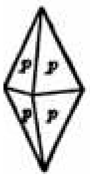


Bariie Cryslalg.

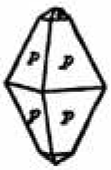
28T are described as tabular \ c; Fig. 286 is priamatic in habit in the direction ot the macro axis (5), and 288,289 prismatic in that of the brachy-axis (di). Figs. 290-394 of native sulphur show a aeries of crystals of pyramidt^ habit with tbe unit domes e (101), w

(Oil), and the unit pyramids p (111), «(II3). Note that e and n truncate respectively tbe terminal Rdges of the faiidamental pyramid p. In general it should be remembered that a macro-dome truncating the edge of a pyramid must have the same ratio of A: I; thns, (■;ui) truncates the edge of (221), etc. Similariy of the brachydomes: (021) truncates the edge of (221), etc. Cf. Figs. 303 and 303.

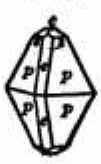
290



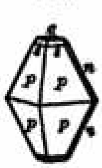
291.



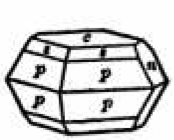
292.



293.



294.



Sulphur Cry stale.

Again, Fig. 295, of staurolite, shows the pinacoids ft (010), c (001), the nnit prism m (110), aud the unit macrodome r (101).

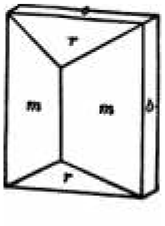
Pigs. 396-298 are prismatic cryBtals of topaz. Here m is the unit prism (110); I and n are tbe brachypriama (120), (140); d and p are the macrooomes (301) and (401); /'and y are tbe brachydomes (021) and (041); i, u, and oare the nnit pyramids (223), (111), (221). ,

In Fi^. 399, of iolite, s and r are the unit pyramids (113), (111); d ie the brachypnsm (130), and u, o are the correspond!og brachypyramids (134), (131). Fig. 300, of brookite, simulates a tetragonal crystal since the prismatic ftDgle is not very far from 90°; here t = (113). In Fig. 301 of tlie same species, e is the bracbypyramid (133); this crystal closely resembles an hexagonal pyramid with ite axis placed horizontal since the angles me (110 A 122) and ee' (123 A l32) are approximately equal.

396.

387.

298.



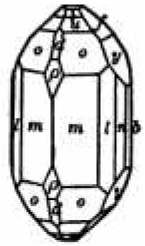
Staurolite.

299.

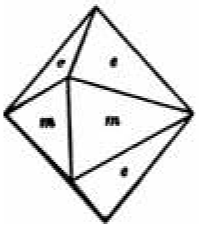
f^

k^^

^^^ f^€^



301.



Brouklte.

Brook iie.

172. Fr^jectioiu.— Basal and spherical projections of a typical ortho-302. rhombic species nave already been given in Figs.

63 and 65 op pp. 27, 28. The subject ia so important, however, that others are given here (Figs. 302, 303) for the species eiilphiir, cf. Figs. 290-294, also Fig. 66, p. 30. In Fig. 303 besides the pinacoids a (100), d (010), c(OOl), the positions of the prisms* (310), w(110), (1301 are shown; the macrodornes m (103), e(lOl) and the brachydomes v (013), n (Oil); the remarkable zone of unit pyramids i//{n5), co (117), t (115), o(114), s (113), y (112), J) (111); finally the macropyramid /S (315) and the braehvpyramids z (135) and x (133). Both projections exhibit clearly the symmetry

characteristic of the groap; the promiuent zones, already spokeo of, sbonld 1^80 be noted.

2. HEMIMORPHIC GROUP (36). CALAMINE TYPE.

173. Symmetry and Typical Fomu.—The forms of the nrthorliombic-hemi-morpkic ^rotip are characterized by two unlike planes of symmetry and one aiis of binfiry symmetry, the line in which they ^304.

intersect; there ia no cenber of Byrametry. The " ,^

forms are therefore hemimorphic, rb define*! in Art. 29. For example, if. as is iisnally the case, x""^

the rertical aiia is made the axis of symmetry, the / two planes of symmetry are narallel to the pina- ,< " colds fl (100) and b (010). The prisma are then ,'

geometrically like those of the normal pronp, as Mf_

are also the maoropinacoid and brachypinacoid ; \ but the two basal planes become two independent \ ^ forms, (001) and f(K)T). There are also two macro- \ domes, (101) and (lOl), or in general l?iVl) and \^_

ikOl); and similarly two sets, foi'a given symbol) of bracbydomes and pyramids.

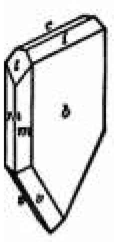
The general symmetry of the CToup is shown in the spherical projection of Fig. 304. Fnrther, Figs. 305, 306, of calamine, and 307, of stroTite, represent

■\

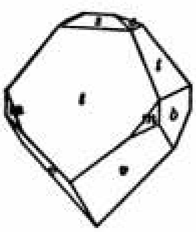
y

typical crysUls of this group. In Figs. 305, 306 the forma present are I (301), a (101), i (031), e (Oil), v (lal); in Fig. 307 they are a (101), s, (lol). g (OU).

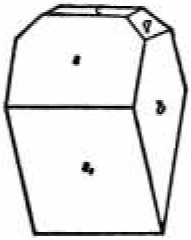
305.



306.



307.



3. SPHENOIDAL GKOUP (27). EPSOMITE TYPE.

174. Bjnnmetry and Typical FonnB.—The forms of the remaining group (tf the6yBtem,th6 orthorhombic-splieiwi stmt ina

dal group, are cliaracterized by three unlike rectangular axes of binary symmetry, bat they have no plane And no center of aymmetry(Pig.308). The general form hlcl here has four faces only, and the correEponding -solid is a rhombic sphenoia, analo. ^^

/^3\

^=^k/

gouBtothe sphenoid of thcteCragonal \

system. The complementary plus \

and minus sphenoids are enantio- \ O

tnorphous. Fig. 309 represents a \^

typical crystal, of epsomite, with the *^

plus sphenoid, £ (111). Other crystals

of this species often show both plus and minus complementary forma, bnt

usually unequally developed.

Hatbematical Relations or thb Orthobhoubic Stbtbu.

171. CholM of AXM.— Ab explaiiieri tri Art. lU, tliu three cryHtnllograpliic axes are Bied as regFirilBdlrcciiiiii in nil oi^liiorlioniblc crysiaU. but anyone of tLera maybe mucie Ibe TerlUal axia. i; and nt Ihe two lateral iiJtes. wbicli is Ihe longer (S) nnil wbirli Ibe shorter (,() eajiLint be (ieleriiiiiin.-(l until it is decided which faces lo iiflsume i* the fundameulBl. or unit, pyramid, prism, or domes.

The chuice is generally so made, in a Riven case, as to best bring out Ihe relation of the cryalala of the species in baud to others allied lo them in form or In chemical comnosition or Iq both respects; or, so na lo make the cleavage parallel lo the fundamentHl form- or' u augijesled by the common habit of the crysials, or other cousideralioua

17*. Axial and Anpilar BlMuanU—Tbe aaiat eltmenU are given by the ratio of the lengths of the three axes Id terms of the macro-axis, I. as unity. For example, with barite tbe axial ratio ia

d:J:i = 0-81520:1 :1-81306.

100 A 110 = 39° 11' 18", 001 A 101 = 68' 10' 86", 001 a Oil = 88' «" «\

Two of these angles obviously determiuc the tbinl angle as well as the aztal ratio. The degree of accuracy to be attempted iu the slHltiment oF the hiIilI ratio depeoda upon the ctisracleT of the fuudmneiitul measure men Is from which this ratio has been deducetl, Tbei-e fs no good reawu for glviug the values of d bdiL^ to mauy decimal placeB if the probable error of the measuremeuts amounls 10 mauy mii'ieB. lu the above case the measurements (by Uelinhacker) are siipixieed 10 be accurate withiu a few sevouds. It is coDveuietit. bow-ever, to have the aogular elumeuis coriect, wy, within 10". so Ibat the calculated angles obtained fixim llietu will not vary from thoee derived direct from the measured iinglea by more tUau 30" 1» 1'.

tan(IOOAllO> = (!, tau (001 A 011) =

D (001 A 101) =

These equRtlons serve to give either the axes from the angular elemeuls, or the angular elements froiu the axes. It will be Doled that the axes are not needed for siuiple purpoaea of calculation, but It fs still Importnnl to have tbeni, for example to use tu compariug the morphological relations of allied species.

la practice it is easy to pass from the measured anglea, assumed as the basis of calculation (or deduced from tbe ohservntlons by the method of least squares), to the angular elements. or from either to any other angles by the application of the tangent principle (Art. 47) to tbe pinacoidal zonee, and by the soluiioa of the right-augied spherical triangles given on the sphere of projection.

Tbua any face Jiil (see p. SS) lies in the thr«e pinacoidal zones, 100 and Okl. 010 and hOt, 001 and hJrO. For example, the poaitioD of the face, 821, Is flxed if the positions of two of the poles, SOI, 021, 820, are known. These last are given, respectively, by the equations

tan (001 A SOI) = 8 X tan (001 A 101). tan (001 A 021) = 8 X tan (OOI a OU), tan (100 A 820) = I X tan (100 A 110).

178. Sumple —Pig- 810 repreaenls a crvatal of sllhulte from Japan, with the faces j)(ltl), r (343), 7 (8IS8), etc. Oa tU* the following measured angles were taken as (undamental:

310, jpf (358 A 8BS) = 55* 1' 0",

Hence, the angles 858 a 010 = 40' lOJ' and 358 A 058 = 27° 801' are known without calculation. The rigbt-angied spherical triangle* OlOOlS-SGSylelds the angle (010 a 053) and hence (001 a 053); also the angle at 010, which is equal to (001 a 101). But tan {001 A Oil) = | X Un (001 a 058). and tan (001 A Oil) = i. Also since tan (OOI A 101) = j. the axial ratio U thus known, and two of the nn^lar elements.

The third angujnr element (001 A HO) can be calculated independently, for the angle at OOI In the triangle 001058 35;! in equul to (010 a ^50) and tan (010 A 850) X (= (010 a 110). the complemenl of (100 a 110).

Then since tnn (100 ^ 110) = a. this can be used to check the value of d already obtained. The fHither use of tbe tangent principle wi!h tbe occnsionnl Botullon of a righl-nngied Irinnglewiil serse tn give any desired angle from either the funduineutal angles direct, or from the angular elements.

Again, the symbol of any unknown face can be readily calculated If two measured angles of tolerable accuracy are at hand. Por example, for tbe face m, suppose the measured angles to be

bat (010 A hkt) = 30* 15', «»' (hkl A ftii) = 51' 32'. The solution of the triangle bat-^kt gives tbe angle (010 A O'U) = 16* S5' 20", aod

tan (001 A Oii) _ ta n 78' 84 f _

-^^^^--, = 8 838+,-

n (001 A Oil) tan 46° 80"l"

" r

* The student In this as In every similar case should draw a spherical projection (not necessarily accurately constructed) to show. If only approximately, the relattvi position of the faces present.

But the ttXia ot k: t muat be mioaal and tbe number derived anMs mMt cIomIt with 10:8.

Again, tlie angle (001 a 'iO{) may now be calculated from tbe same triangle and the value S9' US}' obtalued. From this the r^o of A to f U derived since

tan (001 A ftOf) _ tan S 9° SSf' _,.«_* tan (001 A 101) ~ tan «* 48^' ~ *'™* ~ r

This ratio U nearly equal to 6; 8, and the two Tulues tliua obtained glre tbe aymbol D'10'8. If, however, from tbe triangle 001'OArai, the angle at 001 Is calculated, the value 36° 42|' la obtained, nbich is also tbe angle (010 a hkO). From this tbe ratio ft: t 1b deduced, since

tag (010 A 110} _ tap 45' 18 ^ _ k

lan 1010 A /»«) ~ lan aj° 431' -*""""-»■

The value of r la bence closely equal to 2; tbb combined with that Aral obtained

It- = -^-j gives the aame symbol 6'10'8.

Tills symbol being more than usually complex catU for fairly accurate meamirements. Hon'ncGiii'nte tlie symbol obtained is can best be Judged by comparing tbe measured angle* -with tb'ise ciilciilated from the symbol. For example. In tbe given case tbe calculated angle* forwiS iU3)are6<u(010A6-10-8) = 80"16', omj'(B'108 a fi'10'8) = 51'Sy.

The correctness of tbe value deduced is further established if It is found that the given face falls into prominent zones.

It win be understood further that the zonal TrUltons, explained on pp. SO, 80, play an important part in all calculations. For example, In Fig 310, If the symbol of r were unknown, It could be obtained from a single angle (as bi), sloce for tlifs zone h = I.

170. Formalu.—Although It Is not often necessary to employ formulas In calculatiODS. a few are added here for sake of completeness.

(I) For the distance between the pole ot any face P (hkt) and the piuaoolds a,b,c,yr« have In general:

cos' Pa = COS* {AW A100) =■ """*

(•(AW A 010):

" ft V H-'i'a'c' + Co*"

o faces (UQ and (pgf)t

ftpe' + Agi't' + tr a*

" V£AV"T"We' + i'a'J[pV + «•<.■*' + fa*}'

V. MONOCLINIC SYSTEM.

180. The MoNOCLiNic System inolades all the forma which are referred to three unequal axes, having one of their axial inelinationB oblique.

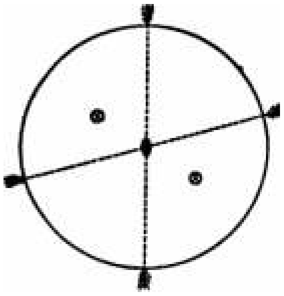
The axes are desif^ated as follows: the inclined or clinodiagODal axis is i; the orthodiagonal axis is S, the vertical axis is d. The acute angle between the axes & and 6 is represented by the letter /S; the anglea between a and ^and S and i are right angles. See Fig. 312. Crystals are usually drawn with the axis d vertical aod the axis d directed to tbe front and inclined downward.

1. NORMAL GROUP (28). GYPSUM TYPE.

181. ByiDmttry.-~-lD the Qormal group of the monoclinic BjBtem there is one plane of symmetry aud one axis of binary symmetry normal to it. The plane of symmetry IB always the plane of the azee a and i, and the axis of symmetry coincides with the axis S, normal to this plane. The poBition of one axis (£) and ^ that of tne plane of the other two

axes (d and i) is thus fixed hy the symmetry; bat the latter axes may occupy different positions in this plane. Fig, 311 shows the typical spherical projection, projected on the plane of symmetry. Fig. 337 is the projection of an actual crystal of epidote; here, aa IB UBual, the plane of projection is normal to the prismatic zone.

182. FormB.—The Tarions-formB* belonging to this group, with their symbols, are given in the following table. As more par-ticalarly explained later, an orthodome inclndea two faces only, and a pyramid four only.



1. Orthopinacoid or

n-pioacoid

2, Clinopinacoid or]

A-pinacoid I

Uiller. ..(100)

(010) 3. Base or c-pinacoid (OOl)

(Unit prism (HO)

4- j Orthoprisms .... (kkO) h>k

' Olinoprisms (AAO) h<k

5. Orthodomes....

6. Clinodomes

[Unit pyramids

((AOO

• \ (hOl)

...{Okl)

(ihk!)

\ (hhl)

J Orthopyramids. | [J*^*»t

Clinopyramids. jj*^J)A<i

•xi i : oio '. i

ni ;}> ita6

A : (tit -.mi d:'x,'b:.mi vid -.o -.mb

& '.o : —md

d : «S : 'Vti

7tti -.h : -mi

Naumaao. 00 PS or i-l, a

00 P3) or i-i, b

OP or 0, c

_ 00 P_or /, m

« Pn or i-«, as (210) i-iS

00 PA ori'-n, as (120) t-2

—mPS or—fft-i,as(101) — l-i

mPm or m-i, as (101) l-j

mPco or m-l, as (011) l-i

— mP or -m, aa (111) — 1

mP, as (111) 1

—mPh or -m-n, as (211)-2-i5

«iPn or m-w, as (Sll) 2-S —mPh or -m-h, as (13I)-2-2 mPn or m-h, as (121) 2-3

Tlie Nauinaon aymboli) jfiven nboTO are nnBlog-'iis to those of iLe ortliorhomhlc

Byslem. Tbe long mark ;m|>loyed U lo be understwxl to be conveatlODal only and tu referring to the ortho-nxls. b. Il does Dot Imply tli:it iliU axis Is longer tban tbe cllno-axis, d, ttiungh this U commonly the case. Tlie Inclined mark rerers to tbe locllned axis, d. Willi aoDie authora iheae mnrka paw through tlie P, lusieail of being writieu over the letter (or Dumber) following.

• On the geeetal u»e of the terma pliiacold, rriamB, domes, pyramids, tee pp. 8d, 90,

1S3. PinacoidB.—The piuacoids are the orthopinacoid, clinopinaooid, and the baeal plane.

The orthopinacoid, (100), includes the two faces parallel to the plaue of the ortho-axis, t and the vertical axis A They have the aymbole 100 and lOO. This form is designated by the letter a, Binoe it is situated at the extremity of the (i axis; it is hence conveniently called the a-piniicoid.

The clinopinacoid, (0101, includes the two faces parallel to the plane of symmetry; that is, the plane of the clino-axis a and to the axis t. i'hey have the symbols 010 and OlO. The clinopinacoid is designated by the letter b, and is called the b-pinacotd.

The base or basal pinacoid, (001), includes the two terminal faces, abuve and below, parallel to the plane of the lateral axes a, t; they have the symbols 001 and OOl. The base is designated by the letter c, and is often (»lled the opinacoid. It is obviously inclined to the orthopinacoid, and the normal an^le between the two faces (100 A 001) is the acute axial angle ff.

The diametral prism, formed by these three pinacoids, taken together. Fig. 312, is the analogue of the cube in the isometric eyatem. It is bounded by three sets of unlike faces; it has four similar vertical edges; also four lateral similar edges parallel to the axis a, but the remaining edges, parallel to the axis h, are only similar two-and-two. Of its eight solid angles there are two sets of four each; the two above in front are similar to those below behind, and the two below in front to those behind abovs

184. Friams.—The prisma are all of one type, the oblique rhombic prism, hey include the unit prism, (110), designated by the letter m, shown ia Fig. 313; also the orthoprisms, {hkO) where h >k, lying between «(100)

and »i(IIo), and the clinoprisms, {hhQ) where Ji<k, lying between m (110) and b (010). The orthoprisma and cHnoprisma correspond respectively to the macroprisms and brachyprisms of the ortborhombic system, and the explanation on p, 91 will hence make their relation clear. Common cases of these prisms are shown in the figures given later.

186. Orthodomei.—The tour faces parallel to the ortho-aiia t, and meeting

the other two axes, fall into two sets of two each, having the general symbols (AOf) and (AO^. These forms are called ortkadomes, they are strictly hemi-nrtbodomea. For example, the unit orthodome (101) has the facea 101 and lOl; they would replace the two obtuae edges between a (100) and c (001) in Fig. 3ia. The other unit orthodome (lOl) hfla the faces lOl and lOT, and they would replace the acute edges between n and c. These two independent forms are shown together, with b (010), in Fig. 314.

Similarly the faces 201, 30T belong to the form (201), and 201, 20l to the independent but ooraplementary form (SOl).

In tbe Bymbols oF NaiiniBDD, Ibe tieinl-onho<loines between the base aud the froat ortliupiiiHculd above, ttaii hence curresporiding to tbts obtuse edge between them, are dlg-tiuguiabed by the mEnuB sign (— 1-i = lOt. etc.), while those m;tween the base and tbe ortuopinacoid behind are civlled plus* (+ 1-i = iOI(; the -j- sign, however, is usualtf omliled. The two sets of hemi-pyrEiiuids (see beyond) are biaiilHrty distinguished.

1B6. CliiLodomei. — Tbe dinodovies are the forms whose faces are parallel to the inclined axis, a, while intersecting the other two axes. Their general symbol is hence (Qkl) and they lie between the base (001) and the clinopinacoid (010). Each form has fonr faces; thus for the nnit clinodoroe these tare the symbols. Oil, Oil, Oil, Oil. Tbe form n (031) in Fig. 321 is a clinodomo.

187. PTntmida.—The pt/nimu/s in the monoclinio system ore all hemi-pyramids, embracing four faces only in each form, corresponding to the general symbol (hkl). This obvionsly follbwa from the symmetry; it is shown, for example, in the fact already stated that the solid angles oi the diametral prism (Fig. 312, see above), wliich are replaced by these pyramids, fall into two sets of four each Thus any general symbol, as (321), includes the two independent forms (321) and (3l^l) with the faces

321, 351,

521,

351.

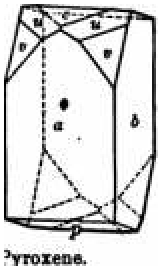
and 321,

321,

351.

The pyramids ma^ be unit pyramids, (hhl), orthopyramlds, (kkl) when A > A, or clinoppramtdg, {hM) when h < k. These correspond respectively to the three prisms already named. They are analogous also to the unit pyramids, macropyramids and brachypyramids of tlie orthorbombic system, and the explanation given on pp. 91, 92 should serve to make their relations clear. Bot it must oe rememoered that each general symbol embraces two forms, (hhl) and {hkl) with four faces each, as above explained.

4^



^^?K

"Mii^

188. Dluitrations.—Figs. 315-318 of pyroxene {^:h:i= 1-092:1:0-589, /3 ^ 74° = ac) show typical monoclinio forma. Fig. 315 shows the diametral

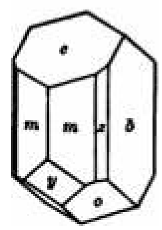
•This cliolce of Hlgns by Naiimann was unfortunate, being contrary to ordinary usage; It Is. linwever, too i;enenvlly iicceptod to admit ot being revereed. He was led to adopt it because the internal angle of the upper front edge between 001 and 100 is obtuse and hence tbe coalue {«.g. in the general cosine formula for the angle between two faces) is ntgatiM.

.dbyGooglc

prism. Of the otber forms, m is the unit prism (110); p (lOl) is an ortho-dome; u (111), V (221), 3 (111) are unit pyr&mids; for other figures see p. 387. Again, Figs. 3m-321 represent common crjstuls of orthoclase (d:i:i = 0-659;l:0-555, /J = 64" = ac). Here « (130) is a clinoprism; f(IOl) and y (301) are ortbodomes; n<031) is a cliodome; o(Ill) a unit pyramid. Since (Fig. 319) c and x happen to make nearly equal angles with the vertical edge of the prism m, the combination often stimuTiites an orthorhombic crystal.

Si

320.



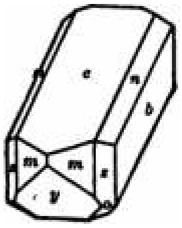
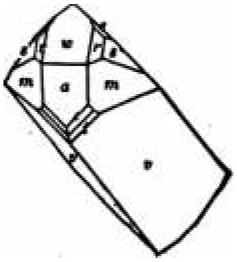
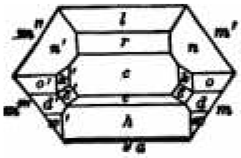


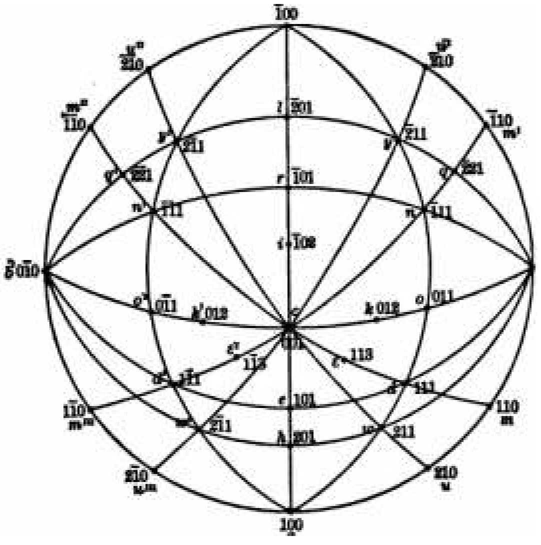
Fig. 333 shows a monoclinic crystal, epidote, prismatic in the direction of the ortho-axis; the forms are r (lOl) and n (111). Fig. 3'^3 of gypsnm is flattened | b; it shows tlie unit pyramid / (111) with the unit prism vi (1Io>. Fig. 334 of monazite is prismatic in habit by extension of the pyramid v (111). It shows also the orthodome w(lOl); the clinodome «(01I); the pyramiae r (HI), «(121), a (311), t (Sll).

^

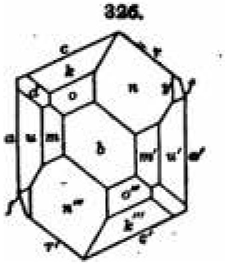


189. FmJMtioiu. —Fig. 325 shows a projection of a crystal of epidota (cf. Fig. 853, p. 43S) on a plane normal to the prismatic zone, and Fig. 326 one of a similar crystal on a plane parallel to b (010); both should be careftilly studied, as also the Bpherical projection of the same sjiecies. Fig, 327. Th* symbols of the prominent faces are given in Fig. 327.





326.



2. HEMIMOHPHIO GROUP (29).

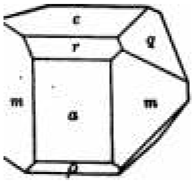
190. The monodinic-hemimorphic group is characterized by a single axis of binary Bymmetry, the CTystallographic axis %, but it has do plane of syni-metry. It is illuatrated by the spherical projection (Fig. 338); rIbo by Fig. 329, a commoQ form of tartaric acid; sugar crystals also belong here.

336.

/'

\.

J



Tarlaric Acid. Forms: f (101), fl(lOl), 5(011),

The hemimorphio character is distinctly shown in the distribution of the clinodomee and pyramids; corresponding to this the artificial salts belonging here often exhibit marked pyro-electricaj phenomena.

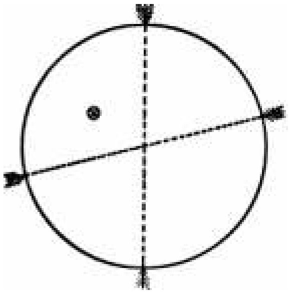
3. CLINOHEDRAL GROUP (30j. CLINOHEDRITE TYPE.

191. The monoclinic-elinokedrai group (the domatic oiasa of Grotb) is characterized by a single plane of symmetrj, parallel to the clino-piiiacoid, b (010), but it has no axis o(Bynimetry (cf. Fig. 330). In this group, ttiercfore, the forms parallel to the S-axis, viz., c

(001), a (100) and the orthoiloines, are represented by a single face only. The other forms hare each two faces, bot it is to be noted that, with the single exception of the clino-pinacoid b (010), the faces of a given form are never parallel to another. The name given to the group is based on this fact.

Several artificial salts belong hero in their crystallization, but the only ktiowti representative among minerals is the rare silicate, clinohedrite (Il.CaZnSiO,),* a complex crystal of which is shown in two positions in Figs. 331, 331«. As seen in those figures, the crystals of the group have a hemi-morphic aspect with respect to their development in the direction of the vortical axis, although they cannot properly be called hemimorphic since this is not an axis of symmetry. The forms shown in Figs. 331, 33la are iis follows: pinacoid, b (010); prisms, m (110), m, (!lo), h (320), n (120), I (130); orthodomes, fl (101), e, (lOl); pyramids, p (111), p, (III), q (III); r(53l), g, (551), t (?71), « (531), o (I31), X (i3l), y (i2l).

330. 831. 331a.



It is to be noted that crystals of the common species pyroxene {also of legirite and titanite) occasionally show this habit in the distribution of their faces, but it is not certain that this may not be accidental.f

Mathematical Rklatioss ov the Mosoclinic Sybtkii.

188. CholMof Aim.— Il is rept-nled here (Art, 181). thai tlie flued position of the plane of symmetrj eHtablishes the direclion of the axis b Biid tlie plane of llie axes li aitd i. The liKter axes, huwever, may hAve varying positions in tlii« plane ucLonling as lo which faces are rakeii as the pioacoids a auJ e, and which the unit pyi-amid. priam. or domes.

19S. AziU Md Anplu ElBmanti.—Tlie niial eUtnenU ai-e llie UngtAt of ihe axes d and ^ In terms of the udU axis b. That is, the axial ratio, with also Uie acute angle of tncllualion of Ibe axes i and h, called /9, Thus for ortboclaBe the axial elements are : d ; S :<! = 0B685: 1 : 0-5554 /S = 68* 56|'.

The aogukr eleroenlt are uaunlly taken as the angle (100 A 001) which Is equal to the aogle B: also the angles between \he three plnacolds 101), 010. Oul. reBpectiTely, aod the udU prism 110, the unit orthodome (191 or lOl) md the unit cIluodoDie Oil. Thus again for cnhoclase, the acigular elements ure :

001 A 100 = 68° 561'. 100 A tlO = 80' 861'.

001 A iOI = 50* ISf, 001 A on = 36° 31'.

ISl. The.malhemalicul relullous couuecliug nzial and augukr elements are as follows:

^^u,, (100 A 110) ^ ,.„ ,100 MIO) = «,*«;»; («

AafS

^^ I.. 1001 A Oil) ^ „„ (001 A Oil) = <..!«,!; (S)

Blu P

' = d.H-«) l7,. u(UOlAlOI) " •" <"" ■" """ = a+i.,0,11 - 1

, ».m (001 A 101) „ .„,^. . ,„,.._ <«l°)' I """

These relations may be made more geueml by writing la the several cases—

iii(l) JAOforllO and -Idford; in (2) OW for Oil and *ifori;

In (8) AOtforlOO and -ktoxt.

Also

h^ _ sin (001 A 10 1) _ sin (001 a lOl) d ~ sin (100 A lOi") ~ sill (l"00 A lOl)' and more generally

A k _ Bin (001 A A OQ _ sin (001 a ^Of) <i ■ 7 ~ sin (100 A m ~ Bin (100 A AOi)' Note also that ■ tnn 0 = (i and - tan Z = h

where 0 la Ibe angle (Fig. 82?) bt'lweeu the zoueclrcles (001,100} and (001,110); also C the angle between (lOO, 001)and<IOO. Oil).

All the above relations nre Important and should be thoroughly understood.

19fi. The probleniB which usiiiilly aiise have as their object either the deducing of the axial ettmeuia, the angle ff and the values of li and h In lerms of 6 (=1). from three measured iinfles, or Ihe flniKng of aoy reqiiii-ed inlerfacliil nuglus from Ihese elements or from the fuDdameiitiil angli:s.

The simple relations of the preceding nrlicle connect the angular and axial elements. and beyond this all ordinary pnibleins can be solved* either by the solulion of splieHcnl triangles on the sphere of projection, or by the uid of the cotangei:! (aniJ lungeut) relation.

It is to be noi«d, in the first place, that aW great circles on ihc splieie r>f projection {¥\g. 337) from 010 cut the zone circle 100, 001, 100 at right angles, but tliose from 100 cut Ihe zone ciiclcs 010, 001, OiO obliquely, as also those frouk 001 cutting the zone circle 100, 010, 100.

196. Tangent and Catangant Bclatloni.—The simple tangent relation holds good for sU zi'Bi* Fnmi OKI to any pole on the zone circle 100, 001, 100; in other words, for the prisms, r laxifonieB. and zones of pyramids in which the mlio ol h: I Is constant ifrom 001 to AOI OT lo M). Thus it is still true, as in the orthnrhombic system, that the tAngenIa of the angles

* The general formnlas. from which i1 is possible ti> calculate directly the angles between any lace and Ihe plnacolds, or the angle between any two faces whatever, are so complex as to Ite of little value.

.dbyGooglc

of tlie priBou 310, 110, ISO, 180 from 100 &re in tbe ratio of }: 1: 2^ 8, or, more geaemlly,

tfant

tail (100 AJU!o) _ * tnnfOlO Aft*o) _ h

tati(100 AllO)~A " taaiOlO AllO)"*'

Also [or the clinodomes the taugenls of tbe sugles of 012, Oil. 021 from 001 Hre fu Ihe ratio of 1:1 -.2, etc. A. similar reludon holds for the Uingeois of llie auglea of pTraDiJda In the zuuva mentiooed, as 131, 111. 312, etc.

For zones olhei tbao tliose meniiooed In the precftlitiK article, ns from UK) 1o a cliun-dome. or from 001 to a prism, the more general eolangeiU formula giveu in A.rl 47 must be employed. ThU relation la simplified for certain ctimitiun ui'ses.

For any zone sUirlitig from 001. aa tbe Koue 001, lOU, or OUl. 110, or 001. 810, elc; if two aoKlee are kDonn. viz., tbe angles between 001 and lliose two facen in tbe given zone wbicli fall (1) in tbe zone 010, 101, and (3) in tbe priamalic zone 010, 100; tlieu tSe angle batween 001 and any other face In Ihe giveu zone can be calculated. Thus.

Let 001 A 101 = PQ and 001 a 100 = PR. or " 001A1I1=PQ " 00lAlI0=PR, or ." 001 Aai2 = PQ " 001 A 210 = PR, et«.

Then for these, or any similar c zone (aa 201, or 221, or 421, etc.,

} Too. to 110, to SlO, etc., tlie expreaaion has Um

PQ = 001 A iOI. PR = 001 A iOO. PB = OOl A AOI, or 001 A in, etc.. 001 A UO, etc., 001 a 'M. etc

If, liowever, 100 Is the atartiog'polnt, and

100 A 101 = PQ, 100 A 001 = PR, or 100 A 111 = PQ. 100 A Oil = PR. elc, then the relation becomes

cot P8 - cot P R_ A cot PQ - col PR" (■

VI. TRICLINIC SYSTEM.

197. The Tricltnic Systeu includes all the forms which are referred to three anequal axes with all their ictersectiona oblique.

Tbe axes are here deeignated as iii the orthorliombio system, the letters nsed for the lateral axes i, B (or d, b), haviDg a short or long mark over them to indicate which is the shorter und which the longer axis. In the majority of cases, d is the brachy-axis and h the macro-axis. Bnt this is not invariably true; thus with rhodonite the ratio of d : S = lOTS : 1. The vertical axis is always designated by i. The angle between the axes h nnd i is called a, that between a and i is 0, and that between a and b ie y (Fig. 333).

It is to be noted that there is no necessary relation between tbe values of a, >3, and y, any one may be greater or less than 90°; this is determined by the choice of the fundamental forms.

-"-r

1. NOEMAL GEOUP (31). AXINITE TYPE.

188. Symmetry.—The normal group of the triclinio eyatein ie characterized by a center of symmetry, the point of interBection of the three axes, but there IB no plane aud no axis of symmetry.* This eym gja

metry is shown in the accompanying spherical pro a

jection (Fig. 332). ,.-—'-—-.,

199. Forms.—Each form of the group iocludeB v^

' two faces, pitrallel to one another and symmetrical y with reference to the center of symmetry. This ia / true as well of the form with the general symbol / (

{hkl) as of one of the special forms, as, for example, { the R-pinacoid (100), \ .-"

Hence, as shown in the following table, the four *'\, prismatic faces 110, IlO, IIO, llO include two forma, \ namely, 110, lIO, and 110, llo. The same ie true '-.,_

of the domes. Further, any eight corresponding pyramidal faces, as, for example. 111, 111, til, ill. Hi, III, III, III belong to four dietinct forms, namely, 111, III; TU, 111; Hi, III; ill. III, and similarly in general.

The TftriouB types of forma are given in the following table:

Hitler. Nnumana.

""piKd""} -I™) •«-«-' «P^.r«,«

Base or c-pinacold (001) 'x, tf: •n I: i OP or 0, c

„.. .^ j(110).'» Hzl-.o^i <BP'oTr,m

Macroprisms) ({kkO) 3:nl -.coi oo /"« or I'-w'

'* > ^) t (hhO) a-.-nh-.'^i -KThoT 'i-n

Brachyprisma) j (AAO) n^ : 5 : oo rf oo Pn or i-»

'*<*)] {/ikO) ni-.h-.'xi ccPnori-n

Macrodom„ 1 jS " i'^'i"^, .»'P'« or W

((hOl) —d:<x>h:mi m^P.-n or ,m.V

Brachydomes iLin » i i , t.

{(Okt) a:>d: — h:mi 'mPas or tn-l

{{hhl) a:b:mc mP' or «t'

(hhl) ~a:h:mc m^P or ,m

(hhl) -a-.-btmc mP, or m,

(hhl) a:-b:mc m'Por'm

{{hkl) S mh: m6 mP'n or w-w'

(hki) -£:nh:mi mJ'H or ,v>-n

(hkl) -S:-nh:m6 mP/i or m-n,

{Ji'kl) (i : —ni:mi m^Pn or '«i-5

* On llie »tber metbed nf viewing tlie symmelry here described, see An. 17. p. 10. \ In tlie dbove table It is awiimml tbat Ihe ftxial raltii iaA:t:k. If h-tieTe a-.l^:i. tbfr n:int<'>. Iiracby- aud macro- would be excbanged, ami also tbe long nod short miirk!i in tbe NftkiTnann eymbols. The use of acceats Co distiuguisb priams, domes, and pyramids accord-iug to their poattton Is to be noted.

CBT8IAU.0QBAPHT.

Brachypjr&midB)

1 (*«)

■ 1 (Mi)

I. ("0

m£ : S : rru!

: — b imi

— himi m'J'

mP'n or m-fi' tn^Fn or ,»»-«

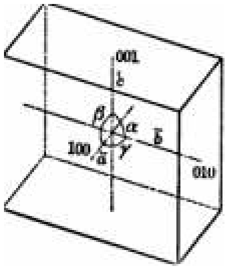
200. The explanations given under the two preceding sjatemB make it unnecessary to discusa in detail the various forma individually, except as 333. illustrated in the case of crystals belouging to cenain

typical triclinic species.

It may be mentioned, however, that Fig. 333 shows the diametral prism, which is bounded by three sets o(unlike faces, the pinacoids a, b, and c. This is the analogue of the cube of the isometric system, but here the like faces, edges, and solid angles include only a given face, edge aud angle, and that opposite to it.

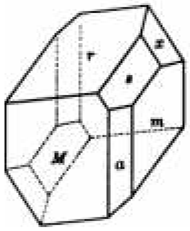
201. Illnitrationi. —A typical triclinic crystal is shown in Fig. 334 of aiinite, already introduced._ Here a (H;0) is the macropinacoid; m (110) and .¥(110) the two unit prisms; s {'iO\) a macrodome, and x (111) and r (ill) two unit pyramids. The axial ratio is as

follows: 1 : 0-48, a = 82° 54', /3 = 91" 52', y = 131° 32'. Figs. 335, 336 show two crystals of rhodonite, a species which is allied to pyroxene, and which approximates to it in angle and habit. Here the faces

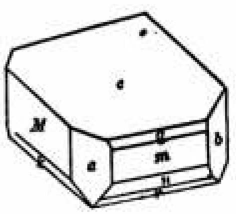


= 0'49 ;

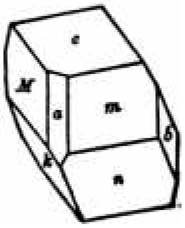
334.



335.

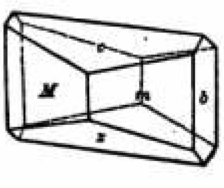


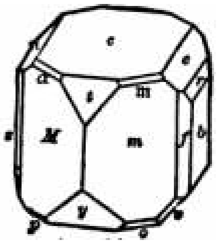
336.



are: Pinacoids a (100), b (010), c (001); prisms m (110), M (llo); pyramids y (221), t (321), » (331), r (111).

Further illustrations are given by Fig. 337 of albtte and Fig. 338 of anor-thite. Thesymbolsof the faces, besides the pinacoids and the unit prisms, are as follows: Fig. 337, X (lOl); Fig. 338, prisms / (130), z (130); domes ((307), y (201), e (021), r (06]),M(05r pyramids m'(lll), a (ill' o(!Il),p(5U). In Fig. 338 of anortbite the similanty of the crystal to one of orthoclase is evident on slight examination (cf. Figs. 319, 320), and careful study with the measurement of angles shows that the correspondence is verj



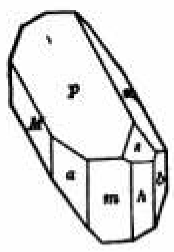


TBIOLINIC BTBTEU.

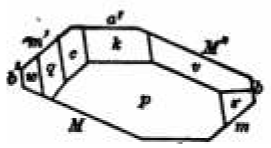
close. Hence in this case tbe choice of the fundamental planes is readily made.

Fig. 339 represents a crystal (artifloial) of blue vitriol, the mineral cbal-

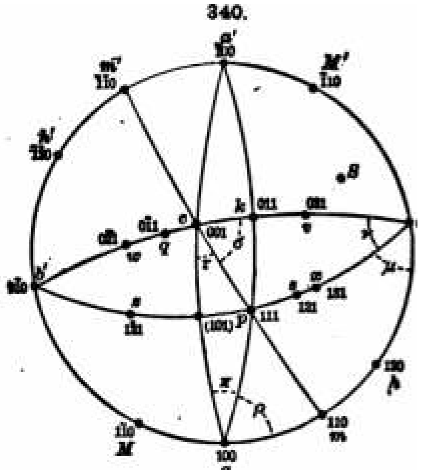
339.



339a.



340.



canthite; Fig. 339it gives a projection on a zone normal to the prisms, and Fig. 340 a spherical projection. The last figure also shows the STmhols of the different faces-

2. ASYMMETRIC GROUP (32).

202. Besides the normal group of the triclinic system there is another possible group, possessing symmetry neither with respect to a plane, axis nor center; in it a given form has oite face only. Tliis group, the asymmetric class of Groth, finds eicamples among a niimbpi' of artificial salts. One of these is calcium thiosiiiphate (CaS,o,. 6H o); as yet no mineral species is known to be included here. This Is the most general of all the thirty-two types of forms classified according to their symmetry and comes first, therefore, if the groups are iirranged in order according to tbe degreeof symmetry characterizing tbem. This group is one of those whose crystals may show circular polarization. This ia true of eleven of the groups which have been described in the preceding pages.

Mathematical Rblationb op tbk TatcLtNio Stbtbh.

SOS. OlioiM of AzM.—It U obvjouE, from wliat)ins beeu said m to Ibe symmetry of this Bystf^m. lljHt ang three fnces uf a trldinlc ciysial may be chostu as Ihc piDocolds. or Ihe faces wliicli lit the posiiion of Ihe aiiiil pliiiies ntid tlie directions of tlie aiea; moreover, there U n like llberly tn tbe cboice of tbe unit prisma, domes or pyramids which further flz the lengths of the axes.

Wbeo Uie C178IBI ia baod 1b ftliled Id form or compoeltlon to otber Epeclet sfUecIM of the stinio or (lifiereut ByHtisma, this fact bhiiplifles Ihe problem unci makes tbe uculcu 01 .he fuudnmealBl Tciraia eauf. 1'lils Is well iltuetraltd, as already uoted, by llie trlcliuic feldBiurB (e.g.. ulbiie iio.l aiiortliite. Figa. 837, 8B8j wbich are uear in Bugle to tbe allied mohoclioic spedeB urtbucloM. KbodunUe (Figs. iiSS, iiStt), ihe iiiclioic member of Ibe pyroieuo gmu]), ia iiuuiber good example.

lu oHiii- caatB, wLere 110 aucb relationship eiials, and wbere varied habit makes difleteni urifnlaiions plausible, Ibere is but little lo guide tlje choice. This ia illuslrated iJi lUe CB'jt! of axiuite ^Flg. »84), wbero at least tec dlsiinct posiiioDS have been assumed by diltereut auLiiora.

SM. Aslkl and Angular Elamanti.—Tbe aaini eUvuntt of a tridlnic crystnl are: (1) the axial t-atio, wliicb expresses tbe leugtbs of Ibt axes a aod i in tenns of the tbiid axis. 6 ; And (2) Ihe auglea between tbe axes a. ff, y {Fig. 838). There are here fl»e quaDtitles to be determined wbich obviously require the meaaurenieut of Ave ludepeudeul augles betweea Ihe Isces.

The anguiav elemenli are usuallT taken as the anc «(iditioD, those between each piuauoid aud the unit u pinacoldsi that is,

Ob. 100 A 010, ac. 100 A 001, be. 010 A 001; also

am 100 A 110. 001 A 101, 001 A Oil;

or, iostead, any one or all of these,

oJf. 100 A liO, 001 A iOl, 001 A Oil.

01 these six angles taken, one Is delennined when the others are known.

SOS. The mHthematlcal relations existing between tbe axial angles and axfa1 ratio, on th« one band, and tbe angles between the facet on the other, admit of being dnwii out with great completeness, but they are neces-iarlly complex and in (irnend have liltle practical value. In Tnct. most of tbe problems likely 10 arise ciiu be solved by means of ibe tilangles of tbe spherical projectioD. together wiib the cotangent foininia conuecMng four planes in the Mine zone (Art. 47. p. 311; tbis will often lie laborious and may require some iogenully, but in general Involves no serious difflculty.]n connection 'niib tbe u^e of the cotangent formubi. it is lo be noted IbKt in cerinbi commonly occurring cases its form la much 'almpllfled; some of these have already been eipbnned under ibe mouocllulc system <Art. 106). The formulas giv^n tbere ure of course equally applicnble here.

206. Tbe Brat problem may be to Qud Ibe axiul elements from measured angles. Since these e'cments include five unknown quautilies. viz.. the three nxinl nnglesit, fl, y and tbe lengths of the axea a and i iu terms of b. five measured anglea are required, us ulieudy «taled.

These anglea, by use of three or more spherical trinngles. will serve to sive tbe angles (see Pig. 840) Jt, (>. fi, V, z, o-(or the coiTesponding angles n", o', etc., in tbe adjacent quadmuts). Tbe ratio of tbe slues of each pair of Uiene angles Hies the rntlos of the corresponding axes (see'.below). Tbe full axial ratio mity be obtained fmni any two pairs and the ibira ratio Mrres as a check upon tbe results given by the other two.

The simple formulas required are ;

slo r _ sin r' _ T sin »- _ sin f' _ i sin jr _ ain i* _ i sin <r ~ sin er*"" i ' sin /j ~ sin/i' ~ a' &\t\ p ~ sin p' ~ b'

If the correaponding angles for tbe general case are given (not those of the unit zones), th« rel lit Ions are similar. Tliat Is, if for Ibe face UI the correspondlag angles be represented bj r,. (T,, etc., where ro, <70 are tbe angles between tbe zone circles 100, 001 and 100. 010 respectively and the zone circle 001. hkO (and similarly for rt, cr, in Ihe adjacent quadrant, also similarly r,, /i*. etc.), these relations may be expressed In the general form

sin r. Bin r,' a k a

.dbyGooglc

lliuB for the face 821 the formulu become

dn r. _ a _ 8 » atn »-. _ 8^ aln it. _ 2i Biu 71 ~ |i ~ B t' alu fit °' ^io ftt i' It is also to be noted that

a = 180* - 4. /S = 180* - B. r = 180* - C,

wliere ^, A 0 »ie the angles in the pluacoldal tpberical Iriitpgle 100-010-00' ^t tlteae poles reapectivelj. Tbat Is,

A = M-\-p = i. + p. = {180' - a);

B=y + M = "< + M. = (180* - 0t;

0 = T+<T=i, + <T, = <180* - y). Alw)

180' - ,A = iC + / = ».' + P.' = n.

HeDce. bavlnr given, by mensurement or calcuUifon, (lie angles between the fare* ai ilOO A 010), ac (100 A 001) imd be (010 a 001), which are the sides of tlils triauKle the angles A, B, C nre calculated and their supplenients are the axial angles a, fi y reaped I vely.

Still nnoCber series of equations are those below, whlcli give tbe relations of the angles l>, r, p, etc., to tbe axes and axini angles. By means of them, with Ihe sine fonnutas given above, tbe angular elements (and other angles) can be calculated from the axial elements.

These equaUons apply when u + y, etc,, Is less than 90'; if tlieir sum Is greater than M° the dzn In the denominator is negntlve.

807. Tlie following equstiona are also often useful; they give the relations between the

angles a, ft, y, and the angles)j, v, etc., already defined.

_ 3 Bin /> rin fl' ~* sin (p — p') '

sin (M -Sstn rf

a + M + p = ft-i.fi + r = y + r + iT = 18o*.

The calcnlatloo. from tbe angular elements or from the aaaiimeri (iiDdamental measnred angles, ellber (1) of the nngakr poellton of any fare whose symbol Is given, or (2) i>r tbe symbol of an unknown face for wh'ch messured anglei are at hand, requires no further explanation. Tbe rotangeiiL formula is all Ibat Is needed In a single zone, and the solution of spherical triangles on the pmjeciton (with the use of the sine formulas) will suffice In addition In all ordinary cases.

MEASUREMENT OF THE ANGLES OF CRYSTALS.

208. Band-Ooniometers.—Tbe ititerfacial angles of crystals are measured by means of iostrumeiite which are culled t/vniometers.

The simpiest form is the hand-goniometer, represented in Fig. 343. It consists of an arc, graduated to lialt-degreea or finer, and two movable arms. In the instrument figured, one of the arms, ab, has the motion forward

343·

and backward by means of slits gh, ik; the other arm, cd, has also a similar slit, and in addition it turns around the center of the arc as an axis, ^he faces whose inclination is to be measured are applied between the arms ao, co, and the latter adjusted so that they and the surfaces are in close contact; further, the a/ms must be exactly at right angles to the iutersecfcion-edge. This adjustment must be made with care, and when the instrument is held up to the light none must pass through between the arm and th« f;tcp. Tbe number of degrees read off on the arc between k and the left edge of d (this edge being in tlic line of the center, o, of the arc) is the angle refpnired. 'I'lie motion to and fro by means of the slits is for the sake of convenience in measuring small or embedded crystals. In a better form of the instrument the arms are wholly separated from the arc; and the arc is a delicately graduated circle to which the arms are adjusted after the measurement.

The hand-goniometer is nseful in the case of large crystals and those w!io8e faces are not well polished; the measurements with it, however, are seldom accurate within a quarter of a degree. In the finest specimens of crystals, where the faces are smooth and lustrous, results far more accurate may be obtained by means of a different instrument, called the reflecting goniometer.

209. Reflecting Goniometer.—This instrument, devised by Wollaston (1809), has been much improved in its various parts since his time by Mitscherlich and others. The principle on which it is constructed may be understood by

reference to the following figure (Fig. 343], which represents the section of a crystal, whose angle, abc, between the faces ab, bc, is required.

The eye at P, looking at the face of the crystal, bc, observes a reflected image of m, in the direction of Pn. The crystal may now be so changed in its position that the same image is seen reflected by the next face and in the same direction, Pn, To effect this, the crystal must be turned around, until abd has the present direction of bc. The angle dOc measures, therefore, the number of degrees through which the crystal must be turned; it may be measured by attaching the crystal to a graduated circle, which turns with the crystal. This angle is the supplement of the interior angle between the two faces, or in other words is the normal angle, or angle between the two poles (see Art, 41, p. 28). The reflecting goniometer hence gives directly the angle needed on the system of Miller here followed.

Many different forms of reflecting goniometer of simple type are in use. The accompanying figure (Fig. 34-1) will suffice to make clear the general character of the instrument, as well as to exhibit some of the refinements added for the sake of greater exactness of measurement.

The circle, C, is graduated, in this case, to twenty minutes, and by means of the vernier at v the readings may be made to minutes and half-minutes. The crystal is attached by means of wax to the little plate at k; this may be removed for convenience, but in its final position it is, as here, at the extremity of the axis of the instrument. This axis is moved by means of the wheel, m; the graduated circle is moved by the wheel, m. These motions are so arranged that the motion of n is independent, its axis being within the other, while on the other hand the revolution of m moves both the circle and the axis to which the crystal is attached. This arrangement is essential for convenience in the use of the instrument, as will be seen in the course of the following explanation. The screws, c, d, are for the adjustment of the crystal, and the slides, a, b, serve to center it.

The method of procedure is briefly as follows: The crystal is attached by means of suitable wax at k, and adjusted by the hand so that the direction of the combination-edge of the two faces to be measured coincides with the axis of the instrument; the wheel, n, is turned until an object {e.g., a window-bar) reflected in one face is seen to coincide with another object not reflected {e.g., a chalk-line on the floor); the position of the graduated circle is observed, and then both crystal and circle revolved together by means of the wheel, m, till the same reflected object now seen in the second face again coincides with the fixed object (that is, the chalk-line); the angle through which the circle has been moved, as read off by means of the vernier, is the normal angle between the two faces.

In order to secure accuracy, several conditions must be fulfilled, of which the following are the most important:

1. The position of the eye of the observer must remain perfectly stationary.

2- The object reflected and that with which it is brought in coincidence should be at an equal distance from the instrument, and this distance should not be too small.

3. The crystal must be accurately adjusted; this condition is satisfied when the line seen reflected in the case of each face and that seen directly with which it is in coincidence are horizontal and parallel. It can be true only when the intersection-edge of the two faces measured is exactly in the direction

of the axis of the instrument, and perpendicular to the plane of the circle. The adjustment is accomplished roughly by the hand and accurately by the screws c and tl.

4. The crystal must be centered as nearly as possible, or, in other words, the same intersection-edge must coincide with a line drawn through the

8*4.

revolving axis. This condition will be seen to be distinct from the preceding, which required only that the two directions should be the same The error arising when this condition is not satisfied diminishes as the object reflected is removed farther from the instrument, and becomes zero if the object is at an infinite distance. In the centering of the crystal the slides a and b are employed.

The first and second conditions are both satisfactorily fulfilled by the use

of a telescope, as t (Fig. 344), with slight magnifying power. This is arranged for parallel light, and provided with a hair-cross in its focus. It admits also of some adjustments, as seen in the figure, but when used it must be directed exactly toward the axis of the goniometer. This telescope has also a little magDifying-glass {g) attached to it, which allows of the crjBtal itself being seen when mounteil at k. This latter is used for th« firabadiuatowBtaafL.Uie crystal, and then dipped aside, when some dietaut object which nos been selected must be seen in the field of the telescope as reBected, first by the one face and then by the other as the wheel h is revolved. When the final adjustments have been made so that in each case tbe object coincides with the center of the hair-cross of the telescope, and when further the edge to be measured has beeo centered, the crystal is ready for nieaanrement.

This telescope, obviously, can be used only when the face is smooth and large enough to give distinct and brilliiint reflections.* In many cases safficient accuracy is obtained without it by the use of a window-bar and a white chalk-line on the floor below for the two objects; tbe instrument in this case is placed at the opposite end of the room, with its axis parallel to the window; the eye is brouglit very close to the crystal and held motionless during the measurement.

The best instruments are provided with two telescopes. The second stands opi)Osite the telescope, i (see figure^, the centers of both telescopes being in tbe same plane perpendicular to the axis of the instrument. This second telescope has also a hair-cross in tbe focus, and this when illuciiuated by a brilliant gaa-buruer {the rest of the instrument being protected from the light by a screen) will be reflected in the successive faces of the crystal. The reflected cross is brought in coincidence with the cross in tbe flrst telescope, flrst for one and then for the other face. As the lineg are delicate, and as exact coincidence can take place only after perfect adjustment, it is evident that a high degree of accuracy is possible. Still more than before, however, are well-polished crystals required, so that in many cases the use of the ordinary double telescopes is impossible. Yery often the hair-cross of the second telescope may be advantageously replaced by a bright hue or cross, the light shining through a cross cut in tin-foil (Schraiif), or as given by the analogous Websky signal. This light-signal is visible in the first telescope even when the planes are extremely minute, or, on the other hand, somewhat rough and uneven; even if the image is not perfectly distinct, it may be sufficiently so to admit ol fairly good measnremeuts (e.g., within two or three minutes).

210. Horizontal Ooniometer.—A form of reflecting goniometer well adapted foraccnrate measurements is shown in Fig. 34f. It is made on the B«binet type, with a horizontal graduated circle; the instruments of the Mitacherlich type, jnat described, having a vertical circle. The horizontal circle has many a'd vantages, especially when it is desired to measure the angles of large crystals

* Wben pinnea are roiiKh and destitute of luster thi- anf^les can orten best be obtained hy use nf & can die-flame, the diffuse reflectina of whtrb In the given face Inkea the place of more distinct imnges. For embedded crystnla, nnd often fii other casee. measuremeuta may be »i-rv adsBrinpeiusly made from impressions In some maierial. like sealiuB-wax. Angles ■ tbiis nhlained ought to be accurate within one degree, or even lefs, and suffice

for many purpose*. It is sometimes of aiivniitnpp to altacb to the planes to be monsiired. wlion quite rough, fraicment^ of ihtn glnw, from whicli reflections can be obtained; this must, however, he clone with cnre. to avoid coDsidrralile error. OccasI'mally dusting the surface with graplille makes a " sidmme'-" mensiiiri'ini.'iit with the caudfe-flame poasible, or, again, cuVL-rlog It wtlfa a thin film of gum arable.

or those which are attached to the rock. Thiii particular form of instrameot hfere figured* is made hy R, Fuess in Berlin.

The instrnmeDt stands on a tripod with leveliug screws. The central axis, o, bae within it a hollow axis, b, with which turns the plate, d, carrying the verniers and also the observing telescope, the upright support of which is shown at B. Within A is a second hollow axis, e, which carries the graduated circle,/, above, and which is turned by theecrew-head, ^; the tangent screw, or, serves as a fine adjustment for the observing telescope, B, the screw, c, being for this purpose raised so as to bind b and e together. The tangent screw, p, is a fine adjustment for the graduated circle. Again, within e is the third axis, h, turned by the screw-head, t, and within h is the central rod, which carries the support for the crystal, with the adjusting and centering contrivances mentioned below. This rod can be raised or lowered by the screw, k.

80 as to bring the crystal to the proper height—that is, up to the axis of the telescope; when this has been accomplished, the clamp at p, turned by a set-key, binds s to the axis, h. The movement of h can take place independently of g, but after the crystal is ready for measurement these two axes are bound together by the seI screw, /. The signal telescope is supported at C, firmly attached to one of the legs of the tripod. The crystal is mounted on the plate, w, with wax, the plate is clamped by the screw, v. The centering apparatus consists of two slides at right angles to each other (one of these is shown in the figure) and the screw, a, whicn works it; the end of the other corresponding screw is seen at a'. The ailjusling arrangement consists of two cylindrical sections, one of them, r, shown in the figure, the other is at r'; the cylinders have a common center.

* Tbe figutv hem used la from the catalogue of Fueu.

The circle is gradnated to degrees and quarter degi^eB, and the vernier gives the readinzs to 30", but by estimate tbey can be obtained to 10". The eignals provided are four in number, eacb in its own tube, to be inserted benind toe collimator lens; these are: (1) the ordinary telescope witb the hair-cross, to be used in the case of the most perfect faces; (3) the commonly nsed signal, proposed by Websky, canBisting of two small opaque circles, whose distance apart can be adjusted by a screw between them; the light passing between these circles enters the tube in a form resembling a double concave lena; also (3) an adjustable slit; and, finally, (4) a tube with a single round opening, very small. Thei'e are four observing telescopes of different angular breadth of field and magnifying power, and hence suitable for faces varying in size and in degree of polisn.

'The methods to be empluyi'd, both in making the preliminary adjustments required by every instrument bi-fore it can be used and in the actual measurement of the angleB of crjBtuIa, have been described by Websky • with a fullness and clearness which leave nothing to be desired, and reference must be here mSde to his memoir,

211. Tbeidclite-Ooniometer.—A form of goniometer f having many practical advantages has two independent circles; it can be used in a manner analogous to that of the ordinary theodolite, as will appear below. Instruments of this type have been devised indnpendently by Fedorow, Czapaki, aud Goldschmidt. In addition to the usual graduated horizontal circle of Fig. 346, and the two accompanying telescopes, a second graduated circle is added which revolves in a plane at ri?ut angles to the first; to the latter the crystal to be measured is attached, witli the addition of suitable adjusting and centering contrivances.

By this iRBtrnment, instead of the interfacial angles being measured directly, the position of each face is determined independently of others by the measurement of its angular co-ordinates. These co-ordinates are the angles (tp and p of Goldschmidt) measured, respectively, in the vertical and horizontal circles from an assumed pole and meridian, which are fixed, in most cascB, by the symmetry of the crystal. In practice the crystal is usually so mounted that the prismatic zone is perpendicular to the vertical circle and a pinacoid in this zone is the zero point. For example, with an orthorliombic crystal, for the face 111, the angle <p is equal to 010 A 110 and o to 001 A HI for the given species. Goldschmidt has shown that this instmment is directly applicable to the system of indices and methods of calculation and projection adopted by him, which admit of the deducing of the elements and symhols of a given crystal with a minimum of labor and calcnlation.i Fedorow has also shown that this instmrnent, with the addition of the appliances devised by him, can be most conveniently used in the crystallographic and optical study of crystals.

•See Webiky. Zs Kryat,, 3, 341. 1879: 4, M5. 1880; also Lfeblscb. Bericht Ober rile wl3«<fnBchsftl)chen iDBinimeDte nuf der Berliner OewerbeausatellutiK in Jabre 1879, pp. SSn-883

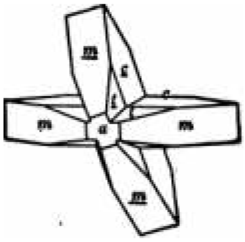
tFedorow, Universal or Theodolit Gntifometer. Zs. Kryst., 21, 574, 1898: 23, S29, 1893: CMp«ki, Zeltschr. f. Instnimprtenltiinde, 1. 1898; Goldschmidt. Zb. Kryst., 21, 310, 1893; 34. 810. 1895: 36, 821, 538. 18B6. On the method of Ooldsrhmldt. we Pslnche, Am. J. Be.. 3, 27S. 189ft. A simnllSed form of the theodolite-goniometer Is deBciibed bv StQbpr, Ze. Ervnt., 39, 3R, 1897.

t Gnldacliin'ldt'i! latent cnDtrlbiillnn to (his subject fa his work, KrysUtlOfrnphfsche

Wlnkeltnbpllen f489 pp.. Bfriin. ISHT). This glvea the angles required by bis system for Mil knowD species. See also Zs. Kryat.. 39, Ml, 1898.

COMPOUND OR TWIN CRYSTALS.

218. Twis Cryitals.—Tvin crystals are those in which one or more part^ regularly arranged are in reverse position with reference to the other part oi-parts. They often appear externally to consiat of tvo or more cryBtuls symmetricallT united, and sometimes have the form of a cross or star. They also exhibit the composition in the reversed arrangement of part of the faces.



ThensnlUe;

Cbftl Bzlt«.

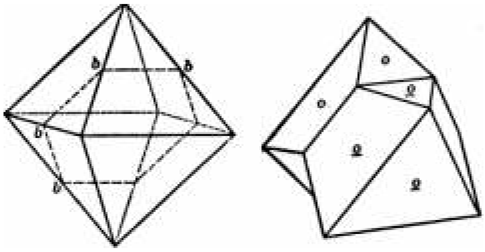
340.

in the strife of the surface, and in re-entering angles; in certain cases the compound structure can only be enrely detected by an eiamination in polarized light. The aboYe figures (Figs. 346-348) are examples of typical kinds of twin ci^stals, and many others are given on the pages following.

To illustrate the relation of the parts in a twin crystal, Figs. 349, 350 are "" given. Fig. 349 shows a regular

octahedron divided into two halves by a plane parallel to an octabedal face. If now the lower half be supposed to be revolved 180° about an axis normal to this plane, the twinned octahedron of Fig. 350 resnltB. This is a common type of twin in the ii>ometric system, and the method here employed to describe the position of the parts of the crystal to one another is applicable to nearly all twine. 213. It is important to understand that crystals, or parts of crystals, so grouped as to occupy parallel positions with reference to eacii otlier—that is, those whose similar faces are parallel—are not called twins; the term is applied only where the crystals or parts of them are united in their reversed position in accordance with some deducible mathematical law. Thus Fig, 3^1, which represents a cinater of partial crystals of analcite, is said to be a ciise of parnllel grouping simply (see

Art. 231); but Fig. 369 illustrates twinning, and this is true of Fig. 378 also. Since though in these cases the axes remain parallel the similar faces (and planes of symmetry) are reversed in position.



214. Twinnlng-azli. —The relative poaition of the parts of a twinned crystal can be beet described ae just explaiued, by reference to that line or axia called the twinning-aHs, a revolution of 180° about ^^^

which would serve to bring the twinned part parallel to the other, or in other words, which would cause one of the parallel parts to take a twinned position relatively to the other.

The twinning-azia is always a po^ible crystalline tine—that is, either a crystallographic asis or the normal to some possible face on the crystal, usually one of the common fundamental forms.

It is not to be supposed that ordinary twins have actually been formed by such a revolution of the parts of crystals, for all twins (except those of secondary Auslciie.

origin, see Art. 221) are the resnlt of regular molecnlar

growth or enlargement, like that of the simple crystal. This reference to a revofuiion, and an axia of revolution, is only a convenient means of describing the forms.

In certain rare cases, particularly of certain pseudo-hexagonal species, a revolution of 60° or 120° about a normal to the base has been assumed to explain the complex group observed,

215. Twinning-pkue. —The plane normal to the axis of revolution is called the twinning-plane. The axis and plane of twinning bear the same relation to both individuals in their reversed position; consequently, in the majority of cases the twinned crystals are symmetrical with reference to the twinning-plane.

The twinning-plane is, with rare exceptions, parallel to a possible occurring face on the given species, and usually one of the more frequent orfundamentd forms. The exceptions occur only in the tricliuic and monoclinic systems, where the twinning-axis is sometimes one of the oblique crystallographic axes, and then the plane of twinning normal to it is obviously not necessarily a crystallographic plane; this is conspicuously true in albite.

216. CotDpOiition-plane,—The plnne by which the reversed crystals are united is the composition~p!nne. This and the twinning-plane very commonly coincide; this is true of the simple example given above {Fig. 350), where the plane about which the revolution may be conceived to take place (normal to the twinning-axis) and the plane by which the aemi-iiulividuals are united are identical. When not coinciding, the two planes are generallv at right angles to each other—that is, the composition-plane is parallel to the axis of revolution. Examples of this are given beyond. Still again, wliere the crystals are not regnlarly developed, and where they interpenetrate, the contact surface may be interrupted, or may be exceedingly irregular. In such cases the axis and plane of twinning have, as always, a 'definite position, but the composition-plane loses its significance.

Thus in quartz twine the interpenetrating parts have often no rectilinear boundary, bnt mitigie in the most i.rregular manner throughout t!ie mass, showing this composite irregularity by abrupt variations in the character of the surfaces. This irregular internal structure, found in many quartz crystals, even the common kinds, is well brought out by means of polarized light; also by etching with hydrofluoric acid.

The com position-plane has sometimes a more definite signification than the twinning-plane. This is due to the fact that in many cases, whereas the former

is fixed, the twionin^-aziB (and twioning-plaiie) may be exchanged for another line (and plane) at ngbt angles to each, respectively; since a revolution about 362. the second axis will also satisfy the conditions of producing the

required form. An example of this is furnished by Fig. 352, of orthoclase; the composition-plane is here fixed—namely, parallel to the crystal face, b (010). But the axis of revolution may be either (1) parallel to this face and normal to a (100), which is then coDse(]uently the twinning-plane, though the axis does not coincide with the crystallograpnic axis; or (2) the twinning-aiis may be taken as coiuciding with the vertical axis, and then the twinning-plane normal to it is not a crystallographic face. In other simpler cases, also, the same principle holds good, generally in consequence of the possible mutual interchange of the planes of twinning and composition. In most cases the true twinning-plane is evident, since it is parallel to some face on the crystal of simple mathematical ratio.

317. ka Intereallng example of llie possible clioice between two twiuniag-axei at right angles to ench other is fiiniisbed by tbe ipecfea st&iiroUte. Fig. 400 abows a piismiilic

twla . from FanDin Oo., Ga, The measured angle for U was 70° 30'. The twianing-aiis deUuced from this maj be normnl to the face (230), whicli would then bo the twinning-plane. Or, iDBtend of lliia nxis, Its coDiplementiiry aiis at right angles to it may be taken, which woii]d equally well produce the observed form. Now In tliia Bpecies it happens that the fnceg, 180 and 230 (over 100), are almost exactly at right angles with each other, and. according to the latter supposition, IHO becomes the twiuuing-plaue. and the axis of revolution is normal to it. Hence, either 230 or 130 may be (be twinning-plsue, either supposition agreeing closely with the measured angle (which could noC be obtained with great accuracy). The former method of twinning (tw. pi. 230) conforms lo the oilier twins observed on tbe species, and hence it may be accepted. What is true in this cnse, however, ia not always true, for it -will seldom happen tliat of the two complementary axes each fs so nearly normal to a face of the crystal. In most cases one of tbe two axes conforms to the law in being a normal to s possible face, aad the other does not, and hence there is no doubt as to which fa the

Another intereatinff case ia that furnished by coliimbile. The common twins of the species are similar to Fig. 347, p. 118, and have «(021) as the twinning-plane; but twins also occur like Fig. 404, p. 12S, where the twinoJng-plane is q (028). The two faces. 031 and 023. are nearly at right angles to each other, but the measured angles are in this case aufflci^Dtly exact to prove that tbe two kiads cauuot be referred to one and the same Inw.

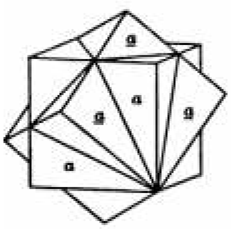
218. Contact- and Fenetration-twiiu.—In contact-twins, when normally formed, the two halves are simply connate, being united to each other by the composition-plane; they are illustrated by Figs. 347, 350, etc. In actually occurring crystals the two parts are seldom symmetrical, as demanded by theory, but one may preponderate to a greater or less extent over the other; in some cases only a small portion of the second individual in the reversed position may exist. Very great irregularities are observed in nature in this respect. Moreover, the re-entering angles are often obliterated by the abnormal developments of one or other of the parts, and often only an indistinct line on some of the faces marks the division between the two individuals.

Penetration-twins are those in which two or more complete crystals interpenetrate, as it were crossing through each other, formally, the crystals have a common center, which is tne center of t)ie axial system for both; practically, however, as in contact-twins, great irregularities occur.

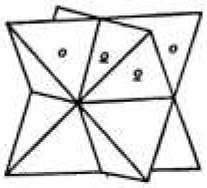
Examples of twins of this second kind are given in the annexed figures. Fig. 353 of fiuorite. Fig. 354 of tetrahedrite, and Fig. 355 of chabazite. Other examples occur in the pages following, as, for instance, of the species staurolite (Figs. 408-411), the crystals of which sometimes occur in nature with almost the perfect symmetry demanded by theory. It is obvious that the distinction

between contact- and penetration-tvins is not of great importance, and the line cannot ^waye be clearly drawn between them.

353.



354.



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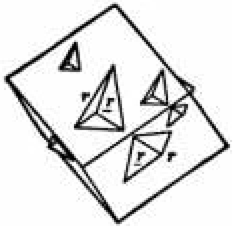
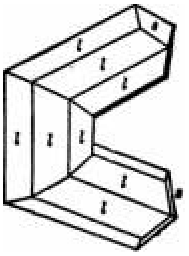


Flnorite.

Tetmhedrite.

Cbabozite.

■IB. PangndB and MaUganis Tvtni.-



Butile.

—TLe di«tiDctioD of pamgeDlc and metagealc twins . slallogniplij-. Yet tbe toiaw are otieu so obviously

e dislinction is iiiiportaiit.

In ordinary twins, the compound structure hud its beginning Id "°-

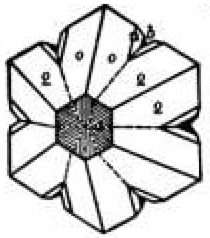
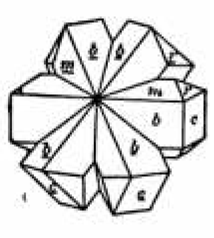
> nucleal compound molecule, or was compound In Its very oririu; and whatever mequulitics In tbe result, tbese art only liregularitiet in tbe development from such & nucleus. But In olliei-s, ilie cryaml wuat flret simple; aod afierwarda, thruugli some change In llseir -in the C'indillon nf the material niippljed tor its IncreaM, recei new lnyers, or n coDtioviatlon. in a reversed position. This mode of (wionlDg is metageitie, or a result subsequent to the erigiD of the crj-atal; wliile tbe ordinary mode is paragenie. One form o(it Is illustnited in Fig. SS6. The middle portion had nttaiued n length of half an inch or more, and Iben became genlculated almultaDeously at either extremity. These geniculatlons are often repeated In rutile, ▪nd tbe ends of the crystal are thus lient Into one another, and occasionally produce nearly regulnr prismatic forms.

This metagenic twinniugis sometimes pri^sented by the successive Inyereof deposition In acrysiiil, as In some quartz crystals, especially smelliyst, the Insepanible layers, exceedingly tliin, being of opposite binds. In a similar mnnner, crystals of tbe Iriclluic feldspars, alblle. elc, are often made up of tbin plates ^Diinllel to b (010), by oscillatory cumposlllou, and tbe face c (001), accordingly, is finely striiitt^i parallel to the ed^e e, b.

220. Repeated Twinning, Polyaynthetio and SymmetricaL—In the preceding paragraph one case of repeated twinning haa been mentioned, that of the feldspars; it is a case of parallel repetition or parallel grouping in reversed position of Buttceaaive crystalline lamelles. This kind of twinning is often called polt/-synthetic twinning, the laniellte in many cases being extremely thin, and giving rise to a series of parallel lines (atriations) on a crystal face or a surface of cleavage. The triclinic feldspars show in many cases polysynthetic twinning and not infrequently on both c (001) and b (010), cf. p. 130. It is also observed with magnetite (Fig. 456), pyroxene, barite, etc,

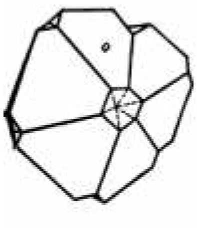
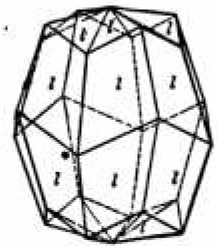
Anotner kind of repeated twinning is illnstrated by Figs. 357-363, where the successively reversed individuals are not parallel. In tbese cases the axes may, however, lie in a zone, as the prismatic twins of aragonite, or they may be inclined to each other, as in Fig. 359 of staurolite. In all such cases the repetition of the twinning tends to produce circular forms, when the angle between the two axial systems is an aliquot part of 360° (approximatelv). Thus six-rayed twinned crystals, consiBting of three individuals (hence called trillings), occur with chryeoberyl (Fig. 357), or cerussite (Fig. 358), or staurolite

(Fie. 359), since three timeB the angle of twinning in each case ie not far fr< 360 . Again, five-fold twins, or fivdinga, occur in the octahedrons of gold a

Chrysoberyl. Cerussite. Staurolite.

360. 361. 362.

Spinel.

Rutlle.

Phillfpaiie.

spinel (Fig. 360), since 5 X 70" 32' = 360° (approi.). Eight-fold twins, or eightlings, of rutile (Figs. 361,357) occur, since the angle of the axes in twinned position goes approximately eight times in 360°.

Repeated twinning of the symmetrical type often serves to give the compound crystal an apparent symmetry of higher grade than that of the simple individual, and the result is of ten spoken of asakiiidof pseudo-symmetry (Art. 20), cf. Fig. 397 of aragonite, which represents a pxeudo-hexnyonal crvstaL Fig. 363 of phillipsite (cf. Figs. 423--4a4) is fin interesting case, since it shows how a multiple twin of a monoclinic crystal may Bimulate an isometric crystal (dodecahedron).

Compound crystals in which twinning exists in accordance with two laws at once are not of common occurence; an excellent example is afforded by stanrolite, Fig. 411. They have also been observed on albite, orthoclase, and in other cases.

221. Secondary Twinning.—When there is reason to believe that the twinning has been produced subsequently to the original formation of the crystal, or crystalline mass, as, for example, by pressure, it is said to be secoiidary. Thus the calcite grains of a crystalline hraestone often show such secondary twinning lamellte. The same are occasionally observed (|c, OOi) in pyroxene crystals. Further, the polyaynthetic twinning of the triclinic feldspars is often

secoDdarj in origin. it is also explained t in a crystal IndiTidnal—0.^., in calcite (1

J in origin. This subject is further discussed on a later page, where is also explained that in certain cases twinning may be produced artificially

B Art. 261).

EXAMPLES OF IMPORTANT METHODS OF TWINNING.

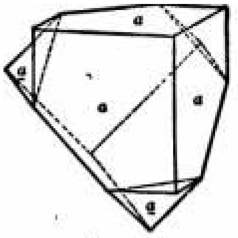
222. iMimetrio System.—With few exceptions the twins of the normal group of this syetem are of one kind, the twianiDg-axis an octahedral axis, and

the twinning-plane consequently parallel to an octahedral face; in most cases.

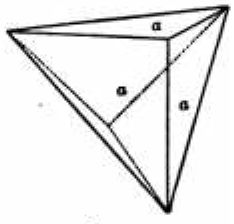
also, the lutter coincides with the com position-plane. _. this kind as applied to the simple octahedron; it is especi spinel group of nunerals, and is hence called in general

ig! 350, p. lia,* shows 'ally common with the a epiml-twin. Fig.

363 is a similar more complex form; Fig. 364 shows s cube twinned by this



Copper.



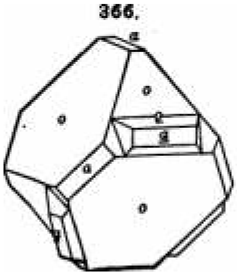
Copper.

Copi>

method, and Fig. 365 represents the same form but shortened in the direction of the octahedral axis, and hence having the anomalous aspect of a triangular pyramid. All these cases are contact-twins.

Penetration-twins, following the same law, are also common. A simple case of fluorite is shown in Fig. 353, p, 121; Fig. 366 shows one of galena;

366.



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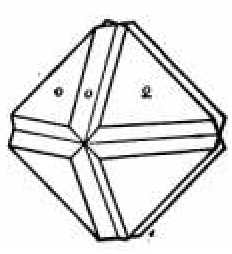


HaQjnite.

167 is a repeated octahedral twin of baiiynite, and Fig. 368 a dodecahedral of sodalite.

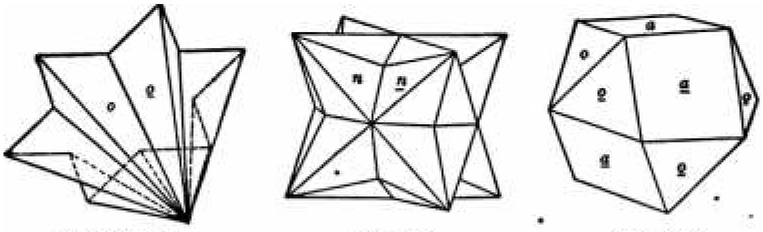
223. In the pyritohedral group of the isoiuetric system penetration-twins 369. of the type shown in Fig. 369 are common (this form of

pyrite is ofteu called tiie iron crosK). Here the cubic axis U the twimiiug-axie, and obviously such a twin is Impossible in the Dormal group.

Figs. 370 and 371 show analogous forms with parallel ^ aies for crystals belonging to the tetraliedral group. 'I'lie peculiar development of Fig. 370 of tetrahedrite is to be noted. Fig. ;iT2 is a twin of the ordinary spinel type of another tetrahedral species, sphalerite; with it, complex forms with repeated twinning are not uncommoa Pyrite. and sometimes polysynthetic twin lamellffl are noted.

224. Tetragonal System.—The most common method is that where the twinning-plane is parallel to a face of the pyramid, e (lOlJ. It is especially characteristic of the species of the rntile group—viz., rutile and cassiterite;

370. 311. 372.



Tetrabedrite. Eulytite. Sphalerite.

Tetrahedrlie.

Euly

SpbuU'ril

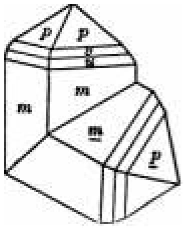
also similarly the allied species zircon. This is illustrated in Fig. 373, and

again iu Fig, 374. Fig. 375 shows a repeated twin of mtile, the twinning

^according to this law; the vertical axes of the snccessive six indiviituals lie

in a plane, and an inclosed circle is the result. Another repeated twin of rutile

373. 374. 37B.



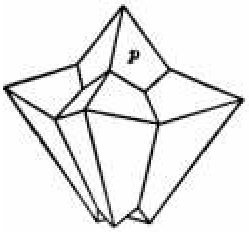
Rutile.

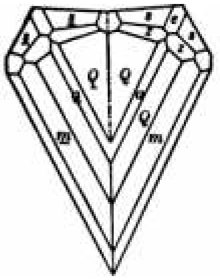
Cas^iturite. Zircon.

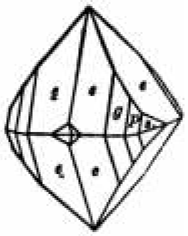
according to the same law is shown in Fig. 361; here the snccessive vertical axes form a zigzag line; Fig. 376 shows an analogous twin of hausmannite. ' Another kind of twinning, twinning-plane parallel to a face of the pyramid (301), is shown in Fig. 377.

225. In the pyramidnl group of the same system twins of the type of Fig. 378 are not rare. Here the vertical axis, d, is the twinning-axis; such a crystal may simulate one of the normal group.

37«. 377. 378.



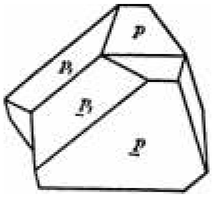




HausmaDnite. Rutile. Sell eel Ite.

In chalcopyrite, of the sphenoidal group, twinning with a face of the unit wramiii, / (111), as the twinniog-plana is common (Fig. 379). As the angles aifler but a small fraction of a degree from those of a regular octahedron, such twins often resemble closely spinel-twins. In Fig. 380 a repeated twin of this type has a psendo-rhombonedral aspect. In Fig. 381 the twiiming-plane ia e (101). Other rarer kinds of twinning have also been noted.

379. 3S0. 381. ■



Clinltopyrile.

226, Hexagonal System.—In tlie hexagonal division of tliis system twine

382. are nire. An example is furnished by pyi'vhotite, Fig.

382, where the twinning-plane is the pyramid (lOll), the

vertical axes of the individual crystals being nearly at

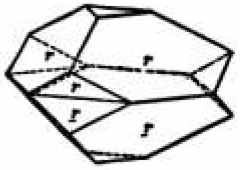
right angles to each other (since OUOl A 1011 = 45° 8').

(Apparent cruciform twins of apatite, of the pyramidal group, have been noted in some rare cases. Hei'e the diagonal pyramid s (ll3l) was the plane which seemed to be the twinning-plane. These cases need confirma-Pyrrlioliie. tion.

237. In the species belonging to the trigonal or rhombohedral division, twins are common. Thus the twinning-axis may be the vertical axis, as in the contact-twins of Figs. 383 and 384,-or t\u: penetration-twins of Figs. 348, 385. Or the twinning-plane may be the obtuse rhombohedron e (0113), as in Fig. 3S6, the vertical axes crossing at angles of 137i° and 52^°; these forms are often curiously distorted, as In Figs. 33T, 388. Again, the twinning-plane may be r (lOll), as in Fig. 389, the vertical axes nearly at right angles (90}°); or (0531), as in Fig. 390, the axes inclined 53i° and 120^°. In Fig. 391 of gmelinite the tTfinning-plane is the rhombohedron (30.12), which corresponds in angle with the common fundamental form of the allied species chabazite.

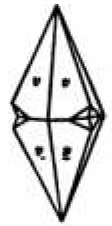
CBT8I4XLoQEAPHT.

383.



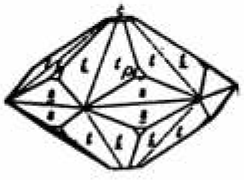
Calcite.

384.



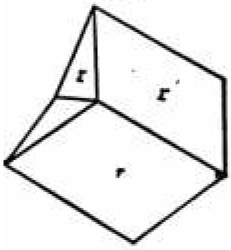
Calcite.

385.

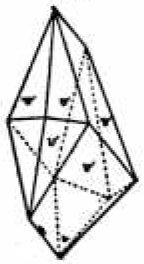


Phacolite.

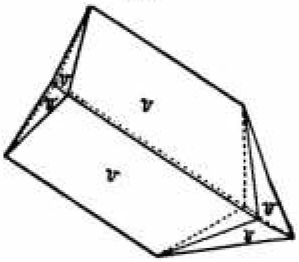
386.



387.



388.



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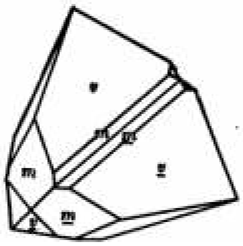
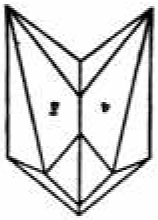
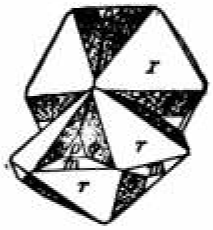


390.



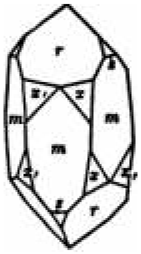
391.



Pigs. 8S6-390, Ciilciie Pfg. 391, Gmeliiiiite. lu the tiapezohedral group, the Bpeciea quartz gIiows several methods of twinuiiig. In Fig. 392 the twinning-]ilaiie is the diagonal pyramid £ (llS2), the axes crossing at angles of 84*° nnd 954°. In Fig. J93 the twinning-aiis ia 6, the axes hence parallel, the individuals both right- or both left-handed but unsymmetrical.r (1011) then parallel to and coinciding with z (0111). The resulting forms, as in Fig, 393, are mostly penetration-twins, and the parts are often very iiregularly united, as shown 6y dull areas (z) on the plus rhombo-hedral face (r); otherwise these twins are recognized by pyro-electrical phenomena. In Fig. 394 the twlnning-plane is a (ll50)—the Brazil law—the individuals respectively right- and left-handed and the twin symmetrical with reference to an a-faoe; these are usually irregular penetration-twins; in these twins r and r, also z and 2, coincide. These twins often show, in converging polarized light, the phenomenon of Airy'a spirals. It may be added that pseudo-twins of quartz are common—that is, groups of crystals which nearly

conform to some more or less complex twinning law, but where theCTOuping is neverthelesB only accidental. See also the remarks in Art. 232 about Fig. 433.

393· 393· 394· 3»B.



FIgi. 893-894, Qtinrrz. Fig. 393. Pheoaclte.

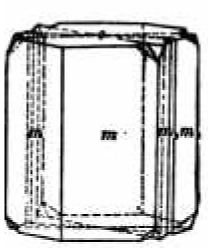
In Fig. 395 of phenacite (cf. p. 80 et seq.) the vertical axis is obviously the twlnning-azis.

228. Ortharhomblo Syatem.—In the ortborhombtc system the commonest method of twinning is that where the twinning-plane is a face of a prism of

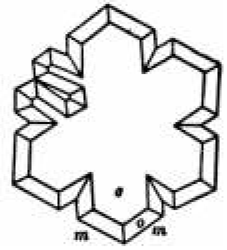
/f^N^

\J^i&E^

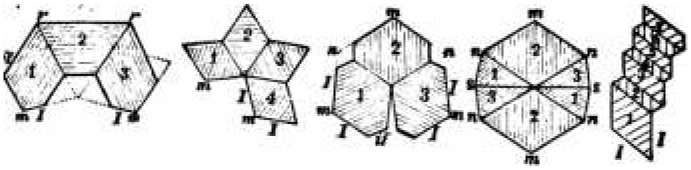
397.



398.



Figs. 39S'398, Arngoalle. 399.



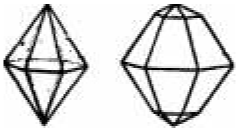
60°, or nearly 60'. This is well shown with the species of tlio nragonite group. In accordance with the principle stateil in Art. 220, the twinning after this law is often repeated, and thus forma with pseud oh exaeonal symnietry result. Fig. 396 shows a simple twin of aragoiiite; Figs. 397,398 repeated forms exhibiting the irregularities on the faces due to the fact that the prismatic angle is not exactly 60°. Fig. 399. a-e, show further some of the methods of composition which have been noted; in e the twinning is poly synthetic.

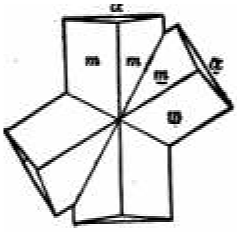
, ,. ..CA>oglc

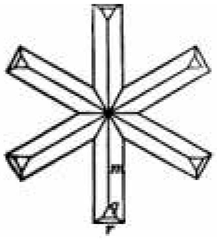
With witberite (and bromlite), apparent hexagonal pyramids (Figs. 400, 401) are comtnoQ, bnt the true complex twinning ie revealed in polarized light, 4QQ 401, as noted later.

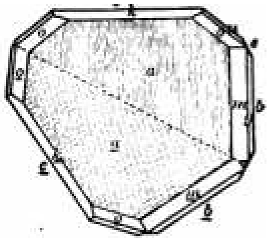
Twiuning of the same type, but where a dome of 60° is twinnmg-plane, is common with araenopyrit© (tw. pi. 6 (101), as shown in Figs. 40-3,403; also Fig. 404 of columbite, but compare Fig. 347 and remarica iii Art 217, Another example is given in Fig. 357 of alexandrite (cbrysoberyl). Chrysolite, manganite, hrnnite, are other species with which this kind of ' twinning is common.

403. 401.

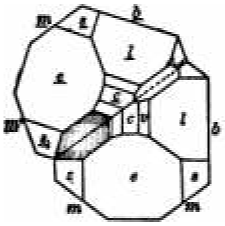


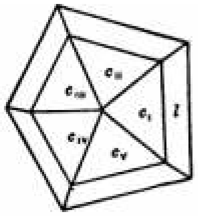


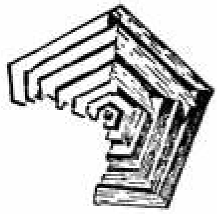




Another common method of twinning is that where the t« inning is parallel to a face of a prism of about 704°, ^ shown in Fig 405 With this method symmetrical ffvelings not infrequently occur (Figs. 406, 407).



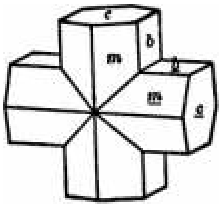


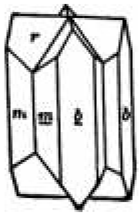


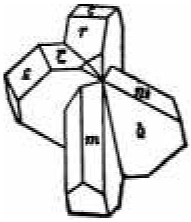
Harcasite. Mnrcaalte. AraennpTnta

The speciea stanrolite illustrates three kinds of twinning. In Fig 408 the

40S. 409. 410.





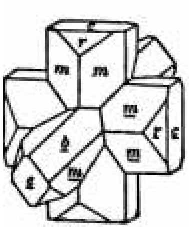


twinuing-plsne m (032),and since (001 A 032) = 45° 41',tlie crystala cross nearly ^,, jio at right angles. In J'ig. 409 the twiiming-

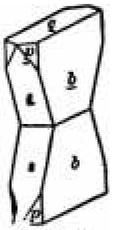
plane is the prism (330). In Fig, 410 it ia the pyramid (5;3"2); the crystals tlieu crossing at angles of about 60", stellate trillings occur (see Fig. 359), and indeed more complex formtf. In Fig. 411 there is twinning according to both (0152) and (232).

In the heniimorphic group, twins of the type shown in Fig. 413, with c its the twin-ning-plaiie, are to be noted.

22B. Honooluua System.—In the mono-clinic system, twins with the vertical axis as twinning-axis are common; this is illustrated by Fie. 413 of angite (pyroiene). Fig. 414 of gypsum, and Fig. 415 of ortho-elase (see also Fig. 352, p. 120). With the latter species these twins are called VarUbad twint (oecause common in the trachyte of Carlsbad, Bohemia); they may be contact-twins (Fig. 352), or irregular penetration-twins (Fig. 415). In Fig. 352 it is to be noted that c and x fait nearly in the same plane.



Staurolite.



Struvite.

ma mi

w

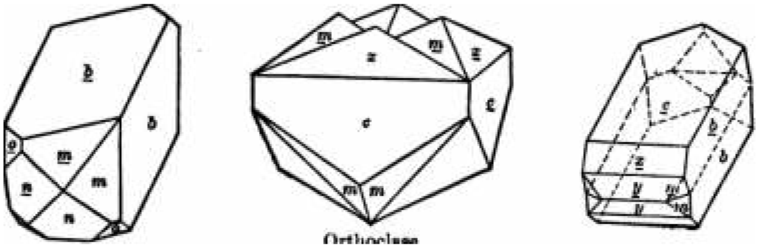
Augile. Gypsum. Orthoclaae.

In Fig. 416, also of orthoclaae, the twinning-plane is the clinodome (021),

and since (001 a 021) = 44" 56^', this method of twinning yields nearly

sqaare prisms. These twins are called Bnreno twina (from a prominent

locality at Baveno, Italy); they are often repeated (Fig. 417). In Fig. 418 a

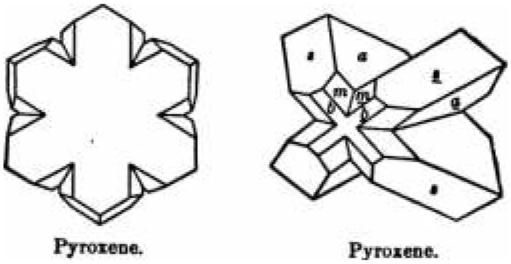


Manebach twin is shown; here the twinning-plane ia c (001). Other rarer types of twinning have been noted with orthoclaee. PolvBynthetic twinning with c (001) as twinning-plane is common with pyroxene (ef. Fig, 430, p. 131).

.dbyGooglc

Twina of the aragonite-chryaoberjl type, are not uncommon with mono-clinic Bpecies, having it proniiueut 60° priam (or dome), as in Fig. 419. Stellate twins after this law are common with chondroiiite aiid clinohumite. An anal-ogoua twin of pyroxene is shown in Fig. 430; here the pyramid (122) is the twinniug-plane, and since (010 A ^23) = 59° 31', the crystals cross at atigles of nearly 60°; further, the ortbopiDacoids fall nearly in a common zone, since (100 A i33) = 90° 9', In Fig. 421 the twinning-plane is the orthodome

419. 420. 42t.



Pyroxene. Pyroxene.

Pyroie

(101). Phillipsite and harmotome exhibit mnltiple twinning, and the crystals often show paeudo-aymmetry. Fig. 422 shows a cruciform fourling with c (001) OB twinning-plane, the twinning shown by the striations on the aide face. This is compounded in Fig. 423 with twinning-plane (Oil), making nearly square prisma, and this further repeated with m (110) as twinnlbg-plane yields the form in Fig. 424, or even Fig. 362, p. 122, resembling an iaometrio dodecahedron, each face showing a fourfold etriation.

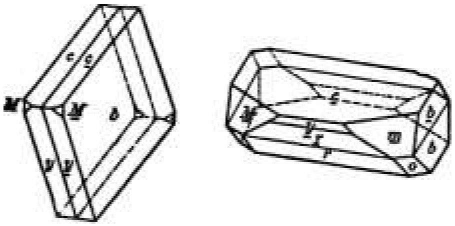
FbUllpdte.

230. Triolinio Syrtem.—The most interesting twins of the tricllnic system are those.afaown by the feldapara. Twinning with b (010) as the twinning-plane ia very common, especially polysynthetic twinning yielding thin parallel lamellee, shown by the striationa on the face c (or the corresponding cleavage-aurface), and also clearly revealed in polarized light. This is known as the atbile taw (Fig. 425). Another important method (Fig. 4^6) is that of the pericline law; the twinning-aiis is the crystallograpbic axis J. Here

the twins are united by a section (rhombic section) shown in the figure and further explained under the feldspars. Polysynthetic twinning after this law is common, and hence a cleavage-mass may show two sets of striations, one on the surface parallel to c (001) and the other on that parallel to ft (010). The

angle made by these last striations with the edge 001/010 is characteristic of the particular triclinic species, as noted later.

426. 43S. 427.



Labradorite. Albite. Albite.'

Twins of albite of other rarer types also occur, and further twins similar to the Carlsbad. Baveno, and Manebach twins of orthoclase. Fig. 437 shows twinning according to both the albite and Carlsbad types.

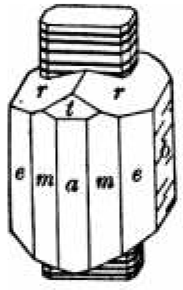
REGULAR GROUPING OF CRYSTALS.

231. Parallel Grouping. —Connected with the subject of twin crystals is that of the parallel position of associated crystals of the same species, or of different species.

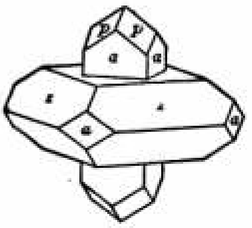
Crystals of the same species occurring together are very commonly in 428. parallel position. In this way large crystals, as of

calcite, quartz, fluorite, are sometimes built up of smaller individuals grouped together with corresponding faces parallel. This parallel grouping is often seen in crystals as they lie on the supporting rock. On glancing the eye over a surface covered with crystals a reflection from one face will often be accompanied by reflections from the corresponding ' face in each of the other crystals, showing that the crystals are throughout similar in their positions.

With many species, complex crystalline forms result from the growth of parallel partial crystals in the direction of the crystallographic axes, or axes of symmetry.



Amphibole enclosing

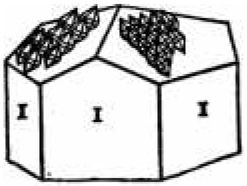


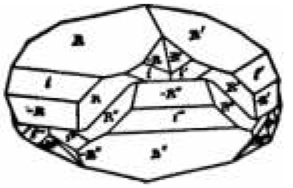
Xenotime enclosing zircon in

Thus dendritic forms, resembling branching vegetation, often of great delicacy, are seen with gold, copper, argentite, and other species, especially those of the isometric system. This is shown in Fig, i'i6 (ideal), and again in Fig. 4^9, where the twinned and flattened cubes (cf. Fig. 365, p. 123) are grouped in directions corresponding to the diagonals of an octahedral face which is the twinning-plane.

232. Parallel Grouping of Unlike Species.—Crystals of different species often show the same tendency to parallelism in mutual position. This is true most frequently of species which are more or less closely similar in form and composition. Crystals of albite, implanted on a surface of orthoclase, are sometimes an example of this; crystals of amphibole and pyroxene (Fig. 430), of zircon and zenotime (Fig. 431), of various kinds of mica, are also at times Observed associated in parallel position.

The same relation of position also occasionally occurs where there is no connection in composition, as the crystals of rutile on tabular crystals of hematite, the vertical axes of the former coinciding with the lateral axes of the latter. Crystals of calcite have been observed whose rhombohedral faces





had a series of quartz crystals upon them, all in parallel position (Fig. 433); sometimes three such quartz crystals, one on each rhombohedral face, entirely envelop the calcite, and unite with re-entering angles to form pseudo-twins (rather trillings) of quartz after calcite. A similar occurrence from Specimen Mountain, in the Yellowstone Park, is shown in Fig. 433.

IRREGULARITIES OF CRYSTALS.

233. The laws of crystallization, when unmodified by extrinsic causes, should produce forms of exact geometrical symmetry, the angles being not only equal, but also the

homologous faces of crystals and the dimensions in the directions of like axes. This symmetry ia, however, so uncommon that it can hnrtlly be considered otber than an ideal perfection. The various possible kinds of symmetry, and the relation of this ideal geometrical symmetry to the actual crystal I ograp hie symmetry, have been discussed in Arts. 14 and 18 et neq. Crystals are very generally distorted, and often the fundamental forms lire so completely disgnixed that an intimate familiarity with the possible irregularities is required in order to unravel their complexities. Even the angles may occasionally vary rather widely.

The irregularities of crystals maybe treated of under several heads: 1, Variations of form and dimensions; 2, Imperfections of surface; 3, Variations of angles; 4, Internal imperfections and impurities.

irkeqclabiubb (

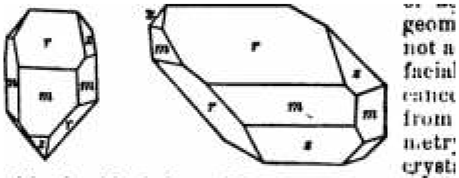
1. VARIATIONS IN THE FORMS AND DIMENSIONS OF CRYSTALS.

234. Dutortion in General—The Tariatione in the forms of crystals, or, in other words, their distvrtiun, may be irregular iu character, certain faces being larger and others smaller than iu the ideal geometrical solid. On the other hand, it may be si/mvietrical, giving to the distorted form the symmetry of a group or system different from that to which it actually belongs. The former casie is the common rule, but the latter is the more interesting.

235. Irregolai I>i«tortion.^As stated above and on p. 11, all crystals Bhow to a greater or less extent an irregular or accidental variation from the ideal geometrical form. This distortion, if i]ot accompanied by change in the inter-fuciiil angles, has no particular signifi-i';nK^<.', and does not involve any deviation from the laws of cryatallograpbio aym-ri.etry. J'ige. 4^4, 435 show distorted ij-ystals of quartz; ibey may be compared

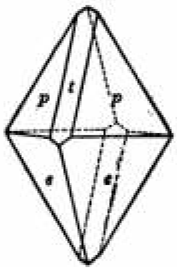
Fig. 436 is an ideal and Fig. 437 an

43B.

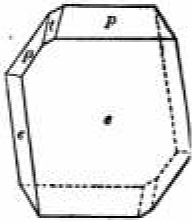


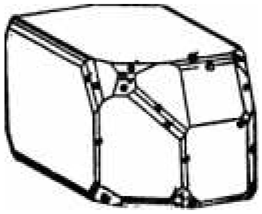
with the ideal form, Fig. 266, p. 83. Fig

436.



437.





Apntlte.

actual crystal of lazuHte. So, too, Pig. 438 is a distorted crystal of apiitite, to be compared with Fig. 216, p. 73.

The corrert ideuUQcation nt tlie forms uu u crystal Is reudeied mucli more difficult because of tbU prevailing diBturtion, eapecially when It results Iu tbe CDIIre dbiiUr.ation of cerinin fnces by tbe enlavgemeul of olbers. In dedpheriag the diBlurlid crystulliue forma it mii<<t bi; remembered that while the appCHraace of the cryatale mtiy he etjtirely altered, the inlerf icial nnglea remnin tbe same ; moreover, like races are physically alike—that is, alike id dezree of luster, in striatlous, huiI so od. Thus the prismatic faces of quartz show •liiiost always chartvcteristlc horizontal atiiatioDS

In addition to the variations in form which have just been described, still greater irregularities are due to the fact that, in many cases, crystals in uatnre are attached either to other crystals or to some rock surface, and in consequence of this are only partially developed. Thus qnartz crystals are generally attached by one extremity of the prism, and hence have only one set of pyramidal faces; perfectly formed crystals, having the double pyramid complete, are rare,

236. STnunetrical Distortion.—The most interesting examples of the symmetrical distortion of crystalline forms are found among crystals of the isometric system. An elongation in the direction of one cubic axis may give

the appearance of tetragonal symmetry, or that in the dirootion of two cubic axes of orthorhombic symmetry; while in the direction of an octahedral axis a lengthening or ehortening gives rise to forms of apparent rhombohedral

Bjmmetry, Such cases are common with native gold, silver, and copper.

A eulie lenfftbeued or shortened aloug oue axis becomes a, riglil aquiire prism, and if varied in tbe direction of two ftxes Ib ckunged to a rectangular prism. Cubes uf pjrile.

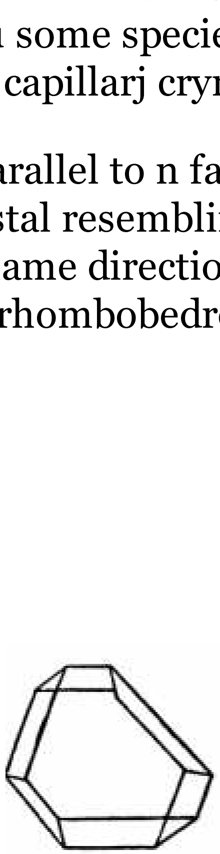
Siena, fluorite, etc.. are orten thus distorlMl. It is very unusual tii find n culiic crvslul il is a true syminelrical rube. lu some species the cube or ocrabedron (or otber isometric form) is lengthened iato & capillarj crynlal or needle, as happens in cuprite and pyrlle.

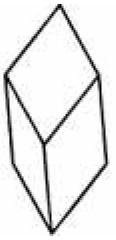
An octahedron JtiK<n0dparallel to n face^that Is. in Iheairectionof atrigODul iiiteruxis—Is reduced to a tabular crystal resembling a rbombobednl crystal with basal plane (fig. 4S9). If lengthmud In the lame direction, to the obliteration of the terminal octahedral faces, it becomes an acute rhombobedrou (cf. Fig. 440),

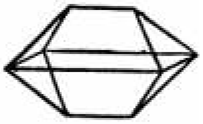
43».

«40.

Ml.



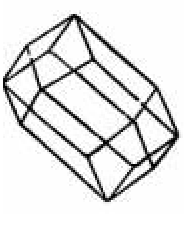




WliflD an oclafaedroQ is extended lo the direction of a line between two opposite edges, or that of a rhombic Inleraxis, it has the general form of a rectangular octsiiedron; and still fariher extended, as In Fig. 441, it is changed to a rhombic prtam with dihedral summits (spinel, fluorite, maguetil«). The figure represents this prism lying on Its acute edse.

The dodteahtdrwi lengthened In the alrectlon of a diagonal between the obtuse solid

442.



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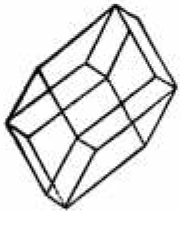

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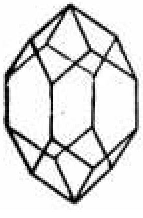
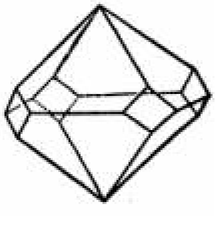


445.

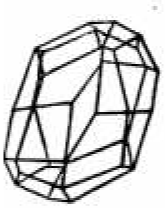


angles—that is, tbat of a trigonal interaxis—becomes a aix'stded prism with three^sided siim-mits, as in fig. 442. If shortened in tbe same diiecliou, it becomes a ihort prism of the same kind (^g. 448). Both resemble rhombohedral forms and are common in garuel (compare Fig. 234, p. 76, of calcite). When lengthened in the direction of one of the cubic axes, the dodecahedroa becomes a square prism with pyramidal summits (Fig. 444). nnd shortened along the same axis it is reduced lo a equare octahedron, with truncated basal angles (Fig. 446).

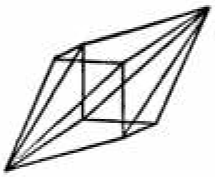
Tlie trapazohedroD elongated In the direction of an octahedral (trigonal) axis aasumea rhombohedral (trigonal) symmetry. The resulting forms referred to tne usual hexagonal axes for both (311) and (811) are ns follows:

For<211^ the resulling form IsBnttbat of Fig. 446, aod If etill farther lenglbened, to tbe obliieratioD of some of the faces, tt becomes ft icalenoliedroii (Pig 44T>. Tbla bos been obserred Id fluorite. Only IweWe faces are bere preseol out of ibe iweDty-four. If the

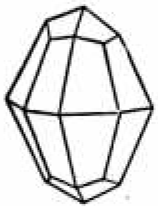
446.



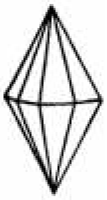
447.



448.



449.



elongation of this trtipezohedron (311) lakes place along a cubic axis, it becomes a double ficbi-sided pyramid with tour-sided summits (Fig. 446); or if ihese BLiininit plaues iiru nl^iterated by a fartber eiteution, It becomes a complete eight-tided double pjmmid (Fip. 448).

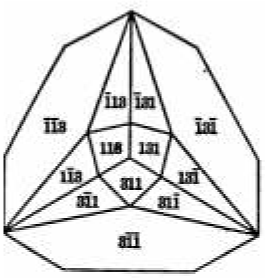
Th« accompanying figures Illustrate the-rhombohedral distortion of Ibe trnpezohedron (311), cf. Fig. B3, p. &. Pig. 4S0 shows the faces as projected on a plane Dormal to ao

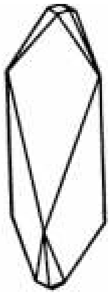
4Bo.

461.

462.

453·





464.

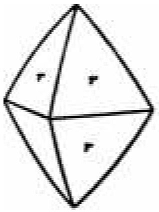
4G6.

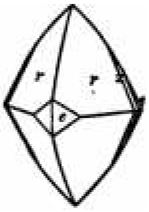
The native gold from Ihu White H ,

UregoD, aoinetimes consists of n slender !<ti'iiig of such rUomtxihedral crystals, Hud not infrqiieiilly there are minor bruncliea in the direction of two or more of the other ociahBiiral axes (Figs. 452. ira). The Irisoctahedron Is mrp ns n prominent form, hut ft Piirloiia example of Its diatort'on in given in Figs. 454. 455 of pyrite from Frencb Creeli. Ptnn. Tbe form, apparently letragonal (or orlliorhombie), shows only eigbt fjices of the trisoctiihedron »'{3S3|, and these are strongly rounded; faces of ihe pyriio-bedroD e (210) also appear as a subordlonte fotiu. Hlmllarly tbe tetr&bezahedion and bexociahedrou

may show distortion of the same kind. Further examples are to be found in Ibe other

lyiums.





2. IMPERFECTIONS OF THE SURFACES OF CRYSTALS.

237. Striatiftiu Dae to Oscillatory Gombinationi.—The parallel lines or furrows on the Burfaces of crystals are called slrUa or striatione, and ench surfaces are said to be striated.

Eiicli little ridge on a striated surface is enclosed by two narrow planes more or less regular. These planes often correspond in position to dinereDt faces of the crystal, and these ridges have been formed by a continued oscillation in the operation of the causes that give rise, when acting uninter-riiptetlly, to enlarged faces. By this means, the surfaces of a crystal are marked in pinullel lines, with a succession of narrow planes meeting at an angle and cuneiituting the ridges referred to.

This combination of different planes in the formation of a surface has been termed oscillatory combination. The horizontal atriations on prismatic crystals of quartz are examples of this combination, in which the oscillation has taken place between the prismatic and rhombohedral faces. Thus crystals of quartz are often tapered to a point, without the usual pyramidal terminations.

Other examples are the striations on the cubic faces of pyrite parallel to the intersections of the cube with the faces of the pyritohedron; also the striatioiLS on magnetite due to the oscillation between the octahedron and dodecahedron. Prisms of tourmaline are yery commonly bounded vertically by three convex surfaces, owing to an oscillatory combination of the faces In the priamatic zone.

23B. Striationa Dne to Repeated Twinning.—The atriations of the basal

plane of albite and other triclinic feldspars, also of the rhombohedral surfaces

4B0. of Gome calcite, have been explained in Art. 230 as due

to polysynthetic twinning. This is illustrated bv

Fig. 45(i of magnetite from Port Henry, N. V.

(Kemp.)

239. Markings tram. Erosion and Other Caaset.— The faces of crystals are not uncommonly uneven, or have the crystalline structure developed as a consequence of etching by some chemical agent. Cnbes of galena are often thus uneven, and crystals of lead sulphate (anglesite) or lead carbonate (cemssite) are sometimes present as evidence with regard to the cause. Ciyatuls of numerous other species, even of Mugnelite. corundum, spinel, quartz, etc., sometimes show the

same result of partial change over the surface—often the incipient ^tcge in a process tending to a final removal of the whole crystal. Interesting investigations have been made by various authors on the action of solvents on different minerals, the actual stnicture of the crystals being developed in this way. This method of etching is fully discussed, with illustrations, in another place (Art. 265).

The markings on the aorfaces of crystals are not, however, always to be ascribed to etching. In most cases such depressions, as well as the minute elevations upon the faces having the form of low pyramids (so-called vicinal prominences), are a part of the original molecular growth of the crvatal, and often serve to show the successive stages in its hiatory. They may lie Imperfections arising from an interrupted or disturbed development of the form, the perfectly smooth and even crystalline faces being the result of completed action free from diBtnrbing Gaases. Examples of the majkinga referred to occur oH the crystals of most minerals, and conspicuougly so on the rbombo-hedral faces of quartz.

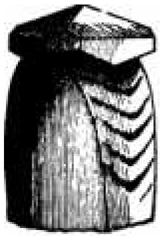
Faces of crystals are often marked with angular elevations more or less distinct, which are due to oscillatory combination. Octahedrons of Quorite are common which have for each face a surface of minnte cubes, proceeding from an oscilhttion between the cube and octahedron. Sometimes an examination of such a crystal shows that though the form is apparently octahedral, there are no octahedral faces present at all. Other similar cases could be menUoned,

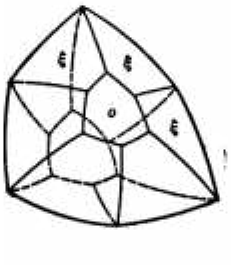
Whatever their cause, these minute markings are often of great importance as revealing the true molecular symmetry of the crystal. For it follows from the symmetry of crystallization that like faces most he physically alike—that is, in regard to their surface character; it thus often happens that on all the crystals of a species from a given locality, or perhaps from all localities, the same planes are etched or roughened alike. There is mnch uniformity on the faces of quartz crystals in this respect.

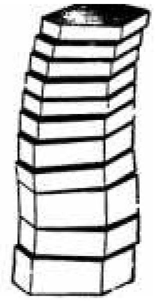
240. Carved Burfaoes may result from (n) oscillatory combination; or (b) some independent molecular condition producing curvatures in the laminte of the crystal; or (c) from a mechanical cause.

Curved surfaces of the Jirsl kind Jiava been already mentioned (Art. 287). A singular curvature of this nature is seen in Fig. 457, of calcite; in the lower

Car^ traces of a scalenohedral form are apparent which was in oscillatory com-ination with the prismatic form. Curvatures of the second kind sometimes have all the faces convex. Thia IS the case in crystals of diamond (Fig. 458), some of which are almost spheres. The mode of curvature, in which all the faces are equally convex, is Ie:i8 common than that in which a convex surface is opposite and panillel to a corresponding concave surface. Rhombohedrons of dolomite and siderite are usually, thus curved. The feathery curves of frost on windows and the flagging-stones of pavements in winter are other examples. The alabaster rosettes from the Mammoth Cave, Kentucky, are similar. Stibiiite crystals aometimes show very remarkable curved and twisted forms.







A third kind of onrvatare is of mechanical origin. Sometimes crystals appear aa if they had been broken transversely into many pieces, a slight;

displacement of which has given a cnrved form to the prism. Tbia is common in tourmaline and beryl. The beryls of Monroe, Conn., often present these interrupted curvatures, as represented in Fig. 459.

Cryetala not infrequently occur with a deep pyramidal depression occupying the place of each plane, as is often observed in common salt, alnm, and snlphnr. This is due in part to their rapid growth.

3. VARIATIONS IN THE ANGLES OF CRYSTALS.

241. The greater part of the distortions described in Arts. 236, 236 occasion no change in the interfacial angles of crystals. But those imperfections that produce convex, curved, or striated faces necessarily cause such variations. Furthermore, circumstances of heat or pressure under which the crystals were formed may sometimea have resulted not only in distortion of form, but also some variation in angle. The presence of impurities at the time of crystallization may also have a like effect.

Still more important is the change in the angles of completed crystals which is caused by subsequent pressure on the matrix in which they were formed, as, for example, the change which may take place during the more or leas complete metamorphism of the enclosing rock.

The change of composition resulting in pseudomorphons crystals {see Art. 293) is generally accompanied by an irregular change of angle, so that the psendomorpha of a species vary much in angle.

In general it ia safe to affirm that, with the exception of the irregnlaritifiB arising from imperfections in-the process of crystallization, or &om the snbBoquent changes alluded to, variations in angles are rare, and the constancy of angle alluded to in Art. 11 is the universal law.

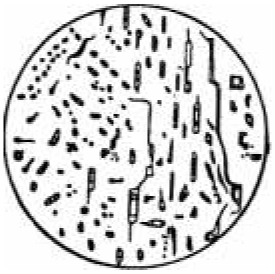
In cases where a greater or less variation in angle is observed in the crystals of the same species from different localities, the cause for this can usually be found in a difference of chemical composition. In the case of isomorphous compounds it is well known that an exchange of corresponding chemically equivalent elements may take place without a change of form, though usually accompanied with a slight variation in the fundamental angles.

The effect of heat upon the form of crystals is alluded to in Art. 41B.

i. INTERNAL IMPERFECTIONS AND INCLUSIONS.

242. The transparency of crystals is often destroyed by distui-bed crystallisation; by impurities taken up from the solution during the process of crystallization; or, again, by the presence ot foreign matter resulting from partial chemical alteration. The general name, inclusion, is given to any foreign body enclosed within the crystal, whatever its origin. These inclusions are extremely common; they may he gaseous, liquid, or solid; visible Co the unaided eye or requiring the use of the microscope.

Rapid crystallization is a common explanation of inclusions. This is illustrated by quartz crystals containing large cavities full or nearly full of water (in the latter case, these showing a movable bubble); or, they may contain sand or iron oxide in large amount. In the case of calcite, crystallization from a liquid largely charged with a foreign material, as quartz sand, mav result in the formation of crystals in which the impurity makes up as mucn



as ttro-thirds of the vhol« mass; thia is seen in the fatnoas Fontaineblean limestone, and similarly in that from other localities.

243. Liquid and Oaa Inclosiont. —Attention was early called by Brfiwster to the presence of fluids in caTitiea in certain minerals, as quartz, topaz, berTl, cliryBolite, etc. In later years this subject has been thorOQghiy studied oy

Sorby, Zirkel. Vogelsang, Fischer, Eosenbnach, and others. The nature oC the liquid can often be determined, as by its refractive power, or by special phyBical test {e.g., determination of the critical point in the case of CO,), or by chemical examination. In the majority of cases the observed liqaid is simply water; but it may be the salt solution in which the crystal was formed, and not infrequently, especially in the case of quartz, liquid carbon dioxide (CO,), as first proved by Vogelsang. These liquid incluaions are marked as such, in many cases, by the presence in the cavity of a movable bubble of gas. Occasionally cavities contain two liquids, as water and liquid carbon dioxide, the latter then inclosing a bubble of the same snbetance as gas (cf. Fig. 460). Interesting experiments can \» made vith sections showing such incluHions (cf. literature, p, 141). The mixture of gases yielded by smoky quartz, meteoric iron, and other substances, on the application of heat, bns been analyzed by Wright.

In some cases the cavities appear to be empty; if tlioy then have a regular form determined by the crystallization ot the apeciea, they are often called wjative crijxiah. Such cavities are commonly of secondary origin, ua remarked on a later page.

244. Solid Inolusioiu. —The aolid inclusions are almost infinite in their variety. Sometimes they are large and diatinct, and can be referred to known mineral apeciea, as the acales of gothite or hematite, to which the peculiar character of aventnrine feldspar ia due. Magnetite is a very common impurity in many mineralSjUnpearing, for example, in thePeiinabiiry mica; quartz is also often mechanically mixEtl, as in ataurolite and gmelinite. On the other hand, quartz crystals Ls very commonly inclose foreign material,

such as chlorite, tourmaline, rutile, hematite, aabestus, and many other minerals. (Cf. also Arts. 245, 246.)

Au ill I en-sling example of llie iiiclosure of one mineral by

I & another iaaSimlei! by tlieuDiiexttl figures of tourmaline envelop-

'-^^ log orlho<lnsc * Fig. 461 hIjowb Ibe crystal of touminllue ; auit

cross aeciione oF it ai tlie potols indicated (<i, b. e) are given by

Figs. 463, 46il, 4S4. Tlie latter >ibow tliHt tlie feldspar Tuci«ii«ei

Id umoiiut in ilic loner jwrt of tlie crystal, the lourmnliiie being

merely a lliiii sliell. Simlliir s|iecimens from the siime locality

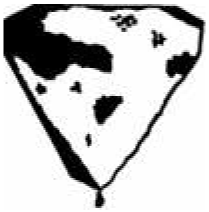
(Port Henry, Essr-x Co., N. Y.) slmw that there is uo necessary

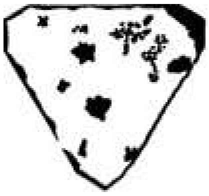
conDcction l)etM'eeu tlie position of the tonrnialine anil that of

\. tlie felds|>ar.

Similar occurrences are tbose of trapezobedroDs of garnet, where the latter it m mere ibell, loclosiug calclie, or sometluies eptdote or quartz (Fig. 47S).

• E. H. Wiliiania, Am. J. Sc- 11. 878. 1876.





The inclQBiona mayconsiBt of a heterogeneoDS mass of material; ns the grauitic matter seen in orthoclase crystals in a porphyritic granite; or the feldspar, quartz, etc., sometimes inclosed in large coarse crystals of beryl or spodumenc, occurring in granite veins.

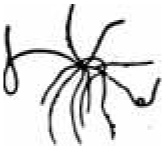
245. Hiorolitei, Cryitallites-^The microscopic crystals observed as incln-eions may aometirneB bo referred to known species, out more generally tlieir true nature is doubtful. The term microliter, proposed by Vogelsang, is often used to designnte the minute inclosed crystals; they are generally of needlelike forni, Bometimes quite irregnlar, and often very remarkable in their arrangement and groupings; some of them are exhibited in Fig. 470 and Fig. 471, as explained below. Where the minute individualB belong to known Species they are called, for example, feldspar microlitee, etc.

Crystallites is an analogous term used by Vogelsang to cover those minute forms which have not the regular exterior form of crystals, but may be considered as intermediate between amorphous matter and true crystals. Some of

460.

«7.

469.

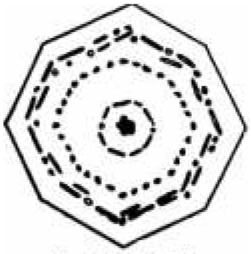


the forms are shown in Figs. 4C5-469; they are often observed in glassy volcanic rocks, and also in furniice-alags. A series of names has been given to varieties of crystallites, such as globulites, margarites, etc. Trichite and belonite are names introduced by Zirkel; the former name is derived from ffpiS, hair; trichites, like that in Fig. 469, are common in obsidian.

The microscopic inclusions may also be of an irregular glassy nature; tliia kind' is often observed in crystals which have formed from a molten mass, aa lava or the slag of an iron furnace.

246. Symmetrioally Arranged Inclniiona.—In general, while the solid inclusions aometimea occur quite irregularly in the crystals, they are more generally arranged with some evic^ent reference to the symmetry of the form, or external faces of the crystals. Examples of this are shown in the following

firareB. Fig. 470 exhibits & crystal of aagite, incloeing magnetite, feldspar aud nephelite inicroliteB, etc. Fig. 471 shows a crjBtal of leucite, a species



Leucite (Zirkel).

whose crystals very commocly inclose foreign matter. Fig. 47S of a crystal of garnet, containing quartz.

Another strilcing example is aflEorded by aiidalnsite (Fig. 473), in which the inclosed carbonaceous impurities are of consitlersble extent and remarkably arranged, so aa to yield symmetrical figures of varions forms. Stanrolite occasionally shows analogous carbonaceous impurities 474.

symmetrically distributed.

The magnetite common as an inclusion iu mnscovite, b alluded to above, is always symmetrically disposed, usnally = parallel to the directions of the percussion-figure {Fig, 477, ^ p.l49). The asterism of phlogopite is explained by the pres- E ence of symmetrically arranged inclnsions (cf. Art. 342). !

FIk- 474 shows nn ialei-eatln^ case nf BymnietHcnIly arrnDEed | JQcliiatDua due to cliemlcal nIteration- Tbe original mitiemi, Bpnau- ' meiie, from BrnticliTllle, Cuoo.. Iius beeu allered In n snbsinnce '. apparently homogeneous to tbe eye. bill found under tbe mici'oicnpe I to b:ive tbe etriicture sbuwii in Fia. 474. Cbemlcal analysis proves I lb« base 10 !« alblle aud the Inclosed hexagonal miueinl to be a liibiutn dlicate (LiAISiOi) called eucryptiie. It has not yet been identified except in tbi»

LlTKKATDRB.

Some of the most important works on tbe subject of microscopic inclusions ai'e referred to iiere; for a fuller list of papers reference may be made to the work of

RoseDbu3ch(1878, 1S92); also that of Zirkel and nthers mentioned on p. 4.

BrawBt«r. Many papers, pulilisbed mostly Id the Philosophical Magazine, and the Edinburgh Phil. Journal, from 1822-1858.

BlKin. I^onhard. Seyfert, and Sfichtlng. Die EiuschlQsse von MineralleD in krystalli-"" (Preisachrin.)

n HlniTalien. Haarlem, 1854.

Borby. On llie mlcroscoptcBl slriicture ol ctjBtala, etc. Q. J. 0. Soc., 14, 458, 18S8 <uid oUier papers).

Sorbjr aud Butler. On llie structure oI rubies, siippblres, dfamonUa, and some otber miiiKnila. Pri>c. Roy. 8oc., No, lOB, 1868.

Reuach. Lubradorlle. Fogg. AuD.. 130,95, 1863.

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CRYSTALLINE AGGREGATES.

247. The peater part of the epecimenH or masseB of minerals that occur may be described

as aggregations of imperfect crystals. Many specimens whose structure appears to tlie eye quite homogeneous, and destitute internally of distinct crystaflization, can be shown to be composed of crystalline grains. Under the above head, conseqtiently, are included, all the remaining varieties of stnicture among minerals.

The individuals composing imperfectly crystallized individaals may be:

1. Columns, or fibers, in which case the structure is colvmnar or fibrous.

2. Htm lamitifB, producing a lanielliir structure.

3. Orainn, constituting &yrannlar structure.

248. Columnar and Fibrona Stmotore.—A mineral possesses a colvmnar atructure when it is made up of slender colnmns, as some amphibole. When the individuals are flattened like a knife-blade, as in cyanite, the structure is said to be bladed.

The structure again is called fibrous when the minerai is made up of flbere, as in asbestus, also the antinapar variety of gypsum. The fibers may or may not be sepiirahh. There are many griidatioiiB between coarse columnar and fine fibroiiB structures. Fibrous mini^rala have often a silky luster.

The following are properly varieties of columnar or fibrous structure:

Reticjililed: when the fibers or columns cross in various directions and produce an appearance having some resemblance to a net.

SleU'iied: when they radiate fron a center in all directions and produce star-like forms. Ex. stilbite, wavellite.

liadiafed, divergent: when the crystals radiate from a center without producing stellar forms. Ei. ouartz. stibnite.

248. Lamellar Structure,—Tlie structure of a mineral is lamellar when it consists of plates or leaves. The laminte may be curved or straight, and thus give rise to the curved lamellar and straight lamellar structure. Ex. wollas-tonite (tabular spar), some Tarietiea of gypsum, talc, etc. If the plates are approximately parallel about a common center the structure is said to be conrentric. When the laminie are thin and separable, the structure is said to be feiliaceous OT foliated. Mica is a striking example, and the term f7 ' often used to describe this kind of structure.

260. Granolar Stracture. —The particles in a granular structure differ much in size. When coarse, the mineral is described na coarse-granular; when flue, Une-graHular; and if not

distinguishable by the naked eje, the structure is termed impalpable. Examples of the &t'st may be observed in granular crystalline limestone, sometimes called saccharoidal; of the second, in some varieties o! hematite; of the last, in some kinds of sphalerite.

The nboTe terms nre indefinite, but from necessity, as there is every degree of fin«iie)-3 of structure among mineral species, from perfectly impalpable, through 111] possible shades, to the coarsest granular. The t&rxn phtmero-crtfs-lalliiie h-M been used for varieties in which the grains are distinct, and cri/^io-cryslaUiie for those in which they are not discernible, although an indistinct crystalline strtictiire can be proved by the microscope.

Granular minerals, when easily crumbled in the fingers, are said to bs frid Me.

291. Imitative Shapes. — The following are important terms used in describing the imitative forms of massive minerals.

Reniform: kidney-shaped. The structure may be radiating or concentric. Ei. hematite.

Bolri/oidal: consisting of a group of rounded prominences. The name is deriTed from the Greek (iorpvs, a bunch of grapes, Ex. limooite, chalcedony, prebnite.

MammiUary: resembling the botryoidal, but composed of larger prominences. Ex. malachite.

Globular: spherical or nearly so; the globules may consist of radiating fibers or concentric coats. When attached, as they usually are, to the surface' of a rock, they are described as implanted globules.

Xmlnhir: in tuberose forms, or having irregular protuberances over the surface.

Amygilaloidal: almond-shaped, applied often to a rock (as diabase) containing almond-shaped or sub-globular nodules.

Coralloidiil: like coral, or consisting of interlaced flesuous branchings of a white color, as in the variety of aragonite called/oa/e'Ti.

Dendritic: branching tree-like, as in crystallized gold. The term den-ilritex is used for similar forms even when not crystalline, as in the dendrites of manganese oxide, which form on surfaces of limestone or are inclosed in " moss-agates."

Mossi/: like moss in form or appearance.

Filiform or Capillary: very slender and long, like a thread or hair; constats ordinarily of a succession of minute crystals. Ex. millerite.

Acicular: slender and rigid, like a needle. Ex. stibnite.

Reticulated: net-like. See Art, 248.

Drnsy: closely covered with minute implanted crystals. Ex. quartz.

Slalaclilic: when the mineral occurs in pendent columns, cylinders, or elongated cones. Stalactites are prodooed by the percolation of water, holding mineral matter in solution, through the rocky roofs of caverns, The evaporation of the water produces a deposit of the mineral matter, and gradually forms a long pendent cylinder or cone. The internal stnictnre may be imperfectlv crystalline and granular, or may consist of fibers radiating from the central column, or there may be a broad cross-cleavage. The most familiar example of stalactites is afforded by calcite. Chalcedony, gibbsite, limonite, and some other species, also present stalactitic forms.

The term autorp/tous is used when a mineral has not only no crystalline

form or imitative shape, bat doea not polarize the light even iu its minute particles, and thus appears to be destitute wholly of a crystalline structure internally, as roost opat. Such a structure is also called colloid or jelly-like, from the Grreelc KoWa (see p. 6), for glue. The word amorphous is from a privative, and fioptptf, shape.

262, Fieadomorphoiu Crystals.—Every mineral species has, when dietinctly cryst^Iized, a definite and characteristic form. Occasionally, however, crystals are found that have the form, both as to angles and general habit, of a certain species, and yet diSer from it entirely in chemical composition. Moreover, it is often noted in such cases that, though in outward form complete crystals, in internal structure they are granular, or waxy, and have no regular cleavage. Even if they are crystalline in structure the optical characters do not conform to those required by the symmetry of the faces.

Such crystals are called pseudomorphs, and their existence is explained by the assumption, often admitting of direct proof, that the original mineral has been changed into the new compound; or it has disappeared through some agency, and its place been taken by another chemical compound to which the form does not belong. In all these cases the new substance is said to be a pseudomorph after the original mineral.

Common illustratioue of pseadomorphons crystals are afforded by malachite in the form of cuprite, limonite in the form of pyrite, barite iu the form of

inartz, etc This sabject is further discussed in the chapter oa Ohemical [ineralogy.

PAET II. PHYSICAL MINERALOGY.

263. The phtbioal chabactebs of minerala fall under the following

beads:

I. Characters depending upon Cohesion and Elasticity —viz., cleavage, -fracture, tenacity, hHrdness, elasticity, etc.

II. Specific Oravity, or the Density compared with that of water.

III. CbaracCers depending upon Light —viz., color, luster, degree of transparency, special optical properties, etc.

IV. Characters depending upon Ileat—yix., heat-conductivity, change of form and of optical chamcters with change of temperature, fuaibility, etc.

V. Characters depending npon Electricity and Magnetism.

VL Characters depending npon the action of the senses—viz., taste, odor, feel.

264. 0«neral Relation of Physical Characters to' Holecnlar Stmetnre.—It has been stated on pp. 5, 6 that the geometrical form of a crystallized miners! is the external evidence of the internal molecular structure. A full knowledge in regard to this structure, however, can onlv be obtained by tbe study of the various physical characters included in the classes enumerated above.

Of these characters, the specific gravity merely gives indication of the atomic mass of the elements present, and further, of the state of molecular agpre^ation. The first of these points is illustrated by the high specific .sntrity of compounds of lead; the second, by the distinction observed, for eiample, between carbon in the form of the diamond, with a specific gravity of 3'5, and the same chemical substance as the mineral graphite, with a specifio gravity of only 2.

All the other characters (except the relatively unimportant ones of Class VI) in general vary according to the direction in the crystal; in other words, tbey have a definite orientation. For all of them it is true that directions vhich are cryataHographically identical have like physical characters.

In regard to the converae proposition—viz., that in all directions crystal-Imjrapkically dissimilar there may be a variation in the physical characters, an important distinction is to be made. This proposition holds true for all crystals, so far as the characters of Class I are concerned ; that is, tiiose depending upon the cohesion and elasticity, as shown in the cleavage, hard* ness, the planes of molecular gliding, the etching figures, etc. It is also true in the case of pyro-electricity and piezo-electricity.

It does not apply in the same waywith respect to the characters which involve the propagation of light (and radiant heat), the change of volume with change of temperature; further, electric radiation, magnetic induction, etc.

Thus, although it will be shown that the optical characters of crystals are in agreement in general with the symmetry of their form, they do not show all the variations in this symmetry. It is true, for example, that all directions are optically similar in a crystal belonging to any group under the isometric system; but this is obviously^ not true of its molecular cohesion, as may be shown by the cleavage. Again, all directions in a tetragonal crystal at right angles to the vertical axis are optically similar; but this again is not true of the cohesion. These points are further elucidated under the description of the special characters of each group.

I. CHARACTERS DEPENDING UPON COHESION AND ELASTICITY.

255. Cohesion, Elasticity.—The name cohesion is given to the force of attraction existing between the molecules of one and the same body, in consequence of which they offer resistance to any influence tending to separate them, as in the breaking of a solid body or the scratching of its surface.

Elasticity is the force which tends to restore the molecules of a body back into their original position, from which they have been disturbed, as when a body has suffered change of shape or of volume under pressure.

The varying degrees of cohesion and elasticity for crystals of different minerals, or for different directions in the same crystal, are shown in the prominent characters: cleavage, fracture, tenacity, hardness; also in the gliding-planes, percussion-figures or pressure-figures, and the etching-figures.

258. Cleavage.—Cleavage is the tendency of a crystallized mineral to break in certain definite directions, yielding more or less smooth surfaces. It obviously indicates a minimum value of cohesion in the direction of easy fracture—that is, normal to the cleavage-plane itself. The cleavage parallel to the cubic faces of a crystal of galena is a familiar illustration. Ad amorphcri^ body (p. 6) necessarily can show no cleavage.

As stated in Art. 31, the consideration of the molecular structure of crystals shows that a cleavage-plane must be a direction in which the molecules are closely aggregated together; while normal to this the distance between successive layers of molecules must be relatively large, and hence this last i:; the direction of easy separation. It further follows that cleavage can exist only parallel to some possible face of a crystal, and, further, that this must be one of the common fundamental forms. Hence in cases where the choice in the position of the axes is more or less arbitrary the presence of cleavage is proDerly regarded as showing which planes should oe made fnndameiitftl. Still M;ain, cleavage is the same in all directions in a crystal which arc crystallographically identical.

Glearsge is defined, (1) according to its direction, aa cubic, octahedral, rhombohedral, basal, prismatic, etc. Also, (2) according to the ease with which it is obtaiDed, and the stnootbnesa oi the surface yielded. It is said to be perfect or eminent when it is obtained with great ease, affording smooth, lastroas surfaces, as in mica, topaz, calcite. Inferior degrees of cleaTage ore spoken of as distinct, indistinct or imperfect, interrupted, in traces, difficult. These terms are sufficiently intelligible without further explanation. It may be noticed that the cleavage of a species is Bometimes better developed in some of its varieties than in others.

U7. GIsBTftg* 1q tha DlSraent iTttHW.—(1) In the ibouetbic bysteh, cleavage is cubic, nheti pnr:i]lul to Ibe fuccfs ot the i^ube; this is the cummon cnite, as illuatrHteil by giileua imlliitlite. It li hIso oflea octahtdral —tliat is, parallel lo ihe octHhednil facts, im with fluorite and tbe dlamnDil. Less frequeDlIf it la dpdeailitdi'al, or parallel lo the faces uf ihu rlinmbic dodecnliedmu, ai with sphalerite.

In the TETHAOONAL siaTEM, cleavage is oflea b'ltal, or pnrallel to the hasa.[plaue, as wiih apophylllle; alsoprumalie, or parallel to one (or lioth) of Ihe .square pri>ins. as wilU ruiile aiitl iveruerile; less freqiieutiy it is pyramidal, nr parallel lo the faces of Che square pyramid, ns with BClieelite.

Ill the UBXAOONAL evsTicif. cleavage Is usually either ba»al. as with beryl, or prumalie. parallel lo ooe of the sixsidetl prtguia, as with nepbelite; pyramidiil cleavage, as with pymmorpbite, la rare and imperfect.

In the HHOMBOSBDRAL DIVISION, besidas tbe basal and prisinaiic cleavages. rhomlM-htdral clt'svase, parallel to tbe faces of a rliombohedrou, is also common, as with calcite and tbe allied species.

in the ORTHORSUHBIC sySTEU, cleavage parallel to one or more of the pluocolds is commoti. Thus il Is6a«alwitk topaz, anil iu all three pliilcoidal directious with anhydiite. Pramalie cleavage is also commoo, ns with baiite; hi Ibis case tbe arbitrary posiiiuii ns4iiineil iu di-scrlbicg the crystal may make this cleavage parallel to a "horizoDial priMii," or dome.

In tlif MONOCLiNic BVBTBSf. Hiuodiogonal cleavage,])aralte1 lo Ihe cliiioptnacoUl, is rnaimon, as wilb orthoclase. gypsum, heulamlite ami enclave; also haial, as with the in:cnsaiid orihocliise. or parallel lo tbe nrlbopiiiatoid; also prMtnad'c. as with amphibolc. Leiw frequently cleiivage is parallel to a heiiii-pyramiil, o4 wilh gypsnm,

III the TBiCLisic BVSTBM, il la uatial iind proper lo so select the fundamental foi-m as to niske the cleiiviige liireclious correspond with the plnacoids.

IGS. iu some cases clenvase which is ordinarily not observed maybe developed by a shsip blow or by snililen change of temperature. Thus, qimrlz is ii=ually con»ip!ciLonsly free from cleavage, but a ■41111112 crystrl heated and phingcd Inio cold water ofien showa pUnes of separaliou* parallel to both the + and - rhnmboliedrons and to the priftm ns well. Similarly, the prismatic cleavage of pyroxene la observed with treat distinctness in iIiId sections, made by grinding, while not so readily noted in laree cryiials

When tlie cleavage is parallel lo a closed form—that is. when it Is cubic orlnhedra) .I'Klecnhcdral, or rhonibolKdral (also pyramidal in the letragoual. hexagonal and onhol rhombic syateiiml—a solid resembling a cr\-Bial may often he broken out from a slnelo crystnlline individual, nod al! the fraLrmenta have the same angles. Il is in geiiemi eiisv to distinguish such a clcnvnge form, as a cleavage ocUhedron ot fluorite. from a ini'a irys'al by tbe splintery diarnctcr of the faces of the fonner.

2J9. Cleavage and iMtw.-Tbc face of a crystiil parallel to which there is perfect rlravBL-e often .tliows a pearly luster (see p, tB91, due to the partfil separation of the crysml into parallel plates. Tins is illustrated by th« Im.sal plane of apophyllile, iho diiiopiuacind of sidbite and heulimdita. An iridescent play of colors is also often seen M with cnlcite, when ihe separation has been sufflclenl lo produce ihe prismatic colors bv interference.

260. GUdiny-planefc—Closely related to the cleavage directions in their connection with the cohesion of the molecnlea of a crystal are the glidihg-

planet,* or directions parallel to which a elipping of the molecnles may take plitce under the applicatiou of mechaoical force, as bj preaaure.

This may have the reaiik of aimply producing a auparatioti into layers in

the given direction, or, ou the other hand, and more commonly, there may be

4<jg a revolution of the moleculea into a new twinning-

poaition, bo that secondary twinning-lameUte are

) formed.

Thus, if a crystal of halite, or rock salt, be snb-jected to gradual pressure iu the direction of a dodec-ahedrai face, a plane of separation is developed normal to this and hence iu the direction of another face of the same form. There are six such direclioiis of molecular slipping and separation in a crystal of this substance. Certain kinds of mica of the biotite class often show pseudo-crystalline faces, which are undoubt-B"""^ edly secondary in origin—that is, have been developed

by pressure exerted snbseqnently to the growth of the crystal (cf. Fig. 475).

Iu gtibnlie, tlie l>ase, e (001). Dormal Ui llie ^liiiie of iierfect cleavage, Is a glidiDg-plaxc. TLiis a »HppitiK of the moleculea without llieir gepanitiou muy be nrnde to inke [ilnce by pressure \a ii pTaue (|«) □oruinl to tlie i)irecti>>a of perfect cleavage {\b). A. sktider prts-lUftlic crystal supporied near tlie eniis aud pressed downward by a Uiill edge is reaillly bent, or kuicked, in this directiOD wilbuut Ibe purls beyond tbe support beiug nllccted.

261. Secondary Twinning.— Tbe other case mentioned in the preceding article, where molecular slipping is accompanied by a half-revolution (180°) of the molecules into a new twinning-position (see p. IIS et seq), is well illustrated by calcite. Pressure upon a cleavage-fragment may result in the formation of a number of thin lamellffi in twinning-position to the parent mass, the twinning-plane being the obtuae negative rhombohedron, e (0112). Secondary twinning-lamellse similar to these are often observed in natural cleavage-masses of calcite, and particularly in the gnuns of & iTystalline limestone, as observed in thin sections under the microscope.

Secondary twinnin^-lamelliB may also be produced (and are often noted in nature) in the case of the triclinic feldspars, pvrosone, barite, etc. A secondarv lamellar structure in quartz haa been observed by Judd, in which the lamellie consisted of right-handed and left-handed portions.

By the proper meiuia a coni|>le[e cftlclte twin may bo nrllScially produced by pressure. Tims. ifaclcavngefraBmemofprismalicform. say6-8mm. in leneth 475

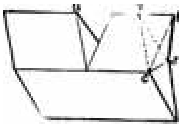
and 3-6 mm. in brendlh. be pincnd wlili tbe obtuse eilgf on n firm bnrJ7.ontn1 Hiipport, and pressed bv tbe blade of nn ordinary table-knife on the other ohluae vAfK (at n, Ffff. 476). the resnl' is ibat tbe portion of tbe cryslnl lytn/j between a and b ia revpraed in p'loition, ns if iwinned parallel in tbe bortzontat plane (0112) If Rltiltrullj done, the twinning surface, gif.-ig perfectly smooth, and the re-eiitmnt anple oorreaponds exactly witb that required by theory.

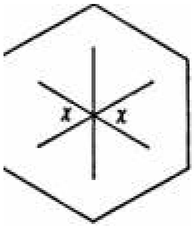
262. Parting. —The secondary twinning-planes described

are often directions of an easy separation—conveniently called parting —which may be mistaken for cloavage-f The basal parting; of pyroxene is a common example of such paeiido-cleavnge; it was long mistaken for cleavage. The basal and rhombohedral (lOTl) and the less distinct prismatic (ll5o) parting

" From the German, OUitfiiiehen.

f The lamellar stmctiiie of a musivo mineral, wllbout Iwinnlng, may also be the cauae of a fracture whicb cat) be mistaken for cleavage.





of cornndum; the octahedral parting of magnetite (cf. Fig. 456, p. 136), are other examples.

An important distinction between cleavage and parting is this: parting can exist only in certain definite planes—that is, on the surface of a twinning-jamella—while the cleavage maj take place in ajig plane having the given direction.

863. PeronMlon-flgUTBB.—Immediately connected with the gliding-planes ■re the figures—ctilled percussion-figures* —produced upon a crystal section by a blow or preasure with a suitable point. In sucli cases, the method described serves to develop more or lees well-defined cracks whose orientation varies with the crystallographic direction of the surface. 477.

Thus upon the cubic face of a crystal of halite a four-njed, star-shaped figQre is produced with arms parallel to the diagonals—that is, parallel to the dodecahedral r-faces. On an octahedral face a three-rayed star is obtained.

The percussion-figures in the case of the micas have beeu often investigated, and, as remarked later, they form n Dieaus of fixing the true orientation of a cleavage-plate having no crystalline outlines. The figure (Fig. 477) is ^ here a six-rayed star one of whose branches la parallel to the clinopinacoid (6), the others approximately parallel to the intersection edges of the prism (m) and base (c).t

Pressure upon a mica plate produces a less distinct Bix-r»ed star, diagonfd to that just named; this is called a pressKve-jigure (Germ. Dntckfiache).

set. flotartioD-pluN.— In the cum of many cryslala, ft fi posatble lo prove tbe ezlBlence ofcen lu dlrectioDB, orstnicturs-planes, in whlcL clie m leal at: I Ion takes place moat reail I ly— for example, when a crystal ia undeTKraiLt preiaure. These directinne of cliemlcal weakue» have been cslled iolmUva--piaiu9. Ttmy often mantfeet lliemsclvea by the preatnce of a muliltuda of oiieoted caviuea of cryaianlne ouillne (Go-cal1ed oegatlve crystals) In tbe given illrectioD.

Tbe«e Bolutlon-planes in certain caves, aa ahown by Judd, are the same aa tbe dlrectiona of aecondnry lamellar twlnniue, as la Illustrated by calclte. Connected with thla Is tbe tchMtriaation (tee Art. MS) observed In certain mluemls lo rocks (as dlalJoge, BChtller-■par).

269. Xtohing'^vni. —Intimately connected with tbe general subjects here considered, of cohesion in relation to crystals, are the figures produced by etching on cryetalUne faces; these are often called etchtng-figures.X This method of investigation, developed particularly by Baumhauer, is of high importance as revealing tbe molecular structure of the crystal faces under examination, and therefore tbe symmetry of the crystal itself.

The etching is performed mostly by solvents, as by water in some cases, more generally the ordinnrv mineral acids, or caustic alkalies, also by steam at : liieh pressure and hydrofluoric acid; the last is especially powerfal in its action, and is used frcc|uently with the silicates. The figures produced are in

'From llie OennsD, Bchlagflgitren. Tbe percussion-flKures are best nbtnlued it the ayslal plate under Investigation be supported upon a liard cushion and a blow be struck with a li^t hammer upon a steel rod the slightly rounded point of which Is held flrmly igahiat tte surface.

tCf. Walker, Am. J. Be , 2, 5, ISH. and o. Priedel. Bull. Soc. Mb., 19, IS. 1866. Walker found the angle oppoatte ((010) (x In Fig. 477) to be 08* to H* for muscovile, GO*

the majoritj of cases angular depressioiiB, such as low triaugular or quadri-

lateral pyramids, whose out!in

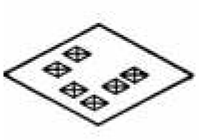
run parallel to some of the crystalliL edges, ill some cases the planes produced can he referred to ocuurriug crystallo-graphic faces. They nppear alike on similar (aces of crystals, ai)d hence serve to , distiiigiiieh different forms, perhaps in

appearance identical, as the two sets of faces in the ordiuary donhle pyramid of ! quartz; so, too, they reveal the compound twinning-Etructure common on some crystals, as Cjuartz and aragoiiite. Fnrther, their form in general corresponds to the symmetry of the group to which the given Qiiurti. Hglit Qunriz. Irft- crystal belongs. They thus reveal the

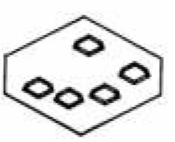
liuudeJ crystal hnmiert rryeial. trapezohedral symmetry of ijnartz anil the

difference between a riglit-handed and left-handed crystal {Figs, 478, 479); the distinction between calcite and dolomite (Figs. 483, 4S3); the distinctive character of apatite, pyromorphite, etc ; the hemimorphic symmetry of calamine and nepnelite (cf. Fig. 220, p. 73), etc,; they also prove by their form the monocliuic crystallization of muscovite and other micas (Fig. 481).

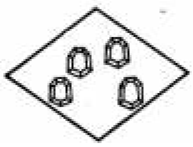
480.



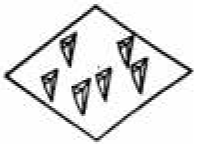
481.

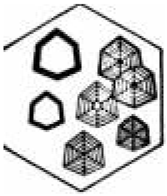


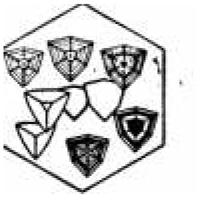
482.

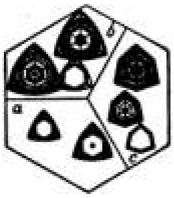


483.



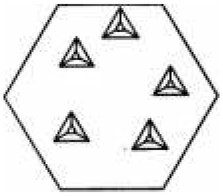






Tbe shape of the etcliing-flgures may vary with the same crrstal with the nature of the solvent employed, though their symmelTy remaius coniCant. For eiainplc, Fig. 484 shows the flguKS obtsiDed with Bpaugollte l>y the nciiou of sulphuric acid. Fig. 485 bj tbe same diluted, and Fig. 486 by hydrochloric acid of dISerent degices of coucentraliou.

Of the same nature as tbe etching-figures artificially produced, in their



RlAtioD to the symmetry of the crystal, are the markings often observed on

the natural faces of crystals. 4B^ 4gg

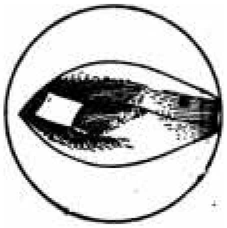
Tbese are sometimes aecoiidary, caused by a natural etcbiiig process, but are more often an irregularity in the crystalline development of tbe crystal. Tire inverted triangular depressions often seen on the octahedral faces of diamond crystals are an eiample. Fig. 487 shows iiataral depressions, rhombohedral in character, observed on comDdam crystals from Montana (Pratt).

Fig. 488 shows a twin crystal of fluorile with natnral etching-figures (Pirsson); these are minute pyramidal depressions whose sides are parallel to the faces of the trapezohedron (311).

266. CorroiioB Forms.—If the etching process spoken of in the preceding article—whether natnral or artificial—is continued, the result may be to destroy tbe original crystalline surface and to snbstitnte for it perhaps a moltitude of minute elevations, more or less distinct; or, further, new faces may be developed, the cryatallographic position of which can often be determined, though the symbols may be complex^ This is illustrated by Fig. 489 of beryl; here x is the berylloid (36-34-60-5). The mere loss of water in some cases produces certain corrosive forms (see Pape, literature).

Penfifid siibjecled a sphere of qiiftrti (from a simple rlBlil-hnnrled iDdlvidiial) to the prolonged acliou of liydroflitoric acid. It was found that It was Attacked rapidly Id tbe din;ctioii of tbe vertical ai!«, but barely at nil At ttie -{- extremities of the Bcea. ¥lgs. isn, 491 iliow the form remainlus After the sphere hnd been etched for seven weeks;

489. 490. 491.



Mg. 400 is a basal view; Fig. 491, a front view; the circle abows the original form of llie sphere, the dotted hexagon the nosltlon of tbe axes. Compare also Uie results of Heyer on calcite (see litemture. p. 1S5).

267, Pntctore. —The term fraclnve is used to define the form or kind of enrface obtained by breaking in a direction other than that of cleavage in erystallized minerals, and in any direction in massive minerals. When the

oleava^ is highly })erfect in eeveral directioos, as the rhombohedral cleavage of calcite, fracture is often Dot readily obtainable.

Fracture is defined as:

(u) Conchoidal; when a mineral breaks with curved concavities, more or leas deep. It is so called from the reseDiblance of the concavity to the viilve of a ahell, from conciia, a shell. Thia is well illustrated by obsidian, also by fliut. If the resuitiog forms are small, the fracture is said to be sniall-conchoiilal; if only partially distinct, it is subconchoidal.

(b) Even; when the surface of fracture, though rough with numerous Bmaill elevations and depressions, still approximates to a plane surface.

(c) Uneven ; when the surface is rough and entirely irregalar; this is true of most mineriUs.

(d') Hackly; when the elevations are sharp or jagged; broken iron. Other terms also employed are earthy, aphntert/, etc.

268. Hardneu.—The hardne»» of a mineral is measured by the resistance which a smooth surface offers to abrasion. The degree of hardness is determined by observing the comparative ease or difficulty with which one miueral is scratched by another, or oy a file or knife.

In minerals there are all grades of hardness, from that of talc, impressible by the fioger-oail, to that of the diamond. To give precision to the use of toie character, a scale of hardness was introduced by Mohs.* It is as follows:

1. Talc. 6. Orthociase.

2. Oypium. 7. Quartz.

3. Catcile. 8. Topaz.

4. Fluorite, 9. Sapphire.

5. Apatite. 10. Diamond.

OrystsIIine varietiee with smooth surfaces should be taken so far aa possible.

If the mineral under examination is scratched by the knife-blade as easily as oalcite its hardness is said to be 3; if less easily than calcite and more so than fluorite its hardness is 35. In the latter case the mineral in question would be scratched by fluorite but would itself scratch calcite. It need hardly he added that great accuracy is not attainable by the above methods, though, indeed, for purposes of the determination of minerals ezactneas is qnite unnecessary.

It slAuld be noted that minerals of grade 1 have a greasy feel to the hand; those of grade 2 are easily scratched by the finger-nail; those of grade 3 are rather readily cut, as by a knife ; of grade 4, scratched rather easily by the knife ; grade 5, scratched with some difficnlty; grade 6, barely scratched by a knife, but distinctly by a file—moreover, tney also scratch ordinary glass. Minerals as hard as quartz (H. = 7), or harder, scratch glasa readily out are little touched by a file; the few species belonging here are enamerated in Appendix B ; they include all the gems.

269. Sderometer.—Accurate determinations of the hardness of minerala can be made in varions ways, one of the best being by nse of an instrument called a sclerometer. The mineral is placed on a movable carriage, with the enrface to be experimented upoD borizootal; this is brought in contact with a stcci point (or diamond point), fixed on a support above; the weight is thea ijetermined which is just Gufficienl to move the carriage and produce a scratch on the surface of the mineral.

By means of such an instrument the hardnesB of the different faces of a given crjBtal has been determined In a variety of cases. It haa been found ibat different faces of a crystal {e.g., cyanite) differ in hardness, and the aanie fiice may differ as it is scratched in different directions. In general, differences ill hardness are noted only with crystals which

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* Tbe iDierva] between 3 and 8. and S and 6, in ihe u»1e of Hobs, being a little greater tban between the other numben, Breltbnupt proposed n Bcnle of ttMlve mluerali; but tbe Miale of Hobs li now unlverMllf accepted.

show distinct cleavage; the iijirdeBt face is that which is intersected by the plane of most complete cleavage. Further, of a single face, which is intersected by cleavage-planes, the direction perpendicular to the cleavage-direction is the softer, those {nruUel to it the harder.

Tlii" Euliject has beeu investlgaled by Kiiier (p. 1S5}, wbo bai given the form of the esrnu of bardnett for lUe dlfferuiil fiices iif many ciystaU. These cqi ves ai-e obtaiued as fo lows ^ the least weight reqiiii'ed to Bcnitcli n crystBltine Biirrnre Id different directions, fur eacli lO" Or 16'. from 0° lo 180°, is delermim-ii wiih the scleromeler; these directions ire laid nff as radii f rojii a center, niid the length of each Is irtnila propnrllonal 10 the weight nxml by eKperimeut—that is. lo the harrtvesa thus deieimintd; the line couueotiug the Mirfniilies of these rndii is the curve of Iianlnesa Tor the given face.

The Following table gives the resulis ohla-tied ■ (see tileratiire) in comparing the hard* tiesauf llie miDt'Dils of tlie scale from connidum, No. 9, taken as IDOO, to gypsum, No. 3. PfaS useil [be muthoil of boring with a stHndard point, the hardness lieing determfued by ilie number of roiatlous: Kosfwal used h stiiudaril powder lo grind the surface. Jnggar emplu/ed his microBClerouieler, the method being esscDllally a modification of that of Pfiiff. By means of this instrument he is able to test the hardness of the minerals present ina tijin section under the microscope. Measurements of absolute bafdneM have also been made by Auerbach.

VttB. 1884. Roslml, IBOI. Jaggar. IStT.

». Corundum 1000 1000 1000

8. Topaz 459 188 152

» 7. Quanai 264 149 40 ,

«. Orthoclaae 161 38'7 2S

S. Apatite 88-5 6-30 1-38

4 Ffuorito 878 470 -76

8. Calcito 15-8 3-68 -26

a. Gypsum 13 08 84 04

tro. BaUtion et Haidnea to OhrailDal Cttmpadtinu—Some general facts of importance «u be Slated t in regard to the conoectiou butweea Ibe bnrdneas of a mineral and its chemical composition.

1. Compounds of the heavy metals, as silver, copper, mercui^-, lead, etc., are «^, Iheir

hardness seldom exceeding 3'5 lo 8.

Among the compouods of the common metals, the sulphides (arsenides) and oxides of iron (also of nickel and cobalt) are reladvelv hard (e.g., for pyrite H. = 6 to S'S; for bematite H. = S, etc.); here belong also columblte, iron nlobate, tanlallte, iron lantalale, wolframite.iron tungslale.

2. The sulphide* are moelly relatively soft (except ns noted iu 1). also moat of the csrboDates. sulphates, end phosphates.

S. Hydrous salts are relatively soft. This is most dlsllnclly shown among the si icatea— i.g.. compare the feldspars and zeolites.

4. The conspicuously hard minerals are found chiefly amoog the OxIdM and alUcales; manyof them are compounds cootalntng aluminium— e.g., corundum, diaspore, chrysobervl, and many alumbio allicatea. Outside of ihese the borate, borscite, ia hard (H. = 7); also iridosmlite.

Od the relation of hardness lo specific gravity, see Art. MO.

* 1liB immbera are here dven aa tabulated by Jsggar. -t See further In Appendix B.

871. PiMtioftl Buffg«ftloni.—Sevenil poliite alioulld be regarded Id the trials of hnrdiiess:

(li If [he mEtierul fs Blighlly allereii. 'is Is often the cuee wltli coruuduai, garnet, etc., tbe surface inuj be readily screiclied wlitu ibis would be impusalbie with tbe miatral Itself; a [rial witli nu edge of tlie lalier will often give a correct result iu such a case.

1^) A miiteral with a granular surface often appears to be scralclied wbeii tlie grains liave been only turn apart urcrusLed.

(it) A reliiitvely Hof t miueral may leave a faiut white ridge OD a surface, as of glaae, wUicU nuu be tnisinkeii for a scratch IF carelessly observed.

(4) A crystal.aBuf quartz, is often slightly BCratclied by the edge of another of Ihe same «peciee and like bardoess

(5) The scratch should be made Iti such a way aa 10 disfigure the ipeclmea as little aa

272. Teaaoitf.—Minerals may be either brittle, aectile, malleable, or flexible.

(a) Brittle; when parts of a mineral separate in powder or grains on attempting to cnt it, as calclte.

(5) Sectile; when pieces maybe cut ofE with a knife without falling to powder, but still the mineral pulverizes under a hammer. This character is intermediate between brittle and malleable, aa gypsum.

(c) Malleable; when slices may be cut off, and these slices flattened oat nnder a hammer; native gold, native Eilver.

{d) Flexible; when the mineral will bend without breaking, and remain bent after the bending force is removed, as talc.

The tenacity of a Bubstance is properly a consequence of its elasticity.

273. Elartioity—The elasticity of a solid body eipresHes at once the resistance which it makes to a change in shape or volume, and also its tendency to return to its original shape when the deforming force ceases to act. If the limit nf elasticity is not passed, tl^e change in molecular position is proportional to the force acting, and the former shape or volume is exactly resumed; if this limit is exceeded, the deformation becomes permanent, a new position of molecnlar equilibrium having been assumed; this is shown in the phenomena of gliding-planes and secondary twinning, already discussed. The magnitude of the elasticity of a given substance is measured by the inefficient of elasticity, or, better, the coefficient of restitution. This is ilefiiied ns the relation, for example, between the elongation of a bur of unit section to the force acting to produt* this effect; similarly of the bending or twisting of a bar. The subject was early investigated acoustically by Savart; in recent years, Voigt and others have made accurate measures of tlie elasticity of many substances and of the crystals of the same substance in different directions. The elasticity of an amorphous body is the same in all directions, but it changes iu value with change of crystallographic direction in.all ci'ystals.

The distinction between elastic and inelastic is ofteti made between the species of tbe mica group and allied minerals. Muscovite, for example, is described aa "highly elastic," while phlogopite is much less so. In this case it is not true in the physical sense that muscovite has a high value for the coefficient of elasticity; its peculiarit;^ lies rather in the fact that its elasticity is displayed through unusually wide limits.

LrrEBATTTRK.

UardMu.

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II. SPECIFIC GRAVITY OR RELATIVE DENSITY.

274. Definition of Speoiflo Gravity.—The specific eraTity of a mineral is the ratio of its deosity • to that of water at 4° C. (39-2° I,). This relative detisitj may be learned in auy case by comparing the ratio of the weight of a certain volume of the given substance to that of an equal volume of water; heuce ilio specific gravity ia often defined as: the weigki of the body divided by Ike n-eig'.l of ail equal volume af water.

The statement that the specific gravity of graphite is 2, of corundum 4, of galena 7'5, etc., means that the densities of the minerals named are 2, 4, and 7'5, etc., times that of water; in other words, as familiarly expressed, any volume of them, a cubic inch for exitmple, weighs 2 times, 4 times, ?'& times, etc., as much as a like volume, a cubic iiicli, of water.

Strictly speaking, since the density of water varies with its expansion or contraction under change of tempenanre, the comparison should be made with water at a fixed temperature, niunely 4" C (39'2° F.), at which it has its maai-miim density. If made at a Jiiglier temperature, a suitable correction should be introduced by calculation. Practically, however, since a high degree of accuracy is not often called for, and, indeed, in many cases is impracticable to attain in consequence of tliu nature of the material at hand, in the ordinary work of obtaining the specific gravity of minerals the temperature at n-hicti the observation is made can safely be neglected. Common variations of temperature would seldom affect tJie value of the specific gravity to the extent of one unit in the tMrd decimal place.

For the same reason, it is not necessary to take into consideration the fact that the observed weight of a fragment of a mineral is less than its tme weight by the weight of air displaced.

Where the nature of the investigation calls for an accurate determinntinn of the specific gravity (e.g., to four decimal places), no one of tlie precautions in regard to the purity of material, exactness of weight-measurement, temperature, etc., can be neglected.f Tlie accurate values spoken of are needed in the consideration of such problems as the specific volnme, the relation of molecular volume to specific gravity, and many others. Some of these have been discussed by Schroder, Hunt, also (for salts) by Playfair and Joule, etc.

275. Determination of the Bpecifio Gravity by the Balanoe.—The direct comparison by weight of a certain volume of the given mineral with an eqnal Volume of water is not often practicable. By making use, however, of a familiar principle in hydrostatics, viz., that a solid immersed in water, in consequence of the buoyancy of the latter, loses in weight an amount wiiich is equal to the weight of an equal volume of the water (that is, the volume it displaces)—the determination of the specific gravity becomes a very simple process.

The weight of the solid in the air (w) is first determined in the nsnal manner; then the weight in water is found (u>'); the difference between these weights—that is, the loss by immersion (w — w') —ia the weight of a volume of water eqniil to that of the solid; final];, the qnotient of the first weight {to) by that of the equal yolame of water as determined (tc — w'] is the BpeciGo gi-Hviiy (G). lleuce,

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* TbB deruxljf of a body la strictly tAe mat* cf Ou unit volume. Thus If & cubic centl-metsr of water (at Its mail mum density, 4' C. or 89'3° F.}fs taken aa tbe unit of most, tbe deustty of any body—as gold—ts pitveo by the number of grams of mass (atMUl 19) in a cubic centlmeier ; lu tlii^ case the same number, 19, gives tb« relative density or speciflc gravity. IF. bowever, a pound is taken as tbe unit of mass, and the cubic foot as Uie unit of volume, tbe maw of a cubic foot of water is <t2'0)ba., ibat of gold about 118S Ibe., and the ■peciflc gravity Is the ratio of tbe second to the fint, or. ag^o, 10.

t Cf.lEail of Berkeley in Hio. Hag., 11, H 180B-

W — W

A common method of obtaining the epecific gravity of a firm fragment of a luiiieral is as follows: First weigh the specimen accnrately on a good clieiiiicHl balance. Then suspend ic from one pan of the Imlmice by a horse-hair, silk tlirend, or, better etiH, by a fine jiJHiiiiimi wire, in a glass of water conveniently placed beneatii, and take tlie weight again with the same care; tlien use the results as above directed. The platinum wire ni:iy be wound around tJie specimen, or where the hitter is email it may be made at one end into a little spiral support,

276. The Jolly Balance.—Instead of using an ordinary Imlancc and determining the actual wciglit, the spiral bidance of Jolly, shown in i-'ig. 4i>2, may be conveniently employed; Iliis is also suitable when the mineral is in the form of small grains. The mineral is first placed on the ghies pun c, and the amount that the spring is stretched noted by the scale number (.V,),opposite to which the indei lit HI comes to rest (the eye sees the reflection in the mirror and thus avoids error by paralluji). If from'..V, be sub-tnicted the number n, expressing the amount to which the scale ia stretched by the weight of spring and pans alone, the difference will be proportional to the weiglit of the mineral. Next, tlic mineral is placed in the lower pan, d, immersed in the water, and again the corresponding scale number, A*„ reail. The difference between these readings (.V, — JV) ia a number proportional to the loss of weight in water. The specific gravity is then

It is obviously necessary to have the wires supporting the lower pan immersed to the same depth in the case of each of the three determinations. If care is taken the specific gravity can be obtained accurate to two decimal places.

277. Pycnometer.—If the mineral is in the form of grains or small fragments, tlie specific gravity may be obtained by use of tlie pucnomeler. This is a email bottle (Fig, 493) having ii stopper which fits tightly and ends in a tube with a very fine o])eniug. Tlie bottle is filled with distilled water, the stopper inserted, and tbe overflowing water ciiretully removed with a soEt cloth. It IS now weighed, and also the mineral whose density is to be determined. The stopper is then removed and the mineral in powder or in small fragments inserted with care, so as not to introduce air-bnhbles.* The water which overflows on replacing tlie stopper is the amount of water displaced by the mineral. The weight of the pycnometer with the inclosed mineral is determined, and the weight of the water lost is obviously the difference between this last weight and that of the bottle and mineral together, as first determined.

The specific gravity of the mineral is equal to its weight alone divided by the weight of the equal volume of water thus determined. Where this method id followed with Bufficient care, eepecially avoiding any change of temperature in the water, the results may be highly accurate.

If the mineral forma a porous mass, ic may be first reduced to powder, but 493. it is to be noted that it has been ebowu by Rose tliut uhem-

ical precipitates have uniformly & higher density than belougs to the same substance in a less finely dividtd state. 'I'bis increase of density also characterizes, though to n less extent, a mineral in a fine state of mecbanical subdivision. It is ex-

Slained by the condensation of the water on the surface of le powder. 278. Use of Liqaidi of High Density.—It is often found conveuieut both in the determiuation of the specific gravity I and in the meclianical separation of fragments of different

specific gravities {e.g., to obtain pure material for analysis, or again in tlie study of rocks) to use a liquid of high density —that is, a so-called hetivi/ -whilton. One of these is the solution of mercuric iodide in potassium iodide, called the Soustadt solution or Thoulet solution. When made with care* it has a maxinmm density of nearly 3*3, which by dilution may be lowered at will.

A second solution, often employed, is the Klein solttlioii, the borotungstate of cadmium, having a maximum density of 36. This again may be lowered at will by dilution, observing certain necessary precautious. Still a third solution of much practical value is that proposed by Brauns, methyl iodide, which has a specific gravity of 3'3SJ. A number of other solutions, more or less practical, nave also been suggested (see papers referred to in tbe literature on p. IGO, which also give tbe necessary directions for the use of tbe liquids). When-one of these liquids is to be used for the determination of the specific gravity of fragments of a certain mineral it mnst be diluted until tbe frng-mcnta Just float and the specific gravity then obtained, most conveniently by the Westphal balance (Art, 279).

When, on the other hand, tbe liquid is to be used for the separation of the fragments of two or more minerals mixed together, tbe material is first reduced to tlie proper degree of fineness, tbe dust and smallest fragments being sifted out, then it is introduced into the solution and this diluted until one constituent after another sinks and is removed. For the convenient application of this method a snitable tube is culled for and certain precautions mnst he observed; compare the papers noted in tbe literature (p. lUO), especially one by Pen field.

878. Waatph*!'* Bftlanoe.—The Weslpliitl balance ia I'onvenieiitly used lo ileiermiD fUM-ific gniviiy "f a li(|uiil, anii Letice of a mineral when a heavy sohition U pmplny ' 278). It cODsIsts esseolially of a grailiiaieil etei'lyanl arm. upon which the weighia

Hperific gniviiy "f a li(|uiil, anii Letice of a mineral when a heavy sohition ia pmplii_v<d (Arl. 278). It cODsIsts esseolially of a grailiiaieil etei'lyanl arm. upon which the weights Jii ilic form of lidvra, are placed. Thesi: roual be so najusled thai the Eitiber in Freelv EUsprmled

he given liquid while the Index at llic end poluts lo the zcri of the scale ami shows ' the arm is horizontal (cf. Itoaenbnscli. Mikr. Phys. Hiu., p. 24G). The grndnatlou usually allows of the spcciBc gravity being rend off diieclly without ca'culntloQ.

SBO. Balation of Dsntltr to Hardniu, GhBiiii«ftl Compoaitlim. (to.—The densily, or specific gravity, of a solid depends, flnt, upon the aature of the cheniicitl substances wjiicli it con-Xnlofi. and, second, upon the stale of molecular ag!;regiiliuD.

Thus, as iiu illuBtratioQ of the first polal, all liiid couipouuds have a high deusiiy (O. = about S), since lead U a heavy melal, or, chemically expressed, has a high alomic weigliC (206'4) Sltnllarly, bftrium sulphate, barite, lias a specitic gravity of 4 5, while for

t See tbe directions by Goldschmldt, refereuce od p. 160.

csldum aulphaU or anhydrite the value Is OD]y 3'95 (at. weight for barium 187, for caldum about 40).

On the other hand, wblle aluminium la a metal of low denally (0. = 2'S and atomic weight = 27), fia oxide, corundum, has a remarkably Aigh deoBlty (Q. = 4) aud Is also verr luudtH. =9). Again, carbon (at. weight = 12) bass b!gh density In the diamond (0.=8'5) aDdlowlnBTaphlle(0. = 2): also, the Brit U hard (H. = 10). iLe second soft (H. = 1'6). In these and •unilar cases the high deuslty ilxnifles great molecular aggregaiioD, and hence It la natural that It should be accompaQted by great faardnesa aad reautauce lo the attack of aclda.

Aa bearing upon iLIs point, It Is to be noted that the density of many Bubslaucea Is altered by fusion. Again, tbe same mineral in different states of moleculHr aggregation may dlOer (but only slightly) In density. Furthermore, minerals havlDK tbe same chemical composition have sometimes dISerent densities, corresponding to llie different cryslallioe forms in which Ibey appear. Thus in (be case of calcium carbonate (CaCOi), calclte his G. = 3-7, aragonlte lias G. = i-0.

Ml. ATirage Bpsstfls SraTltiss.—It is to be noted chat among minerals of unuetaluc LDBTER the aMraga specific gravity ranges from 26 to 8. Here belong quartz {2'M), calclle (2-7), the feldspars (3'6-2'7G). muscovlte (28). A speclQc gravity of 2'S or less Is loa, and Is chanicterUtlc of soft minerals, and often those wlilcb are bydruus {e.g., gypsum, O. =: 2'8). The common species fluorite, tourmaline, apatite, vesuvisuUe, ampblbcie. prrozene, and epldote lie jusl above the limit given, uamely, 'iO lo 3'G. A specific gnivlly 013'5 or above Is relatively hig/i, and belongs to bard minerals (ns corundum, see An. StO), or lo those conlaEoIug a heavy metnl, as compounds of Btronlium, barium, also iron, tungsten, copper, silver, lead, mercury, etc.

With minerals of metallic lustkb, tlie iiverage is about 5 (here belong pvriie, beinmiie, etc.), while if below 4 it is relallvelj- low (gni»hi(e 2, slibuile 4'3); if 7 or iibove, reliitivt'iy high (as galena, 7G).

Tables of minerals arranged accordiui* in their specific gmvlty are glveu In Appendix B.

2>2. Constane^ of Bpsoifla Sravity.— TIil' spei-ilic gravity of a mineral species Is a character of fundamental importance, and is blcbly consinnt for dltfereut specimi-DS of the same species, if pure, free from cavities, solid Inclusions, etc, and it essentially coustiinl in composition. In tbe case ot muny species, however, a premier or less varlaiiou exists in the chemicnl composition, anil tills at once cnusea a varinnon in s|>eciBc gravity. Tbe different kinds of gnrnet illustrate Ibis point: also Ihe various minerals intermediate between the iniitalnie of iron (aod maugaoeKe) and the niobate, varying from O. = 73 or above lo

US. Practical Sngg*stloni.~Ii should be noted tbat the determination oF the specific prnvily Las iilllevtilue unless Ibe fragment taken la pure and is free from impurities, internal and exienial, imd not porous. Care uniat be taken to exclude olr-bubbies, and it will often be founil well lo moisleu the surfnce of the specimen before inserting it in the tvaier, and sometimes boiling (or the use of tbe uii-pump) la necessary to free it from air. If It aluurbs water Ibis latter process must be allowed to gu cm till the substance la fully saturated. No accurate determinations can be made uuleiis the clianges of temperaiute are rigorously excluded and the aaual temperaCui^ noted.

In a mechanical mixture of two coostlluents in known proportions, when tbe specific gravity of the whole and of one are kuowu, that of tbe other can be readily obtained. This method is often Important In the study of rocks.

It is to be noted Ihiit the band may be soon trnloea to detect a difference of specific gravity, If like volumes are Inken. even In n small tmgment—tiiiis the difference hetween calclte oi aiblte and bsrlle, even lite difference between a small diamond and a quartz eryalul, can be detected.

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Websky. Die Miner»lk-n mich < meueii und gcfuudenen Weriheu. 1'

Cm a/ Baatp Bolaliont, tie. :

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ni. CHABACTEES DEPENDING UPON LIGHT.

GENERAL PRINCIPLES OF OPTICS.

SB4. Before considering the optical charactere of minerals in general, and mriTe particulurlj tlioee tliat belong to tlie crj'Btals of the different syetems, it is desirable to review brieSy some of the more important principles of optics upon which the phenomena in qiieation depend.

r'or u fiilk-r (liscl1^4iiun of tlis imtica of crysliiltt. Bpvcial inference is iniide U> Ibe work) of Gruili. Llcbiitcii. Mallard, and Riuietibuficb (mill tniuslatiuD by Iddiucra) meDtioueij ou pp. 3 and 4; also to Ibe vnriiiiia advanced text-books of Pliyaic?. The melbdds of iuveiiii"aLluD. with tb<' results of tbu exBiuiDBtiouurnuiLiy apecies. are given io ibe admirable meiuoire by Des Cloizeniiz in Aud. Midcb, 11, 241-343, 18.^T: 14. 3»9-12U, I8081 6. 557^ 50.7. 18(i4. Also bis Noiivellea Recbercbcs, eic, 2;'2 pp., 1867. Early observaiions were iilso publlsbed by Gniilicb (Vienna, 18:>0) and by Oraiiicb aud ^011 Lang (Bcr. Ak. Wien. 27.:), 1857; 32, 43, 1858: 33. 866. 1858). References to muoy ImporUnt papers iu special flubjei'ls are given Inlet.

285. Sature of Light—The propagation of light from a luminous body, ae the sun or a caTidie-flame, is believed to be accompliahed by a very rapid wave-motion* in the medium culled the Inminiferous ether, which, it is assumed, pervades all space as well us all material bodies.

286. The Etiier—The assumption of the medium called the ether is necessary, since withont this it is impossible to explalin the transmission of light throtigli K|i:ice where no ordinary medium (as the air) is present. Furtlicrmore, as tlie velocity of light even within solid media, though less than that in a vacuum or in air, is still enormously rapid, it is inconceivable that it should be propagated by the molecules of the body; hence the

assnmp-tiou, otherwise verified, that the ether pervades all material bodies. The properties of the ether.f however, are mnailied by the molecular structure of tlie given body, as is proved by the fact that the velocity of light varies with the cJiemical nature of the substance, and ulso in certain cases with the direc-

* It Ix DOW genendly accepted thai llgb' ia an electro.magnetic pliennmeuon and that the nature of the periodic molion in tbe ctber by wbich lliihi is pn>pagaied la tbc siiine as that iuTolved In Ihe transmission of electric wavea pnxiuced. for example, by a very rapid osclllaiory electric discharge between two spark-knobs. In facl these electric wnves have been sliown 10 travel with the same velocity as ligbt-waves, and to exhibit like phenomena of vefli-c'iou. refraction, polarization, etc.; liecne they are believed to differ from Hpht. waves only In llielr nincli greater lengih. For tbe purposes of tbe present work, however, liftbl-waves are treated of aa if a mechanical phenoiTienon, but all assumption of vnilations of tbe "elasticity of Ihe ether" in crystals as an exphinatiou of tbe observed variation of ligbl-velocity la avoided.

t Keference is made to an article by Clerk Maxwell in the Bnej/eioptdia Brilanniea for a discussion of the general properties of the luniiniterons ether.

tion in the ^ven crystallized medium as corresponding to its particular molecular structure.

287, Wave-motioa in OeneraL—A familiar example of wave-motion is given by the series of concentric vavea which on a surface of emooth water

J a out from a center of disturbance, as the point where a pebble has been ropped in. Theee sorface-waves are propagated by a uiotion of the water-particleB which is transverse to the direction in which the waves themselvea travel; this motion is given from each particle to the next adjoining, and eo on. Thus the particles of water at auy one spot oscillate up and down,* while the wave moves on as a circular ridge of water of constantly increasing diitneter, but of diminishing height. The ridge is followed by a valley, indeed both together properly constitnte a wave in the physical sense. This coDipODod wave is followed by another wave and another, until the original impulse has exhausted itself.

Another familiar kind of wave-motion is illustrated by the sound-waves vbich in the free air travel outward from a sonorous body Id the form of concentric sphiires. Here the actual motion of the layers of air is forward snd back—that is, in the direction of propagation of the sound—and the effect «f the transfer of this impulse from one layer to the next is to give rise sllemately to a condensed and nirefied shell of air. which together constitute SBoand-wave and which eipand in spherical waves of constantly decreasing inteuaity (since the mass of air set in motion continually increases). Souud-iTttTes, as of the voice, may be several feet in length, and they travel at a rate of llliO feet per second at ordinary temperatures.

28S. It is important to understand that in both the cases mentioned, as in every case of free wave-motion, each point on a given wave may be considered IS a center of disturbance from which a system of new waves tend to go out, I'hese individual wave-systems ordinarily destroy each other except so far as tiie onward progression of the wave as a whole is concerned. This is further discussed and illustrated in its application to light-waves (Art. 292 and Figs. 495, 496).

In general, therefore, a given wave is to be considered as the resultant of all these minor wave-systems. If, however, a wave eiicoimters an obstacle in its path, as a narrow opening (i.e., one narrow in comparison with the length of the wave) or a sharp edge, then the fact just mentioned explains how the waves seem to bend about the obstacles, since new waves start from them as centers. Tiiis principle has an important application in the case of lightwaves, explaining the phenomena of diffraction (Art. 308).

SBS. Btlll nnotlier ctisc ol wave motion mnj be meiitioDed, since It is porttciilarly helpful in giving II correct iipprGht^nsion of liffbt-plienoRieua. If a long rope. attHCtiecl al uiie tud, bi' grH8[)e<l at tlie other, il quick molfoii oF the himd, up or dowu, will give rise to a half wnvi'-fonn—in one case n crest, \a tbe.otlieia iroiigb—whicli will travtl quickly to Uie oilier liiiDd Hiid be reflected back willi a revtreal in its poailion; that is, if ii weul forward Its a liill-likc wari;, it will return iis ii tnmgh. If. jiiat ns tbe wave iiat reacbeil (he eod. ii W'Cond like one be started, the iwo will mei:t and pnss in Ihe middle, but here for a brief iiiilerval Ibe rope h NsDsibly iit rest, since it feels two equal and opposite impulses. Tbie vill be seen laler to be a case of tiic simple interference of two like waves opposed Id pliase.

Agnin, a double motion of tile hnnd, up ntid dowD, will produce a complete wave, wltlt cresi anil trough, ns the result, and tliis iigain is reUected back as in the simpler case. Still agalD, if a series of Ifke motiimn are conticueil rhythmically and so limed that ench vive is AD even pari of the whole rope, liie two systems of equal and opposite wave* [(issing in Ihe lw« directions will iiiii-rrL-re and a system of so-ciilled stationary wiives will be Ihe result, the rope seeming to vibrate in aegments to wd fro about the posHion of equililiriiim.

Filially, if tlie end of the rope be made to describe a small circle at a rapid. uniforiQ. rliytbmical rate, a system ot atationary naves nill again result, but now the vlbratluus of tbe atring will be seualblv In circles about tbe central line. Tbis last case will be seeu ti>

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* Strictly speaking, the patli of encii piiriicle approximates closely to a circle.

rougbly indicate the kind ot transverse vibrations by wbich tlie waves of circularly polarized light are propagiLled, wbile the former case represents the vibraiions of waves uf wbat Is called p lime-polarized light.

All these cases of waves obtaioed with a rope deserve to be carefully cnnaMereO ami studied by ezperiment, for the cake of Ihe asslsiauce tliey give to an uuderBtimdiug of ilie complex pbeeoiueaa of light-waves.

290. Ware-len^h, Amplitude, etc—In the cases mentioned, as in all kinds of simple wave-motion, the length of a wave is the distance from anj one particle of the mediamto the next which is moving inthe same direction with the same velocity, or, technically ezpresGod, which is in the same phase. The amplitude of the wave is the excursion to or fro from its position of equilibrium made by each particle in Buccesaion. Further, the wave-system travels onward the distance of one wave-length in tbe time that a given particle makes a complete excursion to and fro.

291. Light-wavei.—Tbe propagation of ether-waves-involves the same fundamental principles as the familiar forms of wave-motion just considered. Here the motion of the medium is transverse to the direction of propagation, and this motion may be regarded as communicated from one set of particles to the next and so on, the ether-waves traveling as concentric spherical waves (in an isotropic medium) outward in all directions from the luminous point.

The nature of the vibrations will be better understood from Fig. 494. If AB represents the direction of propagation of the light, each particle of ether must vibrate at right angles to this as a line of equilibrium. The vibration of the first particle induces a similar movement in the adjacent particle; this is communicated to the next, and so on. The particles vibrate succeaaivel; from the line ABto adietance corresponding to 6^, the am/i/i7urfs of the vibration, then return to b and pass on to b", and so on. Thus at a given instant there are particles occupying all positions, from that of the 4M.

extreme distance 6', ore*, from the line of equilibrium to that on this line. In this way the wave moves forward, while the motion of the particles is only transverse. The distauce between any particle and the next wnich is in u like position—I.e., of likepAnsfl, as 6'and c'— is the wai-e-le7igl7i; and the time required for this completed movement is the time of vibration, or vibration-period. The intensity of the light varies with the amplitude of the vibration, and the color, as explained in a later article, depends upon the length of the waves; the length of the violet waves is about one-half the length of the red waves.

In ordinary light the transverse vibrations ore to be thought of as taking place in all planes abont the line of propagation. In the above figure, vibrations in one plane only are represented; light which is thus one-sided or has only one direction of transverse vibration is said to be plane-polarized.

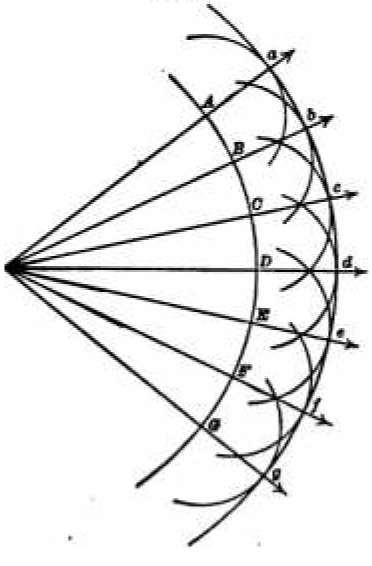
Light-waves have a very minute length, only 0*000023 of an inch for the yellow sodium flame, and they travel with enormous velocity, 186,000 miles

per second in a Tacnnm; thae light passee from the ann to the earth in aboDt eight minutee. The TibrstioD-penoa, or time of one oscillation, is consequently extremely brief; it is given by dividing the distance traveled by light in one second by the number of waves included.

292. Wave-front.—In an isotro[)ic medium, as air, water, or glass^tbat ie, one in which light is propagated in all directions about the luminous point with the same velocity—the waves are spherical in form. The wave-front ia the continuous surface, in this case spherical, which includes all particles which commence their vibration at the game moment of time. Obviously the curvature of the wave-front diminishes as the distance of the source of light increases, and when the light comes from an indefinitely great distance (as the ann) the wave-front becomes sensibly a plane surface. Such waves are usually called plarte waves. These cases are illustrated by Figs. 495 iind 49G. In Fig. 495 the luminous point ' is supposed to be at o, and the medium being isotropic, it is obvious that the wave-front, as JBC^... O, is splierical. It ia also made clear by this fignre how, as briefly stated in Art. 288, the resultant of all the individual impulses which go out from the successive points, as a, b, c, etc., aa centers, form a new wave-front, dbc...g, concentric with ABC. ..G. In Fig. 496 the luminous body is supposed to be at a great distance, so that the wave-front AB...F is a plane surface. Here also the individual impulses from A, B, etc., unite to form the wave-front ab... f parallel to AB ... F.

293. light-ray.—The study of light-phenomena is, in certain cases.

495.



facilitated By the conception of a 496.

t-ray, a line drawn from the Inminous

Soint to the wave-front, and whose irection is tnkeii so as to represent that of the wave itself. In Fig. 49.^ OA, OB, etc., are diverging light-rays, and in Fig. 496 OA, OB, etc., are parallel light-raya. In both these cases, where the medium is assumed to be isotropic, the light-ray is normal to the wave-frout. This is equivalent to saying that the light-wave moves onward in a direction normal to the wave-front.

It must be understood that the "light-ray" has no real existence and is to be taken only as a convenient method ' of representing the direction of motion

of the light-waves nndar varying conditions. Thus when by appropriate means

{e.g., the nse of lenses) the cDiratnre of the wave-front is altered—forezample, if from being a plane surface it is mftde sharply conTez—then the light-raTS, at first parallel, are said to be made to diverge. Again, if the convex wave-front is made plane, the diverging light-Tays are then said to be made parallel.

294. Wave-length. Color. White light.—Notwithstanding the very small length of the waves of light, they can be measured with great precision. The visual part of the waves going out from a brilliantly incandescent body, as the glowing carbons of an electric arc-light, may be shown to consist of waves of widely varying lengths. They include red waves whose length is about xwhrs of an inch and waves whose length constantly diminishes without break, tbrongh the orange, yellow, green, and blue to the violet, whose minimum length is about half of that of the red. The length of each group of these waves determines the sensation of color which the eye perceives. This color is strictly monochromatic only when it cori'espondB to one definite wave-length; this is nearly true of the bright-yellow sodinm line, though strictly speaking this consists of two sets of waves of slightly different lengths.

The effect of " white light" is obtained if all the waveff from the red to the violet come together to the eye aimultaneously; for this reason a piece of platinum at n temperature of 1500° C. appears "white hot."

The radiation from the sources named, either the sun, the electric carbons, or the glowing platinum, includes also longer waves which do not affect the eye, but which, like the light-waves, produce the effect of sensible heat when received upon an absorbing surface, as one of lampblack. There are also, particularly in the radiation from the Bun, waves shorter than the violet which also do not affect the eye. The former are called iiifra-red, the latter ultraviolet waves.

299. Complementary Colon.—The sensation of white light mentioned above is also obtained when to a given color-—that is, light-waves of given wavelength—is combined a certain other so-called complementary color. Thus <^rtain shades of pink and green combined, as by the rapid rotation of a card on which the colors form segments, produce the effect of white. Blue and yellow of certain shades are also complementary. For every shade of color in the spectrum there is another one complementary to it in the sense here defined. The moat perfect illustration of complementary colors is given by the examination of sections of crystals in polarized light, as later explained.

296. Reflection.—When light-waves come to the kinndary which separates one medium from another, as a surface of water, or glass in air, they are, in general, in part reflected or returned back into the first medium.

The refiection of light-waves is illustrated by Figs. 497 and 498. In Fig. 497, MM is the reflecting surface—here a plane surface—and the light-waves have a plane wave-front {Abcde); in other words, the light-rays (OA, Oft, etc.) are parallel. It is obvious that the wave-front meets the surface first at A and successively from point to point to E. Each of these points is to be regarded aa the center of a new wave-system which unimpeded would be propagated onward in a given time distances equal to the lines Aa' Bb', etc Hence the common tangent/oA^j^to the circular arcs drawn with these radii from A, B, etc., represents the direction of the new or reflected wave-front. But geometrically the angle eAE is equal to fEA, or the incident and reflected wave-fronts make equal angles wit/i the reJUecUng surface. If XA is a normal at A, the angle O^iV^called the angle of incidence —is equal to 2fAF, the angla of reflection. Hence the familiar law:

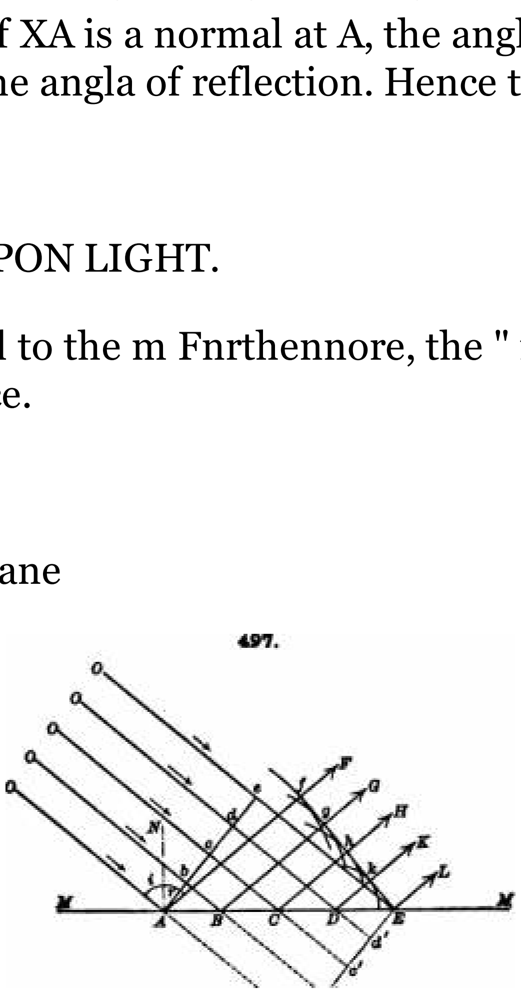
CHA^CTERB DEPBNDINQ UPON LIGHT.

The angle of iticidence is equal to the m Fnrthennore, the " incident and reflectc vitli the normal to the reflecting surface.

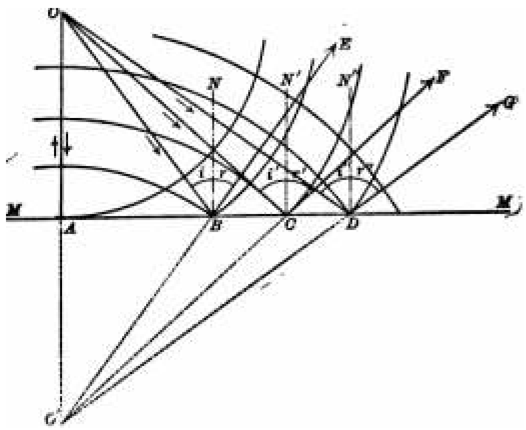
<]le of reflection.

i rays " both lie in the Bome plane

497.



In Fig. 49S, irhere the InminonB point ia at o, the waves goin? oat from it will meet the plane mirror MM&nt at the point A and successiTely at points.



M B, C, D, etc., farther away to the right (and left) of A. Here also it is easy to Bhow that all the new impulses, which have their centers at A, B, C, etc., mnst together give rise to a aeries of reflected waves whose center is at o', at a distance equally distant from MM measured on a normal to the siirfnce {OA - OA').

Now the lines OA, OB, etc., which are perpendicular to the wave-front, represent certain incident ligbt-rays, and the eye placed in the direction BE,

OF, etc., will see the lumiuous point as if at o'. it follows from the consti'uc-tioQ of the figure and can be proved by experiment that if BN, ON, etc^ are normals to the mirror the aiigleB of incidence, OBN, OCN', etc., are equal to the angles of fefleetion, NBE, N'BF, etc., respectively. Hence the above law applies to thie case also.

If the I'eflecting surface is not plane, but, for example, a concave surface, as tliat of a spherical or parabolic mirror, there is a change in the curvature of the wave-front after reflection, but the same law still holoB true.

I lie proportion of the reflected \o Ihe iaclderit ligbt luci-eaaes with llie smoolbness of Ibe aurfiice uud also aa Ihe anglu of tucideoce diminiabee. Tlie iuteodty of Ibe reUecled ligbi is amaiitnumfor agiveu surface hi tbecnaeof perpeQdlculikriDcideDce(o^. Fig. 498).

If the surfiice fa not perfectly polisbed, diffuie reflection will lake place, aud (here will be □□ ilislitict I'tflected »y. It it the di&usely reflected ligbt wbich mahea tbe reflected surface visible ; if the surface of a mirror were abtotuUly tmoot!i Ihe eye would see llie reflected body iu It <mly, not tbe surface itself. Oplicallf eipreased, tbe surface is to be consiilei'ed auioolh if tbe distance between tbe scratcbes upou It is coDsiderably less (say one-fourtb) tbau the wave-length of light.

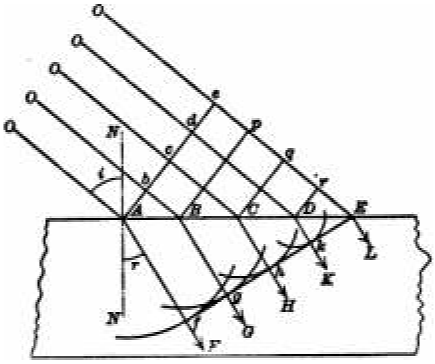
297. Refraction.—When s system of light-waves of the same wave-length pasaes from one medium into another there is, in general, an increase or ^^^ decrease in the velocity of

the light,

and this results in the phenomenon of refraction —that is, a change of direction at the bounding surface. The principles applicable here can be most easily shown in the case of light-waves with a plane wave-front, as shown in Fig. 499—that is, where the light-rays OA, OB, etc., are parallel. Suppose, for example, that a light-wave, part of whose wave-front is Abcde, passes from air obliquely into glass, in which its velocity is about two-thirds as great, and suppose the surface of the glass to be plane. The points A, B, etc., will be successively centers of disturbance which will be propagated in a given time, not to distances equal to bE (from A in the line o^^), top£^, etc., but only two-thirds of these distances. Circles drawn from the points A, B, C, etc., with radii equal to these diminished values (two-thirds of eE.pE, etc.), will have a common tangent in the plane fghkE, and this will be then the new wave-front in the second medium. Here it is seen that there is a change of direction in the wave-front, or otherwise stated, in the light-ray, the magnitude of which depends on the ratio between the light-velocities in the two media, and, as discussed later, also upon the wave-length of the light. The light-ray is here said to be broken or refracted, and for a medium like glass, optically denser than air {i.e., with a lower value of the light-velocity), the refraction is toward the perpendicular. In the opposite case—in an optically rarer medium—the refraction is away from the

perpendicular, the angle of refraction is larger than that of incidence Art, 303).

398. Refractive Index.—It is obvious from the figure that whatever the direction of the wave-front—that is, of the light-rays—relatively to the given surface, the ratio of tE to Af, which determines the direction of the new



wave-front (i.e., the direction of a refracted ray, AF) is constant. This ratio

is equal to — where V is the value of the light-velocity for the first medium (here air) and v for the second (as glass). If this constant ratio be represented by n, we may write:

- £ - f^ - ^-g Sin eA E _ sin eAE _ sin oA2f " ~ V ~ Af~ AE. Sin AEf sin AEf sin FAN'

Here i {OAN) is the angle of incidence and r{FAN) the angle of refraction ; thus, in its last form.

we have the familiar relation usually expressed as follows:

The nine of the angle of incidence bears a constant ratio to the sine of the angle of refraction.

It is also true that the incident and refracted rays lie in a common plane with the normal to the surface.

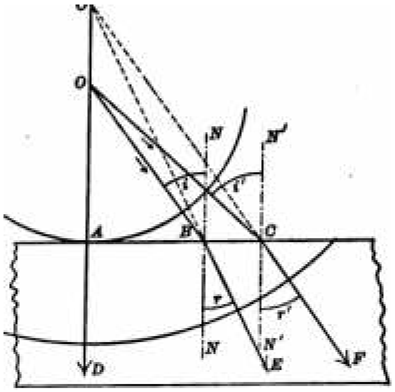
The above relation holds true for any wavesystem of given wave-length in passing from one medium into another, whatever the wave-front or shape of the bounding surface. In Fig. 500 • the luminous point is at o, and it can be readily shown that the new wave-front propagated in the second medium (of greater optical density) has a flattened curvature and corresponding to this a

center at o'fwhere 7)-r=—}■ Here

the incident rays OB, OC, are refracted at B and C, the corresponding refracted rays being BE and BF. For , this case also the relation holds good,

sin i sin i' . n = -. — = -;—;, etc. sin r sin r

This constant ratio for light of a given wave-length passing from one medium to another, expressed here by n, is called the index of refraction or refractive index. In the examples given for air and



the refractive index, or n, for this kind of glass.

The relation between wave-length and refractive index is spoken of in Art. 309.

If tbe bounding surface is not plane hut curved, as in lenses, there is a change in the curvature of the wave-front in the second medium, but the

o long as the medium is isotropic.

* See S. P. TliompEDD (Light Visible aod Invisible. 1S9TV wbo develops the formulu leoKS. etc., on tlie baala of lighr-wiives luatead of ligbt-raya.

299. Relation of Befra«tive Index to Light-velooity.—The discussion of the preceding article shows that if n is the refractive index of a given substance lor waves of a certain length, referred to air, V the velocity in air and v the velocity in the given medium, then

For two media whose indices are n, and n, respectively, it consequently foUowg that

Therefore, The indices of refraction of two given media for a certain wavelength are inversely proportional to their relative light-velocities.

Since light-waves are propagated by a transverse motion in the ether which pervades the given body, and is as it were weighted down by its molecules, it is obvious that the velocity of the light-wave itself is measured by the rate of this transverse motion in the ether; nence for waves of the same length traveling through media of different refractive power, this latter velocity of transverse vibration is inversely proportional to the refractive indices.

300. Principal Refractive Indion.—The refractive index has, as stated, a constant value for every substance referred, as is usual, to air (or it may be to a vacuum). In regard to solid media, it is evident from Art. 298 and will be further eiplaioed later that those which are isotropic, viz., amorphous substances and crystals of the isometric system, can have but a single value of this index. Crystals of the tetragonal and hexagonal (and rhomboliedral) systems have, as later explained, ^wo principal refractive indices, c and fv, corresponding to the velocities of light-propagation in certain definite directions in them. Further, all orthorhombic, monoclinic, and trlclinic crystals have similarly three principal indices, a, /3, y. In the latter cases of so-called anisotropic media, the mean refractive index is taken, namely, as the arithmetical mean

301. Bxamples of Refractive Indices.—The following table inclades the values of n for a variety of substances, for sodium light. For minerals other than those of the isometric system the average value (as defined in the preceding article) is given here.

The refractive index for air referred to the ether of a vacuum is 1'000292 for a wave-length equal to that of yellow sodium light (X = 0-0000589 cm.).

SOS. I^mUo BafnwtlTa ?ow*r.—The relation between the refractive Index and tbo chemical compmiiiun of a giren subilaDce le eiprewed by what hoa been called the Glad- ■tODe law,* namely.

Here n is refracllTe Index (for anisotropic subatances, the mean lodex), and d \a the deuHltj. Tbe value of the conaiaiil ie called tLje ipeeifie refractiM power. The product of the speciflc refractive power Into tlie molecular wtiglitKives Ike r^/roeiiiM tguimltnt, 'I'Lus tor quartz, n — 15, d = 2-6fl, Iherefore tbe value of ine specifli: refractive power is 0-2, and llie refractive equivalent U equal tn lliis uumber niulliplied into tlie molecular weight (80) or la (H - 0-3 X 60). Similarly the v«lue obtained t for CaO ia ViS, iinil for MgO 17-1.

lu the case of a complex uiolecule, ll is nsaumed that the sum of the refractive equivalents of the puTts of the molecule divided by the sum of the correspoudiDK molecular welgbli is equal to the specific refractive power of thi: given compouod. Thus for grossulmr garnet whcse formula may be written 8CaO. Alio..8SiOi, the above relattoue give

= 0 aia.

Further, -

tXl3-a + 19-7 + 8 X 18 6 8x56+103 + 8x60

- = 0-316, aud n = 1 '796; experiment ghea n = 1-747.

303. Total Befleotioa. Critioal Angle.—In regard to the principle stated

in Art. 298 and expressed by the equation » = -. — , two poiutB are to be

noted. First, if the angle i = 0°, then sin i — 0, and obviously also r = 0; in other words, when the ray of light (as OA, Fig. 500) coincidea with the perpendicular, no change of direction takes place, the ray jiroceeda onward (AD) into the second medium without deviation, but with a change of velocity.

Again, if the angle i = 90", then Gin 1= I, and the equation above

becomes n

1

1

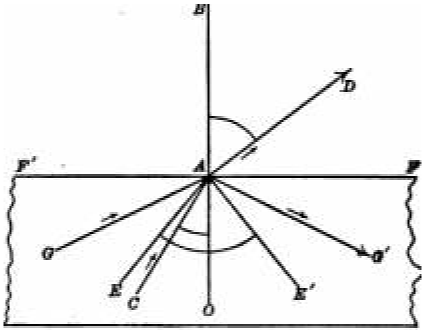
As

n has a fixed value for every substance, it is obvious that there will also be a corresponding value of the angle i- for the case mentioned. From the above table it is seen that

for water, sin r

1

and r = 48° 1



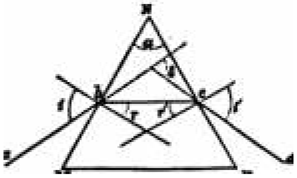
31'; for crown glass, sin t = ^

and r = 38° 27'; for diamond, sin

= ^;'- and r = 24° 25'.

In Fig. 501 the ray OA in the glass is refracted on passing into the air in the direction AD, but if the angle EA o = 38' 27', the ray EA will graze the surface or take the direction AF. Any ray, OA, for which the angle GA o is greater than 38° 27' will not emerge at all, but suffer total reflection, being returned in the direction AG'. The surface of glass illuminated from beneath in the direction last named has a brilliant, almost metallic luster. This is the

502.



appearance also, under like conditions, of the surface of a transparent solid— for example, of a glass prism or a cut gem. The value of r thus found is called the critical angle; the smaller this angle the greater the apparent brilliancy of the given substance.

The relative refractive power of a given substance compared with that of the enclosing medium {e.g., Canada balsam with n, = 1*539) determines on the principle of total reflection whether the surface appears rough with dark cracks ("high relief") as in garnet and zircon, or smooth and even ("low relief') as in quartz.

30C Determination of the Eefraotive Index.—B7 means of a prism, ag MNP in Fig. 503, it is possible to determine the value of n, or refractive index of a given substance. The augle of the prism MNP, a, is, in each case, measured in the same manner as the angle between two faces of a crystal, and then the minimum amount of deviation (J) of a monochromatic ray of light, fg-< yellow sodium light, passing from a slit through the prism is also determined. The , amount of deviation of a ray in passing throngh the prism varies with its position; hut when the prism is so placed that the ray makes eqnal angles witn the sides of the prism, that is, with the normals (i = i'. Fig. 503), when entering and emerging, this deviation has affixed minimum value.

If <^ = the minimum deviation of the ray, and a = the angle of the prism, then

^ ^ sin i(a + rf) ain ia

The application of this method is given in a later article. Several other methods are also explained—for example, one depending upon total reflection.

305. Dispersion.—Thus far the change in direction which light suffers in reflection and refraction has alone been considered. It is further true that the amount of refraction differs for the waves of different length, that is, the different colors of which ordinary white light is conipoaed, being greater for blue than for red. In consequence of this fact, if ordinary light be passed through a prism, as in Fig. 502, it will not only be refracted, but it will also suffer dispersion or be separated into its component colors, thus forming the prismatic spectrum.

This variation for the different colors depends directly upoi; their wavelengths; the red waves are longer, their transverse vibrations are slower, and it may be shown to follow from this that they suffer less change of velocity on entering the new medium than the violet waves, which are shorter an3 whose velocity of transverse vibration ia greater. Ilence the refractive index for a given aiibstance is greater for blue than for rod light. The following are values of the refractive indices for diamond determined by Schrauf:

2-40845 red (lithium flame).

Si'4l733 yellow (sodium flame).

2'42549 green (thallium flame).

306. Speotroioope.—The instrument roost simply used for the analysis of the light by dispersion is familiar to all as the spectroscope.* In it the light

* A. de OronioDt h&s Bhown tliat tbe direct spectroacopfc examiDUtloa of many mlncml

from the given source, received through a narrow slit in the end of one tube, is made to fall as a plane-wave that is, as a " pencil of parallel rays ") upon one surface of a prism at the center, and the spectrum produced is viewed through a suitable telescope at the end of a second tube.

If the light from an incandescent solid—which is " white hot" (Art. 294)— is viewed through the spectroscope, the complete band of colors of the spectrum is seen from the red through the orange, yellow, green, blue, to the violet. If, however, the light from an incandescent vapor is examined, it is found to give a spectrum consisting of bright lines (or bands) only, and these in a definite position characteristic of it—as the yellow line {double line) of sodium vapor; the more complex series of lines and bands, red, yellow, and green, characteristic of barium; the multitude of bright lines due to iron vapor (in the intensely hot electric arc), and so on,

307. Absorption. — Of the light incident upon the surface of a new medium, not only is part reflected (Art. 296) and part transmitted and refracted (Art. 297), but, in general, part is also absorbed at the surface and part also during the transmission. Physically expressed,.absorption in this case means the transformation of the ether-waves into sensible heat, that is, into the motion of the molecules of the body itself.

The color of a body gives an evidence of this absorption. Thus a sheet of red glass appears red to the eye by transmitted 'light, because in the transmission of the light-waves through it, it absorbs all except those which together produce the effect of red. For the same reason a piece of jasper appears red by reflected light, because it absorbs part of the light-waves at the surface, or, in other words, it reflects only those which together give the effect of this particular shade of red.

Absorption in general is selective absorption; that is, a given body absorbs particular parts of the total radiation, or, more definitely, waves of a definite wave length only. Thus, if transparent pieces of glass of different colors are held in succession in the path of the white light which is passing into the spectroscope, the spectrum viewed will be that due to the selective absorption of the substance in question. A layer of blood absorbs certain parts of the light so that its spectrum consists of a series of absorption bands. Certain rare substances, as the salts of didymium, etc., have the property of selective absorption in a high degree. In -consequence of this, a section of a mineral containing them often gives a characteristic absorption spectrum.

The dark lines of the solar spectrum, of which the so-called Fraunhofer lines are the most prominent, are due to the selective absorption exerted by the solar atmosphere upon the waves emitted by the much hotter incandescent mass of the sun.

308. Diffraction.—When monochromatic light is made to pass through a narrow slit, or by

the sharp edge of an opaque body, it suffers diffraction, and there arise, as may be observed upon an appropriately placed screen, a series of dark and light oands, growing fainter on the outer limits. Their presence is explained (see Arts. 312, 313) as due to the interference, or mutual reaction, of the adjoining systems of waves of light, that is, the initiallight-waves, and further, those which have their origin at the edge or sides of the slit in question. It is essential that the oriening in the slit should be small as compared with the wave-length of the lignt. If ordinary light is employed,

the pbenomens are the same, and for tlie same causes, except that the bauda are successive colored spectra.

Diffraction spectra, explained od tlie priociples iilluded to, am oblaiued rrom rtlffrmclinu gntlinjjK. ThtBB gratings consist of a series of eitiremely fiue parHllul lines (say 15.(HX) or SiU.OOO to tiu iiiuJi) ruled witLj great re^njlaiity upua g\itaa, or uj uu u pollslictT surface uf speculum lue 111 I. The glass gralirig is used witli tmn ami lied, mid llie H|H:t-nluni ErrilliiB Willi redeeted. light: tbe Rowland grating of the latter kind lias a concave surface. Encb

5ruling gives u number of spectra, of iLe fii-sl, secoud, iliiid order. u:c. Tliese rpeciia aye ttie mlvauuge, as compared with liioae given by priBina, tliut ILe d!s|«niioti of Ibe diUvrtiut cuiura is slrictlj proportioual to the wave-le.igib,

309. Double Befraotion.—In the discussiou of Art, 297, applying to isotropic media, it was shown tbat light-waves passing from one medium into another, which is also isotropic, suSer simply tt chnnge in wave-front in con-seqiienue of their change in velocity. In anisotropic media, however, which include all crystals but those of the iBometric syelem, there are, in general, two wttve-systema propagated with different velocities aud only in certain limited cases is it true that the light-ray is normal to tlie wave-front. This subioct cannot be adequately explained until the optical properties of these media are fully disciiEsed, but it must be alluded to here since it serves to explain tbe familiar fact that, while with glass, for example, there is only one refracted ray, many other substances give two refracted rays, or, in other words, show double refraction.

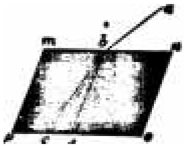
The most familiar example of this property is furnished by the mineral calcite, also called on account of this property " doubly-refracting spar." If mnop (Fig. 50S) be a cleavage piece of calcite, and a ray of light meet« it g at 5, it will, in passing through, be divided into two rays,

be, bit. For this reason, a dark spot or a line seen through a piece of calcite ordinarily appears double. As implied above and also in Art. 300 the same property is enjoyed by all crystallized minerals, except those of the isometric system. The wide separation of the two refracted rays by calcite, which makes the phenomenon so striking, is a consequence of the large differi'nce in the values of its indices of refraction, in other words, as technically expressed, it is due to the sfrenpih of its double refraction, or its birefringence.

310. When the incident light is perpendicular to the surface of the doubly-refracting substance, there is. In the more commonly occurring cases, no change of direction in the transmission; but even then it is usually still true that tbe incident ray is divided into two rays, which, though they may travel in the same path, yet have different velocities, so that one falls behind the other. Further, as later explained, each is in general plane-polarized. For each of these rays, it is true that for waves of the mine length the rate of transverse vibration, and hence the velocity of the ray itself, is inversely proportional to the respective refractive index.

311. Interforenoe of Waves in General.—The subject of the interference of light-waves, alluded to in Art. 308, requires detailed discussion. It is one of great importance, since it serves to explain many nomninn and beautiful phenomena in the optical study of crystiils, for example, the axial interference flgitres shown on the plate forming the frontispiece.

Referring a,gain to the water-waves spoken of in Art, 287, it is easily understood that when two wave-systems, going out, for example, from two centers of disturbance near one another, come together, if at a given point



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they meet in the same phase (as crest to crest), the result is to gire the particle in question iloitble amplitude of motion. On the other hand, if at any point the two wave-systemB come together in opposite phases, that is, half a wave-lengtli apart, the crest of one corresponding to the trough of the other, they intei'fere and the amplitude of motion is zero. Under certain conditions, therefore, two sets of waves may unite to form waves of doable amplitude; on the other hand, they may mutaally interfere and destroy each other. OLivioiisly an indehiiite number of intermediate cases lie between these extremes. What is true of the waves mentioned is true also of Bound-wuves and of wave-motion in general. A very simple case of interference was spoken of in connection with the discDssiou of the waves carried by a long rope (Art. 289).

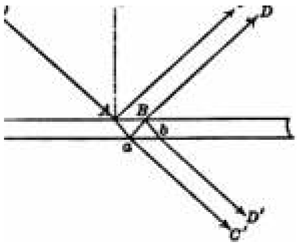
812. biterfereaoe of Light-wavefl.—Interference phenomena can be most satisfactorily studied in the case of light-waves. The extreme cases are as follows: If two waves of like length and intensity, and propagated in the same direction, meet in the same phase, they unite to form a wave of double iutensitv {double amplitude). If, however, the waves differ in phase by half a wavelength, or an odd multiple of this, they inter/ers and extiiignish

each other. For other relations of phase they are also said to interfere, forming a new resultant wave, differing in amplitude from each of the component waves. In these cases monochromatic light-waves were assumed (that is, those of like length). If ordinary white light is used, the waves in the case of interference will overlap, and their interference will be indicated by the appearance of the colors of the spectrum.

313. Illustrations of Interference.—A simple illustration is afforded by the bright colors of very thin films or plates, as a film of oil on water, a soap-bubble. and like cases. To understand these, it is only necessary to remember that the incident light-waves are reflected in 50^

part from the upper and in part from the lower surface of tii" film or plate Hence if the o thickness is very small, these two reflected wave-systems. when they come together (represented'in Fig. 504 by the two rays AC, liD) will differ from one another in phase, and interfering give rise (in ordinary light) to the colored [phenomena spoken of. It is to be noted that the phenomena of interference by reflection are somewhat complicated by the fact that there is a reversal of phase (that is, a loss of half a wave-length) at the surface which separates the medium of greater optical density from the rarer one. Hence the actual relation in phase of the two reflected rays, as AC, fiZ? (supposing them of the same wave-length) is that determined by the retardation due to the greater length of path traversed by Bd, together with the loss of a half wavelength due to the reversal of phase spoken of. As shown in the figure, there are also two transmitted waves which also interfere in like manner.

A plano-convex lens of long curvature, resting on a plane glass surface (Fig. 505), and hence separated from it, except at the center, by a film of air of varying thickness, gives by reflected monochromatic light a dark center and aboot this a aeries of light and dark rings, called Newton's rings. The dark center is due to the interference of the incident and reflected waves, the latter half a wave-length behind the former. The light rings correspond



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to the distances vhere the tvo sets of reflected vavea meet in the same

BOS, phase, that is (noting the ezplanatiuii

above) where the retardation of those

~-~ ~ _——-_-^ having the longer path ia a half wave-

1 ^~~^ -" " 1 length or au odd multiple of this (i^.

jA, |A, etc.). Similarly the dark rings fall between these and correspond to the points where the two waves meec in opposite phase, the retardation being a wave-length or an even multiple of this. The rings are closer together with bine than with red because of their smaller wave-length. In each of tlie caaea described the ring is properly the intersection on the plane surface of the cone of rays of like retardation.

In ordinary white light there can be no dark rings because of the difference of length of the component waves; on the contrary, the overlapping of these waves produces a aeries of colored rings, each showing the successive colors of the spectrum. The aeries of colors are distinguished aa of the first, second, third, etc., order; for a given color, as red, may be repeated a number of times as the waves overlap. After a certjiin number of wavea have overlapped in this wiiy, white light (" of a higher gi'ade") results.

Similarly in the case of tlie thin plate in white light, a certain thickness and consequent retardation producca a superposition of the waves ' which yields, for example, a shade of red; a greater thickness (and retardation) a I'ed of the second order, etc. It the plate is not very thin, simf.le white is reflected from it.

AontliernioBt Futisriictory illuslntlloD of the ioterfereDCe of lljfht-wiivea iB ^*eii I17 tneHD8 of tlie rliffmctlon gmtings spoken of in Art 30>, but the Bubject cunoot be furtLer discussed in tlila pliice.

Other cases of the compoaition of two systems of light-waves will be considered after some remarka on polnrized light.

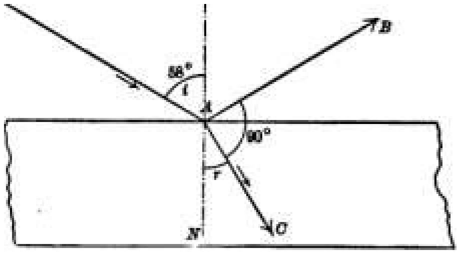
314. Polarisation and Polarized Light.—Ordinary light is propagated by transverse vibrations of the ether which take place alike in all planes about the line of propagation. A ray of ordinary light is, therefore, alike or aym-melrical in all directions about this line; it may be most simpW thonght of as being propagated by two equal sets of transverse vibrations taken in any two planes at right angles to each other.

Plane-polarized light, on the other hand, as stated briefly in Art. 291, is propagated by ether-vibrations which take place in one plane OJih/. The change by which ordinary light is changed into a polarized light ia called polarisnfinn, and the plane at right angles to the plane of transverse vibration is called the plane of polarization.*

Polarization may be accomplished (1) by reflection and by single refraction, and (2) by double refraction.

316. Polarisation by Reflection and Single SefrHotion.—In general, light which has suffered reflection from a surface like that of polished glass is more or less completely polarized; that is, the reflected waves are propagated by vibrations to a large extent limited to a single plane, viz, (as assumed) the plane normal to the plane of incidence, which last is hence the plane of polarization. "Furthermore, in this case, the light transmitted and refracted by the reflecting medium is also in like manner partially polarized; that is, the

"This Is Id accordance with the nuumptlnD of Fresuel; wtlli HacCullagh the vilinition-plaoe and pl&ne of poUrlzntioD coincide. All Bmhjgulty to avoided by spMklog UDiformly of the vibraUon-plane of the light.



fibratioDS are more or less limited to a Biagle plane. Id this case a plane at right SDgles to the former and ^g_

lience comciding with the plane !.

of incidence. For a given angle of incidence, varyine for each substance, bnt aach toat the reflected and refracted rays [AB and A C, Fig. 506) make an angle of 90° with each other, this polarization is a maximum. For this case it is hence true, if we re]ire8ent this angle of polariza-tiou bj t, that

$\tan i' = n$. This law, BBtabliahed by Brewster, may be stated as follows:

ITie angle nf polarization ix that angle whose tangent is the index of refraction of the reflecting substance. For crown glass thia angle is about 58" (see Fig. 506). If light sufFera repeated reflections from a series of thin glass plates, the polarization is more complete, though its intensity is weakened. Metallic surfaces polarize the light very slightly.

If the polarized light-vaves fall opon a eeoond similar reflecting surface at the same angle, they will be reflected again unchanged, on the condition that the two planes of incidence (and hence the two ^' planes of polarization) of the two mirrors coincide.

/ia^_^^* If, howBTBr, these planes are at right angles to each

/^r""^ other, the light polarized by the first mirror will be

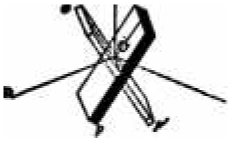
/a *\.^ extinguished by the second. As the polarization is

yi ^^« in no position absolutely complete, the light is not

completely arrested, bnt only reduced to a minimum in the second position.

This case is illustrated by Fig. 507. Here the incident ray AH is reflected by the first mirror m» in the direction fiCand polarized in a plane normal to the plane of incidence-the angle ABH hefag equal to the angle of polarization. If now the second mirror occupy either of the positions op or o'j}', the planes of incidence (and of polarization) of both mirrors coincide and the light-ray, BC, is, therefore, reflected a second time in the direction of oD, or oD . If, however, the second mirror be revolted about a vertical axis the reflected light becomes gradually weaker and is sensibly extinguished when the two planes of incidence are at right angles to each other.

316. PoUri2ation by Donble Re&action.—When light in passing through a crystalline medium is doubly refracted (Art. 308) or divided into two sets of waves, it is always true that both are completely polarized and in planes at right angles to each other. This subject can only be satisfactorily explained after a full discussion of the properties of anisotropic crystalline media, but it mav be alluded to here since this principle gives the most satisfactory method of obtaining polarized light. For this end it is necessary that one of the two wave-systems should be extinguished, so that that due to a single set of vibrations only is transmitted. Tnis ia accomplished by natural absorption in the case of tourmaline plates and by artificial means in the nicol prisms of calcite.



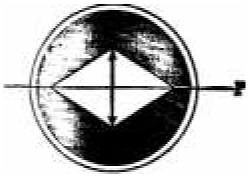
317. Polarized Li^ht by Abiarption.—If from a crystal of toarmftline, which

is suitably tmnaparent, two aectioug be obtaiued, each cut parallel to the vertical axie, it will be found that these, when placed together with the direc-tioii of their axes ceincidiiig, allow the light to pass through. If, however, one section is revolved upon the other, less and less of the light is trail a mi tied, until, when their axes Hre at right angles (90°) to each other, the light is (almost perfectly) eitingniahed. As the revolution is continued, more and more light is obtained through the sections, and after a revolution of 180°, the axes being again parallel, the appearance is as at first. A further revolution (270°) brings the axes again at right angles to each other, when the light is a second ' time extinguished, and so on around.

The eipl»n»tion of this plienoineuon, so far as it can be given here, is analogous to that employed for the case of polarization by reflectiou. Each plate doubly refracts the light; but one of the two sets of waves is absorbed, and only that set whose vibrations are parallel to the vertical axis are transmitted. If now the two plates are placed in the same position, abdc, and e/h^ (Fig. 508), the light passes through both in succession. If, f however, the one is turned upon the other, only that portion of the light can pass through which vibrates sLill in the direction ac. This portion is determined by the resolution of the existing vibrations in accordance with the principle of the parallelogram of forces. Consequently, when the sections stand at right angles to each other (Fig. 509) the amount of transmitted light is nearlv zero, that is, the light is extinguished. Instead of tourmaline, an artificial sait, the sulphate of iodoquinine (hera-pathite) is sometimes employed, but it has little practical value.

318. Polarized Light by Niool Frumi.—The most satisfactory method of obtaining polarized light is by means of a prism of transparent calcite (Iceland spar). Pig. 510 shows the principle involved in the prism early constructed by Nicol, which transmits one only sio. 611.

of the two refracted rays, that represented by the line bde (the extraordinary ray,aa later defined). The other ray, be, suffers total reflection at the surface where the two sections are united together by Canada balsam and is then absorbed by the black surface of the sides. Here the vertical faces are natural cleavage-faces; the face PJ' is ground on so as to make an angle of 68° with the obtuse vertical angle; the prism BO formed is cut diagonally across (////), and then the parts , cemented together. This form of prism, as well as othei-s somewhat different in form but accomplishing the same end with the use of less materia], is ordinarily called a Nicol prism, or briefly a nicol. The section of the ordinary nicol of Fig. 510 is



iozenge-shaped (Fig. 511); the plane of polarization, PP, passes throagh the a,:iiLe angles of the croae-aection, and the vibration-plane, here as usual reprcBeiited by a doable-headed arrow, pasBes through the obtuse edges. The ocher prisma alluded to may have a rectangular croBs-Bection. The vibration-plaue can be readily determined in any case by examiuing with it the light reflected from some suitable aurtace (e.,?., of a wood table). Twice in a rev^u-liou of the prism through SCO" about its axis this light will be weakened; when this is true, the vibration-plane of the prism must be perpendIcnlar to that of the partially polarized reflected light, that is, it must be vertical, since [lie latter is taken as horizontal.

319. FolarUcope. Polarizer. Analyzer.—The combination of two nicols, or other polarizit]|; contrivances, for the examination of a substance in polarized light is called, in general, a polariscope; the common forms are deacribed later. In any polariscope the prism, or other contrivance, which polarizea the light f^ven from the outside source is called the polirizer; the other is the analyzer. If the prisms have their vi brat ion-planes at right angles to each other, they are said to be crossed j the incident light pohirized bj the polarizer is then eitinguisbed by the analyzer; briefly, it is snid to suffer eslinction.

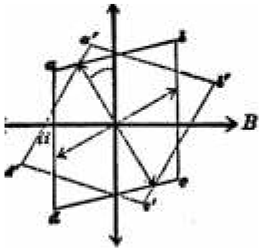
3W). Interference of Plane-polarized Waves. laterference-oolon. — The amplest case of the interference (Art. 312) of polarized light to consider ie that where the two light-waves, .or, more aimple expressed, two raya, are polarized in the same plane. They may then interfere to extinguish each other, or they may give rise to beautiful coior-efEects.

Suppose, for example, that in a polarization-microscope (Art. 328) parallel light passes upwards through the lower nicol, whose vibration-plane is shown in the cross-section of Fig. 512 by the arrow AA; 5ja_

tbis light is polarized in a single plane. Now let ^ '

this polarized light pass through a thin cleavage-plate of selenite; it will in general be separated into two rays, each polarized in planes at lieht angles to the other, having a definite position peculiar to this substance. Tims, in Fig. 512, if abed represents the aeleaite plate, its vibration- B^— planes have the directions of the dotted arrows, rhe two rays corresponding to them travel through the section with unequal velocity, and on emerging one is slightly retarded as compared with the other. Now let these light-raya pass through a second nicol, with its vibration-plane at right ^

angles to that of the first nicol, that is, in the direction of the arrow BB. Then each of the two seta of vibrations (represented by the dotted arrows) will have a component in the direction of BB, and these will emerge now polarized in the same plane, and hence capable of interfering, for light-raya can only thus completely interfere when their vibrationa are in a common plane. Further, an amount oi light corresponding to the other componeuts (in the direction AA) will be extinguished. One of these emergent raya is, as stated, slightly retarded as compared with the other. The amount of thia retardation obviously varies with the strength of the double refraction (in this case y — a), and also with the thickness of the section taken. The interference-col or of the section, supposing ordinary light to be used, depends upon these two conditions, and may be calculated for a given substance. Thus a plate of seieuito of a thickness of 0-066 mm. will give a red (of ihajirst order), and if thinner.



a yellow or ffray. Ae the thickuesB increases, tlie colors (nov of the second order) pass tnrongh succesaive shades of blue, green, yellow, orange, and if the plnte is of snfBcient thickness a second red and bo on (see, further. Arts. 369 and 382). A mineral of very strong double refraction, as calcite, shows only the white of the higher order unless extremely thin.

If the section had happened to have the position of a'b'e'd' (Fig. 513), its vibration-planes would have coincided with those of the two nicols, and the light, after passing through the first nicol and the section, would have been propagated by vibrations in the direction AA only, and hence have been completely eitinguished by the second nicol. The plate would then have appeared

The Biiccessive i Dterfere nee-colon * of thefirit order ■paas from an ItuDgray througlr bluUb-gray to nliile, yellow, and red ; then fullow ludigo, blue, greeo, yellow, oninge, and red oF tlie ttcond order; llieu Ibe similar but paler series of colors of ttie third order, and flnally tlie very)>ali; aliadta of green and red of llie fovTOt order. Beyond this the colors are not very dieliuci; white of a higher order tiniilly results from the iuterference.

An excellent colored plate aliowine these colored bamls U given by Levy and Lacrola (Les Minerauz des Koches, 1888J. It U so nrrnnged as to give the thlcKuess of the section oF a given mineral (all importiint species present in rucks being iacluded) wbich will yield uuy one of the different shades of color luenitoDed. The use to which such a plate miiy ba put ill the practical determination of the birefringence of a givcu mineral will be referred

321. Complementary Colors in Polarized Light.—If in the examination of the selenite plate, as just described (Art. 320), one of the nicols had been rotated 90°, or, in other words, if the vibration-planes of the two nicols had been made parallel, then it is obvions that interference would also have taken jilace between the emerging rays, but the color resulting in each case would hare been exactly the coinplementary tint to that obtained at first when the iiicola were crossed. The section in the position a'hWd' between parallel nicola obviously would appear white.

322. In the preceding articles the two interfering light-rays, after emerginc; from the second nicol, were assumed to be polarized in the same plane; for them the resulting phenomena as indicated are comparatively simple. If, however, two plane-polarized rays propagated in the same direction have tlieir vibration-directions at right angles to each other, and if they differ one-(juartef

of a wave-length (iA) in phiiae (jissnming monochromatic liglit), then it may easily be shown that the composition of these two systems results in a ray of circularly polarized light, liriefly expressed, tliis is a ray which looked at

end-on would seem to be propagated by ether-vibrations taking place in circles about the line of tmnsmission. From the side, the onward motion would be like that of a screw, and either right-handed or left-handed.

If, again, two light-rays meet as above described, with a difference of phase differing from ^X (but not equal to an even multiple of JA), then the resulting composition gives rise to ellipticalli/ polarized light, that is, a light-ray propagated by ether-motions taking place in ellipses.

The above results are obtained most simply by passing plane-polarized light through a doubly refracting medium of the proper thickness {e.g., a mica plate) which is placed with its vibration-planea inclined 45" to that of the polarizer. If the thickness is such as to give a difference in phase of ^A or an odd multiple of this, the light which emerges is circularly pohirized. If the phase differs

from iA (but is not equal to -^ or A), the emergent light is elliptlcally polarized. 1 iu the following article: also the explanation of tlv

The lollowing table from Klein • gives llie relnliou belwecu tbi: retardaliou Iiom jA to W. (A = wftve-leuglb) Cnr a secilon of h doubly retraclive Biibslauce, tbe imerference-color It yields, and Ihe siaie of Die Iransmltted ligbt as regarda polariznticoo. Tlio Bcction U Bup-poaed to be obBarved in parallel sodium light witli crogsed nicols ; further, llie yibration-directlon corresponding to tbe greater refractive index iu the sectior to rigbt bebiDd.

\B from left in front

for Na light. JA iA

*A

iK

iX k

|A

|A ¥A

»i VA ¥A

LBTeader-grsj Qmyisli-blue Clearer-gray Pal* straw-yellow Btlgbt yellow Brownisb-yellow

Red

Indigo Azure-blue

- Brighter green Yellow Orange

Reddish-orange Dark violet-red

Kind of Folarliation.

Elliptic, TighMiBoded, Circular, '"

Elliptic,

- Piane-polarwd. Elliptic, left-handed.

Elliptic. Piaiie-pularittd. Elliptic, light-handed. Circuiur, '" Elliptic, Plaiie-polariud. Eliipilc, lefl-banded. Circular, " Elliplio, Plant-polariud.

323. CryataU OiTin; Circular FoUiizatios.— Iu the case of certain doubly refracting crystallized media (as quartz), and also of certain solutions (as of sugar), it can be shown that the light is propagated by two seta of ether-vibnitious which tal(,e place, not in definite trausverse planes—as in pliiiie-polarized light—but iu circles; that is, each I'ay ia circularly polarized, one being ri^ht-handod, the other left-handed. Further, of these rays, one will uniformly gain with reference to the other. The result is, that if a my of plane-polarized light full upon such a medium (assuming the simplest case, as of a section of quartz cut normal to the axis), it is found that the two rays circularly polarized within unite on emerging to a plane-polarized ray, but the plane of polarization has suffered an angular change or rotation, which may be either to the right (to one looking in tho direction of the ray), when the substance is said to be right-handed, or to the left, when it is called left-handed.

This phenomenon is theoretically possible with all crystals of a given system belonging to any of the groups of lower symmetrv than the normal gronp which show a plagihedral development of the faces;! or, more simply, those in which the corresponding right and left (or + and —) tvpinnl forms are enautiomorphous (pp. 50, 82), as noted in the chapter on crystallogrnphy. In mineralogy, this subject is most important with the common species quartz, of the rhombohedral-trapezohedral group, and a further discussion of it is postponed to a later page (Art. 366).

• Ber. Ak, Berlin, 231, 1863.

t Of the thirty-two powiblc groups among crystals, the following eleven may be characterized by circnlar polarization : Group 4, p. nO ; 5, p. SI ; U and 13, p. 68; 17, p. 78, S^p. 82; 23 and 24, p. 84; 37, p. 96; S9, p. 103; S3, p. 109.

OPTICAL INSTKTJMENTS AND METHODS.

324. HeMQrement of Befractive IndioM. Befraotometer. —For the determination of die refractive indices of crystallized minerals Tarions methods are employed. The most accurate results, when suitable material is at haud, may be ol)tuiued by the ordinary refrac to meter. This requires the observation of tlie angle of minimum deviation (d) of a light-raj on passing; througli a prism of the given material, haviug a krown angle (n), and with its edge cut in the proper direction. The measurements of a and 6 can be made with an ordinary refractometer or with the horizontal goniometer described in Art. 210. For the latter instrument, the collimator is made stationary, being fastened to a leg of the tripod support, but the observing telescope with the verniers moves freely. Further, for this

object the graduated circle is clamped, and the acrew attachments connected with the axis--carrying the support, and the vernier circle and observing telescope are loosened. Light from a monochromatic source passes through an appropriate slit and an image of this is thrown by the collimator upon the prism. With a doubly refracting substance two images are yielded and the angle of minimum deviation must be measured for each; the proper direction for the edge of the prism in this case is discussed later. In c.ases where the highest degree of accuracy is desired sunlight is employed and the angle of deviation pleasured for the prominent Fraunhofcr lines (p. 171). When a and S are known the formula in Art. 304 is used.

325. Total Beflectometer. —The principle of total reflection (Art. 303) may also be made use of to determine the refractive index No prism is required, but only a small fragment having a single polished surface; this may have any direction with an isometric crystal, but in other cjises must have a definite orientation, as described later. The arrangements required (as developed by F. Kohlrausch) are, in their simplest form, a wide-moutlied bottle filled with a liquid of high refractive power, as carbon disulpliide {My = 1"6442 Ka) or «-bromnaphthaUn (/j„ = 1-6626 Ka). The top is formed by a fisod graduated circle, and a vertical rod, with a vernier attached, passes through the plate and carries the crystal section on its extremity, immei-sed in tne liquid. The angle through which the crystal surface lying in the axis is turned is thus measured by the vernier on the stationary graduated circle. The front of the bottle is made of a]iiece of plate glass, and through this passes the horizontal observing telescope, arranged for parallel light. The re.st of the surface of the bottle is covered with tissue-paper, through which the diffuse illumination from say a sodium flame has access; the rear of the bottle is suitably darkened. When now the observer looks through the telescope, at the same time turning the axis carrying the crystal section, lie will finally see, if the source of illumination is in a proper oblique direclion, a sharp line marking the limit of the total reflection. The angle is measured oft on the graduated circle, when this line coincides with one of the spider lines of the telescope. Now the crystal is turned in the opposite direction, and the angle again read off. Half the observed angle i2a) is the angle of total reflection; if fi is the refractive index of the carbon disulphide, then the required refractive index, n, is equal to

/I sin a.

Under favorable conditions the results are accurate to four decimal places. This' method la limited, obviously, to snbstaocea whose refractive index is less than that of the liquid medium with which the bottle is filled.

Different forms of total reflectometers * have been devised by Soret, Polfrich, Czapski, and others.

326. The method of obtaining the refractive index of a transparent mediatn, first

described b^ Duke de Uhaulnes (1767), has been shown by Sorbyf to allow, under suitable conditions, of determinations of considerable accuracy. This method consists essentially in observing the distance {d) which the focal distance of the objective is changed when a plane-parallel plate of known thickness (/) is introduced perpendicular to the axis of the microscope between the objective and the focal point, here

t

Sorby made use of a glass micrometer, upon which two systems of lines perpendicular to each other were ruled. A micrometer-screw in the microscope makes it possible to measure the distance through which the tube is raised and lowered down to 001 mm.; consequently both t and d can be obtained vith a high degree of uccuracy.X

327. Tonn^luie Tongs.—A very simple form of polariscope for converging light is shown in Fig. 513; it is convenient in use, but of limited application. Here the polarizer and analyzer are two tourmaline plates such as were described in Art. 317. They are monnted in pieces of cork and held in a kind of wire pincers. The object to be examined is placed between them and supported there by the spring in the wire. In use toey are held close to the eye, and in this position the crystal section is viewed in converging polarized light, with the result of showing (under proper conditions) tue axial interference-figures (Arts. 360 and 387).

B13.

328. Polaiiuope. Conofoope. fitaurosoopa.—The common forms of polari' scope § employing nicol prisms are shown in Figs. 514 and 515,| Fig. 514 represents the instrument arranged for converging light, which is often called a conoscope.

The essential parts are the mirror S, reflecting the light, which after passing through the lens e is polarized by the prism p. It is then rendered strongly converging by the system of lenses nn, before passing through the

•See Qroth, Pbys. Kiyst., 189(t pp. 654-679; ftiso Das Heflectomeler, etc., von Dr. C. PHltricli. Leipzig, 1890.

IMln. Hag., 3. 1, 101,1B78.

iCr. Rosenbuecb, Micr. Pliys. Hie., p. 84, 1893, who mentions psrticulail7 methods ippUcable to mineralB iu ihia sectiocs.

^8ee rurllier, Qroth, Phys. Eryst. (also FogK. Add., 144, 34, 1871).

j These figures, also Figs. S16, BIT, 544,are lakea from tbe catalogue of R. Tueas, Steg-Us. Berlin.

section under examination placed on a plate at k. TbU plate can be revolved through any angle deBired, measured on its circumference. The upper tube 614. 616.

contains the converging system oo, the lens t, and the analyzing prism q. The arrangements for lowering or raising the tubes need no explanation, nor indeed the special devices for setting the vibration-planes of the nicola at right angles to each other.

The accompanying tube (Fig. 515) shows the arrangement (or observations in parallel light, the converging lenses having been removed. In this form it

is especially used for staaroecopic meaenrementfi, as later explained. In some forme of polariscope of the above type the place of the analyzer is taken hy a pair of black glass mirrors set at the proper polarizing angle.

329. Polarization-MiorOHope.—The inTestigation of tne form and optical propertieB of minerals when in niicroacopie form has been much facihtated by the nse of microBCOpes • Hpecialiy adapted for this purpose. First arranged with reference to the special study of minerals aa seen in thin sections of rocks, they hare now been so elaborated aa largely to take the place of the older optical insLruments. They not only allow of the determination of the optical properties of minerals with greater facility, but are applicable to many coses where the crystals in hand are far too small for other means.

A highly serviceable microscope, for general nse, is that described by Rosenbusch in 1876 and later much improved. A sectional view of one form is shown in Fig. 516, and a later and improved pattern ia given in Fig. 617. The essential arrangements of Fig. 516 are as foUowa: The tube carrying the eyepiece and objective has a fine adjustment-screw at ff; the coarse adjustment is accomplished by the hand. The screw-head g is graduated and turns about a fixed index attached to the tube ^; by this means the distance through which the tube is raised or lowered can be measured to 0001 mm. The polarizing prism is placed below the stage at r, in a support with a graduated circle, 80 that the position of its vibration-plane can be fixed. The analyzing j>rism is contained in a cap, ss, which is placed over the eyepiece; this may be revolved at pleasure, its edge being graduated. When both prisms are set at the zero mark, their vibration-planes are crossed (J.); when either is turned 90°, the planes are parallel (H). The stage is made to rotate about the vertical axis, but otherwise (in this simple form) is fixed ; its edge is graduated, so that the angle throngh which it is turned can be measured to 4°. Three ailjustment-screws, of whicVi one is shown at n, n, make it possible to bring the axis of the object-glass in coincidence with axis of rotation of the stage (see, further, the detailed drawing at ttie side).

The instrument here described may be used in the first place as an ordinary microscope with magnifying power adapted to thu apenial case in hand. In the second place, with polarizing prisms and the usual arrangement of lenses, it serves for determining the planes of lighNvibrntion {like tlie sfniiroscoj/e of Art. 328); also for observing the interference-colors of doubly refracting sections and so on. Finally, with eyepiece removed and special condensing Tenses ailded beneath the object on the stage {as more fnlly described later), it may be used, like the conoscope, for observing nxial interference-figures, etc.

330. A later and improved form of microscope shown in Fig. 517 is essentially like tliat of Fig. 516, but has various refinements for accurate work. Thus, a screw ia added for the coarse adjustment; another screw to raise and depress the lower nicol; a mechanical stage, etc. ' A more essential improvement is the insertion of the upper nicol in a support, N, which can Ije pushed ia or out at will between the eyepiece and objective. The upper nicol above the eyepiece is, however, also needed in certain cases, for example with the Bertrand ocular, described later.

The mlcroKope wblch lias been briefly described Is, aa stated, especially applicable to tbe study of the form, optical properties, and mutual relattous of mloerals as they aie found in thin sections of rocks; it has ttierafore become an Important adjunct to geological research. It can also be used to great advautage fa the study of small independent crystals

•See SoMnbnacli, Mikr. Phys.. 117-130.1892; also Groth, Phys. Kryst., 788-766, 1896.

vid crrstalliDe sectiooa or fnEtueoU. The more important poiots to which (he aUenUon U to be directed, more puUcuhirly in tbe case of miaerala In aections of rocks, are: ll) crystalline form, M shown io Uie outline; (it) direction of cleavage-11 qob; (8) refncilTe

Index: (4) Ugbt'SbiorptloD Id different dlrecttoua, i.e.. dichroism or pleochrolsm; (B) Ibe

Isotropic or anisotropic character, nod If the latter, the direction of tbe plaoea of liglit-TibraMon—thl« wilt generally decide the question ns (o the rrjslalltue sjstemi (6) poaition of the axial plane and nature of thenxinl tntertereDce-fle"reH; (7) the Hlrength ana character (+or—)of the double refraction; (H) Inclusions, solid, liquid, or gnaeoiia. The explanation Id regard to the special optical points mentioned is deterred to later pages.

GENEEAL OPTICAL CHARACTERS OF MINERALS.

331. There are certain characteriatice belonging to all minerals alike^ ciyatallized and non-crystallized, in tlieir relation to light. These are:

1. DiAPHAKEiTT: depending on the relative quantity of light transmitted.

2. Color: depending on the kind of light reflected or transmitted, as determined by the selective absorption.

3. Ldsteb: depending on the power and manner of reflecting light.

1. DXAPHANEITT.

332. Decreet of Trwuparanoy.—The amount of light trananiitted by a solid varies in intensity, or, in other words, more or less light may be absorbed in the passage through the given substance (see Art. 807). The amount of absorption is a minimum in a trsLsparent solid, as ice, while it is greatest in one which is opaqne, as iron. The following terms are adopted to express the different degrees in the power of transmitting light:

Transparent: when the outline of an object seen through the mineral is perfectly distinct.

Suitransparent, or setni-lraitsparent: when objects are seen, but the outlines are not distinct.

Translucent: when light ia transmitted, but objects are not seen.

Siibtranslucent: when merely the edges transmit light or are translucent.

When no light is transmitted, even on the thin edges of small splinters, the mineral is said to be opnqve. This is properly only a relative term, since no substance fails to transmit some light, if made sufficiently thin. Magnetite is translucent in the Pennshury mica. Even gold maj be beaten out so thin as to be translucent, in which case it transmits a, greenish light.

The property of diaphaneity occnra in the mineral kingdom, in everr degree from nearly perfect opacity to transparency, and many minerals present, in their numerous varieties, nearly all the different shades.

2. COLOE.

333. ITature of Color.—As briefly explained in Art. 294, the sensation of

color depends alone upon the length of the waves of light which meet the eye. If they are all of the same length. If the light consists of various wavelengths, it is to the combined effect of these that the sensation of color is due.

Further, since the light ordinarily employed is essentially white light, that is, consists of all the wave-lengths corresponding to the successive colors of the spectrum, the color of a body depends upon the selective absorption (see Art. 307) which it exerts upon the light transmitted or reflected by it. A yellow mineral, for instance, absorbs all the waves of the spectrum with the exception of those which together give the sensation of yellow. In general the color which the eye perceives is the result of the mixture of those waves which are not absorbed.

All minerals may be-divided into two classes: (I) those whose color belongs to the flnest particles mechanically made; and (2) those whose color in the state of fine powder is different from what it is in the mass.

To the first cI&bb belong the metale and manj minerals having a motallio loBter; for iiiatance, the powder of tlie black magnetic oxide of iron, magnetite, is blaclc; lliat of beniutite, which, though often blacli on the surface, is red by transmitted light, is red, and so on.

To the second class belong the silicates, and in fact the l&rge part of all minerals having an unmetallic luster. With them the color is often quite iiijeiisenlial, being generally due to small admixtures of some metiillii; oxide, lo some carbon compound, or to some foreign substance in a finely ilivided 8tute. With most of these, the fine ponder is either white or light-colored; for example, the streak (Art, 334) of black, green, red, and blue tourmaline varies little from white.

334. Streak.—The color of the powder of a mineral as obtained by scratchins the surface of the mineral with a knife or file, or still better, if not too hard, liy rubbing it on an unpolished porcelain surface, is called the streak. It la obvious from the distinctions stuted above that the streak is often a very important quality in diatinguishina; minerals. This is especially true with ininenils of the first class mentionea above, that is, those with metallic luster, 03 defined in Art. 338.

335. Diohroiflm; Fleochrolsm.—The selective absorption, to wliicb the color of a minenil is due, more especially by transmitted light, varies according to the molecular structure of the crystals. It is lience one of the special optical characters depending upon the crystallization, wljich are discussed later. Here belong dichrot'sm or pleochroism, the proiwrty of exhibiting different colors in different directions by transmitted light. This subject is explained further in Arts. 366 and 3d3.

336. Varieties of Color.—The following eight colors were selected by Werner as fundamental, to facilitate the employment of this character in the description of minerals: white, gray, black, blue, green, yelloK, red, and brown.

(a) Tbe vnrlciies of Metallic Colors recogoizod arc us follows:

1. Copper-reit: iiiitive co|i[>er.—2, Bronte-yelU»B: pyrrhotite.—8. Brau-yelha: ctialco-pyHle.—-4. Gold-yeUme: native giild.—5. Silter-whitt: native silver, lets distinct iu arseoo-pyrite.—9. Tin-whiit: inercnry; colwhite.—7. Lead-grny: gsleiia, iD'ilybdenile.—8. Steel-sra'i: Dearl; tlie cuior of llue-graiued aleeX ou & lecciil fructure; native plalinum, uid pallioli^m.

if>: Tlie following are Ibe varieties of Kon-ubtallic Colors:

A. Whitb. 1. Snete-white: Carrnni niurblt:.—2. Hedduh white, 8. Telloteiih tehiUutdi. OrayM aAiU: all illustraled by SDiiie varieltea of ciiti'iie nnd quartz.—5. QraeuUh whiU; talc—6. MMiehitt; wliiie, Kliglitly bliiln'ii some clialcfdony.

B. Qrav. 1. Biuith gray: gray, InMlnitig to diriy blue.—2. PtarUgrny: gray, mixed wirb ri.'d and blue: cerargyritu.—:|. Bmoktgray: gray, with some brown; ulnf.—4. Gretn-Uhgray: gray, with some green: Qit'Heye; some vark'tles of liilc.—5. Yellomiligray: some varieties of compact tlnieslonc.—6 Ath-nray: tlJe purest L;ray color ; zoisite.

C. Black. 1. Orayiih btaek: blark, mixcil wilb p-ay (wltlniui green, brown, or blue lints) 1 basalt: Lydiiin slone.—2. Velvet-blnek: purt black ; ol»itlian. black tourmBliiic—8. OretnUhbtaek ■ auglte.—4. Broumith blaelc: brown coal, llgnile.—S. Bluith black: black cobalt,

D. Blds. 1. BlaekUh blu»: dark varieties of iiznrite.^3. AzuTt-bhie: n, clear Bbade of bright bine; pale vaiietleB of azurile, brlgbt varieties of lazulite.—3 VioUt-biut: blue, iiil:(etl with red : amethyst, fluorite.—t. I^rxadtrblut: blue, witli some red and much gmy. — a. Pnurian-btv^, or Berlin blue: pure blue; snppfaire, cyauite.—6. trniall-biut: some varieties of gypsum.>~7. IfuUgo blvt: blue, with black and green ; blue tnurmaliue.^tj. Sky-blue: pale blue, with a little greeu ; tl Is callcil mountain-blue by paluEers.

£. Qrkbr. 1. Verdiffrii-gretn: green, Inclining lo blue : some feldspar (amnion-stone). ' ~ ' " ' h bitie and gi^y ; aome varieties of laic and berjt. Il Is tbe - _„.___, , _, „ .. ^^^

.dbyGooglc

much blue; berjl.— i. Leik-grMn: green, with some brown: the color of leaves of garlic :

dUcinutlj seeo in pnae, a variety of quarcz.—G, Sraerald-grMH; pure lieep j^reeu ; emerald. —B, Apple-grt»n: liglit green witb some yellow; cbcysopraae.—7. Orau-grten : lirig.i freeu, with more yellDw ; greeo dLdlage.—8. Piitaehio-grten: yellowish green, with Biiiiie rown ; epldote,—9. Atparagiu-greea: pale green, wiili mucji yellow; aspunigus siune (upeilte).—10. Bladdth green: serpeutlDe.^-lI. OUm green: dark grecD, with much tiruwu uLd yellow; chrysolite.—13. Oil-grten: the color of ollve-oii; beryl, pilchstoiie.—18. SUkin-green: light green, much iiicllDiig to yellow ; urauite.

F. Yellow. 1. Salphiiryellov: Guliiljur.—3. Slraa-gallou: pale yellow; lopiiK.—8. Wax yelltm; grayish yellow wjlh some brown ; blende, opal.—4. Boneg-yeilote: yellow, with some red and brown ; cnlcite.—Et. L'lnoit-yellua: sulphur, orplmeul.—o. Oeher-f/eUow: yelloT, wiih browu ; yellow ocber—7. Wiae-yeilovi: topaz and lluorite.—8. Cream-yeUtna: some varieties of litbomarge.—o. Oraiige-yeUovi; orpimeut.

G. Red. 1. Aurora-red: reil. with iiiiicb yellow; some realgar.—2. Hyaeinth'Ted: red. with yellow and some brown ; liyaciulb giiinot.—3. Biidc-rtd: polylialile, some jasper.—4, 8cartet-red: bright red, with n tinge of yellow; ciDUftbnr.~5. Blood-red: dark red. with some yellow; pyrope.— i. Kiei/i-red: ffldspnr—7, Oarmine-red: pure red ; ruby sapphire. —8. fioie-red: rose qunrtz —8. CHmiion-rtd: ruby.—lU. Peacliblouom-red: red, with white null gray : lepidoliti;.—11. Oolun^iu red : deep red, with some blue ; garnet.—13. C/terry-red .' iliirk red, with some blue and bniwu ; spinel, some jasper.—13. Brownith-red: jasper. Hmoiiite,

H. Brown. 1. Beddith brouin: garnet, zircon.—2. Clotebroien: brown, with red and some blue; azioite.—3. Hairbroan; wood opal.—4. Broceoli-brovin: brown, with blue. red, and gray ; zii-con. —5. Chetlnut-br-mcn: pure brown.—8. Yeliowieh brown; Jasp^T.—T. Pinchbeek-brown: jellowiali-bniwa. wilh a metallic or metallic-pearly luster: sev.Tal varieties of talc, bronziti'.—8. Wood-broaiH: color o(old wood nearly rotten ; somt- .linci-meJis of usbestus.—9. Liver-brnren: brown, with some gray and green ; jasper.—10. Black-uhbrown: bituminous coal, brown coal.

337. Nature of Lmter.—The luster of minorals varies with the nature of their surfaces. A variation in the quantity of light refiected produces different degrees of inteDsity.of luster; a variation in the nature of the reflecting surface produces different kinds of luster.

338. Eindi of Laater.—The kinds of luster recognized are aa follows:

1. Metallic: the luster of the metals, as of gold, copper, iron, tin.

In genera!, a mineral is not said to have metallic luster unless it is opaqne in the mineraiogical sense, that is, it transmits no light on the edges of thin splinters. Some minerals have varieties with metallic and others with nnmetal-lic hister; this is true of hematite.

Imperfect metallic hister is expressed by the term swJ-me/«2Wc, as illustrated by colitmbite, wolframite. Other kinds of luster ara described briefly as

UNMETALLIO.

2. Adamaniine: the luster of the diamond. When also sub-metallic, it ia termed metallic-adamantine, as cerussite, pyrargyrite.

Adamantine luster belongs to substances of high refractive index. This may be connected with their relatively great density (and hardness), as with the diamond, also corundum, etc.; or because they contain heavy molecnlea, thus most compounds of lead, not metallic in luster, have a high refractive index and an adamantine luster.

3. Vilreonx: the luster of broken glass. An imperfectly vitreous luster ia termed suf>-vitreous. The vitreous and sub-vitreoua lusters are the most common in the mineral kingdom. Quartz possesses the former in an eminent degree ; calcite, often the latter.

4. Resinous: luster of the yellow resins, aa opal, and some yellow varieties of sphalerite.

5. Greasy; luster of oily glasB. This is near resinoua luster, bat is ofteii qnite distinct, as elffiolite.

6, Ftarly: like [learl, as talc, brncite, BtilbitCj etc. When uiiited with enb-metttllic, as in hypersthene, the term metal!ir-penrhf is used.

Pearly liiBter belouge to the light rejected from a pile of thin glaBS-platee; similarly it ie exhibited by minerals, whicli, having a perfect cleavage, may be iMircially separated into sticceHaive plates, as on ihe basal plane of apophylllte, h ia also shown for a like reason by foliated iniuerals, as talc and brucite.

T. ISilky: like silk ; it is the result of a fibrous structure. Ex. fibrous cal-cice, fibrous gypsum.

The different degrees and kinds of luster are often exhibited diflerently by unlike faces of the same crystal, hat always similarly by like faces. The laterw faces of a right square prism may thus diser from a terminal, and in the right re[;tangnlar prism the lateral faces also may differ from one another. For eiantple, the basal plane of apophyllite has a pearly luster wanting in the pris-matic faces, they having a vitreous luster.

As sliiiwii by UiiiillDgi.'r, oiil/ vllruous. udamonllnu, and metallic lusier belong to fnces IK-rreclly sm.Kiili iLud pure. In llie flrsi, ibe rofmctive itidex cf the mmeral la 1 8-1 8 ; in [liL' »«cuiid. 1 &-2'5: iu Ibetliirtl. iibout 2'ii. Tbi: true UlilereucB between webillie and viirtiiUH lusier iit due l»lbe effect wliiuh tbetlifCvrijiit suiTucesliaTCupua iLe retlecled light: fii gei]i;riil. ihe luster ia prodiicud by Ihe util'iu nt two slmulKtneoua tui|ii'easioDS niqde upon . the eye. If Ihe light ruUecled from u metullic Biirfiice iie exidniDid by a Di<-ol prism (or the dichro!^ei>pv of HaiJbiger, AK. S66). It will be rmmd that boib rnys, thai vibriiliug lu the pUiue of incidence iinil tbiil wbiiae vibmtioitR are normal lo It, are alike, eiicb having the I'oliir of tbe materiiil, only differing a little in bnliiriDcy; on Ihe conirary. of the liglil rt^HecIeil by n vilruoua kdIi.i lance, tbose ruys wliose vil>iiilioiis nre at right iiuglt-s lo the plane or incidence are more or lesa polarized, atid nre colorleiia. if bile those wiiose vibmtiona are in ihls plane, having peiieirated snmewbtit into the medium iinii siiSired »onie absorption, ahow tiie color of the a'lbaieuce llselC A pliile of red glass Ihus examined will aliow a colorless and a ri'd image. Adamantine liisiui' occupies a position between Ihe olliera.

339. Degrees of Liuter.—The degress of intensity of luster are denominated OS follows;

1. Splendent: refiecting with brilliancy and giving well-defined images, as hematite, cassiCerite.

2. Shining: producing an image by reflection, but not one well-defined, as celfstite.

3. GUsfenin/j: affording a general reflection from tbe surface, but no image, as talc, chalcopyrite.

4. Glimmering: affording imperfect reflection, and apparently from points over the surface, as flint, chalcedony.

A mineral is said to be dull when there is a total absence of luster, as chalk, the ocbers, kaolin.

340. Flay of Colors. Opalescence Irideseenoe.—The term play of colors is used to describe the appearance ot several prismatic colors in rapid sticcession on turning the mineral. This property belongs in perfection to the diamond, in which it is due to its high dispersive power. It is also observed in precious opal, where it is explained on tlie principle of interference; in this case it is most brilliant by candle-light.

The expression change of colors is used when each particular color appears to pervade a larger space than in tbe play of colors and the succession produced by turning the mineral is less rapid. This is shown in lahradonte, as explained under that species,

Ojialeacence ia a milky or pearly reflection from the interior of a specimen. Observed in some opal, and in cat e-eye.

Iridescence means the exhibition of prismatic colors in the interior or on the Bui'face of a mineral. The phenomena of the play of colore, irideBCunce, etc., are sometimes to be explained by the presence of minute foreign crystals, in piirallel positions; more generally, however, thuy are caused by the presence of tine cleav age-lam elite, in the light reflected from which interference takes place, analogous to the weD-kuowu Newton's rings (see Art. 313).

341. Taroisfa—A metallic surface is tarnished when its color differs from that obtained by fracture, as is the case with specimens of bornito. A surface possesses the steel tarnish when it presents the superficial blue color of* tempered steel, as columbite. The turnish is irieeU when it eiliibits filed . priamaCic colors, as is common with the hematite uf Elba. These tarnish and iria colors of minerals are owing to a tliiii surface or film, proceeding from different sources, either from a change in the surface of the mineral or from foreign incrustation; hydrated iron oxide, Dstially formed from pyrite, is one of the most common sources of it, and produces tlie colors on anthracite and hematite.

313. Aateriam.—This name is given to the peculiar star-like rays of light observed in certain directions in some mineralB, This is seen by reflected light in the form of a six-rayed star in sapphire, and is also well shown br transimitted light (as of a small flame) with the pblogopite mica from South Burgess, Gan^a. In the former case it is explained by the presence of thin twinning-lamellse symmetrically arranged. In the other casu it is due to the presence of minute inclosed ci'ystals, also symmetrically arranged, which are probably rutile or tourmaline in most cises. Crystalline faces which liave been artificially etched also sometimes exhibit asten'sm. The peculiar light-figures sometimes observed in reflected light on the faces of crystals, either natural or etched, are of similar nature.

343. ScMllerization.—Tiie general term schiller (from the German) is appited to the peculiar luster, sometimes nearly metallic, observed in definite directions in certain minerals, as conspicuously in schiller-spar (an altered variety of bronzite), also in diallage, hypersthene, sunstone, and others. It is explained by the reflection either from minute inclosed plates in parallel position or from the surfaces of minute cavities (negative crystals) having a common orientation. In many cases it is duo to alteration whicii has developed these bodies (or the cavities) in the direction of solution-planes (see Art. 264). The process by which it lias been produced is then called schiller ization.

344. Flnorescenoe.—The emission of light from within a substance while it is being exposed to direct radiation, or in certain cases to an electrical discharge in a vacuum tube, is called fluorescsHce. It ia best exhibited by fluorite, from which the phenomenon gained its name. Thus, if a beam of white light be paased throngii a cube of colorless flnorite a delicate violet color is called out in its path. This effect is chiefly due to the action of the ultra-violet rays, and is connected with a change of refrangibility in the transmitted light.

The electrical discharge from the negative pole of a vacuum tube calls oat a brilliant fluorescence not only with the diamond, the niby, and many gems, but also with calcite and other minerals. Snch snbstances may contmue to emit light, or phosphoi-esce, after the discharge ceases,

345. FhosphoreBcenoe.—The continued emission of light by a substance (not incandescent) produced especially after heating, exposure to light or to an electrical discharge, is (ifi2\^ phosphorescence.

Fluorite becomes highly phosphorescent after being heated to ahont 150° U. Different varietieH give off light of different colors; the chlorophane Tariety, an emerald-green light; others pnrple, bine, and reddish tints. Thi» phoapooreecence may be observed in a dark place by subjecting the pulverized mineral to a heat below redness. It is even called out by a sharp blow with a hammer. Some varieties of white limestone or marble, after slight heating, emit a yellow light; so also tremolite, danburite, and other species.

By the application of heat minerals lose their phosphorescent properties. But on passing electricity through the calcined mineral a more or less vivid light is prodnced at the time of the diechai'ge, and aubseouently the specimen when heated will often emit light as before. The light is usually of the same color as previous to calciDation, but occasionally is quite different. It is in general less intense than that of the unaltered minei'al, but is much iucreased by a repetitiou of the electric discharges, and in some varieties of flaorite it may be nearly or quite restored to its former brilliancy. It has also been found that some varieties of fluorite, and some specimens of diamond, calctte, and apatite, which are not naturally phosphorescent, may be rendered BO by means of electricity. Electricity will also increase the natural intensity of the phosphorescent light.

Exposure to the light of the sun produces very apparent phosphorescence with many diamonds, nut some specimens seem to be destitute of this power. This property is most striking after exposure to the blue rays of the spectrum, while in the red rays it is rapidly lost.

LiTKRATORK.

A$lentm,

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Pr. von Koball. Her, Ak. MUuclieo. 80, 1863.

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ftuore>e/inc«, PhotpJieraeence.

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aW many other memoirs.

SPECIAL OPTICAL CHARACTERS BELONGING TO CRYSTALS OF THE DIFFERENT SYSTEMS.

346. All crystallized minerals may be grouped into three grand classes, which are dietinguiehed by their physical properties, as well as their geometrical form. These three classes are as follows:

A. Isometric class, embracing crystals of the isometric system, which are referred to three equal rectangular aioa.

B. Isodiametric class, embracing crystals of the tetragonal and hexagonal systems, referred to two, or three, equal lateral axes and a third, or fourth, axis nnequal to them at right angles to their plane. Crystals of this class have a fixed principal axis of crystallographio symmetry.

C. Anisoiiietric class, embracing the crystals of the orthorhombic, mono-clinic, and triclinic systems, referred to three uneqnal axes. Crystals of thia class are without a fixed axis of cryatallographic symmetry,

347. I^tropio Crystals.—Of the three classes, the laoMETRic class includes all crystals which, with respect to light and related phenomena involving the ether, are isotropic; that is, those which have like optical properties in all directions. Specifically, a light-wave is propagated in them with the same Telocity in all directions, and its wave-tront is therefore a sphere. Hence, also, the sphere may be regarded as representing the optical structure of an isometric crystal. The geometrical property of the sphere that every cross-section is a circle corresponds to the optical property of the isotropic medium in which the velocity of light-propagation is the same in every direction, for this being true, the

medium must have like properties of the etber in any plane normal to such a line.

It must be repeated here, however, that such a crystal is not isotropic with reference to those characters which depend directly upon the molecular structure alone, as cohesion and elasticity, (See Art, 264.)

Further, amorphous bodies, as glass and opal, which are destitute of any oriented molecular structure—that is, those in which all directions are sensibly the same—are also isotropic, and not only with reference to light, but also as regards their strictly molecular properties,

348. Anisotropic Crystals; Uniaxial and Biaxial—Crystals of the isodia-METRIC and ANI8oMETRIC CLASSES, on the Other hand, are in distinction anisotropic. Their optical properties are in general unlike in different directions, or, more particularly, the velocity with which light is propagated varies with the directiou.

Further, in crystals of the isodiametric Class that variable property of the light-ether upon which the velocity of propagation depends remains constant for al! directions which are normal, or, ngain, for all those equally inclined to the vertical crystallographic axis. In tlie direction of this axis there is no double refraction; it is hence called the optic axis, and the crystals of this class are said to be uniaxial. The optical structure of uniaxial crystals can be represented by a spheroid, that is, an ellipsoid of revolution whose axis of revolution is the optic axis, or axis of crystallographic symmetry. The direction and properties of this optic axis will be seen to correspond to the geometrical property of the spheroid, a section of which normal to this axis is always a

Crystals of the third or anisometric class have more complex optical relations requiring special explanation, but in general it may be stated that in them there are always two directions analogous in character to the single optic axis spoken of above, hence these crystals are said to be optically biaxial. Further,

it will be shown that their optical stractnre may be represented geometi-ically by an ellipsoid with three unequal rectangular axes. Every each ellipsoid has two directions in which it can be cut yielding cross-sectiona which are circles; the optic axes spoken of will be seen later to be normal to these planes after the analogy of uniaxial ci-ystals.

In crystals of the orthorhouibic system the axes of the ellipsoid coincide in direction with the crystallographic axes. In crystals of toe monoclinio system one of these ellipsoidal axes coincides with the axis of crystallographic symmetry, the other two lie in the plane of symmetry. In crystals of the triclinic system there is do necessary relation between the position of the ellipsoidal axes and those assumed to describe the crTstallogrsphic form.

All of these points require detailed discussion, but the abovb statements will partially eerve to bring out the intimate connection between the molecular structure exhibited in the geometrical form and the optical characters depending upon the properties belonging to the light-ether within the crystal.

A. IsoMETBio Crystals. 349. It has been stated that crystals of the isometric system are optically isotropic, and hence light travels with the same velocity in every direction in them. Light can, therefore, suffer only single refraction in passing into an isotropic medium; or, in other words, there can be but one value of the refractiTe index for a given wave-length. If this be represented by n, while V is the velocity of light in air and v that in the given medium, then

The wa?e-front for light-waves propagated from any point within such an isotropic medium is a sphere, and, as already stated, this geometrical figure may be taken as representing the optical structure of an isometric crystal.

This statement holds true of all the gronpa of isometric crystals. In other words, a crystal of maximum symmetry, as fluorite, and one having the restricted symmetry characteristic of the tetrahedral or pyritohedral divisions, have alike the same isotropic character. Two of the gronps, however, namely the plagihedral and the tetartohedral groups, differ in this particular: that crystals belonging to them may exhibit what has already been defined (Art, 333) as circular polarization.

3fiO. Behavior of Sections of Isometric Crystals in Folsrised Light.—lu con-sequence of tlieir isotropic character, isoinetric crystals exhibit no special

Ehenometia in polarized light. Sections of transparent isometric crystals may e always recognized as such by the fact that they behave as an amorphous substance in polarized light. In other words, a section on the stage of the

fiolarization-microscope, when the nieols are crossed, appears dark, and a rovo-ntion of the section in any plane produces no change in appearance. Similarly, it appears light in any position when placed between parallel nieols. Some anomalies are mentioned on a later page (Art. 411).

The single refractive index may be determined by means of a prism cut with its edge in any direction whatever.

B. Uniaxial Crystals, General Optical Relations. 351, The crystallographic and optical relations of crystals belonging to crystals of the tetragonal and hexagonal systems have already been bneffy

Gu nimarized (Art. 348); it nov remaina to develop their optical characters more fully. This can be done most simply by making frequent nse of the familiar conceptiou of a light-ray to represent the character and motion of the lightwave.

352. Optic Axis. Ordinary and Extraordinary Bay.—The study of a crystal belonging to this clasa shows, in the first place, that light-rays which pass in the direction of the vertical axis siifFer no double refraction. This (Jirection is that called the optic axis. Since the rays spoken of are propagated by vibrations at right angles to the vertical axis, that is, in the plane of the lateral crystallograpbic axes, this observed fact proves that for such rays there is but one value of the refractive index, and, further, that all the lateral directions must be identical so far as those properties of the ether are concerned upon which the velocity of light depends.

On the other hand, light wliich passes through the cryetal in any other direction than that of the vertical axis suffers double refraction; in other words, it is separated into two rays, which are propagated with different velocities. This is true (see Art. 310) even when the rays follow the same path, as in the case of perpendicular incidence upon the given face.

Both of these rays are completely polarized, and that iD planes at right angles to each other.

It is found, further, that for one of these two rays, namely, that propagated by vibrations normal to the vertical axis, there is a constant value of the refractive index, whatever its direction; moreover, this value follows the usual]fiw as to the constant ratio between the sines of the angles of incidence and refraction (Art. 293). It is hence called the ordinary ray, and the corresponding refractive index is uniformlv represented by the letter ci>.

For the other ray, on the otner haud, it is found that the refractive index varies, and in general it does not obey the sine law. It is heoce called the extraordinary ray. Further, if the direction of propagation changes progressively from that nearly coinciding with the vertical axis to that in the lateral plane normal to it, it is found that the value of the refractive index of the extraordiuary ray deviates more and more widely from the constant value for the ordinary ray, and diis difference becomes a maximum when the former is propagated in s lateral plane normal to the vertical axis, that is, by transverse vibrations in the direction of this axis. This last value of the refractive index is represented by the letter e. These two indices, la and e, are called the principal indices of a uniaxial crystal. A principal section of a uniaxial crystal is a section passing through the vertical axis.

353. Positivfl and Negative Crystals.^Uniaxial crystals are divided into two claases. Those in which the refractive index of the extraordinary ray, e, is greater than that of the ordinary ray, o), are caWeA.positive. This is illuatrated by quartz for which (for yellow sodium light):

oo = 1-544. € = 1-553.

On the other hand, if oa is ^eater than 6, the crystal is said to be negative. Calcite is an example, for which (for sodium light):

w = 1-658. e = 1-486.

Other examples are given later (Art 866V

364. Wave-anrfaoe.—Remembering that the velocity of light-propagation is always inversely proportional to the corresponding refractive index, it is obvious that the velocity of the ordinary ray for all directions in a uniaxial

crjstal must be the s&me, being uniformly proportional to —. Id other

vords, the ware-front of the ordinary ray must be a sphere.

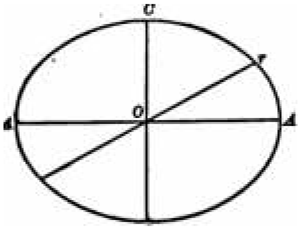
For the extraordinary ray, however, the Telocity varies with the direction,

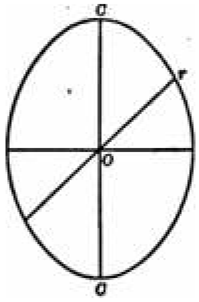
being proportional to — in a lateral direction and becoming sensible equal to — when nearly coincident with the direction of the vertical axis. The

law of the varying change of velocity between these values, — and — is given

by an ellipse whose axes {oo, OA, Figs. 518,519) are respectively proportional to the above values.

618. SIS.

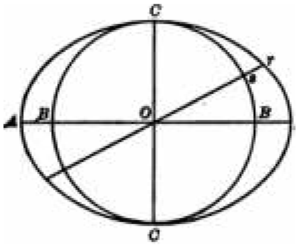


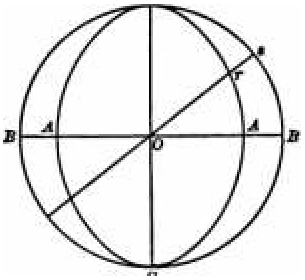


oo : OA = ~: -^ = B : w.

This law, BQggested by Hnygens, has since been verified by accurate experiments by Beveral observers for typical substances, as calcite and soda niter; hence it is accepted without question as a-law of nature. The wave-front of the extraoi'dinary ray ie then a spheroid, or an ellipsoid of revolution whose axis coincides with the vertical crystallograpliic axis, that is, the optical axis. In the direction of the vertical axis it is obvious that the two wave-fronts coincide.

B20. 631.





Kegstlve cryetal, a> > e. Positive crystal, e > no.

Figures 520 and 521 represent vertical sections of the combined wave-■nrtaces for both rays. Fi?. 530 pivps tbnt fnr a I'-nafive crystal like calcite

jc by Google

<» > e); Fig. 521 that of a positive crystal like qnartz {e > t»). Fig. 522 is

,ao an attempt to show the relations of the two

wave-fronts of a negative crystal in perspective.*

The constant value of the velocity of the ordinary

ny I -1, whatever its direction in this plane, is

' expressed by the radins of the circle (= OC). On the other hand, the velocity of the extraordinary ray in the lateral direction is given

by oA{~\, while in a direction as Oer, Fig. 520

[Ors, Fig. 521), it is expressed by the length of

this line, becoming more and more nearly equal to OCi-] as its direction

approaches that of the vertical axis.

365. Indloatrlx.—It will now be understood what was meant by the statement in Art. 348 that the optical strncture of a uniaxial crystal may be represented by an ellipsoid of revolution, and it is further obvious that the ratio between the axes of this ellipsoid must be as already given:

OC: oA=~:\ or e : «.

O} €

It has been shown bv Fletcher f that this ellipsoid, called by him the iodicatrix, may be taken to repreaeut the optical characters of both rays without reference to the wave-surface, since it can be proved geometrically % that for a given direction, as Or, the velocity of the extraordinary ray is expressed not only by Or bnt also by the inverse of the normal upon it from the point R (determined

by the tangents to the ellipse), that is, by -^-y;

also this normal fixes the plane of polarization which ia perpendicular to UN. Further, the velocity of the ordinary ray, having the same direction (cf. p. 195), is expressed by the inverse of the second normal upon the same line, that

is, T—T, since this normal is always in the equatorial plane, the section of which

is a circle. Fig. 523 shows the form of the indicatrix for a negative crystal

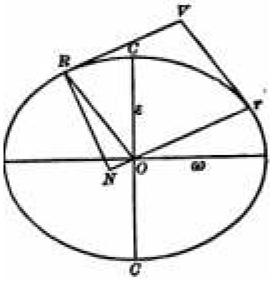
* Figs. 622 and 536 Are taken from Mllller-Pouillet's L«btbucli der PbyBik. fThe Opllcnl JodlciLlrlz &d<1 Ibe TraDsmisaloQ of Light \a Cryitala, by h. Plelcher, LoDdoD. 18S3.

{This follows, from the property of Ihe ellipse Id geDeral, since the paiallelograra

OnVr = OA.OC. llMit li. RN.Or = OA.OC and Or = ^^- ■■■ Or = ^""^K

In other words, the velocity of the eztraordlDarr ray (Si) varies tovenely as ^^ Bhnllarly, tb U repreteDted by Ort, tbat is, Id the iodicatrix by Ml rt. n/i o^oo Constants

523.



like calcite (<»> e); that for a positive cr78ta1, like qnartz {e > tu) would be a prolate

Bpueroid.

ue. EzamplM of FcdtlTi and H*K>tiT« 0r7(taIi.~The following listii give promloeDt pomtive aud Degfttlve uniaxial crystals, with the values of Itie refr&clive iLdlces, m nud e, for each, correspoudiue lo yellow •oUium light." Tlie differeuce bttwten lUesc, m— e or f —ao, fe also Kiveo: llifs measures tbe blrefrlugence or ilrtTigtA of Iht: double rvfnictlon.

It Tiiay b« remarked that Id tome ipecies bnib -4- Rnd — varielii's have been observed. CertAio cryalals of upopbylllte ftre pwiliTe for out: eud of tbe ipectrum and Degnllve for the oiber, aud cuDiequeully for some colnr between tbe two ixlremea <1 has no double refreciiOD. Tbe Mme It true fnr tome other species (t.g.. cbibazile) of weak double lefnctloD. It if to be noted also that while eudlalyte Is positive, tbe related eucoUte Is negative.

Neoativb Cbibtau.

Prouitite	»0877	37924	0-2B88
Caldle	10565	14863	01729
Tourowline.	1'6807	1-6S08	(J'OlBe
Corandum	1-7075	17693	00088
Beryl	l-fi8M	15821	0-0078
Nephellie	IMia	15876	00040
Apatite.	1-QlQl	1-6417	00084
TetuviaoiW.	1'7285	1-7226	00000

POBITITE Cbtitai.b.

Rulile	3-6158	2'9029	02871
Cassllerlte	1 0BS6	30934	00068
Zircon	1-9818	18831	00618
Phenaclte..	16540	1-6697	00157
Brudte	1-5500	1-S705	00205
Qunrtz	1-5448	15588	000»1

Apophylllte 1-5837 15356 0 0010

Lciicile 1-508 1-609 0 001

Examination of Uniaxial CrystaU in Polarized Light.

357. Section Normal to the Axis in Parallel Polarized Light.—Suppose a

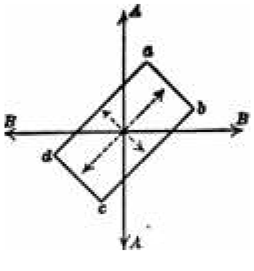
section of it uniaxial crystal to be cut perpendicular to the vortical axis. It baa already been ahowii that light passing thronRb the crystal in this direction suffers no double refraction; consequently, such a section exatiiined in pnri'llet polarized light in tlic inatninient called an orthoscope (Fig. J15), or in tlio polarizat ion-microscope (Figs. 516, 517), behaves as a section of an isometric crystal, or of nn aniorphoiiB substance, if the nicols are crossed it appears dark, and remains no when revolved.

358. Section Parallel to the Axis.—A section cut parallel to the vertical axis, as already explained, has two directions of light-vibration, one jiarallel to this axis and the other at rifjht angles to it. A ray of ordinary light falling upon such a section at right iingles is divided into the two rays, ordinary and extraordinary, which, however, in this special case of perpendicular incidence travel on in the same path through the crystal, but one of them retnrdeil relatively to the other. In parallel polarized light between crossed nicols each a section will appear dark if the directions of its two vibralion-iilaiies coincide with tbe vibration-planes of the nicols. Thus in Fig. 554, A.\ being

'For authorities, sec Dana's System, 1892. For coniadum aad brucite the values of osr and Fr are given.

the vibration-plane of the lower nicol (polarizer) and BB of the upper nicol (Hniilyzer), the light that has passed through the polarizer has its Tibrations limited to the plane A A; theee, therefore, pass through the section abed, but they are iirreatud or extinguished by the second nicol. The same will be true if tim sectiou is turned at right angles to the first position, that is, into the jmsition n'b'c'd', represented by the dotted lines.

If the section stand obliauely, as abed in Fig. 535, it vill appear light to the eye (and usually colored). For the vibrations parallel to AA that have



passed through the polarizer have upon resolution a component in the direction of each of the vibration-planes of the section. Again, each of these componeutB can be resolved along the direction of the vibration-plane of the npper nicol, BB. Therefore, two rays will emerge from the analyzer, both having the same vibration-plane, but one more or less retarded with reference to the other, the amount of retardation increasing with the birefringence and the thickness of the section. In general, therefore, these rays will interfere, and if the thickness of the section is enlScient (and not too great) it will appear colored in white light and, supposing the thickness uniform, of the same color throughout.

Any section whatever of a uniaxial crystal appears dark between crossed nicolB if its principal section (Art. 352) coincides with the vibration-plane of oitlier nicol.

359. Color of a Section in Parallel Fotariced Light. Birefringence.—The interference-color of a section under examination depends (Art. 320) upon its thickness and upon the birefringence; this birefringence has a maximum value, equal to a> — € or e — <», if the section is cut parallel to the optic axis (i.e..\\d).

The following table*' gives the thickness (in millimeters) of sections of a few uniaxial crystals which yield red of the first order:

	Birefi'iDgeiice (to-)or(e-«).	Tliickaess id Millimeters.
Entile	0-28T	0-0019
Calcite ".	0-1T2	0 0032
Zircon	0062	00089
Tourmaline	0-023	0 0340
Quartz	0 009	00612
Kephelite	0-004	01377
Leucite	0001	0-5510

• See further. RnseDbusch (Hikr Pliya. Mlo.. 1892, p. 166). from whom these are taken. Compare bIso remarks made Id Art SSO.

Again. asanolLereiample, it may be noted that nilh zircciu {e — m = d 062), a lliiikiicsa of abi.m O0O9 mm gives reU of tlie flrsl ordur; of 0 017 red of ilie second order; of 0026 Led of tilt: tliird urdtr.

Tlie metlioUa ordinarily used to lieletmlae the birefringence of a section (not ± i) of a utli,'l^illl crystal, as hIho 1o fix tJie relative vulue of [Ix two libmliondirccliouH, are Ibe sama :is tliose employed lor biaxiul ciyslnls. aud the discussiuu ut ibeni is poslpoucd to a later lu^'t! (Art. SH)

360. Uoiazial Interfereooe-flgnre.—If an uxial section, that is, one cut nornjal to the vertical axis d, of suitable thJcknesa, be viewed in converging polarized light iu a polarise ope, e.y., the conoscope (Art. 827, Fig. 514), or the loiirmaline tongs (Fig. 513), or again in the microscope* arranged for the purtKise, it no longer appeai-s durk. On the contrary, a beautiful phenomenon is observed: a symmctrtcul black crosit^when the nicols or tourmaline plates are crossed—with a series of concentric ringa, dark aud light in monochromatic light, bnt iu white light showing the prismatic colors in sncсession in each ring. This is represented without the colors in Fig. 536, and with the colors iu Fig. 1 of the plate forming the frontisj^iiece to this volume.

This cross becomes white when the nicols or tourmalines are in a parallel position, and each band of color iu white light ciianges to its complementarj thit (cf. Fig. 52i). These intorference-figures, seen \ in tiiis form only in a plate cut perpendicular to the vertical axis, mark tli^vniaxial character of I lie crystal.

The explanation of this phenomenon, bo far as it can be given in a brief statement, is as follows: All the rays of tight ^rpendicnlar to the plane ot tl)e section, that is, those whose vibrations coincide sensibly with the vibration-planes of either of the crossed nicols, must necessarily be extinguished. This 636. 637.

gives rise to the black cross in the center, with its arms iu the direction of tba

planes mentioned. Obviously this cross will be darkest along its central axis, while it fades out on the sides. All other rays passing through the given plate obUqiiely are doubly refracted, and after passing through the second nicol, thus being referred to the same plane of polarization, they interfere, and give rise

•After Ibe section is la position on tlie stage, and properly focused, the eye.piece la removed and a condensing lens inserted over tbe lower nicol. It Is importiitit to use a reliiiiively liigli-power rnjective. It is also possible lo see axial fignres wFtboiit removing Ihe eye-|iifce by using a inaeiiifyini; glass iibove the latter. Cf, Klein. Jb. Miu., Bell.-Bd.. 3. r)4(), 1S85: also Berirand, Bull. 8oc. Mln.. 1. 23. 90, 1876; 3, 97. 1860.

tU'iiiiKial crystals wbich produce circular polarization exbibit an axial Interference. figure (Pig. 3 of ilie plnle referred lo above) whicb differs somewhat from that described, M Doted Iu Art 366. Some auomaliea are menttooed later. (Art. 411.)

to K series of coDCeotric rings, light and dark in monochromatic light, but in ordinary light showing the successive colors of the apectrnm. The phenomenon is closely analogous to that of the Newton's rings mentioned in An. 313. A cone of converging rays passes through the crystal a:id, having traversed the second nicol, each is divided into two rays witii common vibration-planes, but one of them (the ordinary ray in positive crystals) slightly retarded with reference to the other. When the amount of retardation is equal to a wave-length (supposing monochromatic light to be employed) the effect of the interference is to destroy the light and the plane seotiou of the cone, or ciri-ie, appears dark. Other dark rings are seen at distances which correspond to a retardation of |, {, }, etc., of a wave-length. If, however, the retardation amounts to a whole wave-length or any multiple of this, the two rays nnite to strengthen each other and give rise to a light ring, I(ordinary white light is employed, the relations are similar but the retardation cones overlap because of the different values of the refractive indices (i.e., velocities) for the different wave-lengths, and tlie series of colored circles is the result.

The distance of each successive ring from the center obviously depends upon the birefringence, or the difference between the refractive indices for the ordinary and eitraordinary ray, and also upon the thickness of the plate. The stronger the double refraction and the thicker the plate, the smaller the itnglo of the light-cone which will give a certain amount of retardation, or, in other words, the nearer the circles will be to the center. Further, for the same section the circles will be nearer for blue light than for red, because of their shorter wave-length. When the thicknesa of the plate is considerable, only the black brushes are distinctly seen.

361, Determiaation of the Refractive Indices.—A single prism sufficos for the measurement of the indices of refraction, m and e, with the refractometer. Further, its edge may be either parallel to the vertical ajcie or at right angles to this direction. Such a prism yields two images of the slit, one corresponding to the ordinary and the other to the extraordinary ray, and for each the angle of minimum deviation is to be determined, that is, the angle d in the general formula of Art. 804. Which of the two rays corresponds to the ordinary and which to the extraordinary ray can be easily distinguished by means of a nicol, the position of whose vibration-plane is known. This will extinguish that ray whose vibratioTis take place in a plane at right angles to its own Tibration-plane.

362. Other Methods for Determining the Refractive Indices.—The method of total refiection (Arts. 303 and 325) may also be employed to determine the values of a> and e. The section takeii of a uniaxial crvstal has its surface most conveniently parallel to the vertical aiis. It is so placed that the direction normitl to the optic axis is horizontal. The

liglit is here separated into two rays, having separate limiting surfaces, and with a nicol prism it is easy to determine which of them corresponds to the vibrations parallel and perpeu-dicnlar, respectively, to the optic axis.

Again, it is possible to obtain the refractive indices with considei'able accuracy from measurements, in the plane of the axes, of the distances between the black rings in the interference-figures as seen in homogeneous light. The relation between these distances and the optical "axes of elasticity" was establislied by Neumann (Pogg. Ann., 33, 357,1834). Bauer has also developed the same method as applied to uniaxial crystals, and employed it in the case of bnicite (Ber. Ak. Berlin, 1877, 704, and 1881, 958).

With the polariz at ion-microscope the most simple method is that of the

jcbyGoOgIC

Dake de Chaulnes, explained in Art. 326; this reqivrea, howeTer, ttiat the two qnantities measured should be determioed with a cousiderable degree of accuracy, if the result is to be more than an approximation. (Cf. further, Bosenbusch, Mikr. Fhys., p. 155 ei seq., 1893.)

S63. Determination of the Positive or Negative Charaoter.^—The moet obvioUB way of determining the oharacter of the double refraction (e > oj or <» > e) is to measure the refractive indices in accordance with the principles 'eiplained in the preceding articles. It is not always possible, however, to obtain a prism suitable for this purpose, and in any case it is convenient to have a more simple method of accornplishin? the result.

In the case of uniaxial crystals, the method which is practically the most simple is that suggested by Dove—the use of a cleavage plate of muscovite of snch thickness tiiat the two rays in passing through sutler a difference of pliase which is equal to a quarter wave-length, or au odd multiple of this, it is often called a quarter-undulation plate (see Art. 322).

Suppose that the section of the crystal to be examined, cut perpendicular to the axis, is brought between the crossed nicols in the polarlacope; tlie black cross and the concentric colored rings are of course visible. Let now, while the given section occupies this position, the mica plate be place<l over it, with the plane of its optic axes {determined beforehuiid, and the direction marked by a line for convenience) making an angle of 45° with the vibration-planes of ihe nicols. The interference-figure is completely transformed. The colored rings are broken by two more or less 539.' 630.

distinct hyperbohc brushes which pass +

through two black spot's near the center, wliile the rings in the corresponding qiiudrants are pushed out from the center, and in the two remiiining ' pushed in.

If now the line joining the two ilark spots Is at right angles to the axial plane of the mica (shown in the figures

by tlie arrow) the Crystal under experiment is opposite in refractive ehai'acter t(} the mica, that is, ponitive (Fig. 5'29); if this lino coincides with axial direction, tlie crystal is like the mica, negative (Fig. 530).

364. Wlih the microscope the nliove metbod niuy iilso be employed. \\\ii mica plate, u<-iiBlly ill tbe form of a. uarrow strip whoM tlongatiim \a thai of tbe plane of Ibe iiplic iixis. bei'iie iulruiluced ILrout^b n slit lu the tiilie between llie seciioD and tbe analyzer. Heio. however, ibe field of view is amaller llian in Uie iKiUriwope, AaA tbe black ilo's sro mil always distinctly observed; tbis is particularly true if tbe section be very tlilti or the nitncriil of low birefriQf;eDce. In sni'b cases a si'leiiiie plate ie conveniently employed. 'Ibis is of such tblckuesa iia lo given iwi of tlie first order, and tbe direction of elniicHllon iiiiinlly corresponds to the nxls a (Art. 378). The plale is Inserted in tlie tube wirb ils nxea iui'liiied 45° 10 the vibml ion-planes of ihe nicols. This serves to increase tlie relnrdiil.liiii helween the two inyH Iraversini; the sectiima in two al termite quad ran In and 10 diininisb iblg in the others; tbe effect bebig sbowji liv the rise or fall of Ibe interfeiciirec'ilors, as coin-|Hired with the UHiial scale (Art. 320). For example, two bine arena (Kecond order) may be wen in two opposite quadrants and two velli>w iRr-i order) in Ihe nibers The blue areaa here correspond in position to the blaok dots In Figs. hW and 530; bence if tbe line joining iliem is tmnsverse lo that of tbe axis [01 of tlie atrlenlle plale the Diiueral is positive ; if It coincides wiih It ibe mineral is negnlire.

365. Absorption Phenomena of Uniaxial Cryitals. Dichroism.—In uniaxial crystals it has been seen that there are two distinct values for the velocity of light transmitted by them, according us the vibrations take place parallel or at right angles to the vertical axis. Similarly the crystal may exert different

degrees of absorptioD upon the rays transmitted by vibrations in tbese two directions. For example, a transparent crystal of zircon looked through in the direction of the vertical uxis appears of a pinkish-brown color, whUe in a lateral direction the color is asparagua-green. This is because the niya (extraordinary) vihratingparallel to the axis are absorbed with the exceptioo of those which together give the green color, and those vibrating laterally (ordinary) are ubsorbed except those which together appear pinkiah-brown.

Again, all crystals of tourmaline in the direction of the vertical axis are opiiqtie, since the ordinary ray, vibrating normal to the axis, is absorbed, while light>colored varieties, looked through laterally, are transparent, for the extraordinary ray, vibrating parallel to the axis, is not absorbed; the color differs io different varieties, 'l^ns all uniaxial crystals tna; be dichroic or have two distinct axial colors.

The absorption-colors are most satisfactorily investigated by examining a section cut parallel to the vertical (optic) axis under the microscope provided with a single polarizing nicol. The light that passes through tlie section is then that corresponding to vibrations coinciding with the known vibration-plane of the nicol, and as the section is rotated 90°, both the two axial colors are observed in successioo. References to some important papers on this subject are given on p. 219.

An iDilniment called a diehroteope, contrived by Huiiiinger. U somutimes used for examiulDg this piopvriy of crjeiala, Au ublong rhombuliedron or Iceland apar has a glass ___. . ... . ._ ___L :... ...___,____ J , .,!_ -.yiiudrfcal - "-

prism of IS° I

tlie figure, Lavlug a

;Dted to ench extremity-

placed in a melallic

c leos at one eud. and a square bole at the oiber. Od looking

631.

through It, Ihc a^unre hi>1e appenm double; one Image belongs to llie ordluarj'nnd the oilier to the eKtriiordiuiiry my. Wlieu a pleochroic crystal ts examined with It by trans-tiiltled light, on revolving It the two ttquares, at lutevvals of 90' in the revolution, have diScri'Ut colors, coires pond lug to ihe vibration-planes of Ihe ordinary and cxtraordiosry ray in cnlclle. Hiuce the two images are Eitual«i side by side, a very slight dJfferaDce of color is perceptible.

366. Cironlar Polarization.^—The subject of elliptically ^larized light and circular polarization has already been brieffy alluded to in Art. 323. This

EhenomenoD is most distinctly observed among minerals in the case of crystals elongingtotherhombohedral-trapezohedralgroup, that is, quartz and cinnabar. It has been explained that a section of an ordinary nniaiial eryatal cnt normal to the vertical (optic) axis appears dark in parallel polarized light for every position between crossed nicols. If, however, a similar section of quartz, say 1 mm. in thickness, he examined under these conditions, it appears dark in monochromatic light only, and that not until the analyzer has been rotated so that its vibration-plane makes for sodium light an angle of 34° with that of the polarizer. In other words, this quartz section has rotated the plane of polarization (t.e., the vibration-plane normal to it) some S4°, and here either to the right or to the left, looking in the direction of the light. The amount of this rotation increases with the thickness of the section, and as the wavelength of the light diminishes (for red this angle of rotation for a section of 1 mm. is about 19°, for blue 33°). The direction of the rotation is to the right

or left, as defined above—according as the crystal is crystal I ographically right* handed or left-banded (p. 83),

If the B»nie section of quartz (cut perpeadicular to the axis) be vieired between crosaed uicola in convet-ging polarized light, it is found that the interference-figure differs from that of an ordinary uniaxial crystal. The central po] lion of the black cross has disappeared, and instead the space within the iiiiier ring is brilliantly colored.* Furthermore, when the analyzing nicol is revolved, this color changes from blue to yellow to red, and it is found that in some cases this change Ib produced by revolving the nicol to the right, and in other cases to the left; the first is true with right-handed crystals, and the second with left-handed. If sections of a right-handed and left-handed crystal are placed together in the polariscope, the center of the interference-figure ia occupied with a four-rayed spiral curve, called, from the discoverer, Airy's spiral. Twins of quartz crystals are not uncommon, consisting of the combination of right- and left-handed individuals (according to the Brazil law) which show these spirals of Airy. With ciunnhar similar phenomena are observed. Twins of thia species also not infrequently show Airy's spirals in the polariscope.

C. Biaxial Crystals.

General Optical Relations.

867, Principal RefraotiTB Indices.—All crystals of the third or anisometric class, that is, those of the orthorhombic, monoclinic, and triclinic systems, are optically biaxial. In the directions of the optic axes there is a single value only for the light velocity, but iu other directiors f a light-ray is separated into two rays propagated with different velocities ; that is, it suffers douBle refraction.

The study of biaxial crystals shows that there are two directions within theiD at right angles to each other, corresponding to which, as vibration-axes, the refractive indices have respectively a viinimuvi (a) and a iiiaxitnvm value iy) for the given substance. Further, in a third direction at right angles to each of those just named, the refractive index has a certain intermediate value, related to the others by a simple mathematical law. These three rectangular directions, or ether-axes, are properly axes of vibration, and the three corre-a^jonding refractive indices determine the rate of this transverse vibration and hence the velocity of the light-ray which corresponds to each of them. The

Talnea of the velocities are respectively proportional to -, -^, -.

The indices a, ft, y are called the principal refractive indices for the given snbstance. The mean refractive power is given by their arithmetical mean,

viz., 5 -. Further, the difference between the greatest and least index,

y — a, measures the birefringence or strength of the double refraction.

368. Optical Stmotnre of Biaxial Crystals.—It is found further that the optical structure of a biaxial crystal can be represented by an ellipsoid having as its axes the three lines mentioned in the preceding article which are at right angles to each other and proportional in length to the indices a, p, y, ITiis indeed would be inferred (following Fresnel) from the analogy of uniaxial ■crystals. The position of tlie axes named, or, in other words, the symmetry of

• Very tliin •ectioos of quartz, liowover. sbow (e.g., with tbe mlcroBcope) the dark cross or nn ordinary uniaxia) crystal.

f Od llie (IfstliictioD between the primary and tbe secoDilary opllc rxi's. we Art. STl.

this ellipsoid, ie such as to correspond to the general crystallogrsphic symmetry of the crystal. For example, to repeat the statement iilready miide (Art. 348), in the ortkorhombiv oystem the axes of this ellipsoid coincide in direction with the crystallographic axes. In the monodinic system, one of them coincides with the axis of crystal lographic symmetry (}), the other two lie in the pkiie ot symmetry, that is, in the plane of the crystal lographic axes h and i. In the tric'Uiiic system there is no necessary connection between the position of the ether-axes and the crystal lographic uxes.

36S. Zndicatrix.—It may be shown, as is done by Fletcher, thiit the ellipsoid ggjj gj^ mentioned, whose axes repre-

sent in magnitude the three principal refractive indices, a, /H, Y (where a < (S < y), not only exhibits the character of the optical symmetry, but also serves to represent the direction, velocity and plane of polarization of a light-ray in any direction wliatevfr, precisely analogous to the spheroid mentioned on p. 198. See Fig. 533 (from Groth), also Figs. 518, 519. That is, for the two rays having any direction, as Or in the plane of the ases A A, VC (Fig. 534), the velocities

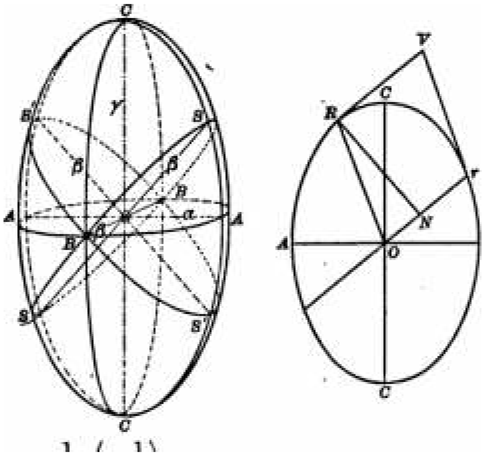
will be proportional to ^-^

and j^ I = ^) respectively, and the planes of polarization will be perpendicular to these lines. From the equation of this index-ellipsoid, called by Fletcher the indicafrix (see Art. 355), it is possible, aa shown by the author named, to deduce by ordinary analytical methods the mathematical expression for the wave-surface, the position of the two sets of optic axes (later explained), etc.

One important relation appears at once from a first study of this ellipsoid. , Obvionsly for two definite positions of transverse planes passing through the center (55, 5'5", Fig. 533), tlle^■e positions depending upon the relative viilues of a and y the cross-sections will he circtes each having a radius equal to the index (i, intermediate in value between a and y> similurlv all sections parallel to these are also circles. Hence, light propagated in a. direction normal to these planes, that is, by vibrations lying in them, will suffer no double refraction—and after the analogy of uniaxial crystals these directions are called oplic axes; they are the primnry oiitic axes mentioned ia Art. 371.

370. WaTe-aorfece.—Following out the analogy of uniaxial crystals, Fresnel deduced the now generally accepted " wave surface" for biaxial crystals. That it gives correctly the law of the varying refractive indices (that is, of varying light-velocity) in a biaxial crystal has been demonstrated by the agreement between the requirements of the theory and the results of experiment.

The form of the eectioos of this wave-surface with the three rectangular



axial planes are easily deduced by very elementary considerations, though the fall ^ualytical development is most satisfactorily derived from the equation of the iiidicBtrix as shown by Fletcher.

First consider the section of the wave-surface for the transverse plane of the axes AB (Fig. 533). Light passing in the direction of the axis AA will be separated into two rays; for one of these the line of transverse vibration will correspond to the axis CC, and hence its rate, or, in other words, the

tion of transverse vibration will be that of the axis B£, and its rate, that is, the velocity of the ray itself, will be proportional to -^. Let these valaes bo

represented in Fig. 535 by Oc' (= -) and Ob f = -^\ Again, m the direction

of the axis BB, there will be two rays whose vibration-directions are respectively parallel to the axes AA and CC, and their velocities in

the direction of BB proportional to — and —

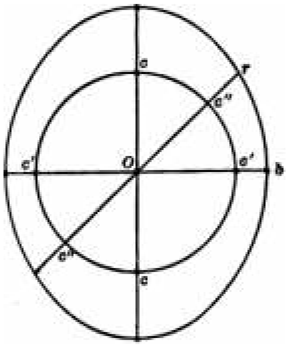
respectively. Let these be represented by Oa ana Oc. For some other direction in the same plane, there will be two rays, one of whose Tibration-directions correaponda to CC, and its

velocity to ~, represented in Fig. 533 by Oc'',

while for the other there will bo an intermediate

vibration-direction and a velocity between — and

—, and it can be shown (iifter the analogy of



uniaxial crystals and as proved b that this value is given by the lin

1

, I

experiment)) Or in the ellipse whose major and minor

axes {Oa and o6) are - and -. Hence the circle ec' represents the section of

the wave-surface for the rays in the given plane, whose vibration-direction

corresponds to the axis CC, and the velocity to the constant value —. While

for other rays the vibration-directions change from A A to BB, and the velocity from - to -3-,

The ray propagated by vibrations in the direction of the axis CC, which

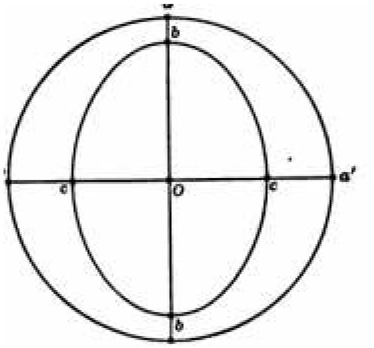
has the constant velocity—, that is, the ray whose wave-front in this croBS-

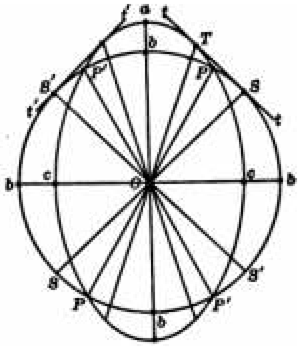
section is a circle, is called the ordinary rap, since on refraction it remains in the plane of incidence. The other ray, whose velocity varies with the direction

from — to 3, is called the extraordinary ray.

Again, take the plane of the axes BC (Fig. 533). Whether the direction of the light be that of B or of C, or any intermediate line in the same plane, there will be in each position one ray whose vibration-direction is that of the

&xis A, and whose velocity is hence expressed by —; for it the section of the waTc-sarface will be a circle. For the other ray, if parallel to B, the vibration-direction will be that of the axis C, and its velocity ie represented by -. If it is parallel to C, its vibration-direction is that of B, and its velocity is given by --=. As in the other case, intermediate values will be given by the ellipse S3«. 637.





having -. and — for its major and minor axes. The combined section of the

wave-surface is shown in Fig. 536. Here also, the ray with the constant velocity

- is called the ordinary ray; the other is the extraordinary ray.

For the third plane, that of the axes

**'■ AC, one ray will always have as its

vibration-dii'ection that of the axis B,

and its velocity will heuce be expressed

by -3-. For the other ray, if parallel to A, the vibration-direction is that of C, and the velocity is expressed by -. If parallel to C, the vibration-directioQ is ' that of A and the velocity -, and similarly for intermediate positions. The section of the wave-surface constructed from these values is given in Fig.

537. Here the circle (radius = -^-l cuts

the ellipse at the points FP, P'P'.

The complete wave-surface, of which

the three axial sections are given in

Figs. 535, 536, and 537, can be constructed, but it is not easy to form a

, ,. ..CA>oglc ■

complete knowledge of the form without having a model in hand. Some idea o(it may be gathered from Fig. 538,

371. Primary and Secondary Optio Axei.—It has already been briefly stated (Art. 367) that there are two directions, namely, those normal to the circular criMB-sections of the indicatrix {Sifi, ^S', Fig. 533) in which the light

ie propagated by transTeree TJbrations of like rate I ~ J. Hence in these directions in a crystal there is no double refraction within the crystal; nor is there vheii the ray emerges. These two directions bear bo close an analogy to the optic axes of a uniasial crystal that they are also called oplic axes, »nd the crystals here considered are hence named biaxial. In Fig. b'i7, thuse optic a.ieB bave the direction iS';S', S'S' normal to the tangent planes ti, ft', and the direction of the external wave is given by the normal S(T (Fig. 539).

Properly speaking the directions mentioned are those of the primart/ optic cLtes, for there are also two other somewhat analogons directions, PP, P'P', of Fig. 537, called for sake of distinction the secondary optic axes. The properties of the latter directions are Kaa

obvious from the following considerations.

In the section of the wave-surface abowti in Fig. 537 (also enlarged, in Fig. 539), corresponding to the axial plane AC, it is

seen that the circle with radius Ob (

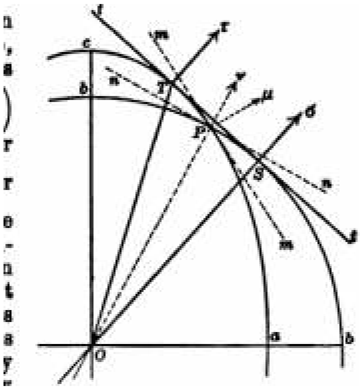
intersects the ellipse whose major and minor ueB are Oa

(=^)

and Oc

(=1]

in the four



Joints P,P, P',P'. Corresponding to these irections the velocity of propagation is obviously the same for both mys. Hence within the crystal these rays travel together withont doable refraction. Since, however, there is no common wave-front for these two rays (for the tangent for one ray is represented by vini and for the other by nn, Fig. 539) they do Buffer double refraction on emerging; in fact, two external light-waves are forined whose directions are given by the normals Pfi and Pv, These dii-ectione, PP, P'P', therefore have a relatively minor interest, and whenever, in tlie pages following, optic axes are spoken of, thoy are always the primary optic axes, that is, those having the directions SS, S'S" (Fig. 537), or OS, Fig. 539.* In practice, however, as remarked in the nest article, the angular variation between the two sets of axes is usually very small, perhaps 1° or leas.

ITS. Istwior ud Xxtarior OonlixJ BafrMtion.—The taDgent pinne to Ibe wavf-surface drawD normal [o the Hue OSthrougb llie pnlnt iS'(Fig 5S0) mity be abown to meet It In a iinsll circle on wbuse circumference lie the points 8 and T. Tills circle la tlie bnne of tbe interior cone of raya 807', wboM remarknble properties will be brieflj btnted Ht. If a section of a biaxial cryital be cut wlib lla faces uurmal in o8, tboae parallel njs. belongtue to a cylinder bavtcE tilts circle aa Its bau. Incklent upon It from wltbout. will be propagated wllbiu ai tbe cone 907*. Conversely, rays from wl I bin correaponiliiig In nnaitlon to rbe ■urface ot tbfs cone will emerKc parallel aod form a circular cylinder. This pbeuomeuon it c&IIrd inttriar eonieal rtfraetion.

"Fletcher calls iliepTimaty axes MMrniaft, the secondary axe* MrottMi.

On the otber baud, If a sectton be cut wilh its fnccB normal to OP, those nys hsvlng Ibe directlou of tbe surface of a cone formed by perpendiculars to ffim and n» will be propagated witbio parallel Co OP, aud emergiug on tbe otber surface form without a similar COoe on the other side. Tbls pbeaomenou is ciilled arlitrior eonioal r^ritction.

lu tbe various Ugnres given (685-58U) the relations are much eiagiierated for the sake «t clearness; In practice iLe relatively amull difference between the indices of refntclion a and y make* this cone of small angular i^ke, rarely over 2*. For example, with sulphur, which has very strong double refraction \j' — a = U'29; compare the values given in Art. U9 and A.rt US), the values of a. /J, j- for yellow sodium light were measured by Schrauf aa follows:

a = l-«6047. /J = 3 08889, r = 2 24068.

373. AxM of Elaatiolt;.—As intimated in Art. 368, FresDel appears to have deduced the ware-stirface of biaxial cryetala, aa it is here called following him, by a ^neralization from that accepted for the more simple uniazi^ orystalB. The explanatioa of the obBerved phenomena, attempted by him, was based upon the aBsumption that tbe varying velocity of light shown by the Tarying valuea of the refractive indices depended upon the variable elasticity of the ether within the cryetal. Since, as stated on p. 160, it eeeme better not to inaist upon this hypothesis and since, further, it is possible,to describe all tbe phenomena withont attempting to explain tbe properties of the ether opon wbicb tbe ultimate values of the pulses depend wbicb manifeet them-s^ves as tight-waves, all mention of elasticity has been thus far avoided.

These "axes of elasticity" are of great con-**"■ venienee in describing the optical properties

C of crystals. And it is hence necessary to make

frequent use of them. Tbey are uniformly represented by the letters a, b, c, where a > t) > c as shown in Fig. 540, and where

further it is true that a ; b : e = — : tt : —. « A r a, /!, y being the three principal refractive indices (a < /J <, y). The three axes as given in Fig. 540 then have the direction of the three ellipsoidal axes (Fig. 533); tbe maximum value of tbe elasticity, a, corresponds to the minimum valne of the observed refractive index a, and this in turn corresponds to tbe maximum velocity of a ray propagated perpondictilar to the plane of tbe axes a and b by vibrations naving a direction parallel to this axis a; similarly for the axes b and c.

Whenever in this work tbe axes a, b, c, which may be simply called the ether-axe.t, are spoken of in describing the optical characters of crystals, it is to be understood that they have the directions indicated, corresponding respectively, as just explained, to tbe ellipsoidal axes; moreover, their relative magnitnde is expressed as follows: a > b > C.

374. Bisectrioes, or Uean-lineB.—Aa shown in Art. 371, the optic axes always lie in the plane of the axes a, y of the indicatrix (that is, of tne etber-axes a and c); tnis is called the optic axial plane (or briefly, ax. pi.). The value of the optic axial angle is known when the values of the refractive indices, a, o, y, are given, as stated in the next article. That axis (cf. Fig. 539, also Figs. 54L, 543) which bisects tbe acute angle of the optic axea is called the acufe bisectrir., or first mean-line, and that bisecting the obtuse angle is the obtuse bisectrix, or second mertn-line.

The acute bisectrix is often represented by Bx^, tbe obtuse bisectrix by Bz^.

^

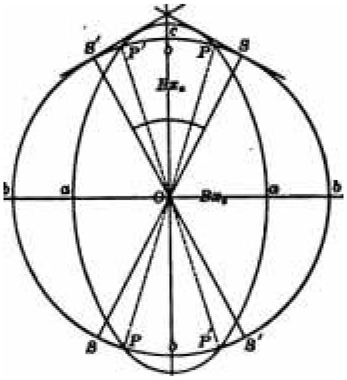
If the word bisectrix is used aloDe witbont special qnalificatiou it is always to be understood aa referring to liie acute bisectrix.

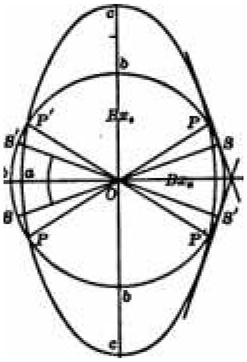
375. Belation of the Axial Angle to the Kefraetive Indioes.—If in a given case the viilaes of a, (i, and v are knovn, the v&lne of the interior optio axial angle ('4 ¥} can be calculated from them by the following formulaB:

I'

376. Poaitive and Hegative Crystals.—Biaxial crystals are distingDisfaed as

opt (call tf positive {-{-) or 7iegative { —) after & manner analogous to the usage with uniaxial crystals. Eeferriog to Fig. 533 of the ellipsoid, and also to Fig, 539, it will be obvious at once that for certain relative values of the indices, a, fi, y, the interior optio axial angle must be 90°. In other words, in this





PoritWe CiTBtal, &■_ = t.

Negative Crystal, Bxa = a.

case the planes of the optic axes will be equally inclined to the two planes of the ether-axes. Such a case, however, is rare in practice, and when it occurs it is true for light of a certain color * (wave-length) only, and not for others.

■ Fbr danburite 2F = Be* U'for green (thalllnm) and 90° 14'for blue (CuSOt).

RoDghly expressed,* the optic axes will lie nearer to c than to a—that ia, c will be the bisectrix—when tne valne of the intermediate index, fi, is nearer that of a than to that of y, Snch a crystal, for which Bx^ = C, is called optically positive. It is obvious (cf. Fig. 541) that in this case, as the angle dimiuishes and becomes nearly equal to zero, the form of the ellipsoid then approaclies that of the prolate spheroid of the positive uniaxial crystal as its limit (Fig. 531, p. 195); this showB the appropriateness of the -|- sign here used.

On the other hand, the optic axes will lie nearer to a than to c—tli^t is, a will be the bisectrix—if the value of the mean index fi is nearerf to that of y than to that of a. Snch a crystal, for which £Xa = o, is called optically negative. It is seen that in this case (Fig. 542) the smaller the angle the more the ellipsoid approaches the oblate spheroid of the negative uniaxial crystal

(Fig. 520, p. 195). f he following

are a few examples of positive and negative biaxial crystals:

Positive (+). Negative (-).

Sulphur. Aragonite.

Enstatite. Hypersthene.

Topaz. Muscovite.

Barite. Orthoclaae.

Ghi^solite. Epjdote.

Albite. Axinite.

377. Sispeision of the Bisectrices.—In certain cases tbeether-axea of Fig. 533 may have different positions in the crystal for different colors; that is, for different wave-lengths. This is true of the two axes which lie in the plane of symmetry of a monoclinic crystal, and of all the three axes in a triclinio crystal. This results in a phenomenon which is often called the dispersion of the bisectrii^es, and which, if pronounced, is always manifest in the axial inter fere nee-fig urea, aa explained beyond.

378. Dispersion of the Optio Axes.—Further, since the three refractive indices may have different values for the different colors, and as the angle of the Optic axes is determined by these three values (Art. 376), the axial angle may also vary in a corresponding manner.

This variation in the value of the axial angle for light of different wavelengths is called the dispersion of the optic axes, and the two extreme cases are distinguished by writing $p > v$ when the angle for the red rays (p) is

freater than for the blue (violet, v), and $p < u$ when the reverse is true. 'hese cases are illustrated later.

Examination of Biaxial Cryfials in Polarized Light.

S79. Sections ia Parallel Polarized Light. Extinction-angle.—A section of a biaxial crystal appears dark between crossed nicols when its vibration-planoe coincide with the vibration-planes of the nicola. In any other position of the

• tan F = 45° and 2 y = 90 for a value of fi givea by Ihe equation

t To compare Figs. 642 and B20, the linriz.inlil nxia of tlie former should be placed in a vertical position; that is, the axis AA of Fig. 580 correapoeds to t of Pig. M8.

section i*^ appears light and may show the nsual bright iuterfereuce-color.

g^_ Hence the use of the polariscope, or polariza-

j^ ' tion-microBcope, by the method of extinctioD, gives a quick means of determining the position of these vibration-planes in a given case.

For example, m Fig. 543, repeated from p. 177, let the two largur rectangular arrows represent the vibration-directions for the two nicolfi, and between the two prisms suppose a section of a biaxial crystal, obcd, to be pluced so that one edge of a known crystallographic plane coincides with the direction of one of these lines. The Held of the microscope, dark before, since the prisms were crossed, is ^ no longer so, and becomes dark again, as

explained, only wLen the crystal Is revolved so that its vibration^directions (the smaller dotted arrows) coincide with those of the nicols, as is indicated bv the maximum extinction of the light. The crystal has then the position a b'c'd'. The angle (indicated in the figure) which it has been necessary to revolve the plate to obtain the effect described, is the angle which one of the vibration-directions in the given plate makes with the given crystallo-graphic edge ad; it is often called the extinction-angle.

'Wlien the vibration-planes of a crystal-sect ion coincide in direction with the]>lanes of its crystallographic axes, the extinction is said to be parallel; if not. it is called ohUqve or inclined. On the practical determiuation of the extinction-directions see Arte. 380 and 389.

380. Determination of the Extinctioa-direotions with the Hicrosoope.- In the use of the microscope, in cases to which the method of the stauroscope is not applicable, instead of depending upon the somewhat uncertain estimate of the point of maximum tight-extinction, a convenient way is to employ a plate of quartz, which for a certain position of the analyzer gives the field a tint of color (a purplish pink), to slight, changes in which the eye is very sensitive. When the section is revolved on the stage till it has precisely the same tint as the surrounding field, its vibration-planes are those of the cross-hairs in the eyepiece (supposing the lower nicol has the noroial position), and from the gradnation of the stage their position in the section can be at once determined.

Instead of the quartz, a plate of seleuite (Art. 364) of such a thickness as to give the red of the first order is often employed, the nicola being crossed. When this plate is inserted as usual, the crystal-section can have the same color only on condition that its vibration-directions coincide with those of the nicols; hence their crystallographic orientation in the section is readily determined and with oonsiderable accuracy.

A Hlill mnro delicare melhod InvolveE (Le use at llie Berlrand ocular. TliU lias four sectoiB of quarl7. cut i t: two of these, diagonally oppogite. are from a right haacled. Ihe otber pair from a left-handed crystal. When Die diameters in which the sectors meet coincide wlih the vlhmtlon-direcliiins of the two crossed alcols, the two pairs of qunilranla liave precisely the same color; any change of position, however, of the upper nlcol causes them to assume linta complementary lo each olher.

Assuming uow the nicols to be crossed and in the normal position, If a section of a doubly refracting niuieral be introduced on the stage of the microscope, the quadrants In genenit take uuliKe llnte and are brought to the same color as before only wlien by the revolution of ibe stage the vlbratioa-directions of the section si'e maiie lo correspond precisely to those of the cr(Msed uicols, that Is. of the diameters of the ocular. The edjusimeut can be made in this case with great accuracy,

general case, for any section whatever, the relation between the yibration-planes and the ether-axeB is highly complex.'*' A common special case is where the section is parallel to one of the ether-aies; this then fixes one vib:iition-pliine, and the other will obviouslj be at right angles to it. A still more spcciitl case is that of a section parallel to the plane of two of the ether-axes; tliese axes then at once fix the directions of light-vibration and conversely; or, ill other words, these directions being determined by observation, the position of tlie axes in the crystal section is Ki)own from them.

The practical application of the above relations depends upon the crystallo-griipliic orientation of the ether-axes, and is spoken of later under the different systoms.

3S2. Color of a Section in Parallel Polarized Light.—The interference-color of the section under examination depends, as before explained, upon its thickness iind upon the birefringence; the latter varies with the orientation of the section, bnt is a maximum (equd to ^ — o') if the section is cut parallel to the axes a and c. that is, parallel to the plane of the optic axes. In any case for a given thickness the interference-col or will depend upon the difference between the refractive powers of the two vibration-directions. For sake of illustration, the following table is added (from Kosenbnsch) giving the thickness of section for a few biaxial crystals which yield red of the first order, with also their masimuta birefringence {y — a).

	BIrefringeDCe ly — a).	Thickness la tnlllimeters.
Brookite	0-158	0-0034&
Muscovite	0-042	0-01318
Epidote	0037	-0-01490
Augite	0-022	0-02505
Gypsum	0-010	0-05510
Orthoclase	0-008	0-068»7
Zoisite	0-006	0-09183

Turlher, it mny be noted tliAt with a iection of epidnte lb (OlD), wliile h lliicknew of about 0-015 mm, gives rei\ ot ihe flrat order, one of 0026 give* red uf the second order, and of 0-013 red of the third order.

383. Determination of the Birefringence with the Microioope.—The value of the maximum birefringence {y — a) is obviously given at once when the refractive indices are known. It can be approximately estimated for a section of proper orientation and of measured tnicJcness by the comparison of the interference-color with the table referred to in Art, 380, p. 178. This is on the assumption that the thickness is such as to yield a tint of readily recognized position in the interference-scale. To which order a given interference-color belongs can be readily determined by the compensation method involving the nse of the quartz-wedge or the mica-wedge of Fedorow (Art. 384).

More accurate meosnremeuta of the birefringence can be made by otlier methods, as with tlio quartE-comparator of M, L6vy.*

384. Seterminabion of tlie Relative BefracUre tower.—The relative refractive power of the two vibration-directious in a thiu Bection is readily deter-miued with the microscape (in parallel polarized light) by the method of compensation. This 19 applicnbte to any section, whatever its orientation and whether uniaxial or biasial. Practically, however, it is ohieBy employed when the section is parallel to the plane of two of the ether-axes; it then serves to determine the relative magnitude of these axes. If the position of cither bisectrix in the section is known, it also serves to determine whether the crystal is opticully positive or negative. In practice a mica-plate or selenite-plate may be used with very thin sections; orwitli thicker ones a quartz-wedge or the excellent mica-wedge of Fedorow.f The section under examination must be placed so that its vibration-directions make an angle of 45° with those of the crossed nicols; the ^-undulation mica or selenite-plate is then inserted. The change in the interference-colors is noted, and i^ain after the stage has been revolved 90", In the case where the effect of the compensating plate is to rflisfl the interference-color in the scale the retardation of the section is added to that of the plate; for this position the plate and section are then alike in optical character. In the case of a fall of color the plate diminishes the retardation due to the section; obvionsly for this position they are opposed in optical character.

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* The vHriiilioii in dlrecliotiB of extinction with ciiniige of the orieiilnlioii of the scclioti under examinnllon !b chiefly inlei-estlug In the microscopic study of rock-BecUoii«. It is miiintelj discussed in the Minersiix dea Roches of M. L£vy and Lncroix. The snme suh-Ject hns :il»o been eiliBiisiivdy treated in the ciwe ot the plagloclBSe feldopnrt by M. Levy in a work in two parts enlltled " Etude sur la d^lermlDation des Fsldspaths dans lea platjues minces" (Paris, 1894,1896). Cf. also Fedorow, %. 'K.TyKt.,'i2.'i^, 16&8; 37, BS7, 18&6; 39. 604. 1898; also Viola. Min. petr. Hiith., 16. 481, 1895.

For thicker sections placed in position as before with vibration-directions inclined 45° to those of the crossed nicols, the quartz-wedge or mica-wedge ia employed. This is advanced across the field until a thickness is reached which serves to make the given section, previously colored, dark, that is, to bring it sensibly to extinction. The optical character of the jilato and section aro now opposed, and in fact just balanced against each other. By observing the position of the section the relative value of the refractive power is given.

A crystal-sect ion is said to have positive elongation if its direction of extension approximately coincides with the ether-axis c; if with a the elongation is negative. The same terms are also used in general, according to the r^ative refractive power of the two directions.

365. DetenninatioiL of the Ke&aotive ladloea.—The values of the three refractive indices, a, (i, y, for biaxial crystals, may he determined from three prisms cut with their refracting edges parallel respectively to the three axes, a, b, and c, corresponding to the indices a, p, y, respectively. See Art. 304.

It is possible, however, to obtain the values of tx, fi, and y by the use of two prisma; in this case one of the prisms must bo so made that its vertical edge is parallel to one asia, while the line bisecting its refracting angle at this edge is parallel to a second. In the caae of such a |iri8m the angle of minimum deviation is obtained for both rays, that having its vibrations parallel fo the prism-edge, and that vibrating at right angles to this, that is, parallel to thb line bisectins; the prismatic angle.

Of the three indices the mean index, fi, is one which it ia most important to determine, since by means of it, in accordance with the formnlas in Art. 389, the true value of the axial angle can be calculated from its apparent value

'aee M. Levy, Bull. Soc. Min.. 6, 143, 18^8; also Levy.Liicroix,^Miir~RocheB, p7^4 tlieq.; Roaeubuscli, Mikr. Phys.. p. lOSei*'?.

\ This coi>iisra of alripg of \ undultilion mica, overlapphig step-like and all placed wllh their axial planes (i.e., tbe axis t) iu ft common line coinciiiing witli ilie liirect.ion of eionpi-linn. InBerled l)elween crossed ojcols. the uxis c mnkinj; nu anjile nf 45° wllh llieir libralioD-plaues, it givea a series of area» of liilerference^olura nhose poattiuu In tlie scale ■ 'iw(Arl. 330; '=--■'-■ "- --■ — ■>■'■ -~"

« obvious (Arl. 330). See Pedorow, Za. Krysl., 26, 848, 18»5.

in air. The prism to give the value of fi should obviously have its refractiug edge parallel to the asis ti, that is, at right angles to tLe plane of the optic axes.

The other methods* alluded to on pp. 160, 181 may also be applied here. For the method by total reflection the sections should be cut normal to the acute bisectrix. This will give by actual observation the values of a and y, and if "iE, the apparent asiul angle in air, is linown, then p, the mean index, can bd ciilciiluttiti.

386. laterference-flgore for a Section Normal to an Optic Axia.—A section cut perpuiidiuular to either optic axis vill show, in converging polarized light, a sytitem of concentric ringa analogous to the concentric circles of uniaxial crjatuls, I'ig. 5'J6, but more or leas elliptical in shape. There is, moreover, no bliick croBs, but a aingle black line, which revolves as the section is turned around on the stage.f

387. Interference-flgnres for Bectloni Normal to a Bisectrix.—If a section of a biaxial crystal, cut perpendicularly to the acute bisectrix, is viewed in the conoscope (p. 181), two types of characteriatic interference-figures are observed, according to the poaition of the optic axial plane relative to tne vibration-planes of the crossed nicols.

First, suppose that the plane of the axes coincides vith the vibration-plane of one of the crossed nicola; an unsymmetrical black cross ia then observed, and also a series of elliptical curves, surrounding the two centers and, finally uniting, forming a series of lemniacates. If monochromatic light is employed, the ringa are alternately light and dark; in white light each ring shows the successive colors of the spectrum. If one of the nicoT prisms be revolved, the dark hyperbolic brushes gradually become white, and the colors of the rings take the complementary tints after a revolution of 90°.

The smaller the axial angle the nearer together are the oval centers and the more the interference-figure resembles the simple cross of a uniaxial crystal. On the other hand, when the axial angle is large the hyperbolas are far apart, and may even be so far apart as to be invisible in the field of the polariscope. When this is not the case a micrometer scale in the polariscope. Fig. 514, p. 188, allows of an approximate measurement of the axial angle, the ralue of each division of the scale being known.

Afrain, suppose that the plane of the axes makea an angle of 45" with the vibrution-planea of tlie crossed nicols; two black hyperbolas are then noted, marking the position of the axes; further, there is a system of curves similar to those described before.

Both of these figures are well exhibited on the plate forming the frontispiece (Pips. %(i and 3A). The one gradually changes into the other as the crystal-section IS revolved in the horizontal plane, the nicola remaining stationary.

A section of a biaxial crystal cut perpendicular to the obtuse bisectrix exhibits the same figures under the same conditions in polarized light, when the angle is not too large. This is, however, generally the case, and in consequence the axes suffer ioioX reflection (Art. 303) on the inner surface of the section and no axial figures are visible. This is sometimes the case also vrith a section cut normal to the acute bisectrix, when the angle ie large.

(See, also,

• Becke baa friven a Bimpla metLod for determtninK approilmatel v tbe retalm Tefracliva power of 1 wo adjacent mineralB (e.g.. quartz nn<i acerlaln kind orpl«(rfocIa8e) !n Uiin aectlong. Bar Ak. Wlen, 103 (1), July. 1898. See also Viola. Min. petr, Mittli., 18, 150, 18M.

t On Ihe special phenomens of secllona of Wnxial cryBtsls cut normal to an opilc axis, in pai»llel and converging pobrized Hglit, bm Kalkowsky, Zb. Krysl., «, 486,1884.

Art. 389.) The pecnliavitiea in the interferecce-figures dae to the dtapersioii of the optic axes and that due to the dleperHiou of the bisectricee, or both together, are alluded to later.

388. The explanation of the biaxial interference-figures—moat simply understood for the firet case mentioned—ia analogons to that for the analogous phenomenon of the uniaxial crystals (Art. 360). The arma of the black cross mark the directions in which the tight-rays, which are sensibly norma! to the section, are extinguished, since the vibration-planes of the uicols coincide with those of the section. The dark ellipses and lemniscate curves seen in mono-chromatic light are dae to the interference of the two raya produced by the double refraction of the section and referred back to a common vibration-plane by the polarizer. This interference takes place when the rett^rdation of one ray relatively to the other is equal to half a wave-length, i\, or to f A, ^A, etc. The intermediate light-spaces correspond to a similar retardation of a whole wave-length, A, or 3A, 3A, etc. When ordinary tight is employed there is complete extinction only in the direction sf the vibration-planes of the nicols, and the curves become colored rings showing the prismatic colors. The number of colored rings noted in the field of view increases, and their distance from the axial centers and from eacli other grows less as the thickness of the

flate is increased, and also aa the strength of the double refraction is greater. f the plate is very thick, only the black cross may be distinctly visible.

389. Heasorement of the Axial Angle.—The determination of the angle made by the optic axes is ordinarily accomplished by use of the instrument shown m Fig. 544. The section of the crystal, cut at right angles to the bisectrix, is held in the pincers at p, with the plane of the axes horizontal, and

making an angle of 45° with the vibration-plane of the nicola. There ia a cross-wire in the focus of the eyepiece, and ns the pincers holding the section are turned by the screw at the top (liere omitted) one of the axes, that is, one black hyperbola, is brongfat in coiscideiice with the vertical cross-wire, aiid ,^ then, by a further revolution, the seconii.

_', The angle which the section hafi been turned

from one axis to the second, us i-ead otf at the vernier on the graduated circle above, is the apparent angle for the axes of thegjven crystal as seen in the air (acn = -lE, Fig. 545). It is only tlie apparent angle, for, on passing from the section of the crystal to ' ^ the air, the tme axial angle is more or less increased, according to the refractive power of the given crystal. The relation between real interior angle and the measured angle is given below.

If the axial angle is so large that the ax«s snfler total reflection, oil * or some other liquid with higher refractive power is made use of, into which the axes pass when no longer visible in the air. In the instrument described a small receptacle holding the oil is brought between the tubes, aa seen in the figure, and the pincei-a holding the section are immersed in this and the angle measured as before.

In the majority of cases it is only the acute axial angle that it is practicable to measure; but sometimes, especially when oil (or other liquid) is made use of, the obtuse angle can also be determined from a second section normal to the obtuse bisectrix.

If ^ = the apparent semi-acnte axial angle in air (Fig. 545), H^ = " " " " " in oil,

ff^ = " " semi-obtuse angle in oil, F, = the real (or interior) aemi-actite angle, Va= " " " " semi-obtuse angle, n = refractive index for the oil or other medium, /3 = the mean refractive index for the given crystallized substance, the following simple relations connect the various quantities mentioned:

sin E = n sin ff^'t

These formulas give the tnie interior angle (2F) from the measured apparent angle in air (2£') or in oil {^H) when the mean refractive index (yS) is known.

Instead of the oil, carbon disulphide with a refractive index of 1'6442 for X(i{n^) may be employed; or the aolution of mercuric iodide in potassium iodide, who'se refractive index (J\o) is l'il76. The axial angle measured in the latter is usually represented by 2K. Methyl iodide may also be used, since its refractive index is alao high; for it n^ = 1-7466. The axial angle in this case is called ZM.

Another modified form of axial iuetruinent <lbe Adams-Schaelder) tncloeei tbe tection in a sphere of glass wbicli csD be luraed at the proper angle; for tbie tbe axial angle ls3(7.

— ' - —•.>-<- '----umeul consist in Ihefact tlist the field of view-' '- -

II any desired positioi

• Almond-oil which has lieeii decolorized employed; its refntctive index is about 1-46.

' exposure to the light to commonlj

ftzU. Horeover, tbe aag]e meoaured ii niG made, so that tbe uxes are viBible ii lcH,it reflection, eltlier in i,ir or In oil.

890 AzlklAngl* Haunred vltb tlie]U«roMop«.—Tbe microscope, witb eyepiece reiiioveil ami ciiiideusiiig ieiisiur lensei.) added iibove the lower iilcol, often serves to show (with auft-abie liigh-power ubjective) tbe axial iuterrereuce-flgiirtw in very iblii secliuua wltb only lie liiintiilKitis beloagiug to the loBtruineut (utie p. Iit9i. Bertraad* has gbowo ihnt i>y tbe . additiun of a simple piece of apparntus tbe axial angle can be uieusured wiih fair accuracy. Further, u very couveulent appiintlus for tbia objett baa been devtaed by Kli-iu. Again, by tbe caieful measiiremeDt of the linear dialunce between tbe two Ljperboias the axial angle can be calculated as shown by Mallard.f

391. SetenuinittioiL of the Positive or R^ative Character of Biaxial Crystala.

—The qnestion of the positive or negative chiii-acter of a hiazial crystal is determined from the vulues of the indicea of refraction, wiiero these can be obtained. If C, the ether-axis corresponding to the index y, is the acnte bisectrix, the cryatal is optically pusiiive; if a, the ether-axis corresponding to a, is the acute bisectrix, the crystal is optically negative; as explained in Art. 376 and illustrated by Figs. 541, 543, this relation follows from the values of the refractive indices.

There are, however, more simple methcds of determininjir the character by experiment. The quarter-undulation mica ^ilate may be employed just as with uniaxial crystals, but its use is not very satisfactory excepting when the axial divergence is quite small. In this case it can be used to advantage, the plane of the axes of the crystal investigated being made to coincide with the vibra-tioQ-platie of one of the nicols. With the microscope the selenite plate may be employed after a manner similar to that explained in Art. 364,

392. The more general method is t)ie employment of a thin, wedge-shaped piece of quartz; this is so cnt that one surface coincides with the direction of the vertical axis, and the other makes an angle of 4° to 6° with it. By thia means a wedge of varying thickness is obtained. The section to be examined, cut normal to the acute bisectrix, is brought between the crossed nicols of the polariacope (Fig. 513), and with its axiiU plane making an angle of 45"-with the polarization-plane of the nicol prisms; that is, so that the black hyperbolas are visible. The quartz-wedge is now introduced slowly between the section examined and the analyzer, first, in a direction at right angles to the axial plane, that is, to tlie line joining the hyperbolas, of the plate investi^ted; and sec'iiid, parallel to the axial

plane, that is, in the direction of the line joining the hyperbolas. In one direction or tlie other it will bo seen, when the proper thickness of the quartz-wedge is reached, that the central rings appeal' lo increase in diameter, at the same time advancing from the center to the extremities

The effect, in other words, is that which would have been produced by the thinning of the given section. If the phenomenon is observed in the first case when the axis of the quartz is parallel to the axial plane, that is, to the obtuse bisectrix, it shows that this bisectrix must have an opposite sign to the quartz, that is, the obtuse biaectrii is negative, and the acute biecctrix positive. It the mentioned change in the interference-figures takes place when the axis of the quartz is at right angles to the axial plane, then obviously the opposite must be true and the acnte bisectrix is negative. This method of investigation

•Berlninil- Bull- Boc. Min.. 3. 97. 1880; see, also, Sachet, Ibid., 10, 186. 1887; Klein. Ber. Ak. Berlin. 61, 1895. Alan references in p- 199.

\ Mnlliird, Bull. 8nc. Mlu., 6, 77, 1883; Ihia last method Is explained bv Rosenbuscb, Uikr. Pliyi,, 194, 1893.

can be applied even iu cases where the axial angle is too large to appear in the air.

The same effects may be obtained by bringing an ordinary quartz section of greater or less thickness, cut normal to the axis, between the analyzer and the crystal examined, and then ioclining it, first in the direction of the axial plane, and again at right angles to it.

The method of determining the optical character in thin sections inparallel polarized light is mentioned in Art. 384.

393. Auorption Phenomena of Biaxial Ciystali. Pleo<:hroiaiii.^Biaxial crystals, corresponding to the fact that they have three principal refractive indices [a, §, y') may show difierent degrees or kinds of absorption in different directions, usually assumed as those of the ether-axes, viz., a, b, c. 'I'he degree of absorption is designated aso>b> cora>b — c, etc. Fnrtlier, according to the kind of selective absorption, the crystal may be dichroic or trichroic, or better, in general, pleochroic;* in this case tlie colors corresponding to the vibrations parallel to the ether-axes are usually given. It has been shown, however, that the axes of absorption do not in all cases coincide with the ether-axes.

In order to investigate the absorptive properties of a biaxial crystal, aectiouB mi^st be obtained which are parallel to the several ether-axes, cf. 646. Fig. 546. In an orthorhombic crystal the faces are those of

the three pinacoids; in a monocfinic crystal one side coincides with the clinopinocoid, the others are to be determined for each species. The light transmitted by this solid, or by the corresponding sections, is examined by means of a single nicol prism. Suppose, first, that the light transmitted (Fig. 546) in the direction of the vertical axis is to be examined. When the shorter diagonal of the nicol coincides with the direction of the axis l>, the color observed belongs to that ray with vibrations parallel to this direction; when it coincides with the axis n, the color for the ray with vibrations parallel to a is observed. In the same way the nicol separates the different colored rays vibrating parallel to C and Q respectively, when the light passes through in the direction of b.

So also finally when the section is looked through in the direction of the axis o, the colors for the rays vibrating parallel to b and c, respectively, are obtained. It is evident that the examination in two of the directions named will give the three possible colors. All of these observations are readily made with the microscope provided with one nicol.

For epidote, according to Klelu, tbe colors for tlie three aiial directions are' . f VibrnUoDS parnllel in i. brown (absorbed).

} " " " «. yellow.

a I ytbratloDS parallel In I ^rpen. *■ 1 ■' " ■■ a. yellow.

^ jTibratloDB parallel to c freeo.

\ " " " h. brown 'absorbed).

Tlie colon observed by [lie eye alone are the re!>ultaiiiB at the double Kt of vlbrattoni.

Id which the stroager color predomlnateB \ tlius, tn Ibe nbove example, the plane normal to

(is brown, lo b yellowish-green, to a green. In any other direction In the crystal tho

aiparent color is <be result of a mixture of those corresponding to the three directions of brations In different proportions. When A section (normal to an optic axis) of a crystal characterized by a high degree of color-absorption is examined by the eye alone (or with the * Early observations were made by Haldlnger, see literature below.

ilKlglc

microBCope) in strongly converging light, it often ehowa the eo-called epoptie figures* or polarization-brushes, somewhat resembling the ordinary axial interference-ligures. This is true of andalueite, epidote, iolite, also tourmaline, etc. A cleATftge section ot epidote ||c (001) held close to the eye and looked through to a bright sky shows the polarization-brashes, here brown on a green ground.

It, is hIbo to be noted that certain strongly absorbing crystals {e.ff., biotite) often show spots where the color is particularly deep; snch areas are sonie< times culled pleochrotc halm.

LiTERATCKE. HaidiDger. Fogg. Ann., 61, 295, 1844; 66, 1. 184S: Ber. Ak. Wien. 13, 8, 806, 1854. aeiuuniont. C. &.. 38. 101, 18M; or Fveg. Ann., 9, 491, 18S4. Trchemuk. Ber. Ak. Wien, 60 (1), S, 1869. Iduig. Improved dichtoKcope. Ibid., 83 (2), 174, 1881. muiD. Eplilulu. .Til. Mid., n&, 1872.

Bertin. " Uuuppea," etc. Aiin. Cli. Pl>rs., 16, 896, 18T8, andZs-Kryst., 3,449.18T9. Also BerLniiid. Uiill. Si>c. Mlu., 2, 67, 1879; Mallard, ibid., p. 73. LMpevTM. Piedmonllu. Zs. KitbL, 4, 444, 1880. Pulfrich. Zs. Krysl., 6, 142, 158, 1881. Mallard Bull. Sue. MId.. 2. 73. 1879; 6, 45, 1888. Voigt. Jb. Min., 1, lie, 18W5; Wicil. Ann.. 31, 288, 1887. Ranuay. JCpidole. Zs. Erysl., 13, 97, 1887. UablMh. Nacbr. Oea. Qaitlngen, No. 8, 202, 1888. Bblan. Jb. Hin., Beil.-Bd.. 11, 269, 1897.

Special Optical Characters of Orthorhombtc Crystals.

894. Foaition of the Ether-axes.—In the orthorhoubic system, in accordance with the symmetry of tlio crystallization, the three azes of the indicatrix, that is, the ether-axes a, h, c, coincide with the three crystallographic axes, and the three unlike crystallograpliic planes of symmetry correspond to the planes of symmetry of the ellipsoid. Further than this, there is no immediate relation between the two sets of axes in respect to magnitude, for the reason that, as baa been stated, the choice of the crystallographic axes is arbitrary so far aa relatiye length and position are concerned, and hence made, in most cases, without reference to the optical character.

Sections of an orthorhombic crystal parallel to a pinacoid plane (a, b, or c) appear dark between crossed nicols, when the axial directions coincide with the vibration-planes of the nicols. In intermediate positions a section will appear light (or colored if of the proper thickness). Hence such a section when revolved on the microscope will appear dark four times.

The same will be trne of a section cut in the prismatic zone (| &, the vertical axis) or in the plane parallel either to the axis S or d.

395. Determlnatioii of the Plane of the Optio Axes.—The plane of the optic axes, that is, pf the axes a and c, corresponding to the indiues a and y, mnst bo parallel to one of the three pinacoids. In order to determine in which plane the axes lie, it is necessary to examine sections parallel to these directions. One of these will in all ordinary cases show, in converging polarized light, the interference-figure peculiar to biaxial crystals. It is evident also that two of the sections named determine the character of the third, so that the plane of the optic axes and the position of the acute bisectrix can be in practice generally told from them.

The position of the optic axial plane is briefly indicated according to the pinacoid to which it is parallel: as, ax, plane H rt (100), etc. Fnrtlier. the

poaitiou of the acute bisectrix is described according to the pinacoid to whicb It is uornial, as Bx„ SI", etc.

396. Siipersleii of the Axes.—From the section showing tlie uxiul figures, that is, normal to tlie acute bisectrix, the axial angle can be mtutured iti the manner whicli has been described (Art. 389). If it is practicable to deiertiiiue also the obtuse axial angle from a second section normal to tlie olituse biseu-trix, the true aiiaJ angle (31') mid also the mean refractive index (p) can then be calculated.

There ia further to be determined the dispersioK of the axes (see Ait. 378). Whether the axial angle for leJ i-ays is greater or leas tlian for blue (/) > v, 01 p < v) can be often seen initnudiately from the axial interference-figure in the colored plate (frontispiece); it is obviously tiue, from Fig. 3n, as also Fig. 3b, that the angle for the bine raya is greater than that for the red {o < !■), and 80 in peneral. This same point ^ ' is also accurately determined, of course, by

" the measured angle for the two colore.

In all cases the same line will be the bisectrix of the axial angle for both blue and red rnys, eo that the position of the respective optic axes is symnietricul with reference to each bisectrix, in Fig. 547, the dispersion of the axes is illnstrated, where p < V, it is shown also that the lines H'B' and B'B' bisect the angles of both red (pop') and blue {vOe') rays. It also needs . no further explanation tliat for a certain relation of the refractive indices of the different colors, the acute bisectrix of the axial angle for red raya may be the obtnse bisectrix for the angle for blue rays. This ia true, for example, in the case of the species danburite, aa already noted (p. 209).

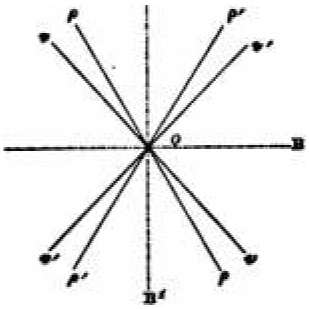
397. Refractive Indices, eto.—The determination of the refractive indices and the character (-f- or —) of the acute bisectrix ia made for orthorhonibic crystals in the same way as for all biaxial crystak. It is merely to be mentioned that, since the ether-axes always coincide with the cryatallographic axes, it sometimes happens that crystals, without artificial preparation, furnish, in their prismatic or dome series, prisma whose edges are parallel to these axes, and coQSC<juently at once suitable for the determination of the indices of refraction. This is often true, for example, with topaz. It must be noted, however, that if the refractive angle is too large, the refracted ray wili not emerge (see Art. 303), the limit being when the angle of the prism is equal to twice the critical angle.

Special Opliml Ckarncters of Monoclinic Cri/slah,

398. Foiitian of the Ether-axei and Optic Axial Plane.—In crystals belonging to the MONOCLisic system one of the ether-axes always coincides with the ortbodiagonal axis b.

and the other two lie in the plane of symmetry at right angles to this axis. Here obviously three cases are poasible, according to which two of the axes, a, b, or c, lie in tlio plane of symmetry.

Corresponding to these three positions of the ether-axes, there may occur three kinds of dispersion of these axes, or dispersion of the bisectrices (Art. 377). This dispersion arises from the fact that, while the position of



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one axis is fixed, the position of the other two may be different for the different colors (wave-lengths), so that the bisectrices of the different colors may not coiiiciile.

399. StauroHope. —The position of the two usee in the plane ot symmetry may be determined by use of the microscope iia di-scribed in Art. 380. A more accurate method, applicable in certain cases, involves the principle of the Ktantoscope, an instrument first devised by von Kobell (1855 •), and since then mncli improved. In its present form it is simply the orthoscope of Fig. 515 with a composition plate of calcite inserted at m in the tipper tube. This gives n pecDliar interference-fignre the form of which is altered if a doubly refracting section is placed on the stage below, unless its vibration-planes coincide with those of the crossed nicols. The adjustment which restores the normal figure can be made with great precision. To accomplish this, it is essential that the direction of the known edge of the crystal should be exactly parallel to the yibration-directioii of one of the nicols. This condition, in the case of small crystals especially, is hard S48.

to fulfill, and to accomplish it most sHtisfactorily

the holder shown in Fig. 548 is made use of.

A pliite of glass, v, held in its present position

by a spring, has one edge polished, that which

adjoins », and the direction of this is made to

coincide exactly with the line joining the opposite

zero points of the graduation. The crystal section is attached to this plate over the hole seen in v,

and with a plane of known cryatallographio '

position, either n, c or a face in that zone {or a

corresponding edge), coinciding with the direction

of the polished edge of the plate. Whether this

coincidence is exact can be tested by the reflecting goniometer.

After the adjustment of the section on the plate v, the latter is inserted in its place, the whole plate placed in position (Fig. 515), and the nicols so adjusted that the vibration plane of one coincides with the line 0° to 180°, The angle of revolution of tne circnhir plate, /, is'obtained from the graduated Boale on k.

It is not always easy to make the adjustment of the nicols allnded to, but the error arising when the vibration-plane of the nicol does not coincide with the line 0° to 180° is easily eliminated. This is accomplished by removing the plate V, and, without disturbing the crystal section, restoring it to its place in an inverted position. The measured angle, if before too great, will now be as much too small, and the arithmetical mean of the two measurements will be the true angle. (Cf. Groth, 1. c.)

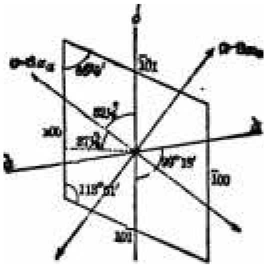
400. Position of the Plane of the Optic Axea. —The investigation of a section of a monocliuic crystal parallel to the plane of symmetry determines the position of the two ether-axes lying in this plane, but it does not fix the relative position of the axes a and C, that is, the plane of the optic axea. To solve the latter point, sections normal to each of the three axes must be examined in converging polarized light, and one of them will show the characteristic interference-figure. The section parallel to the plane of aymmetry is first to be examined, and if it does not show the axes even iu oil, one or both of the other sections spoken of must be employed.

The position of the optic axial plane is described as \botXb according as it is parallel or normal to tlie plane ot symmetry, that is, to tlie face 6(010). lu the former case, the position of the bisectrices may be defineJ according to the ungle which the acute bisectrix (Bz,) makes either with the normal to the face a (100) or that of c (001) or with the vertical axis i. Tbe last niethod is

rrttcularly convenient bidcb the direction of the vertical crystuUogrupliic axis, , ia that marked by the prismatic zone (e^,, in a section by cleavage linea), and still more since ttie extremity of i is the middle point of the sphera of projection (Fig. 550) and the angle is either -|- (in front, toward 100) or — (behind, toward 100).

For example, Kypsum is optically positive, hence the sxts, e, h tbe acute bisectrix, Bxa. Farther (Figs. 6&, 650), the pOBltloo of Be. U defined by the angle Bxa Ai= + 6fH°. But BlQce the hkUI angle /S, oi ik (001 A 100), = 80° 43', it Is nlra true that tlie normal

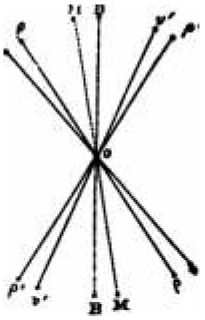
649. 660.



a and the planes e, a are as follows: « = + 48' 13', ac = 4- ST 80*, The poaitlone of the bisectrices ale shown iu the section parallel to ft (010) ot Fig. 646. and also Id the sphere of pvojeclloii, Fig. 650,

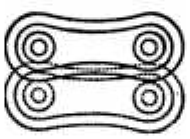
551. 401, Siapereiou of the Biseotrioes.—1. Inclined

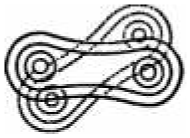
DiSPKRSiON.—In this first case the plane of the optic axes is parallel to the face h (010); in other words, the two bisectrices (the axes a and C) lie in the plane o(symmetry, and the mean axis b coincides with the orthodiagonal axis. The optic axes may hera suffer a dispersion in this plane of symmetry, and, as already stated, they then do not lie symmetrically with reference to the acute bisectrix. This is illustrated in Fig. 551, where JOf is the bisectrix for the angle vOv', and BB for the angle pOp'- This kind of dispersion was called by Dea Gloizeaux inclined (dispersion inclinee). The position of the two axial planes is further illustrated by Fig. 553 (from Schrauf), and corresponding to this the axial interference-figure, when the dispersion is considerable, shows a distribntion of colors illustrated by Figs. 4a and 4b of



tho plate (frontispiece), which should be compared with the Dormsl figures (Figs. 3a and Bb), where there is no dispersion of the bisectrices.

553.





S. Horizontal. Ax. pl.X6; Bx„±b.

' 8. Crossed. Ax. plX^; Bx^±b.

1. loclioed. Ax. pi. B b (010).

2. HoEizoNTAL DlSPBBBiON. In the second case the acnte bisectrix and b lie in the plane of sjmmetrj, and the optic axial plane is heuoe normal to it. In other words, the plane of the optic axes for aJl the colors lies parallel to the orthodiagonal axis, but these planes may have different inclinations to the vertical axis. This was called horitovlal diaperaion by Des Cloizeaox.

The relative positions of the axial planes is illnBtrated by Fig. 553, and the resulting interference-figure is shown in Fig. 5 of the plate.

3. Crossed Dispersion. In the third case the obtuse bisectrix and b lie in the plane of symmetry, that is, the plane of the optic axes is normal lo this plane and the acuta bisectrix coincides with the orthodiagonal axis t. This was called crossed dispersion by Dea Cloizeaux (dispersion tonmante or crois^e). The relative positioiis of the axial planes is illustrnted by Fig. 554 and the corresponding interfereiice-flgure is shown in Fig. 6 of the plate.

402. Axial Angle, Dispersion, etc.—The metliod of measuring the axial angle has been

already explained, and if this ie determined for the different colors it will determine tlie dispersion of the axes p^v.

The dispersion of the bisectrices has been shown to be in general indicated by the character of interference-figures; its amount, where considerable, may be determined by making the stauroscopic measurements for different colors.

The remaining points to be investigated, the refractive indices, the + or — character of the crystal, etc., need no further explanation beyond that which has been already given.

Special Optical Chnracters of Trielviic Crystals.

403. The crystals of the trtci.inic system are characterized by the absence of a plane of crystal log raphic symmetry, the position and inclination of the axes being thus arbitrary. It follows from this that there is no necessary connection between them and the rectangular ether-axes. More than one of the three kinds of dispersion mentioned in Art. 401 may occur in a single crystal, and the interference-figures will indicate the existence of both.

The practical investigation of triclinic crystals optically involves considerable difficulty; in general a series of snccessive trials are required to determine the position of the axes. When these are found, the axial sections can be prepared and the axial angle determined, and the other points settled as with other biaxial crystals. Cf. Fig. 341, p. 109, of chalcanthite, where S repre-

eents approximately the poaition of Bx^, or in otiier words is the pole or normal to the plane at right suglee to the acute bisectrix. On the genera) relatiou between the extinction-directions, ether-axes and optic axes, see the authors referred to on p. 212.

404. Effect of Heat npoa Optical Characters,—The general effects of heat upon crystals as regards expansioti, etc., are spoken of later. It is convenient, however, to consider here, briefly, the changes produced by this means in the special optical characters. It is assumed that no alteration of the chemical composition takes place and no abnormal change in molecular structure. The essential facts are as follows:

(1) Isotropic crystals remain isotropic at all temperatures. Crystals, however, which like sodium chlorate (NaClO, of Group 5, p. 51) show circular poUrization, may have their rotatory power altered; in this substance it is increased by rise of temperature.

(2) h niaxiat crystals similarly remain uniaxial with rise or full of temperature; the only change noted is a variation in the relative values of mand e, tlint is, in the strength of the

double refraction. This increases, for example, with calcite and grows weaker with beryl and quartz. It is, further, interesting to note that the rotatory power of quartz increases witli rise of temperature, but the relation for all parts of the spectrum remains sensibly the same.

(3) With Biaxial crystals, the effect of change of temperature varies with the system to which they belong.

Tlie tkxial anele ot biaxial crystals may be measured at any required temperature by tlie UK of A metal atr-batl]. Tills is placed nt P{Fi£, 644), and extends beyond tbe lusinitueDt «n eilber side, so us to allow of lis being heateawhh gas-biiroerE ; a tliennomeler inseried In the bath makes it possible lo regulate the temperature as may be desired. This bath has two iip«iiliig«, c'liiped with j^lasa plates, correspouding lo the two lubes carrying the k-uses. and the crystsl-seuliuo, held as usiinl iu tbe piucers, is seen tlirougb these glass windows. Suitable awewcies to the refraclometer also allow of the measurement of the refmctive Indices at different tempers in res.

In the case of orthorhombic crystals, the position of the three rectangulw* ether-axes cannot alter, since they mnat always coincide with the crystallo-

fraphic axes. The values of the refractive indices, however, may change, and ence with them also the optic axial angle; indeed a change of axial plane or of the optical character is thus possible.

For example. Des Clolzeaux gives the following values for barite: 2S. = 68° 5' •< m* C. 6fl-49-at 05-5°, 74" Wat 195S". Fnrtlier, Ar^rnni oblalued the following m--of the refractive Itidlces of the same sjiecirs for the I) Hoe:

« /S ^ SB

With mofiocUnie crystals, one ether-axis must coincide at al! temperatures with the axis of symmetry, but the position of the other two in the plane of symmetry may alter, and this with the possible change in the value of the refractive indices may cause a variation in the degree (or kind) of dispersion as well m in the axial angle.

With tridinic crystals, both the positions of the ether-axee and the values of the refractive indices may change. The observed optical characters may therefore vary widely.

A Mriking example of the chKnge of opilcnl cLarsclera with change of temperature U (umished by gypsum, its luveslieated by Des Cliiizesui. At ordinary temperatureB, tbe dispenilou la luctiui^, the Hxiiil pTutie ia [b aud 2Br — U5°. An tiin temperature risen Ibit auglr Uimiuisbes ; ibus at 47°, SK - V(J°; at 05°. 2E^ = »9"; auil at 116°. iSr = 0. At thii luisl iL'iupeMiture tbe azea for blue rays have alreaily separated lu B plaue 1 6; at 13<J°

the lUes [or Ttd rays also seiiuriiltt lu this p.aiie (j. b) sod the disporsioa becomea horiiontal. Tbe uiullOD towiiTd the center of one red azia is mure ra))ld tliua tliut of the other, uamely betwuvD 30° aud 85°, 83° 55' aud Zi° 88', respectively; lliua Bx, moves B° 88'.

Auuther ialereatlDg case Is that (if glauberlte. Its optical cbaraclers under uoruial conditions are described as follows : Optically —, A*, pi. 1 6, Bx„ a A = - 31° 8", Bx^, = - 30° 46', Bi^w A A = - 80° 10'. The optical characttT (-) and the poaltion of the axes of elasticity remain sensibly consiiinl betwei-u 0° aud 100°. 'i'he ax. pi., however, at first X b with horizontal dIapeiBion nnd v <, fi becomes on rise of temperature fb with incliued dispersion and t> > p. Tbe axial augle accordingly diminisbes to 0° at a temperature depending upon the wave-lunglh aud then increaaea lu Ibe new plane. In wblle light, therefore, tbe Iuierference-figures are abuurmal and cliange with rise in tempernture. Axial angles, L.iapeyrea:

red (Li) yellow (Na) green (Tl) blue

At S° 3E = 16' 0' 14° 8 11° 43' 8° 81'

32° " =18° SO ir 8' 8° 14' 0° (at 18")

;'14' tlie feldsoni change in the position of the axet they do not return again to Ibelr o:

In addition to tbe typical cases referred to, it ia tobe noted that vhoii elevation of temperature is connected with change of chemical comjiosition wide changes in optical characters are possible. This is illnstrated bj the zeolites and related species, where the effect of loss of water haa been particularly investi-

Further, with some crystals, heat serves to bring about a change of molecular etructure nnd with that a total change of optical characters. For example, the

freeniah-jeHow (artificial) orthorhombic crystals of antimony iodide (Sbl,) on eating (to about li4") change to red uniaxial iiexagonal crystals. Note also the remarks made hiter in regard to the effect of heat upon leucite and boracite (Art. 411).

iOS. BomaPseollaritleiln Axial InterfertnBS-flgurM.*—In Ibeciise of uniaxial cryatala, the cliarncteristic iiili:rferauce-flgure varies but liLlle from one apecies to auiuhor. such variation OS is ubaervecl being usually due In the thickness of tbe sucliou and the birefringence. In some ciises, however, peculiarities are noted. For example, the Inlerferencu-flgure of npophyillte la aomewhat peculiar, sliico its liltefrlDgcnce la very weak, aud It may be optically positive for one part of tbe apeclruiu and negative for the other.

In tbe case of biaxial crystals, peculiarities are more common. The following are some typ'c-nt examples ■

BrKriklie Is optically-f nnd the acuti: bisectrix Is always normal to a (100). While, how-cv.T. the fixial piano Is [a for red and yellow, willi 2ff,. = 65°, 2Bi, = 80°. it ia commonly \b for green anil blue, with 2S!^ = 34°. Hence n section la Iii the c<iuoscoi>e shows a flgura sompirhnt resembling llmt of a unlnxial cry-tnl but witli f.uir sets of bypcrboUc bands.

Titnnlte iil»o elves n pecnllnr [nteiferencp-figure with colored hvperbolas bccniise of the high color-di«per-ion. o > n: I'uii r>es Oloizpaiix gives 2Br = 55° to 66°, 2E, = 84°; the 'linpendon of the Miiwtrirea 1». howi-vcr, very araall.

The mmt xtriklng canes of p'-oiillnr iirin! fli;iircB nrc affonted by twin cryatala (Art. 40T).

408. Relation of Optical Propertiea to Chemical Compoiition.—Tbe effect of

Taryiug chemical composition upon the optical characters haa been minutely

studied in the case of many series of isomorphons salts, and with important results.* It is, indeed, only a part of the general subject of the relation between oryatalline form and molecular structure on the one hand and chemical composition on the other, one part of which has been discussed in Art. 302. It was shown there that the refractive index can often be approximately calculated from the chemical composition.

Amoug inluKTiils. Ilie most important examples of the relutlau between cotnpodliou iind oplfcal uL&ntcturB are afforded by llie triclluic felilspurs or tUe albUe-atiortbite seiies. Here, us uxpluJued !□ detail iu Ibe tlescrijiiive part of this work, the relatloD is so close lliut thecumpusltionof any tmermedlste member oF this isomorpboua group cau be predicted from llie posltlou of ll« etlier-axes, or more aimply from (lie TibTB^ondlrectluns od the fuiidBmeulul clesTsge-dirsctlouB,]e (001) mid [b (010).

The effect of Tarjing uroouDts of liOD protoxide (FeO) Is illiistrfiled Iu tbe case of lbs

orthorliombic species of the same group, eustatlte, MgSiOinlth llllle Iron, and byper«tbeDe, (Hg,Fe}SiOi with iron to uearly SO p. c. With both of these species tbe mini plsne ii

Etralle] to 6(010), but the former is optically + (Bv. = c)Ht]i] the liispt-rsioD/> < c: tbe latter optically -' (Bx, = a) aud dispeision p > v. In other words, tbe optic axial augle Increosea rapidly with the FeO percentage, Ijeinc about B0° for FeO = 10 p. o. Iu tbe cuse of the chryeblitea, the epidotee, the species tdphyJite uud lithiopbltiie, and others, analogotu telatlona have been mode out.

407. Optical PropertiH of Twin Cryatab.—The examination of sections of BBS. twin crystals of any other than fhe isometric

sjBtem in polarized light serves to establish the compound character at once and also to show the :=Bx. relative orientation of the several parts. This is

most distinct in the case of contact-twins, but is also well shown with penetration-twins, though here the parts are usually not separated by a sharp line.

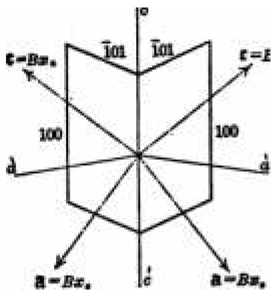
Thus the exatninntioD of a section parallel to b (010) of a twin crystal of gypsum, ol the tym of Fig. 555, makes it easy not only to establish toe fact of the twinning but also to fix the relative positions of the ether-axes in the two parts. The measurement can in such cases be made between

the extinction-directions in the two halves, instead of between one of these and

some definite crystallographic line, as the vertical axis.

The polygynthetic twiuning of ceilain species, as the tricllnlc feldspars, appears with.

great distinctness in poliirized light. For example, in the case of a section of alUte. parallel

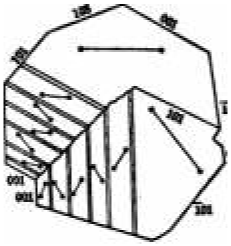


S&6.

to tbe basal cleavage, the alternate bands extinguish together sad assume tbe same tint wheu the quartz section U inserted. Hence tbe angle between these directions is easily menaured, and this Is obviously double tbe eitInc1ion'«ngle made with the edge b/e. A basal section of inicrocline Iu the same way shows its compound twinoing according to both tlie albite and pericline Inwa. ' iLe characteristic graliDg structure being t clearly revealed In polarized light. Fig. 556 of a section of r chondrodite (from Des Clolzeaux) abowa bow the compound [structure is shown by optical examination ; the position of the [sztat plane is indicated in the case of the successive polysyn-tbetic lamelle. The complex penetration-twins of right- and Isft-handed crystala of quartz (see the description of that species) also have their character strikingly revealed In polar Ized light.

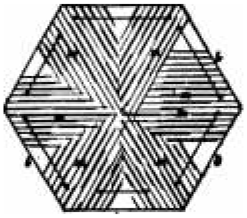
Still again, the true structure of complex multiple twins, exhibiting pseuda-eyminetty

' See a recent paper by Pockels, Jb. Mln., Beil.-Bd., 8,117. 1896.



:,CoogIC

Id tliL'Jr exiernal form, can only be fully made out in tbis way. Tlila Is illiiatrated by Pie. A.17, a basal sectiou of au appnraot bekaf.'Otial pyramid of wllherlte (cf. Fig. 400. p. 1S8). Thu aualugoua Blx-aided pyramid of bromlite (Fig. 056) has a still more com['

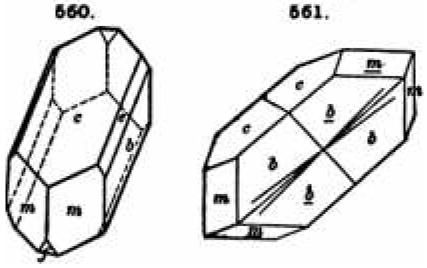


Bromlite (E>ea Clolzeaux).

in polarized Itgbt. Other flluBtrations

rized light. Other illustrations are given in ,

560. 561.



Art. 411. It will be understood Ihat

gMlbite (Laaauli). the Bzla) iaterference-flgurea of twla crystals, where the parts are superpoied, often show maoy peciillaritiea; the Airy spirals of quarlz (p. 208) will serve as an lilitgtrnilon.

408. A particularly interestlog caae, related to the subject digciisi-< i| in the

preceding article, is that of the special propertiea of superpoeed cieavage-

663, sections of mica, as developed by Reusch.* It three or

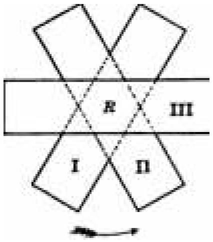
more of these, say of rectangular form, be superposed and

80 placed that the lines of the nxial planes make equal

angles of 60" (45°, etc.) with each other the effect is that

I polarized light which has passed tiirough the center suffers circular polarization, with a rotation to right or left according to the way in which the sections are huilt np. The interference-figure resembles that of a section of quartz cut normal to the axis. This is illustrated in Fig. 563.

If the sections are numerous and very thin the imitation of the phenomena of quartz is closer. As shown by



rheorle der KrystallBtruktur, 187S.

; Bohncke, fbld., £rg.-Bd., 6, 16, 1876, aud

.dbyGooglc

Sohncke and others, tbeee facts throw much li^ht upon the altimate molecnlar structure of a crystallized medium showing circular polarization. Further, it is easy from this to understand how it ia possible to have in sections of certain cryatals {e.g., of clinochlore) portions whicD are biaxial and others that are uniaxial, the latter being due to an intimate twinning after this method of biaxial portions.

40V. Optlo«l FroptrtlM of CryitalUn* AggimatM.—The speciSil optlcfti pbeaomena of tbe dlfFerenl kinds of crystalliue s^regHtea deacrRjed od pp. 142, 148. and the eitenl to which their opLical chamcteis can be determined, depeud upon the distiiictuesB in the developmeDt of the individuals and their relative oiientation. The i;ase of oniinary gntouUr, fibrous, or columnar Hggregatea needs no special discusaloD. Where, however, the doublj refracting gmitiB lire eitremcly Btnall, the mlcroacupe may hardly aerve to do moie than lo ihow tbe aggregate poiarieation present.

A case ol speciul iuierest is that of gpberulltes, iLat Is, aggre^es splierical in form and radiated or coucentric In alrncture; such aKgregatea occur with calcite, varloua chloriles, feldapars, elc. If they ara formed of a doubly refracting crystalliae niiueral, or of an amorphous au'istance which has hirefriugent cliaracters due to Internal tension, Ibey commonly exliiblt a dark cross in tlie microscope between crossed picols: further, this cross, as the section ia revolved on the stage, though octnally stationary, seems to rotate backward.*

A distinct and more special cose is that of spherical aggregates of a mineral optically uniaxial (or blailal with a small angle) Sections of these |not central) in parallel polarized light show more or less distinctly ilic inlerfereuce-figure of a uuiazlal ciyaial.f Tbe objective must be focusaed on a point a little removed from the aectlon llaelf, say od tbe sui-face of tlie sphere of which It is a part. In such cases the -|- or — character of tbe double refraction can be determined as usual.

410. Changs of Opttoal Choriotar ladneed by Prenars.—As the difference between tbe optical phenomena exhibited by au iaometric crystal on tlie one hand and a uniaxial or biaxial crystal on the other is referred to a difference in molecular structure modifying the properties of the ether, It would be inferred that If an amorphous substance were subjected to conditions tending to develop au an a I ogi ma difference in its molecular structure it would also show doubly refracting properties.

This is found to be the case. Glass nhich baa been suddenly cooled from a slate of fusion, and which is therefore cbaraclerized by strung Internal tension, usually sliowa marked double refraction. Fiirlber, glass plates subjected lo great mechanical picssiiro in one direction show in polarized light more or less distinct interference-curves. Gelniiae sections, also, under pressure exhibit like phenomenii. Even the strain In a gloss block developed under tbe influence of unlike chargeaof electricity of great difference of potential on its opposite aides la sufficient to miike It doubly refraclliig.

In an aualogoos manner, as shown by Klein, BOcking. and others,! the double refraction of a crystal may be changed by the iippliratiou of niechaiiieal force. Klein found that pre«ure exerted normal tn tbe vertical axis of a sectiim of n Ittragonnl or hexagonal crystal which \\i\a been cut x i. changes tbe uniaxial inturfei-etice.Qgure Into a biaxial, and with ■ubHiances opticalty positive, tlieplime of the optic axes was parallel, and with negative aubslances normal, to the direction of pressure.

The ijuartz cryalala In rocks, which have been subjected to great pressure, are often found ■ to be in au abnormal state of tension, showing an undulatory extinction in polarized light. 411. Optical Anomalies. ^Since the early investigations of Brewster, Herschel, and others (1815 et se^.) it has been recognized that many crystals exhibit optical phenomena which are not in harmony with the apparent symmetry of their ezterual form. Crystals of many isometric species, aa analcite, alum, boracite, garnet, etc., often show more or less pronounced double refraction, and sometimes they are distinctly uniaziaJ or biaxial. A section examined in parallel polarized light may show more or less sharply

•Cf. RosenbuBch, Mlhr. Phys.. 88eii/-g., 1892.

IBertrand, C. R., 94, 542, 1888; Mallard, Bull. Soc. Min., 4. 67. 1881.

J This subject lias been discussed by various authors, among whom (in recent yean) ars the following: Klocke. Jb. Min.. 2, 24». 1881; BDcking. Zs. Kryst., 1. SM, 1888; Brauns, Jb. Min., 1. 288. IB86: Klein, Ber. Ak. Berlin, 734, 18B0; Pockels, Wied, Ann., 37, 144 etc, 1889; 39, 440, 1890; Jb. Hin., Bell.-Bd., 8, 317,1698. See also literature on p. S81.

defined doubly refracting areas, or parallel bands or Umellee with varying eitinction. Occ&eionally, as noted by Klein in the cose of garnet, while most crystals are normally isotropic, others show optical characters which seem to be determined by the external bounding faces and edges; thus, a dodecahedron may appear to be made up of twelve rhombic pyramids (biaxial) whose apices are at the center; a hexoctahedron similarly may seem to be made up of forty-eight triaugular pyramids, etc.

Similni'ly, crystals of many common tetragonal or hexagonal species, as vesuvianite, zircon, beryl, apatite, corundum, chabazite, etc., give interference-figures resernbliuK those of biaxial crystals. Also, analogous contradictious between form and optical characters are noted with crystals of orthorboinbic and monocliuic species, e.g., topaz, uatroltte, orthoclase, etc. All cases stich as those mentioned are embraced under the common term of optical anomalies.

This subject has been minutely studied by many investigators in recent years (see literature), and important additions have been made to it both on the practical and the theoretical side. The result is tbut,-tliougb doubtful cases still remain, many of the typical ones have found a satisfactory explanation. No single theory, however, can be universally applied.

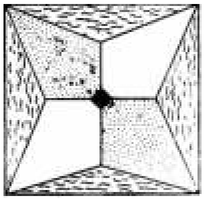
The chief question involved has been whether the anomalies are to be considered as secondary and non-essential, or whether they belong to the inherent molecular strneture of the crystals in question. On the one hand, it has been urged that internal tension suffices (Art. 410) to call out double refraction in an isotropic substance or to give a uniaxial crystal the typical optical structure ota biaxial crystal. On the other hand, it is equally ckar that twinning often produces pseudy-symmetry in external form, and at the same time conceals or changes the optical characters. From the simplest case, as that of aragonite (Fig, 397), we pass to more complex cases, as witherlte (Figs. 400, 401, and 557), bromlite (Figs. 558, .'■i,'i9), phillipaite (Figa. 362, 433-424), which last is sometimes pseudo-isometric in form, though optical stndy shows the monoelinic character of the individuals.* Reasoning from the analogy of these last cases. Mallard was led (1876) to the theory that the optical anomalies could in most cases be explained by the assumption of a similar but still more intimate grouping of molecules which themselves without this would unite to form crystals of a lower grade of symmetry than that which their complex twinned crystals actually sijunlate.

In regard to the two points of view mentioned, it seems probable that internal tension (due to pressure, sudden cooling, or rapiditv of growth, etc.) can he safely appealed to to explain the anomalous optical character ot many species, as diamond, halite, beryl, quartz, etc. Again, it has been fully proved that the later growth of isoniorphous layers of varying composition may produce optical anomalies, probably here also to be referred to tension. Alum is a striking example. The peculiarities of this species were early investigated by Biot and made by him the basis of his theory of "lamellar polarization," but the present explanation is doubtless the true one. Fig. 564 (from Brauns) shows the appearance in polarized light of a secti«n || o (ill) from a crystal in which tho successive layers have different composition. Further, according to Brauna the optical peculiarities of many other species may he referred to this same cause. He includes here, particularly, those cases (as with some garnets) in which the optical characters seeip to depend upon the external form, as

V called mimetic crj^tali

noted above. Here belongs also apophyllite, a section of which (from Golden, Colo., by Klein) is shown in Fig. 565, The section has been cut || c {001 j tlirough the center of the crystal and is represented as it appears in parallel

polarized light.



Alum. I m.

ApopTi;l11te | 001

Leucite, | 100.

Another quite distinct bnt most important class iff that including species ▪such as boracite and lencite which are dimorphoua; that is, those species which at a certain elevation of temperature (300 for boracite and 500° to 600°

for leucite) become atrictly isotropic Under ordinary conditions, these species are aiiiBotropic, but the fact stated makes it probable that originally their crystalline form and optical characters were in harmony. The relations for leucite deserve to be more minutely stated.

Leucite iiaunlly bIiows Tery feeble double refraction ; i» ~ 1'508, * = r509. TTiU nnmnalouB double refrnclion, early not td (Brewster. Biol), wnsvaiiouBly eiplnined. In 1873, Rati), on tbe basis of cureful measuremeitts. reren-ed Ibc H['einlii!.'ly Isometric ctystala to tbe tetragoTiBl system, tlie traptzobedral face 113 lidng tiikrn as 111. and 311, 121 tis 431, 341. -respectively: also 101. Oil ii3 201, 031. Later WeUbticli <]830), on tbe same ground, made tlieiii ortlioi'hombic; Mnllard, however, referred tlicm (18761, cliieBy on optical groiinds.

, to reiippear apiiu tn d< iwlnniug-filinellffi | (1(110); la some cc a cubic fiice, tbe aiial niiKle beiner ■ (Klein) to tbe loterpenetmlioii of th

iidly or uoequally developed; or there may be

position on cooliiiK. Sections ordinarily sliow 1 bispctrix (-|-) is normal to what corresponds to small. Tlie structure corresponds In geueml crystals, in twinnlni; posilion | d, wblcb may be ' ■ ■ ' loeed

.e fundniiientnl individtial wlifa Incloi

Still again, in a limited number of cases it can be shown that the inter-growth of lamellsB having Blightly different crystallographic orientation is the cause of the optical peculiarities. Prehnite is a conspicaons example of this class.

After all the various]Jo8sible explanations have been applied-there still remain, however, many species about which no certain connliision can be reached. This is true, for example, of perovskite. To many of these species the theory of Mallard may probably be applicable. Indeed it may be added that mucn difference of opinion still exists as to the cause of the "optical anomalies" in a considerable number of cases.

Opiieal Anomaiitt.*

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Biot. Rechercbes sur la polarisaiion lamellalre. etc. C. R., 13, M7, 1841i 13, ISO, 3»1, 839, 1841; io full in Hem. de I'lostlmt, 18, 589.

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IV. CHARACTERS DEPENDING UPON HEAT.

413. The more important of the special properties of & mineral species with respect to heat include the following: Fusibility; conductivity and expansion, especially in their relation to crystalline structure; change in optical characters with change of temperature; specific heat; also diathermancy, or the power of transmitting radiation, that is, ether-waves. The full discussion of these and other related subjects lies outside of the range of the present text-book. A few brief remarks me made upon them, and beyond these reference must be made to text-books on Physics and to special memoirs, some of which are mentioned in the literature (p. 233).

413, Fusibility.—The approximate relative fusibility of different minerals is an important character in distinguishing different species from one another by means of the blowpipe. For this purpose a scale is conveniently used for comparison, as explained in the articles later devoted to the blowpipe. Accurate determinations of the fusibility are difficult, and though of little importance for the above object, they are interesting from a theoretical standpoint. They have been attempted by various authors, for example by Joly, who employed the "meldometer" for this end. This consisted of a strip of platinum in which the mineral in powder was inclosed; it was heated to the necessary point by an electrical current. He obtained the following values for the minerals used in von Kobell's scale (Art. 474): Stibnite, 525°; natrolite, 965°; almandite, ISGo"^; actinolite, 1296°; orthoclase, 1175°; bronzite, 1300°; also for quartz, 1430°.

414, Conductivity.—The conducting power of different crystallized media was early investigated by Senarmont. He covered the faces of the substance under investigation with wax and observed the form of the figure melted by a hot wire placed in contact with the surface at its middle point. Later investigations have been made by Routgen (who modified the method of Senarmont), by Jannettaz, and others. In general it is found that, as regards their thermal conductivity, crystals are to be divided into the three classes noted on p. 192. In other words, the conductivity for heat seems to follow the same general laws as the propagation of light. It is to be stated, however, that experiments by B. P. Thompson and O. J. Lodge have shown a different rate of conductivity in tourmaline in the opposite directions of the vertical axis.

415, Expansion.—Expansion, that is, increase in volume upon rise of temperature, is a

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" A complete bibliography Is given in the memoir by Brauus (1891), see below.

nearly universal property for all solids. The increment of volume for the unit volume in passing from 0° to 1° C. is called the coefficient of expansion. This quantity has been determined for a number of species. Further, the relative expansion in different directions is found to obey the same laws as the light-propagation. Crystals, as regards heat-expansion, are thus divided into the same three classes mentioned ou p. 192 and referred to in the preceding article.

The amount of expansion varies widely, and, as shown by Jannettaz, is influenced particularly by the cleavage. Mitscherlicb found that in caloite there was a diminution of 8' 37" in the angle of the rhonibohedron on passing from 0° to 100° C, the form thus approacliing tliat of a cube as the temperature increased. The rhombohedron of dolomite, for the same range of temperature, diminishes 4' 46"; and in aragonite, for a rise in temperature from 21° to 100", the angle of the prism diminishes 2' 46". In some rhombohedrons, as of calcite, the vertical axis is lengthened (and the lateral shortened), while in others, like quartz, the reverse is true. The variation is such in both cases that the birefringence is diminished with the increase of temperature, for calcite possesses negative double refraction, and quartz, positive.

It is to be noted that in general the expansion by heat, while it may serve to alter the angles of crystals, other than those of the isometric system, does not alter the zone-relutions and the crystalline symmetry. In certain cases, however, the effect of heat may be to give rise to twinning-] amellie (as in anhydrite) or to cause their disappearance (as in calcite). K^rely lieat servei

to develop a new molecalar strticture; tbas, ae explained in Art. 411, bonioit» and leucite, which are anisotropic at ordinary tamperaturas, become iaotropio vbeu heated, the former to 3UU~ the latter to SOU or tlOO". The change in the optical properties of crystals produced by heat has already been noticed (Art. 404).

416. SpeoiSe Heat.—Determinations of the specific beat of many minerals have been made by Joly, by Oeberg, and others. Some of the results reached are, as follows :

417. Diathermancy.—Besides the slow molecular propagation of beat in a body, measured by its thermal conductivity, there is also to be considered the rapid propagation of what is called radiant heat through it by the wavo-motion of the ether which snrroutids its molectiles. This is merely a part of the general subject of light-propagiition already fully discussed, since heatwaves, ill the restricted sense, differ from ligbt-wavea only in their relatively preater length. The degi'ee of absorption ejterted by the body is niensnred by its diathermancy, which corresponds to traiiBparency in light. In this sens© halite, sylvite, and fliiorite are higlily diclhermanoics, since they absorb but little of the heat-waves passing throngh them; on the other hand, selenlte and, still more, alum are Gomparai.ively iithermanouf, since while transparent to the slioit light-waves they absorb

the long hoat-waves, transforming the energy into (liiit of sensible heat. Measurements of the diathermancy were early madft by Melloiii, later by Tyndall, Langley, and others.

LlTEBATCRX.

Beat.

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V. CHARACTERS DEPENDING UPON ELECTRICITY AND MAGNETISM.

1. ELECTRICITY.

418. Electrical Condnotivity. —The subject of the relative conducting power of different minerals is oue of minor interest,* In general most minerals, except those having; a metallic luster among the sulphides and oxides, are nonconductors. Only the DOn-conductofB can show pyro-electrical phenomena, and only the conductors can give a thermo-electric current.

419. Frictional Electricity. ^The development of an electrical charge on many bodies bi/ frictioti is a familiar subject. All minerals become electric by friction, although the degree to which this is manifested differs widely. There is no line of distinction among minerals, dividing them mtopositively electric and negatively (Aacina; for both electrical states may be presented by different varieties of tlie same species, and by the same variety in different states. The gems are in genera! positively electric only when polished; the diamond, however, exhibits positive electricity whether polished or not. It is a familiar fact that the electrification of amber upon friction was early observed (600 B, C), and indeed the Greek name (t/Xeierpov) later gave rise to the word electricity.

420. Pyro-electricity.^The simultaneous development of plus and minus charges of electricity on different parts of the same crystal when its tempera-tnre is suitably changed is called pyro-electricity. Crystals exhibiting such phenomena are said to be pyro-electric. This phenomenon was first observed in the case of tourmaline, which is rhombohedral-hemimorphic in crystallization, and it is particularly marked with crystals belonging to groups of relatively low symmetry, especially those of the hemimorphic type. It is possible, of course, only witii non-conductors. This subject was early investigated by Eiess and Rose (1843), later by Ilaukel, also by C. Friedel, Kundt, and others (see literature).

lu all cases it is true that directions of like crystallogrspbic symmetry show charges of like sign, while unlike directions may exhibit opposite charges. Substances not crystallized cannot show pyro-electricity. A few of the many possible examples will serve to bring out the most essential points.

Boracite (isometric-tetrahedral, p. 46) on heating exhibits + electricity on one set of tetrahedral faces and ~ electricity on the other. Cf. Fig. 567.

Tourmaline (rhoniboJiedral-hemimorphic, p. ^9) shows opposite charges at the opposite extremities of the vertical axis corresponding to its hemimorphic crystallization. In this and in other similar cases, the extremity which becomes positive on heating has been called the analogous pole, and that which becomes negative has been called the antilogous pole.

Calamine and struvile (orthorhombic-hemimorphic, p. 95) exhibit phenomena analogous to these of tourmaline.

Quarti (rhombohedral-trapezohedral, p. 82) shows + electricity on heating at the three alternate prismatic edges and — electricity at the three remaining edges; the distribution for right-handed crystals is opposite to that of left-handed. Twins may exhibit a high degree of complexity. Cf. Figs. 568, 569.

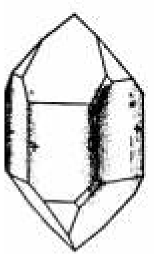
Axiiiite (triclinic, p. 107), when heated to 130° or 130°, has an analogous pole (Riess & Rose) at the solid angle rxM"; the antilogous pole at the angle mr'M' near plane n.

A very convenient and simple method for investigating the phenomena is

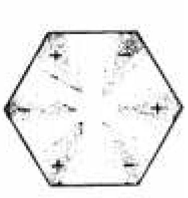
• On tlie conducdviiy of mitieralH, see Beljcriuik. Jl>. Hiii.. Bcil.-Iid. 11, 403, 1898.

the following, which is dne to Kundt: First heat the crystal or Bection carefully in an air-bath; puss it several times through the Qame of an alcohol lamp and then place it on a little upright cylinder of bnisa to cool. While cooling, a mistnre of red lead and sulphur finely pulverized and preyiouely agitated is dusted over it through a fine cloth from a suitable bellows. The

568.



569.



positively electrified red lead collects on the p^rta having a negative charge, and the negatively electrified eulpliur on those with a positive charge. This ia Illustrated by Figs. 5C7-569, and still better by the illuatrationa given by Eundt and others. (Of. Plate III of Oroth, Phys. Kryst., 1895.)

431, Piezo-eleotriolty. —The name piezo-ehctricUy has been given to the development of electrical charges on a crystallized bod;y by pressure. This is shown by a cleavage-maaa of calcite, also by topaz. This phenomenon ia most interesting where a relation can he established between tlie electrical excitement and the molecular structure, as is conspicuously true with quartz, tourmaline, and some other species.

This subject has been investigated by Hankel, Curie, and others, and discussed theoretically by Lord Kelvin (see literature). Hankel has also employed the term acHuo-ehctricity, or, better, photo-eleclriciip, for the phenomenon of calling out of an electrical condition by the influence of direct radiation ; floorite is a conspicuous example.

422. BiintgeiL-rays in Mineralogy.— The power of different minerals to transmit the so-called X-rays, or Rontgen-rays, emitted from a suitable vacuum-tube during the discharge of an induction-coil has been investigated by Doelter.* He haa found, for example, that sulphur, beryl, epidote, pyrite, etc., are nearly opaque; tourmaline less so; fluorite transmits the rays slightly, the feldspars and auartz better; corundum is nearly transparent and diamond and graphite are highly so. Diamond is easily distinguished in this way from its imitations, which are relatively highly opaque.

423. Thenno-electrioity. —The contact of two unlike metala in general reaiilts in electrifying one of them positively and the other negatively. If, further, the point of contact be heated while the other parts, connected with a wire, are kept cool, a continuous current of electricity—shown, for example, by a suitable galvanometer—is set up at the expense of the heat-energy supplied. If, on the other hand, the point of junction is cooled, a current is set Tip in the reverse direction. This phenomenon is called thermo-elecli-icity, and two metals so connected constitute a thermo-electric couple. Further it is found that different conductors can he arranged in order in a table—a so-called thermo-electric series—according to the direction of the cnrreut sei iij> on heating and according to the electromotive force of this current. Ar>ion>; the metals, biBmuth (-|-) and antimony (—) stand at the opposite ends of the series; the current passes through the connecting wire from antimony tn bismuth.

This subject is so far important for mineralogy, as it was shown hy BiinBeii that the natural metallic sulphides stand farther off in the series than bismuth and antimony, and consequently hy them a higher electromotive force is Sroduced. The t her mo-electrical relations of a large number of minerals were etermined by Flight. >

It was early oMerved that some minerals have varieties which are both + and —. Bose attempted to establish a relation between the plus and minus pyritobedral forma of pyrite and cobaitite, and the positive or negative thermo-eiectrical character. Later investtgatione by ^chruuf and Dana have shown, however, that the same peculiarity belongs also to gluucodot, tetradymite, Bkutterudite, danaite, and other minerals, and it is demonstrated by them that it cannot be dependent upon crystalline form, but rather npoo

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*Jb. Mln.,2, 67, ISH; 1, SM, 1897. Also Qoodwiu, Nature, April 30, 1S96.

chemical composition.

LiTEHATPRE.*

Pyro-eUciricity, etc.

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2. Maoketism.

424. Magnetic Minerals. Natural Magnets.—A few minerals in their natural state are capable of being attracted by a strong steel magnet; they are said to be magnetic. This is conspicuously true of magnetite, the magnetic oxide of iron; also of pyrrhotite or magnetic pyrites, and of some varieties of native platinum {especially the variety called iron-platinum).

A number of other minerals, as hematite, franklinite, etc., are in some cases attracted by a steel magnet, but probably in most if not all cases because

of admixed magnetite (but see Art. 428). Occasional varieties of the three minerals mentioned above, as the lodestone variety of magnetite, exhibit themselves the attracting power and polarity of a true magnet. They are then called natural magnets. In such cases the magnetic polarity has probably been derived from the inductive action of the earth, which is itself a huge magnet.

426. Paramagnetism. Diamagnetism.—In a very strong magnetic field, as that between the poles of a very powerful electromagnet, all minerals, as indeed all other substances, are influenced by the magnetic force. According to their behavior they are divided into two classes, the paramagnetic and diamagnetic; those of the former appear to be attracted, those of the latter to be repelled. For purposes of experiment the substance in question, in the form of a rod, is suspended on a horizontal axis between the poles of the magnet. If paramagnetic, it takes a position parallel to the magnetic axis; if diamagnetic, it sets transversely to it. Iron, cobalt, nickel, manganese, platinum are paramagnetic; silver, copper, bismuth are diamagnetic. Among minerals compounds of iron are paramagnetic, as siderite, also diopside; further beryl, dioptase. Diamagnetic species include calcite, zircon, wulfenite, etc.

By the use of a sphere it is possible to determine the relative amount of magnetic induction in different directions of the same substance. Experiment has shown that in isometric crystals the magnetic induction is alike in all directions; in those optically uniaxial, that there is a direction of maximum and, normal to it, one of minimum magnetic induction; in biaxial crystals, that there are three unequal magnetic axes, the position of which may be determined. In other words, the magnetic relations of the three classes of crystals are analogous to their optical relations,

426. Corresponding to the facts just stated, that all compounds of iron are paramagnetic, it is found that a sufficiently powerful electromagnet attracts all minerals containing iron, though except in the cases given in Art. 424 a bar magnet has no sensible influence upon them; hence the efficiency of the electromagnetic method of separating ores,

Pliicker* determined the magnetic attraction of a number of snbstances compared with iron taken as 100,000. For example, for magnetite he obtained 40,237; for hematite, crystallized, 633, massive, 134; limonite, 71; pyrite, 15U.

LlTERATORB.

Magntlimi.

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' Pogg. Aon., 74, 348, 1S48.

VI. TASTE AND ODOR.

In their action npon the senseB a few minemls possess taste, and others under Bome circnmBtances give off odor.

487. Tute belongs only to soluble mineralB. The different kinds of taste adopted for reference are as follows:

1. Astringent: the taste of Titriol.

2. Sweetish astringent: taste of alum.

3. Saline: taste of common salt.

4. Alkaline: taste of soda.

5. Cooling: taste of saltpeter.

6. Bitter: taste of Epsom salts.

7. Sour: taste of sulphuric acid.

428. Odor.—Excepting a few gaseous and soluble species, minerals in the dry unchanged state do not give off odor. By friction, moistening with the breath, and the elimination of some volatile ingredient by heat or acids, odors are sometimes obtained which are'thus designated:

1. Alliaceous: the odor of garlic. Friction of arsenical iron elicits this odor; it may also be obtained from arsenical compounds by means of heat.

2. Horse-radish odor: the odor of dei^Hying horse-radish. This odor is strongly perceived when the ores of selenium are heated.

3. Sulphurous: friction elicits this odor from pyrite, and heat from many sulphides.

4. Bituminous: the odor of bitumen.

5. Fetid: the odor of sulphureted hydrogen or rotten eggs. It is elicited by friction from some varieties of quartz and limestone.

6. Argillaceous: the odor of moistened clay. It is obtained from serpentine and some allied minerals, after moistening them with the breath; others.

. pyrargillite, afford it when heated. 429. FeeL ""

. FeeL—The feel is a character which is occasionally of some importance; it is said to be smooth (sepiolite), ^rso^.^ [talc), harm, or meager, etc. Some minerals, in consequence of their hygroscopic character, adhere to the tongue when brought in contact with it.

PART m. CHEMICAL MINERALOGY.

GENERAL PRINCIPLES OF CHEMISTRY AS APPLIED TO MINERALS.

430. Minerals, as regards their chemical constitution, are either the uncombined

elements in ti native state, or definite compounds of these slements formed in accordance with chemical laws. It ia the object of Chemical Min-erulogj to determine the chemical composition of each species; to show the chemiciil relations of diiferent species to each other where such exist; and also to explain the methods of distinguishing different minerals by chemical means. It thus embraces the most important part of Determinative Mineralogy.

In order to tiuderstand the chemical constitution of minerals, some knowledge of the fundamental principles of Chemical Philosophy is required; and these are here briefly recapitulated.

431. Chemical Elements.—Chemistry recognizes about seventy substances which cannot be decomposed, or divided into others, by any process of analysis at present known; these substances are called the chemical elements. A list of tnem is given in a later article (436); common examples are: Oxygen, nitrogen, hydrogen, chlorine, gold, silver, sodium, etc.

433. Atom. Holeonle.—The study of the chemical properties of substances and of the laws governing their formation has led to the belief that there is for each element a definite, Indivisible mass, which is the smallest particle which can play a part in chemical reactions; this indivisible unit is called the atom.

With some rare exceptiouB, the atom cannot exist alone, but unites by tha , action of what is called chemical force, or chemical affinity, with other atoms of the same or different kind to form the molecule. The molecule, in the chemical sense, may be defined as the smallest particle into which a given kind of substance can he subdivided without undergoing chemical decompoai-tion. For example, two atoms of hydrogen unite to form a mole/^le of hydrogen gas. Again, one atom of hydrogen and one of chlorine form a molecule of hvarochlorio acid gas; two atoms of hydrogen and one of sulphur form a molecule of the gas hydrogen sulphide.

483. Fhyiioal Moleoolea.—An important distinction must be mode between the simple chemical molecules, regarded as made up of the smallest possible Dnmber of the atoms of each kind, united in the given proportion, and the actual physical molecules which together build np the structure of a particular

mass of matter. These pbyBical molecoleB may be much more complex, each being made up of a number of chemical molecules but neceasarily coiitaiuing the respectiiTe atonia in the same proportion. Iti the case of a gas, it is always possible to determine the constitutiou of the molecule, as is explained later, but in the case of liquids and eolids this ie in general impossible.

For example, it is certain that a molecule of water vapor conBists of two atoms of hydrogen and one atom of oxygen, but the molecules of water which unite to build up a snow crystal, though containing the atoms of the two elements hydrogen and oxygen in the same proportion, may be highly complex, aa if made up of many gas molecules. Since it is in general impossible in the <iase of solids to fix the constitution of the actual molecule, it is usually better to regard it as a chemical molecule of the simplest poseil>le form.

4Si, Atomic Weight.—The atomic weight of an element is the weight, or, better expressed, the mass of its atom compared with that of the clement hydrogen taken as the unit Thus the mass of an atom of oxygen is very nearly sixteen times that of the atom of hydrogen (exactly 15'96), and hence this number is called the atomic weight of oxygen. Of the methods by which the relation between the masses of the atoms is determined it is unnecessary here to speak; the results that have been obtained are given in the table on p. 241.

435. SymboL Formula.—The symbol of an element is the initial letter, or letters, often of its Latin name, by which it is represented when expressing in chemical notation the constitutiou of substances into-the composition of which it enters. Thus 0 is the symbol of oxygen, H of hydrogen, CI of chlorine, Fe (from ferriim) of iron, Ag (from argeiitum) of silver, etc. Further, this symbol is always understood to indicate that definite amount of the given element expressed by its atomic weight; in other words, it. represents one atom. If twice this quantity is involved, that is, two atoms, this is indicated by a small subscript number written immediiitely after the symbol. Thus, 8b,S, means a compound consisting of two atoms of antimony and three of sulphur, or of 2 X 120 parts by weight of a7itimony and 3 X 32 of sulphur.

This expression, Sb,8,, is called ih^ formula of the given compound, since it expresses in briefest form its composition. Similarly the formula of the mineral albite is NaAISi.O,.

Strictly speaking, such formulas are merely empirical formulas, since they express only the actual result of analysis, as giving the relative number of atoms of eacb element present, and make no attempt to represent the actual constitution. A formula developed with the lal.ter object m view is called a rational, structural, or constitutional formula (see Art. 493).

436. Table of the Elements.—The fallowing table gives a list of all the definitely established elements with their accepted symbols and also their atomic weights.*

Of the elements given in this list—about seventy in all—only a very small number, say twelve, pla^ an important part in making up the crust of the earth and the water and air surrounding it. The common elements concerned in the composition of minerals are: Oxygen, sulphur, silicon, aluminium, iron, calcium, magnesium, sodium, potassium. Besides these, hydrogen is present in water, nitrogen in the air, and carbon in all animal and vegetable substances. Only a very few of the elements occur as such in nature, as native gold, native silver, native sulphur, etc.

* These coirespoiid in value la tliose commonly accepted, ftod are given accurate to oae decimal place. In strict chemical leiue tlie atomic weight of oxygen u IS'96, eic.

^ ^*^e'

■Acfif-fc-/ ^j Lii

Of the elemflDts, oxygen, hydrogen, nitrogen, chlorine, and flnorine are gaaes; bromine is a volatile li<^uid; meronry is also a liquid, but the others are aolida under ordinary conditions.

Symbol Alum in turn. Alum la um ^Al Autimony {StMum) Sh Argou A

.(.Weight. , Byml:

37 ' Manganese ^i_

130 I Mercury {Hydrarffffrum) Hg

89'ft ^ .KMolybdeoum Mo

ibol. At. Wdebt.

-Ba Be(orGl) 91

B,.ri Berylliudi

J - Bisiuulti

' BuroD B 10-9

Bromine Br 79-8

Ciidmlum Ca 111-7

Ciesium Cs 66'7

JiO Culcium -43a ■«»»

Cnrbon C 19

Cerium Ce 141

CLlortae CI - 85*4

Clironiium ^""Cr 52'5

CobfiU -Co 58-7

^ ColuDibluni.see JRoMum. ^ 69, t

k \A Copper (Ouprwwi) --Ca " -< o %

Diciymium Di 142

Erbium Er 160

Fluorine ^ f 191

ORtlium Ga 69-9

tieroiftDfuin Oe 78'8 Oliicinum, see Berj/lUvm.

Gold {Aumra) —An 194-7

Hdium He 4-4

Hvdrogen H 1

Imlium In IIS'4

Iodine I 130-6

^ Iridium Ir 192-5

J t Iron (FoTvm) --Fo 65-9

Untbaiium La 138

-Pb im^

_it 7

-wMg 24

- .KMolybde 74'9 - / i Nickel "" Niobium

I OiyRen ' Palladium

Phosphorus

Platinum

Polosalum (Saiiuiit)

Rbndlum

Rubidium

Rutbenium

Scandium

Selenium

Silicon

Silver (Argentum)

Sodium (Xfalrium)

Strouiium

Sulphur

Tantalum

Tellurium

Thallium

Tburium

Tin (Stannum)

lltauium

Tungsten (Woffiramiw

Umuium

Viinadium

Ytl erbium

Yttrium

Z{nc

Zirconium

1D4-I 85 9 108-e

WW- /of

90-4

437. Hetala and Non-mstals. —The eleinente may be divided into two more or less distinct classes, the metals and the non-metals. Between the two lie'a number of elements sometimes called the semi-metals. The metals, as gold, silver, iron, sodinm, are those elements which,pAy.nca% described, possess to a more or less perfect degree the fundamental characters of the ideal metal, viz.: malleability, metallic luster (and opacity to light), conductivity for heat and electricity; moreover, chemically described, they commonly play the part of the positive or basic element in a simple compound, as later defined (Arts. 446-449). The non-metals, as sulphur, carbon, silicon, etc., also the gases, as oxygen, chlorine, etc., have none of the physical charaetei-s alluded to; they are, if solids, brittle, often transparent to light-radiation, are poor conductors for heat and electricity. Chemically expressed, they usually play the negative or acid part in a simple compound.

The so-called aemi-metala, or metalloids, include certain elements, as tellurium, arsenic, antimony, bismuth, which have the physical characters of a metal to a less perfect degree {e.g., they are more or leas brittle); and, more important than this, they often play the part of the acidic element in the compound into which they enter. These points are illustrated later.

It is to be nnderetood that the distiDctions between the classee of the elements named cuiinot be very sharply applied. Thus the typical metallic characters mentioned are possessed to a very unequal degree by the different mbstances classed as metals; for example, by silver and tin. Corresponding to this a number of the tme metals, as tin and manganese, play the pare of an acid in numeroQS salts. Further, the mineral maKnetite, FeFe,0„ is often described as an iron ferrate; so that in this compoana the same element would play the part of both acid and base.

438. Fositive and Negative Element!.—It is common to make a distinctioa between the electro-positive and electro-negative element in a componnd. The paas^e of a snfficiently strong electrical current through a chemical componnd in many cases results in its decomposition (or electrolysis) into its elements or parts. In such cases it is found that for each compound the atoms of one element collect at the negative pole (the cathode) and those of the other at the positive pole (the anode). The former is called the electro-

positive element and the latter the electro-negative element. Thus in the eiectrolysis of water (H,o) the hydrogen collects at the cathode and is hence called positive, and the oxygen at the anode and is called negative. Similarly, in hydrochloric acid (IICl) the hydrogen is thus shown to be positive, the chlorine negative. This distinction is also carried to complex compounds, as copper sulphate (CuSO,), which by electrolysis is broken into Cu, which is found to be electro-positive, and SO, (the last separates into SO,, forming H 80, and free oxygen).

For reasons which will be explained later, the positive element is said to play the basic part, the negative the acidic. The metals, as already stated, in most cases belong to the K)rmer class, the non-metals to the latter, while the semi-metals may play both parts.

It is common in writing the formula to put the positive or basic element first, thus H,o, H,S, HCl, H,SO , 8b,S , As.O., AaH,, NiSb, FeAs,. Here it will be noted that antimony fSb) and arsenic (As) are positive in some of the compounds named but negative in the others.

439. Periodio Lav.—In order to understand the relations of the chief classes of chemical compounds represented among minerals, as still more their further subdivision, down finally to the many isomorphous groups —groups of species having analogous composition and closely similar form, as explained in Art. 456—the fundamental relations and grouping of the elements must be understood, especially as developed of recent years and shown in the so-called Periodio Law."

Although the subject can be only briefly touched upon, it will be useful to give here the general distribution of the elements into Groups and Series, as presented in the Principles of Chemistry (Engl. Ed., 1891) of D. Mendeleefl, to whom is due more than any one else the development of the Periodic Law. A few remarks are added on the grouping of the elements as illustrated hy mineral compounds; artificial compounds show these relations still more fully and clearly. For the thorough explanation of this subject, more particulai'ly as regards the periodic or progressive relation between the atomic weights aud various properties of the elements, the reader is referred to the work above mentioned or to one of the many other excellent modern text-books of chemistry.

The relations of some of the elements of the first group are exhibited by the isomorphism (see Art. 456, also the description of the various groups ana species here referred to, which are given in Part IV of this work) of NaCl, KCl, AgCI; or again of LiMnPO, and NaMnPO,, etc. In the second group,

D if the validity of the Periodic Law

reference mav be made to the isomorphism of the carbonates and sulphates (p. 250) of calcium, barium, and strontium; while among the sulphides, ZnS, CaS, and HgS are donbly related. In the third group, we find borou aud aluminium oiten replacing one another among Bilicatce. In tbe fourth group, the relations of silicon and titanium are Bhown in the titano-silicates, while the compounds TiO,, SnO,, PbO, (and MiiO,), aUo ZrSiO and ThSiO., have closely similar form. In the fifth group, nian^ compounds of arsenic, antimony, and bismuth are isomorphoua among metallic compounds, while the relations of phosphorus, vanadium, arsenic, also antimony, are shown among the phosphates, vanadates, arsenates, and antimoiiates; again the mutual relations of the niobatea and tantalates are to be noted.

In the sixth group, the strongly acidic elements, sulphur, selenium, tellurium, are all closely related, as seen in many sulphides, selenides, tellurides; further, the relations ot sulphur and chromium, and similarly of both of these to molybdenum and tungsten, are shown among many artificial sulphates, cbromates, molybdates, and tungstatea.

In the seventh group the relations of the halogens are too well understood to need special remark. In the eighth groun, we have Fe, Co, Ni alloyed in meteoric iron, and their phosphates and sulphates are in several cases closely isomorphous; further, the relation of the iron series to that of the platinum series is eihibited in the isomorphism of FeS,, B'eAsS, FeAs,, etc., with PtAs, and probably RuS,.

440. Combining Weight.—Chemical investigation proves that the mass of a given element entering into a compound is always proportional either to its atomic weight or to some simple multiple of this; the atomic weight is hence also called the covibixinii weiffhl. Tluia in rock salt, sodium chloride, the masses involved of sodinm and chlorine present are found by analysis to he equal to 39'4 and 60*6 in 100 parts, and these numhers arc in proportion to 33 : 35-4, the atomic weights of sodium and chlorine; hence it is conolnded

that one atom of eacb la present in the componnd. The formula is, therefortj, KaGI. In calcium chloride, by the same method the masses present are fouud , to be proportional to 39*9 : 70'^, that is, to 39'9 = 3 X 35-4; hence the formula is CaCl,.

Still agalu, a series ol componnds of nltrogea with oxjeea \e known Id wlilcli ihe ratios ottbe masses of tlie two elements are ua follows: (1)28:16, (Sj 14:16, (8)28 i 4a, (4j 14:32, i5) 28:80. 11 Is seen at oDce that llieae must Lave Uie formulas (I) N,0. (2) NO. (3)N,Oi, (4) NO,, (5) N,Oi. Oq Ibe contrary, atmospberic air wblcb conuiluii tbeae i-k-iueuis in about tlie mtiu of 76'8 to 282 ciiuoot be a cliemlcal coiiipouod uf llieijeelemeuu. since (aside from otber coasideratious) tbese uumbera are not in tlie ratio of n X 14 : wi: Itt wliere n apd m are simple nliule uumbers.

441. Holeoular We^;ht.—Tlie molecular weight is the weight of the molecule of the given substance, expressed in terms of the mosa of the hydrogen atom as unit. The molecuhir weight of hydrogen is 2 because the molecule can he shown to consist of two atoms. The molecular weight of hydrochloric acid (HCi) is 36'4, of water vapor (H,0) it is It), of hydrogen sulphide (H,S) it is 34.

Since, according to the lnw of Avagadro, like volumes of different gaa«s under like conditions as to temperature and pressure contain the same number of molecules, it is obvious that the molecular weight of substances in the form of gas can be derived directly from the relative density or specific gravity. If the density is referred to hydrogen, whose molecular weight is 3, it will be always true that the molecular weight ia twice the density in the state of a gas and vice versa. Thus the observed density of carbon dioiide (CO,) is 22, hence its molecular weight must be ii. It is this principle that makes it - possible iu the case of a gas to fix the constitution of the molecule when the ratio in number of the atoms entering into it bus been determined by analysis. In the case of Bolids, where the constitution of the molecule in general canuot be fixed, it is best, as already stated, to write the molecular formula in its simplest form, as NaAlSi o, for albite. The sum of the weights of the atoms present is then taken as the molecular weight.

442. Valence. —The valence of an element ie given by the number of its atoms which are required to unite with one unit atom, as of hydrogen or chlorine. Thus, nsing the examples of Art. 440, iu NaCl, since one atom of sodium unites with one of chlorine, its valence is one; or in other words, it is said to be univalent, and is called a monad. Further, calcium (as in GaCl,), also barium, etc., are bivalent; gold is (usually) trivalent; tin is tetravalent, etc. The valence may be expressed by the number of bonds by which one element in a compound is united to another, thus:

Na-Cl, Ba=CI,, Au=Cl„ Sn=CI., etc

The valences of the common elements, expressed by their symbols, are as follows:

Univalent: H, CI, Br, I, F; Li, Na, K, Eb. Cs. Ag.

Bivalent: o, S, Se, Te; Be, Mg, Ca, Sr, Ba, Pb, Hg, Cu, Zn, Co, Ni.

Trivalent: B, Au; probably also Al, Fe, Mn, Cr.

TetramUnt: C, Si,Ti, Zr, Sn.

Pentavale7it: N, P, As, Sb, V, Bi, Kb, Ta.

The above list, though convenient for reference, is not to be taken aa complete or final. A considerable number of the elements show a different valence indifferent compounds. Thus both 3b,o, and Sb,o, are known; also FeS, Fe,o, and FeS,; Cu,Cl„ CnCl,, and similarly Cu,StCu,o) and OuS(CuO),

etc. Id certain caaea the composition of two componnds of the same elements may be made conaiatent vith each other, bj au assumption aa to the possible grouping of the atoms. Thus in cupric chloride, CuCl,, or cupric oxide, CnO, copper ia bivaleot aa usual.

But the cuprous compounds, Gu,Gl, and Cn,o, also occur, aud for tbem the formnlas may be written

Cl-Cu-Cu-Cl and (Cu-Cu)=o.

Again, the elements Al, Fe, Mn, Cr, which form the compounds AlCI,, Al,o„ etc, are Bometimes called tetravaleut and the formula of the oxide written, for eiample, (Al = Al) = o,.

443. Chemical Heaotioiu.—When solutions of two chemical snbatances are brought together, in many cases they react upon each other with the result of forming new coiupoands out of the elements present; this phenomenon is called a chemical reaction. One of the original substances may be a gas, and in many cases similar results are obtained from a liquid and a solid, or leu often from two solids.

For example, solutions of sodium, chloride (KaCl) and silver nitrate (AgXO,) react on each other and yield silver chloride (AgCI) and sodium nitrate (NaNO,). This is expressed in chemical language as followa:

NaCl + AgNO, = AgCl + NaNO,.

This is a chemical equation, the sign of eqnality meaning that equal weights are involved both before and after the reaction.

Again, hydrochloric acid (HCl) and calcium carbonate (CaCO,) yield calcium chloride (CaCI,) and carbonic acid (H,CO,); which last breaks up into water (H,o) and carbon dioxide (CO,), the last going o9 as a gas with effervescence. Hence

CaCO, + 2HC1 = OaCI, + H,o + CO,.

444. Badioals.—A compound of two or more elements according to their relative valence in which all their bonds are satisfied is said to be saturated. This is true of HO, or, as it may be written, H—o—H. If, however, one or more bonds is left unsatisfied, the resulting combination of elements is called a radical. Thus —o—H, called briefly bydroiyl, is a common radical, hitving a valence of one, or, in other words, nnivaient; NH, ia again a univalent riwlical; so, too, (CaF), (MeF) or (AlO). Radicals often enter into a componnd like a simple element; for example, in ammonium chloride, NH,o!, the univalent radical NH, plays the same part as the univalent element Na in XaCI. In the chemical composition of miiierul apeciea, the commonest radical is hydroxyl (—o—H) already defined. Other examples are (CaF) in apatite (see Art, 488), (MgF) in wagnerite, (AlO) in many bacic silicates, etc.

445. Chemical Componnd.—A chemical componnd ie a combination of two or more elements united by the force of chemical attraction. It is always true of it, aa before stated (Art. 440), that the elements present are combined in the proportion of their atomic

weights or some simple multiples of these. A substance which does not satisfy this condition is not a compound, but only a mechanical mixture.

Examples of the simpler clasa of compounds are afforded bv the oxides, or componiida of oiygen with another element. Thus, among minernlH we have Cu,o, cuprous oxide (cuprite); ZnO, zinc oxide (zincite); A1,o„ alumina

(corundum); SdO„ tin dioxide (oaaBiterite); SiO„ silicon dioxide (quartz); As,o„ arsenic trioside (nreenolite).

Another simple cUss of componnds are the sulphides (vith the aelenides, tellurides, arseuideB, antinionides, etc.), compoundam which snlphnr (seleninin, tellurium, arseuic, autimou;, etc.J plays the same part as oxygen in the oxides. Here belong Cu,S, cnprons sulphide (chalcocite); ZnS, zinc sulphide (sphalerite); PbTe, lead telluride (altaite); Fe8„ iron disulphide (pyrite); Sb,S„ antimony tnsulphide (stibnite).

446. Acids.—The more complex chemical compounds, an nnderstandiDg of which is needed in a study of minerals, are classed as acids, bases, and salts; the distinctions between them are important.

An acid is a compound of hydrogen, or hydroxyl, with a non-metallic element fas chlorine, sulphur, nitrogen, phosphorus, etc.), or a radical containing these elements. In them the hvdrogen atoms may be replaced by metallic atoms; the result being then the formation of a salt (see Art. 448). Acids in general turn blue litmus paper red and have a sharp, sour taste. The following are familiar examples:

HCl, hydrochloric acid, H - CI.

HNO„ nitric acid, (HO) =No,.

H,CO„ carbonic acid, (HO), = CO. H,SO„ sulphuric acid, (HO), ^ 8o,. H,SiO„ metasilicic acid, (HO), ^ SiO. H,PO„ phosphoric acid, (HO), £z PO. H.SiO., orthosilicic acid, (HO), = 8i.

The full explanation of the constitution of the difFerent acids requires a more detailed discussion than is possible here. The second series of formulas given above must serve as suggestions in this direction.

It is to be noted that with a given acid element several acids are possible. Thus normal, or orthosilicic, acid is H SiO., in which the bonds of the element silicon are all satisfied by the hydroxyl (HO). But the removal of one molecule of water, H,o, from this gives the formula H,SiO, or metasilicic acid.

Acids which, like HNO, , contain one atom of nydrogen that may be replaced by a metallic atom {e.g., in KNO,) are called monobasic. If, as in H.CO, and H^SO., there are two atoms (e.g., in CaCO,, BaSO,) the acids are dwaaic. Similarly H,PO, is trihasic, etc.

Most acids aie liquids (or gases), and hence acids are represented very sparingly among minerals; B(OH),, boric acid (sassolite), is an illustration.

447. Bases.—The bases, or hydroxides as they are also called, are compounds which may be regarded as formed of a metallic element (or radical) and the univalent radical hydroxyl, —(OH); or in other words, of an oxide with water. Thus potash. K,o, and water, H,o, form 2K(oH), or potsssium hydroxide; also CaO + H,o similarly give Ca(OH^, or calcinm hydroxide. In generid, when soluble in water, bases give an alkaline reaction with turmeric paper or red litmus paper, and they also neutralize an acid, as explained in the next article Further, the bases yield water on ignition, that is, at a temperature sufficiently high to break up the compound.

Among minerals the bases are represented by the hydroxides, or hydrated oxides, as Mg(OH),. magnesium hydrate (bmcite); A1(oH)„ aluminium hydrate (gibbsite); also, (A1o)(oH), diaspore, etc.

448. Baits.—A third ciaaa of compoands are th« talis; these ma; be regarded as iormed chemically by the reaction of a base upon an acid, or, in other words, by the neutralization of the acid. Thus calcinm hydrate and sulphuric acid give calcium sulphate and water:

Ca(OH), + H,SO. = CaSO, + 8H,o.

Here calcium sulphate is the salt, and in this case the acid, sulphuric acid, is aaid to be neutruized by the base, calcium hydroxide. It is instructive to compare the formulas of a base, an acid, and the corresponding salt, as iollows:

Base, Ca(On),; Acid, H,SO.; Sail, CaSO..

Here it is seen that a salt may be simply described as formed from an acid by the replacement of the hydrogen atom, or atoms, by a metallic element or radict^

449. Tjrpical Salts.—The commonest types of salts represented among minerals are the following:

Chlorides: salts of hydrochloric acid, HCl; as AgCl, silver chloride (cerar-gyritej.

Nitrates: salts of nitric acid, HNO,; as KNO„ potassium nitrate (niter).

Carbonates: salts of carbonic acid, H,CO,; as CaCO^ calcinm carbonate (calcite and aragonite).

Sulphates: salts of sulphuric acid, H,SO.; as GaSO,, calcinm sulphate (anhydrite).

Phosphates: salts of phosphoric acid, H,PO,; as Ca,(PO,)„ calcium phosphate.

Silicates: several classes of salts are here inclnded. The most common are the salts of metasilicic acid, H,SiO,; as MnSiO,, manganese metasilicate (rhodonite). Also salts of orthosilicic acid, H,SiO,; as Mn,SiO„ manganese orthosilicate (tephroite).

Numerous other classes of salts are also inclnded among mineral species; their composition, as well as that of complex salts of the above types, is -explained in the descriptive part of this work.

450. Hormal, Acid, and Basic Salts.—A neutral or normal snlt is one in which the basic element completely neutralizes the acid, or, in other words, one of the type already given as examples, in which all the hydrogen atoms of the acid have been replaced by metallic atoms or radicals. Thus, K,SO, is normal potassium sulpnate, but HKSO,, do the other hand, ia acid potassium sulphate, since in the acid H,SO, only one of the bonds is taken by the basic -element potassium. Salts of this kind are called acid salts. The formula in such cases may be written"' as if the compound consisted of a normal salt and an acid; thus, for the example given, K,SO,.H,SO,.

A basic salt is one in which the acid part of the compound is not sutScient to satisfy all the bonds of the base. Thus malachite is a basic salt—basic carbonate of copper—its composition being expressed by the formula Cn,(OH),CO,.

This may be written CuCO,.Cu(OH)„ or (Cu.) Z. /q*^\ . The majority of

e name ofteo given to the com*

minerals consiEt not of eimplo saltB, as those noted above, but of more or less complex double salts in whicli eeveral metallic elemeotB are present. Thus common grossular garnet is au orthosilicate containing both calcium and aluminium as bases ; its formula is Ca,Al,(SiOJ,.

4S1. Solpho-ialta.— The salte thus far spoken of are all oxygen salts. There are also others, of analogous constitution, in which sulphur takes the place of the oaygen ; they are hence called sulpko-salis. Thus normal sulphareenious acid has the formula H.AsS,, and the corresponding silver salt is Ag^AsH,, the mineral proustite. Similarly the silver salt of the analogous antimony acid is Ag,SbS„ the mineral pyrargyrite. From the normal acids named, a series of otner hypothetical acids may be derived, as HAsS,, H^As,S„ etc.; these acids are not known to exist, but their salts are important minerals. Thus ziukenite, PbSb,S^ is a salt of the acid H,SbS,, and jamesonite, Pb.Sb.S,, of the acid H.Sb S., etc.

462. Water of Crystallization,— As stated in Art. 447, the hydroxides, or bases and further basic salts in general, yield water when igoited. Thus calcium hydroxide Ca(OH) breaks up on heating into CaO and H,0, as expressed in the chemical equation

2Ca{0H), = 2CaO + H.O.

So also the basic capric carbonate, malachite (formula given in Art. 460), yields water on ignition; and the same is true of the complex basic orthosilicates, like zoisite, whose formnia is (HO)Ca,Al,(SiO,),. It is not to be understood, however, in these or similar cases, that water as snch is present in the substance.

On the other hand, there are a large number of mineral compounds which yield water readily when heated, and in which the water molecules are regarded as present as so-called water of crystallization. Thus, the formula of gypsum is written

CaSO. + 2H,0,

and the molecules of water {2H,0) are considered as water of crystallization. So, too, in potash alum, KA1(S0.), + 12H,0, the water is believed to play the same part.

453. Fonnnlaa of Hinerals. —The strictly empirical formula expresses the kinds and numbers of atoms of the elements present in the given compound, without attempting to show the way in which it is believed that the atoms are combined. Thus, in the case of zoisite the empirical formnia is HCa,Al,Si,0„. While not attempting to represent the structural formula (which will not be discussed here), it is convenient in certain cases to indicate the atoms which there is reason to believe plav a peculiar relation to each other. Thus the same formula written (HO)Ca,Al,(SiO.), shows that it is reErarded as a basic orthosilicate, in other words, a basic salt of orthosilicic acid, H.SiO..

Again, the emDirical formula of common apatite is Ca.FP.O,,; but if this is written [CaF)Ca,(POJ,, it shows that it is regarded as a phosphate of the acid H,PO„ that ia, n,(POJ„ in which the nine hydrogen atoms are replaced by four Ga atoms together with the univalent radical fOaF). In another kind of apatite the radical (CaCll enters in the same wav. Similarlv to this the formnia of pvromorphite is {PbC])Pb.fPO,)., of vanadinite (PbCDPb.tVO.l,.

Further, it is often convenient to emplov the method of writing the formulas in vogue under the old dualistic system. For example.

CaO.CO, for CaOO,, 3CaO.Al,o,.3SiO, for Ca,Al,Si,o,,,

3Ag,S.Sb.S. for Ag,SbS., etc.

It is no longer beliefed, however, that the molecular groups CaO, A1,o,, etc., actually ezist in the molecule of the substance. But in part because these groups are what analysis of the substance affords directly, and in part because 80 easily retained in the memory, this method of writing is still often used.

4f>4. Oxygen Aatio.—In the case of certain compounds, more especially the silicates, it is sometimes regarded as convenient to take note of the oxygen ratio, that is, the ratio in the nnmber of oxygen atoms combined with the several elements, basic and acid. For example, the formula for grosBular garnet given above is

Ca.Al,Si,o,, or 3C»O.Al,o,.3SiO^

Here the oxygen atoms combined with the basic elements (calcium aid aluminium) and the acid element (silicon) are

or again, for the basic elements combined,

3 + 3 : 6 or 1 :1.

It mnst be noted that the oxygen ratio is in tact the ratio of the total valence of the elements of the different groups, the valence being measured by the combining power with hydrogen, while the oxygen ratio really notes the com* bining power with oxygen.

4S5. Calculation of a Formula from an Analyila.—The result of an analysis gives the proportions, in a hundred partG of the mineral, of either the elements themselves, or of their oxides or other compounds obtained in the chemical analysis. In order to obtain the atomic proportions of the elements:

Divide the percentages of the elements itf the respective atoxic weights; or, for those of the oxides: Divide the percentage ammints of each by their HOLECTTLAR WEIGHTS; then fiid the simplest ratio in whole numbers for the numbers thus obtained.

Example.—A.n annlysla of bournoDlte from Wolfsberg g»vo C. Bromela tlie resulla under (t) below. TLese percentages divided by tlie respecilve atomic weights, as iodicaied, give ilie Dumbers under (3). PinBlly Ihe ratio of these numbers gives very nearly 1:8:1:1. Hence

the formula derive' ' " """ ™. .- —---. ,..j »___ l_ .i_ . .. . _

added under (4).

Second EranpU. —The meao of two analyses of a.garnet from Alaska gave Eoiiuizc the results under (1) below. Here as usual the perceiiluge nmounttiof the severHl molecular frroups (SiOi. Al,Oi. etc.) are given instetid of those of ihe elements. These aroimnis divided by the reapeclive molecular weights give Ihe numbers under (3l. In this esm the aninnutt of the prntoiidea are taken together and Ihe riilio thiia ohtnined i« SOfl ; 1 :2 92, wlitcli cnrresponds approximately to the formula 8FeO. A.1,Oi.3SiO„ or Pe,Ai,(SIO,),. The niagueslum In this garnet would ordinarily be cxphdned by the presence of the pyrope

molecule (UgiAI>[8iO.]>) together with the simple almaodlte molecule whose composftloa is Klveu above.

(1) (8) (8)

SIO, 89 39 + 00 = 0-eSS 809

At.0. 21-70 4- 108 = 0'S12 1

Fe,0> (r.

FeO 80-83-i-719 = 0429'l

MnO 1-81 -«- 70-8 = 0 022 I

MgO 5-M -+- « = 0188 f

CaO laO -t-SB-B =■ "■"°° '

100'67

0«1»

It U a aboTe) are preeeot tc „ „

which thej replace, that la, with those of the ume quantlvalence. Thu degree of correepondeuce between theanalyslj and the formula deduced, it the latter Ucoriectly assumed, depends entirely upon the accuracy of the former.

41(6, Isomorphiim.—Chemical compotmdB which h&ve an analogous composition and a cloeelv related cryBtalline form are said to be Uomorphoua, Tbie phenomenoD, called ibouoephish, was first; clearl; brought out by Mit-scherlich.

Many examples of groups of isomorphous compounds will be found among the minerals deecribed in the following pages. Some examples are mentioned here in order to elucidate the Eubject, In the brief discnssion of the periodic classification of tlie chemical elements of Art. 439, attention has been called to the prominent grou{» among the elements which form analogous compounds. Thus calcium, barium, and strontium, and also lead, form the two series of analogous compounds, Aragonlte Group. Barlte Group.

CaCO,, aragonite. Also CaSO,, anhydrite.

BaCO,, witberite. BaSO,, barite.

SrCO,, strontianite. SrSO,, celeetite.

PbCO,, cerussite. PbSO., anglesite.

Further, the members of each series crystallize in closely similar forms. The carbonates are orthorhombic, with axial ratios not far from one another; thus the prismatic angle approximates to 60° and 120°, and corresponding to this they all exhibit pseudo-hexagonal forms due to twinning. The sulphates also form a similar orthorhombic series, and thoagh anhydrite deviates somewhat widely, the others are close together in angle and in cleavage.

Again, calcium, magnesium, iron, zinc,and manganese Kirm a series of carbonates with analogous composition, as shown in the list of the species of the CalciiB Oroup given on p. 353. This table brings out clearly the close relation in form between the species named. Incidentally, as an example of the deviation in form sometimes observed, it is to be noticed that dolomite (and perhaps others) are not normally rhombohedral like calcite, but belong to the pnenacite type (p. 80).

This table also illustrates another essential point in regard to an isomorphous series, viz., the presence of intermediate members, or isomorphoits mixtures of the simple compounds. These are viewed by most authors as due to the presence of both molecules crystallized together, nsnally in a certain definite ratio. Thus in normal dolomite, (CaOO) and (MgCO.) are both present in the ratio of 1 : 1, and its formula is GaMg(CO,), or GaGO,.MgCO,. In mesitite (MgCO,) and (FeCO,) are present in the ratio of 3:1; its formula is Mg.Fe(CO,), or 2MgOO,.FeCO,. If it is not desired to express the ratio of

the elemflBts present, it is convenient to write the elements together in aparen-theais separated by a comma. Thus (Cii,Mg,Fe)GO, would meaui a carbonate in which calcinm, magnesium, and iron are all present.

The Apatite Group forms another Taluabie illuatration since in it are representea the analoeons compounds, apatite and pjromorphite, both phosfihates, but respectively phosphates of calcium and lead; also the analogous ead compounds pyromorphito, mimetite, and vanadinite respectively lead phosphate, lead arsenate, and lead vanadate. Further, in all these compounds the radical (RCl) or (BF) eaters in the same way (see Art. 493). Thus the formulas for the two kinds of apatite and that for pyromorphito are as follows:

(CaF)Ca.(PO.>,. {CaCl)Ca.(PO,)„ (PbCl)Pb.(PO.)..

Some of tbe nioru fmpnriniitisiiiiiorplious groups are mentioned below. ForadlBcusslon of tliem, RB well lis of iiiitiiy ' >,1)<"h ilint might be meatloned here, reference must be made to the descriptive part of thU wi rli.

Itometrie Syti&m.^The S,>iiiel group, lacluding iptnel, HgA1i04: also magnetite, cbromile, fraokliulie, giilmiii:, etc. Tlie Oiilena group, as galena, PbB; argentite, AgiB, etc Tbe Qarnet group, iis gi-oasuliirite, CniAl>S!.0,i; etc.

Tetragonal ^»(*m.—Rniile group, including rutlle, TiO,; citssiterlte, BnO,. The Bcbeelite group, lacludlng scbeelite, CaWO,; Btolzlte, PbWO.; wulfetilte, PbHoO..

HexagoTtal 8ytUm. —Apatite group, already meutioQed, Including apatlle.pjromorpblte, mimetite, nnd Taundlnlte. Corundum group, corundum, Al,Oi; bemalite, FetOi.

BhoTi^hedral Bj/iimn. —Calclte group, already meulioued. Phenaclte group, etc.

OrlAorhombie Syttem. —Arngoaue group, and Barlte group, Ixtlh mentioned above. Cbrysolile group, (Mg.Fe)iSIOi ; Topaz group, etc.

MoruKlinxo Sstttm. —Copperas group, including meianterite. FeBOt-f*? >Q; bieberlte, CoSO, -\-1 aa^. etc. Pyroxene and A mpb I bole groups, and tbe Mica group.

Monoelinie aTid Triciinie ^«(«nu.—Feldspar group.

457. Iiomorphont Hixturei.—It is important to note tbat the intermediate compounds in the case of an isomorphous series, such as those spoken of in the preceding article, often show a distinct gradation in crystalline form, and more particularly in physical characters (fl.,?., speciflc gravity, optical properties, etc.) This is illnstrated by the species of the calcite group already referred to; .also Btill more strikingly by the group of the triclinic feldspars aa fully discussed nader the description of that group. See further Art. 406.

The feldspars also illustrate two other important points in the subject, which must be briefly alluded to here. The triclinic feldspars have been shown by Tschermak to be isomorphous mixtures of the end compounds in varying proportions:

Albite, NaAlSi,0,, Anorthite, CaAl,Si,0,.

Here it is seen that these compounds have not an analogons composition in the narrow sense previously illustrated, and yet they are isomorphous and form an iBomorphous series. Other examples of this are found among the pyroxenes, tbe scapolites, etc.

Further, the Feldspar group in the broader sense includes several other species, conspicuously the monoelinie orthoclase, KAlSi,0„ which, though belonging to a difEerent system, still approximates closely in form to the triclinic species.

458. Dimcrphiim. Isoduncrphiim.—A chemical compound, which crystallizes in two forma genetically distinct, is said to be dimorphous; if in three, irimorpJious, or in general pleomorpAous. This phenomenon is called DIUOB'

PHISM or PLEOHORPHISH.

An example is given by tbe con^pound calcium carbonate (CaCO,), which is dimorphous: appearing as calcite and as aragonite. As calcite it crystallizes

in the rbombohedral Bvatem, and, unlike as its many cmtalline forms are, they may be all referred to the same fundamentnl rhomboneOron, and, what ia more, tiiey have all the same cleavage aud the same Bpecific gravity (27), and, of course, the same optical characters. As aragonite, calcium carbonate appears in oithorhombic cryatals, whose optical characters are entirely different from those of calcite; moreover, the specific gravity of ara^onite (3'9) is higher than that of calcite (3*7).

Many other examples might be given: Silica (SiO,) is dimorphous; appearing as quartz, rhombohedral, Q, = 2 '66; as tridymite, hexagonal, G. = 2 3, anil perhaps in other forms. Titanium dioxide (TiO,) is trimorphons, the species being called rtitile, tetragonal (i = o'6442), Q. = 4'25; octahedriie, tetragonal {t = 1*778),G. = 3'9; and ftrtwii'ie, orthorhombic, G, = 4*15. Carbon appears in two forms, in diamond and graphite. Other familiar examples are pyrite and marcaaite (FeS,), sphalerite and wurtzite (ZnS), etc.

AVhen two or more analogous compounds are at the same time isomorphous and dimorphous, they are said to be isodimorpkom, e-nA the phenomenon is called isoDiMORPHiBU. An example of this is given in the Pyrite and Mar-casite groups described later. Thus we have in the isometric Pyrite Group, pyrite, FeS,, smaltite, CoAs,; in the orthorhombic Marcasite Group, marcaaite, FeS,, safflorite, CoAa^, etc.

459. Chemical and Kicroohemical Analysis,—The analysis of minerals is a subject treated of in chemical works, and need not be touched upon here except BO far as to note the conrenient use of certain qualitative methods, aa described in the later part of this chapter.

Of more importance are the microchemical methods applicable to sections under the microscope and often yielding decisive results with little labor. This subject has been particnlarly developed by Boficky, Haushofer, Behrens, Strong, and others. Reference is made to the discussion by Rosenhnsch (Mikr. Phys., 1893, p. 259 et sea., also the list of authors on p. 313.)

460. Mineral Syntheaia.— '5^hB occurrence of certain mineral componnda (e.g., the chrysolites) among the products of metallurgical furnaces has long been noted. But it has only been in recent years that the formation of artificial minerals has been made the subject of minute Byatematic experimental study. In this direction the French chemists have been particularly anccessful, and now it may be stated that the majority of common minerals—

?uartz, the feldspars, ampbibole, mica, etc.—have been obtained in crystallized orm. Even the diamond has been formed in minute crystals by MoiEsan. These studies are obviously of great importance particularly as throwing light upon the method of formation of minerals in nature (e.g., the diamond). The chief results of the work thus far done are given in the volumes mentioned in the Introduction, p. 4.

461. Alteration of Minerals. Fsendomarplii.—The chemical alteration of mineral species under the action of natural agencies is a subject of great importance and interest, particularly when it results in the change of the original composition into some other equally definite rompound, A crystallized mineral which has thus suffered change bo that its form no longer belongs to its chemical composition has already been defined (Art. 262. p. 144) OS a pseiidomorpA It remains to deGcrihe more fully the different kinds of psendomorphs. Pseudomorphs are classed under several heads:

1. Pseudomorphs by auMUuimi.

3. Pseudomorphs by simple deposition, and either by (n) incrustation or (ft) infiltration.

3. Psendomorphs by alteration; and tlieBe maj be altered (a) without a change of compositioD, by paramorphism; ib) by the)obb of an ingredient;

(c) by the aeBumptioii of a foreign Bnbstance;

(d) by a partial exchange of constituents.

1. The first claea of paeudomorphs, by substitution, embraces those cases vhere there has been a gradual removal of the original material and a corresponding and simultaneous replacement of it by another, without, however, any chemical reaction between the two. A common example of this is a piece of fossilized wood, where the original fiber has been

replaced entirely by silica. The first step in the process was the filling of the poree and cavities by the silica in solution, and then as the woody fiber by gradual decomposition disappeared the silica further took its place. Other examples are quartz after flnorite, calcite, and many other species; cassiterite after orthoclase; native copper after aragonite, etc.

3. Pseudomorphs by incrustation form a less important class. Such are the crusts of quartz formed over finorite. In most cases the removal of the original mineral has gone on simultaneously with the deposition of the second, 80 that the resulting psendomorph is properly one of substitution. In peendomorphs by ijifiltration a cavity made by the removal of a ci^slal has been filled oy another mineral.

3. The third class of pseudomorphe, by alteration, includes a considerable proportion of the observed cases, of which the number is very large. Conclusive evidence of the change which has gone on is often furnished by a nucleus, of the original mineral in the center of the altered crystal^e.^., a keruel of cuprite in a pseudomorphous octahedron of malachite; also of chrysolite in a pseudomoi'phona crystal of serpentine, etc.

\a) An example of paramorphiam—t'h&i is, of a change in molecular constitution without change of chemical substance—ia furnished by the change of aragonite to calcite (both CaGO,) at a certain temperature; also Ww para-morphs of rutile after brookite (both TiO,) from Magnet Cove, Arkansas.

{b) An example of the pseudomorphs in which alteration is accompanied by a loss of ingredients is furnished by crystals of native copper in the form of cQprite.

(c) In the change of cuprite to malachite— e.g., the familiar crystals from Ghessy, France^an instance is afforded of the assumption of an ingredient— viz., carbon dioxide (and water). Pseudomorphs of gypeum after anhydrite occar where there has been an assumption of water alone.

{d) A partial exchange of constituents—in other words, a loss of one and gain of another— takes place in the change of feldspar to kaolin, in which the potash silicate disappears and water is taken up; pseudomorphs of limonite after pyrite or siderite, of chlorite after garnet, pyromorphite after galena, are other examples.

The chemical processes involved in such changes open a wide and important field for investigation. Their study has served to throw much light on the chemical constitution of minei-al species and the conditions under which they have been formed. For the literature of the subject see the Introduction, p. 3 (Blum, Bischof, Roth, etc.). As typical studies of special cases the following_artides are referred to:

Omtb. Corundum, etc. Am. Phil. Boc. Phnad., 13. 861, 1878.

J. D. Dana. Serpentine pseudomorplia, Till; Foster mine. Am. J. Sc, B, 871, 1874.

Bnub aod Dana. Spodiimene, eto., BrancliTille, Ct. Am. 3. Sc. 20, aS7, 1880.

Sehraof. - Serpentine of BuhemU. Zs. Erysl., 6, 331. 1883.

CHEMICAL EXAMINATION OF MINERALS.

462. The complete investigation of the chemical composition of a mineral incladee, first, the identification of the elements present b; qualitative analysis, and, second, the determiDation of the relative amounts of each by quantitative analysis, from which last the formula can be calculated. Both processes carried out in full call for the equipment of a chemical laboratory. An approximate qnalitative analyBis, however, can, in many cases, be made quickly and simply with few conveniences. The methods employed involve either (a) the nae of acids or other reagents " in the wet way," or (b) the Qse of the blowpipe, or of both methods combined. Some practical instractious will be given applying to both cases.

EXAMINATION IN THE WET WAY.

463. Reagents, etc.—The most commonly employed chemical reagents are ihe three mineral acids, hydrochloric, nitric, and sulphuric acids. To these may be added ammonia, also solutions of barium chloride, silver nitrate, ammonium molybdate, ammonium oxalate; finally, distilled water in a wash-bottle.

A few teat-tubes are needed for the trials and sometimes a porcelain dish with a handle called a casserole; further, a glass funnel and filter-paper. The Bunsen gas-bnrner (p. 256) is the best sonrce of heat, though an alcohol lamp may take its place. It is unnecessary to remark that the use of acids and the other reagents requires much care to avoid injury to person or clothing.

In testing the powdered mineral with the acids, the important points to be noted are: (1) the degree of solubility, and (3) the phenomena attending entire or partial solution; that is, whether (a) a solution is obtained quietly, without effervescence, and, if so, what its color is; or (b) a gas ia evolved, producing efFervescence; or (c) an insoluble constituent is separated out.

464. Solubility.—In testing the degree of solubility hydrochloric acid ie moat commonly used, though in the case of many metallic minerals, as the sulphides and compounds of lead and silver, nitric aoid is required. Less often sulphuric acid and aqua regia (iiitro-hydrochloric acid) are resorted to.

The trial is usually made in a test-tube, and in general the fragment of mineral to he examined should be first carefully pulverized in an agate mortar. In most cases the heat of the Bunsen burner must bo employed.

(a) Many minerals are completely soluble without effervescence; among these are some of the oxides, as hematite, limonito, gothite, etc.; some sulphates, many phosphates and arsenates, etc. Gold and platinnm are soluble only in aqua regia or uitro-hydrochloric acid.

A yellow solntion is usually obtained if much iron is present; a blue or greenish-blue solution (turning deep bine on the addition of ammonia in excess) from compounds of copper; pink or pale rose from cobalt, etc.

(i) Solubility with effervescence takes place when the mineral loses a gaseous ingredient, or when one is generated by the mutual reaction of acid and mineral. Most conspicuous here are the carbonates, all of which dissolve with effervescence, giving off the odorless gas carbon dioxide (CO,), though some of them only when pulverized, or. again, on the addition of heat. In applying this teat dilute hydrochloric acid is employed.

Sulphureted hydrogen, or hjdroeea sulphide (H,S), is evolved bj some ealphides when dissolved in hydrocQiorio acid; this is true of sphalerite, stibnite, etc. This gas is readily recognized by its offensive odor.

Chlorine is evolved by oxides of manganese and also chromic and vanadio acid salts when dissolved in hydrochloric acid.

Nitrogen dioxide (NO,) is given off, in the form of red BnSocating fames, by many metallic miuerolB, and also some of the lower oxides (cuprite, etc.), when treated with nitric acid.

(c;) The separation of an insoluble ingredient takes place; With many silicates, the silica separating gometimee as a fine powder, and again as a jelly; in the latter case the mineru is said to gelatinize (sodalite, analcite). In order to test this point the finely pnlverized silicate is digested with strong hydrochloric acid, and the solution afterward slowly evaporated nearly to dryness. With a considerable number of silicates the gelatin!zation takes place only after ignition; while some others, which ordinarily gelatinize, are rendered insolnble by ignition.

With many sulphides (as pyrite) a«epar&tion of sulphur takes place when they are treated with nitric acid.

Some compounds of titanium and tongsten are decomposed by hydrochloric acid with the separation of the oxides of the elements named (TiO , WO.). The same is true of salts of molybdio and vanadic acids, only that nere toe oxides are soluble in an excess of the acid.

Compounds containing silver, lead, and mercury give with hydrochloric acid insoluble residues of the chlorides. These compounds are, however, soluble in nitric acid.

When compounds containing tin are treated with nitric acid, the tin dioxide (SnO,) separates as a white powder. A corresponding reaction takes place under similar circumstances with minerals containing arsenic uid antimony.

Insoluble Minerals. —A large number of minerals are not sensibly attacked by any of the acids. Among these may be named the following oxides: Corundum, spinel, chromite, diaspore, rutile, caaaiCerite, quartz; also cerar-gyrite; many silicates, titanates, tantalates, and niobates; some of the sulphates, as barite, celeatite; many phosphates, as xenotime, lazulite, childreuite, amblygouite; also the borate, boracite.

465. Examination of the Solntion.—1(the mineral is diificultly, or only partially, soluble, the question as to solubility or insolubility ia not always settled at once. Partial solution is often shown by the color given to the liquid, or more generally by the precipitate yielded, for example, on the addition of ammonia to the liquid filtered off from the remaining powder. The further examination of the solution yielded, whether from partial or complete solution, after the separation by filtration of any iusolable'residue, requires the systematic laboratory methods of qualitative analysis.

It may be noted, however, that in the case of sulphates the presence of sulphur is shown by the precipitation of a heavy white powder of barium sulphate (BaSO.) when barium chloride is added. The presence of silver in solution is shown by the separation of a white curdy precipitate of silver chloride (AgCl) upon the addition of any chlorine compound; conversely, the same precipitate shows the presence of chlorine when silver nitrate is added to the solution.

Again, phosphorus may be detected if present, even in small quantity.

in a nitric acid Bolntion of a mineral by the fine jellow powder which Beparates, aometimes after standing, when ammonium moljbdate has been added.

EXAMINATION BY MEANS OF THE BLOWPIPE.*

466. The use of the blowpipe, in skilled hands, gives a quick method of obtaining a partial knowledge of the qualitative composition of a mineral. The apparatus needed includes the following articles:

Blowpipe, lamp, platinum-pointed forceps, platinum wire, charcoal, glass tubes; also a small hammer with sharp edges, a steel anvil an inch or two long, a horseshoe magnet, a small agate mortar, a pair of cutting pliers, a three-cornered file.

Further, test-paper, both turmeric and blue litmus paper; a little pure tin-foil; also in small wooden boxes the fluxes: borax (sodium tetraborate), soda (anhydrous sodium carbonate^, salt of phosphorus or microcosmic salt (sodium-ammonium phosphate), acid potassium sulphate (HE8o.); also a solution of cobalt nitrate in a droppingTjulb or bottle; further, the three acids mentioned in Art. 463.

467. Blowpipe and lAinp.—A good form of llowpipe is shown in Fig, 570. 670 '^^^ air-chamber, at a, is essentia] to stop the condensed

moisture of the breath, but the tip (b), of platinum or of

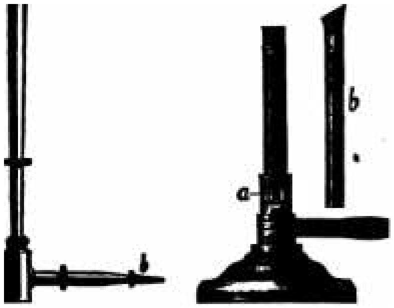
T brass, though convenient is not essential, and many will prefer to do without the mouthpiece (c). The most convenient form of Jump is that furnished by an ordinary Bunsen gas-burner f (Fig. 571), provided with a tube, J, which when iuserted cuts off the air-supply at a; the gas then bums at the top with the usual yellow _„, flame. This flame should be one to

one and a half inches high. The tip of the blowpipe is held near (or just within the fl^ame, see beyond), and the air blown through it causes the flame to take the shape shown in Figs. 573, 574.

It is necessary to learn to blow continuously, that is, to keep up a blast of air from the compressed reservoir in the mouth-cavity while respiration is maintained through the nose. To accomplish this successfully and at the same time to produce a clear flame-without unnecessary fatiguing effort calls for some practice.

* The subject of the blowpipe &nd Its use Is treated very briefly In this place. The student who wishes to bo fully informed noL only In regnrd to tlie use of the tbHous luBtruments, but also us to all the valuable reactions praclfcally useful fo the IdenllQcation of miuerals, should consult a manual on the subject. The Manual of DelennlDatlTe MtnenilogT, with na Inlrodiictlon on Blowpipe Analyals, by Ooorge J. Brush; revised and enlarKed by Snmuel L. Penfleld (New York. 18B0}. is pnrCicularly to be recommended. Another recent work li the ManusJ of Qualitative Blowpipe Analysis and DetermlDative Mineralogy by F. M. Erdllch (New York. 1893).

\ Instead of this, a good steoria candle will answer, or an oil Same with flat wick.



When the tube, b, ie removed, the gas bnnis with a colorlees flame and ia need for beating glass tnbea, test-tobes, etc. An alcohol lamp will serve the same purpose. 672.

468. Porcepa. wire.—The forceps (Fig. 573) are made of steel, nickel-plated, and should have a spring strong enongh to support firmly the small fragment of mineral between the platinum points at d. The steel points at the other end are used to pick up small pieces of minerals, but must not be inserted in the fiame. Care must be taken not to injnre the platinum bv allowing it to come in contact with the fused mineral, especially if tkis contains antimony, arsenic, lead, etc

The platinum wire required should be of the size designated Ifo. 37. A piece of platinnm-foil is often useful; also a small platinum spoon.

469. Cnarooal.—The charcoal employed should not snap and should yield bat little aah; the kinds made from basswood, pme or willow are best. It is most conTeniently employed in rectangular pieces, say four inches long, an inch wide, aud three-quarters of an inch in thickness. The surface must ^ways be perfectly clean before each trial.

Instead of charcoal a support of the metal aluminium, as suggested by Boss, is used bj some workers with good results.

470. Glass Tubes.—The glass tubes should be of rather hard glass and say one-sixth to one-quarter of an inch in interior diameter. The smaller size is suitable for the closed tubes; these are simply made by beating a piece six laches longin the middle and then drawing the ends apart, the long ends being fused and pinched off. The larger size serves for open tubes, which may be five inches or bo in length.

471. Blowpipe Flame.—The blowpipe flame, shown in Figs. 573, 574, consists of two cones: an iuner of a blue color, and an outer cone which is nearly invisible. The heat is most intense just beyond the extremity of the blue flame, and the mineral is held at this point when iti fusibility Ib to be tested.

The outer cone is called the oxidizino tlame (O.F.); it is charucterized by the excess of the oxygen of the air over the carbon of the gaa to be combined with it, and has hence an oxidizing effect upon the assay This flume is best produced when the jet of the blowpipe is inserted a very little in the gas flame (see Fig. 573); it should be entirely non-luminous. The mineral is to be held at d.

The inner flame is called the beducino flahe (R.F.); it is characterized fay the escesB of the carbon or hydrocarbons of the gas, which at the high temperature present tend to combine with the oxygen of the mineral brought into 673. 574.

it (at d), or, in other words, to reduce it. The best reducing flame is produced when the blowpipe is held a little distance from the gas flame; it should retain the yellow color of the latter oti its upper edge (see Fig. 574).

472. Methods of Biamination.—The blowpipe investigatioD of minerals includeB their examiDation, (1) in the pUtinum-pointed forceps, (2) in the closed and the open tnbes, (3) on charcoal or other support, and (4) with the fluxes on the platiDum wire,

1. EXAHINATION IN THE FOKCBPS.

473. Use of the Foroeps.—FlatiDOm-pointed forceps are employed to hold the fragment of the mineral while a test is made as to its fasibility; also when the presence of a volatile ingredient which may give the flame a characteristic color is tested for, etc.

The rolliinlue practlcAl polnls must be regarded : (1) HetaUlc raineraU, etpsclBllj those coDttunlng arseaTc or ftDtlmoiiy, which when fused m[ght lajure the platlDuiii, should firat be eiatulaed on charcoal*; (2) the fragment labeu should bu thin, ana tu Bmall as can coii-Teniently be held, with lU edge protectlug well beyond the poiols; (8) when decrepltAtloa lakes place, the heat must be applied hIowIj, or. if tbia does not prevent It. the mineral may be powdered and a pasM made with water, thick enougb to be held in the forceps or an the platinuin wire; or tiie paste may, with the saaie end hi view, be heated od charcoal; (4) the fragmect wbose fusibility is to tie tested must be held In the hottest part of the flame, just beyond the extremity of the blue cone.

474. Fusibility.—All grades of fusibility exist among minerals, from those which fnse in large fragments in the flame of the candle (atibnite, see below) to those which fuse only on the thinnest edges in the hottest blowpipe flame (bronzite); and still again there are a conBiderable number which are entirely infusible {e.g., corundum).

The exact determination of the temperature of fusion is not easily accomplished (cf. Art. 413, p. 332), and for purpoees of determination of species it i» unnecessary. The approximate relative degree of fusibility is readily fixed by referring tue mineral to the following scale, suggested by von Eobell:

1. Stibnite. 4. Actinolite.

2. Natrolite. 5. Orthoclase.

3. Almandite Qamet. 6. Bronzite.

476. In connection with the trial of fusi^bility, the following phenomena may be obserred ■ (a) coloration of the flame (see Art. 476); (6) swelling up (stilbite), or w/oKaii'on of the mineral (Termiculite); or {c) glowing withont fusion (calcite); and (cf) intumeeceilce, or a spirting out of the mass as it fuses (scapolite).

The color of the mineral after ignition is to be noted; and the nature of the fused mass is also to be observed, whether a clear or blebby glass is obtained, or a black slag; also whether the bead or residue is magnetic or not (due to iron, less often nickel, cobalt), etc.

The ignited fragment, if nearly or quite infusible, may be moistened with the cobalt solution and again ignited, in which case, if it turns blue, this indicates the presence of aluminium (as with cyanite, topaz, etc.); but note that zinc silicate (calamine) also assumes a blue color. If it becomes jiinit, this indicates a compound of magnesium (as brucite).

Also, if not too fusible, it may, after treatment in the forceps, be placed upon a strip of moistened turmenc paper, in which case an alkaline reaction proves the presence of an alkali, sodium, potassium; or an alkaline earth, calcium, magnesinm, barium, strontium.

476. Flame ColoTatioa.—The color often imparted to the outer blowpipe flame, while the minerul held in the forceps is being heated, makes possible the identification of a number of the elements.

The colors whioh may be produced, and the substances to whose presence they are due, are as follows:

Odlat.	Subatanoe,
Garmiiu-red	Lithium.
PurpU-rtd	Btroutium.
Orangt-red	Calcium.
YMme	Bodium.
TtUowuhgrtm	Buium.
Si*lcin4-grt4n	Borou.

Emtrald'grtan Oxide of copper.

Bluithgrttn Ptioepboric acid<pboBphates).

OrttnitA Hut AntimoDj.

WhUkb blue Anenic.

Ature-Uaa Chloride ot copper; also nleulum.

FioM Potatdum.

A yellowieh-green Qnme la also given by ibe oxide or sulphiile of molybdenam; a bluleh-greeD flame (In ttreaka) by eIdc; a pale greenlfb flame bj lelluiium; a blue flame b^ lead.

477. VotM.—Tbe preaecce of soda, even In small quautltiea, produces a yellow flame, which (except In tbe spectroecope) more or le&B completely masks tbe coloration of the flame due to other siibBtancei, e.g., potassium. Tbe use of a wedge of blue glass then allows tbe cbarncterlslic violet color to be observed. Silicates are ofrec so difflciiltly decompuied that do distinct color Is obtained even wbea tbe substance U present; in such cases ('■o., potash feldspar) tbe powdered mineral may be fused on the platinum wire with au eqtuu volume of gypsum, wlieii tbe flame can be seeu (st least through blue glass). Assln, a siHcate like tourmaline fused witii a mixture of fluorlle and acid poiassium smphate yields Ihe characteristic green flame of boron. FhospLates and borates give the greeo flame in general best when tbey have been pulverized and motstened with sulphuric acid- Uolsteumg with hydrochloric acid makes the coloration In many cases (as with the carbooatet of calcium, barium, strontium) mure dlstiuct.

3. Heating in thb Clossd ahd Open Tubes.

478. Tbe tnbes are nseful chiefly for examining minerals containing volatile ingredients, given off at the temperature of the gas flame.

Id the case of the closed tube, the heating goes on practically uninfluenced by the air present, since this is driven out of the tnbe in the early stages of the process. In the open twbe, on the other hand, a continual stream of hot sir, that is, of hot oxy^n, passes over the assay, tending to produce oxidation and hence often materially changing the result.

479. Cloud Tnbe.—A small fragment is inserted, or a small amount of tbe powdered mineral—in this case with care not to soil the sides of the tube— and neat is applied by means of the ordinary Bnnaen flame. The presence of

a volatile ingredient is ordinarily shown by the deposit, or aublimate, upon the , tnbe at some distance above the assay where the tube is relatiyelv cool.

Independent of this, other phenomena may be noted, namely: decrepitation, as shown by fluorite, calcite, etc.; glowing, as exhibited by gadolinite; ^Aos»Aorfl«ce»ice, of which ilnorite is an example; chnnge o/'co7o7-(iimonite), and here the color of the mineral should be noted both when hot, and again after cooling; fusion; giving off oxygen, as mercuric oxide; yielding <irid or alkaline vapors, which should be tested by inserting a strip of moistened litmus or turmeric paper in the tube.

Of the suMimaiet which form in the tabe, the following are those with which it ia most important to be familiar:

aab>tin;a. Snb'lnuM in fh* Closed Tabe.

Water |H,0| Colorleu liquid drops.

Sulpbur (8) Red to deep yellow, liquid; pale fellow, tolld.

Telluriuni dioxide (TeOi) Psle yellow to colorless, liquid; colorlen or white, solid.

Arsenic sulphide (Aa,B>) Dark red, liquid; reddish yellow, solid.

Auiimony oxysulphlde (BbtBiO) BIsck to reddish brown on coollDg, solid.

Arsenic (As) BIsck, brilliant metallic to gmy crjstalllDe, solid.

Mercury sulphide (HgS) Deep bluck, red when Tubbed very floe.

Mercury (Bjc) Omy metallic globules.

Id-addition to the above: Tellurium gives black fusible globules; seleniuni the same, but In part diirk red when very smull; the chloride ot lead and oxides of arsenic and aDtimouy give white solid sublimates.

480. Open Tube.—The small fragment is placed in the tabe about an inch from the lower end, the tube being stiehtly inclined (say 20°), but not enough to cause the mineral to slip out, and heat applied beneath. The cnrrent of air passing upward through the tube during the heating process has an oxidizing effect. The special phenomena to be observed are the formation of a sublimate and the odor of the eEcaping gases. The acid or alkaline character of the vapors is tested for in the same way as with the closed tube. Fluorides, when heated in the open tube with previously fused salt of phosphorus, yield hydrofluoric acid, which gives an acid reaction with test-paper, has a peculiar pungent odor, and corrodes the glass.

The more important sublimates are as follows:

Bubstanoe. aubUmata In the Oiwn Tube.

Arsenic trioxide (AsiO.) White, cryBtalllne, voiallle.

Aotimony antimonate(Sb|0,) Straw-yellow, hot; white, cold. Infusible. non-Tol«lDe, amorphous. Obtained (ram stibnite. also the sulph-antimoDltes (e.g., Ixiuriionite) na dense white fumes. Usually nccompanied by the following:

AntimoDy trioxide(Sb)Oi)... White, crystallinu. slowly volatile. From native antimony and compounds not con lain I tig sulphur.*

Telluriuni dioxide (TcO,).... White to pale yellow globules.

Selenium dioxide (8eO,) While, crysialliue, volaille.

Molybdenum trioiide (MoO,) Pale yellow, hoi; white, cold.

Mercury (Hg) , Gwy metallic glo1 mles. easily united by rubbing.

It is also to be noted that if the heating process ia loo rapid for full oxidation sublimatea, like those of the closed tubes, may be formed, especially with sulphur (yellow\ arsenic (black), arsenic sulphide (orange), mercury sulphide (black), aotimony oiysulphide (black to reddish brown).

3. Heating oit Chahcoal.

481. The fragment (or powder) to be examined is placed near one end of the piece and this so held that the flame passes along its length; a slight ridge to prevent the mineral being blown off is sometimes useful. If the mineral decrepitates, it may be powdered, mixed with water, and then the material employed as a paste.

The reducing flame is employed if it is desired to reduce a metal («.ff., silver, copper) from its ores: this is the common case. If, however, the minerri

• The distinclion here made Is Important; cf. Peofield. revised edition of Brush's Determlnatlve Mineralogy, 1S96.

18 to be roasted, that is, heated Id contact with the air bo as to oxidize anil Tulatilize, for example, the sulphur, araenic, antimony presei^t, the oxidizing flame is needed and the mineral should he in powder and spread out. The points to be noted are as follows:

(a) The odor given off after short heating. In this W117 the presence of sulphur, arsenic (garlic or alliaceons odor), and selenium (odor of decayed horseradish) may ^ recognized.

{b) Fusion. —In the caeo of the salts of the alkalies the fneed mass ia absorbed into the charcoal; this is also true, after long heating, of the carbonates and enlphatea of barium and strontium. (Art. 484.)

{d) The Sublimate. —By this means the presence of many of the metals may be determined. The color of the sublimate, both near the assay (K^) and at a distance (D), as also when hot and when cold, is to be noted. The important sublimates are the following:

. Subotuios. Sni linute on OhkcoiHU.

Aneolc trioktde (A8,0t) Wlifte, very volatile, disUnt from tbe nssay; also

g&rllc fumes. Antimony osldea (SbiOi nnd SbiOi) Dense whjw, volallle; foruia near tLe nsiaj.

Zinc oxide (ZnO) CannrT-Tellow, Lot; wlilte. cold; molHteued with

cobalt nitrate and Ignited (O.F.) becomes green.

Uolybdenum trioside (HoOt) Pale yellow, liot; yellow, cold; touched for a moment

with the K.F. becomes uzure-b]uc. Alsoacupper-red sublimate (HuO,) near the luaay.

Lead oiide (PbO) Dark yellow, hot; pale yellow, cold. Also (from

aulpliides) dense white Ireeembling antimony), a mixture of oxide, aulpbite, and sulphate of lead.

Bismuth trioside (Bi|0>) Dark omnre-yellow .N), paler on cooling; also bluish

white (D). See further, p. 260.

Cadmium oxide (CdO) Nearly blnck tn reddish brown (N) and orange yellow

(D): often iridescent. To the above are also to be added the followfoE:

Selenium dioxide SeO,. sublimate St eel-gmv (N) lo white llnged with red (D); touebed with R.F. gives nn aziirebtuc Same: also nn oSensive selenium odor.

Tellurium dioxide, TeO,, eubllmate dense while (N) to gray<D); in B.F. volatilizes with green flame.

Tin dioxide. 8tiO„ subllmale f«Iot vellow hot to white cold; becomes bluish green when moistened with cobnit sohillon nnd ignited.

Silver {with lead and antimony), sublimate reddish.

(e) The Infusihle Residue. —This may (1) glow brightly in the O.F., indicating the presence of calcium, strontium, magnesium, zirconium, zinc, or tin. (3) It may give an alkaline reaction after ignition: alkaline earths. (3) It may be magnetic, showing the presence of iron (or nickel), (4) It may yield a globule or mass of a metal (Art. 482).

482. Bednotion on Charcoal.—In many cases the reducing flame alone suffices on charcoal to separate the metal from the volatile element present, with the result of giving a globule or metallic mass. Thus silver is obtained from argentite (Ag,8) and cerargyrite (AgCl); copper from chalcocite (Cu,S) and cuprite (Cu,o), etc. The process of reduction is always facilitated by the use of soda aa a flus, and this is in many coses (siilpharsenites, etc.) essential. The finely pulverized mineral is intimatplv mixed with soda, and a drop of water added to form a paste. This is plai^eil in a cavity in the charcoal, and gnbjected to a strong reducing flame. More soda is added as that pieeent sinks into the coal, and, after the process has been continued some time, a metallic globule is often visible, or a number of them, which can. be removed

and eeparately examined. If not distinct, the remainder of the flux, the assay, and the surrounding coal are cut oat with a knife, and the whole gronnd np in a mortar, with the addition of a little water. The charcoal is carefully washed away aud the metallic globules, flattened out by the proceas, remain behind. Some metallic oxides are very readily reduced, as lead, while others, aa copper and tin, require considerable skill and care.

Tne metals obtained (in globules or as a metallic mass) may be: iron, nickel, or cobalt, lecogoiz&A. by their being attracted by the magnet; copper, color red; bismuth, lead-gray, brittle; gola, yellow, not soluble in nitric acid; silver, white, soluble in nitric acid, the solution giving a silver chloride precipitate (p. 255); h'w, white, harder than silver, soluble in nitric acid with separation of white powder (SuO,); lead, lead-gray (oxidizmg), Boft and fusible. The coatings (see the list of sublimates above) often serve to identify the metal present.

The metals obtained may be also tested with borax on the platinum wire.

463. Seteetion of Snlphor in Snlphatet. —By meaus of soda on charcoal the presence of sulphur in the sulphates maybe shown, though they do not yield it upon simple heating. AVhen soda is fused on charcoal with a compound of sulphur (sulphide or sulphate), sodium sulphide is formed, and if much sulphur ia present the mass will have the hepar (liver-brown) color. In any case the presence of the sulphur is shown by placing the fneed

mass on a clean surface of silver, and adding a drop of water; a black or yellow stain of silver sulphide will be formed. Illuminating gas often contains sulphur, and hence, when it is used, the soda should be first tried alone on charcoal, and if a sulphur reaction is obtained (due to the gas), a candle or lamp must be employed in the place of the gas.

484. It is also useful in the case of many minerals to test their fusibility or infusibility with soda, generally on the platinum wire. Silica forms if not in excess a clear glass with soda, so also titanic acid. Salts of barium and strontinm are fusible with soda, bnt the mass is absorbed by the coai. Many silicates, though alone difficultly fusible, diesolve in a little soda to a clear glass, but with more soda they form an infusible mass. Manganese, when present even in minute quantities, gives a bluish-green color to the soda bead.

4. Treatment on the Platinum Wies.

485. Uh of the noxes. —The three common fluxes are borax, salt of phosphorus, and carbonate of soda (p. 354). They are generally used with the platinum wire, less often on charcoal (see p. 360). If the wire is employed it must have a small loop at the end; this is heated to redness and dipped into the powdered flux, and the adhering particles fused to a bead; this operation is repeated until the loop is filled. Sometimes in the use of soda the wire may at first be moistened a little to cause it to adhere.

When the bead is ready it ia, while hot, brought in contact with the pow-dered mineral, some of which will adhere to it, and then the heating process may be continued. Very little of the mineral ia in general required, and the experiment should be commenced with a minute quantity and more added if necessary. The bead must be heated successively first in the oxidizing flame (O.K.) and then in the reducing flame (R.F.), and in each case the color noted when hot and when cold. The phenomena connected with fusion, if it takes place, most also be observed.

Hiiierala conUltilnii; sulpbur or arsenic, or both, must be firet roatted (see p. S61) till these Biibsiaiices Lave lieen volatilLzed. 11 too much of the miaeral has been added and the

hernd ta hence loo opaque to ihon the color, It may, while hot, tie tUttened out with ibe hammer, or drawn out hito a wire, or port of It may be removeU and the rejuainder diluted witli more of the flux.

With salt of pbosphonu. the wire should be held above the flame eo that the escaping gases may support the bead; this fs coutiuued till quiet fusion Is aitaia«d.

It U to be uoled that the colors vary much with the amouat ut material preeeot; the^ are also modified by the preaence of other metali.

486. Borax,—The following list emimerateB the difEerent colored beads obtained with borax, both in the oxidizing tO.F.) aud reducing flames (R.F.)> and also the metals to the preaence of whose oxidee the colore are dne. Compare further the reactions given in the list of elements (Art. 4B8).

Oolta In Boiax Bead. Bubstanoe.

1. OxiPiziNO Flauk. Colorlen, or opaque white... Silica, calcium, aluminlumi also silver, ^c, etc Iron, cold—(pule yellow, hot, if in smiill amount). Bed, red-brown to brown.... Chromium (CrOi), Lot—(yellowUb green, cold).

Manganese (Hn,Ot), amethysllDe-rM—{rlolel, hot). Iron (Fe,0,), hot—HJellow, cold)—It saturated. Nickel (NiO), red-brown to brown, cold—<Tlolet, hot). Uranium (UO,), hotHyellow, cold).

Green Copper (CuO), hot—(blue, cold, or bluish green if highly

saturated). Chromium (CrOi), yellowish green, cold—(red, hot).

Tellow Iron (FeiOi). bot—fpale yellow to co1orl«M, cold)—but

red-brown aud yellow if saturated. Uranium (UOi), hot. If in small amount; paler on cooling. Chromium {CrOi), hot and in small amount—(yellowish greeu, cold).

Blue Cobnlt(CaO), Lot and cold.

Copper (CuO), cold If highly saturated—{green, hot),

Violet Nickel (NiOl. hot—(red-brown, cold).

Mangniieec (HuiOi), hot—(amethystine-red, cold),

S. RsDucufo Flamx (R F.).

Colorleai. Hanganese (UuO), or a faint rose color.

Red • Copper (CuiO. with Cu). opaque red.

Green Iron (FeO), bottle-green.

Chromium (CriOi), ememld-green.

Uranium (U,Oi), yellowish green If uturated.

Blue Cobalt (CoO), hot and cold.

Gray, turWd Nickel (NI).

487. Salt of Fhotphorni.—This flux dyes for the most part reactions similar to those obtained with borax. The only cases enumerated here are those which are distinct, and hence those where the flux is a good test.

With silicates this flux forma a glass in which the bases of the silicate are dissolved, but the silica itself is left insoluble. It appears as a skeleton readily seen floating about in the melted bead.

The colore of the beads, and the metals to whose oxides these are dne, are: Color. , Bubstanoe.

Red Chromium In O.F., hot—(fine green when cold).

Green..,.,,...,, Chromium in O.F. and R.F., when cold—(red in O.F., hot).

Uolybdenum in R.F., dirty green, hot; fine green, cold—(yellow-cmen

in O.F.). Uranium In R,F., cold; yellow.greeo, hot.

Vanadium, chrome-green in R.F„ cold—(brownish red, liot). In O.F. dark yellow, hot, paler on cooling.

Tallow HolTbdennm, jellowiih green lu O.F., liot, pkler on cooling—<Iti B.F.,

' dirty gr««ii, hot; floe Kreen, cold).

Uranium In O.F., hot; yellowish green, cold—[in K.F., yellowish green,

cooling—(in R,F.,

Geabactekibito Reactions of the InpoRTAin' Elehehtb aitd of soke

OF THEIB COHPOUDDB.

498. The following list contains the most characteriBtic reactions, chiefly before the blowpipe and in some cases also in the wet way, of the different elements and their oxides. It is desirable for every student to gain familiarity with them by trial with as m&oy minerals as possible. Many of them have already been briefly mentioned in the preceding pages. For a thoroughly full description of these and other characteristic tests (blowpipe and otherwise) reference should be made to the volume by Brush and Fenfield referred to

on p. 256.

It is to be remembered that while the reaction of a single substance may be perfectly distinct if alone, the presence of other substances may more or less entirely obscnre these reactions; it is consequently obvious that in the autual examination of minerals precautions have to be taken, and special methods hare to be devised, to overcome the difficulty arising from this cause. These will be gathered from the " pyrognostic characters" (Pyr.) given in connection with tne description.of ea<^ species in the Third Part of this work.

For many substances the most satisfactory and delicate tests are those which have been given by Bnnsen in his important paper on Flame-reactions.* The methods, however, require for the most part so much detailed explana-tioQ, that it is only possible here to make this general reference to the subject.

Alnminium. —The presence ol aluminluEa in moat infusible minerals, containing n cou-slderable smount, may be detected by the blue color which they assume when, after being beated, they are moistened with cobalt solution and again iKniled {e.g., cynnlte, andnlusile, etc.). Very bard minerals (as corundum) must he GtM finely pulverized. The test Is not conclusive with fusible minerals dace a glass colored blue by cobalt oxide may be formed. It la Id be noted that the infusible calamine (zinc silicate) also assumes a blue color when treated with cobalt nitrate.

.^niimonu.—Antlmonlal minerals rossled on charcoal give dense white inodorous fumes; metallic antimony and its sulphur compounds give In Ibe open tube a white sublimate of oxide of antimony (see p. S60). Antimony sulphide Isllbnite), also many solphnntimonltea, give In a strong beat in the closed tube a sublimate of antimony oxysulphiae, black when hot, brown-ren when cold. See also p. 260.

In nitric acid, compounds contniniiig antimony deposit white Insoluble metantimonic acid.

Aiienui.—A.nenidea. sulpharsenites, etc., give oR fumes when routed on cbarcoal, usually easily recognized by tbeir peculiar garlic odor. In the open tube they give a white, volntile, ciratalllne sublimate of arsenic trioxide. In tbe cloaed tube arsenic sulphide gives a siibllmale dark brown-red when hot. and red or reddish yellow when cold: arsenic and some arsenides yield a black mirror of metallic arsenic In the closed tube. In arsenates tbe arsenic can be detected by the garlic odor yielded when a mixture of the powdered mineral with cbarcoal dust and sodium carbonate la heated (R F.) on cbarcoal.

Bnrium. — A. yellowish-green coloration of the flame ia ^Iven by all barium salts, except tbe silicates; an alkaline reactiou is usually obtained after Intense ignition.

* Flammeoreactionen, Lieb. Ann., laS, S5T, 1B66, or Phil. Hag., 33. 81, 1866.

In aoluiiiii tlm preieoce uf bnrtum is proved by the hetvy wlitte pnclptUte (BaSOt) formed upoii llie uddilion of dilute aulpburlc kcld.

Bvwulh.—On charcoal alone, or bM«r with tod*. bUmuih Kives m very cbmrscteiistlc orange-yellow ■ubUmktei brittle gkibulei of the reduced metal ar« also obtained (with «oda). Also when Ireated with 8 or 4 times tbe volume of a mixture in equal parts of potassium Iodide and aulphur, and fused on charcoal, a beautiful red subllmatA of bUmuth Iodide is obtained; near the mineral the coating is fellow.

Boron.—lSAay compounds ooalaiulog boron (borates, also the silicates datoUte, danburite. eIcO tinge Ihe flame intense Tellowisb green, eapecEally tf moistened with sulphuric acid. For some silicates (as tourmaline) the best method ia to mix the powdered mineral with one part powdered fluorlte and two parts potassium bisulphale. The mixture is moistened and placed on platinum wire. At tbe moment of fuaion the gtttn color appears, but lasts but a moment,

A dilute hydrochloric acid solution contaiiJng boron kItcs a reddish-brown color to turmeric paper which has been moislened with It and then dried at 100°; tlM color ofaangea to black when ammonia Is poured on the paper.

Oaleinm, —Hany calcium minerals (carbouatee, sulphates, etc.) elve an alkaline reaction on turmeric paper after being ignited. A yellowish-red color Is given to the flame by some compounds {».g., ctUcite after moistening with HCI); the strontium flame ia a much deeper red.

In solutions (not too acid) calcium Is precipitated as oxalate by the addition of ammonium oxalate.

Cadraium. —On charcoal with soda, compounds of cadmium give a characteristic sublimate of the reddish-brown oxide.

GarboTiatei.—All cnrbODstes effervesce with dilute hydrochloric acid, yielding the odorless gas Co(le.ff., caklte); many require to be pulverized, and some need the addition of heat (dolomite, slderlte). Carbonatea of lead should be tested with nitric acid.

Ofiioridei. —If a small portion of a mineral coutBlulng chlorine (n chloride, also pyromorphite, etc.) is added to the bead of salt of phosphorus, saturated with copper uzide, the bead when heated Is instantly surrounded with bu intense purplish flame of copper chloride.

In solution chlorine gives with silver nitrate a while curdy precipitate of silver chloride, which darkens In color on exposure to the light; it is Insoluble in nitric acid, but entirely so in niumoula.

O^remium. —Chromium elves with borax abend which (O.F.I is yellow to red (hot) and yellowish Kreeo (cold) and R.F. a flue emerald-green. With salt of phosphorus In O.F. the bead Is dirty green (hot) aud clear green (coldj; In H.F, the same, Cf. Tauadlum beyond (also p. 3S8).

(MalL —A beautiful blue bend is obtained with boras in both flames from miDerats containing cobalt; tbe color may be obscured by considerable Iron or nickel unless Ihese are first oxldlted off [p. 182), Where sulphur or arsenic is present the mineral should first be thoroughly roasted on charcoal.

Copper.—On charcoal, at least with soda, metallic copper can be reduced from most of Its compounds. With borax It gives (O.P.) a green bead when hot. becoming blue when cold; also (R.F.), If saturated, an opaque red bead containing Cu,o and often Cu is obtained.

Host nieialilc compounds are soluble in nitric add. Ammonia produces a green pre-dpltate in the solution, which la dissolved when an excess is added, the solution taking an intenHc blue color.

^uortn«.~-Heated In the closed tube many fluorides give off fumes of hydrofluoric acid, which react acid with test-paper and etch the glass. Sometimes pota^um Uaulpbste must be ndded [see also p. 200).

Heated gently In a platinum crucible with sulphuric acid, many rompounda («.ff., fluorite) give off hydrofluoric add, which corrodes the exposed parts of a glass plale plnced over It which has been coated with wax and then scratched.

/nm.—With borax iron pives a bead (O.P.I which Is yellow to brownish red (according to quantily) while hot, but is colorless to yellow on cooling; R,F, becomes bottle-green (see p. 8G8). Minerals which contain even a small amount of Iron yield a magnetic mass when heated In tbe reducing flame.

Lead.—With soda on charcoal a malleable globule of metallic lead is obtained from lead compounds; tbe coating has a yellow color near tbe assay; the mlphide gives also a white coatini; (PbSOi) farther off (p. 201), On being touched with the redudng flnme the coating disappears, tingeing the flnme azure-blue.

In solutions dilate sulphnrlc acid gives a white predpltate of lead sulphate; when

delfcBcj Is required an excess of tbe acid is added, tbe solulfon evaporated to dryoen, uid WHlur iiddtid; tLe lead lulpbule, If preseat. will llieu be lefl as a residue.

XifAiun).—Litbiutn gives an iutense canaine-red lu Uie outer tlaioe, Ibe color somewhat resembliDg that of the stnintluiu dame but ia deeper; In veiy small quantities It b evident in the spectroscope.

Magnamm. —Holsleoed, aflai heatlug, wltli coliatt ultral« and axain Ignited, a pink color Is ubtalned from some Infusible compounds of magnesium {'.g-, brucllel.

Mangaiitae. —With borax manganese gives a bead Tiolet-red [O.F.). and colorless (R.F.). With soda (O.F.) it gives a bluish-green bead: this reaction is very delicate and may be relied upon, even Id presence of almoat any other meiat.

UeTmry.—la tbe closed tube a sublimate u(metallic mercury ia yielded when tbe mineral is heated with dry sodium carbonate. In the open tube the sulphide gives a mirror of metallic mercury; in the closed tube a black lUBlerleas sublimate of HgB, red when rubbed, la obtained.

UoMydenvm.—Oa charcoal molybdenum sulphide gives near the assay a copper-red Btalu (O.F.), and beyond a while coating of the oxide: the former become» azure-blue when for a moment touched with the R.P. The salt of phosphorus bead (O.F.) is yellowlsli green (hot) and nearly colorless (cold); also (RF.) a fine green.

Nickel.^'W\l\i borax, nickel oxide gives a bead which (O.F.) is violet when hoi and red-brown on cooling; (R.F.) the glass becumes gray and turbid from the separation of metallic nickel.

il'ti'Mufn (Columbium).— Ad add sol u lion boiled with metallic tin gives a blue color. The relictions with the fluxes are not very satisfactory.

Nitrate*. —These detonate when heated on charcoal. Heated in a tube with sulphuric acid they give off red fumes of nitrogen dioxide (NOi).

iVuMjjA^fus.^Most phosphates impart a green color to the flame, especially after having been moistened wiih sulphuric acid, though this lest maybe rendered unsutisraclory by the presence of other coloring agents. If they are used in the closed tube with a fragment of memllic magnesium or sodium, and afterward moistened with water, phospUureled hydrugen is given oB, recognizable by lu disagreeable odor.

&. few drops of a nitric acid solution, containinr phosphoric add. produces in a solution of ammonium molybdale a pulverulent yellow preclpltnte of ammonium phospbOr molybdate.

PoloMium. —Potaali imparts a violet cotoc to Uie flame when alone. It Is best delected In small quantities, or when soda or liihia Is present, by the aid of the specttoacope. See also p. Sw.

SeUniuTn. —On charcoal selenium fnses easily, giving oS brown funea with a peouliar disagreeable organic odor; the sublimate on charcoal is rolatlle, and when heated (ILF.)

gives a fine azure-blue flame.

BUioon. — h. small fragment of a silicate in the salt of phosphorus bead leaves a skeleton of silica, the buses being dissolved.

If a silicate In n fine powder Is fused with sodium carbonate and the mass then dissolved Id hydrochloric add and evaporated to dryness, tbe silica la made insoluble, and when strong hydrochloric acid is added and then w&t^, the bases are dissolved and the silica left behind.

Many silicates, especially those which are hydrous, are docompoeed by strong hydrochloric ncld. the atUca separatiag as a powder or, after evaporation, as a jelly (see p. 265).

-Siirer.—On cliarcnal In O.F. silver givea a brown coaling, A globule of metallic silver may generally be obtained by heating on charcoal in O.F., especially If soda is added. Under some circumstances it la desirable to have recourse to cnpeliation.

From a solutiim containing any salt of silver, the Insoluble chloride Is thrown down when hydrochloric acid la added. This precipitate is insoluble in acid or water, but entirely so in ammonia. It changes color on exposure to the light.

SCTOTitiutn. —Compoi)nds of stvonllum are usually recognized by the flike crimson-red which they give to the blowpipe flame; many yield an alkaline reaction after ignition. (Cf. barium,)

Sodium. —Comiwimds containing sodium In large amount give a strong yellow flame.

Sulphur. Sulphide; 5wipftato«.—In the closed tube some sulphides give off sulpliur; in the open tube they yield sulphur dioxide, which tuis a characteristic odor and reddens a strip of molatened litmus paper. In small qunDtilies, or In sulphates, sulphur is best detected by fusion on charcoal willi soda. The fused mass, when sodium sulphide has thus been formed. Is placed on a clean silver coin and moistened; a distinct black stain on the silver Is thus obtained (Ihe precaution mentioned on p, 382 must be exercised).

A solution In hydrochloric acid gives with barium chloride a white tna of barium sulphate.

Teavrium. —Tellurldes heated la the open tube give a white or g: , fualble to colorless drope (p, 360). On charcoal tliej give a white co^ng aod color the B.P. green.

Tin. —Hlnerala contaliilng tin {e.g.. caasiterlte), when heated on charcoal with soda or potasalum cjraulde, yield metallic tin in minute Rlobules; these are malleable, but harder' than ailver. Dissolved iu nitric acid, white Insoluble HtaoDic oxide separates out.

ntanfum.—Titanium gives Iu the R.P. with salt ot pbospborus a bead which Is violet when cold. Fused with sodium carbonate and dlsaolTe'l with liydrochloric acid, and heated with a piece of metallic tin, the liquid takes a violet color, especially after portlal evaporation.

WnfsteN.^Tungsten oxide gives a blue color to the salt of phosphorus bead (It.F.). Fused and treated as titaolum (see above) with the additiou of ziec Instead of tin, gives a One blue color.

Oranium. —Umnium compouods give to the salt of pbosphorus bead (O.F.) a greenish yellow tiead when cool: also (h.F.) a due green od cocilitig (p. ZfiiS).

Viinadium.—Vfilh borax (O.P.) vanadates cive a bead yellow (hot) chaoging to yellowish green and nearly colorless (cold); a)Bo(H.F.) dirty grei^n (liol), flne green (cold). With salt of phosphor]I |O.F.) a yellow to umber color (thus differing from chromium); also (R.F.) fine green (col'Ii.

Zine.—Oa charcoal compounds of xlnc give a coating which is yellow while hot and white on coollnfc, and moisiened by the cobolt solution and again healed becomes a fiue green. Note, however, that the sine silicate (calamine) becomes blue when heated after moistening with cobalt aolution.

Zn-eoniunt.—A dilute hydrochloric acid soluiion, coutalnlng xlrcooluro. imparts an oraoge-yellow color to turmeric paper, moifilened by the solutioD.

DBTBaMINATITB UlKEBALOOT.

488. Determinatiye Mineralogy may be properly considered nnder the general head of Chemical Minemogy, since the detertninatioD of minei-aU dependB mostly upon chemical teste. But crystallographicand all the physical characters have also to be used.

There is but one exhaustive vay in which the identity of an unknown mineral may in all cases he fixed beyond question, and that is by the use of a complete set of determinative tables. By means of such tables the mineral in hand is referred succesaively from a general group into a more special one, until at last all other species have been eliminated, and the identity of the one given is beyond doubt.

A careful preliminair examination of the unknown mineral should, hov-ever, always be made before final recouree is had to the tables. This examination will often suffice to show what the mineral in hand is, and in any case it should not be omitted, since it is only iu this way that a practical famiHarity with the appearance and characters of minerals can be gained.

The student will naturally tnke note first of those characters which are at once obvious to the senses, that is: crystalline form, if distinct; general struc-/tire, cleavage, fracture, luster, color (and streak), feel; also, if the specimen is not too small, the apparent weight will suggest something as to tne specific ^rnviltf. The characters named are of very unequal importance. Structure, if crystals are not present, and fracture are generally unessential except in digtinguishing varieties; color and luster are essential with metallic, but gener^ly very unimportant with unmetallic, minerals. Streak is of importance only with colored minerals and those of metallic luster (p. 187). Crystalline forrn and cleavage are of the highest importance, but may require careful stinly.

The first trial should be the determination of the hardness (for which eud

the pocket-knife U often sufficient in experienced hands). The Beoond trial should be the determination of the specific gravity. Treatment of the pow> dered mineral with acids may come next; by this means (see pp. 354, 255) a car- -bonate is readily identified, and also other resnlts obtained. Then shonld follow blowpipe trials, to ascertain t\io fusibility; the color given to the flame, if any; the character of the sublimate given oS in the tahea and on charcoal; the metal reduced on the latter; the reactions with thej?n»o«, and other points as explained in the preceding pages.

How mnch the observer learns in the above way, in regard to the nature of his mineral, depends npon hia knowledge of the characters of minerals in general, and npon his familiarity with the chemical behavior of the varions elementary substances with reagents and before the blowpipe (pp. 264 to 367). If the resnlts of snch a preliminary examination are sufficiently definite to snggest that the mineral in hand is one of a small number of species, reference may be made to their full description in Part. IV. of this work for the final decision.

A number of tables, in which the minerals included are arranged according to their crystalline and physical characters, are added in the Appendix, They will in many cases aid the observer in reaching a coQcIusion in regard to a specimen in nand.

The first of these tables is intended to include all well-defined species, grouped according to the crystalline system to which they belong and arranged under each system in the order of their specific gravities; the hardness is also added in each case. The relative importance of toe individual species is shown by the type employed. Following tnis are minor tables enumerating species characterized by some one of the prominent crystalline forma; that is, those crystallizing in cubes, octahedrons, rhombohedrons, etc. Other tables give the names of species prominent because of their cleavage; structore of different cypee; hardness; luster; the various colors, etc The student i inded t

i to make frequent use of these tables, not simplv for aid in the identificntion of specimens, but rather because they will help him in the difficult task of learning the prominent obaractmra of tiie more important minerals.

PART IT, DESCRIPTIVE MINERALOGY.

489. Soopo of DeMTlptin Kin«rftli^7. —It is the province of Descriptive Mineralogy to deecribe each miDeral species, as regards: (1) form and atructore; (3) physical characters;

(3) chemical composition and allied blowpipe characters; (4) gccurrence in nature with reference to geographical diBtribution and association with other Hpecies; also in connection with the above to show how it is distingnished from other species. Further, to classifj mineral specifiB into more or less comprehensiTe groape according to those charactera regarded as most essential. Other points which may or may not be included are the investigation of the methods of origin of minerals; the changes that they undergo in nature and the results of such alteration; also the methods by which the same compounds may be made in the laboratory; finally, the □ses of minerals as ores, for ornament and in the arts.

490. Boheme of Clauification.—The method of classification adopted in this work, and the one which can alone claim to be thoroughly scientific, is that which places similar chemical compounds together in a common class and which fnrther arranges the mineral species into groups sccordine to the more minute relations existing between them in chemical composition arfd in crystalline form and other physical properties.

Upon this basis there are recognized eight distinct classes, beginning with the Native Elements; these are enumerated on the following page. Under each of these, sections of different grades are made, also based on chemical relatioDshtpa. Finally, the mineral species themselves are arranged, as far as possible, in iaomorphouB groups, inclnding those which have, at once, analogous chemical composition and similar crystallization (8ee Art. 466). It la unnecessary to take the apace here to develop the entire scheme of classification in detail, since a survey of the successive sub-classes under any one of the divisions will make the principles followed entirely clear. A few j-emarks, only, are added for sake of illustration.

Under the Oxides, for example, the clasaifleation is as follows: First, the Oxides of silicon (quartz, tridymite, opal). Second, the Oxides of the semi-metals, tellurium, arsenic, antimony, bismuth, also molyhdenum, tungsten. Third, the Oxides of the metaU, as copper, zinc, iron, manganese, tin, etc. The third section is then subdivided into the anhydrous and hydrous species. Farther, the former fall Into the four divisions: Protoxides, R,0 and RO; Ses-qnioxides, R.O,; Intermediate oxides, RO,R,0,; Dioxides, RO,. Under each of these heads come finally the individual species, arranged so far as possible in isomorphons groups. Thus we have the Hematite group, the Rutile group, etc.

In regard to the various classes of salts it may be stated that, in genera], they are separated into anhydrous, acid, basic and hydrone sections; the special subdivisions called for, however, vary in the different cases.

For ui explanRtloD at the abbreviatloQS used Id tlie deacriplion of species, aee p. 4.

SCHEME OF CLASSIFICATION.

I. HATIVX XlBMBim.

IL SVXFEIBla, SKLSmiU, TSILITRIIIU, AUIHIDXt, AaTIMOnDXB.

III. Snlptao-saltB—BULFEABmnna, SUIPHAVTIMOKITEB, SirLPHOBIIXDTE-

tT».

IV. Haloids.—GELoan>i>, Baoumn, looniu; Pi.iroxiinB. V. OzmiA

VI. Oxygen Salts.

1. Casbosatib.

2. SnlCATXB, TiTABATlS.

3. HlOBATEB, TAjn'AI.ATtl.

1. PHOBPEATEB, AXSKHATXS, TAVADATU; AlTTIMOBATIS. Hl-

6. BOBATEB. UBABATBB.

6. SlTLFEATEB, CHBOXATBI, TIILVBATEB.

7. TintCWIATBS, MDLTBSATXS.

Vn. Salts of Organic Acids: OxalateB, Mellates, etc. VIII. HYSBOOABBOH COKFOITBU.

NATIVE ELEMENTS.

I. HATIVi: BT.FWmWTS.

The NATIVE ELEMENTS are divided into the two distinct sections of the Metals and the Non-metals, and these are connected by the transition class of the Semi-metals. The distinction between them as regards physical characters and chemical relations has already been given (Art. 487).

The only non-metals present among minerals are carbon, sulphur, and selenium; the last, in one of its allotropic forms, is closely related to the semi-metal tellurium.

The native semi-metals form a distinct group by themselves, since all crystallize in the rhombohedral system with a fundamental angle differing a few degrees only from 90°, as shown in the following list:

Tellnrinm, rr' = 93° 3'. Arsenic, rr' = 94° 54'.

Antimony, rr' = 92° 53'. Bismuth, rr' = 93° 20'.

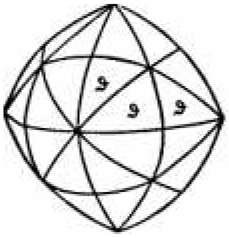
An artificial form of selenium is known with metallic luster and rhombohedral in crystallization, with rr' = 93°. Zinc (also only artif.) is rbombohe> dral (rr' = 93° 46') and connects the semi-metals to the true metals.

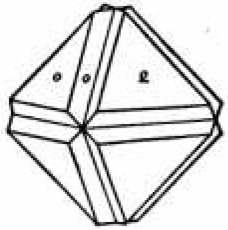
Among the TnetaU the isometric Gold qbouf is prominent, including gold, silver, copper, mercury, amalgam (AgHg), and lead.

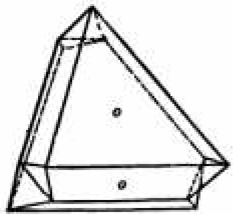
Another related isometric group includes the metals platinum, iridinm, pslladinm, and iron; further palladium is rhombohedral and also iridosmine flrOa).

DIAMOND.

Isometric and probably tetrahedral, but the -|- and — forms not distin-gnished. Commonly in octahedrons, also hexoctahedrons and other forms; lAtxa frequently ronnded or striated and with triangular depressions (on o).







Twins common with tw. pi. o. Crystals often distorted. In spherical forms; massive.

Cleavage: o highly perfect, Fractnre oonchoidal. Brittle. II. = 10. G. = 3'5l6-3'535 crystals. Luster adamantine to greasy. Color white or colorless; occasionally various pale shades of yellow, red, orange, green, bine, brown; sometimes black. Usuallv transparent; also translucent, opaque. Refractive and dispersive power high; index n^ = 2'4I95. (See Art. 305.)

V«r.—1, OrdiTUiry. In crystalii usuttllr wilb rouDded faces and varying from those which fin colorieas and free from flaws {firtt reaier) through ranoy fninl sbndes of color, yellow the moat commou; oftea full of flawB tkod hence of value only for cutting purposes.

2. Bort or Boort; rounded forms with rougli exterior uid radiated or confused cry bIaI-

witbuut cleuvage. Color black or giuylah black. Opaque Braul.

Comp.—Fure carbon; the variety carbouado yields on combnation a slight ash.

Pyr., etc.—Uosffected by beat except at very bigb temperatuiw, wbeo (lu an oxvKen BtmoBpbere) It burus to carbon dioxide (COi); out of contact with the air trauafortned Into a kind of coke. Not acted upon by acids or alkulies.

Difi. — Disllngulslied («.f., from quartz crystal} b;r its extreme liardneas and brilliant adaniantine luster; the form, cleavage, and hieli specific gravity are also distinctive characters; it is optically isotropic; transpureut to X-rays.

Oba.—Tlie diamoud occurs chietly In alluvial deposits of gravel, sand, or cl^, ano-ciated with quartz, guld, platinum, z&con, ociaLedrite, ruille, lirookite, hematite, ilmeiiit«, and also andalusita, chryaoberyl, topaz, corundum, tourmaline, garnet, etc.; llie associated minerals being those common in granitic rocks or granitic veins. Also found In quartzose conglomerates, and further in connection with the laminated gi-anular quartz rock or quartzose hydroiulca schist, ilaeolamsle, which in thin slabs is more or less flexible. Tfala rock occurs at the mines of Brazil and the Urals; and also in Georgia and North Carolina, where a few dlamoads have been found.

It has been reported as occurring in tilji In a pegmatite vein in gneiss at Bellary In India. It occurs further in connection with an eruptive peridollle in BmiUi Africa. It has been noted as Krayish particles forming one per cent of the meteorite which fell at Novo-Urel, Russia. Sept. 23, 1988; also in the form of black diamond (H. = 6) in the meieorite of Carcote, Chili; in the mel«oric iron of CaOon Diablo, Arizona. It has been formed Brtidclally by MoIssHn.

India wus tbe chief source of diamonds from very early times down to the discovery of the Bmzlliun mloes; the yield is now small. Of the localilies, ihnt insoutliein India, in the HadrHs presidency, iucluded the famous "Golcoiida nlues." The diamond deposits of Ilmzil bare been worked since the early part of llie IStli century, pud Lave yielded very largely, iiltbougb nt the present time Ibe amount obrained Is amnll. The icobI Important region was that uear Diamantiua In the province of Minirs Oei-ses; tilso from Bahls, eir.

Tbe discovery of diamonds in Boulh Africa dates from l&OT. They were Hist found in the gmvel of the Vaal river; Ibey occur from Puicbefstroom down to ihe Junclion wiih ibe Orange river, and along the latter iis far as Hope Town. These m«f digging* »ie now comparatively unproductive, aud have been nearly abandoned tor the dry disffingi, discovered in 1871.

Tbe latter aie chieflv in Qriqualnnd-West, south of the Vaal liver, on the border of llie Orau|re Free Stale. There am here n number of limittd areas approiluialHy eiiherlcal or oval lu form, with an average diameter of some 200 to 300 3aids, of which Klml.erlev, De Beer's, Du Toll's Pan aud Biiltf.iniein are llie most Important. A circle Sj miles in diameter encloses the four principal diamond mines. The general structure Is similar: a wall of nearly horizontal bhick carbonaceous shnle with uplumed edges euctosing ibe diamautiferoua area. The upper |)ortioii of the deposit couslsta of a friable maes of lliile coherence of a pale yellow color, called the " yellow ground." Below Ihe teach of atmospheric Influences, the rock is more ilrm and of a bluldi green or greenish color; it is railed the "blue ground" or simply "Ibe blue." This consists essenlially of a Eerprnliuous breccia: a base of hydrnted magnesian silicate pcuelrated by calclie and opaline silica and

iiig fnign: on ly smnr

_ _ , .mnrngdite, pyrile, zircon, etc. Tbe diamonds are rnlher abundaully dits*nil-

naled through tbe mass, in some claims to the amount of 4 to 8 carnts per cubic yard. The original rock seems lu bnve been a peculiar type of peridolite. These artas are believed to be volcnnic pipes, and Die occurrence of the diomonds Is obviously connected with the eruptive oulflow, Ibey having pvobably been brought up from underlying rocks. The Soiitli African mines in Griqualand up to June 1890 are estimaied to have yielded 60 railliiin carnts (13 tons) of diamonds, valued at about 870 million dolhirB.

Diamonds are also obtained in Borneo, associated with platinum, etc.; In Australia, aud the Urals.

Ill llie U. S. a few crystals have been met wiih in No. Carolina, Georgia, and Virgiuhi; several have been found in Wisconsin, also in California nl several poinu. Reported from Idaho and from Oregon with platinum.

Some of the famous dlamocids of the world with their weights are as follows: tbe

KtdilBODr, which wdgbflJ when brou^t to Euglaod 1B6 carats, and m recui as a brllllaat, 106 carata: tbe Orlov, 198 cants; the Kegent or Pitt, 187 carals; tbe Floieutine or Grand Duke of Tuscany, 183 carats; the Hancy, 08 carats. Tbe "Star of tbe aoutU," found to Brazil in 185^, weighed before aud after cutting respectively 264 and 125 carats. Also fimoUB because of tbe rarity uf tbeir color are the green diamoud of Dresden, 40 carats, and ihe detp blue Hope dliunuad from ludia. velgbiug 44 carata. Tbe blstory of tbe aboTe aionea aud of ullien la given id many works on gems.

Soutli Africa baa yielded some very large stones. Among lliese may be mentioned the folluwing: The Victoria (or tbe Imperial) from oue of tlJe Kimberley mines weighed M found 4.^ carats; (be Stewart weighed before and after cutting 288 and 120 carats respectively; ttie Tiffany diamond, of a tjrlllinut goldeu yellow, weighs, cut as a double brilliant, 1^ carats. The Excelsior from Jagerafonteln weighed when found 971 curaCa and was 8 inches In its largest dlmeniilon; tbls Is tbe largest ever known lo have been discovered.

CWFTONITB.—Carbon lu minute cubic cryslals. H. = 3S. Q. =213. Color and streak, black; from the Youndegln, West Australia, meteoric Iron, found in 1884.

OHAPBITB. Plumbago. Black Lead.

Bhombohedral. Id six-sided tabnlar crystals. Commonly in embedded foliated masBes, also columnar or radiated; scaly or slaty; granalar to compact; earthy.

Cleavage: baaal, perfect. Thin laminee flexible, inelastic. Feel greasy. H. = 1-2, G. — 2'09-2-23, Luster metallic, BOmetimes dull, earthy. Color iroD-black to dark eteel-gray. Opsqae. A conductor of electricity.

Comp.—Carbon, like the diamond; often impure from the presence of iron sesqnioside, clay, etc.

Pyr., etc—At a high temperature some graphite burns more easily than diamond, other varieties less so. B.B. Infusible. Unaltered by adds.

Ditt—Charaoterlaed by lis eitreme softness (soapy feel): Iron-blsck color; metallic luster; low specific gravity; also by infuaibillty. Cf. molybdenite, p, S85.

ObB.^Qraphite occurs In beds and embMded masses, liLmlnfe, or scales. In granite, gneiss, mica scblst, crystalline limestone. It is in some places a result of tbe alteration hj heat of coal. Often observed In meteoric irons. A common furnace product.

Occurs at Borrowdnle In Cumberlimd; at Arendal In Norway, in qiimtz; In the Ural, Finland; Pasaau in Bavaria. In Irkutsk, in the Tunkinsk Hta., lu eastern Siberia, tbe Alibert grapliite mine nffurds some of tlie best graphite of the world. Large quantities are brought from the East Indies, especially from Ceylon.

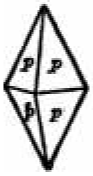
Forms beds in gneiss, at Sturbridfre, Mass,; at Ticonderoga, N. T., with pyroxene and tilanite: and at Hillsdale. Columbia Co., N. Y.: Byers. Chester Co., Ps.; LoudonCo.. Va.; Wake Co., N. C. A graphitic enrtb is mined for paint in Arkansas. In California, in Alpine Co.. Kern Co., etc. In HumlHildt Co., Nevada; Beaver Co.. Utah; Albany Co., ■Wyoming. A large deposit occurs al St. John, New Bninswick.

The name black lead, applied to this epedi'S. Is inappropriate, as it contains no lead. The name graphite, of Werner, is derived from y(id4tfir, to write, alluding to its use for '■ lead" pencils.

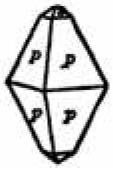
SCHCDOITB. Amorphous carbon observed in some schists.

Orthorhombic. Axes S:l:h = 0-8131 :1:1-9034. 678. S79. BSO. 681.

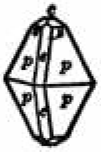
578.



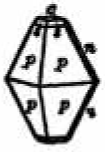
579.



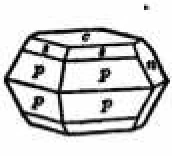
580.



581.



582.



Crystals commonlr acute pyramidal; aometimes tliick tabular | c, also ■phenoidal in habit (Fig. 583). See also Figs. 66, p. 30, and 303, p. 94. Also ""^ moaaive, in reniform shapes, in-

,110 A 110 = 78* H'. ■ ■ '

001 A 101 = W 58'. 001 A Oil = 63° 17'. 001 A 118 = 40* 10'. 001 A HI = 71' 40'. Ill A 111 = 94'82'. , 111 A 111 = 78" 84'.

ciUBtiii^, stalsctitic and Btalag-mitic; in powder.

Cleavage: c,m,p imperfect. Fracture conchoidal to uneven. Bather brittle to imperfectly soctile. H. = 1-5-2-5. G. = 2-05 - 2-09. Luater resinous. Color sulphur-yellow, straw- and

^^_ honey-yellow, yellowish brown,

greenish, reddish to yellowish gray. Streak white. Transparent to trans-Sicent, A non-conductor of electricity; by friction amatively electrified. Optically +. Double refraction strong. Ax, plane \b.. Bi.J_c. Dispersion p <v. 2H^, = 103° 16' Di. Refractive indices, see p. 208.

Comp., Tar.—Pure sulphur; often contaminated with clay, bitumen, and other impurities.

Sulphur may also be obtsinod Id the Uborotoiy Id other allotropio fomu; a tnonocllnic form U commoD.

Pyr., «to.—Helta at 108' o., and at 370* buroa with a blulah flame vIeldInK aulpfanr dioxide. iDBoluble in water, and not acted on by the acide, but soluble in carbon dtaulpbide.

Dlff.—Beadtty distinguished by tbe color, fusibility nnd combuBtibility. Oba,—The great repositories of sulphur are eitlier beds of Kypsuni and the aMOclate rocks, or the regions of active and extinct volcanoes. In the valley of Nolo and Mazsaro, Id Sicily; at Conil, in Spain; fiei, Switzerland; Cracow, Poland, ft accura In tbe former sltuaiion; near Bologna, Italy, in flue crystals, embedded in bitumen. Slcilv and the neighboring volcanic Isles; the Solfalara, near Naples; the volcanoes of the Paciflc ocean, etc., are localities of the latter kind. It is also deposited from hot sprinn in Iceland: aod Is met with in certain metallic veins, thus with lead ores near HOsen ana at Monte Poni, Sardinia. The Sicilian mines at Qirgenti yield large quantities for commerce, including beautifully crystallized specimens.

Sulphur is found near tbe sulphur springs of New York, Virgiula, etc.. sparingly; In many coal deposits and elsewhere, where pyrites Is underirolng decomposition; lii minute crystals on cleavage surfaces of galena, PhenlKvIlle, Pa. Some Important deposits occur Id the western UTS., as In Wyoming, In the Ulntsh Sits., 30 miles s.e. of Evan^toii; In Nevada, Humboldt county; Steamboat Springs. Waalioe Co.; Columbus, Esmeralda Co. In southern Utah Id large deposits, at Cove Creek, Millard county. In Oaliforniii, at the

Eysers of Napa vnlley, Sonoma Co.; in Santa Barbara In good crystals; near Clear Lake, ike Co., a large deposit. In tbe Yellowstone Park, In deposits and about the fumarolee. S«leiiBiilphar. Contains sulphur and selenium, orange-red or reddish brown; from the islands Vulcano and Lipari.

Rhombohedral. Generally granular massive; sometimes reticulated, reniform, stalactitic.

Cleavage: c highly perfect. Fracture uneven and fine granular. Brittle. H. = 3-5. G. = 5-63-5T3. Luster nearly metallic. Color and streak tin-white, tarnishing to dark gray.

Comp.—Arsenic, often with some antimony, and traces of iron, silver, gold, or bismuth.

Pyr.—B.B. on charcoal volalilizes without fusing, coats tbe coal with white arsenic trioxlde, and affords a garlic odor; the coating treated In R. F. volatilizes, tingeing the ^me blue.

Oba.—Occurs In veins in crystalline rocks and the older schists, often accompanied by ores of antimony, ruby silver, realgar, sphalerite, and other metallic minerals. Thus in tbe

•llT«r mlDM of SasODV; alio AndreaBberr; Joachiauthsl. Bohemlft; tii Hungaiv; Norwar. etc. Abundant at Chatlai^tllo, Cbili- la the U. 8. •parlaglr at HaverbilT and Jackaon N. H.; uear LeadTtlle, Colorado; Walaon Creek, Brltlib Columbia.

Allcmontlte. Arsenical Antimony, SbAsi. In rcQlforni uiasse*. O. = 6-208. LuBter metallic. Color tln-irfalte or reddish gray. From Allemont; PHbnun, Bohemia, etc.

TaUnrlnm. In prlamatic crystals (Fig. 14. p. 10): commonly columnar to flne-graoular mawive. Q. =63. Color lio-wblte. From TntoiyivMiIa and Colorado.

Rhombohedral. Generally tnaMive, lamellar and distinotly cleavable; also radiated; grsnnlar.

Cleavage: c liigblj perfect; also other cleayagee. Fracture nneTen; brittle. H. = 3-3-5. G. = 6'65-6-72. Luster metallic. Color and Btreak tin-white.

Gonp.—Antimony, containing sometimes silver, iron, or arsenic. Pyr.—B.B. on cbarcool fuses, gives a while coaliur In bolb O. F. and R. F.; If the blowing be Intermitted, the globule continues to glow, giving off white fumea, until It Is flnnlly crusted over with prismatic ciystala of antimony iriozide. The white coating tinges the B. F. bluish green. Crystalllzts readily from fusion.

Oba.—Occurs near Sala in Sweden; Andreasberg lu the Bare; Allemont. Dauphin^; Pfibram, Bohemia; Mexico; Chili; Borneo. In tbe U. 8,. at WarreD, TS. J., rare; in Kern Co., Cal. At Prince WillUm parish, York Co., N. Brunswick.

Rhombohedral. Usnally reticnlated, arboreBceot; foliated or granular. Cleavage: c perfect. Seotile. Brittle, but when heated somewhat malleable. H. = 2-3-5. G. = 9-7l>-9'83. Luster metallic. Streak and color silver-white, with a reddish hue; subject to tarnish. Opaque.

Comp., Var.—Bisiiinth, with traces of arsenic, sulphur, tellurium, etc.

Fyr., eto.~B.B. on charcoal fuses and entirely vulattllzea. giving a coating oranpe-yellow while hot, lemon yellow on cooling. Fuses at 266° C. DlBaoIres in nitric acid; Bub»^ueut dilution csiises n wliite precipitate. Ciystallizea readily from fusion.

Obi Occurs in vehia in gucisa and otljer cryBlalliije rocks and clay slate, accompanying

various ores of silver, cobalt, lend and zinc. Thus at tbe mines of Saxony and Bohemia, etc.; HcTmnc. Coi-r^ze, France. Also at Mndum, Norway; at Falun, Sweden. In Cornwall ana Devonshire; near Copiapo. Cbili; Bolivia.

Occurs nC Monroe, Conn.; Brewer's mine, Cheaterfleld district, S. Car.; near Cummins City, and elsewliere In Colorado.

Zlno. Probably does not occur in the native Btate. In tbe laboratory It is obtained iu hexagonal prisms with tapciing pyramids; also in complex crystalline aggregates. It also appears to crystallize In the laomelrlc system, at least in various alloys.

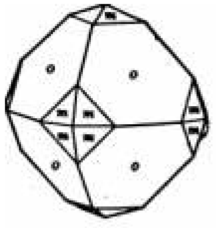
Gold Group.

aoij>.

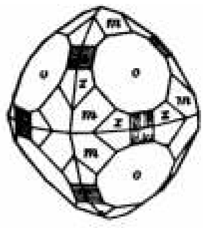
Isometric. Distinct crystals rare, o most common, also d (110), m (331), aud X (ISlO'l); crystals often elongated in direction of an octahedral axis, giving rise to rhombohedral forms (Figs. 452. 453, p. 135), and arborescent shapes; also in plates flattened | o, and branching at 60° parallel either to the edges or diagonals of an o face (see pp. 131, 132). Twins: tw. plane o. Skeleton crystals common; edges salient or rounded; in filiform, reticulated, dendritic shapes. Also massive and in thin laminse; often in flattened grains or scales.

Cleavage none. Fracture hackly. Very malleable and ductile. H. = 2-5-3. G. = 15-6-19-3, 19-33 when pure. Luster metallic. Color and streak gold-yellow, sometimes inclining to silver-white and rarely to orange-red. Opaque.

Comp^ Tkt. —Gold, bnt nsnally alloyed with silrer in Taiying uDonnta snd sometimes containing also traoea of copper or iron.



m = (311)



x = (18·10·1)

Tar.—1, Ordinary. Contalalng up to 16 p. c. of ailver. Color varying uccoi-dingly from deep gold-yellow lo pale yellow, aud specific gravity from 19-3 to 16 5. TLe ratio of

Sold lo silver of 8 : 1 cnrrespondB to 15*1 p. c. silver. For Q. = 17-9, Ag = B p. c ; ■. == 16-8. Ag = 18-3; G. = 14-6, Ag = 38'4, Rose. Tbe purest gold wiiicb Itiis beeu deicribed is ttiat from Mount Hur^iin, In Qiiueusland, whicli lius yielded B9'T lu B8-8 of gold, tlie remainder being copper witli a, little iron; silver is present utily as a rainiKe inLce.

2. Argentiferout: BUctrum. Color pale yellow to yellowiab white; G = I5'5-13*5. Rntio for the gold and silver of 1 : 1 corresponds to 86 p. c. of silver; 1^ : 1, to 26 p. c; 2:1. t<) 31 p. c.; 3^: 1, to 18 p. c. The word in Ureek meuns also amber; aud its use tor this alloy probably arose from the I'sle yellow color it bos as com)mrtd with gold,

VtLrietics have also Oeeu described coutaiuiiig palladium to 10 p. c. (-porpenU), from ' Porpez, Brazil; bismutb, lucludlog the black gold of Aiistralia [.miUdonite, Ulricb); also rliodium(?l.

PyxT Mo.—B.B. fuses euaily (at 1100" C). Not acted on by duxes. Insoluble in any siugle acid; soluble io uiiro-bydrochloric acid (aqua regia), the separation not complete if more than 30 p. c. Ag Is present.

Di£—Readily recognized {eg., from other metallic minerals, also from scales of yellow mic'i) by lis malleubillty and high specific gravity, which last makea it poitsible to se|>ttrBte it from the gaiigue by waabiug; distinguished from cbalcopyrite and pyrile by Insolubility in nitric acid, both of which are brittle.

ObiarvaUons—Native gold Is found, when in titu, with compafatively amall eiceptioos in the quartz veins that iniersect metamorpblc rocks, and to some exteut in the wall rock of these veins. The melaraorphic rocka thus intersected are mostly chlorltlc talcose and argillaceous schist of dull green, dark gray, and other colors: also, mueh le^ commonlv. mfca and horablendic schist, gneiss, diorite, porphyry; and still more rarely eranKfi A laminated qiiartzlte, called Itacolumlte. is common in many gold regions as those of Brazil and North Carolina, and sometimes specular schists, or slaty rocks containing much foliated specular Iron (bematile|. or magTielite In grains. A qunrtzose conelomerale Is somotlmea richly auriferous as in Transvaal. Less frequently catcitc Is the vein material

The (!old occurs in the quartz. Irregularly dUtribuled. In strings, scales, plales. «n(! tn masses which are sometimes an aKlomeralion of crystals; and the scales are often Invlalble to the naked eye. The aasociateT minerals are: pyrite, which far exceeds In quantity all others, and Is generally aur^Tmu; neit, cbalcopyrite, galena, sphalerite arsenopyrite each frequently auriferous; often tetradymlte and other lelliirium ores native bismuth native araeuic, slibuile. tJonabar magnetite, hematite: sometlmasbarite, sc'ieellle. apatite, fluorite. sldente. chrysocolla. The quartz at the surface, or in Ihe upper part of a vein Is usuallv cellular an<i rusted from the more or less complete disappearance of the pyrite and other sulphides by decomposition; but below, It Is commonly solid

The gold of the world was early gathered, not directly from the quartz vHna ftlie " quartz i-eefs of Australia and Africa), but from the gravel or snnds of rivers or vallevs In audferoua regions, or the slopes of mounlalni or hills, whose rocks contain in snme nnrt and generally not far distant, auriferous veins; In Catifomia tbiR method of hvdriVilIc mining (yiaeer digging*) has been carried on on a rtupendous scale. Host of the'gold ol

tbe Urals, Brazil, Auatimlla, and sll otber gold redone bascotne from luch sllurlal wasbtngs. At the present time, however, tbe alluTul wnabrnga are mucb leas depended upon, In many regious all the eold being obtained direct from tbe rock.

Tbe ulluTialgold is usually in flutleued scales of different degrees of flnenesa, tbe sjxe depeuding partly on the original couditjun in the quarlz veins, and partly on the distance to which It has been traiispoi'led iind assorted by running water. The rolled masses when of some size ore called ntiffgtts; in rare cases these occur very large and of great value. TLe Australian gold region bas yielded many large nuggets: one of tbese found In 1858 weighed 164 pounda, and another (186B) weighed 190 pounds. In the auriferous sands, crystals ot zIrcoD are very common; also garnet and cyanlte Id grains; often also monazlte, diamond, topaz, corundum, iridosmiue, platinum. Tbe zlrcona are aometimea mistaken for diamonds.

Besides tbe free gold of the quartz veins and gravels, much gold la also obtained from auriferous sulpbldea or the oxides produced by their alteration, especially pyrite, also arwnopyrlte, cbalcopyrite. sphalerite, marcasite, etc. The only minerals containing gold la combioatiou are the rare lellurides (sylvauite. etc.).

Qold exists more or less abuudautly over all tbe continents in most of tbe regions of cryslalline rocks, especUUy those of the semi-crystal line scblsis; and also iu some of tbe larpe Islands of the world where such rocks exist. In Europe, it occura with silver ores iu Hiiugary; in Transylvania at Verespaiak and Kagy^; in tbe saods of the Rhine, the Danube, and other rivers; on the southern slope of the Pennine Alps; In Piedmont; In many of the streams of Cornwall; in North Wales; In Scotland, neat Leadhllls; in the county of Wlckliiw. Ireliiud; in Sweden, at Edclfora; in Norway, at Kougsberg.

Iu Asia, gold occurs along tbe eastern fliUJks of the Urals for 500 miles, and Is especially abuudaut at tbe Berezov miues near Ekaterinburg: also at Fetropavlovski: Nizhni Tagilsb; Hiask, near Zlatoust and Ut. Ilmen. etc. Ekateruiburg is tbe capital of the mining district. Siberian mines less extensive occur in tbe lesser Altai; nt Nerchinsk, east of L. Baikal, Including the Earn mines. Aaialic mines occur also in Little Thibet, Ceylon, and Malacca, China especially In tbe Amur district, Corea. Japan, Fomiosa, Sumatra, Java, Borneo, tbe Philippines, and other East ludia Islands; at uumerous points in British India.

In Africa, gold nccura at Kordofan, between Dartur and Abyssinia; also, south of the Sahara in western Africa, from the Senegal <o Cape Palmas. Also In Transvaal In southern Africa, at Lydeuburg, liotb quartz veios and alluvial washings, and at Eeratellng; recently the Kaap gold fields in souchenstem Transvaal have liecome very productive; the chief town of the region is Biirberlon. The quartz reefs of Witwatersrand In tbe immedlata vicinity of Johannesburg, farrber west, are also veiy productive; here the gold occura largely la a quartzose couglomcrate.

In South America, gold is found in Brazil; In the U. B. of Colombia; Chill; Bolivia; sparingly In Peru. Also in Central America, especially In Honduras; also San Salvador, Guatemala, Costa Ilica.

In Australia, the principal gold mines occur along the streams In the mountalas of New South Wales and along the continuation of tbe same ranee in Victoria. Also obtained largely in Qiieensbind. N. Australia, panicular iy at Mt. Morgan, Rockbamptnn district Alan occurs in Tasmania, New Zealand, and New Caledonia.

In North America, there are numberless mines along the mouiilalna of western America, and others along the enslem range of the Appalachians from Alabama nnd Georgia ,to Labrador, besides "ome in portions of tbe intermediate Arcbean region about Lake Superior. Th'-v occur nl many potnis along the higher regions of the Rocky Mountains. in Mexico; in New Mexico, near Santa Fe, CerllIos. Avo, etc.; In Arizona, in Ihe San Fraadscn. Wn.ibi, Yuma, and other diatricts; in Colomdn. abundant, tbe gold largely in auriferous pyrites, also in connection with tellurium minerals; tbe Cripple Creek reeinn In Colorado affords at present laree quantities of gnld; also in Montana: the Black Hills of Dakota; Idaho espectallv the Ccsur d'Alfine district, also Utah. Along ranges between the summit and the Sierra Nevada, in the Humboldt region and elsewhere. Also in Ihe Sierra Nevada, mostly on its western slope (the mines of tbe eastern being principally silver mines). The auriferous belt may be said to begin in the Callfomian peninsula. Nenr the Tejon pass ft enters California, and beyond for 180 miles it Is sparingly auriferous, the slate rocks being of small breadth; but beyond this, northward, the slates increase in extent, and tbe mines In number and productiveness, nnd thev continue thus for 200 miles or more. Gold occurs also In the Coast ranges in many localities, but mostly in too small quantities to he profitably worked. The regions to ibe nortii in Oregon and in Wnshiiiglon and Alaska, with British Columbia, are nt mnnv points auriferous, and productively so. iboueh to a less extent than California, The Cnrihoo region on the Prawr river, and Ibe C'lssiar district oa the Stickeen, have yielded considcmble amounts. The Alaska quartz mines have

btsen worked lo some advaiitage. u also ilie gravels of the Yukon river and fti Iributaiiea; of Ibe lutter, Iho Klondike U now <ie98) reputed to be fabutouslj rich.

lu eaateru Noi'lb America, the cbief mines are mostly coDflued to the Stales of Virginia, North and South Carolina, and Georgia, or along a line from the Kappahannock to the Coosu lu Alabama. In Canada, gold occurs to the south of the 8t. Lawrence, In the soil od the CbaudiSre and elsewhere; In Nova Scotia, at Deloro, near Hastings, Ontario {In arseno-pyrile), also lu the Port Arthur region, north of Lake Superior, and In the river-gravels of the Paciflc slope, as before noted.

The world's production of gold was In 1897 about 9300,000,000, having considerably more thnn doubled Hlnce 1890. Of this amount the United States afforded about $B1,600,-000, Africa about t6S.000,0OO, Australia nearly fSO.OOO.OOG, Russia about $2«.TOO,0Oo, and other countries (China, Canada, India, So. America, etc.) the remainder. It is also interesting to note that in ltJS7 ilie production was nearly the same for tlie States of California anil Colorado, the former (17,000,000, the latter a little la ezcesB of this amount. In 1890 Colorado produced only a little more than t4,000,000.

shjVer.

Isometric. Crystals commonly distorted, in acicnlar forme, reticulated or arborescent Bhapes; coarse to fine filiform; also massive, in plates or flattened aoales.

Cleavage none. Dnctile and malleable. Fracture hackly, H. — 2'5--3. G. = lO'l-ll'l, pare 10-5. Laster metallic Color and streak silver-white, often gray to black by tarnish.

Comp^ Tar.—Silver, with some gold (op to 10 p. c), copper, and sometimes platinum, antimony, bismuth, mercury.

Pyr- ate.—B.B. on charcoal fuses easily to a stiver-white globule, which in O.F. gives a faint dark-red coating of silver oxide ; crystallizes on cooling; fusibility about 1050° C. Soluble in nitric acid, and deposittrd again by a plule of copper. Preclpitaied from Its

■oluLions by hydrochloric acid In while curdy forms of silver chloride.

—Dlatfnguished by lis malleabilily, color (on the fresh surface], and specific gro

■iij.

ir in arborescent and fllifomi shapes, in vi ...-,. ir rocks. Also occurs disseminated, but usually

invisibly, in native copper, galena, cbalcodte, etc.; rarelv in volcanic ashes (Halirt).

The mines of Kongsberg. fn Norway, have affordtd magnificent specimenR; alao the Baxon mines; occurs in Bohemia at I^bram and Joachimslhalj at Andreaabcrg; HiiDgaiy: AlleiDont, Dauphint: In the Uml near Berezov; in the Altai, at Zmeov; and in some of the Corniali mines. In Dumngo, Sinaloa, and Sonera, In Mexico, are noted mines affording native silver; abundant In Peru.

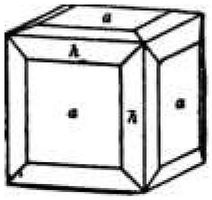
Id the United States disseminated through much of the copperof Michigan; at Silver Islet

and at Port Arthur, Lake Superior. Occurs in Idaho, at the "Poor Man's ^ide": in Nevada.

• aq rare: in California, sparinElyi In Silver Mountain district. Alpine

' Co,: In the Maria vein, in Los Angelea Co. Id Colorado, at many

localities, especially with argentfferous ores; hi Montana, near Butte, Silver Bow Co., with manganese ores. In Arizona, at the Silver King mine, and with argentiferous ores elsewhere.



OOPPBR.

Isometric. The tetraheiahedron the most common form (Fig. 587); also in octahedral plates. Crystals often irregularly distorted and passing into twisted and wire-like forms; filiform and arborescent. Massive; as sand. A = (<10) Twins: tw. pi. o, very common, often flattened or elongated

to spear-shaped forma. Cf. pp. 131,132.

Cleavafre none. Fracture hackly. Highlydnctile and malleable. H.= 2-5-3. G. = 8S-8'9. Luster metallic. Color copper-rod. Streak metallic shining. Opaque. An excellent conductor for beat and electricity.

Comp.—Pure copper; often containing some silver, bismuth, mercury, etc, Pyr., ato.—B.B. fuses readily; on cooling becomes covered with a coaling of black

oxide. DUsolres retdfly In nitric acid, etvlng off red oltrous fumei, and producer a deep azure-blue solution with wnmouis, FusTbiiity 7S0° C,

Obo, —Copper occurs In bedsaDd veins accotnpaaying its various ores, especially cuprite, malacbite, and azurlte: also wllli the sulpbldes, clialcopyrile, chulcociie, eit;,; ulten abuiidaDt In Lbe vicinity of dikes of Igneous rucks; also in clay slaie and sandstone.

Occurs at Tiiriusk, in tbe Ural, iu flne cryslals; at Nizhni Tagilak and elsewbere; Silwria. In Germany, at Uie Friedricbssegen mine, Kassnu. Common in Cornwall, Brazil, Clilli, Bolivia, and Peru uSord uative copper. Iu Boutb A.ustralliL abuudnnl at Wallaroo; iu New South Wales.

Octiin DBiive tlirougboui tbe red sandstone region oF lbe e.<s1eru Uuited Slates, spar^ ingly In Hassuchusclts, OonDeclicui, and moiu abundantly in New Jersey. Near New Haven, Conn., a mass was found in the drift welching nearly 200 ponuda; amsller iaolnted masses buve also been fouud. The Lake Superior copper region, near Keweenaw Point, iu norCbcm Micblean. is tbe moat Important locality in the world. The copper is obtained practically all in tne native state, soineiimes tn immeuse masses, and is obtained over an area 200 milea in length. It occurs in both amygdaloldal dolerite and aundstooe, near Uie jiiuctioQ of these two rocks; associated with cnJcite. prehntte, datolite, anatcite, etc.; also distributed widely in grains through tbu sandstone. Occurs sparingly iu California. In Arisoua, common at tbe Capper Queen mine, Cochise Co.; also In Grant Co.,

N. Mexico, «t tbe Sauia Rita and olber mlues.

MBROURT. Quicksilver. Oediegeo Quecksilber Oerm,

In small fluid globules scattered through its gangne. G. = 13*596. Ltu-ter metallic, brilliant. Color tin-white. Opaque.

Conp.—Pure mercnry (Ug); with aametimes a little silver.

Pyr., atc—B-B. entirely vtilalile. vaporizing at 8S0' C. Becomes solid at — 40* C, crystallizing in regular octahe<lTonB with cubic cleavage; G. = 14'4. Dissolves iu nitric acid.

Oba.—Mercury in the metallic stale is a rare mineral, and is usually associated with the sulphide ciunabar, from wblcli the supply of commerce is obtained. The rocks affording the metal and its ores are cblefly clay shales or scbisla of different geological ages. Also found in connection witli bot apriugs. See cinuabar.

ZiBAI).

Isometric. Crystals rare. TJaually in thin plates and small globular masses. Very malleable, and somewhat dactilo. H. = 1-5. G. = 11-37, Harstig mine. Lnster metallic Color lead-gray. Opaque.

Conp.—Nearly pure lead; sometimes contains a little silver, also antimony.

Pyr.—B.B. fusea easily, coating the charcoal with a yellow oxide whlcb, treated fn R.F., volatilizes, giving no azure-blue tinge to tbe flame. Fusibility 880° C. Disaolvei easily iu dilute nitric acid.

Ob«,—Of rare occumtnce. Found at Pajsberg, BarsiU. and Lftugban Iu Sweden; similarly at Nordmark; also In the gold washings of the Ural; reported elsewhere, but localities often doubtful. In tbe U. &., occurs at Breckinridge and Qunnison, Colorado; Wood Kiver district, Idaho,

AaOAIXIAM.

Isometric. Common faabit dodecahedral. Crystals often highly modified (Fig. 100, p. 39). Also massive in plates, coatings, and embedded grains.

Cleavage: d ia traces. Fracture conchoidal, uneven. Hather brittle to malleable. H. = 3-3-5. G. = 13-75-14-1. Luster metallic, brilliant. Color and streak silver-white. Opaqae.

Conp.—(Ag,Hg), silver and mercury, varying from Ag.Hg, to Ag„IIg. -

'Vmi.—Ordinary amalgam, AggHp, (silver S&i p. c.) or AgHg (silver 3G'0j; alto AgiRgi, etc.

Arquenl*. Ag„Hg (Bilver 86-6); G. =10-8; malleable and soft. Kongt-bergiu. Ag.,Hg or Ag,.Hg.

Pyr., ato.—B.B. on charcoal tbe mercury volatiliiea and a globule of sliver Is left In the closed tubp the mercnry sublimes and condenses nn tbe cold part of tbe tube In minute globules. Dissolves in nitric acid. Itubbed on copper it gives a silvery luster,

Oba.—From the Palatinate at Moschellandsberg; at Frtedrlchsaegen, Nassau; fiem

Bala. Sweden; Eongaberg, Norw&y; AUemoDt, Daupbiu^; Almadeu, Bpoiu; Ctiili; Vitalle Creek, Br, Columbia (arqvarile).

Tin. Native liu baa beeu reported from seTeral Inralities. The only occurraoce Tairly above doubt is Ibat from the waaUlnga at (he beadwatera of the Clarence river, near Obiia, Nen South Walea. It has beeu found here iu grajiah-white rouaded grains, with platinum, Irldosmine, gold, coaelterite, and corundum.

PlatiDuiD*Iroii Group.

Isometric. Crystala rare; nsnally in grains and scalea.

Cleavage none. Fracture hackly. Malleable and ductile. H. = 4-4'5. Q. = 14-19 native; 21-33 chem. pure. Luster metallic. Color and streak whitish steel-eray; ehining. Sometimes magnetipolar,

Comp,—Platinnm alloyed with iron, iridium, osmium, and other metsls.

r only eligbtly magnetic. O. = 16-6-18-0 mo«ily.

f. !_ _.j '---"-" ■^aa polarity,

B „..,_..j p.. , „ ,..„u-platlunm,

jliuenplatin 6erm.\ altbougb this dlsliociioii does not bold vitbout eiceptioD.

Pyr., sto.—B.B. iufusible. Not affected by borax or ult of phospbonia, except In the Btate of fine duat, wheu reactions for Irou and copper may be oblained. Soluble only in healed uitro-bydrocbloric acid.

Dlfi.—Disttuguislied by lis color, malleability, high apecIUc gravity, Infustbllity and

nil grains, aasoclaled wllb Iridium, T Pinto, In tlie district of Choco, ina (platlna del Pinto) from p'

_ ial mulerial in the Ural at Ni

Tagiisk. and with chromlle in a Berpentlne probably derived from a perldotite; also ii Qoroblagodatsk district. Alao found on Borneo; In New Zealand, from a region cbaracterized by a cbryaollte roclc witb serpentine; in New South Wales, in the Broken Hill district, and in gold washings at various points.

Id California, In tbc KlamnlU region, at Cape Blanco, etc., not abundant; in the gold washings of Cherokee, Butte Co.; ut St. Francois. Beauce Co., Quebec; at several points in Briiteh Columbia.

Iridium. Platin-irldlum. Iridium with platinum and other allied metals. Occurs usually in aneular grains of a silver-white color. H. = 6-7. G. = 23'6-83-8. With tha platinum of the Urala and Brazil.

IRIDOBMINB. Osmlrldlnm.

Rhombohedral. Usually in irregular flattened grains.

Cleavage: c perfect. Slightly malleable to nearly brittle. H. = 6-7. G. = 19-3-21-12. Luster metallic. Color tin-white to light steel-gray. Opaque.

Comp., Tar.—Iridium and osmium in different proportions. Some rhodium, platinum, ruthenium, and other metals are uenally present.

Var.—1. Ifwj/arukiU. H. = 7; G. = 18-8-19-5. In flat scales; color tin-while. Over 40 p. c, of iridium. 2. BUvnkiU. In flat scaleii, often sii-Bided, color grayish while, steel-gray. G. = a>-8rS. Not over 80 p. c. of Indium. Less common than ihe light-colored

Dii—Distiaguiahed from platiuum by greater hardness and by Its lighter color.

Oba.—Occurs witli platinum in South America; in the Ural mountains; in 'auriferona drift in New South Wales. Rather abundant iu the auriferous beach-Bands of norUiem California,

PaUadinm.—Psllailium, alloyed willi a little plallnum H.=4-5-5. G. = 118-ll-8. ColorwL-" ' ' " bIso from tbe Urn is.

Isometric. Uaoftlly massive, rarely in crystals.

Cleavage: a perfect; also a lamellar etruotnre Q o and | d. Fracture hackly. Malleable. H, = 4-5. Q. = 7-3-7-8. Luster metallic. Color steel-gray to iron-black. Strougly magnetic.

Vkt. —1. TMTMtilal Iron. Found Id nuisaes, occ&aloDally of Kre&t'Bize, as well as Id small embedded panicles. Id busalt at Blaafjeld, Ovifak (or Ulfnk), Disko Isliiud, West Greeoliiudi also elsewhere on the aame coast. Tills Iroo codIhiub 1 to 3 p. c. of Nl. Some olher occuireDces. usually classed ns meieoric, miiy be la fact terrestrial; «.g., the Sitota Calhiirina iron of Brazil discovered lu t87S.

A nickellferoiis metallic iron (FkNIi) called awarut(« occurs lu Ihe drift ot tbe Gorge river, which empties into Awarua Bay on the west coast of the south Uluud of New Zeuland; Associated with go!il, plalluum. ctissilerile, chromEle; probably derived from a partially serpentlnteed peridotlte. Joatpkinilt is a uickel-lrou (FeiNii) from Oregon, occurring In stream gnivel. Native Iron also occurs sparingly lu some basalts; reported from gola or platinum washings at various points.

H. H«t»orio Iron. Nntlve iron a1>o occurs to most meteorites, forming in some cases (a) the entire mass (iron meUoritet-, also (b) os a spongy, cellular matrix in nhich are embedded grains of chrysolite or other sllicai miiidtroliit*); (e)in grains or scales disB«mtuated more or leas freely [hroughioul aalony miklrix {meUorie ...

tlone»). Rarely a meteoiite consists of a single cryaial ^"º-

Hue individuiil (Briuuau) wlili nunieniiis twlnulng lamellffi | o. Cubic cIuiiVHt'e gometlmesobserved; also an oclahedral. less oflen dodecnliednil Inmellar alnic-iiire. Etcliliig wiih dilute nitric acid (or Iodine) commonly di'vrlopa a crystalline stninlure (called Wtdmanttdtten figuru) (F!g. 088); usually cousisiiug of tines or bands crossing at various nnctts according lo the direction of the seeKon. at G0° if \o. W \ n. etc. They are formed by the edges of ervsinlline plates, usually I o. of tbe nickeliferoiis iron of different composition {kamaeiie, taniU, pUuiU), iia sliiiw[i by the fact that they are differently attacked by the acid. Irons with cubic structure Hiid with twinning lamells

\t.g., Brauuau) hare a aeries of fine lines correspond I

log lo those developed by etching (Neumann lint»\ /ii ^ . -u. -u u '

A d..n«K»™ lu,i., I. alio prod.fcil I., «.»i. cuei, '"»'<"* Ml- H." Mex,, o

due to quadrilateral depressions. Borne irons show no distinct crystalline structure upon

The exterior of masses of meteoric iron is usually more or less deeply pitted with rounded IbumbUke depressions, and the surface at llie time of fall la covered wiib a film of iron oxide in fine ridges showing lines of flow due to the mellinc caused by iliu heat developed by the resistance of the air; this film disappears when the Iron Is exposed lo the weather.

Meteoric iron is always alloyed with nickel, whkh is usually present In amounts varving from 5 to 10 p. c.. sometimtES mucli more; small amounts of other metals, aa cobalt, manganese, tin. copper, chromium, are also often present. Occluded gases cnu usually be detected. Qraphlte. in aeams or nodules, also troilite (iron sulphide), scbrelberaite(irou-nlckel phosphide) are common in masses of meteoric iron; diamocd, daubreellte, etc., are rare. CoheniU, sometimes Identified, is (Fe,Ni.Co),C In tin-white crysUlsL

.dbyGooglc

DESCRIPTIVE MISEUALOQT.

n. SUZiFHIDEB, SKLENIDES, TKLIiURIDES, AKSXnTIDES, ANTXMONIDES.

The Bnlphidee, etc, fall into two Gronpa according to the chsraoter of the positive element.

I. Snlphides, Seleniden, Telltiridei of the Semi-Metalfi. n. Salphidea, SelenidoB, Telluiidea, Anenidea, Antimonidea of the Metals.

I. Snlphidea, etc., of the Seml-Metala.

This section includea one distinct group, the Stibnite Group, to which orpiment is related; the other apeciee inoladed stand alone.

HZ1AI.OAR.

Monoolinic Axes i-A:i = 1-4403 : 1 : 0-9739; /3 = 66° 5'. 88» mm"', 110 A liO = 105' 84'. rr', 012 a 013 = 47* 57.

j^'i I y\ Crystalashort prismatic; striated vertically. Also grannlar,

// *' l^^ coarse or fine; compact; as an incrustation.). ^L'^t] Cleaves: b, rather perfect. Fractnre small conchoidal.

; Y' ;] 1 Sectile. fl. = l'5-2. Q. = 3'556. Lneter reainoiia. Color I I • I) aurora-red or orange-yellow. Streak varying from orange-red o^(J i-n^j, to anrora-red. Transparent—translucent. ^ '.' /} Comp.—Arsenic monosnlpbide, AaS = Sulphur 39 '9, arsenic

V' J-' 70-1 = 100.

V .~^^ ^3^1 ato.—In tlie closed Inbe mulu, volatilizes, snd gives a tnuis.

Natrvfiff parent red sublimsiei Id llie open lube (if heated very slowly] gulpburous

fumea. and a wbite cryarsllitie lubllniaie of arsenic trioxIda. B.B. on charcoal bums with a blue flame, emltllug areeolcal and suliriiuroua odors. Soluble in caustic alkalies.

Obs.—Orieu associated witb orpiment: occurs with ores of silver aud lead, al FelsCbdnyk and Kapnik, Huu^Hry: Nagya^ Joacbimsthal: Scbneeberg; Andreasberg; Blnm^uthal, Swltzerlaud, in dolumlte: nenr Jul nine rk lu Eiirdisian. lu the U, S., In Iron county, Ulab; alsoia California, San Berusrdino Co.; Trinity Co., In calcile. Norrls Geyser Basin, Yellowstone Park, as a depoeilinn from the hoi waten. The naipe rtaigar is from the Arabic Rab j al ghSr, powder <ff the mint.

Monoclinio.* Axes d : X : <! = 1-2061: 1: 0-6743, ft = 90°. approx.

Crystals small, rarely distinct. Usnally in foliated or columnar tt aometimes with reniform surface.

Cieavage: b highly perfect, cleavage face vertically striated; a in traces; gliding-plane c (001). Sectile. Cleavage laminsfiexible, inelastic. H. = r5-S. Q. = 3'4-3-5. Luster pearly on b (cleavage); elsewhere resinous. Color lemon-yellow of several shades; streak the same, but paler. Subtranaparent— subtranslucent.

Comp.—Arsenic triaulphide, A8,S, = Sulphur 39-0, arsenic 610 = 100.

The floe crystals from H«rcur, Utah, nre distinctly

Pjrr^ eto.—lu the cloaed lube, fiiws, TolMilizet, and gives a dark yellow sublimate; other reactiODB ibe suae as under realgar. Dlstolvea In aquu regis aud caustic alknlies.

Diff,—DlsiiuguUhed by iu fine yellov color, pearl; lualer. easy cleuvoge, aud Qexiblllltj when iu pU;e8.

Obs—Occurs In small ciystals !□ cisj at Tajonn, In Upper Buugaiy; in foliated and flbrou? mawes. alMoldawalu ibe Ban&t; ni Kapnlk and FelsSb&uyit in nietnlllferous veins; al ibe Hulfalura near Naples. Near Julumerk in EurdistsD a large Turkiali mitje. Occurs wltlt realgar in senuis lu compact clay beneatti lava in Iron cuimty, Utub; also fiuelv crystallized at Hercui. Among Ibe deposiu of the Steamboat Springs, Nevada; also nilb

Stibnitfl

Bismathuiite

Oouu^natite

Stibnlte Group.

Bi.S. Bi.Se,

0-9926 : 1 : 10179

0-9679 : 1 : 09850

1 : 1 approz.

The species of the Stibnite Qronp crystallize in the orthorhombic system and have perfect bracbydiagonal cleavage, yielding flexible lamiiife.

Tbe speck's orplment is In pbyaical properties somewbat related 1o stibnite. but KCms to be monocliulc in crystallizalion. Orolh notes tbat the oilde, AstOi. is inouocliulc la ckudetiie. while the corrcspouding compound. Sb,0.(vaIentiuIle), iBorthorbombic; further he remarks on the relatlou in form aud pliysi(»l characters between orplment and cluudetfle.

STIBNITE. Antlmonite, Antimony Qlance, Gray Anltmony, Antlmonglauz Gmtn. Orthorhombic. Axes a:l:d= 0-9936 • 1 : 10179.

", no A 110 = 89*84'. Ill A ill = 71*341'. 118 A 118 = 85° 62i'. 118 A li3 = 86"B8'.

60, 010 A 131 = 88° 8'.

fur. 010 A 853 = 40* 104'.

6r, 010 A 848 = 46* 88'.

bp, 010 A 111 = 51° W.

Crystals prismatic; striated or furrowed vertically; often curved or twisted (cf. p. 148), Common in con aoo. rbi koq

fased aggregates or radiating groups of acicnlar crystals; massive, coarse or fine columnar, less often granular to impalpable.

Cleavage: b highly perfect'. Slightly sectile. Fracture small snbconcboidal. H. =2. G. = 4-52-4-62. Luster metallic, highly splendent on cleavage or fresh crystalline Burfaces. Color and streak lead-gray, inclining to steel-gray: subject to blackish tanitsh, sometimes iridescent

Comp,—Antimony trisulphide, 9b,S, = Sulphur 28'6, antimony 71*4 = 100. Sometimes auriferous, also argentiferous.

pyr^ "te^Fuses very easll;^ (at 1), coloriog the flame frreenlab blue. In the open tuba

a>

California.

Hungary.

D-volatile. On charcoal fusae, spreads <

fumefl. aod contB Ihe co&l while wilh oiide of Rnttmony; this cofttlog treated In R. F.

volatilizes nnd tloces iheUame ftreenlsb blue. When pure perfectly soluble Id bydrocblorio aclil: in iiilric acia decumposed willi sepanttlOD of natliiiouy peuloxide.

Dift—Distinguislied {e.g., from giilemL) by cleuTtige, culor. softDesB: also by its fusibility und other bTiiwpIpe tharBcters. It fa Lanier tbau graphite. Resembles someLinies certain of ihc rarer sulphauiimouites of lend, but ylelila tio lead coatlug ou charcoal.

Obi.—Occurs niiii quartz lit beds or veins In granite and gneiss, often accompsDied witb viirloiis other iinrlnioiiy minerals produced ay ita alteration. Aha aasociaieii in metalliferous deposits witU sphalerite, galena. cinoatHir, barlle, quartz; sometimes accom-puuies native gold.

Occurs at Wnlfeberg, in the Ban; Brnunsdorf, near Freiberg; I^bram; Caiparizecbe. near Arnsberg, Weglphalin; Fel»Sli6uya, Hungary; In Cornividl. abundant Alio abundant tu Borneo; in Victoria and New South Wales. Groups of large splendent crystals have come from the antimony minra in the Province of lyo. island of fihikobu. Japan.

In Ibe United States occurs as a. vein of some extent iu Sevier county, Ark.; in Call* fornia at San Emlgdlo. Kern county, aud neur AItu, Benito Co.; in the Humboldt mining reginn in Nevada; tn Iron county, Utah. In New Brunswick in Prince William. YorE county, 30 m. from Frederfcton; In Rawdon township, Hnnis Co.. N. S.

Mataatlbnlte. An amorphous brick-red deposit of iiinimouy trisulphide, SbtSi, oc-currinc vrilb clnoabar and araenfc sulphide upon siliceous sinter at Steamboat Springs, Washoe Co., Nevada.

BISUDTUINITB. Bismuth Glance. Wismuthglanz Qwm. Orthorhombic. Harely in acicular crystals, mm''' = 88° 8'. Usually massive, foliated or fibrous.

Cleavage: 6 perfect. Somewhat sectile. H. = 2. G. = 6'4-6'5. Luster metallic. Streak and color lead-gray, iactJning to tiu-white, with a yellowish or iridesceDt tarnish. Opaque.

Coaip.—Bismuth tristilpnide, Bi,S, = Sulphur 188, bismuth 81-^ = 100. Sometimes contains a little copper and iron.

Pyr^ etc—Fusibility = 1. In the open tube sulphurous fumes, and a while sublimate wliich B.B. fuses into drops, brown while bot and opaque yellow on cooling. On cbar-coiil at first gives sulphurous fumes; then fuses with spirting, and coats the coal with yellow bismuth oxide; wlih potassium iodide a bright red contlng of bismuth iodide is obtMliied. Dissolves readily In hot nitric acid, and a while precipitate falls on dllnllDg with water,

Oba.— Found at Brandy Gill. Carrock Fells, in Cumberland; near Rednilh. etc. In Prance at Meymac, Corrdze: at Jolianugeorgeuscadt, Scbneeberg; at Witticben, Baden; at Riildnrliyitan, Sweden; near Borata, Biilivla.

In the U. B., occurs with gold in Kowan Co., N. C, at the Bamhnrdt vein; sparingly at Willlmantic, Conn.; abundant in Beaver Co . Ulab.

OnanaJuatiU. Frenzeliie: Selenwismnthtflanz Qerra. Blfimuth selenide, Bi.Sei, sometimes with ii small amount of sulphur replncing selenium. In acirular crvslals; also massive, granular, foliated or fliiroiis. Cleavage: B distinct, H. t= 2-5-8-5. 'G. = 6 25-6-63. Luster mei«llic. Color bluish gray. From the Santa Catarina mine, near Guanajuato, Mexico.

TBTRADYMITB. Tellnrwlsmuth Germ.

Rhombohedral. Crystals small, indistinct. Commonly in bladed forms, foliated to granular massive.

Cleavage: basal, perfect. Laminae flexible: not very aectile. H. = l'5-2;

soils paper, G. = 7 2-7'6. Lttster metallic, cplendent. Color pale steel-gray.

Comp., Tar.— ConeiBta of bismuth and tellurium, with sometimes snlphnr

and a trace of selenium; the analyses for the most part afford the general

formula Bi,(Te,S),.

BI,Te, =

SO 0 ~ 100. Tbia is Ibe more cominaD vorletj and Include* tbe Uiradymite ot Uiildinger Id crystals from Bchubkaii.

F^.~Iq ilie open tube a wblte sublimate <St tellurium dioxide, which B.B. fuses to colorJesa drops. Od cbarcoal fiues, give* white fumes, and entirely rolatillzes; tin^ tbe RF. bluish green; couls the coal at first wblle (TeO,), and finally orange-yellow (Bi,0,); some v&Hellea gWe siilpburous and aelenoua odors.

aba. —Occut^ at Schubkau near Bcbemoltz; Rezbunya; Orawilza in the Banat; Telle-mark in Norway; Bastuaes mine, near RiddHrhyltiin, Sweden. In tbe U. S., in Virginia Bt the Whiteliall gold mines, Spotuylvanla Co.; in DaWdson Co.. N. C. aud Id tbe gold washines of Burke and HcDowell coiintles, etc.; similarly in Honlaua. At thu Uonlgomery mitio, Arizona. Named from iftpdSvitoi, fowfold, in allusion to complex twin crystals sometimes observed.

JoaolUL—A blimulh tellurlde (Te 80 p. c, aleo 8 and 8«). Q. = 7'9. San Jos£, Bnull.

WshrUte. A foliated bismuth tellurlde (Te 80 p. c.) of doubtful fonnula. O. = 8'4. Deutscb-PIlsen, Hungary.

MOLTIUDDHmi. HoljbdaDglaDZ Oerm.

Crystals hexagonal in lortn, tabular, or short prisms slightly-tapering and horizontally striated. Commonly foliated, masaive or in scales; also fine gran utar.

Cleavage: haaal eminent. Laminee very flexible, bat not elastic. Sectile. H. = l-l*5. G. = 4'7-4'8. Luster metallic. Color pure lead-gray; a bluish gray trace on paper. Opaque. Feel greasy.

Coup.—Moljbdennm disnlphide, MoS, = Sulphur 400, molybdenum 60*0 = 100.

Pyr., ato.—In the open tube aulpburous fumes and a pale yellow crystalline sublimate of molybdenum tvloxtde (MoOi). B.B. In the forceps infusible, iinp:irta a yellowteli-Ereeii color to tbe flame; on cbarcoal the pulverised mineral gives in O.F. a strong odor o? sulphur, nnd coats the coal with crystals of molybdic oxide, yellow while hot, white oti cooling: neiiT ibe assay tbe coating is copper.red. and If the white coating l)e touebed with an Intermittent R.F,. Il assumes a beautiful azure-blue color. Decomposed by nitric acid. leaving a while or gniyisb residue.

DUt—Much resembles gmphile In softness and structure (see p. 273), hut has a bluer trace on paper and readily yields sulphur on charcoal.

Oh«.—Qenerslly occurs embedded in, or disseminated through, eranite, gneiss, zircon-syenite, ffrnnular limestone, nnd other crystalline rocks. At Numedal, Sw^en; Arendal and Laurvik in Norway; Allenberg, Saxony; Zinnwald, Bohemia; near Miask, Urals; Chessy in France; in Italy, at Traversella; Corrock Fells, In Cumberland; at several of the Cornish mines.

In Uaint. at Blue Hill Bny; In Conn., nt Haddam, in gneiss; In Vermaat, at Newport; In S Homp»aire,ntWestmorelajiii; in JV. Tark. two miles KOutboaat of Warwick; In Penn,, In Chester, near Reading; near Concord, Cabarrus Co., N. C. In Canada, at St. Jerdme, Quebec: in large crystals in Renfrew county, Ontario; also In Aldfield township, Ponliac Co.. Quebec.

Named from ftoXvpSoi lead; the name, first given to some substances containing lead, later Included graphite and molybdenite, nnd even some compounds of antimony. The distinction between graphite and molybdenite was established by Scheele In 1778-n.

n. Sulphides, Selenides, Tellurides, Arsenidei, Antimonldei of

the Metals.

The sulphides of this second section fall into four divigions depending npon the proportion of the negatire element present. These divisions vith the groups belonging to them are as follows:

A. Basic DWlsion. B. Monosulphides, Monotellurides, etc., B,S, RS, etc.

1. Galena Oroop. Isometric, normal group.

2. Cbalcoclte Oronp. Orthorhombic

3. Sphalerite Group. iBometric-tetrshedral.

4. Cinnabar—Wurtzlte—Mlllerite Group. Hex&gonal and rhombohedral.

C. Intermedial Division. Embraces Melonite, Te,S,; also Bomite, 3Cn,S.Fe,S,; Linnsite, OoS.Go,S,; ChalcopyriU^ Cn,S.F8,S,; etc.

D. Bisulphides, Diarsenides, etc., BS„ BA^,, etc.

1. Pjiite Group. iBometric-pyritobedral.

2. Haroaslte Group. Orthorhombic.

A. Basic Division.

The basic diTJsioii embraces Eeverd rare basic oomponnds of Bilrer or copper chiefly with antimony and arsenic. Of these the crystallization of dyscrasite only le known.

DTBOHABTTB. Antimonrilber Q«Tm.

Orthorhombic. Axes & •.h:& = 0'5775 : 1: 0-6718. Cmtals rare,peeudo-hejagonal in angles {rnvi'" = 60° 1') and by twinning. Also massive. Frac-tnre uneven. Sectile. H. = 3-5-4. G. = 9-44-9*85. Luster metallic. Color and streak silver^white, inclining to tin-white; sometimes tarnished yellow or blackish. Opatjae.

Comp.—A silver antimonide, including Ag,Sb = Antimony 27*1, stiver 72-9 = 100, and

Ag.Sb = Antimony 15-7, silver 84-3 = 100, and perhaps other compounds.

Analyses vary widely, some coafonnlDg also to AgiS, Agi(Sb,Aa)i, etc. By some authors claMed with cbslcocite.

Pyr., etc.—B.B. on charcoal fuses to a globule, coaling the coal with wblleantimoDy trioxlde and flnnllj giving a globule of almost pure silver. Soluble In oitrlc acid, lenviag antimony trioiide.

Obi.—Occurs near Wolfiich, Baden; Wittlcben; Andreasberg Id the Harz; Allemont, Fmnce. Named from dv<TK/jdtrti, a bad alloy.

Honforillta, A EilTer.-white. massive copper antimonide. probably CuiBb (Sb 24 p. C). G. = 8'8. Asia Minor, near Mytiiene.

HcNTiLiTB, AsiOTKiTK. Tlio orcs from Silver Islet. Lake Superior, apparently coDlain n stiver arsenide (^iinlt'Iite, ARiABT)and perhaps also a silver antimonide (anirniAiM. AgiSb?), the latter related lo or identical wllb dyscrasite.

I>oineykite.—Copper arsenide, Cu.As. Reiilform and hotryoldal; also massive, dissemiiiated. G, = 7'2-7-7.'S. Luster metallic. Color tin-wliile to steel-gray, readily lat-nlahed. From several Chilian mines; also Zvrickau. Baxony. In N, America, with niccoltle al Michipicoten Island, L. Superior.

AlRodonite. Copi>er arsenide, CQ,Aa{Aa 16-6 p. c); Q. = 7(12. Reaemblea domeyk* ite. From CbiH; also L. Superior.

Whitnaylta. Copper arseottle, Cu.As (As ll-« p. c). Q. =a 8-4-8'6. Color pale reddish white. From Houphton Co., Michigan; Sonora, L. California.

Ohilenlta. Perhaps AgtBl. Copiapo, Chili.

Stfitzlt*. A rare silver tellurlde (Ag.Te?)'. Probably from NagyHg.

B. Nonosulphides, Honotsllurides, etc., B,^ 1, Galena Oroup. Isometric Od«u PbS A^catito

Also,

Ag.3

(Ag.Cn),8

Ag.Te

Ag.Se

(Pb,Cn,)8, (Cu„Pb)S Jalpaite

Altaito PbTe Eeuit«

ClautliaUta PbSe .^TulUrlt* Hftomuuiitfl (Ag.,Fb)Se

The following, knoTD oni; in masaive form, probably also belong here: Benelianite Cn,Se Zorgite (Pb,Cii.,Af,)Se f

Lehrbaekite (Fb,Hg,)Se Crookedt* (Cn,Tl,Ag),Se

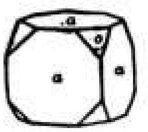
XooairiU Cn,Se.Ag,Se

The Galbna Qboup embracea a nnmber of monosnlphidea, etc., of the related metala, eilver, copper, lead, and mercnry. These crystallize in the normal group of the Isometric Bygtem, and seTeral show perfect cabic cleavage.

These cEaracters are most distinctly exhibited i QAIiBHA, or Oalehitb. Leul glance. Blelglan:

the type apeoiee, galena.

594.



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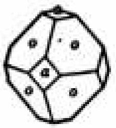
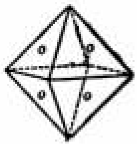


596.



Isometric. Commonly in cubes, or en bo-octahedrons, lesa often ootahedral. Also in skeleton crystals, reticolated, tabular. Twins: tw. pi. o, both contact-and penetration-twins (Figa. 363, 366, p. 123), sometimes repeated; twin crystals often tabular || o. Also other tw. planes giving polysynthetic tw. lamelise. Massive cleavable, coarse or fine granular, to impalpable; occasionally fibrous or plumose.

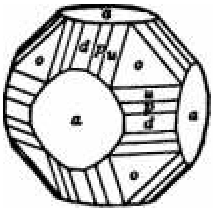
Cleavage : cubic, highly perfect; less often octahedral Fracture flat sub-conchoidai or even. H. = 2-5-2-75. G. = 7'4-7'6. Luster metallic. Color and streak pure lead-gray. Opaqne.

Comp., Tar.—Lead sulphide, PbS = Sulphur 13-4, lead 8G'6 = 100. Often contains silver, and occasionally selenium, 2inc, cadmium, antimony, bismuth, copper, as sulphides; besides, also, sometimes native silver and gold. Var.—1. Ordinary. (i) OrystnlllEed; (ft) umewhat flbrouB and pliimoBe; (c) cleavable, gniiiular coarge or fine; (d) ciypto-crysinlline. The variety wub ocUhedml clenvage la rare; the uBual cubic cleavage Is obtained readily after healing to 200° or

300*: the peculiar cleavage may be connected with tbe blamulh p(aBl), u(&S4)

uaiiallj preunl.

a. Argsntiftrmt'. Ali galena li more or lesa argenUferous, and no eileinal characten BCTTe to dlstingulsli the kinds that are much so from those tliat are not. The silver la detected by cupellatioo, and may amount from a few thousandthB O* one per cent to one per cent or more; when mined for atlver tt ranks as a *iJwr on.



8. CoDtalnlDK nnenlc, or antimoiiy, or a compouad of tlieee metals, as Impurity. Here belong biniehv^ from CkiuLbal wlOi 0-8*2 8I>, and tUinmanMU fnim Pflbram, wllh both

BTbeuiu uud uuiiiiioiiy.

Pyr,—lu the open tube etrea sulpbuTOUS fumea. B.B. on charcoal fuses, emits sulphoi'ous fumes, coats the coal yellow near the assay (PbO) aud wblte vitb a bluish border at a distant'^ (PbyOt, cliieUy). and yields a globule of metallic lead. Decompoaed by stroDi; DJtrlc add with tbe separation of some sulpbur and Che formatloD of lead sulphate.

TiJi. —Distinguished, except la very flue graaular varieties, by Its cubic cleavage; the colui' aod the hiKh specitic gnvity are cbsracleristic; also tbe blowpipe reactions.

Oba.—One of the most widely distributed of the metallic sulphides. Occurs iu beds and veins, both in crystalllue and un crystal line rocks. It is often assoctaied with pyrile, marcastte, sphalerite, chalcopyrite, arsenopyrlte, etc.. In a gangue of quartz, caldle, Wile or fliiorlte, etc.; bIho with cerussite, anglesile, and other salts of lead, wbieh are frequent results of Its alteration. It Is also common with gold, and In veins of silver ores.

Al Freiberg In Saiony it occupies veins in gneissi in Spain, in Eranlte at Linares, also In Calalonia, Oreiiada, and elsewhere; at Clausthal and Neudorf In the Hai-z. and at Pfibram in Bohemia, It forms veins iu clay slate; similarly in Styria; at Sala In Sweden iu veins lu granular limesloue; through tbe graywacke of Leadhills and the klltus of Curuwall, In veins; SlUna cnvities In the Subcarbonlferous limestone In Derbyshire, Cumberland, and tbe northern districts of Eugland; also at Bleiberg, Cartntbia. In the English mines it Is associated with calcite, pearl spar, Quorite, barite, wiibeilte, calumlne, hucI sphalerite. Other localities are Joacbimstbal, Bohemia; Puullaouen and Huelgoet, Brittany; Sardinia;

Ifurchinsk, Bast Siberia; Australia; Chill; BoUvie, etc.

Extensive deposits of this ore it) the United States exist in Uissourl, Illinois, Iowa, and Wiscuosin. The ore occurs not In veins but filling cavities or cbiimbers In sti-atlfled limestone, of different periods of the Lower Silurian, especially the Trenton, also in part Sul)carboniferous, It is associated with sphalerite, sniithaouite, calcite. pyrite. The Missouri mines are situated In the counties of Washington, JeSersou, MadisOD and othera. Good crystals are obtained at Joplin, Jasper Co, Also occurs in New York, at Ross]e, St. Lawrence Co., In crystals with calcite and chalcopyrite'. lu Maine, at Lub'C. etc.; in Man., at SonibamptOD, Newburyport, etc; in Ptnn.. at Phenixvllle and elsewhere; in Virginia, at Austin a mines in Wythe Co., and other places; In Tenn , al HaTsboro. near Nashville; lu Jfi«A.,io the Lake Superior copper district and on tbeN. shore or L, Su^rior; iu Caifftyrjiia, at many of tbe sold mines; in ^leada, abundant In the Eureka district; in Arixoiia, in the Castle Dome, Eureka, and other districts. In Colorado, at Leadvllle there are productive mines of krgenttferous galena, also at Georgetown, the San Juan district and elsewhere. Mined for silver in tbe Coeur d'AlSne leglun Iu Idaho; also at various'points in Montana.

The uame galena Is from the Latin gi^tTut {yitX-^vt)), a name given to lead ore or tbe dross from melted lead.

CuPBOPLUUBiTR. A mosslve mineral, from Chill, varying iu chamcters from galena to those of cbalcoclte and covellite; composition, Cu,B 3P1)S(^. Aluonite is mssslve, deep iudigo.biue quickly tarnishing; correspouds to 8Cii,S.PbS. From Hina Grande. Cblh. Whetlier these and similar minerals represent definite homogeueous compounds, or only ill-defined alteruK on-products, is uucerlidn, and if so It Is not clear whether they should be classed with isometric galena or with ortborhomblc cbalcoclte.

Altaita. Lead telluride, AgTe. Rarely In cubic crvstals, .._.. _ cleavage. G, = 816. Color tin-white, with yellowish tinge tarnishing to bronsa-jellot From the Altai, with hessite; Coquimbo, Chill; California; Colorado

Olaosthali'iA. Lead sclenlde, Pb3e. Commonly in fine granular masses resembling

Bilena. Cleavage: cubic. G. = 7ft-8-8, Color lead-gray, somewhat bluish. From tbe arz, at Clausthal, etc.; Cocbeutamlne, Mendoza. S. A, TVUmxIife is a cobaltiferoua variety. Haunuumita. Bilver-lead telluride (Ag,.PblSe. In cubic crystals; also massive, grauular, In thin plates. Cleavage: cubic. G. = 8*0. Color and streak Iron-black. From Tilkerode in the Harz.

AROBNTITEI. Silver Olance. Sllberglanz Qerm.

Isometric. Crystals often octahedral, also a, o; often distorted, frequently grouped in reticulated or arborescent forms; also Sliform, Massive; embedded; as & coating.

Cleavage: a, d in traces. Fracture small snbconcboidal. Perfectly sectile.

H. = 3-3-5. G. = 7-30-7-36. Lnater metallic Color and streak blackUh lead-graji streak Bhiniiig. Opaqua

Comp.—Silver Bulphide, Ag.S = Sulphur 13-9, silver 87-1 = 100.

PyTi., 010.-^111 tbe open tube gives off sulphurous fuincB, B.B, od charcoal fuses nitb Intumtiscence la O. F., umltliDg sulpburous fuoiea, and yieldlug a globule of silver.

Dl£—DlsiJDgulsbed from uiher sulpbides by being readily cut with a knife; alio by jieldiug metallic silver aa charcoal.

Oba.-'FouDd at Freiberg, Joacbimatbal, etc.; Scbemntlz, Hungary; In Norway near Eongsberg; in Ibe Altai; in Cornwall: Peru; Chili; Mexico Ht Ouauajuato, etc.

Occurs iu Nevada, at the Coaislock lode; at the Bilver King mine, Arizona; at mines near Port Arthur on norlli shore of Lake Superior; with native silver and copper Id Donliem Michigan.

Jalfaitr is a cuprifeious arjfeutlte from Jalpa, Ueiico.

Hvadte. Silver lelluride. AgiTe. Isometric. Usually massive, compact or flne-rrained. Cleavuge Indistinct. BooiewLat sectile. E. = 3'5-S. Q. =8-31-8 46. Color Between lead-gray and Bteel-gray. From the Allni; at Ma.ET&g io Transylvania; Rezbanva, Hungary; Chili, near Ai'queroe, Coquimbo. In the U. &.. Calnveraa Co., Cal.: Boulder Co., Colorado; U[ah. This species also of.en coniaiiu gold and thus graduates toward

Patsitc. (Ag',Au)tTe with Ag; Au = S: 1. Hauive; granular to compact, SllRhtly sectil Io brittle. H. = S5-8. G. = 8-7-903, Color sleel-gray 10 Iron-black; Uraishing. From Nagy&g, Transylviinla; Colorado; Catiforaia.

AgnUarita. Silver aelentde, AgiS and Agi(8 8e). In skeleton dodecabedral cryataK Sectile. O. = 7380. Color Iron-bluck. From Guiinajuato, Mexico.

Benelianite. Copper selenide, CiiiBe. In tliin deDdrilic crusts and disseminated. G. = 0'T1. Color sllver-vrbits tarnishing. From Skrikerum, Sweden; Lehrbach, In the Hue.

I.aIurl>aohit«. Selenide o(lead and mercury, PbSe with BgSe. Haasive, granular. O. = 7'8. Color lead'gmy to Iron-black, From Lehrbat^, in Ihe Harz.

Ettcairlta. CuiBe.Ag.Se. Massive, granular, Q. = 7'50, Color between silver-white and lead-gray. From the Bkrlkerum copper mine, Sweden; also Chill.

Zorglte, Selenide of lead and copper In varying amounts. Massive, granular. O, = 7-7'5. Color dark or light lead'grsy. From the Harx; Cacheula, Argentina.

Orookedte. Selenide of copper and thallium, also silver (1-B p. c), (Cu,Tl,Ag)iSe. Massive, compact. O. =6'9. Luster metallic. Color lead-gray. From the mine of Skrikerum, Sweden.

Umangita. CuSe Cu,Se. Massive, flne-granular to compact. H. = 8. G. = S'SaO. Color dark cherry-Ted. From La Rloja, Argentina.

a. Chalco«lte Group.

The Bpecies of the Chalcocitb Group crystallize in the orthorhombio flystem with a prisiiiatic angle approximating to 60°; thej are hence pBendo-hexagonal in form especially when twinned. The group is parallel to the Oalena Gronp, since Cn, appears in isometric form in coproplnmbite and Ag,S also in argentite. Some authors include dyscrasite here (see p. 286),

OHAIiOOOrrB. Copp«r Qlance Redruthite. Kupterglaoz Q«rm. Ortnorhombic. Axes (i:h:& = 0-5822 :1: 0*9701.

M, 031 A Oai = 135° aff. pif". in a hi = 68' 8f.

Crystals psendo-hexagonal in angle, also by twinning (tw. pi. m). Often massive, atracture grannUr to compact and impalpable.

Cleariige : m indistinct. Fracture conchoidal. Rather brittle. H. = 2-5-3. G. = 5 5-5-8. Luster metallic. Color and streak blackish lead-gray, often tarnished blue or green, dull. Opaque.

Comp.—Caprona sulphide, Cu,S = Snlphur 20-2, copper 79-8 = 100. Sometimes iron in small amonnt is present, also silrer.

PyT,eto.—lu ttae open tubu glvea sulphurous fumes. B.B. on charcoiil melts lo a globule, which boila with spirtiug; ihe fine ponder roasttd at a low tempernture on charcoal, then healed iu R.F,, yields a globule of melallic copper. Soluble In nitric actd.

DiA—Ri-BembleB argeultc but much more brittle; bomfte , baa a different color au tbe fi'esh fmcture and becomes mag-uelli' B.B.

Obs,—Coruwall aSorda splendid ciyatals, esfieclall; tbe districts of Bnint Just, Camborne, and Bedruth (rtdruthiU).

Occurs at Juacblmstlial, Bohcmin; Tellemarken, Norwar;

compact arid mftssive varieties Iii Siberia; Saiouy; Ml. Catfnl

mines Id Tuacnny; Meiico; S. America.

In the U. S., Bristol. Conn., has afforded larjre and brilliant crysUls; also found at

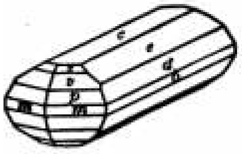
Bimsbury and Cheshire; at Schuyler's mines, N. J.; in Nevada, in Washoe. Humboldt.

Churchill and Nye counties: in Moolana, massive at Butte City. Pouud in Canada, wllh

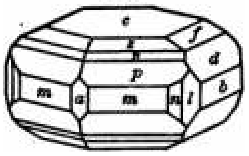
chalcopyrile and bornite at the Acton mines and elsewhere in the province of Quebec.

Stromarerita. (Ag,Cu),8, or Ag,a.Cu,8. Rarely In orthorbomblc crystals, often twinned. Commoulv mssaive. compiicl. H, = 2-5-8. G. = 615-6-8. Luster metallic. Color and streak dark sleel-gmy. From the Zmeinoitorsk mine. Siberia; Silesia; also Chili; Zacatecas, Mexico; Ihe Helntzelmaa mine in Arizona; Colorado.

598.



599.



BTERNBHRarm,

Orthorhombic Crystals tabular | c. Commonly in fan-like aggre^tions; twins, tw. pi. m- Cleavage: c, highly perfect. Thin laminaa flexible, like tin-foil. H. = 1-1-5. G. = 4-215. Lnster metallic. Color pinchbeck-brown. Streak black. Opaque.

Comp. AgFe,8, or Ag,S.Fe,S. = Sulphur 30-4, silver 34-2, iron 35-4 = 100.

Oba.—Occurs with pynirgyrlte and stepbanlte at Jonchlmsihal, Bohemia, and Johanngeorcenatadt, Saxony.

FRIB8B1TK. Near slernberglte. In thick tabular crystals: H. = 3-6; Q. = 4-32. Color dark gray. Composition AgiFeiS>. Occurs with marcasite at Joachlmathal.

Acaothit*. Silver sulphide, Ag.S, like argentite. In slender prismatic cryslals (orthorhombic). Sectlle. G. = T3-7-3. Color Iron-black. Occura at Joachlmstbal; alsi> at

Freiberg, Saxony, and at Schneeberg.

It has been suggested that scanthlie may be only argentite in distorted Isometric crystals.

Sphalerite Group. RS. Isometric-tetrahedral.

Sphalerite ZdS Onofrite Hg(S,Se)

Hetaoiimiibaiite HgS Alsbandite MnS

Guadalcazarite (Hg,ZD)S Coloradoite HgTe MaaeiYe

Tiemaimite HgSe

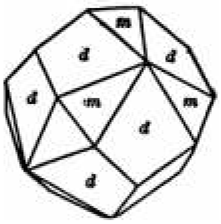
The Sphalerite Group embi-aces a number of sulphides, Belenidea, etc, of zinc, mercury, aud manganese. These ure isometric-tetrahedral in crystallization.

SPHAI.EIIUTB, Zinc Blende ot Blende. Block-Jack, Hock-Lead. False Oaleiu Enffl. Zbkblenile Oerm.

Isometric-tetrahedral- Often in tetrahedrons. Twins common: tw. pL o; twinning often repeated, sometimes as polysjntfaetic lamellie. Commonly

600. Ml.

602.



m = (311) massive cleavable, coarse to fine granular and compact; also foliated, sometimes fibrous and radiated or plumose; also botryoidal and other imitative shapes. Cryptocrystalline to amorphous, the latter sometimes as a powder.

ClesTage: dodecahedral, highly perfect. Fracture conchoidal. Brittle. H. = 3-5-4. G. = 3-9-4-1; 4-063 white, N. J. Luster resinous to adamantine. Color commonly yellow, brown, black; also red, green to white, and when pure nearly colorless. Streak brownish to light yellow and white. Transparent to translucent. Refractive index high: 7ty= S'36d2 Xa.

Cemp.—Zinc sulphide, Zn8 = Sulphur 33, zinc 67 = 100. Often containing iron and manganese, and sometimes cadmium, mercury and rarely lead and tin. Also sometimes contains traces of indium, gallium and thallium; maybe argentiferous and auriferous.

V«r.—1, Ordinary. ContnlDlng little or no Iron; from colorless white to yellowish brown, sometimes green: O. ^J'CM'l. The red or reddish-brown tranipnrent crystnjllzed liitids are eometiraes called ruby bUiide or tTifty tine. The mnaslve cleavable forms are the most common, varying from coarse to fine granular; also cryptocrystailme. fkliaUabUrKU (Germ.) Is a closely compact variety, of a pale liver-brown color. In concentric layers with reiiiform surface; galena and marcaslle nre often inters!ratified. Tbe fibrous forms (/iuitw< Zinkiiende Qemi.) are chiefly wurlzile. A aofl white amorphous forui of zinc sulphide occurs Id Cherokee Co., Kausas.

3. Ferriferovt; Marmatitr.. Contalninjc 10 p. r. or more of lr"D: dark brown lo black; G = 8-9-4'05. The proportion of FcB to Zd8 varies from 1 : 5 to 1:2, and the last rstio is that of the chritlop/tiU of Brelthnupt. a brilliant.black sphalerite from St. Chrlstoplie mine, al Brelienbninii. havinc O. = 8-91-!t'(l23.

-t Cadm^ermu; PrUirimit'. Pititiramite. The amount of cadmium present in any sphalerite thus far analyzed Is less llian S per cent.

Pyr, etc—Difficultly [iiaible. Il the open tube sulpburous fumw, and generallj cbnnges colur. B.B. on cliarcoftl, In K.F.. tome vaiietles giTe At Sta » reddl^-brovrn coaliDE o[cadiiiiuDi oxiJe, aud lal«r a cuatiDg of doc oxide, nhtch Is yellow nblle hot and white after ciiollug. With cobalt Bolution tbe zisc coating gives a green color when heMed In O.F. HoBt viirieilea, after roasting, slve with borei n reaction for Iron. With soda on charcoal iu B.F. a slroug grecD zluc name. Dissolves lu hydrochloric add with «TolutiOD of hj'drugeu sulphide.

tUS. —Varies widely In color and appearance, but dlatlngulsbed by the resinous luster in all but deep bliicti varieties; UBually eiblbils dUlinct cleavage; much softer than garnet; neai'ly Infusible B.B.i yields a zloc coating on charcoal.

Obs.—Occurs very commonly in bolh crystalline and sedlmentarj rocks, aod as a frequcDi associate of galeoa; also associated with cbalcopyrlio, barlie, fluorite. siderlie: common in silver mines. Jt often forma lieda of cousidemblo magnitude fllling cavities In limestone.

Some of the chief localities for crystallized sphalerite are: Alston Moor In Cumberland, black variety; Derbyshire, St. Agnes and elsewhei'e in Cornwall; Oberlalinat«in in Nassau. £ms, red; Audreasberc, fellow aud brown; Neudorf iu the Harz, Freiberg, Brelteubrunn, aud other localities In Saxony, black and brown; Pi4bram, green or yellow, and Schlackcn-wald in Bohemia, black; Eapnik, Hungary, green or yellow; Nagyig, lYansylvanla, brown; Bodna. black; the BInuenlhal In Switzerlaud, Isolated crystals of great beauty, yellow lo brown, In cavities of dolomite; Bula In Sweden; Nordmark, bliick, brown, also siiowwhile. A beautiful truusparent variety yielding large cleavage masses is brought from Picos de Europa, Saulander, Spain, where It occurs In a brown llmcBlone. Fibrous varieties (see wurtzite) are obtJklued at I^bnim; Gsroldseck lu Baden; Rolbel; also In Cornwall. The original marmatile Is from Harmato near Pi>payau, Italy.

Abounds with the lead ore of HlMourf, Wisconsin, Iowa, nod Illinois. In If. York, Sullivan Ca, near Wurtzboro'; In Si. Lawrence Co., at Mineral Point with palena; at the Aucrsm lead mine In Columbia Co.; iu limei'toue at Lockport. In Mat*., at the Southampton lend mines. In N. Hamp., at tbe Calon lead mine; at Warren. Iu Maine, at Ihe Lubec lead mines, elc In Conn., at Roxbury. In S. Jenty, a white vnriety [cleiopKaiu) at Frankliu Furnace. In Penn., at the Whealley and Perkiomcu lead mines, In crystals; near FHedenBvllle, Lehigh Co., a white waxy var. In Virginia, abundant at Austin's lend mines, Wythe Co. In Miehigan, at Prince vein, Lske Superior, abundant. In lUtnott. nenr Roslclare, with galena and cnlclle; nt Miir«deu's dttrginps, near Galena. In stelaclites, with cryst. marrasite, nud galena. In Witeoitnn, at Mineral Poliil, In fine crystals. Id TennettM. at Hajiboro', near Nsahville. In Mittavri, in beautiful crystallizations wilh

Siena, marcaslte and calclte at JopUti and other points In the soulhwesiero part of the slalc; 9 deposits here occur In limestone and are of great extent and value; also In udjoiulng parts of Eansns.

Named blende because, while often resembling galtna, Il yielded no lead, the word In German meauiog blind or deeeiviag. Sphalerite ia from vipuXeiioi, treacherout.

HatacinuabariU. Mercuric sulphide. HgS. In composition like cinnabar, but occurs in btaek tetraliedral crysmls; also massive. G. = TS. From the Beddlngton mine. Lake county, Callforoia, with cinnabar, quartz and marcaslte; also elsewhere sparingly.

Ooadalouarlte, Near metoclnnabarile. but contains zinc (up lo 4 p. c), Guadalcazar, Mexico.

Tinnannlta. Selonquecksllber. Mercuric selenlde. HRfle. Isometric-tetrahedrvl. Commonly massive- compact. G. = 819 Utah; SBO-847 Clausthal. Luster metallic. Color Bieel-fn«y to blackish lead-gray. Streak neariy black. Occurs In the Harz; California, In the vicinity of Clear lake; Marysvale, Piute Co., Ut*h.

OnoMt*. Hg(B.Se) with 8e = 4'B to 6ti p. c. Ssn Onofre, Mexico; Marysvale, Utah.

Ooloradoits. Mercuric telluride, HgTe. Massive. G. = 88. Color iron-black. Colorado.

Alabuidlte. Maiignnblendc. Manganglanz Gctttj. Manganese sulphide, MnS. Isnmetric-tntmhedral; iwuallv granular massive. Cleavage: cubic, perfect. Q-= 8"&5-404 Luster Bubmetallic. Color Iron-black. Streak green. Occurs at Nagrftg, Tran-sylvapia; Kar.nlh, Hunpiry; Mexico; Peru; crystallized and massive on Snake Klver, Summit county, Colorado; Tombstone, Arizona.

Oldhamlte, Calcium sulphide, CaS. In pale brown spherules with cubic cleavage in tiie Bust! meteorite.

FEHTI.ANZ}mi. ElseDDickelUwOmA.

iBometric. Masaire, granoUr. Cleavage: octahedral. Fractare aneven. Brittle. H. = 3*5-1. 6. = 4-60. Lnater metallic Color light bronze-yellov. Streak light bronze-brown. Opaque. Not m^netic.

CvMp.—A ealphide of iron and nickel, (Fe,Ni)S. In part, 2FeS.NiS = Sulphur 36*0, iron i'i'O, nickel 22-0 = 100.

OtM.—Occurs niili chatcopyrfte Dear Lillehnmmer. Hortray. The mineral from Sudbury, Ootarlo. is mlutd eiteneiT«1y for nickel; it shows dUtlnct octnbedral cleavage (or partlDg). The same looillty also Affords Dickeliferous pyrlte aud pyrrhotlte.

^oUlt*. Ferrous sulphide. FeS, occurring io nodular masses and in tbln veins in maof lion meteoritea. O. = 4-T.V4'83. Color toubac-brown. By aome aulbore regarded at Ideatlcul wiUi pjTrhoUte (p. 2M).

4. Ctnnabar-Wurtzlte-Hfllerlte Group. RbombohedralorHexagonaL

i Cinnabar HgS Bbombohedrsl-Trapezohedral 1-1453

Covellite CuS ' 11466

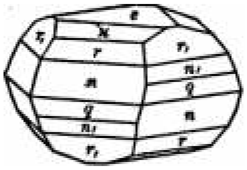
Thia fonrth group among the monosulphides includes aeveral anbdivisiona, as ahown in the scheme above, and the relatione of the species are not in all caaea perfectly clear. It is to be noted that the sulphides of mercury and zinc, already represented in the sphalerite group, appear here again.

If, AS sugeestml by Oroih, Uie prominent pyramids of wurlzite. greenocklte, etc,, be made pyrnmlds of llie secnod series («.;,, x = 1132, Instead or 1011). then the .values of h In the second column are oblalne<l, wlitcb correepond to mlllerfte. The form of several of these species, however, is only imperfectly known. A rbombohedral form for greeoocklle has beeu suggested.

CINNABAR. Zinnober, Scbwefelquecksilber Q«rm. Rhombohedral-trapezohedral. Axis i = 1*1453.

Crystals nsuallj rhombohedral or thick tabular in habit, rarely showing trapezo-hedral faces; also acicular prismatic. In crystalline in cru station a, granular, massive; so:..etimeB as an earthy coating.

Cleavage: nt perfect. Fracture sub- K-(:oi4), «(2(^1), y (0441) conchoidal, uneven. Somewhat sectile. H. = 2-2-5. Q. = 8*0-8'2. Luster adamantine, inclining to metallic when



o^

dark-colored, and to dull in friable Tarieties. Color cocliiiieal-red, often incliDiug to brownish red and lead-gray. Streak scarlet. Transparent to opaque. Optically -|-. Indices: a^ = 2-854, e^ = 3'201, Dx. See Art, S66.

Tm-.~1. Ordinary: eilher {a) eryttatUted; {b) mauivt, grBDular embedded or compact; bright red to roddUli bronru 1q color; (e) wirtAy aud biighi red. 2. Hepatic. Of a liver-brown color, wltb soni«tini«s a browoUti alKak. occaaiuually duty fu siructun, tliougb coidiiiudIj grauular or coupact.

Comp.—Mercuric sulphide, HgS = Sulphnr 13-8, mercury Se-S = 100. Usually impnre from the admixture of clay, iron oside, bitumen.

Pyr.—In tbe closed lube aloue a black sublimate of mercuric sulpbide, but with aodlum carbouate oue of muialUc mercury. CarcrullT beated bi tbe open tulie gives sulphuroua fuuiea and melallic mercury, whIcL coadenBea id mluule glubuleit ou Ibe cold walla of tlie tube. B.B. on cliarcnal wbolly volatile, but imly when quite free fri)in gaiiKue.

Dlft—CliaracterlEed by lis color and TermllfoD streak, bigli apeclQc gravUy (reduced, however, by tbe gangue usually present), soflness; alau by the blowpipu cliatacters {e.g., la the closed tube). Resembles some varielleB of bematlte aud cuprite.

Oba.—Occura clifeHy in veins In slate rocks and sbales, and nirely in granite or porpLyry. Il has been observed in veins, wilh ores of iroD. Sometimes occurs in couiieclloii with bot apringa as the result of solfataric action. Pvrite and marcualle. siilpbtdes of co|iper. ;llb-nite, realgar, i^old, etc., are associated uilnerala; calclte, quariz or opiil, niso burite, fluorite, are gangue mmemlei a biiiimlnous mineral is common.

Tbe most important European deposits are nt Almaden in Spain, and nl Idria in Car-nfola. where it is usualIv masiive; also nt Bakmut In southerti RussIil. Crystallizeil at Hoscbeltandsberg aud Wolfstein in the Palatinate and at the mines of Ht. Avala. tiear fielgtade, Servia: at Rlpa In TuBcany; In the Urals; tbe Nerclilnsk region la Transbaikal; tu China: Japan; Meilco; Huaucaveltca, Peru; Chill.

Id the U. 8. forms extensive inines Iq California, Ibe moat Important at New Almadea and thevlcinlly, in Santa Clara Co.; also at Altoonn, TrinltyCo.; il Is now forming by eolfataric action at Sulpbur Bank, Cal., and Steamboat SprTogs, Nevada; also occurs In Boutbern Utah.

The name cinnabar is supposed to come from India, where It is applied 1o (he red resin, dragon's blood. The native cinnabar of Theopbnistus is true cinnnbar; he speaks of its affording quickailver. The Latin name of ciDDabar, minium, is now given to red leiui, a substance which waa early used for adulteratlag cinnabar, and so got at last the name.

OoTolUta. Eupferiodlg Oarm. Cupric sulphide. CuS. Rarely in hexagonal c^stals. Commonly maisive or spheroidal. G. = 4'59. Color indigo-blue or darker. From Badenweller, Baden; Hansfeld, Thuriogia; Vesuvius, on lava; Chili, etc.

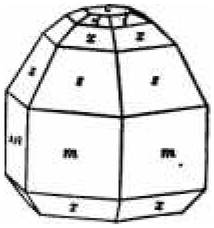
OREENOOKrm.

Hexagonal-hemimorphio. Rarely in Lemimorphio crystals; also as a coating.

OleaTage: a distinct, c imperfect. Fracture conchoidal. Brittle. H.=3-3-5. <o». G. = 4-9-5-0. Luster adamantine to resinous. Color

honey-, citron-, or orange-yellow. Streak-powder between orange-yellow and brick-red. Nearly transparent. Optically +,

Coup.—Cadmium sulphide, CdS = Sulphur 22-3, ' ■ 77-7 = 100.



Pyr., etc.—In the closed tube assumes a carmine-rod color while hot, fading to the original yellow on cooling. In the open tube gives Hulpliiirous fumes. B.B. on cbaTcoal. either alooe or with soda, gives in R.F. a reddish-brown coating. Soluble In hydrochloric acid, affording hydrogen sulphide.

Obi.—Occurs wilh pr«hnile at Bishoplon, Kenfrewahire, and elaewherelu Scotland. At Pflbram In Bohemia, aa a coating on sphalerite; similarly at other points; so too In the U. 8. near Friedensville, I^, and In Ibe line region of soulh-westerti Missouri: in Marion Co.. Ark., It colore amlibBonlte bright yellow. Not un-a furnace product.

Wnztolte. Zinc sulphide, ZnB, \ike spbiJerlU, but In hcmlmorplilc hexagonal cryaula; also fbroua and massive. O. = ii'98. Color brownUh black. From a siWer-mbe Dear OruTO lu Bolivia: PortugBt; Peru. la crystals nitb ipbalerite imd quartz at tUe "Orlglual Butte" mine. Butte City, MoDtuna.

TLe luu^lye fibrous forms of " ScbalenbleDde " occur at PHbram, Llskeard, etc. Other forniB, from Siolberg, Wieelocb, Attenberg, are iu part wuitiile, iu part spbalerits.

ERTTHROiUKCiTB is (Zu,Mu)S. From jjlberia.

MIZ.IJ1RITE. Capillary Pyrites. Eaarkies Germ.

Rhombohedral. TjBiially in very sleiider to capillary crystalB, often in delicate radiating groups; Bometimes interwoven like a wad of hair. AUo in columnar tnfted coatings, partly eemi-f^lobular and radiated.

Fracture nneven. Brittle; capillair crjetals elastic. H. = 3-3*5. G. = 5-3-5'65. Luster metallic Color brass-yeltow, inclining to bronze-yellow, with often a gray irideecent tarntsb. Streak greenish black. Comp.—Nickel sulphide, NiS = Sulphur 35-3, nickel 64-7 = 100.

Pyr., etc,—In the open tube sulpLiii-ous fumea. B.B. on charcoal fuses to a globule. When roiisied, gives with borax and salt of phosphorus a violet bead in O.P., becoming gray in R,F. from reduced metallic nickel. On charcoal !u R.F. the roasted mineral gives a coherent metallic mass, attr«ctible by the magnet. Most varieties also show traces of copper, cobalt, and Iron witli the fluxes.

Oba.—Occurs commonly lu capillary crystals, In the cavities and among crystals of other mlnei-als. Fouod at Joachimslhui lu Bohemia: JobanngeorgeDStadl; rabram; Rlocbels-dorf; Audreasberg; Freiberg. Saxouy; Cornwall.

In (lie U. 8., nt Antwerp, N. T., iu cavities In hematite; in Lancaster Co.. Pa , at the Gap mine, lu thin velvety coatings of a radiated flbrous structure. "Wiih calcite. dolomite and fluorite, forming delicate tungled balr.like tufis, lu geodes in limestone, often pene-Iratiug the calclte crystals, at St. Louis, Mo.; similarly near Milwaukee. Wis. At Orford, Queb«j.

Betrichitb. NIS like mlllerlte witli also Co.Pe. From Westerwald. The relation of the two species is doubtful.

HArcHECOKRiTK. Perhapa NI(Bi,Sb.S). In tabular tetragonal crystals. H. = 0. Q, =: 6-4, Color light bronze-yellow. From Hamm a. d. Bleg.

NIOOOUTB. Copper Nickel. Eupfernickel. Rothnickelklea Qerm.

Hexagonal. Crystals rare. Usually mnaBiYe, atructure nearly impalpable; also reniform, columnar; reticulated, arborescent. Fracture uneven. Brittle. H. = 5-5'5. G. = 7-33-7'67. Luster metallic. Color pale copper-red. Streak pale brownish black. Opaque.

Comp.—Nickel arsenide,MiAs = Arsenic 56-1,nickel439 = 100. Usually contains a-little iron and cobalt, also sulphur; sometimes part of the arsenic is replaced by antimony, and then it graduates toward breitbanptite. The intermediate Tarieties have been called ariie.

Pyr., eto.—In the closed tube a faint white crystalline sublimate of arsenic trioxlde. Iu the open lube a eubllmate of araeulc trioilde. with a trace of sulphurous fumes, the assay becoming yellowish green. On charcoal gives arsenical fumes and fuses to a globule, which, treateuwith borax glass, affords, by successive oxidation, reactions for iron, cobalt, and uickcl: the antimonia! varieties give also reactions for antimony. Soluble in aqua regia.

Ob«.—Accompanies cobalt, silver, and copper ores In the Saxon mines of Annaberg. Schneeberi;. etc.; also io Tlmringla. Hesse, and Styria; at Allemout, Dauphine; iit the Ko mines in Nor<lmark, Sweden: at Balen in the Basses Pyrenees (arite); occasionally in (>>rnwall; Chili; abundant at Mina de)a Rioja, Orlocha, Argentina. In the U. S., at Chatham, Conn., iu Knelss; sparingly at Franklin Furnace, N. J.; Silver Cliff. Colorado; Tilt Cove, Newfoundland.

Br^Uuiqitlts. AntimoiiDlckel o«rm. Nickel Anllmonide, NiSb. nal cryatnls; usually mBssive. arborescetit, disseminated. ~ red. From Andreasberg la ilie Huz,

' PTBaHOTITD. HftgUftic Pfrites. Hagnelkfea Gem. Eezagonal. 6 = 0 8701.

a. OOOlAlOil =«' 8*.

cu, 0001A4M1 =78' ff.

cj/. OoOlA(200Sft8) = 81* »!'. Twins: tw. pi. s, with vertical axes nearly at right angles {Fig. 383, p. 125). DiatiDct crystals rare, commonly tabular; wao aonte pyramidal with faces striated horizontally. Usually massive, with granular structure.

Parting: c, sometimes distinct. Fracture uneven to BubconchoidaL Brittle. H. = 3'5-4'5. G. = 4-58-4'64. Luster metallic. Color between bronze-yellow and copper-red, aud subject to speedy tamieh. Streak dark grayish block. Magnetic, but varying much in intensity; sometimes possesB-ing polarity.

Comp.—A sulphide of iron, often containing also nickel; formula chiefiy Fe,|S„; analyses, however, vary from Pe,8, up to Fe„S„ while conforming to the general formula Fe.S.^.„. Percentage oomposiiion Fe„S„ = Sulphur 38-4, iron 616 = 100; Fe,S, = Sulphur 39-6, iron 60-4 = 100; Fe.S, = Sulphur 39-3, iron = 60-8 = 100.

s fumes.

h1 oxide,

ild small

icid, with evolution of

—DlsllDguisbedbyUs peculiar reddish-bronze color; al»ol]7ftameg:iietlcproperiies.

Obs.—Occurs at Kongsberg, Hodiim, etc., la Norway; Falun, Swedeo; Aodreasberg; BoileDinnis: BreitenbruaD; JoiicbiuisChal. Bohemia; NizbolTtigilBk; Hioas Qeraea In Brazil, in large tabular cry^laU; the lavas of Vesuvius; Cornwall.

In N. America In Main«, at Standlsh with atidahisile: In Vtrmant, at Stafford, etc. In If. Tort, near Diana, Lewis Co.; Orange Co. In PenTUylmnia, at the Gap mine. Laocasler Co.. nickeliferous. In Tennestft, at Ducklown mines, abundant. In Canada. In large veins at St. JerOme, Elizabeth town, Ontario; at Sudbury, etc. This species is often mined for the nickel It contains.

Pyrrhotite is often present In disseminated particles or crystals in meteoric Stones; the iron sulphide oF meteoric irons is generally referred to troillte (p. 208).

Named from nvfifiSi};i, nddith.

C. Intermediate Divi^on.

HorbaohltB. An iron-nickel sulphide, perhaps 4Fe,Si.NI,6,. Crystalline, massive. Color pinchbeck-brown lo steel-gray. O. =^ 443. From Ilorbach in the Black Forest.

Polydrmita. A nickel sulphide, perhaps NinSi. In octahedral crystals; frequently twinned- G. — 4-54-4 81. Color gray. From GrQnau, Westphalia.

A nickel ore from Sudbury, Oalarlo, conespords lo NiiFeS., conforming to the general formula of potydymlte; another Sudbury ore agrees with ,pentlnndlte (p. 293), and still another la a nlckeliferous pyrrhotite,

OrUnanita. Contains sulphur, bismuth, nickel. Iron; perhaps a mixture. From GrQnau.

Halonlto. Tellunilckel Oerwt. A nickel telluride, Nl.T«i, In Indistinct sraoular and (olUted particlea. Color r«cidl«h white, with matalllc tiuter. From the StaaU&iu mioe, California; probably also in Boulder Co.. Colorado.

The following Bpeoiea are aoraetitnu regarded aa 8alpho-«alta, namely, Snlpho-femtes, etc

BORNim. Buntkuplererz Otrm. Purple Copper Ore. Variegated Copper Ore. Erubeaclte.

Isometrio, Habit cubic, faces often rough or oarred. Twine: tw. pi. o, often penetration-twins. AtassiTe, atrnctnre grannlar or compact.

Cleavage: o in traces. Fracture Bmall conohoidal, uneven. Brittle. H. = 3. G. = 4'9-5'4. Luster metallic. Color between copper-red and pinchbeck-brown on freeh fracture, speedily iridescent from tarnuh. Streak pale grayish black. Opaque.

Comp., Tar.—A sulpbide of copper and bon, but vjirying in the proportions of these metals. The cryetallizea mineral agrees with Gn,FeS, = Sulphur 28-1, copper 55-5, iron 16'4 = 100; this may 1m written 30a,S.re,S, (Groth) or Cn,S.CuS.Fe8 (Rg.).

Analyses of massive Tarietiea give from SO to 70 p. c of copper and 15 to 6'S p. c. of IroD. The varlntloQ Ib due, in part at least, to mechanical admixture, chiefly of chalceclte.

Fjrr., etc.—In lbs closed tube gives a faint aubllmate of sulpbur. In the open tube yields sulphurous fumes, but no sublimate. B.B. on charcoal fuses inR.F, to a brittle magnetic globule. The roasted mioeral gives with the fluzes the reaclioug of iron and copper, and with soda a metallic globule. Soluble in nitric acid with sepanttiou of sulphur.

DUt—DistiDeiilshed (e.g. from chnlcoclle) by the peculiar reddish color on the fresh fracture aed by Its brtlliant tarnish; B.B, becomes stro'nffly magaetlc.

Ob*—Occura with other copper ores, and is a valuable ore of copper. Crjstalllne varletieg are found in Cornwall, called by the miners " horse-flesh ore." Occurs massive St Ross Island. Killsrney, Ireland: Monte Catlnt, Tuscany; the Hansfeld district, Oer-maey: In Norway, Sweden, Siberia, Silesia, and Hungary. It is the principal copper ore at some Chilian mines; also common in Peru, Bolivia, and Heiico.

In tlio U, 8., found at the copper mine in Bristol, Cnna,; massive at Uaboopeny, near Wilkesbarre, Peon. A common ore in Canada, at the Actoo and other mloes.

Named after the minerali^ist Ignatius toQ Bom (1743-1791).

Xiinnalts. A sulphide of cobalt, CoiS, = CoS.Co,6i, analogous to the spinel group. Also contains nickel (var. Htgeniu). Commouiy in ociahedronsi also massive. H. = 55. 0. = 4'S-5. Color pale steel-gray, tarnishing copper-red. Occurs at Basuaea, etc., Sweden; MQsen, near Sie^en, Pnissia; at Slegen (tie^tenitej. In ootahedrous. In tbe V. 8., at Hlne la Hotte, Hlssoui'i; Hiiieral Hill. Maryland.

OaobrSoIlta. An Iron-chromium sulphide, FeS.CriBi, occurring with tt^lite in some meteoric irons. Color black. G. = 601. <

Onbanita. An Iron-copper sulphide, perhaps CuFegBi = CuS.FeiSi. Isometric; massive. Color tietweeu bronze- and brass-yellow. 6. = 4'08-4'17. From Banacanao, Cuba; Tunaberg and Kafveltorp, Sweden.

CarroUlt*. A copper'Cobalt sulphide, CiiCo,Si = CuS.CoiBi. Isometric; rarely In octahedrons. Usually massive. G. = 485. Color light steel-gray, with a faint reddish hue. From Carroll Co., Maryland, near Finksburg.

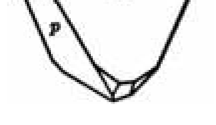
OHAIiOOFTBITB. Copper Pyrites. Yellow Copper Ore. £upferkies 0«rm. Tetragonal-sphenoidal. Axis d = 0*98525. pp'. 111 A ill = 108* 40'. pp,, m A III = 70* 7i'. «, 001 A 101 = 44* 84i'.

Crystals commonly tetrahedral in aspect, the sphenoidal faces p large

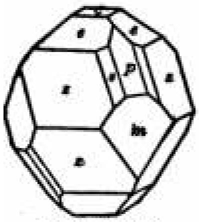
, small and brilliant. Sometimes both forms equally

developed, and then octahedral in form. Twins: (1) tw. pi. p (111), reaembling spinel-twins (Fig. '679, p. 135); sometimes repeated ae a fiveling (Fig. 609). (2) Tw. pi. andcomp.-face e (Fig. 381, p. 125) often in repeated twins. (3) Iw. pi. m, tw. axis c, complementary penetration-twins. Often massive, compact.

Cleavage: 2 (201), sometimes distinct; c, indistinct. Fracture nneveD. Brittle. H, = 3-5-4. G. = 4-1-4-3. Luster metallic. Color brass-yellow; often tarnished or iridescent. Streak greenish black. Opaqne.

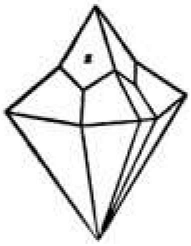


608.



s (201), s (518).

609.



Conp —A sulphide of copper and iron, OuFeS, or pu ^.Ee^g . = Snlphar 35'0, copper 34 5, iron 305 = 100. Analyses often show^riatioDB from this formula, often due to mechanical admixture of pyrite.

Sometimes auriFerouB nud argentiferous; also coulaliis' traces of selenium Bud tballium.

Pyr., Bto.—la Ihe cloeed tube decrepllatcs, and gives a iulpliur sublimate, iu the o|)en tube sulptiurous fumes. Oq cburcoal fuses I0 a magnetic globule; with soda tlie roasled mineral gives a globule of copper coulainlng Iron. 'Hie riiasled mineral reacts for copper aad Iron witb the fluxes. Dissotves lu nkric acid, excepting the sulphur, and forma a greeii ■oIiitioD; nmmoula iu excess changes tbe green color to a deep blue, and precipitates red ferric hydroxide.

DUE—Distill guisLed from pyrite by lis iuferlor hardness and deeper yellow color. ' Resembles gold wben disseminated in mioute grains in quartz, but diflers in being brittle aud in having a black streak; further It Is soluble Iq nitric acid.

Obs.—A widely dlEeemlnated mloeral Iq metallic veins and uests in gneiss and crystalline schists, also in serpentine rocks; often intlmutely associiited wlih pyrita, also with alderite. telrshedrlte. etc, sometimes with nickel and cobalt sulphides, pyrrbotlte, etc. Observed coated with tetrahedrlte crystals In parallel position, also aa a coating over Ihe latter.

Cbalcopyrite is the principal ore of copper at the Cornwall mines: there aasocialed with CBssilerite, galena, bornite, chalcoclte, tetrahedrlte, sphalerite. At Falun, Sweden, It occurs in large masses embedded In gneiss. At Rammelsberg, near Qoslar In the Harz, forma a bed In arglllnceous schist; occurs with nickel and cobalt ores in the Eupferschiefer of Mftcsfeld. The KurprinK mine at Freiberg affords well-defined crystals; also Hor-hniisen, Dlllenburg, Neiidorf, HOseu; Schlackenwald In Bohemia. Common elsewhere as at Mte. Callul In Tuscany; in New South Wales; Chill, etc.

Ill Maint, at the Lubec mines and elsewhere. In Vermont, at Siafford, etc. In Mau.. at the Southampton lead mines. In Conn., at Bristol. In N»w York, in crystals and massive at ElleovUle, Ulster Co. In Ptnntylvania, at Phenlxvllle; at tbe French Creek mines, Chester Co.. with pyrite. magnetite, etc. In Marylatid, near Finksbury, Carroll Co.. abundant. In Virginia, at the Pbeolx copper mine*, Fauquier Co., and tbe Walton gold mine, Louisa Co. In N. Carolina, near Qreensboro', abundant massive. In Taiintuee, 30 miles from Cleveland, in Polk Co, In MiMOwri, with sphiilerlte at JopJin, Jasper Co.

In C<U.. In different mines along a belt between Mariposa Co. aud Del Norte Co., on west side of, and parallel to. tbe chief gold belt; occurring massive !n Calaveras Co., and In crystals on IJomingo Creek, etc. Abundant In Montana, near Butte, wlib bomite,

£yrlte, etc., also at other points, often arpentiferoiis and auriferous. In Colorado, abundant I Ollpin, Boulder, OhaSee, Qunuison counties, etc.; commoaly nssociated with pyilte.

tetniliedrite, sphalerite, and often bigtily argentfferouB. Also mined In Arizona, Ctab, but fu most caaes chiefly for iilvor aud gold. Grant Co., New Mexico.

lu Canada, in Penb and near Sherbrooke and at nianj polnu In the eastern part of the province of Quebec: la the Niplaslne distr., Ontario, at Tarlous points; extensively mined At Sudbury; at tbe Bruce mines, onL»ke Huron; atFolat-au-MinesandeliewLereonLake Superior.

Named from xaAffiFc, bran, and pi/ntM, by Hencbel {172&).

D. Disulphides, Diarsenides, etc.

The disulpbidea, diaraeiiidea, etc., embrace two distinct gronps. The promiiieiit metijs included are the same in both, viz.: iron, cobut &nd nickel. The ^npa present, therefore, aeveral cases of isodimorphism, as is shown in the hsts of Bpecies below. These sulphides are all relatively hard, H. = 5-6; they bence strike fire with a steel, and this has ^ven the familiar name pyrites applied to most of them. The color varies Mtween pale brass-yellow and tin-white.

Pyrite Oroup. B9,,RA£,,RSb,. Isometric-pyritohedral.

Pyrite FeS, Oendotffite NiS,.NiAB,

Hanerite MnS, Corynite NiS,.Ni(Aa,Sb),

J Smaltite CoAs,, also (Co,Ni)As, Ullmaimit« N'iS,.2liSb, (isometric-tetar-1 Chloantfalte NiAs,, also (Ni,Go}AB, Sperrylite PtAs, [tohedral)

Cobftlttte GoS,.GoAs, Lanrits BuS,?

Marcaalte Oroup. BS,, RAs,, etc. Orthorhombio.

The Pybite Group includes besides the compounds of Fe, Co, Ni, also others of the related metals Mn and Pt. The crystallization is isometric-pyritohedral.

The species of the Mabcasitb Group crystallize in the orthorhombio system with prismatic angles of about 70" and 110° and a prominent macro-dome of about 60° and 130°. Hence fivefold and sixfold repeated twins are common with several species, in the one case the prism and in the other the macrodome named being the twinning-plane.

.dbyGooglc

^1

DESCBIPTITE HIKKRALOOT.

Pyrjte Group.

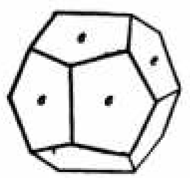
PTKITB. Schwelelklcs, Eisenkies, Germ, Iron Pyrites.

iBoinetric-pyritoliedrttl. Cube and pTritobedron e (210) the common forms, tfae facee of both often with striations { edge a/e, due to oscillatory combination of these forms and tending to produce rounded faces; pjritohedral faces also striated J. to this edge; octahedroD also common. See Figs. 610-617, ako Figa, 117-123, pp. 44,45, Twins: tw. ai o, usuallypenetration-twins with parallel axes (Fi^. 369, p. 124); rarely contact-twins. Freouently massive, fine granular; sometimes subfibrous radiated; reniform, globular, stalactitic

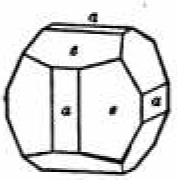
Cleavage: a, o indistinct. Fracture conchoidal to uneven. Brittle. H. = 6-6-5. 0. = 4-95-5-10; 4-967 Traversella, 5-027 Slba. Luster metallic, «11. 612. 618.

610.

611.



612.



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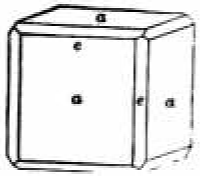

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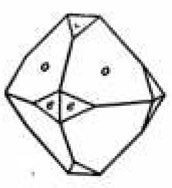

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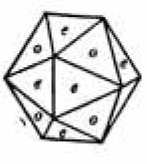

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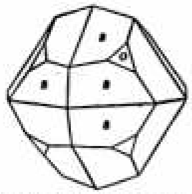

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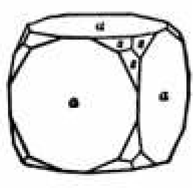


splendent to glistening. Color a pale brass-yellow, nearly uniform. Streak greenish black or brownish black. Opaque.

Comp., Tar.—Iron disulphide, FeS, = Sulphur 53-4, iron 46-6 = 100, ^^ Nickel, cobalt, and ihalllum, and aliio copper !□ small qitautiiies, sometitDes replace part

^vC of the iron, or else occur as mixtures; seleiiiuin is sometimes preaeal in traces, Qold U ,^ sometimes distributed iuvisibly tbrough it, auriferous pyrlte being an important source of -T gold. Arsenic Is rarely present, as in octahedral crystals from French Creek, Pcdd. (0*3 p. c. As).

Pyr., etc,—In the closed tube a sublimate of sulphur sni) a magnetic residue, B.B. on charcoal gives off sulphur, burning with a blue flame, leaving a magnetic residue which reacts like pyrrhotlle (p. 290). Insoluble in hydrochloric, but decomposed by nitric acid,

Diff—Distinguished from chalcopyrile by its greater hardness and paler color; in form and specific griivily different from marcoslie, which hns also a vvblter color.

Obs.—Pyrite occurs abundantly in rocks of all ages, from the oldest crystalline lo the most recent alluvial deposits. It usually occurs in small cubes, pyrllohedrons, or in more higlily modified forms; also (often with marcasite) la irregular spheroidal nodules and in veins, in clay slate, arettlaceous sandstones, the coal formation, etc,

Fiue crystals have been found in some of the Cornish mines; also in great variely with hemialte on ihe island of Elba, and with magnetite at Traversella and Brosso in Pteamont. Other localities for crystals are HQaen near Slegen; Preiberf;, Baxony; Schneeberg; Waldenstein In Carinthia; Pfibram, Bohemia: Sebemnitz, Hungary; Persberg, Falun, and Lftngban In Sweden ; Kongsberg In Norway.

In Maine, at Peru, Waterville, etc. In N. HnmjttUre. at Unity, massive. In Mat*,, at Rowe, Hawley, massive. In V&rmont. at Shoreham. In limestone; Hartford. In Conn., at Roxbury. finely crystallized. In N. Yorlc, at RobbIc, fine crvslals; at Schoharie; ut Chester, Warren Co.; io Omnge Co., at Warwick; massive In Franlilln, Putnam, and Orange Cos.,

etc. Id Pemuylwmia, at Chester, Delaware Co.; at KuaueiiowL, Chester Co.; at French Creek mlues, oclshedrooa aud other forma, sometimeB tetragonal or ortborhumbic lu symmetry; Goruwall, Lebonoti Co.; iu Sf. Car,, n«aT Greensboro', Giillfurd Cu., Id cryaials. la Coloratlo, crygtals near Central City, Oilpln Co., and elsewhere. Auriferous pyrlle la common at the mlnea of Colorado, and many of those of California, as neil as in Virginia u)d the States soulb. In Cajiada, 2 miles N. W. i)f Brockville, Ontario, a cobaliiferoua

Large quBnlilies of maBsive pyriLe are mined at the Rio Tinto and olher mlues in Spain, also iu Portugal. Among important deposits tu the U. S. are those al Rowe, MasH.; Herman, St. l«wrenca Co., uud Ellenville, Ulster Co., N. Y.; TolersTllle, Louisa Co., Va.; Dalhis, Pauldiog Co , Gn.

The name pyrile Is derived from Tcvp, firt. and alludes lo Ihe sparks from fricllon ; hence ilie early uame pj/ntet (p. 309).

Pyrlte leudily changes lo au iron sulpliote by oxidation, some sulpliur being set free. Also to limonite on lla surface, and uflerward throughout, by the scliou of a solution u(bicarbonate of lime carrying uS. the sulphuric acid as change proceeds, and from llmoDlte to red iron oxide.

Hanarite. Mangnneae disulphlde, Hn8|. In octahedral or pyrilohedral cryaials; also masslTe. 6. = S'M. Color reddish brown or browDlsh black. From E^llnka, Hungary; Kaddusa, Catania. Sicily.

8HAI.TITZI-OHZ.OANTHITB. Speiakobalt Otrm.

iBometric-pyritobedr&l, Comtnonl; massire; in reticulated and other imitative shapes.

Cleavage: o distinct; a in traces. Fracture granular and uneven. Brittle. H. = 5-5-6. G. = 6-4 to 6-6. Luster metallic. Color tin-white, inclining, when masaive, to steel-gray, sometimes iridescent, or grayish from tarnish. Streak grayish black. Opaque.

Com p.— Shalt ITE is essentially cobalt diarsenide, CoAs, = Arsenic 718, cobalt 2S-2 = 100. Chloanthite is nickel diarsenide, NiAs, = Arsenic 71 9, nickel 281 = 100.

Cobalt and nickel are usually both present, and thua'ihese two species graduate Into each other, and uo sharp line can be drawn beiweeii them. Iron is also preceut iu varying amount; tbovnriety of chlnanlhite contiilnlug inurfa iron haabeen culled<;Anl/ti mitt. Funher sulphur la usually present, but only in small quanlilies. Many unalyiea ilo not conform even approximately to the formula RAai, Ihe ratio Htlng from less ILnn 1:3 to 1 ; Z'C end □early 1:3. thus showing a tendency toward skulleruilile iRASi], perhaps due to either molecular or mtchanlca! mixture.

Much thai haa been called smaltite (spetskobalt) Is ahown by the high speciGc gravity lo belong to Ihe orthorhombic apecles safflorile.

Fyr.. etc.—In Ihe closed tube glvea n sublimate of metallic arsenic; In Ibe open tube a white aublimalB of arsenic trioxide, and sometimes traces of sulphur diojide. B B, on charconl clvea an araeulcat odor, and fusea to a globule, which, treated with successive portions of botax-glais, affords reacliona for irou, cobalt, and nickel.

Obs.—Ususlly occurs in velne. accompanying ores of cobalt or nickel, and ores of silver and copper; also, in aome inslances. wi'li nlccollte and areenopyrite. Found at the Saxon mines; Jonchiinstfaal. Bohemia; WhenlSparnon, Cornwall; Rlechelsdorf. Hease; Tuoaberg, Sweden; Allemont, DanphinS. In the U. S.. at Chalhem, Conn., Ihe cAaMam^ occurs In miia slate, wlih nrsenopyrite and ulccoUte; al Franklin Furnace, N. J.

OOBALTTTB.

laometric-pyritohedral. Commonly in cubes, or pyritohedrons, or combinations resembling common forms of pyrite. Also granular massive to compact.

Cleavage: cubic, rather perfect. Fracture uneven. Brittle. H. =^ 55. G. = 6-6'3. Luster metallic Color silver-white, inclined to red; also steel-gray, with a violet tinge, or grayish black when containing much iron. Streak grayish black.

'CoMp.—Sulpbareenide of cobalt, CoAaS or OoS,.OoA8, = Sulphur 19-3, arsenic 45-3, cobalt 35-5 = 100.

Iron Is preaent. and in the VAviety f«rroeobaUile in large amouDt.

Pyr., flto.—Unaltered tu the closed tube. In the open lube gives sulphuroiu fuma, and a cryst&lllDe sublimate of arsenic triozide. B.U. on charcoal givea oft sulphur ftnd arsenic, and fuses to a magnelic eloliule; wilh boruz a cobalt-blue color. Soluble In warm nitric acid, with tbe stparaiioo uf sulphur.

Obs. ^Occurs at Tuuiiburg uud HakausbO Id Sweden; at the Nordmark mines; also at Sbutterud In Norway; iit Scbladmlue, Ktyrla; Biegeu la Westphalia; Botallack roloe, uenr St. Just, in ComwaH; Khetri mines. Kajpuiaua. India.

G«radorffit«. Bulpbarsenide of nickel. KIAsS or N[6,.NIAS(. Iron, and somelimea cnbult, ruplace more or Irss of tbe nickel. Isometric-pfillohedral: usuallj massive. H. = 5-S. Q. = 0 6-6-2. Color dlTEr-wbite to Blcel-grny. From Loos, Sweden; the Han; Sclilitdming, Btyria. etc.

Oorrnita Is near geradorfflte, but conlains also antimony. From Olsa, Carinthla.

WlUyamita. CoBi.NiB,Co8b,.Ni8b,. Cleavage cubic. Color tin-while to steel-gray. Broken Hill mines, New South Wale*.

nununnlts. Bulpbanlimonlde of nickel, NiBbS or NiBtNIBb,; arsenic la usually present In smnll amouat. Isometric-tetartohed ml; both p^rituhedral nnd tetmhedral forms occur (see Figs. 1«, 147. p. 61). Usually msasive, grimular. H. = 5-55. G. = 6 2-6-7. Color sleel-gray to silver-white. Occurs In the mines of Freusbiirc, Nassau; SleEOU, Prussia; LOllliig. Ciirlntlita (tetrahedral); Montenarba. Siirrabus, Surdlnui (pyritobedraT).

Ealliute. WlsmulLaQdmounlckelglanx Germ. NI'Sb.BDS or NlHi.NI(Bb.Bl),. Hussive, culor light bluish gray. From the Friedrich miue uenr Scb&nsteln a. d. Sieg, Oenniiny.

Bpanrrllta. Fliitinum dlarwoide, PtA<t. In minute cubes, or cubo-octahedrons, H. = 6-7. G. = 10-eoa. Luster metallic. Color tin-white. Streak black. Found at the Vermillion mine, 33 miles west of Sudbury, Ontario, Canada; also in Mncou Co., N. Carolina. This is tbe only known native compound of platinum,

LanrltA. Sulphide of ruthenium and osmium, probably esseatially RuSi. In minute octahedrons; in gmlua. H. = 7-5. O. = 6-M. Luster metallic. Color dark Iron-black. From tbe platinum washings ot Borneo. Also reported from Oregon.

Skuttemdit*. Cobnlt arHenldo, CoAsi. Isometric-pyrl I oh edral. Also totttiv* granular. Cleav^: a distinct. H. = 6. Q. = 6-72-6'86. Color between tln-whlte and pale lead-gniy. From Skuttenid. Norway.

NicKm. BKTTTTBRCDCTE. (NI,Co,Fe)Asi. Hasslve, granular. Color gray. From near Silver City. New Mexico,

BisutiTO-Bif ALTiTK. Co(As,Bi)i. A Bkuttefudlte containing bismuth. Color tln-whlte. o. = 6 03. Zschorlau, near Scbneeberg.

Marcafifte Oronp.

For the list of speoieB and their relations, eee p. 399.

MABOASTTB. White iron pyrites. Orthorhombic. Aim dil:i = 0-7662 : 1 : 1-2343. mm"', 110 A iTO = 74* SBf. w", 101 A iOl = 116*30'. Twins: tw. pi. m (Fig. 619), sometimes in stellate fivelings {Fig, 406, p. 138, cf. Fig. 630); also tw. pi. e (101), less common the crystals crossing st angles of nearly 60°. Crystals commonly tabular || c, also pyramidal; the brachydomes Btriated || edge b/c. Often massive; in stalactites; also globnlar, reniform, and other imitative shapes.

CleaYaj;^: m rather distinct; ? (Oil) in traces. Fmctnre uneven. Brittle. H. = 6-6'5. G. = 4-85-490. Luster metallic. Color pale bronze-yellow, deepening on exposure. Streak grayish or brownish black. Opaque.

C«mp.— Iron diaulphide, like pjrite, FeS, = Sulphur 53'4, iron 46'6 = 100. Areenic is sometimes present in small amount.

Tar.^Tlie varieties named depend mainlj on state of cry^tullizatiou. Itadialed (StiahUda Qerm): Radialud: also tbe ilmple crystals. Cockicomb P. {Kammltiet Genu,): AggregiitiouE of HiLlceui'd Iniu ciyslala 1q crest-like forms. Npear P. (SpterkUt Uenii.): Twiu cryslals, witb re-uuienug uugles a \\\x\e like tbe hrad of a spear In form. CapiUary (Haarkiit Qetm.); In capillary cr^Blalliuitions.

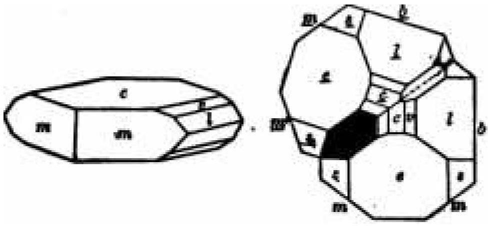
Pyr., etc.—Like pjrite. Very liable to ciecomposition, more so than pjiite.

S4fi.~ReBembles pyrite, bul bas a lower speciHc gravity, and the color when fresb {e,g.

after ireatment with acid) Is paler; when crystnllizud easily distingulsbed by the forms.

JoachiiDBlbal, Bohemia, and in Saxouy and Uie Harz. Occurs with galena and fliiorile In Derbjrahlrei lu chalk-marl between Folkestone and Dover; near Alston Moor, CamberlBDd;

818. SIB. «ao.



Common Form.

.1 Galena, III., in stalaciltea vilh concentric laye

,-... „ , Wis., in flue crystals; on sphalerite at Joplln, M..

The word mareatitt. of Arabic or Moorish origin (aud variously used by old writers, for

•pbalerite and galena; Mineral Point, Wis., In fl

: layera < In, Mo.

bismuth, antimony), was tbe name of common crystallized pyrite among r . .

mineralogists In later centuries, until near the close of the last. It was first given to ihta spetdes by Hnidiuger Id 1B4S.

IfttUlnglte. Eseeollally iron diarsenlde, FeAsi, but passing into Fe^Ast (feUfWpyrM);

■' ■ ■ - ..-.-.--.---.-----|„50^ . "

Occurs In the LOI1 Inc-HQtienberg district In Carinthia; with niccoHte at Scbladming, etc. In the U. S., lOllinglte occurs Iq Gunnison Co., Colorado, etc.

Oetxbitb Is near lOllfnglte, but conlalus sulphur; from Oeyer, Sasony.

ABSENOPTBITB, or Mibpickbl. Arsenkies Oerm. Orthorhombio. Axes il:h:b = 0-6773 :1 :1-1882. mm'", 110 A liO = OS" IV.

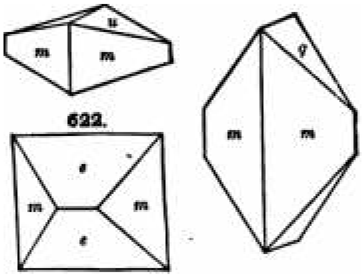
d, 101 A ioi = lao' 88'.

Mtt'. 014 A 01* =-. 88° 6'.

nn', 013 A 0i2 = 61° 36',

^. on A Oil = SQ" 50*. Twins: tw. pi. m, Bometimea repeated like marcasite (Fig. 407, p. 128) j e (101) crnciform twins, also trillings (Fiffs. 402, 403, p. 128). Crystals prismatic m, or flattened vertically by the oscillatory combination of brachydomea. Also columnar, straight, and divergent; grannlar, or compact.

Cleavage: m rather distinct; c in faint traces. Fracture nnerec. 1


622.

H. = 5-5-6. G. = 5-9-6'2. Luster metallic. Color silver-white, inclining to steel-gray. Streak dark grayish black. Opaque.

Comp^ Tar.—Sulpbarsenide of iron, FeAsS or FeS,.FeAB, = ArBenic 46*0, sulphur 19'7, iroa 34'3 = 100. Fart of the iron is sometimes replaced by cobalt, as in the variety danaiU (3 to 9 p. c Go).

Pyr., etc.— Id Ibe closed tube ftt flnt gives & red Hublfm&te of aiaenfc trisulphlde. theo B black lustrous subllmiite of metallic aiMiitc. Ip the opeo tube givw eulpburous romeB sod a wbite autilimftte of arsenic trloxlde. B.B. on charcoal gives anenldu fumes aud a magoetlc globule. The vu-letles containing cob>ll give, after the arsenic has been losMed ofl, a blue color with boTai-glass when fused in O.K. with successive portioos of flux until all the Iron is oildi>ed. OTves lite with steel, emitiing an alliaceoua odor. Decompoted by nitric acid with the separation of sulphur.

Dt£—Characterized bj Its hardness and tin-white color; closcl j resemblea some of the ▪ulphldes and arsenides of cobalt and nickel, but identified, in most casea easllj, bj its blowpipe characters. LOlHngite does not gire a decided aulpliur reaction.

Ob«,—Found principally ID crystalline rocks, lu usual mineral associates being ore* of silver, lead, and tin, also pyrite, cbalcopyrlle, and sphalerite. Abundant at Freiberg, etc., InBaxonj: Rclcbeniteln, Silesia, In serpentine: lu beds at Breltenbrunn, Andreatberg, JoacLltnethaU Tunabers, Sweden; Skntlerud. Norway; at several points In Cornwall.

In (he TJ. B., in N. SampthiM, In gneiss, at Frabconla (danatie). In Maine, at Blue Hill, etc. In Conn., at Chatham; at Mine HUl, Roiburj, wlib eideriie. In JIT. Fork. massive. In Lewis, Essex Co., wilh hornblende; near Edenville. and elsewhere Id Orange Co. In CVi^omia, Nevada Co.. Qrass valley. In crystals at St. Fniu9oia, BeauceCo.. Quebec; large beds occur in quartz ore veins at Deloro, Hastings Co., Oniarlo, wbere It la mined for gold.

The name mlsplckel is an old German term of doubtful oilgln. DaTuiite is from J. Freeman Dana of Boston (1798-1687), wlio made known the Franconla locality.

Baffiorite. Like amaltite, essentially cobalt dlaraeulde, CoAsi. Form near thai of arwnopyrlte. Usually niaKslve. H. = 4'S^. O. = 6'9-7-8. Color tin while, soon lar-nishlng. FromSchneeberg, Saiony; Bleber, Hesse; WItliclien, Badeni Tunuberg, Sweden.

Rammelsborgite. EsaentiBlly nickel diarsenlde, NlAsi, like chlounthlte. Cryitala resemblInK arsenopyrite; also raasdve. G. = 6-8-78. Color tin-wblle with llnge of red. Occim at Bchueeberg and at Rteclielsdorf.

Olancodot. Sulpbarsenide of cobalt and Iron, (Co,Fe)Ae8. In ortbortiombic cryaliiile (aiea, etc., p. 269). Also mn-slve. H = 5. G. = 6-90-6-01. Luster metallic Color grayish tin wlilte.' Occurs In the province of Huusco, Chili; at HakansM, Sweden. Named from yXavito^, blvs, because used (or miiklng smnlt.

Alloclailts. Probably essentially Co(As.Bi)S with cobalt in part replaced by Iron; or a glaucodot containing bismuth, CommoDly in columnar to hemispherical aggregates. H. = 45. G. =6-6. Color steel-griiy. From Orawilza.

TolfaohiU. Probably Ni(As,8b)8, near t-orynlte. In small ctrslals resembling arsenopyrite; also colurauBT radluted. H. = 4-B-5. o. =6-878. Color silver-wbite to tin-white. From Wolfach, Baden.

The following species ara telluridos of gold, silver, etc

STLTAHITXI. Graphic Tellurium. Schrift-Tellur Germ.

Monoclinic. h:l:t = 1-6339 : 1 :1'1265; /J = 89° 35'. Often in branching arborescent forms resembling written characters; also bladed and imperfectly columnar to f^nular.

Cleavage: i perfect. Fracture nneven. Brittle. H. = l'5-2. G. = 7*9-8-3. Luster metallic, brilliant. Color and streak pure steel-gray to silver-wbite, inclining to yellow.

Comp.—Tellnride of gold and silver (Au,Ag)Te, with Au : Ag =] : l; this requires: Tellurium 62-1, gold 245, silver 13*4 = 100.

Pyr., etc. —Ill tlie open tube givea a wbite subllmale of tellurium dioxide which near the a«si,T is gray: nben treated wftli llie blowpipe tlanie the sublimaie fuses to clear tru)t> parent drops. B.B. on charcoal fuses to a dark gray globule, coTeriUf; the coal wlih a while toiiilng, which ITeatL'il in K.F. disappears, giviug a bluish-creeu culor to the Uame; after liiii)r blowing a yellow, malleuble metallic globule is obtained. Musi Tarielies give u fuint cuaiiuf iif leiid oxiUe aud aniimonj oxide on cbarcoat.

Obi ^Witb gold, at Oifenb&ujra, TruuH^lvanla; also at Nagy^. lu Californtn, Calaveras Co., at the HeUines and StuuiiilauB mines. lu Boulder Co., and elsewhere in Colorado. Named from Transylvauia, where fli-st found, and la allusioa to sjfjninium, one of the names at first proposed for the metal lelliirtum.

Krennarita. A telluride of gold and silTcr (Au,Ag)Tei like syWauite. In priamatlo orvstttls (orthorhombtc), vertically sirialed. G. = 8853. Color silveT-white to braas-jellow. From Nagy&g, I'musylvauia; Cripple Creek Colorado.

C'ALAVERITB A gol^l-silrer telluride. Like syWaaite (Au,Ag)Tem with Au : Ag = 6 : 1 or 7 ; I. Massive. H. = 25. Q. = 9043. Color pale bronze-yellow. Occurs with l>etz<te nt the Sianislnus mine, Calaverus county, Callforuia. Also at the Red Cluud and other mines, Colorado,

Calaverite bat ihe same general formula ai syWanite but a much higher percentage of jfold. and miiy belong with it; or, aa aeema prol»bl«, krennerlte may De the cryatallized form of calaverite.

Na^aglte. A sutpbo-lelluride of lead and gold; containing also about 7 p. c. iif antimony. Orthnrhombic. Cryatala tabular Tb; alau granular massive foliated. Cleavage: ft pevfeci; flexible H. = l-l 5. G. = 6 85-7-3.. Luster metnllie, Bplendenl. Stirok and color blncklaU lead-gray. Opaque. From NagyAg, Transylvania; and at Offenb&uyu. Reported from Colorado.

Oxy sulphides.

Here are included Kermeaite, Sb,S,o, and Voltzite, Zn,S,o.

Hermaalte. Anlini on blende, Rotlispiassglanzerz o»rm. Pyroslibile. Antimony oxy-•ulpbide. ab,8,o or 3Sb,Si.Sb,o.. Monoclinic. Usually in litfts of rapillary cryilals. Cleavage: a perfect. H. = 1-1 S. G, = 4 5-4 6. Luster adamantine. Color cherry-red.

Kesults from tbe alteration of stibnlle Oncurs at Malaczka, HiiDgary; Brflunedorf, Saxony: Allemoni, DaupbinS. At South Hnm, Wolfe Co., Quebec. Canmlii; with native anlimony and stibnito al tbe Prince William mine, York Co., Hew Brunswick.

Named from ktrne*, a name given (from the Persian gurmitg. crimson) in the older chemistry to red amorphous antimunv trisiilpliide, often mixed with antimony trioxide,

VoltiiU. Zineoxyeulphlde. Zn.S.O or 4Zn8,ZuO. In implanted spherical globules; n _< ..« n ^8-66-880. Color dirty rose-red. yellowish. Occurs at RoBiSres, Puy —u„i. «._.„v— o y(Mtrilmdt).

de Ddme; Joachlmsthal; Marleuberg. Saxony (I

m. STTIf HO-SAI.TS.

L Snlphanenitei, SnlphantimoniteB, SnlphobUmuthltei. n. Snlpharsenatea, SnlphoBtauuates, eto.

X. Snlphanenitei, Snlphantlmonitei, etc

In these sulpho-soltB, as further explaiaed on p. 248, sulphur takes th« place of the oxygen in the commoner and better understood oxjKen-acide (as carbonic acid, H,CO„ sulphuric acid, H,SO„ phosphoric acid, H,PO„ etc.).

The species included are salts of the sulpho-acids of trivalent arsenic, antimony and bistnuth. The most important acids are the ortho-acida, H,AsS„ etc, and the meta-acids, H,A8S„ etc.; but II^As,8„ etc., aud a series of others are included. The metals present as bases are cliiefly copper, silver, lead ; also zinc, mercury, iron, rarely others (as Ni, Co) in small amount. In view of the hypotheticaJ character of many of tbe acids whose salts are here represented, there ia a certain advantage, for the sake of comparison, in writing the composition after the dualistic method, RS.Ab,S„ 3RS.As,S„ etc.

As a large part of the fifty species here included are rare and hence to be mentioned but briefly, the clossincation can be only partially developed. The divisions under the first and more important section of sulpharsenites, etc.> with the prominent species under each, are as follows:

D. Ortho- Division. BS -. (As,Sb,Bi),9, = 3:1.

General fononla: B.ABS>,B,Sb8.; B.AB,S^B,Sb,S^ eto.

BouFDODlte Group. Bounonite 3(0n.,Pb)S.Sb,8, Wittiohenite 3Cti,S.Bi.S,

Aikinlte 3(Fb,Ou.)8.Bi.8. XiUiuiito 3FbS.Bi,S^ etc

Pyrargyrite Qronp.

Pyn^yTite 3Ag,S.Sb,S, Frovstite 3Ag,S.A£,9,

E. Basic Division. BS : (A8,Sb,Bi),8, = 4 :1, 5 :1, 6 : 1, 9 : 1,12: L Tetrahedrite Group. 4Cn,S.Sb,S, Tennanttto 4Gu,8.Aa,S.

JTordanlte Group.

Tetnhediite

A. Acidic Division.

ObiTtaUte. 3PbS.8BI,S,. Foliated ma»ive. Color lead-gray. From Chivlato, Peru.

Onprobiunntita. Probribly 3Cu,S.4BliB>. i" pirt argentiferous. Rwembles bisuuUi-Inlte. G. = ea-6-7. From Hdll Taljey, Park Co., Coloiado.

RMbamjrita. 4PbS.5Bf^,. Fine-gnnular, masfiive. Color lead-gray. 0. =6-1-4-4. From RezMnya, Bungaiy.

B. Meta- Division. E8.Ab,S„ RS.Sb,S„ etc. ZlDkeiilte Group. Orthorhombio. ZINILIINITB. B1 elan tin) OQglaDZ Qerm. Zliickenlle.

Ortliorhombic Atsb il:h:i-= 05575 :1 : 0-6353. Crystals seldom di». tinct; sometimeB in nearly heiagonal forms throngh twinning. iJatersl faces Ion si tad in ally striated. Also colaninar, fibrone, massive.

Oleavage not distinct. Fracture slightly uneven. H. = 3-3'5. G. = 5-30-fi'3&. Lneter metallic Color and str^ steel-gray. Opaque.

C»mp.—pbSb,S. or PbS.Sb.S, = Sulphnr 22-3, antimony 41-8, lead 35*9 = 100. ArseDiu aometimes replaces part of the antimony.

Pyr,, «to, —DecrepiiulSH aud fusee very eiially: lu the closed tube gives a faint lubll-male of sulpLur. and outimouy iriaulphlcfe. Id tbe opeo lube sulphurous fumes and a while subliiiiale of o:tide of nniitnony; ilie areenical variety gives ulBoaraenlcnl fumes. On cLurc<iul ia Himoal entirely volaliliied, giving a contiug nhicJi on the ouler edge is while, nnd iiuir the utia»y dark yellow; with suda iu R.F. yields globules of lead. Bohible Id hot Lydi'ochloric ucid with evolution of hydrogen sulphide and lepantloD <rf lead chloride ob

Obs—Occurs at Wotfsberg in the Barz; Einiigthal, Baden; Sevier County. Arkansas; Sail Jiiiiu Cu,, Coiorudo.

Andoiita. AgiS.2Pb8.38bi8i. Iu prismatic, orlhorhombic crystals. Color dark gray to lilock. From FcisOhAnya. WAnerite and Sundtitt belong here.

Bartorlte. Skierokius Oerm. PbS.AsiSi. In slender, atrlated crystals. O. = 6-808. Color dark lead-gray. Occurs In the doEouitte of Ibe BinoeDthai.

Emplactite. EupfiirwiBmutbglaDZ Otrm. CuiS.Bl,S|. In thin striated prismi. O. = 6 3-6'5. Color grayUh white to tlu.white. Occui-a In quartz at Bchwarzenberg aod Anuaberg, tiaxouy.

ObalcoiUUta. Wo] fsbergite. Kupferant1 monglanz ofrm. Cu,8.Bb,B,. In amall aggre-

gated prisma; also fine granulBT, mafisive. O, = 4'?&-6-0. Color between lead-gray and on-gray. Frnm Wolfsuerg in tiie Rarz. Oufjaiite from Spaiu is the &ame species.

Oalenobiamutlte. PbS.Bl,8,; also with Ag.Cii. C'yElnlllne columuar to compact. Color lEini-gray io liii-wliile. Q. = B'B. From Noidmsrk, Sweden; Pougbkeepste Oulcb, Coloradi) laladkaite, nrgentlferouaj; Fainn, Bwedeu (Belenlftrous}.

Berthieiite. Probably FeS Bb Bi. Fibrous massive, granular. 6. = 40. Color dark steel-gray. From Cbazelles and Bbirtouret, Auvergne; BrSunsdorf, Baiony, etc.

Matlldita. Ae.B.BI.S.. In slender, prismatic crystals. G. = 69 Color gray. From Morocfaoca, Peru; Lake City, Colorado. PLBNABaYBiTX, from Scbapbach, Baden, bas prubably the tame composition nnd may be identical.

Mlargyrita. Ag,B.ab,Si. In complex nionoclinic crjsuls. also masdve. H. = 3-3'5. G. = 01-6 SO. Luster metnllic-adamMiline Color iron-black to steel-gray, In thiti splints rs deep blood-red Streak cherry-red. From BrBunsdorf, Bs^iony; FersObfinya; PHbram, Bohemia; Clausthal, etc

Lonndite. A sulpbarsenide of tballlum, TlAsS^ MoDoclioic. Color oochiDeal-red. .From Allchur, HacMdonla.

, C. Intennediate Division.

Plaglonlte. Perhaps 6Pb9.4Sh Si. Crystals tblck tabular, monocllnic; also maailTB, granular to compact. O. = G'4. Color blackish lead-gray- From Wotfaberg, etc

BcUnoerits. S(A7„Pb)8.96l,Bi. Hastlve, granular. G. = «-7t- Color lead-gray. Treasury lode. Park Co., Colorado.

Klaprotbollta. SCuiS Bi,Bi. In furrowad prismatic cryital*. G. = 4'S. Color steel-gray. WItlicben, Baden.

Binnlte. Perhaps 8Cu,S.2Aa,8i Isometric-letrahedral; also maaslve. Q. = 4'477. Color dark steel-gray to iron-black. From the dolomite of Ite Binnenthal.

Waireidte. Domlndte. 8PS.2Sb,8i- In wool-like aggregates of acicular crystals. Color grayish black. Qunnlson Co., Colorado.

Jamesoiilte Group. 8B8.Ab,S,, 2RS.8b,S„ etc. Ottborliombic. Pria-matic angle about 80°. JAMESONITB.

Orthorhombic. Axes: &'.h = 08915 ; 1. mm'" = 78° 40'. In acionlar crystala; common in capillary lurnis; also fibrous magaive, parallel or divergent; compact massive.

.dbyGooglc

Cleavage: basal, perfect; b, m lebs so. Fractpre iiiieTen to conchoidal. Brittle. H. = 2-3. G. = 6'5-tJ-O, Luster metallic Color steel-gruy to dark lead-gray. Streak grajieh black. Opuqne.

Comp.—Pb,Sb,S. or2Pb8.8b,8, = Sulphur 19-7,antimony 295,lead 50-8 = 100. Moat varieties show a little iron (1 to 3 p. c.), and some contain also silver, copper, aud ziuc.

Pyr.^Sauie as fuT zlnkenili:, |>. 807.

Ob«.—Occurs priuclpaIly iti CumwHll; also In Slberin; HuDg&ry; at Valeotlad'Alcftnura ill Bpaiu; at the autluionj mints lu Bevkr Co., ArkauMS. Named after Prof. liobert Jameeon of Edinburgh (iTT^-ltiM).

The feather vrt (Fnlerei-z Qtrm.) occurs at Wolfaberg, etc.. In the H&iz; Freiberg. Bchemnuz; lu TuBcaoy, ueai' Bottiuo.

Dnfranoyaltfl. 3PIiS.AslBi. In liiglilj modified orlhorbombic cryitala; alw> massive. ClMvage: e perfect. H. = 8. Q. = 6-U-B'57. Color blackish lead-gray. From the Bin-QenlhaT, Switzerland, in dolomile.

Ratbits. a BUlpharsenite of lead resembling dufrenoysite. From the Blonenthal.

OoMOit*. SPb8.Bf,B>. Uauslly massive, fibrous or radiated. G. = 6-S»-6'T5. Color iMd- or st«ei-gr«7. CoMla, Province of Sinaioa, Mexico; Bjelke mine (bj^leUe), Nord-mark, Swedeu) Colorado.

KolMlllt*. Sn)8.(Bi,Sb),8.. Fibrous radiated or granular maifive. 0. = 0-3. Color l«ad-gnj to steel-gray. Prom Hvena, Sweden; Ouruy, Colorado.

Broagniardlt*. PbB.AgiS.Sb,Bi. In isometric octabedroDS and massive. G. = 0-030. Color grayish black. From Hezico.

Samsaylta. Near Jamesonlte, perhaps TPbS.SSbiBi. !□ small tabular mwocllnic ciysials. Q. = 5'9S. Color gray. From FelsOb&aya, Hungary.

Boluipbaohlta. PbS.A^.B.Bl.Bi. !□ aclcular crystals and granular masdve. Q. = V'ti. Cohir lead-gray. ;n«m Schapbach. Baden.

MoDoclinio. Aiea d : 5 : <! = 0-5871 : 1 : 0-9277; fi = 87' 46'. Habit prie-matic. Q. = 6'2-6'4. Luster metallic. Color and streak light steel-gray inclining to silver-white, alao to blackish lead-gray.

Com^—(Pb,AeJ.Sb,8 or 5(Pb,AgJS.2Sb,S ."

Ob*.—From tht^ HimmelaFUrst mine, at Freiberg, Saxony; Eapnlk. Hungary; b£nya; HiendeleQclna, Spain; also from Ibe Augusta Mt., Qunnison Co., Colorado.

Diaphorite. Like freleslebenlte in compodliou but orthorbombic In form, G. = Q-S. From PFibram, Bohemia.

BonxiANauKmi.

Orthorhombic. In crystalline plumose masses; graniilar, compact. H. = 2'5-3. G. = 575-60. Luster me^llic. Color blnian lead-gray; often covered with vellow spots from oxidation. Opaque.

CoMp.—Pb.Sb.S,, or 5PbS.2Sb,S, = Sulphur 18-9, antimony 25-7, lead 65-4 = 100.

Pyr.—Same aa for ifnkenlle, p. 807.

Obs.—Moliires, Depart, dii Gard, France; at Nerchinsk; Wolfaberg in Ibe H&rz; Pfihram, Bohemia: near Bottino Tuscany: Echo District, Union conntv, Nevada.

Bn^riiJtUt and plumbotUb are from Nercblnsk; tbey correspond nearly to 10PbS.S8b(Si, but the material analyzed may not have been quite pure.

.dbyGooglc

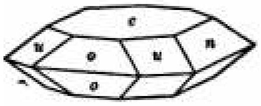
DB8CR1PTITE HINEBALOQT.

D. Orlho- Division. 3RS.Ab,S„ 3Rg.Sb,S„ etc Boamonlte Group. Ortborhombic. PrtBmatic angle 86° to 87°.

BOITRNONITB. Radclerz Germ. Wheel Ore. Ortborhombic. Axes; £:i -.6 = 0-9380 : 1 : 0-8969.

sn, 001 A Oil = 41* 63' su. 001 A 112 = 88° 16'

624.



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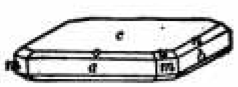

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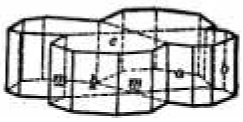


Huz,

Nagyig.

Kapnik.

Twins; tw. pi. m, often repeated, forming cruciform and wheel-shaped crystals. Also maBsire; granular, compact.

Cleavage: b imperfect; a, c lesfi dititinct. Fracture sabconchoidal to iiueTen.

Rather brittle. H. = 2-5-3. G. = 5'7-0-9. Luater metallic, brilliant. Color

and streak steel-gray, inclining to blackish lead-gray or iron-black. Opaque.

Comp.—{Pb,Cu,);Sb,S. or 3(Pb,Cn,)S.8b,8. = PbCuSbS, (if Pb : Cu, =

2 : I) = Sulphur 19-8, antimony 347, lead 42-5, copper 13-0 = 100.

Pyr., eta.—In the closeil tube decrepitates, and gives a dark i-ed sublimute. In tbe open tiib« glvta iulpbur dioxide, &□(! a white sublimate im oxide of ntitlmony. B.B. on charcoal fuses eHslly, aud at UrBt coata the coiil nhile; contlDued blntving gives a yellow coaling- of lead oxide; ihe residue, treated with soda in B.F., gives a globule of copper. Decomposed by dUHc acid, affording a blue solution, aod lenvlug a residue of sulpbur. and a wbile ponder coulaiuiiig antimony sud lead.

ObB.—From Ncudorf iu ilio Harz: also Wolfsberg, Clausihal, and AudreasbeTg: FNbram, Bohemia; Kaputk. Hungary; Bndelliou al Wheal Boys, Cornwall; ia Mexico: Huasco-Alto, CblSI.

In ihe U. 8., at the Boggs mlQe, Yavapai Co., Ariznon; also Montgomery Co.. Arkauaas; reported from Sao Jean Co., Colorado. Iu Canada, In the towDsblp of Marmora, Hoatlngs Co., and Darlinz-. Lanark Co.. Outarlo.

AttdnlU 8(Pb.Cu,)S.Bi,8.. Aclculnr crystals; also massive. G. s 8-1-6-8. Color blackish lead-gray. Prom Burezov uear Ekaterinburg, Urals.

WitUcbanlt*. 3Cu,8.Bi,3,. Rarely in crystals resembling boumonlte; also massive. Q. = 4-6. Color steel-gray or tin-wbite. Wilticben, Baden, etc.

Btylotypite. 3<Cu,,Axi,Pe)S.Bb,Si. In orthorhombic CTystals, in cruciform twins like boumonite. G. ~ 470. Color iron-black. Copiapo, ChfU.

SPbSBiBbS. and SPbS.BI.S.. Massive, crysUlHue. Color steel-gra;. Evens, Sweden: LeadvIUe, Colorado (argemiferous).

Qnltemunlta. Perhaps 3PbS.As,Si. Massive, compact. o.= 5'M. Color bluish gray. Zuill mine, Silverton, Colorado.

Tapalplta. A SDlptao-teDuride of bismuth and sliver, perhaps 3Agi(B,Te).Bii(S,Te)i. Haaslve, granular. G. = T-80. Sierra de Tapslpa, Jalisco, Mexico.

.dbyGooglc

BULPHo-8ALTB.

Pyrai^yrlte Gronp. Rhombohedrsl-lieinimorphic.

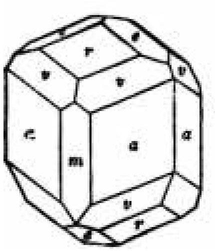
PTRASOTRTTB. RuLy Bllver Ore. Dark Red SlWer Ore. Duukles RotliKtLltlgerz, ADdmoudlberbleDde Qtrm.

Ehombohedral-hemimorphic. Axis: (1 = 0 7893; 0001 A lOll =42°20i'.

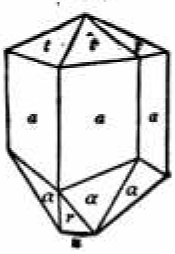
«■. oiia A ioia = 43* r w/, ai6i a ayii = 74' 86'

TT', lOia A ilOl = 71' 89 wi\ 2181 A 8l5l = 85° 12-637.

628.



629.



Crystals coniraoraly prismatic. Twins: tw. pi. a, yery common, the axes <! parallel; « (10l4), also common. Also maeeive, compact.

Cleavage: r distinct; e imperfect, Fractureeonchoidal to uneven. Brittle. H. — 25. tr. — 5~7-5'86; 5'85 if pure. Luster metallic-sdamaDtine. Color blaclc to grayish black, by transmitted light deep red. Streak porpligh red. Nearly opaque, but transparent in very thin splinters. Optically —. Refractive indices, a> = 3-084, e = 2-881 Fizeau.

Comp,—Ag,SbS, or 3Ag,S Sb,S, = Sulphur ITS, antimony 22-3, silver 59-» = 100. Some varieties contain small amounts of a

Pyr., eto.—In the clused tiiLe fuses aud gives & reddish sublimOite at aDtlmoDj' oiyBul-

g'lidt;; Id the iJpeQ Cube sulpliureua fumes uod a white Bublimate of oxide of autimony. .B, on cliiirciml fuses with spfrlirig to a gliibiiie. cotits the coal while, aod the assay U converted inio silver sulphide, wlilcli. treated iu O.F.. or with soda in R.F.. gives n globule of silver. lu case ar^L'uic is present it may be detected by fusing the pulverized iniDeral with snda on chttrtoul In R.F. Decomposed by nilric acid with lue separallon of sulpliur and of iintimony trioxjde.

01i«. —Occurs nt Andrensberg In the Hare; Freiberg, Saxony; PHbram, Bohemfn; Srhemnllz. elc. Huiigiiry; Koiigsherg, Norway; Gaudtilcanal, Spain; la Cornwall. In Mexico it is worked at Ouitnnjuato aud elsewhere as ad ore of silver. lu Chili with proust-ile at ChntiRrcillo nenr Coplapo.

In Coliimdo, not uDdiinmon; thus in Ruby district. Gunnison Co.: wiiL sphalerite Id Siieffle's dlstr . Ouray Co.. etc In Nevncla, nt Wasbne !□ Daney Mine; about Austin, Rec'ii' river; at Poornmu lode. Idaho, In mas>ea wilh cerurgyrite. In New Mexico, Utah, uud Arizona wilh silver ores nt vni-ious points.

Naiiied from Jivp, flrt, aud a/jyv/joi, ttlver, In allusion to the color.

Light Red Silver Ore. Lichtes Roihgliltigerz,-Kbombohedral-hemim Orphic. Axis i = 08039; 0001 AlOll = 42° 63'. «■, 0iia A ioia = 42° iff

vtf. aiSi A aaii = 74- 89" w, 2181 A alai = 35-18*

it', loii A iioi = 7a° 13' . Crystals often acute rhombohedral or scaleuobedral. u (10l4) and r. Also massive, compact.

tw. pi.

Cloav^e: r distinct. Fracture conchoidal to uneven. Brittle. H. = 2-2*5, G. = 5-5i-564; 5'57 if pure. Luster adamantine. Color soarlet-vermilion; streak same, also inclined to aurora-red. Transparent to translucent. Optically negative. Double refraction strong. a>r = 2*979.

Coap.— Ag,A8S, or 3Ag,8.AB,S, = Sulpbur 19-4, areenio 15-2, silver 65-4 = 100.

Prr., ate.—In Ihe cloaed tube tusM easily, and gifea a faint aubllmaM uf arseulc Iri-■ulpbide; !□ tlie open tube sulpliurouB fumes utid a wliiie oiTStulllne Hiibliiithic of urseuic trioxide. B.B. ou churcoal fuses aud eniita odora of sulpliiir aud urseoic; villi sudu In R.F, gives a globuJe of tillrer. Dccomposed bj nitric acid, witli sepnraitoo of biilpliur.

Oba.^lccurs al Freiberg, Joliaungeorgeusladt, etc.. iu Saxouj'; JoHCblmstbnl. Bobemia; Cbalnocljes iu IHupLlne; Quad&lcaiial Iu Spuiu; in Hezico; Peru; Cbltf, at CbaBarcillu iu uiagiiificeut crystallisHilouB.

In Cuiorado, Ruby distr., OunnUou Co.; Bheridau mlue, 8au Ulguel Co.; Vankee Oirl mine, Ouruy Co. In Arizona, wltb silver ores at various poluls. Iu Nevada, Id Ibe Daney mice, aud Id Comstock lode, rare; Idabo, at tbe Pnorniiiu lode.

Named after the FrencU chemtsi, J. L. Proust (1765-1826).

SangoUilta. Near prouatite in composition. In glltteriug scales, bexagonal or rhombohedral. From Cbafiarctllo. Cbili.

Falkenhaynita. Perhaps SCQiS.BbtBi. Massive. resembUug galena. From Joachtma-thal, Bobemia.

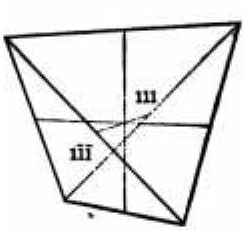
Fyroitilpnlte. Like pyrargyrlte, 8AgiB.Bb|Bi. Id tufts of sleader (moDOcliaic} crystals. Q. =4'25. Color liyaclnib-red. From Andreasbsrg iu tbe Harxi Freiberg; Pfibram.

Slttlngaiita. Coulalus arsenic, seleuiuin, and silver. Id small tabular crvsials. Q. =S-6S. Color blackisbbrowDtolrau-black; hyaci nth-red by I ransmitied llgbt Streak orange-yellow. From Ch&fiarclllo, CbilL

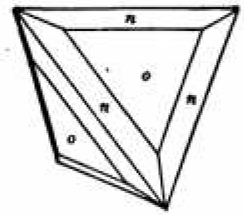
E. Basic Division. Tetraliediite Group. Isometric-tetrabednl. TSTRABEDRITB. Gmy Copper Ore. Fnhlerz Otrm. Isometric-tetrahedral. Habit tetrahedral. Twina: tw. pi. o; parallel axes (Fig. 354, p. 121, Fig. 370, p. 124). Also massive; coarse or fine; compact.

also with granular.

630.



631.



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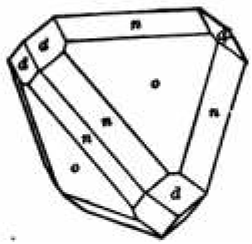


Cleavage none. Fracture aubconchoidal to nneven. Rather brittle. H. = H-4. G, = 4'4-5-l. /Luster metallit:, often splendent. Color between flint gray and iron-black. Streak like color, sometimes inclining to brown and cherry-red. Opaque; sometimea aubtranalncent (cherry-red) in very thin splinters.

Comp.. Tar.— Easentially Cu.Sb.S, or 4Cii,S.Sb,S, = Salphur 231, antimony 24-8, copper 521 = 100.

AnlimoD}' and nrsenlc are usually both present and ihua tetrahedrlte ^radufttea Into tbe allied species tennautite. TLere are also Tarielles coDlBiDlng biamutli, cliietly nt Itie Hrarnical end of tbe scries. Fuitber Ibe copper maj be replaced by iruD, zinc, bilver. mercury, lead, and rarely cobalt and nickel.

Vu.—Ordinary. CoutaiDa Ultle or do silver. Color steel-gray to dork grny and JroD-black.

G. = 4 75-i9.

Argentfferottt; FrtilMrgiU, Weiugiltigerz Qerm. Coutalus 3 lo 30 p. c. o[silTcr. Culor ^ usually sluel'gmy. lighter Ihaa Lbe oidloary TKrletles; aomellDies irou-blacki'streak oficu reddish. G. = 4-8B-S-o.

Mereuriul; Hchaattitt. Conlalns 6 to IT p. c at mercury. Color davk gray to Iron-black. Lu9ter often dull. O. = 5-10 cliletly.

Maliruneakite. from Peru and a similar variety from Arizjna, cootaln 18-16 p. c. of kad.

Pyr., etc.—Differ in ilie diS^reut varieties.]u ilie closed lube all Ilie antimoiiial kinds fuse uud give n dark red BUbilnialu of aDIlmony oiysuljibide: if much sTsenlc is present, a sublimate o[arBenic irisulpliidu tlrst forms. lu the oprn lube fuses, gives sulpburous futne* and a while subliuiMle of aotimouy oiide- if arsenic is piesenl, a crysialline volalile subli-male cod deuses with ihe aaiimony; if the ore cuniuiiiij inerrury it condenses in miniile nietullic globules. B.B. on cliarcoal fuses, givesa coaling of the oxides of antimony and SQiiietimea arsenic, ziuc, ami lead; Hrseuic is delected by the odor wbeu the coating is treated ID R.F. Tbe roasted mineral gives with tbe fluxes reactlous for Iron and copper; with soda yields a globule of metallic copper. Decomposed by nilric acid, with separation of sulphur aod antimony trioxide.

Diff.—Distinguished by its form, when cryslsllized, by its deep black color on fracture ADd brilliaut metallic tusler. It is harder than bournouite and much tofler than u:sguelbe: the blowpipe cbaraciers are usually distinctive.

Obs.—Oflen associaled viib chalcopyrlLe, pyrlie. splalerite. pslena. and VBri(.u> other •liver, lead, and copper ores; also sldente. Occurs at many Coruish mitits; tijiiti ai the Berod!<fi>ot mine. Liskenrd in tetrahedral crjsiiils often coaled wTib iiidtcci-nt cIih1< <i]'Viie; theXevaut mine near St. Just. From Andteiisberg and Cluusthsl in lbe Barz; t'rcWrg. Saxony; Dlllenburg and Horbnusen iu Nassau; at Altlfeii; larioiis mines in ihe Black Foreii; Pfibram. Bobemin; Eogel near Brixlegg in Tyrol; Kiipuik, Heriengnind. Hungary. In Mexico, at Durango. Quaaajualo; Chili; Bolivia, eic. The argtntiie^<w* verieiy occurs esprcinllv al Freiberg; I^ibnun; Hiiallanca in Peru, and elsewhere. The mrreurial variety at Sclijit'Olniiz. Hungary; Schwstz. Tyrol; valleys of Angina and Caslello. Tuscany.

In Ihe U. 1} , letrahedrlte occurs at lbe Kellogg mines, Arksntas. In Colorado, iu CIrar Creek and Summit Cos.; tbe Uluy mine, Luke Co.; witli pyrargyriie in Ruby district, Gunnison Co.. etc. Much of Ihe Colorado "gray copper" is leuuiinlile (see below). In Nevada, iibundant lu Humboldt Co.; near Ausliu in Lander Co.; I»ibel1a mine, Reese river. Iu Arizona at the Heinlzelman mine; at various points Id British Columbia.

TE HNAN TITS.

Isometric-tetrahedral. Orystalg often dode'Ahedral. Also ciassiTe, compact. H. = 3-4. G. =

4-37-4-49. Color blackish lead-gray to iron-black.

Oomp.—Eaaentially Cu.As.S, or 4Cu,S.A8,S, = Sulphnr 25-5, arsenic IT'O, copper 57-5 ^ 100.

Var—Of'en contnins Hutlmony and thus graduates into te trailed rile. The original teunantile from Cornwnll coittaina only copper and froD. In crystals, habit dodecnliedriit.

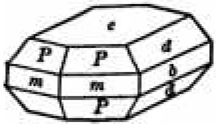
.Sandbergerite. KupferbUnde Oerm., contains 7 p. c. of zinc. Fredticite from Sweden has, besides copper, iilso iron, lend, silver, and tin.

Pound nl the Cornish mines, particularly at Wheal Jewel in Gwennap, and Wheal Unity biGwinear: ftlFreil>er2(X'«p/erWen(fo)i at the Wilhelmine mine in the Ppessarl: Bkutterud, Korway. Near Central City and elsewhere in Colorado, AlCspeltoo, Pr. Quebec, Canada. Named after tbe chemist. Smithson Tennanl (1761-1815). See further above.

Jordanita. 4Pb8.Asi8.. Honocllnic: often pseudobeiagonal by twinning. G. ^ 6 SIf. Color lead-gray. From the Binnenlhal; Nagyfig. Transylvania.

Meaeghinlte. 4Pb8,Sb,B,. Orlliorhomblc. In slender prismatic crysta's; alwi ui^B-iiu. G. = 0 34-6-43. Color bluckUh lead-gray. From Botllno, Tuscany; Marble Lakt, Kairie uwiisliip, Ontario.

633.



STDPRANmi. Melaoglaoz Owm. Brittle Bltver Ore. Orthorhombic. Axes A: I-.6 = 0-6292 : 1: 0-6851.

mm", 110 A liO = 64" 31' ed. OOl A 031 = 68' 62* eff. 001 A 101 = 47° 36' eA. 001 A 113 = 83* iff ek. 001 A Oil = B4* 25' eP. 001 a 111 = S3" 9" CrvaUls usually short prismatic or tabular | i. TwIds: pi. m, often repeated, pseudo-hexagonal. AIbo uittSsive, compact and disseminated. Cleavage: i, cf imperfect. Fracture subconchoidal to uneven. Brittle. H. = '2-2*5. G. = 6'2-6-3. Luster metallic. Color and streak iron-black. Opaque. Comp.—Ag.SbS, or SAg.S.Sb.S, = Sulphur 16'3, antimony 152, silver 68-5 = 100.

Pyx.—In Ihe closed tube ilecrepllHtea, fuses, aod after lung beating gives a faiut Buhliniule of antfinoDy oiysulpbide. lu [be open lube ftises, giving off aiitliiionlal and sulpburou* fiiraes. B.B. on cbsrcoiil fuses with piojecilou of smiill particles, coats the coal with oxide of aDtlinony, nhicb after long blowing Is colored red frotn oxidized silver, and a globule of metallic sliver Is obtaiued. Soluble tu dilute heated nitric iicid, sulphur and nutiinouy tiloxide belug deposited.

Obs. — In veins, wllli other silver ores, nt Freiberg. Schneeberg, etc., In Snxouy; Pi4bmtn, Bobemla: Bdicmiiiiz. Himgdrj: Andreiisberjir]„ the Hiira; Koiigsberg, Norway; Wheal Newton, Cornwall; Mexico; Peru; CbaBarclllo. Chili.

In Kevndu, In the Comstoctt lode, Reese riier, etc. In Idabo, at the silver mines at Tanhee Fork. Queen's River district.

Named after the Aicbdiike BlepliHQ, Miuiiig Director of Austria. a«ocroiilt«. 6PbS.BbiS(. Rarely in ortborliombic cryelale; usually massive, granular. a. ■= d-4. Color le&d-gmy. From ^la, Sweden, etc.

Boagerlts. ePbS.Bi,Bi. Hasslvc, indistinctly crysUllized. Q. = 7-ST, Color llgbt to ■dark gmy. Prom Psrk Co., Colorndo.

EUbriokanlte. Perb^^ps ePbS.Sb,8i. Massive. O. = 6-41. Color lead-gray. From Kilbrlcken, Co. dure, Ireland.

Polybasite Group. gRS,.Ae,S., 9ItS,Sb,S,. Uonoclinic, peetido-rhombobedral.

POLTBASTTB. BprOdglnserz, Eugeiiglanz Oerm. •^ Monoclinic. Axes a:t:i= 1-T309 : 1 : 1'5796, /3 = 90° 0'. Prismalio angle 60° 2'. In short six-sided tubular priGme, with beveled edges; c faces with triangular striationB; in part repented twins, tw. pi, m.

Cleavage : e imperfect. Fracttire uneven. H. = 2-3. G, = 60-6 2. Luster metallic. Color iron-black, in thin splinters cherry-red. Streak black. Keai'ly opaque.

CoiBp.-Ag,SbS, or 9Ag,S.Sb,S, = Sulphur 15-0, antimony 9-4, silver 75-6 = 100. Fart of the silver is replaced by copper; also the arsenic by antimony.

Pyr,, etc.—In ihe open tube fuses, gives Bulphurons and aDtlmonial fumes, the latter forraiiig n while sublimate, sometimes miied with crystalline arsenic trioxide. B,B, fuses with spirting In n globule, gives off sulphur (sometimes arsenic), and coals the roal with antimony irloside: with long-continued blowing some varieties give a faint yellowish-white coating of zinc oxide, and a meiallic globule, wliich with salt of phosphorus reacts for copper, and cupelled with lead gives pure silver. Decomposed by nitric acid.

Oba.—Occurs In the mines of Ouaosjusto, Mexico; at Tres Puotos. desert of Atacaina; nt Freiberg and Pfibram. In Nevada, at the Reese mlpes and at the Comstnck Lode, ia, Colorado, at the Terrible Lode, Clear Creek Co. Id Arizona, at the Silver Elng mine.

Named from itoXdt, many, and fiiitrti, bate. In allatloD to the bade clutracter of the cotnpouDd.

Fearcelte. 9AgiS,AeiSi. HoDOcllulc, pseuda-rLombohedral. From Aspeo, Colorado; HaryRTllle, Iiewis and CIsrbe Co., HodIrdo.

XI. Sulpharsenatea, Solphantimonatei; Sulpbo-atumatei, etc.

Here are included a few minemlH. chiefly Bulpbo-salts of qu&iiti vale tit arscDic and antimony; alao several snip ho-stan Dates and rare aalpho-german-ates.

ENABQITE.

Orthorhombic. Axes: d:i:i = 0-8711 : 1 : 08248.

Crystals usually snjall; prismatic faces vertically striated. Twins: tw. pi. X (520) in star-shaped trillings. Also massive, granular, or columnar.

Cleavage: m perfect; a, b distinct; c indistinct. Fracture uneven. Brittle. H. = 3. G. = 4 43-4-45. Luster metallic. Color grayish black to irou-biack. Streak grayish black. Opaque.

Comp.—Cu,AsS, or 3Cu,S.As,S, = Sulphur 32-6, arsenic 19-1, copper 48 3 = 100. Antimony is often present, cf. faniatinite.

Pyr.— In the cloird tube decrepiliktea. sud gives a sublimate of snlpbur; kI a bfglier tempurilure fuses, niiil givett ii subhmule iif aiilpliidu of iiriseidc. In the open lube, iieutcd genily. the powdered miiitrnl gives ofl Hulpburoiia niii! iirseideal fumes, Ihe l&tler ondeusing to n !<ub1iiimte coiil&ining some aiilimony oxide. B.B. od chnrronl fuses, und gives a fnint conling of Ibe oxi'les of tirsenlc. atulmony, nnd zinc; the rousted niioeral ivlib the Aux.s j^ven a globule of metnllic cop]^r. Soluble in aqua reg-lii.

OtM —From Morococha, Cordilleras of Peru; in Cljlli and ArgenllLa: Mexico; Halzen-knpfl, Brixlegg, Tyrol; Maocayan. lalniid nf Luzon.

In Die U. 8., nt Brevver's gold mine, Cbeslerfluld 6\n., 8, CarollDRi In Cnlomdo, at mines near Central City. Oiipin Co.; in Park Co.. al the Missouri mine, elc In iioutiierD Utah: nlso In ihc TIdiIc dUlHct: n>«r Butte. Houinna.

Clakitb. CerimpB identical wilb eniirgile. Fmin the Clara mine. Schapbacb. Baden.

LnzoNiTB. CompoBJlion of cnargite, but supiwscd to diSer in crystallizalion. Hussive. O. = iil. Color Bte«l.giBy. yrnin the island of Luzmd.

F»matinit«. 8Cu,8.8b,8., i omorpbou- vrilh enargile. G. = 4-57. Color gray with tinge of copper-red. From the Sierra de Famiitina, Argentina.

Zasthoconite.—8AgiS.A3,8i. In Ihln tabiilsT rhombobedral crystals; also massive, reniform. G. = S, Color orange-yellow. From Freiberg.

ZlplboD]aiigeril«.—8PbS.Bb,Bi. Id striated prismatic needles and granuhr. G. = 6'31. Color dark bluUh gray to black. From Altenberg.

Bplgsnils.—Perhaps 4Cu,8.IIFe8.A!t,S.. In short prisms resembling areeDopyrlte. Color sieel-gny. Prom Wittichen, Baden.

STAHHTm. TlnPyriles. Bel I-metal Ore. Zinnkles <7mn. Isomotric-tetrahedral. Massive, granular, and disseminated. . Cleavage: cubic, indistinct. Fracture uneven. Brittle. H. = 4. G. = 4*3-4-522; 4-506 Zinnwald. Luster metallic. Streak blackish. Color steel-gray to iron-black, the former vrhen pure; sometimes a bluish tarnish; of ten yellowish from the preaence of chalcopyrite. Opaque.

Comp.—A Giilpbo-stannate of copper, iron and sometimes zinc, Cu,FeSiiSj or Cu,S.FeS.SriS, = Sulphur 299, tin 27-5, copper 295, iron 13-1 = 100.

Pyr., etc.—In tbe closed tube decrepiUtes, Bud giFes a faiut sublimaie; In lUe open tube Hulpburous fumeH. B.B. on cbarcoiil TiiseB lo a globule, nbicli iu O h. gives oil aulpliur, Aud cuals Uii; coiil wllh tiu dioxide; (Ije roasleu mineral treated willi borax gives reactlouB for Iron ftud cop|>er. Decomposed by uUric acid, iiSoiding a blue Boluiiou, wiili separaliou of aulpliur and liu dioxide.

Ob«.—Pormerly fouud at Wlieal Rock, Coruwall: nud at Cam Breii: more reteutly iu grraulle at St. HlcWl's Mourn: also al Steuna Gnyuu, etc.; at tlie Crunebane mine, Co. Wlcklow, lu Ireland: Ziuuwald, iu the Eizgeliirge. From llie Black HiHb, 8u. Dakota.

Argyrodlt*. A silver eulplio-gvrmatiate, Ag>OeSi or 4Ag,B.Ge8,. Isouielric, crysiuls usually ludUtluct; also niusslve. compact. H. = 2 5. G. = e'08&-6-lll. LuBter metallic. Color steel-gray on a fresh frHtlure, wilb a tinge oC red turning to violet. From llie HimmelsrOrst mlue, Freiberg. Siixony.

Oanfialdlte. AgiSnSi or 4Ag,S.SiiS,, tbe lio iu part replaced by germanium. Isomelric,

Grliapsteiratiedral; iu ocluhedroDBwItbddlO). o. = 6'28. Luster metallic. Colorblnck. Paz, Bolivia.

PranckaiU. Perbaps PbtSb,8uiS,„ Groth. HaadTo. O. = SBS. Color blackish gray to black. Boltrla.

OyUndriU. Eyllodrlte. Perhaps Pb.SbtSn.S,,, Groth. H. = S-6-& Q. = 5-42. Luster metallic. Color blackish lead-gtay. Poop6, BoUrla.

IV. HALOZDS-OHLORISES, BROMIDES, IODIDES; FLUORIDES.

I. Anhydrous OHloridei, Bromidea, Iodides; Fluoridei. n. Oxyohlorides; OxyfluorideB. ni. Hydrous OhloirideB; Hydrous Fluorides.

The Fonrth Class includes the haloids, tliat is, the compounds with the halogen elements, chlorine, bromine, iodine, and also the less closely related

I. Anhydrous Chlorides, Bromides, Iodides; Fluorides.

OALOHBIi. Horn Quicksilver. ClilarQueckailber, Queckdlberbornerz G,rm. Tetragonal. Axis i = 1-7299; 001 A 101 = 59° 52'. Crystals sometimes tabular | c; also pyramidal; often highly complex.

Cleavage: a rather distinct; also r(lll). Fracture conchoidal, Sectile. H. = 1-2. G. — G'489 Ilaid. Luster adamantine. Color white, yellowish gray, or ash-gray, also grayish, and yellowish white, brown. Streak pale yellowish wiiite. Translucent—subtraualucent. Optically +.

Comp.—Mercurous chloride, Hg^Cl, = Chlorine IS-l, mercury 84'9 = 100.

Pyr.. etc.—Ill the closed tube volalilizes witliout fugion. poniieiisiiig in the nold p«rt of Ibe lube as h while Bubtinmle; witli sodii givw ii sublimate of raelr.llic mercury. B.B. on «liarcoiil volnlillzca, conliug the corI wliiie. Insoluble in water, but dissolved bv nnivi reela; blackens wheu treated with alkalies.

Ob«.—Ususlly Msociated with ciiioftbar. Tliua at Mr>sr'>elltiMiiBherff In the PalnUnate; at Idriu in Cftniiula; Almaden in Spain; at Mt. Avaln near Belirrade in Bervin.

Calomel is an oH lenii of uncerliiin orlciii and meaning, p«>rbapK from »frtAiJf. AwutffW, and h4.U. ftonjy. the tasre being sweet, nnd the compound the Mtrevriui duleia of early chemistry; or from (C.rAoS aticl iif.l.t!. Hack.

HMtoWU. Cupr-ius chloride. Cu,CI.. Gr«nnlar, massive. Cleavage cubic. H. = 3-?,■?;,. *L=^a"" , ^.V^'" "d'"n»""«- Colorless to white or grayish. Prom Nanloko. Chill; New Boiilh Wnlea. "^

Mmhlt* Ciiprouiiodide, Cu.I,, Isoznetric-tetrahedml. Color oil-brown. Broken Hill lulnes. New South Wulea.

Halite Group. HCl, BBr, RI. Isometric. Halite NaCl Embolite Ag(Cl,Br)

BylTite KCI Bromyrite AgBr

Bal Ammoniw (NH.)CI lodobromite Ag{Cl.Br,I)

Cerargyrite AgCl Mierute Agl

The Halite Grocp includes the halogen compounds of the oloaely related metals, flodinm.potaasiuni, and silver, also ammonium (NH,). They crystallize in the isometric system, the cubic form being the most common. Sylvite and sal-ammoniao are plagihedral, and the same may be true of the others.

BAUTB. Common or Rocs Salt. Sieliisolz, Bergaalz Oerm. Isometric. Usually in cubes; crystals sometimes distorted, or with cavern-034. oua faces. Also massive, granular to compact; less

often columnar.

Cleavage: cnMc, perfect. Fracture conchoida). Hather brittle. H. = 2-5. G. = 2-1-2G; pure crystals 3135. Luster vitreous. Colorless or white, also yellowish, reddish, bluish, purplish. Tratispurcut to translucent. Soluble; taste saline. Refractive index 1*5442 Na. Highly diathermauous.

Comp.—Sodium chloride, NaCl — Chlorine W 6, •^ sodium 39-4 = 100. Commonly miied with calcium sulphate, calcium chloride, magnesium chloride, and sometimes magnesium sulphate, which render it liable to deliquesce.

Pjrr,. ttXc. —111 ibe closed lube fusps, ufleu wIlli decrepiiutioii; wlieu fused ou llie

Eklinum wire colon (lie fliiiue cleep yellow. Adittd tu u Mil of pliospli'irus bead which as beeo salur&lcd with oxkte of copper, it colors the diiiue a ileep ozurc-blue. Diaaolvta skdily iu three parts o(wut

" lisaolubilUv (tuste), soUuesa. nerfeci cubic cleuVBp..

I vHrloua ages. .. indaloue, and cslclte; also _ _ ^ , □ . . " the water of the ocean and anil seas.

The principal salt mioea »C Europe ai-e at Stasarun, Dear Magdeburg; Wlellczka, iu Poland: nt H:dl, Id Tyrol; nnd nlong Ihe rangi; throu^'b Helclieniliul iu BaTarlu, Hailein ill Salzburg, Hallsludl, lacbl, and Ebensee, lu Upper Austrlu, aod Austce lii Slyriu; iu Runenry. at Hnrmoros aod elaewhcre: TmosylTimia: Wnlliichiii. Galicfii. nod Upper Silesia: Vic and Dieiize tu France; Valley of Cai-dunn and elsewhere iu SpHin; Bex iu gwitzerlaud; and Nnrtliwicb iu ('heshlre. EiislaDd, At the Auptriuu tollies, wbere it coninina much clay, the aalt is dissolved In large cliauibers. and the clay thus preclplialcd. After A time ihe water, saturated with Ihe siilt, is rouveved by nqutducls lo evaporatiiig; houses, and the chambers, after beioiE cleiired out, are agnln filled.

Suit also occurs, foriiilng liilla and covering exieuiled plidus. near Lake Uruoila, the Caspian Sea, eic. In Alceria: in Abywinia. In India In enormous deposlm iu the Salt Rani^ of Ihe Punjnb. In China and AsixElc Russia; in South America, in Peru, and at Zlpaqiiera and Nemiicnn. the former ii Inree nilnc lore exploieil in the Cordilleras of U. S. of Ciiliimbin; clenr aalt is obtained Trom the Cerro ile Bnl, San Domingo.

Tn the United Stales, anlt has been fnund iu laree amount In cenlral and western New Torlt. Salt wells had long been woikeH in this legion, but rock salt is now known lo exist over a large area from Ithnca iil. the bend of Cnyufra l^ake, Tompkiiiis Co.. and Cannntlaigiia Ijike, Oiiiiirln Co.. Ihronuh LivinQsiiin Co., nisn Genesee, Wjouiiug. and Erie Cos. The aalt Is found in lieds with nn iivernire th<ckne)>» of 7S feet, but sometimes much iblcker, and at vniTing depths from 1000 to 2000 feet and nioie; the depth inrreases soulhwanl wlih the dip of tbe airala. llie rocks bidong lo tbe Sallna period of ihe Upper Silurian Salt bus aiso been found near Cleveland. Ohio, asiociated with Eyp«um; in Washinglon Co., West Virginia, in the Ilolsion and Kanawha vallevs: in Kansas; at Petlle Anse. LoulFiana; along Ihe Rio Virgin in Lliie«ln Co.. Nevada, iii extensive beds of great purity: in Utah. near Nephi, Juab Co., and Salinn, Sevier Co ; in Arlmiia, on the Hio Verde, with Ibeuard-ile etc.: In Cnlifomla, San Dtego Co.

Brine 'springs are very numerous In the Mi'ldle and Weaiern Sinles. Vast lakes of mlt water exist bi many parta of the world. Tbe Great Sail Lake in Utah is 3,000square mi1«s ill area; L. Oale found in thia water 20-]96 per cent, of so<liiim chloride. The Dead and Caspian seas are salt, and tbe waters of tbe former ronlain 20 to 26 parts of solid matter in 100 parts. Biidium chloride is the prominent salt present in tlie ocean.

Huantajayita. 20NaCl + AgCl. In cubic crystals and na an Incniatatlon. H. = 2, not aectlle. Color white. From Huantajaya, Tarapnca, Chill.

STX>V1TJB.

Tsometric-pUgihedral. Also in granular crystalline masses; compact. Clesvage: cubic, perfect. Fracture uneven. Brittle. H. = 8. G. = 1'97-

1-99. Laster vitreouB. Colorleaa, white, bluish or yeilowiah red from inclnsions. Soluble ; taste resembliog that of common salt, but bitter.

Comp.—Potassium chloride, KCl = Chlorine 47-6, potsasinm 52-4 = 100. Sometimes contains sodium chloride.

Pyr., eto.—B.B. Id (he plalioum Iwp fuaea, Kod riveB a vtolet color to the outer lUme. DisaolTCH completely In water. Heated with sulpltuiic add rivei off bvdroclilortc acid eas.

Ob«.—Occurs aiVeauTius. about tbe fumarolee of the Tolcauo. Alsoat Staaafurt' at Leopoldsball (UopoUite); at Kalusz lu Qajicla.

Bal Aumoniao. Ammonium chloride, NH,01. Obteired u a wlille facruBtalioa about Tolcaaoea, as at Etaa, VesuTiua, etc.

OBRAROTSITB. Silberhorners, Honullber Germ. Horn Bllver.

Isometric. Habit cubic. Twins: tw. pt. o. Usually massive and resem-blitig wax; sometimsa columnar; often in cruBts.

Cleavage none. Fracture Bomewhat conchoidal. Highly Bectile. H. = 1-1'5. G, = 5'552, Lnster reeinouH to adamantine. Color pearl-gray, grayish green, whitish to colorless, rarely violet-blue ; on esposure to the light turns violet-brown. Transparent to translucent. ludei, w, = 20611

Comp.—Silver chloride = Chlorine 24-7, silver 75-3 = 100. Some varieties contain mercury.

Pjnr., eto.—lu the closed tube fusea wltbout decomposition. B.B. on cliaicoiYl gives a globule of metallic silver. Added lo a tiead of salt of pbospLorus, prcviotiHly saiurati d nitli oxide of copper nnd beated ie o.¥., imparla an inteiise azure blue to tbe flnme. Insoluble in nitric acid, but soluble in ammonia.

Ob».—Occurs in veins of clay slate, accomriinying oilier ores of silver, nnd usually only in Ibe bigher piitis of iLi-sc veins. Ii hm also been observed witb oclitrous VRileliea of bripwQ iron ore: ulso witlj several cupper ores, ailcite, bsrite, etc.; upon slibicoiiile.

Tbe Inrgesl masses are brought from Peru, Cbili. and Mexico, wbere it occurs vitb native silver. Also once oblslued from Johaungeoi^enstadt and Freiberg; Andi-easljerg (eaniiy var.. ButUrmilchtrt); occurs in tbe Altai; at Kongsbergin Norway; in Alsnce.

In tbe V. B., in Colorado, near Leadville, Lake Co.; near Breckenridge Summit Co., nnd e1s"w1iere. In Nevada near Austin, Lander Co.; at mines of Comslock lode. la Idnbo. nt ilie Poorman mine, in crysials; also at various otlier mines. In Utah, in Beaver, Summit and Salt Lake counliee.

Named from K^tiai, horn, and anyvooi. tilner.

Bmbollta. Silver chloro-bromide. Ag(Br.Cll, the ratio of cblorine to bromine varying widely. TTaiinlly massive. Besenibles cerargyrite, but color gtayiBb green lo yellowM green and yellow. Abundant In Chili, leas so elsewbere, Bromyrite. Silver bromide, AgBr. G. =5B-.«. Color bright yellow lo amber-yellow; slightly Rreeniah. From Mexico: Chili; Hiiolgoet in Brittany.

lodobromlte. SAcCI.SAeBr.Agl. Isometric; o with a. Q. = S-718. Color sulphur-jiellow. greeniiih. From near Dernbacb, Nassau.

BOloialte. Silver iodide, Agl. crystallizing in the Isometric oyatem ; probably telrabedral-like marshile (p. 817). In bright yellow crystals from tbe Broken Bill Silver Mines. New South Wales.

Onproiodarffyrlte. A copper-sllver iodide, occnrring as a aulpbur-yeliow lucruatailou. alHuanlaJaya. Peru.

lodyrlt*. Silver Iodide, Agl. Heiagonal-bemimorpbic (Fig. 211, p. 71); iisunlly ii> thin plates; pale yellow or green. Ck = 5-6-5'7. From Mexico, Chill, etc. Lake Valley. Sierra Co., New Mexico.

Fluorlte Group. UF„&01,.

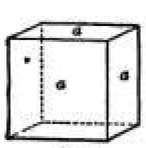
The BpecieB here iociuded are Fluorite, CaF,, and the r CaCl,. Both are isometric, habit cubic.

e Hydrophilite,

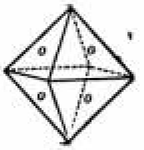
FIinORTTB

r Fi.uoB Spab. Fluaupalh Qtrm. 636.

635.



636.



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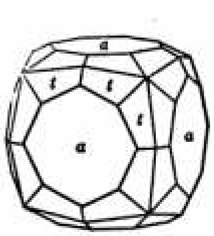

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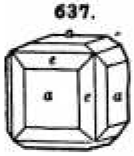

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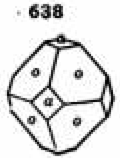


Isometric. Habit cubic; less frequently octahedral or dodecahedral; forin8/(3I0), e (310) (fluproids) common; also the vicinal form C(32'1'0?), producing aCriations on a (Fig. 640); heioctahedrou t (431) also common witli tlie cube (Fig. 639). Cubic crystals sometimeB grouped in parallel position, thus forming a pseudo-octaliedron. Twins: tw. pi. o, commonly penetration-twins (Fig, 640). Also massive; granular, coarse or fine; rarely columnar; compact.

Cleavage: o perfect. Fracture flat-conchoidal; of compact kinds splintery. Brittle. H. = 4. G. = 301-3-25; 3-18 cryat. Luster vitreous. Color white, yellow, green, rose- and crimeon-red, violet-blue, aky-blue, and brown; wine-yellow, greenish blue, violet-blue, most common; red, rare. Streak white. fraraparent—subtranslucent. Sometimes shows a bluish fluorescence. Phosphoresces when heated (p. 191). Refractive index: n, = r4339 Na.

Comp.—Calcium fluoride, CaF, = Fluorine 48'9, calcium 51'1 = 100. Chlorine is sometimes present in minute quantities.

Id colon: <fi) flbroua to SDtor (e) coHrse lofine yields a greeD pbo*-

gniDUlul-; {d) eartliy, dull, aud pboresceiit llgllt.

Fyr., eto —In llie dosed tube decrepitates imd iilioaplioresces, on cbnrcuiil fuses, coloring tlie flume red. lo an enamel wlilcli reac . . -

Fused iu ail open tube with fiiwd BLlt oi phoapbonis jrive* the reaction for fluoHDe. Treated witii anlpliurip Rciil (fives fumes of lijdronuoric acid which elcb rlass.

Diff.—DistiDgiiUhe'l l>y ita crystidlice form, octaliedrai clntvage, relative softness (as compared with certain preoinus slonea, nlso with tlie feldspars); etching power when treated with siilpburic acid. Does not effervesce with ncid like cnlclte.

Obs.—Sometimes In beds, but generally in veins, in gneiss, mica slate, clay slate, and also in limesiones. both crystalliDe aod uncrjslnlllDe. and sandstoDes. Often occurB as (he gangue uf metallic ores, especially nf lead. In the Norili nf England, it is the giiogue of the lead veins, which intersect the coat formalion In Nnrtliumberland, Cumlwrland, Durham, and Yorkshire. In Derbyshire It U abundant, aiid nlsn In Cornwall, where ihe vdna intersect metamorpliic rocks. The Cumberland and Derbyshire localities cspeclBlly iiave afforded magniflcent specimens. Common in the mining disirict of Saxony; floe near

EougBberg In Noma;. Id the dolomitea of SU Oolliard occurs in pluk ocUUedront. Baruly in toIcuuIc re^oua. hh in tbc VesuTiaD lava.

Sunie iuculities id llie U, S. are, Tniinbui], Conn. (cAlorophaiu); Muscolouge Lake. Jellir-iiu Co.. N. Y., and Matoiub, St. Lawrence Co.. boib lu very large sen-ErMD cubei' FriUkliiiFuruuce. N. J.; Amelia Courl Houw), V(u; QallaUn Co., III.; St. Louis, Mo.

BydzopliUito. Clilorocalcite. Calcium cbloiidi^ CaCIi. lu whiw cubic crfsiats or as uu iucrusiaiimi at Vesuvius.

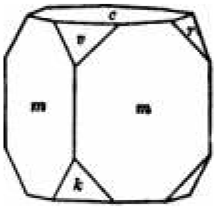
The (ollovrlug are froui Vesuvius: OUorotnunaalta, HeCli: Softocbita, MnCIi - OhloraUainiiilU, AlCl. + 3H,0; Molydt«, FeCl..

Sallaita. Huguesium fluoride, MgFi. In prisinallc tetrngonal cryslals. H. = 6. ■Q. = 3-9?-S']3. Colorless. From, the moraine of ilie OebroulnE glacier Id Mavoj.

LaWToioit*. Ferrous chloride, FeCli. Occurs iu meteoric iron.

CotatuiiU. Lead chloride, PbCI.. In acicular crysbils (orthorhombic) and la semi. <;rystM.>iue uiiibbi.-;-. Soft. Q'=:B-24. Color wliile, yellowish. From Vesuvius; also Tunpiii'a. Cbili.

Tysoolte. Fluoride of the cerium melsK (Ce.Lii.DljFt. Iu tblck bexagonal prisms, and massive. Cleavage: e pertect, H =4-3-6. G. = BIS. Color pale vrBZ-yenow,cbaDgiDg to yelluwiiJi and reddish bruwu. From Uiegranile of Pike's Peak, Et Paso Co., Colorado.



ORTOUTE. Eisatein Germ.

Moiioclinic. Axes d : t: i = 0-9663 : 1 :1-3882 ; ft mm'-, 110 A liO = 88° 2'. ck, 001 A lOl = 55* IT.

em. 001 A 110 = 89° W. tr. 001 a Oil = M° 14".

eo, 001 A 101 = 55° 2". op. 001 a HI = 88* 18".

Crystals often cubic in aspect and gronped in parallel position; often with twin lamellEe. MaasiTe, cleavable.

Cleavage: c most perfect, alEO m, it (lOlj somewhat less so. Fracture uneven. Brittle. H. = 25. G 2-95-3-0. Luster vitreous to greasy; somewhat pearly on V. ColorleBS to snow-white, sometimes reddish or brownish to hrick-red or even black. Transparent to tranBlucent.

Comp.—A fluoride of sodium and aluminium, Na.AIF, or SNaF.AlF, = Fluorine 54-4, aluminium 13-8, sodium 3S-8 = 100. A little iron geBt|nioxide is sometimes present as impurity.

Pyr., etc.—Fnstble in small fnigments in the flame of a candle. B.B. In the open lube faented so that the flume enters Ihe lube gives off hydrofluoric xcid. etching tiie gldsa. In the Torceps fuses very easily, coloring the Bnme yellow. On charcoal fuses easily to u clear bead, wbicli on cooling becomes npaque; after long blowing, Ihe assay spreads out. ihe fluoride of sodium fs absorbed by Ihe coal, a suffocaliug odor of fluorine Is given of!, and a crust nf aluminii remnlns, which, when heated with cobalt solution In O F., gives a blue color. Soluble in sulphuric acid, wilh evoluiion of hydrofluoric aclil.

DiS.—DIsi in mulshed by lis extreme fusibility, and Its yielding hydrofluoric acid in the open lube. A1x'> by its cleavages (resemhiing cubic cleavage)ana foflnees.

Oba.—Occurs In a bay In Arksukflord, Id West Greenland, at Ivlciui (or Evigtok). vhouE 12 tn. from the Danish settlement of Arksuk. where it constituies a large bed In a granitic vein in a gray gneiss. Cryolilcand Its altornilon products, pucbnolite, Ihom-oenollte, proeoplte, etc.. nlso occur in limited qunnilty at the soulbem base of Pike's I'etik, Fl Paso county. Colorado, north iind west of Bnint Peter's Dome.

Named fmm trpjir^. frml. Xi%'i~, tlont, hence meaning ice-ttone, in alliiBlon to the transliici'Dcy of the while cleavage inai^sBs.

Ohiolite. 5NaF.SAlFi. In small pyramidal crystals (letragonal); also masstre granu-!— H. = 8B-4. a, =2-84-2-90. Color anow-while. From near Mlssk in thellmen His.; also with the Greenland cryolite.

Hlentlt«. A fluoride of potassium and rilicon. In graylah atalactitlc coacreiiona; (•ometric. From the famaroles of the cniter of Vulcano.

n. Oxychlorides, Oxyfluoxidet.

ATAOAMTTB.

Orthorhombic Azea d:l:l = 0-6613 ; 1 : 0-7515.

643.

mm", 110 A no = M* 67'. rr"'. Ill a 111 = 63* 4S(,

ee", Oil A Oil = 78' 51'. mr. 110 A HI = Be' 18J'.

CommoDly In slender prismatic crystals, vertically striated. In COD fused crystalline aggregates; also massive, fibrous or granular to compact; as sand.

Cleavage: 6 highly perfect. Fracture coochoidal. Brittle. II. = 3-3*5. G. = 3'75-3-77. Luster adamantine to vitreous. Color bright green of various shades, dark emerald-green to blackish green, W4_i^ Streak apple-green, Ti-ansparent to translucent. X^^ Comp.— Cu,CIH,0, or CuCl,.3Cu(0H), ^ Chlorine 16-6, copper ■ '-9, ciipric oxide 55-8, water 127 =

Pyr., «tc.—la the closed tube Kives off mucb water, and forma a eray iubllmate, B.B. cbaicoal fuses, coloring the O.F. azure-blue, wfili a green e^, and giving two coaliLss, B brownlsli and tbe otber grayish white; couliiiued blowing yiuldB a. globule of melafiic iper; the contiug*. touched with the R.F., volatilize, coloring the flame azure-blue. In as easily soluble, -ba —Orlginalli . . and Bolivia; ? the U. S., with cuprite, etc., at the United Vei-de mine, Jerome, AHs

Peroylita. A lead-copper oxychloride, perhaps PhCuO,HtCli, Iu sky-blue fubes. From

Sonora, Meilco; Atttcama; Bullvla, ■"" "-■-'■ » t. i. _ i. r.___ ., ■.

California, U a percylite containing a ing to be tetragonal.

HaUooldt«. Lead oxychloride, PbiOCI,. In tabular telragonal crystals. G. = 7-21. Luster adamantine to pearly. Color yellowish or eligblly greeDlab. From Cromford, near Hatiocli, Derbyshire.

Mendlplte. Pb O-CI, or PbC1..2PbO. In flbrons or columnar masaes: often radiated. H = 3-5-8. G. = 7-7-1. Color white. From the Heudip Hills, Somersetsbire, England; near Brilon, Weatphalia.

Laorioulte. PbClOH or Pba, Pb(OH),. In minute prismatic colorless cryctals (orthorhombic), in ancient lead slags at Liiurioti, Qreece. Fiedlerlte, associated with laudonite. Is probably also a lead oxychloride: In colorless monoclloic crystals.

Panfioldlle. Pb.OCl, or Pbo.2P&Cl,. In white hexagonal crysUls. Laurion, Greece. Davleilta. A lead oiychioride of uncertain composition. In minute colorless prismatic crystals (orthorhombic) from the MIna Beatriz. Sierra Qorda, Atncama.

Bohwartaembarglta. Probably Pb(I,Cl)i.2PbO. In druses of small ciyslals; also in crusts. Q. -= 6'3. Color honey-yellow. Desert of Atacama.

PlnooBrita. (Ce.La.Di),OP,. Heiagonal. H. = 4. Q. = B-7-6-9. Color reddish yellow. From Oaterby In Dnlarne. Sweden.

Noosrits. Perhaps 3(Ca,Mg)F,(Ca,Mg)o(7). In white hexagonal adcular crystals fwHO bombs In the tufa of Nocera, Italy.

Danlwedt*. An earthy yellowlah oqrcUwIde of bismuth. From Bolivia, Orthorhombic. Crystale rare. Commonly massive, granular. No distinct cleavage. Fracture oonchoidal. Brittle. H. = 1. G. = 1'60. Luster shining, greasy. Color milk-white, often reddiali. TmiiBparent to translucent. Strongly phosphorescent. Taste bitter. Deliqnescent. ■

Comp,—KMgCl,.6lI,0 or KCl.MgOI, + 6H,0 = Chlorine 38-3, potassium 14 1, magnesium 8-7, water 39-0 = 100.

Ot».—Occura ut Blasafurt, In beds, alternatiDg with thlDner beds of common sail aod kieaeritc.

DouaLASiTK, associated with camallite, is said to be SECl.FeC1,.SH,0. Bkohofita. HgCI, + 6H,0. CrjsUlline-granular; culorless to white. From Leopolds-ball, PrUBBllI.

Kramanite. KCI,NUtCI.F«Cl, + H,0. Id red oclahedroDS. Prom Veraylus. EcythroriderfU. aKCl.FeCl,.H,0. In red tabulw crystals. Vesuvius. Taohbydilte. CaCI,.2MgCl,+12B,0. In wax- to boney-yeUow masses. From Btassfurl.

Pra*opit«. CaF,,3AI{P,0H).. In monociinlc crystals, or granular massive. H. = 4-6. O. = 2-88. Colorless while, grayish. From Altenberg, Saxony; St. Pater's Dome near Rke's Peak. Colorado.

Paohnolita and ThomHnoIite, occurring wllh cryolite in Qreenlaitd and Colorado, have the same cumpositioQ, NaF.CaF,.AlF8-4-H,0. Both occur Id monociinlc prlsmadc crystals: prisnuiiic ungln for pacbuolite, 98 86', crystals twins, orlhorbomblc iii aspect. For thoiusenoTile, 8S' iff, crystals often resembling cubes (tn, c), also prlsmatici distinguished by its basal cleavage; also massive.

OMTktntlta. C8F,.A1(F,0H)8.H,0. Earthy, clay-like. Occurs with cryolite.

Halrtonite. (Ns^MglF, 8A1(F,0H),.2H,0. In colorless to white, Isometric, octahedrons. H. = 4-6. G. = 256-2-62. With tbe QreenUnd cryolite.

Talllnglte, A hydrated copper chloride from tbe Botallack mine, Cornwall; In hlua globular crusts.

Foat«lt«. A hydrous oxychlorlde of copper occurring in deep blue prismatic crystals (moDOcliuic) at the Copper Queen mine. Bisbee, Atizona.

TttrooMlto. (T,£r,Ce)Ft.6CaF,.H,0. Hasslve-cleavable to granular and earthy. H. = 4-0. O. = 8-4. Color violet-blue, gray, reddish brown. Ftem near Falun, Sweden, etc

V. OXIDES. L Oxidei of Silicon, n. Oxidea of the Semi-Metala: TeUarlniii, Ammiio, Antimcmy, Bismuth; also Molybdenum, Tunggten. m. Oxidei of the Metali.

The Fifth Class, that of the Oxides, is subdivided into three sections, according to the positive element present. The oxide§ of the non-metal silicon are placed by themselves, bat it will be noted that the compounds of the related element titanium are included with those of the metals proper. This last is made necBSSary by the fact that in one of its forms TiO, is isomorphouB with MnO, and PbO,.

A series of oxjgeu compounds which are properly to be viewed as salta, e.g., the B|>ecies of the Spinel Group and a few others, are for conTenience also included in this class.

I. Oxides of Silioon.

QUARTZ.

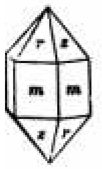
Rhombohedral-trapezohedral. Axis: i =109997.

rf. lOil A ilOl = 85' «'. rt, lOll A Olil = «° 16'. mr, lOiO A lOll = 88' Iff.

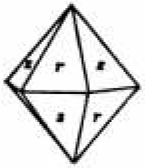
WW. lOiO A Olil = «* W. m#, lOlO A llSl =8r58'.

mi. loio A 5i6i = ia° r.

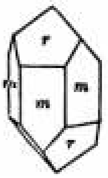
643.



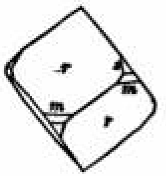
644.



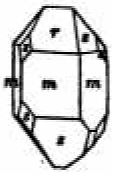
645.



646.



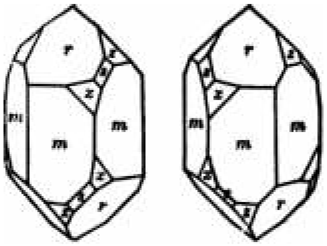
647.



Orystals commonly pnsmatic, with the m faces horizontally striated; ^^^ ^^^ terminated either by both rhombonedrons, or

** by one only; the nredominating rbombo-

hedron is in almost all cases r (lOll). Often in double six-sided pyramids or quartzoids through the equal development of r and z; when ;■ is relatively large tlie form then has a cubic aspect {rr ~ t'^" 46'). Crystals fre-q^uently distorted, when the correct orientation may be obscure except ns shown by the striatrons on m. Crystals often elongated to acicular forms, and' tapering through the oscillatory combination of snrcessive rhombohedrons with the prism. Occasionally twisted or bent. Frequently in radiated maaaeswith a surface of pyramids, or in dmsee. Simple crystalH nre elllier ridit- or IcFi-lmnded. On a righl /laiuUd crystal (Fie. S48). «, It preient. lie* lo Ibe right of the m fnce, which b below the predomlDaling pliii rnombo-



bedroD r, sad wllh this belong Ibe plus right trapezohedrouE, aa x, and minus left trapesohedrOQS (cf. Fig. B70, p. 831, alwitdBft). On a itflhandad cryual (Fig. 649). * lies lo Ihe Ipfl of iliem below r.Hudiritb il Uie plus teFt and mlDUH right trapezohedrous, also a (right). The right- uud lefl-lianded forniB occur together ouly Id twin*. In the absence of trape-zobednl faces the Btrialions on * || edge r/m), if disiluci, serre to distlnKiilsb the faces r aoil (, and heuce sliuw the right- and left-baaded character of the crjistals. The tlght-ftpd U-ft-hauded character is also revealed bj etching (Art. 865) and by pyro-electridty (Art. ISOj.

Twins: (1) tw. bxIb i, axes pumllel, (3) Tw. pi. a, Boroetimee called the Brazil law, usually as irregular penetratiou-twins (Fig, C50). (3) Tw. pi, S (1122), contact-twins, the axes ci-osBing at an angle of 84° 33'. See further p. 137 and Figs. 393-394. Massive forms common and in great variety, passing from the coarse or fine granular and crystalline kinds to thoBe which are flint-like or cryptoci'yatalline. Sometimes mammillary, stalactitic, and iu concretionary forms; as sand.

Cleavage not distinctly observed; sometimes fracture surfaces (| r, z iind m\ developed by sudden cooling after being heated (see Art. 258). Fracture conchoidd to sub-conchoidal in crystallized forms, uneven to splintery in some massive kinds. Brittle to tough. If. = 7. G. = 2'653-2-(i60 in crystals; cryptocrystalline forms somewhat lower (to 2-60) if pure, hut impure massive forms {e.g.,

jasper) higher. Luster vitreous, sometimes Basalaectioulnpolarlz«illight.ahow-greasy; splendent to nearly dull. Colorless . "" """"-"■'~"™ ""1"1.,.„„h when pnre ; often vurions shades of yellow, red, brown, green, blue, black. Streak

white, of pure varieties; if impure, often the same as the color, but much paler. Transparent to opa»]ue.

Optically +. Double refraction weak. Polarization circular; right-handed or left-handed, the optical character corresponding to right- and left-handed character of crystals, as defined above; in twins (law 2), both right and left forms soraelimes u'lited, sections then often showing Airy's spirals in the polariscope (cf. Art. 366, p. 202, and Fig. 650). Rotatory power proportional to thickness of plate. Refractive indices for the D line, &>= 1'54-H8, _e = l-.^5328; also rotatory power for section of I"""- thickness, a = 31-71 (D line). Pvroelectric ; also electric by preBsnre or piezo-electi-ic. See Arts. 420, 421. On etchiugfignreB, see Arts. 265, 266.

Comp.—Silica, or silicon dioxide, SiO, = Oxygen 53-3, silicon 4(5-7 ^ 100. In innsaiTe vnrietics often mixerl wllh a lillle opal silira. Impure varieties contain iron oxide, <-nii ium cnrlwuale, clay, wind, and various miuerala ns inclusions

Var.—1. Phbnocrybtallinb: Crystallized, vitreous In luster 3. Crvptocrtstai.mnb: Flint-like. miiKslve.

The first division Incliideq nil ordinary vitreous quartz. wheMier having crystalllnp ftirea or Dot. The varieties under the second are in geiieml aciMl npon aomewhsl more by attrition, anrj by chemical agents, as liydrofliioric ncid. tlinn those of the first. lo ult klndl made up of layers, as agile, successive layers are unequally eroded.

A. Phknocrybtalline or Vitrkocs Vauieties. Ordinary Crytialliud; Rae/c f>y«(^(,—Colorli-ssqimrtz, or nearly so. whether In distinct cryglsls or not. Here belong the Brislol diamonds. Lake George diamonds, Bnizilian pebbles, etc. Some variations from the common type ur«: (a) cavernous crj'stals; (A) cap.

quartz made up of sepiiruble laycra or caps; (e) drusj quartz, & crust of waM or mlnule quHrlz crystals; (d) i'iidiui«d quartz, often separable inU> mdiated parts baviug pyramidal Ici'mliialioQii: ie) Qbrous, rarely delicately su as a klud from Qriquuland West, South Africa, iillered from crocldolil« (see cal'i-efig below, also crocidolife p. 4M).

Atleriated; &ar-$uarl«.—Cuutalnltig wilhiu the crystal wliilisli or colored radUtioua ((long tlic (ILiiiietial placeH. OccasiouaTly eililblts distinct asteriam.

Ametliytline; Amttltytt. —Clear purple, ur bluiali violet. Color perhaps due to mauguueae.

VfoM.—Huse-red or piuk. but becoming paler oil exposure. Oomtuun massire. Lustel-poiiiciimes a little irreasy. Color perhups due to titauiuui.

Yfiioio; Faltt iopat or CiCrin«.—Yellow acd pellucid; resembliug yellow lopaz.

timoiff; Vuirnfforia Stone. —Smoky-yellow lo dark smoky browu, luid often tracs-iwri'iit; viiryliig lo browuish black. Color is probably due to some orgauic compound (ForHler). Cam-d eairiigomt* from tlie locality at Cairngorm, 8.W. of Banff, lu Scutlsiud,

is given to uearly black

Milkji —Hllk-wbiie iiud uearly opnuue. Luster often greasy,

SitUi-iU, or Siipphire-guarU. —Uf Indigo or Berlin-blue color; a i-arc variety.

tiag riilie. —Iuc1r>sii)gacicular irysials of rutile. Olbcr included minerals in acicular .Tuniii arc; bluck toiirmnllue; eOlbile: alibnile; asbestiis; actiiiollte; horDblende; epidote. -Cat! fi'y«(KalseQHUgeG'r'nn„ffiil de Chat .FV.) eibibils opalescencL-, but without prismalic •coluis, espocially when cut ea eaboc/uin, uii ellect sometimes due to fibcn of nsbcslus. Also present lu the siliceous paeudomorpha, aflercrocidolite, called Uger-rynaee crocidolite). ' Tile liiylily-prized Uriculal cal's-eye is u variety of clirysoberyl.

ATtiituriiie. —Spangled witli sculoa of mica, bumalite, or other mineral.

Jiiipart from Vt« prttentt of di*tiiirt mCii^raU dUlribuleiJ densely ibrongh the mssG. The more common kiuita ai'e those in which the Imporitiea are: {a)/«TUfJno>u(BisenkicBcl Oerm.), either red or yellow, from aithydrous or hydroua iron sesquioside; (6) ehion'tk, /roiii some kind of chlorite; {c) atUnolitie; i^d) mieaeeont; {e) artnaceen*, or saitd.

Containing liquid* in eutitiet. The liquid ubusIIv water (pure, or a mineral w>lulion), or Fome petroleum-like compound. Quarts, especially unoky quartz, also often contains luclusioDs of bolL liquid and gaseous carbon dioxide.

B, Crtptocrtbtaluhb YAKiKTiza.

(7Aaic«tony.—Having the luster nearlv of vrai, and eflher transparent or tnostncent.

O, —26-284. Color while, grayish, blue, pale brown to dark brown, black. Also of

other shades, and then having other names. Often mammillnry. botryoldiil, stalaclilic,

and occurring lining or filling cavities in rocks. Il often coDlalna some disseminated opal-

-■ silica. The name tnliydrot is given to nodule" of chalcedony containing water, someliroea

in Inrge amount. Embraced under the general nam«^ clialcertony i-lhecrysbilKna fotm of

silica miilch forms concretirmary ma.ssea with nidfal-flbrous md concentric slrwlare. and

which IV? shown by Roaenbusc'i, is optically impntfw;. unlike trne quartz. Ithasn^s l-liS7;

*o = 3 58-3-64. Often iu spheruliles. showing the sphemlltie interference-Bgnre. l.vfo-

lite of Mallard has a like siriicture. but Is opifefttly + and has the apectfic gtsrlty and

refractive hidei of opal. See also quartzine, p. 928. , , v ....

Cnmaian. 8ard.—k clear rod chalcedony, pale to deep in ahade; atoobrownfsb red to brown. , ,.

OArysoprow.—An apple green chalcedony, the color due to nickel oxide-.

i>r(is«.—Translucent and dull leek-green.

R(7«mo.—Rather bright green lo leek-green, and also somellmeB nearly emerald-green, and subtransluceiit or feebly translucent. Heliotrope, or Btoodtone, is the aanae stone essentially, with small spoU of red jasper, looking like drops of blood.

Agate.—A. variegated chslcedonv. The colors are either (ol banded; or (ft) irregularly clouded; or Ie) due lo Tisible Impurities as in mo« agaie, which hns brown moss like or dendritic forms, as of manganese oxide, distributed through the mass. The bands are delicate parallel lines, of while, pale and dark brown, bluish and olher shades; ihey are S'-mctimes slroighl. more often waving or zlgrag. and occasionally conceulrlc circular The bands are the edges of layers of depmilion. the agate having been formed by a ilepoBit of silica from solutions Intermittently siinplled, iu irregular cavities in rocks, and deriving their concentric waving courses from the irregularities of the walls of the cavity The layers differ in porosity, and therefore agates may be varied in color by arliflcinl menus, and this i' done now to n larpe extent with the agates cut for omamenl. There is also aeatiud wood: wood peirtfled with rlnudcd agate.

Onyx —Like agate in consisting of lavers of dlfTcrent colors, white and black, white and zed, etc., but the layers in even planes, anti the banding straight, and hence lla nse for cameos.

Siiiiont/x.—IAke odvi in structure, but tucludes laven of cameliui (sard) along with others of white ur nliilisb, imd browo. anil anmetloieg Slack colors.

Affiilejaiper.—Aa ugnte consisting of jasper wiLli veinings of cbalcedooy.

BiUceoiu ti'nleI-.—Irregularly ceiluliir qiiiirtz, formed by (luposUIoo from nstera coulaiD-iug silica or bi>tuble alKcHles in solution. See iilso uuder opal, p. 339,

FliAt. —Souiewbul allied to cbalcedoiiy, but more opaque, aud of dull colon, usually gray, auioky browu, aud browtiisb black. Tbe exterior is ofteu wbitisli. from mixlure u'itli lime orcbalk, iu wbicli.it is eoibediled. Luster barely gllsteuiuK, lubvilreouB. llreiikswiib a deeply coucboid.d fracture, and n abiirp cutilug edge. The fliut of tbe -liulk formalioo couslals largely of liie reniains of dinioms, spouges, aud olber marine ~ >ducti<m8. Tbe coloring tnulter of the comiuou kiuds U mc«tly carbounccoua matter.

nt implements play au iiiiporliiut piirl amouj; Ibe reilcs of early man.

lioruntont. —Resembles flint, but \a m(>re brittle, tbe fracture more apliolery. Chert ts ft icrrii iifleii applied to borniituue. uud to iiuy impure tibily rock, including tbe Jaspers.

li'itaiiiie; Lydim l>toit«. or '1 oueh»toiie.—A. veWei-black siliceous stciue or dbiiy Jasper, used oil a<:couoi of lit bardiiess anil black color for tryiug llie purity of tbe pi'ecious melala. Tbe color left on ibe stoue after rubbing tbe metal aci-oas li indicates to tbe expcrleuced e>c tbe amount of alloy. It is uot spliiilery like bornstone.

Jatper. —Impuie opuque colonsl qunriz; couiuionly red, also yellow, dark greeu and gtuyiaii blue. Striped or riband jatper lias tbe colors in broiid stripes. I'oreelain jatper is uotbing but balled clay, uud diilers from true jasper iu biiug B.B. fusible on tbe edges.

C. Besides Ibe nbove tliere lire also:

OrtiH'ii'ir Quiirlt, QuarltToek. or (^wruite.—A rock consietinp of qiianz gi-alns ycry Brndy compacted; tbe grnius often bardly distiuct. (tvarliote Sandttuna, Qvartx-con-glomerate. —A rock made of pebbles of tjuarlK wllb xitud. Tlie pebbl'-s M^metiines are Jnaper and cha1ce<lony, aud muke u beaullt'ul stone wIjcd polfsbed, JtarolvtHile, at Fler^ Saniittone. —A friable snnd-rock, coDsislIng niHlnly of quanz-sand, liui conlaiuiug a little _.,._ .._j ,___ :, .^_..,..,„ ,._y j^,,.,. , ... ,

. ind possesBiDga decree of dexibllity wbeu in tbiii lamtDie. JJuliriUtu, ot hi —A cellular, Sfiily rock, buying tbe untuie iu purl of course cbulcedony.

PtmidomoTphouM Quarts. —Qusrls appears aliio under Ibe forms of many of Ibe mineral apecles. wbicli It has taken Ibroagh eitber the alteration or replacement of crystals of tbose speries. The most common quartz pseudomorpbs are those of calcite, harlte, fluorite, and siderile. Bilirijtrd wood is quurtx pseudomorph after vood (p. 25S).

Pyr.. etc.—B.B. unnllered; with bomx disaolTes slowly to a clear glass; with soda dissolTCB with effervescence: unacted upon by salt of phosphorus. InEolubte In liydro-' cblorlc acid, and only sligljlly acted upon by soludons of Hied caustic alknlies. tbe crypto-cryBtalllne varieties to tbe greater extent. Siiliibleonly In hydrofluoric acid. When fused aud cooled it becomes opal-silica having G

Diff.—Churacteriied ' . • - ■

also <ti geuerul by bardm

Eiisily recognized in rock sections by its low refraclion (" low relief," p. 170) and low birefringence (^ — oi := OOOB): Ibe interference colors In ^ood sections uot rising above yellow of Ibe lirst order; also by Its limpidity and the positive uniaxial cross yielded by axial sections (p, 203. note), wlncb remain dark when revolved lietwceu crossed uicols.

ConiDionly in formless grains (grunile). also wilb crystal outline (porphyry, eta).

Oba.— Quart* is an esscnlinl coiuponent of certain igneous rocks, as granite, granite-poipbyry, quartz-porphyry and rbyollte in the granite group; in such rocks it la commonly In formless grains or masses filling the interstices between the feldspar, as tlic last product of orystnllixiitton. Fuither it Is an essential consllluent in quarlzdiorlle. tjiiartz-diorlte porphyry and dnciles in the djorlte group; in the iwirphyrles frequently in distinct crystals. Iioccurs'ilsoasan accessory in other feldspnlhic igneous rocks, such as syenite aud trachyte, Amonir tbe meiamorpliic rocks it is un essential componeul of certain varieties of gneiss, of qunrtzlte. etc. It forms ttie mass of common sandstone. It occura lu tbe vein.stone in varioua rocks, and for a large pari of mineral veins; as a foreign mineral in some liflieslones, etc., making gecKlesof crystals, or of chalcedony, agate, carnelian. etc,; ns embedded nodules or masses In vailous limestones, constituting Ibe liint of tlie Cbiilk formnlion. tbe bornstone of other Ibnestnnes—tbese nodnle!> aomctlmes hpcondug continuous layers; as masses of jasiier occasionally in limestone. It is tbe principal material of Ibe pebbles of gravel-beds, and of the sands of the seaabore. and sandleds eveijwhere. In graphic graniti! {jvgmaiita) (he quartz individuals are ari-anged In parallel position in feldspar, Ibe angulnr piirlicles rewmbling written cbumclera. The qunriz gniins in a fragmentai saudsione are often found lo have undergone a secondary growth by tbe deposition of crystallized silica with like orientalion to tbe original nucleus.

Switzerland Dauphlne, Piedmont, the Carrara quarries, and numerotis olber foreign

localities, afford floe epecimeDB oF rockcryHtnl; also Jspsn, whence tbe beftutlful crystal spheres, !□ rare cases up lo 6 ladies Id dUuieter. Smoky quarit crystsls of great beauty, and ofteu bigbly complex iu form, occur at many points Id tbe central A-lpa, also at Calrn^rm. Scotland. Tbe most lieauliful atuethysla are brouglil from India, CtyloD, and Perslii, also from Bruzll; inftrlorspeclii: ens occur iu Transylvania. The flneBl air7t«f wiu and agnta axe found Iu Arabia, India, Brszil, Surinam, also fonneriy at Obersteiu and Saxony. BiMtliiDii affrjrds smaller but handsome speclineDB (fjcotch pebbles). Tbe banks of the Nile uOord tbe Egyptian jiisper; the striped jssper is met with in Siberia, Bazony. uiid DevoDsbire.

In New York, quartz crystals are abundant in Herkimer Co.. at Middleville, Little Fulls, etc.. liMise Iu cavltlts Iu tbe Calciferous siind-rock, or embedded lo loose earth. Flue quarizoida, at the beds of hematite Iu Fowkr, Herman, and Edwards, St. Lawrence Co., alsoatAiitnei'p. JeSerwD Co. On tbe baoksof Laldlaw Lake, Rossie, large Irapliioted crystnls; at Bllenville lead mine, Ulster Co , In fine groups. At Paris, He., handsome crysUils of brown or smoky quartz. Beautiful colorless crystaU occur at Hot Spriugs, ArkacsHS. Alexander Co., N. C, has aSorded great numbeia of blgiily complex crystals, with rare modllicatioiis. line crystals of smoky quartz come from tbe eranlteof the Pike's Peak region, Colorado. Qeodes of qusrtz crystals, also enclosiDg calclle, sphalerite, eic, are common iu Ibc Keokuk limi-stonu of Ibe west.

Rom quarit occurs at Albany and Paris, Me.; Acworth, N.; H. Bouthbuiy, Conn. Am/ihytt. iu trap, at Konveuaw Point, Lake Sujieriur; Specimen Hi , Yellonslone Park-. hi PeiJilsylvauia. fn East Bradford, Chester, and Providence (one tine crystal over 1 lbs. iu weight], in Chester Co.-. at tlie Prince vein. Lake Superior; I argu crystals, near Greensboro. N U.; cryRtullized green quartz, In talc, at Providence, Delaware Co., Penu. Chalcedony and agntea abiiudaai and beautiful on N. W. shore of Lake Superior. Re<i jasper is found on Sugar L'mf Mt., Maine; In pebbles on the banks of tbe Hudson at Troy; yellow, with chalcedony, at Chester. Muss. Agatizeil and jaspeHzed wood oF great beauty and variety of color is oblnined From the petrified Forest called ChalcedoDy Park, near Carrizo. Apache Co.. Arizonii; also From Ibe Yellowstone Park: near Florissant and elsewhere in Colorado; Ainetbyst Mr.. Utah; Napa Co., CallFornia. Moss agates from Humboldt Co., Nevada, aud ninny other poinls.

The word quarlz is of Oermau provincial origin Agate Is from the name of the river Aclintes, to Sicily, whence specimetis were brought, as stated by Theophrastus.

Qr&uTZINB is a name wbicb has been given U> a form of silica which is present in chiilci^dony and is inferred to be tdcllnlc in crystalline structure. Lutaetle belongs here.

TRmTMTTB.

Hexagonal or paeado-hexagoiial. Axis ^ = 1-6530. Orystala usually minute, thin tabiuar | c; often iu twitis; also united in fan-shaped groupB.

Cleavage: prismatic, not distinct; parting | c, Bometimes observed. Fracture concKoidal. Brittle. H. = 7. G. = 2-28-2-33. Luster vitreous, on c pearly. Colorless to wliite. Transpai'ent. Optically-h- .Often exhibits anomalous refraction phenomena.

Comp.—Pure silica, SiO,, like quartz.

Pyr., etc.—Like quartz, but soluble In boiling sodium carboniile.

Obs.—Occurs cbJeHy in acidic volcanic rocks, trachyte, andepile, Hparlte, less often In dolerite: usually iu cavities. oFlen nssociiited wllb snnidine, also hornblende, angile hema-tile: someilmeein opal. Fii-st observed iu crevices nnd druses in an aitgite.andeslte from the Cerro Sau Cristi>bal, near Pachucii, Mexico; later proveil to be ratlier generallv distributed. Thus in traciiyie of tbe Siebengi'birge; of Bugnneau Hills Iu N. Italy: Put Capiicln (Mont-Dore) In Central France, etc In the elected masses from Vesuvius consisting chiefly of sanidlne. With quartz, feldspiir, fayalite In lithophyscs of Obsidian cliff Yellowslone Park. In the nndeaite of Mt. Rainier. Wa.sliington.

Niinied from rriiSvfioi, thre^otd. in allusion to the common occ-urrence In trillings.

AsMANiTB, A form of silica found in the meteoric iron of Breltenbacb, In very minutft gni lis. probably Identical with tridymlle; by some referred to the onhorbomblc svstein.

Cristobal IT1C. Chrlstoballte. Silica in white octahedroTis (pseudo-isomclrlc?) Q = 2-27. With tridymlte in andestte of tbe Cerro 8. Cristobal, Pacbiica. Mexico.

Melakophlooitk. In minute cubes and spherical agETegates. Occurring with calcllA nnil celestite implanted upon an incnistnllon of opaline silica over the sulphur crystals of Girgpnii. Sicily. Consists of BIO, with 5 to 7 p, c. of SO,, The mineral turns black superficially when healed B.B.

Amorphona. Massire; sometimes small reniform, stalactitic, or large tuberose. Also earthy.

H. — 55-65. G. = l"9-3'3; when pure 21-2'S. Laater vitreooB, frequently enbvUreoDg; often inclining to reBinous, and sometimes to pearly. Color white, yellow, red, brown, green, gray, blue, generally pale ; dark colors arise from foreign admixtures; sometimes a rich play of colors, or different colors by refracted and reflected light. Streak wnite. .Transparent to nearly opaque. «,= l'44-l-45.

OFlen Bliona double refractioii Blmilar to that obserred in colloidal subslaocea due to leusiou. Tlie cause of Uie play of cotur in tbe precious opal was investigated by Brewster, who oBcribed il to tbe presence of micnj«copic cavities. BebreudB, however, iiiu given a mouogi-apb on the subject IBer, Ak. Wieu, S4(l}, 1871), aud basebowo t^at tljis eiplunslloo is iocorrect; lie refers the colon lo thin curved IdmellK of opal whose refraciive power may differ by 01 from that of tbe maas. Tliese are conceived to have been originally formed Id puraltel position, but have been changed, beut, and finally cracked and broken in the loUiilflcalion of the groundmass.

Comp.—Silica, like quartz, with a varying amount of water, SiO,.nU,0. The water is sometimes regarded as non-eBsential.

The opal condilion la one of lower dei;i'eea of hardness and specific gravity, and, as generally lielieved, of incapability of crypialliwition. The water present vanes from 3 to 18 p. c. or more, hut mostly from 3 to 9 p. c. timiill gunnlilien of ferric oxide, alumina, Itmu, maguesla, and alkalies are usually prssenl he impurilivs.

Vai.— PTtao\it Opal. —Ezliibiis a piny cif dilicate colors. .

Fire opal. —Hyacinlh-red to houey-yellow colors, with flre-like reflections,- somewhat

Oiiaiol.—'B\u\s\\ while, tmnslucent, with reddish reflectiona is ii bright light.-

Common Opal.—In part Iranslucent; (aj milk-opal, milk-white to greenish, yellowish, bluish; (b) Btiinopai, wax-r honey- to ocher-yeliow, with a resiuous luster; (e) dull oiive-Kreen and mountain-green; (<^ brick-ri-d. Includes i3«7uc]>a{; (f) Hydrophane, a variety which becomes more tmnalucent or Irnnsparent In water.

Cadtolong. —Opaque, bluish while, porcelaln-white, pale yellowish or reddish.

Opal-agaU.^K%ate.\\yi.e In strucluie, but consisting of opal of different shades of color.

Meniliie. —In concretionary forms; opnque, dull grayish,

Jatp-opal Opal-jasper —Opiil conlainlng some yellow iron oxide and other impurities, and haviii<: the color of yellow jaspir. with Che luster of common opal.

Wood-opal Holz-opal Berm.—Wood petrified by opal.

Uyalil". Huller's Glass.—Clear as glass and colorless, constituting globular concretioDS, and crusta with a globular or botryoidal surface; also passing into Iranslncent, and whitish. Less readily dissolved In caustic alkalies than other varieiie<:.

Morilg, SUietout Sftifer.—Includes translucent to opaque, gtayish. whitish or brownish Incrustations, porous to firm in texture: somelimps fibrous-like or filamentous, and. wbeni ▪o. pearly in luster {then called Pearl-niiter); deposited from the siliceous waters of hot 'springs.

i7ep*«r>(«.—Conslltu'esconcretlornry deposits about the geysersoftlie Yellowstone Park, Icehind, and New Zealand, preseuting white or grayish, porous, stolactitic. filamentous, canllltower like forms, often of great beauty; also com pact-massive, and scaly massive.

Float itont. —In light porous concretionary masses, while or grayish, sometimes cavernous, rouch in fmclure.

TripoliU. —Formed from the siliceous shells of diatoms (hence called dialomiit) and other microscopic species, and occurring in fxtcnMve depositn. Includes Infiiforinl Barth, or Earthy Tripelitt. a very tine jcraincd earth Inokins often like an earthy chalk, or a clay, but haish lo the fpe1. and scratching Klass when rubbed on it.

Pyr., etc.—Yields water. B.B. Infnailile. but becomes opaque. Some vellow varieties, contalninc iron oxide, liirn red. Soluble in hydrofluoric acid somewhat more readily than quartE; also si'luble in caustic alkalies, hut more readily in some varieties than in others,

ObB.—Occurs filling cavities and fissures or Reams In igneous rocks, as trachyte, porphyry, also in aome metallic veins. Also embedded, like flint, in limestone, and siiinetlmea, like other quartz concretions, In argillaceous beds; formed from the siliceous waters of

■ome hot Bprlugs; often reaultlng from tlie mere BccumtilBtlon, or nccumutation and partUl

Boliitlnu iiud EulidlliciitloD, (jf the eiliceiiua shells of ioruKnin, of epooge spfciili-s, tic, wlili:b cousiat esstnllAll; of opul-silicn. Ibe lust mtolloneil is Ihe piobHblu source of tlie i>pul of limtsiuues aod HrgjlUceous beilg (its it ia of Uiot in Ibe man: lOcks), uud of part of tliiit ill igutoua rockH. It eiUlA in most cbalcedon; Hnd tlinl.

Preeioia opal occurs in porphyrj at Cierwenit7ji, near KasLau in Hungary; nl GrocruB a Dios in HuuduruBi Queretaro izi Mexicu; u benutiful blue opnl iin Bullii Cieek, QiKciisknd. Fire-opal occura at ZiiiiapHn iu Mexico; tbe F^rOer; near San AutoLiio, Honduras. Common opal ia iibuiidiiul at Telkeb&nya lu Hungary; neur Peniateiit, etc., in MoraTiu; in Boheniin; 8letizellit-ig Id Slebengebtri'e; in Iceland. UyaliU occura in amygdaloid at tichemiiiiz, BuiigHiy; in diukbtouc at WallMli.'BoljemiR; at Sun Luis Potoai, Meiico.

lu tn S.p hyaliU occura sparingly Id connection with Ihe trap rock of New Jersey and Connecticut. A nnter-worii specimen of Bre-opal baa been found on tbe John Davia river, In Croyk Co., Oregon.

Common opal in found at Coruvrall, Lebiinou Co . Penn.; at Aiiuas Callentes. Idaho Springs, Colo.; a white variety at Mokeliimne Hill, Calaveraa Co., Cal., and on tbe Ht. Diablo range. Oerserite occurs in great abundance and variety in tbe Tellowstoue region Icf. above); alao BUleeous ainler at tileamboat lijprliiga, Nevada. Olber localities are given by Kunz, Gems and Precious Stones of N. A., liJSO.

II. Oxides of the Semi-Uetals; also Molybdenum, Tungsten.

Arsenollt*. Arsenic trlokide. As,Oi. Id isometric octjihedrona; in crusts and eftHhy. Colorless or white. Q. = 8-7. Occurs witli araenlci.l ores.

Olandatite, Also A9it>i, bul uionoclitilc in form,

Ssnaimoatlte. Antiinoiiy liioKidc. Sl>iOi. Id Isometric oclabedrous: in crusts and granulur niasalve. G. =; 5 8. Colorless, gmyisb. Occurs with ores of antimony.

Valentinite. Also 8b,Oi, but in prismatic orlhorbombic crystals.

Blimitc. Bismuth liioxide. Bi.Oi. Pulverulent, earthy; color straw-yellow.

TaUnrit«. Telliiriitm dioxide, TeO,, In while to yellow alender jiriaitiaUc eryalals.

Holybdit*. Molybdenum trioxlile, Mod. In capillary tnf ted forms and earthy. Color straw-yellow.

TungaUta. Tungsten trioiide, WO.. Pulverulent, earthy; color yellow or yellowbh green.

Oarvantita. Sb.Ot.Sb,o,. lo yellow to while aclcular crystals; also massive, pulverulent.

BtJbloonltv. H,Sb,Oi. Hasdve, compact. Color pale yellow to yellowish white.

ITT. Oxides of the Metals. A. Anhydrous Oxides.

I. Protoxides, R,o and RO.

II. Sesquloxides, B,o,.

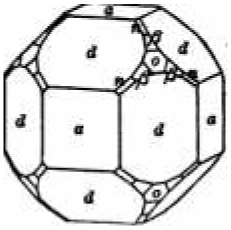
III. Intermediate, BR,o, or RO.B,Oi, etc. iV. Dioxides, RO,.

The Anhydrons Oiidee include, ae shown above, three distinct divisions, the ProtoiideB, the Seaquioxides and the Dioiides. The remaining Inter-mediate division embraces a number of oxygen compounds which are properly

to he regarded chemically as salts of certain acids (alnminates, ferrates, etc.); here is included the wellcliarncterized Spinel Group.

Among tlie Protoxides the ouly distinct aroup is the Periclase Gkoup, which iiicliiiies the rare species Periclase, MgO, Manganosite, MnO, and Jiiinsenito, NiO. All of these ure isometric in crystallization.

Tiie Scs(iDioxides include the well-cliaracteriKed Hematite Group, E,o,. 'I'lie Diosides include the prominent Kutile Group, RO,. Both of these groups are further defined later.



I. Protoxides, R,o and RO.

OUPRTTE. Ited Copper Ore. Rotlikiipferer?. Oerm.

Isometric-plagiJiedral. Commo)iIy in octahedrons; also in cubes and ^lodecahedrouB, often highly modified. Plagiliedral ^ci

faces sometimes distinct (see pp. 50, 51). Also massive, granular; someCimea earthy.

Cleavage: o interrupted. Fracture conchoidal, uneven. Brittle. H. = a-5-4. G. = 5-85-615. Luster adamantine or submetallic to eartliy. Color red, of various shades, particularly coclimeal-red, sometimes almost black; occasionally crimson-red by transmitted light. Streak several shades of brownish red, shining. Sub transparent to subtraiislucent. Refractive index, «r = 2-8+9 Fizeau.

Vm.— 1. Ordimrj/. la) Ciygtiilllied; commoDly in oclii Arizona,

lietlrons. dod ecu bed rolls, cuIk:b. nud I iiler median: fotms; the crystals often wltb a crusl of maiacliite; (ft) iiiagsivt'.

2. Capt'liiiT/; C/ialeotrieAili: Plush Cunp^r Oie In capillary or aclculsr crysialllza-tions, wbicli aru Mimettmes cubes ehmgivivd in ihe dlrecliim of the culiic axis.

8. EarOi}/; Tile Orf, Zic^lerz Oeria. Brlok-rei! or n-ilcliBh brown unil earlby, oflea mixed wiUi red oxide ol iron; wnneliniw nearly black.

Comp.—Cuprous oxide, Cii,o = Oxygen 11-3, copper 88-8 = 100.

Fyr.. etc.—UD:iiien-d in thu closed lube B.B. in liie forceps fuses and colors llie flume emernUi green On Miari'oal fliBl bliickens. then fuses, and is reduced to nietalitc copper. With ihe fluxes gives reiicllons for copper. Solulile In concenlriited bydrocbloric acid, and a strong solulion when cooled and diluted with cold water yields a beavy. wbile predpltale of aubcbloriile of copper.

Ufi.—Dlstlnguisbed from hemnlite by inferior hardness, but Is harder than cinnabar and prouslile and differs front tliem in Ibe color of tbe streak; rcactioua for copper, U,B., are conclusive,

Oba.—Occurs at Kamsdorr In Thurlnfitn; In Cornwall, In fine crystals, at When] Oorlnnd and olhr r minea; in Devonshire near Tavistock: in isolated crystals, more or leas altered ID maiiiriiiii', lit Cbesay, ueiir Lyons, France; in ibe Ural; Soutii Australia; also abundant in Gblli. l-erit. Bolivia.

Ill tbo U, 8. observed at Snmerville. etc., N. J.; at Cornwall. Lebanon Co., Pn.; in tbe Lake Superior region. With malacliile, llmonilc, etc , nt the Copper Queen mine. Blsbee, Arliooa, sometimes In fine cryslaU: beautiful ekaUotriehitt nt Morenci; at Clifton, Oraham Co., In crystals, and massive.

Ic*. B.O. Hexagoual. Familiarly known In six-rayed anow cryatali; also coating ponds In wlniar, further as glaciers and icebergs.

Pe rid use Group. Fmlolaae. Magnesia, HgO. In cut>es or ociaheiirons. and In gralna Cleavage cubic. ^ ..... r^ " -s Id while limestone al Mt. Bomnia; at the Kittein m&nga-

d-green, becoming black od exposure. From L&agbua &>id Nordmark, Sweden.

Nickel protoxide, NfO. In green oclabL-drons. From Jobsnogeurgeustall L

ZINOITB, Red Oxide of Ziuc Bed Zink Ore. RoUiziukerz Germ. Hexagonal-hemiroorphic. Axis 6=^ 1'6319. Natural crjatals r^re (Fie. 50, p. IS); usually foliated massive, or in coarse particles and graine; also witli granular structure.

CleavB^: c perfect; priBmatic, sometimes distinct. Fracture subconchoidal. Brittle, fi. =4-46. G. = 5-43-5'7. Luster Bubftdaraantine. Streak orange-yellow. Color deep red, also orange-yellow. Translucent to snbtrauslucent. Optically +.

Corap.—Zinc oxide, ZnO = Oxygen 197, zinc 80-3 = 100. Manganese proto:^ide is sometimes present.

Pjrr., Btc—B.B. infusible: wltb tbe fluxes, on tlie plaliuuni wire, gives reactions for manganese, and ou obarcoal in It.F. gives h coaling of ziuc oxide, yellow wblle bot, and while on tooling. Tlie coating, moistened with cobalt solution and treated InO.F., asBumes a green color. Solulile in acids.

Dlff.—Cbanicteni^ by its color, particularlj that of tbe streak; by cleavage; bj

Obs.—Occurs with franklinlle and wiUeinite, at Sterling Hill near Ogdensbiirg, and at Mine Hill, Franklin Furnace. SuEssex Co,. N. J., sometimes in lamellar masses Id pink calcile. A not uncomniiin furuacc product.

HsBSicot. Lead mnuoiide. PliO. Ha-^sive, eculy or earthy. Color'yellow, reddish.

Tenorlte. Ciipric oxide. CuO. In minute black scales with metallic luster; from Vesuvius. Also black eartliy mttssivc {melaeoniie); occurring wltb ores of copper as at Ducklown, Tenn.. and Keweenaw Point, Lake Sni>erlor.

Paramelaconita is essentially ciipric oxide, CuO, occurring in black pyramidal crystals referred lo the tetragonal system. From tbe Copper Queen mine, Bisbee, Arizona,

Hematite Group. E,Oi. Rhombohedral.

it' i

Conindum Al.O. 93° 56' 13630

Hematite Fe,0. 94" 0' 13656

nmenite (Pe,Mg)O.TiO, Tri-rhombohedral 94" 29' 1-3846

Pyropluuiite MnO.TiO, " 94" 5i' . 13C92

The Hematite Group embraces the sesquioxides of aluminium and iron. These compounds crystallize in the rhombohedral system with a fundamental rhombohedron differing but little in angle from a cube. Both the minerals belonging here. Hematite and Corundum, are hard.

To these species the titanatea of iron (and magnesium) and manganese, Ilmenite and Pyrophanite, are closely related in form though belonging to the tri-rhombohedral group (phenacite type); in other words, the relation between hematite and ilmenite may be regarded as analogous to that between calcite and dolomite. It is to be noted, further, that hematite of ten contains titanium, and an artificial isomorphouB compound, Ti,0„ has been described. Hence tbe ground for writing tne formula of ilmenite (Fe,Ti),0„ as is done by some anthors. It is shown by Fenfleld, however, that the formula {Fe,Mg)TiO, ia more correct.

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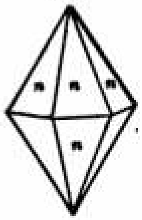
652.



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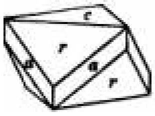

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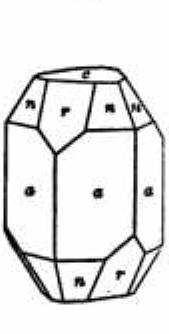

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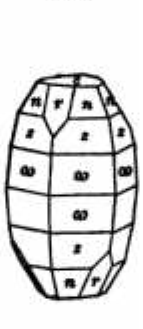


Ehombohedral. Axis i = 1-3630. er. 000lAloil = S7*84'. «fi3.

en. 0001aS2« = 61*I1'.

rt'. loilAllOl =W6«'. nn', 3i4aAS423 = Sr S8'. w-. 4488A4848 = ST" Sff. b', 2341a2421=:S8°65'.

Twins: tw.pl.r; sometimes penetration-twins; often poly-synthetic, and tiias producing a laminated structure, Crys* tais uBiially rough and rounded. Also massive, with nearly rectangular parting or pseudo-cleavage; grannlar, coarse or fine.

Farting: c, sometimes perfect, but interrupted; alsordae to twinnine, often prominent; a less distinct. Fracture uneven to conchoidal. Brittle, wnen compact very tongli. H. = 9. G. — 395-4'10. LuBter adamantine to vitreous; on c sometimes pearly. Oc-caeionally showing asterism. Color bine, red, yellow, brown, gray, and nearly white; etreak uncolored. Pleochroic in deeply colored varieties. Transparent to tranBlucent. Normally uniaxial, negative; for sapphire <»,= l'T6T6 to 1-7682 and e, = 1-7594 to l-r59B Di. Often abnormally biaxial.

V«r.—There are three siibdivlaions of the species proniioeiitly recognized in the srls, but (llfFering only In piiritj nnd slule of crysIallizBlloD or atmctiire.

Vau. 1. Sappkirk. Rcbv.— Includi-a Ihe purer kinds nt Sue colors, transpiircnt to Iraiii-lucem, useful as gems i^toneB are uunied scconlmj; tu their colors: Sapphire hlue: true Ruiy. or Orienlal Rubjf, reil; O. Topta, yellow; o. Emerald, greeu; o. Amtthytt, purple. A vurieiy having a sU'llale onalescence wlieu viewed lu the dtreotion of Ibe vertlcul hxIs of Ihc rrystal, Is ihe A'le-iaCfil Sapphire or Smr SHpphire.

2. CoRTJNDTiH.—Includes the kiuds of daik or dull colors and not 1[);lit bTue lo grsy, brown, niid black. The original ad/im/intine ipar frt gnu ish »nn]ky-br"wn tint, but greenish or bliiUli hy Irnuamitled light, i

it Emekt. Schmlrgel Oerm —Iiicliidea granular corundum, of blai'k or grayish blnck color, sod contains magnetite or Lemntite iutlmsieiy mixed. Sometimes assoolaied with iron spinel or hercynlte. Feela &nd looks much like a block fine-grained iron ore, whicli It was long considered to be. There are gradations from the evenly finegrained emery to kinds Id which Ihe cOTundam la lu distinct crystals.

Comp.—Alumina, A1,0, = Oiygen 47-1, aluminium 52-9 = 100. The crystallized varieties are essentially pure; analyses of emery show more or less impurity, chiefly magnetite.

Pjrr.. ato.—B B. unaltered i slowly dissolved in borax and salt of phosphonu to a clear ainsa, which Is colorless when free from iron; not acted upon by aurta. Tlie finely pulverized mineral, after long heating with cobalt solullon, gives a benuUful blue color. Not acted iipoa by acids, but converted into a soluble compound hy fusion with potassium bisnlpliHte.

Dill—Characterized by Its hardness (si^ntching quartz and topaz), by lis adsmanttne luster, bigh specific gravity and infusibi'lity. The massive variety with rhombobedral parting resembles cleavable feldspar but is much harder and denser.

Ob«.—Usually occurs In crystalline rocks, as granular limestone or dolomite, gneiss, fcranile. mica slate, chlorite slate. The nssoclaied ininenilB often Include some species oF the chlorite group, as. prochlorlte, comndophilite, margarlte, also tourmaline, iplnel.

n India li.

cranite, dinspore, and a Berieg of alumioous mlueralH, in part produced from Its altemlioD. OccBsioually found Id ejected musses encloaed lu juunger volcanic rocks, u at KOiii|,'a-wiiiter, Niedermendig, etc. Rarely observed as n contact-mineral. Tlie tint-sapphires are usually oblataed from i)ie beds of rivers, cillier in modified beiagoual prisms (ft- iu rolled mas-ses, accompauied by ({iiiiiia of mu^neiite, aud aevei-al kloda of gems, iia fpiiiel, elc. The emery of Asia Miuor, Dr. Smith slates, occui-s <□ graaular limestone.

The boat rubies come from the miiies !□ Upper Burma, oorlb of Maudaliiy. iu au arva coverluK 23 Co 30 square miles, of which Hogok ia the center. The rubies occur tn titu iu crystalline llmestooe, also lu the soil of tbe hillsides uud iu gem-bearitig gravel. Blue sapphires are brought from Ceylou, oftea at rolle<l pebbles, also as well-presfrviKl crystals. Coruudum occurs In the Caniatic o:i the Malabar const, ou Ibe CLauiibuu hllU iu ESmiii, aod elsewhere in tbe East Indies; also near Cantuu, Chlua. At til. Quthard, It occurs uf & red or blue tinge In dolomite, and near Huzzo in Pledmoul, in white compact feldspar. Adamantine spar is met with in lur^^B loarae. hexagonal pyramids In Gellivara, Bwt-den. Other localities are iu Boliemlii. ui'ar PetKchau: iu the Ilmen mountains, not far fnun Hiask; In tbe gold-waabiugi uorihia-t of Zliitoust. Corundum, sapphires, and le^a often rubies occur in roiled puliblus in thi^ diiimojd gnivels on the Cudgeeong river, at Mud^e« Uid other points in New South WoIot, Einerj- is found iu larye bowlders at Naios, Nicaria, and S iDios of the Grecl in islands; al-io in Asia Minor, 13 m. E. of Ephesus, near Gumucli-dagh and near Smyrna, nstocinled wit li iiiargiLrile, chloriloid, pyrlte.

Ia N. America, in l£ut-tthuielii, at Ch.'^<tcr. with magnetite, diaspore, ripldolite, mnr-gartts, etc.. mined for use at emery. In C-maecUiml. near Litchlield. In Nea Tork, at Warwick, bltilsh and pink, with spiiiel: Auiity, In gran, limestone; emery with magucttle and green spinel (hercyuite) iu We.-tiche-ter Co., uear Cruger'a Station, and elsewhere. In New Jirtey, at Newton, blue crystals in grnn. lltuestoiie; iit Vernon. Iu Ptntuyltauia. In Delaware Co., In Aston, neiir Village Qrueu. In large crystals; at Mineral Hill, lu loose CTjst.; in Chester C >, at Uninnvllle, abuudant in crystals: in laree crystals Ioo~e In tbe soil at Bhimersvllle, Lehigh Co. In Virginia, in Che mica schiala of Bull Mt., Patrick Co.

Common nt inauy points along a belt extending froin Virginia across wentem North nnd South Carolina and Georgia to Dudlcyville, Alabama; especially in Madison, Buncombe. Haywooil, Jackaou. Macou, Clay, ivud Gaston counties In North Carolina. Tbe localiiles at which most work has been done are Che Cuia:igce mine, Corundum hill, near Franklin, Macon Co., N. C aud 36 Rkile^ 8. B. of this, at Laurel Ci-eek, Ga. Thi' coruudum occui-s In betis in chrysolite (and seriieiiliue) aud borublendlc gneiss, aisociated with a species of tlie chlorite group, also spiuBl. etc.. and here as elsewhere with many minerals resniiing from Its alteration. Boiue fine rubles liave been found. Flue pink crystals of corunduiit occur aC Hiawaasee, Towns Co., Georgia. In Colorado, small blue crystsU occur in tiitcn ■cbist near S.ilida. ChaSee Co. Gem sapphires are found near Helena, Montana In gold-washings and in bars in the MIsKuiri river, especially the.Eldorado bar; at Togo Gulch ou tbe Judith river and at other points In Montana. Tn Calijornia, in Los Angeles Co,, in the drift of San Franclsqueco Pass. In Canada, at Burgess, Ontario, red and blue crystals.

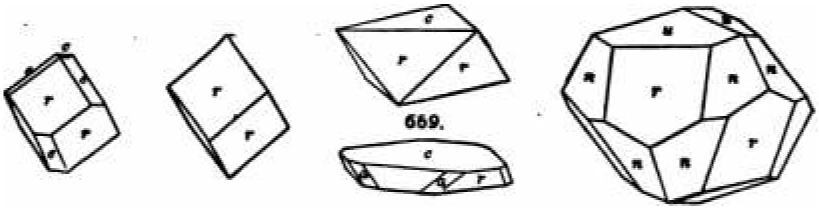
HEMATITB. EEsenglaiiE, Oerra. Bhombohedral. Axis i = 13656. er. 0001 A lOil = 57° dT. n', lOil A iioi = W o*.

a. oiia A iois = 64"Gi'.

uu'. 1014 A il04 = 87* y. »n', 3548 A 3438 = 61 ■■ Wf. en, 0001 A 2^48 = 81° 18".

658.

6S7.



Twins: tw. pi, {]) c, penetntdon-tvius; (8) r, leas common, uanfill; u

poljeynthetic twinning lamellfe, producing a fine Btriutioa on c, and giving rise to a diatiuct parting or pseudo-cleivage y r. Crystals often thick to thin tiibnlar H c, and grouped in parallel position or in rosettes; c faces striated II edge c/d and other forms due to oscillatory combination; also in cube-like rfaombohedrons; rhombohedral faces u (10l4) horizontally striated and often rounded over in convex forma. Also columnar to granular, botryoidal, and stalactitic sliapes; also lamellar, Jaminte joined parallel to c, and Tariously beut, thick or thin; also granular, friable or compact.

Parting: c, due to lamellar structure; also r, caused by twinning. Fracture subconcboidal to uneven. Brittle in compact forms; elastic in thin lamiuffi; soft and unctuous in some loosely adherent scaly varieties. H. = 5-5-6'5. G. = 4.9-53; of crystals mostly 520-5'25; of some compact varieties, as low as 4*3. Luster metallic and occasionally splendent; sometimeB dull. Color dark steel-gray or iron-black; in very thin particles blood-red by irans-mitted light; when earthy,red. Streak cherry-red or reddish brown. Opaqne, except when in very thin laminae.

Vtir. 1. Speeul'ir. Luster inetanic, nnd cryitala often aplendeot, whence the UBine apeailar iron (GlauMistceiz Germ). Whtn llie structure ie foliated or mfciceous, the ore is called mioaetout hematite (BUenglimmer Grrm.): some of the mlcnceousvarletieB are Boft iiJid unctuous (Eiiiearahm Germ.j. Some vaneties are mnguelic, but probably from adiniied mngiieille (Arts. 424, 426).

2, Compaet evlumnar; ur fibroiii. The masses oflen loar rsdiadng; luster submetallic to ineiuilic; color btowiiish red to Iron-black. Somellmea called red hematite, to contrast ft wllb limouiteaiKllurglte. Ofieiiln reniform masses with smooth fracture, c»]\etl kidney ore.

S, Ihd Ocheroui. Red auii earthy. Beddle and red ehaUc are red ocber, mixed with more or less clay.

4. Clny Iron-itone; Argillaceinia hematite. Hard, biownlah black to reddish brown, often in part deep red; of eubmetalljo to uiimetatllc luateri and affording, like all Ibe preceding, a red slreiik. It conaiBts of oxide of jiOD wllb clay or sand, and sometimes olber

Comp.—Iron sesquioiide, Fe,o, = Oxygen 30, iron 70 = 100. Sometimes contains titanium and magnesium, and 18 thus closely related to ilmenite, p. 336.

Pyr., «tc.—B.B. infusible: on charcoal In B.F. becomes magnetic; with bornx givcft tlie iron reactions. With soda on cLarconl in R.F. is reduced to a gray magueilc melalljo powder. Soluble in concentrated hydrochloric acid.

' Diff.—Distinguished from magnetite by Its red ttreak, also from limonlte by the same means, as weH as by its not containing water; from lurgite by lis greater hsTdnees aud by Dot decrepitaliiig- B.B. It ie hard in all but some micaceous viirleties (hence easily disllnguisbed frnni the black sulphides); also infutible, and B.B. becomes strongly majineiic.

Obs.—This ore occura in rocks of all sgea. The specular variety is mostly confined to crystnlline or inetamorpbic rocks, but is also a result of igneous action about some Tolcanoes, us at Vesuvius. Many of the geoiogicul fonnations contain the argillaceous variety or ciay iron-stone, which Is mostly a marsh-formation, or a deposit over the bottom of shullow, s'A^nant water; but llils kind of clay iron-stone (tbnt giving a red powder) Is less common than tlie corresponding vailety of limcmite. The beds that occur in metftmorpblc rockt are aomellmes of very (Treat thickness, nnd, like thoxe of miignetlle in the same situation, have resulted from the slteralion of sirnlified beds of ore, orlglnnlly of marsli origin, which were formeil at the same time with the enclosing rucks, and underwent meiamorphlFm, or a chanj;^ to the crystnlline condition, at the same time.

Beanlifui cryslalllzallons of this species are brought from the Islsnd of Elba, which baa nftordod it from a very remote period; Ihe siirfncea of the crystals often present an Irlsed tamish and brilliant Insler. St. Gothard nfforris heautiful specimens, composed of crystnlllzed tnbles grouped in the form of rosettes lEiteji/roeen): near Limoges, France, In large crytals; fine crystals are the result of volcnnlc ncHon at Etna and Vesuvius. Arendal 1"

pfendld specImeD*.

Red tiemaltte occur* Id renlform rouses of a fibrous conoeotric MructtiTe, neutTlventoiifl 1b LancBsliire, lu Saxony, Bohemia, and ibe Hara,

Id N. Amtriea, widely Ulstrlbuted, uud somelimes In beds of vaat IliickDess fu rocks of tlie Archxau age, aa in llie upper prulDSula of Micbigftn. Id the Harqiielle district, also ia Meiiomluee coumj and weal of Lake Afogebic in Gogebic county; further tlirougli iiortbem WiscuuBiu. lu Florence, Asliland and Dudge Cos., aud Id HlDDoaota near Vermiliuii litke, 8t. Luuls Co.; in HUsourl, at tlie PitoL Kuob and ihe Iron Mtu.

In New Tork, In Oneida, Herkimer, Madlsou. W&yne Cos., a lenticular argillaceous vur , coNstiLutlng one or two beds In the Clinton group of tbe Upper Silurian; ibe sume In Pennsylvania, and aa far soutb as AlHbamu; and fu Canada, aud Wisconsin to tbe weal; in Alabama there are eileuslve beds; prominent mluea are near Birmlngliam. Besides these regiuua of enormous beds, there are uiiroeruus others of workable value, either crystallized or argillaceous. Some of these loculiliea. iuleresting for their specimens, are in uortbem New Tork, at Gouveroeur, Antwerp, Hennon. Edwards, Fowler, Canton, etc.; Woodstock aud Arooaiouk, He.; at Hawley, Mass.. a micaceous Turiety; In North aod South Carolina a micaceous variety In schistose rocks, constituting tbe aO'Calted ip»etttar tehitt, o[ilabtrUt.

Named hematite from a^ua, blood.

Hastitk. Iron sesquloxlde under an isometric form, occurring in ocIahedroDS or dodecahedrons like magueiite, and believed 1o be pseudooiorphous afier magueille; perhaps In part also after pyrite. Fariing octahedriil like magnetite. Fracture conchoidal. H. = 0-7. G. = 4'8 (Brazil) to S'8 (Monroe). Luster snbmctalllc. Color iron-black, sometimes urith a bronzed tarni^. Streiik reddish brown or purplish brown. Not magnetic, or only feebly so. The crystals are sometimes enibedded in the massive eesquioxlile. They are distinguished from magneiile tiy tlie red streak, and very feeble, if any, action on tbe magnetic needle. Found in tiJe Marquette iron region south of Lake Superior, where crystals are common In tbe ore; Monroe, N.Y.; DIgby Co , M. 8.; at th<! Cerro de Hercado, Duraueo, Mexico, in large octajiedrons; in the schists of Minas Oeraes, Brazil; near Rltters-grliD, &uony.

ILHBNITB or Hkhacoahitb. Titanic Iron Ore. Titanelsen <7«n». Tri-rhombohedral; Axis <! = 1-3846.

663. er. 0001 A lOll = 57* 081'.

fT". lOil Ail01=9r29'. en. OOOl A 2248 = 61'S8'. Crystals Qsually thick tabular; also acute rhombo-hedral. Often in thin plates or lam inn. Massive, com* pact; in embedded grains, also loose as aand.

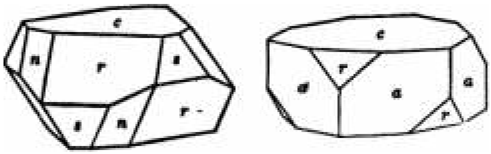
Fracture conchoidal, H. = 5-6. G, — 4-5-5, Lnster submetallic. Color iron-black. Streak submetallic, powder black to brownish red. Opaque. Influences slightly the magnetin needle,

Comp., Yar.—If normal, FeTiO, or FeO.TiO, = Oiygen 31-6, titanium 31-6, iron 368 = 100. Sometimes written (Fe,Ti),0,, but probiibly to be regarded as an iron titanate. Sometimes also contains niaguBBium (pieroH/ani/e), replacing tbe ferrous iron; hence the general formula (EB,Mg)O.TiO, (Penfield).

Pyr.. etc-B.B. infusible In O.F.. nltlinugh slifrhtly rntinded on Ibe edircs in R,F. With borax and sail of phosphorus reacts for iron in O.F.. and wlib the talter flux assumes a more or lera Intense brownlshred color In R.F.: Ibis treated with lln on charcoal changes to a Tlolet-red color when tbe aronunt of lllanium ix not too smnll. The pulverized mtnetal, heated wiib hvdrncliloric acid, is slowly dissolved to a yellow solution, which. Altered from Ibe tin decomposed mineral and boiled with the addition of tin-foil, assumes Rixmuliful blue or violet color. Decomposed by fusion with bisulphate of sodium or potassium.

Diff.—Resemble* taematUe, out has a submetallic, nearly black, streak; not magnetic like magnetite.

Oba.—Occurs, aa an accessory component, in many igneous rocks in gnina, aaauioiDg



the place of magnetlta, eapeoUIly Id gabbroc and dIorilM. In these occurrences, It Is often found in veins or large aegreKoted maaacB near tbe borders of the igneouB rock wbere tt la aupposed to hnve formed by local diftereollatloD or fracllond cryitullfiBlion ta the molten amas. Some principal European localities are St. Cristonbe, Dauphinfi (var. enehtottiie); Ulnafc in the itmen Mis. {Umenile); in tlie form of sand at HeDnccuu, Cornwall (tntnoocoa-iU); Gaslein lu Tyrol (ilaiilfJopAarM); Iserwieee (iMn'nfj. One of tliu moat remai kable Is at EragerO, Norvruy, wliereil occurs in reins or beds lu diorile, whlcb Bumelimes afford crystals weighing over 16 pounds. Others are .Egersund, AreuduJ, Ijnarum in Norway; St. Gol^ard, etc.

Fiue crystals, sometimes an Inch in dismettr, occur (d Warwick, Amitr, and Uonroe, Oraage Co., N. Y.; Litchfield, Cotiu. {washingtonite). Vast deposits or beds of titanic ore occur at Bay St. Paul In Quebec, Canada, in syenite: also lu ibe Beisnory of St. FnnciB, Beauce Co. Grains are found In tlie gold sand of California.

Tbe Uranic irou of massive rocks Is extensively altered to a dull wbite opaque substance, called lettamtna by GUmbei. This for tbe most part Is to be identified ifitb titanlte.

Pyrophanlte. Manganese illaoate, HnTlOi. In thin tabular rhombobedral crystals and seales. near iimenite in form fp. SS2). U. = G. O. = 4587. Luster vitreous to sub-Dietsilic. Color deep blood-red. Streak ocher-yellow. Fiom tbe Harstlg mine, Pajsberg, Sweden.

111. Intermediate Oxides.

The Bpfloies here ioclnded are retained among the oxides, althongh chemically oonsidered they are properly oiygen-Balts, oluminatea, feiratee, manganates, etc., and hence in a strict claseincatioii to be placed in section 5 of tbe Oxygen-s^ts. The one well-characterized group is the Spinel Q-roup.

Spinel Group. RB,o. or RO.R,o,. Isometrio.

Spinel MgO.A1.o,

Oeylonite (Mg,Fe)O.Al,o,

Chlorospiael MgO. (Al,Fe),o,

Picotite (Mg,Fe)o.(AI,Cr),o,

Hercynite FeO.Al,o,

Othnlte (Aatomolite) ZnO.Al,o,

Dyalnite (Zn,Fe,Mn)o.{Al,Fe),o,

Kreittonite {Zn,Fe,Mg)o.(Al,Fe),o,

M^netite FeO.Fe,o,

{Fe,Mg)O.Fe,o.

Kagnedoferrlta MgO.Fe.O,

Pranklinlte (Fe,Zn,Mn)o.{Fe,Mn).o,

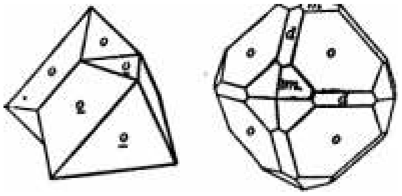
Jaoobiite (M;n,Mg)o.(Fe,MD),o,

Chromite FeO.Cr.O,

(Fe,Mg)o.{Cr,Fe),o,

The species of Spinel Group are characterized hy isometric crystallisation, and, further, the octahedron is throughout the common form. All of the species are hard; those irith nnmetallic Inster up to ?'5-8, the others from 5'5 to 6*9.

.dbyGooglc



DB8CBIFTITB UINEBALOOT.

iBometric. Usaally in octahedrooB, rarely cubic Twins: tw.<pl, and oomp.-face o common (Fig. 663), hence ***• ••*• often called spinel-twins; also re-

peated and polysjnthettc, producing tw. lamellse.

Cleavage: o imperfect. Fracture oonchoidaL Brittle. H. =8. G. = 3*5-4*1. Luster vitreous; splendent to nearly dull. Color red of varioua shades, paseing into bine, green, yellow, brown and black; occaaloually almost white. Streak white. Transparent to nearly opaqne. Refractive index: n, = 1'7155 Na, Dz.

Conp., Tar.—Magnesium alnminate, MgAI.O, or MgO.Al.O, = Alumina 71-8, magnesia 28-2 =- 100. The magnesium may be in part replaced by ferrous iron or manganese, and the aluminium by ferric iron and chromium.

Var.—KuBT Spinel or Magneiia Spintl.—dear red or reddUh; transparait to trans-lucent; Mtneilmea aubtraaslucent. G. = 8-63-8-71. Com position nonnal, with little or do iron, RQd sometimes chromium oxide to wbich the ."red color has been nscribed. The varieties &re: (a) ^net-Sul^, deep red; (b) Balat-B^, rose-red; (e) SvHeelU, yellow or oitknge-red: (<j) J,iinandin«. violet.

Cbtlonttb or PUonatU, Iron-Magnttia Bpinel. —Color dark green, brown to black, mostly opaque or nearly so; G. = 8-Jh-86. Conwius Iron replacing tlie magnesium and perhaps also the aluminium, hence the formula fMg,Pe)o. Al,Oi or fMg,Pe)o.(AI,Fu),O|.

Chlobostinkl or Mdgnetia-Iron Spinei. —Color grass-green, owing to the preaeoce of copper; G. = 3-681^-694, Contains Iron replacing the aluminium, MgO.(A!,Fe),o,.

PicoTna or Chrome-Spintl.-'^oat&iha chromium and also has Ihe magnealum largely repliiced by Iron. (Mg,Fe)o.(Al.Cr},Oi, hence lying between spinel proper and cbromite. Q. = 4-08. Color dark yellowish brown or greenish brown. Transluceat to nearly opaque. Pyr , etc.—B.B. alone infusible. Slowly soluble in borax, more readily In salt ot phosphorus, with which it gives a reddish b^ while hot, becoming faint chrome-green on cooling. Black varieties give reactions for iron with the fluxes, Soluble with diflicully in concentrated sulphuric acid. Decomposed by fusion with potassium blsulphate.

DIS.—DistinguUhed by its octahedral form, hardness, and infuslblllty; zircon baa a higher specific gravity; the true ruby (p. 83S) Is harder and is distinguished optically; garnet Is softer and fusible.

Obi.—Spinel occurs embedded In granular limestone, and ^vlth calcfte In serpentine, gneiss, and allied rocks. Buby spinel Is a common associate of the true ruby. Common epluel is often associated with chondrodlte. It also occupies the cavities of magses ejected from some volcanoes. Spinel (common spinel, also picotlte und chromite) occurs as an accessory constituent in mnn^ basic igneous rocks. eBpectally those of t)ie peridolite group ; it is the rusult of tlic crystallization of a magma very low In silica, high In magueda and con-tainiug alumina; since, as In many of the peridotltes alkalies are abseot, feldspars cannot form, and tlie AliOi and CrtOi (also FeiOi perhaps) are compelled to form spinel (or corundum). The serpentines which yield spinel are altered peridolites

In Ceylon, In Slam, and other eastern countries, occura of beautiful colon, as rolled pebbles: In upper Burma with the ruby (cf. p. 834). Pleonaste is found at Candy. In Ceylon; at Aker, In Sweden, a pale blue and pearl-gray variety in limestone; small black splendent cnntali occur in the ancient ejected masses of Monte Somma; also at Pargaa, Finland, with chondrodlte. etc.; in compact gebleolte at Honzoni, in the Fassa vallev.

From Amity, K. Y., to Andover. n! J., a distance of about 80 miles, is a regfon of granular limestoue and serpentine. In which localities of spinel abound; colon, grees. black, brown, and len commonly red, along with cbonarodlte and other minerals. Locnlitloi are numerous about Warwick, ind also at Monroe and Cornwall: Gouvemeur. 8 m. N. and | m. W- of Somerville, Bt. Lawrence Co.; green, blue, and occasionally red varielies occur at Bolton, Boxborough, etc., Haas. Franklin, N. J., sffords crystals of various shades of black, blue, green, and red; Newton, Bterlina:. Sparia. Hamburgh and Vernon, N. J., are other localities. With the corundum of Morth Carolina, as at the

Culsagee mine, near FraokllD, Hacou Co.; Bimlluly at Dudlejrrllle, Alabama. Spinel ruby lit Gold BluS, Humboldt Co., Cat.

(ivod black aplnel 1b fouud \a Burgess, Ontario; a bluish spinel bavin); a rough cubic f»MU occurs at Wakefield, OtUwa Co.; blue wUli cllutooite at Daillebout, Jollette Co., Quebec.

Heroynite. Iron Spinel, FeAUOi. laoineiric; massiTe, fine granular. H. = 7'5-8. G. = 3'91-S'9fi. Color black. From Roneberg, at the eastern foot ot tbe BOhmerwald. A related iron-alumina spluel. nrltb about 9 p. c. HgO, occurs with magnetilean J corundum in Cortlaudt township, Westcliester Co., N. Y.

aAHKITEI. ZInc-Bplnel.

Isometric. Habit octahedral, often witn faces striated | edge d/o; aleo lesB commonly in dodecahedrons and modified cubes. Twine: tw.-pl. o.

Cleavage: o indistinct. Fracture conchoidal to uneven. Brittle. H. = 7-5-8. G. = 4'0-4'6. Luster vitreous, or somowbat greasy. Color dark green, grayish green, deep leek-green, greenish black, bluish black, yelloviBn, or grayish brown; streak grayish. Subtranspareot to nearly opaqne.

Comp., Tar.—Zinc alutninate, ZnAl,0, = Alumina 55-7, zinc oxide 44'3 = 100. The zinc is sometimes replaced by manganese or ferrous iron, the aluminium by ferric iron.

Var.—AlyroMOLiTB. or Zinc GoAnifc.—ZnAl.O,, with Bometimos a Utile iron. G. = 4K 4-0. Colors as above given,

Dtbloitk. or Zine-Maaganete-lTtm ffoAnite.—(Zu,Pe,Mn)0.(AI,Fe),Oi. Color yellow-Uli browQ orgrayisb browu, O. = 4^-8,

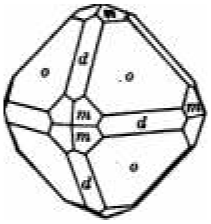
Krbittonctk, or Ziiu. Iran Gaftii(».~(ZnFe.Mg)0.(Al,Fc),0,. In crysinls. and granular massive. H = 7-8. Q. = 4-48-1-SO. Color veWel-black to greeolsb black; powder graytsb erecn. Opaque.

Pyr., etc.—Gives a coating of zluc oxide when treated wilh a mliture of borax and Eodii on charcoal; otherwise like spiael.

Obs.—Occurs iu talcoae scliiat at Falun, Sweden (nutomolitr); at Tiriola, Calabria; at Bndenmais, Bavaria (kreiUoitiU); Hinas Geraes. Bmzll. In tliell. S.,Bt Franklin Furnace, N. J., with fronklinite and willemile; also at Sterling Hill, N. J. (dy»ii«'to); wilh pyrile at Itowe. Mass.; nt a feld)!par quarry iu Delaware Coi Peun.; apariugly at tbe Deake mica miue, Mitchell Co., N. C; at the Canton Mine, Georgia; withgalena, chalcopyrite. pyrite at liie CoKipaxi miue, Ciiaffei; Crt., Colo.

Named alter the Swedish cLeinist Gahu. The mme Aulomotile. ctEithere, is from avTOftoXoi. a deterler, alluding to the (act of the zinc occurrlug In an uneipected place.

Magnetic Iron Ore. Hagneteisensteia, Magneleiscnerz. Isometric. Most commonly in octahedrouB, also in dodecahedroris with faces etriated \ edge d/o from oscillatory combination; in dendrites between 668. 667. sea.



plates of mica ; crystals sometimes highly modified ; cubic forms rare. Twins: tw.-pl. o, sometimes as polysynthetic twinning lamellie, prodncing

striutione on an octahedral face and often a pseudo-cleavage (Fig. 456. p. 136). UsBsive with laminated structure; granulur, coarse or fine; immiipiible.

Oleayage not distinct; parting octahedral, often highly developed. Fracture subcouchoidal to uoeven. Brittle. H. = 65-6o. G. = 5*168-5-HJl> crystak. Lnater metallic and eplendent to submetallic and rather dull. Color iron-black. Streak black. Opaque, bat in thin dendrites in uiica nearly transparent and pale brown to black. Strongly magnetic; sometimes possess-iug polarity (lodestooe).

Comp, Tar.—FeFe.O. or FeO.Fe,o, = Iron sesquioiide 69-o, iron protoxide 31-o = 100 ; or, Oxygen 27'6, iron 72 4 = 100, The ferrous iron sometimes replaced by magnesium, and rarely uickel; also sometimes contains titanium (up to 6 p. o. TiO,).

Vmt. — Ordinarj/. —(a)

coiiiae or flue, (e) As lot . , , „ „

Is altracted by a magnet but bus uo power of uUraeiing paniclea of iron iiself. Tlie proptrly or polarity wbfcb dtstluguislies tbe lodtttont (less pro|>«rly writteti loadsione) U cxceptioiml.

Magnttian. Talk-Eisenerz.—Q. ■= 4'4l-4'42; lutler submetallic; wciik roiignt-tic; In crystnls from Sparta. N. J., and elsewhere.

Manganetian. —Containing B'8 to 6 3 p. c. muuganesc (Manganmagnttilt). From Vesier Bilfberj,'. Sweden.

Pyr., otc.—B B. very difficultly fusible. In OF. loses Us influence on the inngnct. Willi the Uuxes reacts like bemslile. Soluble in bydrocbloHc ncid.

Siff—Distinguisbed from otlier members of tbe spinel graiit>. as also from gurnet, bj ils being attrac led by thomnguet, as well nsbyita high apeciflc gravity; rraDkliuiteandcbromitc are only feebly maKnetic (if at all), and luive a brown or blackish-brown streak; nl^^o, n-bcn massive, by its black streak from hematite and liinonite; much harder than letrHbethiu-.

Obi.—Maguetire is mostly confined Lo oryslalUne rocks, and Is most abuudsnt In metamorpblc rocks, though widely distributed also In strains in eruptive rocks. In the Arcliieiia rocks the beds are of immense-extent, and occur under the same conditions iis I hose of hemalite. It Ik an ingredient in most of the mnssive variety of coniudiini called emcr^. The earthy magnetite Is found In bogs like bog-iron ore. Occurs In meteorites, and forms the crust of meteoric Irons.

Present In deudrlte-like forms in the mica of mnny localities followiug the direction of the liuL's of the percusslon-tlgure, and perhaps of secondary origin. A common alteration-product of minerals containing Iron protoxide, e.g., present'ln veins in tbe BGr|>fDtlne resulting from sitered chrysolite.

Tbe beds of ore st Arendsl, Norway, and nearly all the celebrated Iron mines of Sweden, consist of maasive magnetite, ns nt DancemoraandlbeTabergin Smiland. Ftilun, In Sweden, and Corsica, sSord octahedral crystnls, embedded In chlgrlle sinte. Splendid dodecabednl crystals occur at Nordmark In Wcrmland. The most powerful native magnets are fnund In Siberia, and In the Harz; they are also obtained on the island of Elba. Other localities for tbe crystallized mlneml are Traversella in Piedmont; Achma-tnvsk in the Ural; Bcalotta. near Prednzzo, in Tyrol, also Rothenkopf and Wildkreuzjoch; theBlnnentbal, Switzerland.

In N. America, it constitutes vast beda In the Archsan, In the Adirondack region, Warren, Essex, and Clinton Cos., In Northern N. Tork, vriilis In Bt. Lawrence Co. the iron ore is mainly bematite; One crvslals and mavises showini; broad partini; surfaces nnd yielding largo pseudn-crvstala are obtained at Port Heniy, Essex Co.; similarly in New Jersey; iti CiLQada, In Hull. Grenville. Madoc, etc.; at Oimwall In Pennsylvania, and Magnet Covo, Arkansas. It occnrs also In N. York, in Saratoga, Herkimer, Ornnfre. and Putnam Cos.; at tbe Tilly Foster iron mine, Brewster, Putnam Co., In rrystnls and mssRive accompanied by chondrodite. etc. In N. Jmef/. nt Hamburg, near Fninklln Furnace nnd else-nbere. la Penn., st Qoshen. Chester Co.. and at the French Creek mines; dellnentinns forming hexagonal flgures In mica atPennshury. Good lodeslones are obtained nl Magnet Cove, Arkansas. In Galifomui, in Sierra Co . abundant, massive, and in crystals; in Plumas Co.; and elsewhere. In Washington, in larpre deposits

Named from the loc. Mitgiu»ia, bordering on Macediinia. But Pliny favors Nicnnder's derivation from Hagnei, who flist discovered It, as the fable runs, by finding, on taking his herds to pasture, uat the nails of his shoes and the iron ferrule of his staff adhered to the ground.

FRANXUNCTB.

Isometric. Habit octahedral; edG;e8 often rounded, and crystals passing into rounded grains. Massive, graonuir, coarse or fine to compact.

Pseu do-cleavage, or parting, octahedral, as in magnetite. Fractnre con-choidal to uneven. Brittle. H. = 55-6-5. G. = 5-07-5'22. Luster metallic, sometimes dull. Color iroD-black. Streak reddish brown or black. Opaque. Slightly m^netic.

Comp.—(Fe,Zn,Mii)O.(FeJHn),o„ but varying rather widely in the relative quantities of the different metals present, while conforming to the general formula of the spinel group.

Pyr., «to.—B.B. iufuslble. With borax io O.F. glvea ft reddfsh tunethyBtlne bead (manganese), and in R.F. this becomes bottle-greaii (Iron). With soda gives a bluish-green mftugnnate, and on charcoal a faini coating oi ziuc oxide, which Is much more marked nlieo a mixture with boru and soda is used. Soluble in hydrochloric acid, Bometlnws with evoluLion'of a small urnount of chlorlae.

DIA—Resembles magnetite, but Is only slightly atlracted by the msgoet, aud has a dark browD iireak; It aim reacts for zinc on charcoal B.B.

Oba.—Occurs in cubic crystals near Eibach In Nanau: io amorphous masses at AJten-berg, nwr Aii-la-Chtipelle. Abundant at Mine Hill, FraakllD Furnace, N. J., wllh wlllem-ite and liucito in grunular limestone; also at Sterling Hill, two miles distant, aModated with willeuilte.

HagnaaiofeTTlte. Marnoferrite. MgFeO,. In octahedrons. H. = 6-6'6. O. = 4968-4654. Luster, color, and streak as in magnelilo. Strongly mwaetlc. Formed about the - fumaroles of Vesuvius, and especially those of the eruption of 166C.

Jacobalto. (Hii.MgJO (Fe,Mn|,o,. Isometric; In distorted octahedrons. H. = S. Q. = (-75. Color deep black. Magnetic. From Jakobsberg, in Kordmark, Wermland, Sweden; also at L&ngban.

OHROMITB.

Isometric. In octahedrons. Commonly massive; fine granular to compact

Fracture uneven. Brittle. H. = 5-5. Q. = 432-4*57. Luster snbmetallic to metallic. Color between iron-black and brownish black, but sometimes yellowish red in very thin sections. Streak brown. Translucent to opaque. Sometimes feebly magnetic.

CoKp.—FeCr,o, or FeO,Or,o, = Chromium sesqnioxide 68-o, iron protoxide 320 =100.

The iron may be replaced by magnesium; also the chromium by aluminium and ferric iron. The varieties containing but little chromium (up to 10 p. e.) are hardly more than varieties of spinel and are claaeed under picotite, p. 338.

Pyr., etc.—B.B. in O.F. infusible: In R.F. slfehtly rounded on the edges, and becomes magnetic. Wtlh borax and salt of phosphorus gives beads which, while liot, show only a reaction for iron, but on coolinit become chrome-green: the green color Is heiehtened by fusion on charcoal with metallic tin. Not acted upon by acids, but decomposed by fusion with potassium or sodium bisulphate.

IWff.—Distinguished from magnetite by feebly magnetic properties, streak and by yielding the reaction for chromic acid with the blowpipe.

Oba.—Occnrs in serpentine, forming veins, or in embedded masses. It assiats In giving the variegatad cnlnr tn verde-antiiiue marble. Not uncommnn in meteoric Irons, sometimes in nodules as In the Cofthuila Iron. less often in crystals (Lodran).

Occurs In the Oulsen mountnlns. near Kranbat In Siyria: in crystals In the Islands of TTnstandFetlsr. inSbellnnd; in tin- province of Trondbjem in Norway: in the Department dn Var in Fmnee; in Sllesln nnd Boheiiifa; abundant tn Asia Minor: In the Eastern and Western Urals; In New Caledonia, affording ore for commerce.

At Bnltiraore. Md., In the Bare Hills. In veins or masses in serpentine; also in Mont-

Smerv Co-, ere. In Pennsylvania, Chester Co., near Unionville, abundant: at Wood'a Ine, near Texas, Lancaster Co., very abundant. Uaasive and in crystals at Hobokeo, N.

OHRTSOBBRTIi. Cfmopbtine. Orthorhombic. Axes d:h:i = 0*4701:1: 0-5800. e«». 670.

Twins: tw.pl./sfOSl), both contact-and penetration-twins; often repeated and forming paeudo-heiagonal crystalg with or without re-entrant angles (Fig. 357, p. 123). Crystals generally tabular || a. Face a striated vertically, in tvina a feather-like atriation (Fig. 670).

Cleavage: 1 (Oil) quite distinct; fiimperfect; n more so. Fracture uneven to conchoidal. Brittle. H. — 8'5, G. = 3'a-3'84. Luster vitreous. Color asparagus-green, grass-green, emerald-green, greenish white, and^ yellowish green; greenish brown; yellow; sometimes raspberry- or columbine-red by transmitted light. Streak uncolored. Transparent to translucent. Sometimes a bluish opalescence or chatoyancy, and asteriatcd. Pleochroic, vrbra-tions lb {=h) omnge-yellow, c (= d) erne raid-green, a (= d) columbine-red. Optically-I-. Ax. pi. |(J. Bi±«. y9 = 1-7484. 2E = 84° 43'.

Vat. 1. OnKnary.—Color pale green, being colored by Iron; Blsoyellnwand transpsrenl and Iheu tised u a gem.

3. Alexandrite.—Color erne raid-green, but columbine-red hy trauemtUed light; valued as

a gem. G. ^ 3-644, meaD of resiiltg. Supposed to be colored by chromiuin. Crystals often very large, nnd !u twins, like Fig. 857. either six-sided or sixrayed.

8. C'ai'i-eye.—Color greeuiah and esbibiiing a floe clialoynnt effect; from Ceylon. Comp.—Beryllium aluminate, BeA],o, or BeO.Al,o, = Alumina 802, glucina 19-8 ^ 100.

Pyr., etc.—B.B. alone unaltered; with soda, tbe surface 1b merely rendered dull- With borax or gaU of pboapltarus fuses with great difficulty. With cobalt solulion, the powdered minenil gives a bluish color. Not attacked by acids.

DIB. —Distinguished by Its extreme hardness, grea llity; also characterized by Its tabular crystallization. _..

Ob«,—In HInaa Oeraes, Brazil, and also io Ceylon. In rolled pebbles; at Hanchendorf In Mora via, i[i the Ural, 8G verste from Ekaterinburg, In mica slate with beryl and pbenaclte, tlie variety alexandrite; fn the Orenburg district, B. Ural, yellow; in the Hourne Uta., Ireland.

In the U. 8.. at Haddam, Ct.. in cranite traverilng gneiss, with tonrmallue. garnet, beryl; al Greenfield, near Saratoga, N, T.. with tourmaline, garart, and apatll«; Norway, He,, in granite with garnet; also al Stoneham, with flbrolfle, etc,

Ghrytdberyl is from j'pi^froi, golden, ff^fivXXoi, ierj/l. Cj/mophane, from Kvua, wave, and ipaivo), appear, nlliidt-s to n peculiar opalescence the crystals sometimes exhibit. , Al^anArile Is after Ihe Czar of Russia, Alexauder I.

HaDunamiite. HniO, or HnO.M,Oi. In tetrngonal octahedrons and twins (Fig, 876, p, 128); also graoular massive, parlieles strongly coherent. H. = IS-5'5. O. = 4*858. Luster anbmelalllc. Color brownish black. Streak chestnut-brown. Occurs near Ilmenau in Tburiugia; Ilefeld in the Ilarz; Fillpsiad, L&ngban, Nordmark, In Sweden.

. Uennfge Germ. PbiO, or 2PbO.PbO,. PuWeruleDt. u cryElalltne scAlea. Q. = 4'0. Color ylvid red, mixed with yellow; streak orauge-yellow. Occurs ul BleEalf lu tbe Ejfel; Badenweiler In Baden, etc.

Orednarit*. CuiHa,U, or 8Cu0.2M[i,Oi. FolliLted cryatalline. H. = 4'5. O. = 4-9-S'l. Luster metallic Color iron-bluck to Bteel-gi-ny. Slrenk block, biuwiilsli. From Fried riclia rode.

PsendobrooUta. ProbnblT Fei(T10,)i. TJBUally Id minute ortborbombic crystola, tsbuUr I It kod often prismaLfc | S. G. = 4-4-*-l«t. Color dark browu to black. Streak ocber-yullow. Fouod with Lyperstbene (szaboiie) Id cavitlee of the andeslte of AraDver Bvrg, TnusylTaDlu, aod eiaewliere: ou recent lava (1872) from Vesuvius; at Havredal, Biimle. Korway, embedded in kjerulflne (wagueritej altered to upatlie.

Tetragoaal. Axis i = o'9850. Commonly in octahedrons, nearly iBometrio in angle (pp' = 70° 7'). Also maBsive.

Cleavage: ^perfect. Fracture uneven to snbconchoidal. Brittle. H.= 6~ ^■5. G, = 4-75-4-82. LuBter HubmetaHic. Color dark brownialk black to steel-gray. Streak same.

Comp.—3Mii,0,.MnSiO, — Silica 10-0, mangauese protoxide 11'7, manganese sesquioxide 78 ii = 100,

P^T.. ate.—B.B. Infiialble. With borax aud salt of pbospborus fi\yei an amethyatiDe bead ill O F.. becoming colorlesa in R.P. With sodn gives a bluiBh-green bead. Dissolves in hydrucblorlc iicid evolving cblni'Inc, and leaviDg a residue of gelatinous or flocculeot silica ^Rg). Miirceliue gelallaizea with acids

Obs.—Occurs in veins traversing porphyry, at Oehrenstock, near Ilmenau; near Uefeld In tlie Harz; Si. Marcel in Piedmont; at Elba: at Botuedal. Upper Tellemark. Id Norway; nt the miinganeee mines of Jakobsberg, Sweden, also at lAagban, and at the SjO mlae, OrythytlaD.Orebro. iffirMftn«{beterocline} from fit. Marcel, PiedmoDt, Is Impure braunite.

Hxbyita. Essentially FeO.MnO, In Msck isometric crystals. H. = 6-6.5. O. = 4-M5. Occun with topaz in cavities In rhyolite; from Utah.

IV. Dioxides, RO,. Bntile droup. Tetragonal.

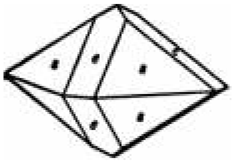
The RuTiLE Group includes the dioxides of the elements tin, manganese, titaninm, and lead, ' These compounds crystallize in the tetragonal system ^th closely similar angles and axial ratio; furthermore in habit and method of twinning there' is much similarity between the two beat known species inclnded here.

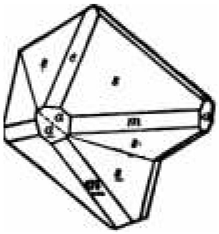
With the Rnlile Group Ih also Bomerlmes Included Zircon. ZrO.SiO,: h — O'e404. In this work, however. Zircon is classed among the silicates, with the allied species Thorite, ThC.SiOi. i = 0fi408.

A letragODsl form, approxlmntlng closely to that of tbe species of the Rutile Group, belongs also to a number of other species, as Sellaite, HgF,; TaploUte. Fe(Ta,Nb),Ot; Xenotlme, TPO,, etc.

It may be added that ZrOi, as tbe species Baddeleylte, ciystalUzes Jn tbe moDoclinio system.

OASSITBRITE. Tln-Btone. Tin Ore. ZlonaWii Germ. TetragoDal. Axis i = o'6723.





«*, 101 A Oil = 46° 38'. nu, 110 A 111 = 48' Sr.

«". 101 A 101 = er W. ff", 331 A 281 = 20' Mi'.

m", 111 A ill = 58* IV. B'l', 821 A 831 = 61' 42".

m". Ill A in = 87° r.

Twins common: tw. pi. e, both contact- and penetration-twins (Fig. fl73, also Fig. 373, p. 134); often repeated. Crjstale low pjramidal; also prismatic and acutely terminated. Often in reriform shapes, structure fibrous divergent; also maesive, granular or impalpable; in rolled grains.

Cleava^: a imperfect; s {ill) more so; »i hardly distinct. Fracture Bubconchoidal to uneven Brittle. U. = 6-7. G. = 6-8-71. Luster adamantine, and crystals usually splendent. Color brown or black; sotnetimea red, gray, white, or yellow. Streak white, grayish, brownish. Nearly transparent to opaque. Optically -j-. Indices: oOj = 19966, €j = 2*0934.

Tar.— Ordinary. Tin.alODe. In ciTBtals and massive.

Wood-lln (Holzztniierz Oerm.). In bolryoldal and renlform shapeB, coDcentrJc in slructure, and ladinled flbrouu iutemallj, altliougli very com pad, will) the color browuiili, of mixed shades, looking somenljal like dry wood in ila c<>lorB. ToaiTt-tj/e tin U llie same, on a smaller scale. Stream tin Is the ore In liie slute of sand, as It occurs along llie beds of streams or tn gmvel.

Comp.—Tin dioxide, SiiO, = Oxygen 21-4, tin 78-6 = 100. A little Ta,o, is sometimes present, also Fe,o,.

Pyr., etc.—B.B. alone nnalteicd. On cbarconl wllb sods reduced to metallic tin, and fdvea a wliitc costing. Witb the fluxes aomelimes gives reactfoos for fron and manganese. Only slightly acted upon by acids.

Dlff.—DisllniTulstied by Itn hiph specific fravily, bnrdnesa, infuaibllllv. and by its yielding metallic tin B B ; resembles some varieties of garnet, spbaltrrite, aod black tourmaline. Specific gravity (8'5) higher than thai of i-utile (4): wolframite is easily fusible.

Oba.—Occurs In veins tnvverstng granite, gneiss, mica schist, ehloi'lle or clay schist, and porphyry; also in finely rellculaled veins forming the ore deposits called slockworks, or simply impregnating the enclosing mck. The cotnmonly associated minerals tire quartz, wolframite, sclieellte; also mica, tnpa/. tourmaline, npalile, fiuorlte; further pyrlte, urseuo-pyrlte, sphalerite; molybdenite, nnllve bismnth, etc.

Formerly very abundant, now less sii. in Cornwall, in fine crystals, and nlso as wood-tin and stream-tin ; in Devonshire, near Tavistock nnri elsewherf; In pseudomoiphs after feldspar at Wheal Coates. near 8t. Apnea. Cornwall; in fine crystals, often twins, at Bcblackenwald, Graupen, Joachimsthal, Zinnwald, etc., in Bobemiu, and at E liven fried ers-dorf. Allenherg, etc., in Baiony; at Limoges lu splendid crystals; Sweden, at FInbo; Finland, at PitkOranta.

In the E. Indies, on the Malay peninsula nf Malncca and the neJi-Lboring islands. Banca. and Bilitnng near Borneo, Tn New South Wales abnndanl over an area of 8500 sq. n ilea. also In Vlclona. Qiiei-Tislnnd and Tasmania. In Bolivia; Hc:iico, in Durango; alio Guanajuato, Zacalecos, Jalisco.

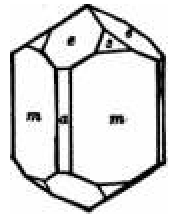
In the United States, lo Maine. spariDgljr at Paris, Hebron, etc. Id Matt., &t Cliesterfleld nud Gi)SbeD, rare. In N. Hamp,, at JucksoD. In Virginia, oa Irisli Creek, Rockbri(lt'<! Co.. with wolfremfte, etc. In Altibama. io Coosa Co. In 3. Dakota near Haroey Peak iiud near Custer Citj \a tbe Black Hills, where It has been mined. Id Wyoming, in Crook Co, Id Montana, Denr Dillon. In California, iu San Bernardiuo Co., at Temescui.

FoliauIt«, Uanganese dioxide, HnOi. In compotiile parallel groupings of minute ciyslais: also forming tbe outer sUei) of crystals liaving Ihe form of mnnganite. H, = (t-6'5. G. = 4'993. Luster metallic. Color ligbt steel-gray or iron-gray. Streak black. From Platten, Bohemia. It Is diatingulshed from pyrolu^te by its bardnesa and Ita aubydrous cLaracier. Like pyrolustle It is often a paeudomorpb after manganlie.

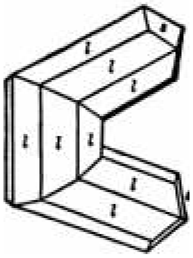
RUTILB.

Tetragonal. Axis 6 = 0*64415.

474. 675.



676.



U"K 810 A 310 = 86° 54'. ft*. Ill A ill = 66° 52;'.

•e". 101 A Oil = 45° 2". «". Ill A 111 = 84° 40'.

«", 101 A iOl = 65° Ui'. If. 818 A 188 = 20° 6'.

Twine: tw. pi. (I) e, often geniculated (Fig. 676); also contact-twins of very varied habit, sometimes sizlings and eigbtlings (Fig. 361, p. 122; Fig. 375, p. 124). (2) r(301) rare, contact-twins (Fig. 377, p. 125), Crystals commonly prismatic, Tertically striated or furrowed; often slender acicular. Occasionally compact, massive.

CleaTage: a and m distinct; e in traces. Fracture subconchoidal to uneven. Brittle. H. ^ 6-6'5. G. = 4-18^-25; also to 6-2. Luster me tall ic-ttdamantine. Color reddish brown, passing into red; sometimes yellowish, bluish, violet, black, rarely grass-green; by transmitted light deep red. Streak pale brown. Transparent to opaque. Optically +. Refractive indices high: CO, = 2-6158, e, = 2-9029 for Na. Birefringence very high. Sometimes abnormally biaxial.

Oomp., Tar.-^Titanium dioxide, TiO,= Oxygen 40-0, titanium 600= 100. A little iron is usually present, sometimes up to 10 p. c.

Var.—Ordinary. Brownish red and other shade*, not black. Q. = 4-18-(-35. Trans.

Birent tjuarlz (tagenite) is somellmes penetrated thickly with acicular or capillary crysliila. rirk smoky quartz peneiraied with the acicular rutile is the FlScbes d'amour Fr. (or Venus hair-stone). Acicular cryatala often implanted Id parallel position on tabular crystals of hematile: atao somewhat similarly on magnetite.

Ftrrif«rov». ia) Niffrint la black in coloi'. whence the name: ronlnins 2 to 3 p. c. Fr,Oi (S) limenor-ttlile is n bbick varltty frrim the Ilmeii Mis., cimlalnlng up Io 10 p. or more of Pe,0,. G = 5 07 - BIS

Pyx., ato.—B B. infuaible. With salt of phnspbonis pivea a colorless bead, which In R.F.

assumes a violet color on cooling Most variiHes coniain Iron, and give a browtiish-vellow or red bend in R.F.. Ihe violet only nppcarliip after Irenlmeiit of the liead with nielallic tin on cb&rcoal. lusoluble In aci^s; made soluble by fusion wllb an alkali or

alksllDe cnrbonate. The snlution coDtklniiig an excess of ecld, wlib tbe addilion of tio-foil,

givea ft beBUtlful violet color wUeu concentrated.

DiS.—ChBi'iicieriztd by its peculiar sub-adamantine lueter and brownisb>red color. DifCei's frum tourmaline, vesuvi&nile, auglte in beiug entirely unaltered when lieated alone B.B. Sp<.-cilic gravity about 4, of caesitetite 6 6.

Oba.—Rutile occurs In granite, gnelas, mica alate, aod ayenitic rocks, and sometimes in

Srmnular liraestone and dolomite; common, as a secondary product, in tbe form of microliies I many alal«s. It is generally found in embedded crystals, often in masses of qnarlz or feldspar, und frequently iu acicular crystals peuetniting quartz; also in pblogopite (wh. see), and has been olMerved In diamond. It haa also been met with in bematite and ilmenitu, rarely iu cbromite. It la commoD in grains or fragmeula in many auriferous sands.

Prominent localitiea are: Arendal and KragerO in Norway; Horrajliberg, Sweden, wiih lazuliteandcyanlte; Saualpe. Carlnthia: in the Urals; in Tyrol; at St. Oothard andBiiiuen-thai, Switzerland; at Trioiix, n^r LimogesJn France; atOblaplan In Transylvania, nigrina

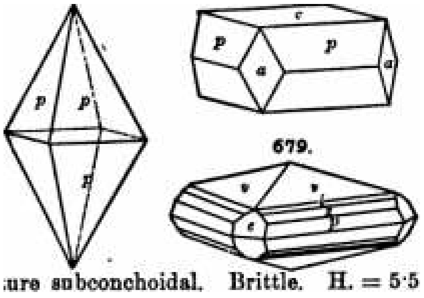
northern Vermont, acicular. some specimens of great beauty Intmnaparent quartz. In Mat»„ at Barre, in gneiss; at Bbelbume, in mica slate. IniV, Jin-A:, in Orange Co., Edenvilln; Warwick; E, of Amity. In Petvn., at Budsbury, Chester Co., and tbe adjoininir district In Lancaster Co.; at Parkaburg, Concord, West Bi-adford, and Newlin, Chester Co.; at the Poor House Quarry, Cbesler Co. IniV.Jsrwy, at Newton, with spinel. In S, Oar., at Cmwder's Hounta'n; at Stony Point, Alexander Co., in splendent crystals. In OMrgia, In Habersham Co.: in Lincoln Co., at Graves' Mountain, with lazulite In large and splendent crystnla. In Arieantat, at Harnet Gove, commonly in twins, with bruokite and perovskite, also as pammorpbe after orookjte.

Plattnaiite. Lead dioxide. PbOi. Rarely In prismatic crystals, usually m.issive. H. = .'3-5-5. G. =S'5. Luster siibmetHllIc. Color iron-black. Streak chestnut-brown. Fniin Leadbtlls and Wanlockhead, Scotland. Also at Uie " As Tou Like " mine, Uullaii, C(EUr d'Aleufl Mts., Idaho.

Baddflleylte. Zircon dioxide, ZrOi- In tabular moDOclinic crystals. H. = 6 6. O. = S'5--6'o.

Colorless to yellow, brown and black. From Geyloa; also Jacupiranga, Brazil (tyratUiit) where it la associated with wirkdiU, (Ca,I^}0.3(Zr,Tl,Th)O,.

OOTAEBDBini. Anatase. TetragonaL Asia i = 17771. «79. 618.



ture aubconchoidal. Brittle.

Commonly octahedral in habit, either acnte {p. 111), or obtuse {v, 117); also tabular, e predomi-Tiating; rarely prismatic crystals; freqaeutly highly modified.

m", 101 A on = 76° 5'.

et/\ 101 A lOl = lai* 18'.

j>^. Ill A 111 = 82° 9.

Pt*'. niAlil =136"86'.

•f", 118aI13= 84° r.

mf ii7Aii7= 2ri».

Cleavage: c and p perfect. Prac-" G, = 3 82-3 95; sometimes 411-

416 after heating. Luster adamantine or metallic-adamantine Color variotis shades of brown, passing into itidigo-blue, and black; greenish yellow by transmitted light. Streak uncolored. Transparent to nearly opaqne. Optically —. Birefringence rather high. Indices: oOj = 2'554, e, = 2*493. Sometimes abnormally biaxial.

Comp.—Titaninm dioxide, TiO, = Oxygen 40'0, titanium GO-O = 100.

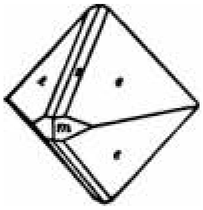
Pyr,, etc.—Same as for rutile.

Om.— Host abundaut at Bourg d'Olsnns, In DaupblnS, witli feldspar, asintle, and llmenlte; near Hof in the Fichteleeblrge: Norwsj; ihe TJnilB; Id clilorite Id Devonshire, near TnTlHtock; with brookite at Tremtdoc. in North Wales; in Cornwall, [lear Llskeard and &t Tlulagd Cliffs; iu Brazil lu quartz, auil in dolacbed crvitlU, lu Switzerlatid ia Ibe BiuiieDtbal iLh varielj vnatriTit, long supposed to be xcDOlluie; alsu Cavimdi, Tavetsch; Raurls, Salzburg, In tue Kasteru Alps; also at Pfitscb Juch.

Ill Ihe U. Stales, at the Dexter lime rock, Smltbfield, R. I.. Id dolomflei Is the waah-iDgs at Brludletowu, Burke Co., N. C, Id tratispareDt tabular ctjsutla.

Ortborbombic. Axes a:h:i = 0-8416 : 1: 0-9444. 680. 481.

^:J^



', 110 a 110 = 80° IV. 112 a iia = 08°48'. 112 A 118 = 44' 46'.

M*. 123 A 123 = 44° 23'. e«'". 182 A I32 = TS" ST. AM, 110 A 123 = 4S° 42'.

Fracture subconchoidal to un-Luster inetallic-adaniantine

Only in cryBtalB, of varied habit. Cleavage: m indistinct; c still more so. even. Brittle. H. = 5-5-C. G. = 3-87-4

to siibmetallic. Color hair-brown, vellowish, reddish, reddish brown, translucent; also brown to irou-blaCK, opaque. Streak uncolorcd to grayish or yellowish. Optical characters, see p. 225.

Comp.—Titauium dioxide, TiO, = Oxygen 40-0, titaDlnm 600 = 100.

Pyr.—Same as for riitlle.

Oba.—Occurs at Bnur;; d'Olsniis Id Dauphin^: at St. Gothnrd. with alblte and quaHz; Maderaoer Tlinl, Swlizerland: In the Ural, district of ZInlouel, near Allask, and In the gold-wanhmgs Id Ibe Bnnurka river and elHewbere; at Fronolen, near Trfmadoc, Wales.

In the U. S., lu thick black crvstnls (arkanrile) at Magnet <'ove, Ozark Uta., Arkansas, with elsollte, black gamei, sclmrlomlle. rutile, etc.; in iniali crystals from the guld-wssblngs of North Caroliua; at tlie Imid mine nt Ellenvllle, Ulster Cu., N. Y., on quartz, with clialcopyrite nud gnlena; at Paris, Haine, NaLned after the English mineralogist. H. J. Brooke {1T71-1867).

FTSOLITSmi.

Orthorhombio, but perhaps only psendomorphonB. Commonly columnar, often divergent; also granular massive, and frequently in reniform coats.

Soft, often soiling the fineers. H. = 2-2-5. G. = 4T3-4-86. Luster metallic. Color iron-black, dark steel-gray, sometimes blnish. Streak black or bluish black, sometimes Bubtnetallic. Opaque.

Comp.—Manganese dioxide. MnO,, like polianite (p. 345). Commonly contains a little water (9 p. c), it having had nsually a pseudomorphans origin (after manganite).

It is uncertain whetlier pyrolnslte Is an independent species, with a crystalline form of Its own. or nnlv a secondary lulnerftl derived chiefly from the debyiimtion of manganltei also from polianite (Brelth.). Pseudomorphoua crystals having distinctly the form of manganlle ai

.dbyGooglc

Fyr., etc.—Like poliaolte, but moBt varii-liea jfelil some WRter In tbe closed tube.

lUS. —Hardness lexs Ibvi timt oF psilouielaue. DiBers From Iron ores In its reactlou for miiDmiuese B.6. Easily dislinguialied from psilumelune by lis inferior hardness, and usuiiTly by bduj; cr^sCaltlue. lis streuk Is black; tbat cif matiguuite is more or less browu.

Obs,—This ore is exteusifely worked aX Elgersberg near IlineiiBU, Btid oiber places iu Thuilti)(lii: Ht VorderehreawDrr fu Muniviii; Ht Plallen in Bobemla, and elsewbere; near Jobanuguorgenstadt; at H rscbbcrg iu WrstpUiilia; Hatzkii, TrauBylvanlu; in Australia; iu

Occurs in the United Slnlea whb psilomelnne, abundantly in Vermont, at BraodoD, etc.; at Plainlield and West Stockbridge, Moss.; Augusta Cu., Vlrglula; Pope, Pulaski, Montgomery Cos.. Arkansas. Iu New Brunswick, 7 m. tv, Buthursl. Iu Soto Scotia, at Teny Cape; at Waliou, etc.

Tbe name Is from itvfi, firs, and Xoi^eiy, to oath, because used to discbarge tbe brown and green (PeO) lints of glass; and for the same reason It Is wbimsically entitled bj tbe French U tawn ae verrUr*.

B. Hydrous Oxides.

Among the hydrous oxides the Diaspoee Group is well characterized. Here befoug the hydrates of alnmiDiutn, iron and manganeBe. The general formula is properly written BO(OH). The three species here included are orthorhombic in crystallization with related angles and axial ratios; this relation is devialied from by manganite in the prismatic zone.

Another less prominent group is the Brucite Group, incliidiDg tha rhombohedral species Bracite, Mg(OH), and Pyrochroite, Mn(OH).

Oibbsite, Al(OH)„ and Sassolite, B(OH),, are also related, and further Hydrotalcite and Pyroaurite.

Dlaspore Group. RO(OH) or B,0,.H,0. Orthorhombic.

a Diaspora A1,0,.H,0 09372 :1 : 06039 or 0-6443

Gfithite Fe,0,.H,0 0-9185 :1 : 0-6068 or 0-6606

■anganite Mn,0,.H,0 0-6411 :1 : 0-5448 or 0-6463

DIASPORE.

Orthorhombic. Axes: &:l: 6 = 0-9373 : 1 : 0-6039. Crystals prismatic, mm''' = 86° 17'; naually thin, flattened j b; Hometimesacicnlar. Also foliated masaive and in thin scales; sometimes stalactitict.

Glearage: 6 eminent; k (210) le?s perfect, Fractnre conchoidal, very brittle. H. = 6-5-7. G, = 3-;i-3-5, Liinter brilliant; pearly on cleaTage-face, elsewhere vitreons. Color whitish, frrayiBli white, greenish gray, hair-browji, yellowish, to colorless. Pleochroic. Transpiirent to snbtranshicent. Optically +. Birefringence high. Ax, pi. || 5, Bx J. a. Dispersion p <v, feeble. 2H^,= 103'' 53'. /? 7= 1-722.

Comp.—A10{0H) or A1,0,.H,0 = Alumina 850, water 15-0 = 100. Pyr., Btc.^In tbe cloBCd lube uauntly decrepitates strfingly, separaMng Into white pearly scales, and nt a liieb tempcriLiiire yieldo waler Infusible; with cobalt solution gives a deep blue color. Not attacked by acids, but afler ignition soluble iu sulphuric

Diff—Dlstingulshrd by its bnrdness and pearly luster; nlfo IB.B.I by lis decTepilnlion and yieldltie water; by the reaction for alumina witii cobalt solution. Resembles some varieties of hornblende, but is harder.

Oba.—Commonly found with coniudum or emery. Occurs near Kossoibrod, in ihe Ural; at Bchemuiiz, Hungary; with corundum in dolomite at CampoloDgi>, TcsbId, in

Switzerland; Greioer !□ the ZUlertluI. Id the U. 8., vltb coruDdum aod niargarite at Newllu. C'tieBLcr Cu., Fa.; ul Ibe emeiT mlDes of CbeUer, Mass.; In cavitlei In masilve corunilum kI tlie CulsaicM niiue. Dear FruukllD, Hacon Co., N. Caroiiua; wjUi uluiiite forming ruck masses at Ht. KobinsoD, Boeita UUls, Colorado.

Named by HaQy from Siatmfipeiv, lo««it(«r,alludiug to tbe usual decrepitation before the blowpipe.

Orthorhombio. Axes i'.l:i = 0-9185 :1 : 0-&

In priams verticall; striated, and often flattened into scales or tables y i. Also fibrous; foliated or in scales; massive, reniform and stalactitic, with concentric and radiated structure.

Cleavage: b very perfect. Fracture uneven. Brittle. H. = 5-5-5. G. = \-0-i-^ Luster imperfect adamantine. Color jellowisb, reddish, and blackish brown. Often blood-red by transmitted light. Streak brownish yellow to ocher-yellow.

Tar.—In tbln scale-like or tabular crystals, usually attached by one edge. Also in adcular or capillary (not flexible) cryslala, or slender pnsmg, often railiately grouped; (he NeedU-Ir<m*tom. It passes luto a variety with a velvety surface: the Prt^nnmite {fktmnut-bleiidd) of Pribram la of this kind. Also columnar, fibrous, etc., aa above.

Comp—FeO(OH) or Fe,0,.H,0 = Oiygen 37-0, iron 62-9, water 101 = 100, or Iron aeaqnioxide 89"9, water lO'l = 100.

Pyr., eto.^In the closed tube gives off water and Is converted Inio red Iron sesqul-oxide. With the fluxes like hematite; most varieties give a manKsneae reactioD. and some, treated in the forceps in O.F., after moisteniug in nulphurlc acid. Import a bluish-green color to tlie flame tphosphnric acid). Soluble In liydrocblnric ncid.

Diff.—Distinguished from hematite by Its yellow atreak; from llmonlte by crystalline nature; It also contains less water than llmonlte.

Obs.—-Found with the other oxides of iron, especially hematite or llmontla. Occurs at Eiserfelil near Siegen, in Nassau: at Clifton, near Brlslol, England; la Cornwall. In ilie U. 8., at the Jackson Iron mine, Negaunee, L. Superior; In Conn., at Salisbury; [u Pepn., near Eulon; inothe Pike's Penk region, Colorado. Named G^iie (Qoelhlle) after the poet.phllosopher Goethe (1749-1882).

MANOAMTTB,

Orthorhombic, Axes /i:h:i = 0-8441 :1 : 0-5448.

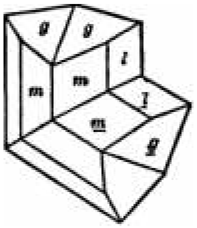
684. 086. hh"\ 410 A 4T0 = S8' SV.

mm'", 110 A 110 = 80° aO*.

ee', 305 A 205 = 28' 57. «', Oil A Oh = B7" IC. Plf, 111 A ill = 59' BJ'.

Crystals commonly prismatic, the faces deeply striated verticallyj often grouped m btindles. Twins; tw. pi. e (Oil). Also columnar; stalactitic.

Cleavage: b very perfect; m peril. = 4. G, = 4-2-4-4. Luster sub-metallic. Color dark steel-sray to iron-black. Streak reddish brown, some-



feet. Fractare uneven. Brittle.

times nearlyblack. Opaque; in minnte Bplioters aomedrnds brown by trane-mitted light.

Comp.—MnO(OH) or Mii,0,.H 0 = Oxygen 27-3, manganese 62'4, water 10-3 = 100, or Manganese Besqniozide 89-7, water 10-3 = 100.

Pyr.,, - - . . . _

Ob«.-places; sIbo !□ CumberlaDd. etc.

Degauuee; DbyjI's Head, Douglm . _ ... _ _ . . .. _ .

Bud WalUiu. In New Brunawlck, ai Btiepody mouataln, Albert Oo., etc

LIMONITU. Brown Hematite. Brauneisenateiu Q«rm.

Not cryBtallized. TJsaally in stalactitic and botryoidal or mammillary forms, having a fibrous or subfibrons atructure; alao concretionary, masBive;

and occasionally earthy.

H. = 5-55. G. = 3-6-40. Luster silky, often Eiubmetallic; Bometimes dull and earthy. Color of surface of fractnre various sbodeB of brown, commonly dark, and noue bright; eometinies with a nearly black Tarnish-like exterior; when earthy, brownish yellow, ocher-yellow. Streak yellowish browu. Opaque.

V>r.—(1) Gompaet. SiibmetHlllc to ailky in luBter; often stalactlilc, botryoEdal, etc. (Incl. braiiner Glaskopf Qerm). (3) OefurouM or earthy, browuisli yellow to ocher-yellow, often impure from the preaence of cluy, aaod, etc. (3) Bog ore. The ore from manhy plBcea, generally loose or porous In texture, often petrifying leaves, nood, nuts, etc. (4) Brown clay-iroTuUmt, in compact muasea, often in concretionary nodules.

Comp 2Fe,0,.3H,0 - Oxygen 25-7, iron 598, water 14 5 ^ 100, or Iron

Beaquioxide 85'5, water 14'5 = 100. In the bog ores and ochers, sand, clay, phosphates, oxides of manganese, and humic or other acids of organic origin are very common impurities.

Pyr., etc.—LUte cOihlie. Some varieties leave a alliceous skeleton In the salt of phospboruq bead, and a siliceous residue wben dissolved in acids.

Diff.—Disllnguisbed from hematite by Its yellowiab streak, Inferior liiiTdness, and its reaction for water. Does not decrepitate B.B., likK lurgite. Not crystallized like g&thlte and yields more water. , , ...

ObB —In all coses a result of the nlleration of oilier ores, or minerals conlBlning iron, throngh exposure to moisliire. air. nnd cnrbonicor organic acids; derived largely from the change of pyrite. magnetite, stderlle, ferriferous dolomite, etc.; also varioils species (as mica, pyroxene, hnmblende. etc.). which contain iron in the ferrous slnle (PeO.>. It cousequently occupies, as a hog ore, mnrsliy places, into vtlilch il has been home l)y streamlets from the hills aroiuid. It is often associated Willi manganese ores. Liint>iiile is a common ore In Bavaria. Ihe HnrK, Liixembourp. Bcotliind, Bweden, etc.

Abundant in the United States Eitensive beds exist nt Salisbury and Kent, Conn., also In the neigbboHng towns of New York, nnd lu a similar situation in Berkshire Co., Mass., and In Vermont; in Pennsylvania widely distributed; also in Tennessee. Alabama, Ohio, etc.

Named LimoniU from XeifK^v. mendoT.

TrRoiTB. HydrohematitP. Fe.H.O, or 2Fe,O,.H,0. Resembles limonite but has a red streak. G. =414-48. Decrepitates BB. Prom the Turginsk mine In the Ural, etc.; also from Salisbury, Conn. Intermediate between hematite and limonite.

XnthoBlderite. Gel bei sen stein. Fe,0i.2H,0. In fine needles or fibers, stellate and concentric; alao as an ocher. Color golden yellowish, brown to brownish red. AsBOCisled with manganese ores at Umenau, etc.

BADXmi. Beauxite.

In ronnd concretionary disseminated grains. Also massive, oSlitic; and earthy, clay-like. G. = 3-55. Color whitish, grayish, to ocher-yellow, brown, and red.

Ymr.—l. In coDcrelloDarrffTalng, oroOlitic; bauxiu. 1 Cl&y-llke, tRKJUnOt.* thepurar kindgrayJsh.clay-llke.canlalDingrerj little Iron oxide; klaoredfmui the [tod oxide present.

Comp.—EgaeBtiallj A1,0,.2H 0 = Alnmina 73-9, water 361 = 100; some analyses, howeyer, give A1,0,.H,0 like diaapore.

Iron (esqutoxide ie ueually present, sometlines in large amount, in part leplaciug alumina, iu pan only an Impurity. Silica, pbospboric acid, caibonic acid, lime, magnesia are common Impurities.

Oba.—From Baui (or Beaux), near Aries, and elsewhere In France, disseminated Iu gratia Id compact limestone, and also oOUtlc. WoehMiiitt occurs In Carciola, between Felstrilz and Luke Wocbelu. The purest bauxite 1b uaed for the manufacture of alumlu-ium (aluminum), and is called aluminium ore. In the U. S., bauxite occurs in Saline and Pulaski Cos., Arkansas; also Id Cherokee and Calhoun Cos., Alabatua, and in Floyd, Barton aad Walker Cos., Georgia.

Brucite Oroup. B(OH),. RhombohedraL BRUOTTB.

Rhombohedral. Axis 6 = 15208; cr = 60° 20^', rr' = 97° 37J'.

Crystals aaaally brood tabalar. Also commonly foliated massive; fibrous, fibers separable and elastic.

H. = as. G, — 2'38-2'4, Cleavage: c eminent. Folia separable and flexible, nearly as in gypsum. Sectile. Luster | c pearly, elsevtaere waxy to vitreous. Color white, luclining to gray, blue, or green. Transparent to translucent. Optically+. Indices: a), = l'059, e,= 15795.

Comp., yar.—Magnesium hydrate, Mg{OH), or MgO.H.O = Magnesia 69-0, water 31'0 = 100. Iron and manganese protoxide are sometimes present.

Var.^OnKnory, occurring in plales, white to pale greenish in color; slrong pearly luster on the cleavage surface. NemaUte is a Hbrous variety contalnliig 4 to 5 p. c. iron protoxide, with O. = S'44 Nattall. Manganbrvcite contains mauganese; occurs granular; color honey-yellow to brownish red.

Pyr., etc.—In Ihrf closed tube gives off water, hecoming opaque and friable, sometimes turning gray to brown: the mangaueaian variety becotnes dark brown. B.B. infusible, glows wub a bright light, and the Igniteil mineral reacts alkaline to test-paper. With cobnlt solution gives the pale pink color of magnesia. The pure mineral is soluble in acids without enervesceuce.

Ditt—Distinguished by its infusibllity, Boflneas, cleavage, and foliated structure. la harder than talc und differ? In its solubility In acids; the magnesia test and optical cbaraclers separate it from gypsum, which U also somewhat softer,

Oba. —Accompanies other raagneslan minerals In serpentine, also found In limestone. At Swinauess in Unat, Shetliind Isles; at the iron mine of Cogne, Ansta, Italy: nearFilipsiadt in Sweden. At Holioken. N. J , in serpentiue; at the TlRv Foster iron mine. Brewster, N, T., well crystallized; Richmond Co.. N. Y.; at Wood's mine, Texas, Pa., in large pbites or masses, and often crystallizations several Inches across: at Low's mine with hydromagn68ite. IftTnalite. the fibrous variety, occurs al Hobokeo. and at Xetles In the Vosges, Mnjiganbrucile occurs with liausmannite nnd other manganese minerals in the gmiiular IfmeBlooe of Jakolwberg. Nordmark, Sweden.

Named after the early American mineraloRiBt, A. Bruce (1777-1B18). Pyrochroit.. Manganese hydrate. Mn(OH),. Usually foliated, like brucite. Luster pearly. Color white, but growing dark on exposure. Occurs in magnetite at Pajsberg, Swedeti; also at Nordmark; aud at Franklin Furnace N J

aiBBSTFE. Hydrarglllfte.

Monoclinic. Axes a : i : . = 1-7089 : 1 : 1-9184; /? = 85° 29', Crystals tabular Q c, hexagonal in aspect. Occasionally in spheroidal concretions. Also stalactitio, or small mammillary, incmsting, with smooth surface, and often a faiut fibrous structure within.

Cleavage: o eminent. Tough. H. = 2-5-3-5. G. = 2-3-2-4. Color white,

grayish, greenish, or reddish white. Luster of c pearly; of other faces TitreoiiB; of surface of Bt&lactites faint, 'fransluoeat; sometimes trausparent in crystals. A strong argillaceous odor when breathed on.

Comp.—Aluminium hydrate, Al(OH), or A1,0,.3H,0 = Alumina 65-4, water 34 6 = 100.

Pyr.. eto.—In tbe closed tube becomes white Mid opftqoe, and jielda water. B.B. tofua-ible, wbiUiiB, and doea not import a green color to the flame. With coball solution gives a deep blue color. Soluble In cuDcentraled sulphuric ucld.

Obfl.—The crystallized gibbsite (hTdrargilllte) occurs Id the Bhiahlmsk mouutaius near Zlatoust in the Ural; also in crystals tilling cavltlea In nstrolite In the Langesundflord. Norway: OuroPreto, Mlrnta Oeraes, Brazil, la the U. S., In stalactitic form at Richmond, HasB.,lna bed of limonile; at the Clove Mine, Uuioa Vale, DutcheaaCo., N. Y., on llmonite; in Orange Co., N. Y.

Named after Col. George Qibba.

SaisoUt*. Boric acid, B(OH)i. Crystala tabular | c (triclluic). UBually small white, pearly scalea. O. = 1 '48. From the walera of the Tuscan lagoons of Hnuie Rotondo uid CastelLiuoTO. ExistB also in other natural waters, as at Clear Lake, in Lake Co., Califomta. Occurs also abundantly iu the crater of Vulcauo, LIparl Isles.

HydTotaloita. Perhaps Al(OH]..8Hg(OH),.8H,0. Lamellar-massive, orfollateil, somewhat tlbrous. H. =3- d. =3M-2'0B. Color white. Luster pearly. Occurs nt the mines of

Shlshimsk, dlBtrlct oi Zlstouat, Ural; at Snarum, Norway, iu serpentine {hydrataleite).

Pyroaurite. Perhaps li'e(OH),.3Mg(OH),.8H,0. Occurs at the Langbau iron-mine, Wermland, Sweden, in gold-like submctallic scales (;wroaur>fa). In tliiu seams of a silvery white color in serpentine In the island Haaf-Gruuay, Scotland (igelttromitt).

Ohaloophanlte. Hydrofranklinite. (Mn,Zu|0.3MD0,.2H,0. In druses of minute tabular rhombohedral crystals; sometimes octahedral In aspect. Also in follnted aggregates; BtalacUtIc and plumose. G. = 8-B07. Luster metallic, brilliant. Color bluish binck to iroQ-black. Streak chocolate-brown, dull. Occurs at Sterling Hill, uenr Ogdensburg, Sussex Co,. N. J.

pbhamblanb.

Massive and botryoidal; renitorm; etalactitio. H. =p~6. Q. = 3-7-4-7. Luster submetallic, dull. Streak brownish black, shining. Color iron-black, passing into dark steel-gray. Opaque.

Comp.—A bydroDs manganese man^nate in which part of the manganese is often replaced by barium or potaaeium, perhaps conforming to H,MnO,. Tbe material is generally very impure, and tbe composition hence doubtful,

Pyr., ato.—In the dosed tube roost varieties yield water, and all lose oxygen on Iznilion; with the fluxes reacts for manganese. Soluble in hydrochloric acid, with evolution of chlorine.

Oba.—A common but impure ore of manganese; frequently In alternating layers with pyrulusite. From Devonshire and Cornwall; Ilefeld in the Harz; also at Ilmennu, Siegen, etc. Forms mammillarv masses at Brandon, etc., Vt. In Independence Co., and elsewhere in Arkansas. With pyrolusile at Douglas, Hants Co.. Nova Bcolla. Named from ipiXSi. tmooih or naied, and fi^kas, blaek.

The following mineral aubstanceH here included are mixtures of varioua oxides, chiefly of manganese (Mnd. also HnO). cobalt, copper, with also iron, and from 10 to 30 p. c, water. These are results of tbe decomposition of other ores—partly of oxides andaul-phides, partly of mnnganeslan carbonates, and can hardly be regaraed as represenling distinct mineral species.

Wad. In amorphous and renifdrm masses, either earthy or compact; also tncrusting or as stains. Usually very soft, sniltnc the flueera; leas often hard to H. = S. O. s= 8'0-4-26: often loosely aggregated, and feeling very light to the hand. Color dull black, bluish or brownlsii black. ,

Boo Manqaitksk consists mainly of oxide of manganese and water, with some oxide of Iron, and often silica, alumina, baryta

AsBOUTB, or Earthy Cobalt, contains oxide of cobalt, which sometimes amounis to

"IS,

I. or Oapremt* Manganett, Is a wad Ciontalnlng 4 to 18 p. c. of oxide of copper, and often oxide of cobalt also.

VI. Oxyjreu-salts.

The Sixth Class inclndeB the salts of the various ozjgen acids. These fall into the foUowiDg seven sections: 1. Carbonates; 2, Silicates and Titanates; 3. Niobstee and Tantalatea; 4. Phosphates, Arsenates, etc.; also the Nitratesj 5. Borates and Urauates; 6. Sulphates, Ghromates and Tellnrates; 7. Tung-states and Molybdates.

1. OASBOHATES. A. Anhydrous Carbonates. The ADhydrons Carhonates include two distinct isomorphoua groups, the CA.LCITE Qkoup and the Aragonite Oboup. The metallic elements present in the former are calcium, magnesium, iron, manganese, zinc and cobalt; in the latter, they are calcium, barium, strontium and lead. The species included are as follows:

Monganocalcite pt. (MD,Ca)CO, Smithsonlte ZnCO, 72° 20' 0-8063

Monheiraite {ZE,Fe)CO,

Spberocobaltite CoCO,

This list gives DOt only the promineat Bpecles of thla group, but also some of the isomornhous fntermedlate compounds.

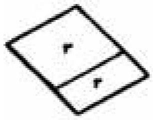
The Calcite Gboitp ie characterized by rhombohedral crystallization. All the species show, when distinctlr crystallized, perfect rhombohedral cleavage, the angle varying from 75° (and 105°) in calcite to 73° (and 107°) in siderite. This is exhibited in the table above.

The species oi the Aragon:te Group crvstallize in the orthorhombtc avHU-m, but the relation to those of the Calcite Group is made more close by the fact that the prismatic angle varies a few degrees only from 60° (and 120^) and the twinned forms with the fundamental prism as twinning-plane are pseudo-hexagonal in character.

1. Calcite Oroap. BCO,. Bhombohedral. OALOITB. Ealkspftth Oerm. Calc Bpar; Calcsreotu Bpor. Rhombohedrah Axis i — 0-8543.

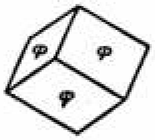
<8«. 6BB. CM).

686.

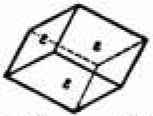


688.

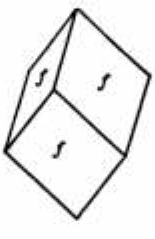
689.



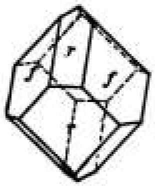
687.



690.



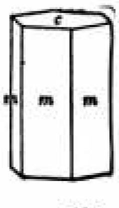
691.



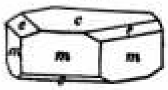
692.

693.

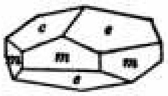
694.



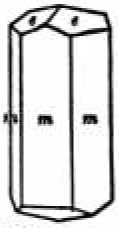
695.



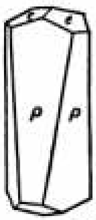
696.



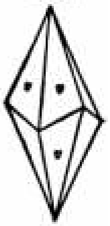
697.



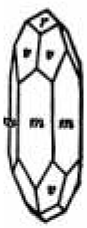
698.



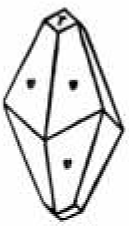
699.



700.

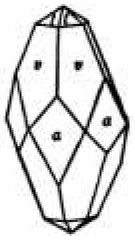


701.

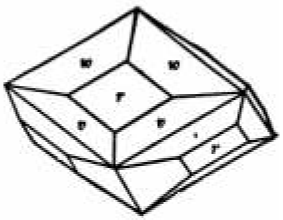


702.

703.



704.



• See the aphericnl projfcilon, Pig. 252, p. 70.

Habit of crystals Tery varied, as shown in the figures, from obtuse to acato Thombohedral; from thin tabular to long prismatic; and scalctiobedral of many types, often highly modified.

Twins (see Figs. 383-390, p. 126): (1) Tw. pi. c, common, the crystals having the same vertical axis, (2) Tw. pi. e (0Ll2), very common, the vertical axes inclined 137" 29i' and 52° 30^'; often producing 706.

twinning lumellie as in Iceland Spar, vbicb are, in many cases of secondary origin as in granular limestones (Fig. 705); this twinning may be produced artificially (see p. 148). (3) Tw. pi. r, not common; the vertical axes inclined 90° 46' and 89° 14'. (4) Tw. pi. / (03Sl), rare; the axes intersect at angles of bZ" 46' and 126" 14'.

Also fibrons, both coarse and fine; sometimes lamellar; often granular; from coarse to impalpable, and compact to earthy. Also stalactitic, tuberose, nodular, and other imitative forms. •

Cleavage: r highly perfect. Farting \ e (0ll2) doe to twinning. Fracture concboidaf, obtained with difficulty. H. = 3, but varying with the direction on the cleavage face; earthy kind^s softer. G. = 2'714, lu pure crystals, but varying somewhat widely in impure forms, as in those containing iron, manganese, etc. Lnster vitreous to aubvitrooue to earthy. Color white or colorless; also various pale shades of gray, red, green, blue, violet, yellow; also brown and black when impure. Streak white or grayish. Transparent to opaque.

Optically—. Birefringence very high. Befractive indices for the D line: a = 1-65849, c =

148625.

Comp. —Calcium carbonate, CaCO, = Carbon dioxide 44*0, lime 56 0 = 100. Small quantities of magnesium, iron, manganese, zinc, and lead may be present replacing the calcium.

V«r.—The vsriBtlwi are very numerous, and divene in appearance. They depend mainly on the following points: diflereoce* In cryttallizatloo and structural coDditiou, presence of Impurlliea, etc.. tbe extreme* being perlcct cryititlB and earthy niasalve forms; also on compofilttoii as affected by isomorphous replacement.

A. Vahibtibb based chieflt upon CnTSTALLiEATioK ARD Accidental litPDRiTtBS.

1. Ordinary. In cryatalR and cleavable msHes. tlie cryslnls varying very widely In habit as already noted. Dog-loolA Spar le nn scute BCaleiiobedml rorm; Nail-head Spar, acorn.

Kslte vftriely linving the form Buggtsted by ihe name. The traiiapareot variety from "land, used for polarizing priinu, etc.. Is cxlli'd Iceland 8p ir or DouMy-rtfraetinf Spar (I>opl)eUpnth Oerin.). Aa regftrdiaotor, cryslalllied ciilclle varies from tlie kinds which are perfectly clear and colorless through yellow, pink, purple, blue, to brown and black. Tbe color is UBUftUy pale except as caused by Impurllles. Tlisse Impurities mti? Ite pyrite, native cupper, mnlnchfte, sand, etc.: they are somclitncs nrmnged In symmetrical form, as depending upon the growth of the crysrals and hence prndure many varieties.

FonlaintbUnti iimentont. from Pontainebleau nnd Nemonrs, France, contains a large amount of sand, some 60 to 68 p. c. Similnr forma occur at other localities,

3. Filrrou* and lamtiinr kind*. Satin Spar Is flue fibrous, wilb a, silky luster; resembles fibrous p-ypsum, also called satin S|)ar, but \f much harder than gypsum and effervesces with acids.

Argenliiie is n pearly lamBllar celcile. the lamellte more or lees undulntitig; color white,

?rav<sli, yellonish AjibriU, in Its harder and more sparry variety {SeAaunupalA). is a nllnled white pearly calclte. near argentine; lu Ito softer kinds {Schavmerde) it iipptoncbe^ chalk, tboMKh li^iiter, pearly in luster, silvery white or j-ellowish in color, soft and greasy to the touch, sud more or lesa scaly in elnicture.

S. Oranular mattiTt to eryptaeri/tfalliTU kindt: Limalone, Marblt, Chalk.

Orajiatar limeiUiite or Saeeharoidal UmMtoae, wo named becnuw like loaf lugar in fracture, VBryiug rrom coarse to very fine grsDulu, and Leace to eompaet limeaLDne; colon »re varioiiB, as white, yellow, reddiBh, green; usually tbey are clouUeii and give a handsome effect wbeu tbe materinl is poltabed. When hucIi limestones are tit for pollifalng, or for ucuitectural or ornamental use, they are culled marbUi. Many TarieOes have special names. Sfidi-marblt codbUU largely of fossil sliells; LumachtlU or Jire-mattU is a dnrk brown shell-marble, with brilliant nre-Uke or cHatoyant InLerual reHecIions. RMn-marble is a kind of a yellovr to browu color, showing, when polished, figures bearing some resemblance to forllScnClonB, temples, etc.. in ruins, due to infiltration of iron oxide, etc.

Liihograp/iic ttona Is a very eyeu-gtaiued compact limestoDe. of buff ar diab color; as that of Solcnhofen. Hydraulio titnetUtru is an impilre limestone trhicb after igpitiou sets. I.e., takes a solid form under water, due to the forroation of a silicate. The French varieties contain 3 or 8p. c. of magnesln, and 10 to 20 of silica sDil alumina (or clay). Tbe varieties in the United States coutaiu SO to 40 p. c. of uiuKuesia, and 13 to 80 p. c. of silic& and alumina. Htird eomvaet timetUme viiries from nearly pure while, through gi-ayisb, drab, buS, yellowish, and reddish shades, to bluish gray, dark brownl^ gray, and black, and sometimes Tarlously veined. Many kinds make beautiful marble when polished. Red oxide or iron produces red of difCerent shades. Shades of green are due to iron protoxide, chromium oxide, iron silicate. •

Chalk is white, grayish white, or yello^TlBh, and soft enough to leave a trace on a board. Oalcartaat mart is a soft earthy deposit, with or wilhout distinct fngments of ibells; it generally contains much clay, and graduates into a calcareous clay.

OoUU is a granular limestone. Its gnilns minute coucretlons. looking somewhat like the roe of fiah. the name cotniag from uJf. tgg. Pitolile (Erbseusteiu) consists of conci-etlon* as large often as a small pea, or larger, having usually a distinct concentric structure.

DepotiiMl from eaieaT«ou» »pring», t1r«am», or in eavfm». etc. (a) Stalaetilet are calcareous cylinders or cones that hang from the roofs of limestone caverns, and which an formed from the waters tbit drip through tbe roof: these walers hold some calcium bicarbomite in solution, and leave calcium carbnnate to form the stalactite when evaporation takes place. Stalactites vary from transparent to nearly opaque; from a crystalline structure with single cleavage directions to coarse or fine granulnr cleavable and to radlnling fibrous: from a white color and colorless to yellowish gray and brown. {b)SialaffmiU is the same material covering tlie floors of caverns. It being made from the waters that drop from the roofs, or from sources over the bottom or sides; cones of it sometimes rise frum the floor to meet the stalactites above. It conalBtB of layers, irregularly curved, or bent. Stalagmite, or a solid kind of travertine (see below) when on a large scale, is tbe alabaster stone of ancient wrliers, that Is, the stniie of which ointment vases, of a certain form called alabiitltri, were made. A. locality near Ttiebes. now well known, was largely explored by tbe ancients, and the material has often been hence called ^yptinn alabatter. It was also formerly called onyx atid onj/dtita because of its beautiful banded structure. In the arts ft is often now culled Oriental atabiuter or onyx mariU. Very beautiful marble of this kind is obtained in Algeria, JfcMain onyx is a similar mateiial obtained from Tecalt, Pui-bla, Uexico; also in a beautiful brecciated form from the extinct crater of Zempoaltepec In ■outbem Mexico. Similnr kinds ocRur In Missouri, Arizona, San Luis Obispo Co., California, (e) Cate-iinUr, Travertine. Caie '/-ufa. Travertine is of essentially the same origin with stalagmite, but is distinctively il deposit from springs or rivers, e^wcially where in large deposits, as along tlie liver Auio. at Tivoll. near Home, where the deposit u scores of feet in Iblckness. (d) Agaric mintrai; Rock-milk is a very soft white material, breaking easily in the Angers, deposited sometimes In caverns, or abotit sources holding lime in solution, (a' J»ck-mMl is white and light, like cotton, becoming a powder oa the allghtest pressure.

B. Variktibb based KPon Coupobition.

These Include; Dolomitie ealSle. Contains magnesium carbonate, thus gradtutting toward tnie dolomite. Also baricalcite (which contains some BaCOi); similarly, ttrontiano-eaUiU (SrCO,), ferroeaUiU (FoGO,), mavgaTiocaiHte (MuCOi), xincocaleitt (ZnCO,). phiv^ioeaUiU (PbCO,).

Pyr., etc.—B.B infusible, but becomes caustic, glows, and colors the flame reddish yellow; after ignit'Ou the assay renctn alkiiline; moistened with bydrocliJoric acid Imparts tbe characteristic lime color to llie flfime. In the solid mass effervesces when moistened with hydrochloric acid, and fragments dissolve with brisk effervescence even in cold nctd.

.dbyGooglc

DidL—DisIiDguItbfng cbaracters: perfect rbombohedrsl clesvage; aoftness, cbd be ecratcbed witb a knifei efterTesceuce !□ cold iKlute acid; In fusibility. Less liard and of towel specific grnvily ihau anigotiite (wli. we) Kesenbles in its Oiffercut Tsrielies tbe oilier rfiomboliedral carboimtes, but is less bard, of lowur sjKiClfic gravity, aud more readily iLlIacked by acid. Also resembles some Turiellts o(btirite, but haB lower specific gravity; it is less Imrd tbnu fi-ldspar aud barder tbao Eypauni.

Keco^nlzed <u liiin sectioos by lis low Tefracliou iind very h\gb blrefrlugence, tlie polMriEivtioQ colors in tbe tbiDnest sectionsutlaioiug wbile of Ibe bigheai oider. Tbe negative iiiterfereoce figure, with mnuy closely crowded culored riuga. la also clmructerieiic. Tbe rhombobedral cleavage is ofteu sLuwd Id lite Que fracture Hues; aysteme of twiuued larueltK ofieu conspicuous (Fig. 70S), espt'cially lii crysutlline liineaioue.

Oba.— Calcile, in its viirloiu forms, is one of the most widely distribuled of oiiuerals. Beds of sedimeutary Itmestiiue. fcnmed from organic remHlos, shells. criLiohls, corals, etc., yield on metamorphlsm crysialliae limealoae or miuble, imd iu coiiuecliou wlib Ibese crystallized calcite and also deposits in caves of staluclíles and statagmilea often occur. Common with the zeolilea lA ciivilies and veins of Igutoiis rocks as ii result of alteratiou. and similarly tbough less abundant witb granite, syeulle. etc. A frequent mineral in metalliferous depoafls. wllb lead, copper, silver, etc. Deposited from lime-bearing waters aa calc sinter, travertiue, etc., especially in connctioD wiih but springs as at ibe Mammoth Hot Springs iu the TellowsCone region.

Some of the best known localities for crystallized calcite are the following; Andreaa-bergiu the Uarz: tlie mines of Freiberg, Schiieeberg. etc., in Baxouy; Kapuikin Hungary: Anssig in Bohemia: Blelberg in Cariiitliin; Traverselln In Piedmont; Elba. In England at Alalon Moor aud E-remonl In Cumberland; Matlock. Derbyshiie; Beer Alatoa Id Devonshire; at numerous points in Cornwall;. Weardale in Diirbum; Stank mine, Lancashire, In twin crystals of great variety anil beauty at Guanajuato, Mexico. Tbe leelartd tpar baa been obtained from Iceland near Helgustailir on tbe Eakeflord. It occurs in a large c»viiy in basalt. Tbe crystals, usually sbowiug tlie fundamental rbombohedroo, are often couled Willi tufta ot alitbite.

In tbe U. Stales, crysialliztd calcite occurs in N. Tor/c. in St. Ijiwrence Co., especially at tbe Rossie leiid mine; in JeSerson Co., near Oxbow: dog-looChgptir, in Nlagai-a Co, near Lockpori,wiih pearl spiir, celestite, etc: In Lewis Co.. at Leyden and Lowvllie. and at the Hartinsbiirg lead mine; nt Anthony's Nose on tbe Hudson, formerly groups of large tabubir crysiala. In N. Jeriey. at Bergen, yellow calcite with daloliie. '■Ic. In yirginia, at Wler's cave, ttalaetitft of great beauty: also in the large caves of Keniuek;/. At the lake Superior copper mines, complex crystals oflen conifiining scalers of native copper. At Warsaw, lUinoit, in great variety of form, lining geodes and implnnted on quartz crysliils: at Quincy. In Mitsouri, with dolomite near 8l. Louis; also with aplinlerile at Jopllit and other points in Ihe zinc region in tbe soulbwcnlern part of the slate, tbe crystals lisiiall; scalenohedral and of a wine.yellow color. From the Bad Lands. South Dakota, In Nova Scotia, at Partridge I., a wine-colored calciic, and other Interesting varieties.

TuiHoLiTB. A tufa deposit of catcluin carbonate occurring on an enormous scale in north-western Nevada; also occurs about Mono Lake, California. It forms layers of Interlaced crystals of a pale yellow or tiglit brown color and often skeleton structure except wheu covered by subsequent deposit of calcium carbonate.

DOLOMITEI. Pearl Spar pt. Tri-rhombohedial. Aiis t! = 0 8322. er. 0001 A lOil = 43° 52". Jflf', 4041 a 4401 = 118° Sr. '°*"

XT', lOil Ail01 = 73"46'.

Habit rhombohedral, usually r or if{40ll): the preseiice of rhombohedroiia of the second or third seriea after the phenacite type very characteristic. The r faces commonly curved or made tip of sub-individ-uala, attd thus passing into eaddle-shaped forms (Fig. 706). Also granular, coarae or fine, resembling ordinary marble.

Cleavage: r perfect. Fracture snbconchoidal. Brittle. H, = 3-5-4.

, ,. ..CA>oglc

Q. = 2'8-2'9. Luster Titreoas, inclining to pearly in some varieties. Color white, reddish, or greenish white; also rose-red, green, brown, gray, and black. Transparent to translacent. Optically —. Wj = 1-68J74 Na, e, = l*50i56 Na, FizeaD.

Comp.—Carbonate of calcium and magnesiam (Ca,Mg)CO,; for normal dolomite CaMgC.O, or CaCO.-MgCO. = Carbon dioxide 47-9, lime 30-4, magnesia 31'7 = 100, or Calcium carbonate fi4'35, magnesium carbonate 4565 = 100. . Varieties occur in which the ratio of the two carbonates varies from 1 : I. The carbonateB of iron and manganese also sometimes entur; rarely cobalt and zinc carbonates.

Pyr., etc.—B.B. acts like cslclte. Fragmenta throwD Into cold add, unlike cnlciti', nre only very slowly acted upon, if ftt all, while <□ powder in warm acid tbe mloeral ie rtadily diuoWed with eScrveBceace. The ferrlferouH dolomites becoyie brown ou exposure.

Dtff.—Reaemblta calcile (see p. SC7), but generally tu be dlstiuguished fa that It does DOL effervesce i-eadlly iu the moM tu cold acid.

Obi.—Hastive dolomite conBlitiitea extensive strata, c;il!ed limeatODe strata, in variotis regions, bb in the dolomite region of Ihe soiithern Tyrol, Cryatallioe nod coinpiici varielies are often associated with serpentine and other inagueBian rucks, and wIlli ordioiiry limestones. Some prominent lociiliiies iire: Leogaog in Sal/biirg; ScbemuilK and Kiipnik iu Hungary: FrefberK in Saxony. In Switzerliind, at Bex, it) crystals; also in the BiaueDlLal; Traversella in Piedmont; Campolongo,

In tlie U. Stales, In Vermoitt, at Roxbury. Id N. Jtftey, at Hoboken. In N. York, nt Lockport, Niagara Fiiili, etc.: at the I1lly Foster iron mine. Brewster, Putnam Co., with magnetite, choudrodite. In Baddla-aiiaped crystals with llie sphalerite of Joplln, MiuauH. In S. Car,, at Stony Point. Alexander Co,

Niimed after Dolomieii (1T60-I801j. who announced some of the marked characteristics of the rock In lT91~IIs not eServesclug with acids, while burning like limeatone, and solubility after heating in acids.

Anketlta. CaCO,.[Mg.Fe,Mn)CO,, or for normal ankerite 8CaCo,.MgCo..FeCo., In rbombobedral crystals; n^ = 7S° 48"; also cryllalline massive, granular, compact. Q, = 3'B5-S-I. Color white, gray, reddish. Occurs wlib slderlte at Ibe Styrlan mmea.

MAaNUSTTB,

Ehombohedral Axis: ^ = 08112. rr' = 73° 36'. Crystals rare, usually rhombohedral, also prismatic. Commonly massive; granular cleavable to very compact; earthy.

Cleavage: r perfect. Fracture flat conchoidal. Brittle, H, = 3'5-4'5. G. — 3*0-312, cryst. Luster vitreous; fibrous varieties sometimes silky. Color white, yellowish, or grayish white, brown. Transparent to opaque. Optically —. Double refraction strong,

Comp.—Magnesium carbonate, MgCO, = Carbon dioxide 52-4, magnesia 47'6 = 100, Iron carbonate is often preseiit,

BrmnnerUt contains several p. c. of FeO; G. := 8-8-3; white, yellowish, brownish, rarely black and bituminous; often becoming brown on exposure, and hence called Brown

Pyr., etc.—B.B. resembles calcite and dolomile, and like the latter is but slightly acted upon by cold acids; In powder la readily dissolved with effervescence in warm hydrochloric acid.

Obs.—Found in talcose schist, serpentine and other magnealan rocks, also gypsum; as veins in serpentine, or mixed with it so as lo form a variety of verd-anlique marble. Occura at Hruhschntz In Moravia; at Eranbat and Harla-Zell, Styria; Greiuer in the Zillenhal, Tvrol; Snarum, Norway.

In the v. 8., at Bolton, Mass.; at Roxhury, veining serpentine; at Bareblls, near Baltimore, Md.; in Penn., in cryatnlsat WestGoahen. Cheater Co.; near Texas, Lancaater Co.; In Tiilnre. Alameda Cos., California. A while aaccharoidal magnesite resembling stiitunry marble lias been found as loose blocks on an island fa the SL Lawrence River, near the Thousand Island Park.

lulermedlate between magnetite and sfdeiite are:

Mesitite. SMgCOi.FeCO.. W = IT 46'. Q. = 8'S6-8'86. Usually In flat rliom-tM>liedroua («, oll2) wllli rounded facea. TrnTersella, Piedmont.

PiSTOMBBiTB. MgCOi.FeCUi = Hagneatum carbonale 430, iron carbonate 6B'0 = 100. rr^ = 72" 42'. G. = 8-48. Thuniberg. Salzburg; aUo Traversella.

SIDBRTTB. Cbalfblte, BpatLIc Iron. BUenvpatb Oerm. Ehombohedral. Axis d = 0-8184. ■w, MOl A lOil = 43° SB", rr', 1011 a IlOl = 78° ff. '*"•

V. 0001 A 4041 = 7B' 11'. MM', 4041 a i401 = 118° 42*. i, 0001 A 0551 = 78" 8'. •»', OoSl aS051 = 113°W)'. ed, 0001 A 0881 = 82" 28'. dd. 0681 A 8081 = 118° 18*'.

Crystals commonly rhombobedral r or e, the faces often curved and built up of sabmdividuala like dolomite- Often cleavable mossiTe to coarse or fine granular. Also in botryoidal and globular forms, Eiibfibrous within, occasionally silky fibrous; compact and earthy.

Cleavage: r perfect. Fracture uneven or subcoachoidal. Brittle. H. = 3-5-4. G. = 3-83-3-88. Luster vitreous, inclining to pearly. Color ash-gray, yellowish gray, greenish gray, also brown and brownish red, rarely green; and sometimes white. Streak white. Translucent to subtranslucent. Optically —. Double refraction strong.

Comp.—Iron protocarbonate, FeOO, = Carbon dioxide 37"9, iron protoxide 621 = 100 (Fe = 48'3 p. c). Manganese may be present (as in oligonite), also magnesium and calcium.

Pyr.. et«.—Ill tlie closed tube decrepitates, gives ofi CO,, blackens and becomes magnetic. B.B. blackens uud fuacB at 4-B. Wilb the fluxes reacts for iron, and wlih soda anaiiiler on platluiim foil generally gives a miingauese resctiun. Duly slowly acted upon by cold odd, but dissolves with brisk effervesceDce in hot hydrochloric acid. Expoture to the nlmospbere darkens its color, rendering it often of a blackish-brown or browDisb-ied

Biff—Chnracterized by rbombohedral form and cleavage. Specific gravity higher than that of calcite, dolomite and nnkertle. Reaeniblea some spWerile but lacks the reaiiioua luster, diflfere in cleavage nnple and yields COi |uol H,S) with hydrochloric acid.

Obs.—Occurs in many of the rock xlrata. In gneiss, mica slate, clav slale, and as clay Ironstone in connection with the Coal formation nnd many other slrallfled deposits. It is often asaociatod with metaliic ores. At Freiberg it occurs in silver mines. In CoruwuU it accompanies tin. It Is also found accompanying copper and iron pyrites, galena, chalcocite, tetrahedrile. Occasionally it is to be met with in trap rocks as ipherotidtrile iu globular coiicretloDB. Exienstve deposits occur In the Eastern Alps, in Slyriaand Curiulhia. At Hsrzperode in the Hara, it occurs In fine crystals in gray-wacke; also In Cornwall of varied babit at many localities; at Alslon-Moor, and Tavistock, Devonshire. Fine cleavage miisseB occur with cryolite in Oreenland.

lu tlie United States, In Vtrmoat, at Plymouth. In Matt., at Sterling. In CVmn., at Roxbury. nn extensive vein in quartz, traversing gneiss. In N. Fm-k, a serlea of deposits occur in Columbia Co.; at the liossie iron mines. St. Lawrence Co. In Jf. CarottTta. at Feiitresf and Harlem mines. The argillaceous carbonate. In nodules and beds (clay troo' ■tone), is abundant in the cool regions of Penn.. Ohio, and many parts of the country. Jd a clay-bed under the Tertiary along the west side of Chesapeake Bay for 50 m.

RHODOOHROSTTB. Dlalogite. Hanganspath, Himbeerspath, Otrm. Rbombohedral. Axis i = 0'8184, rr' = 73° 0'. Distinct crystals not common; usually the rhombohedron r; also e, with rounded striated faces.

Cle&Yable, maasive to granular maseive and compact. Also globular and botryoidal, with columnar structure, sometimes iodistiact; incrusting.

CleaTBge: r perfect. Fracture uneTBo. Brittle. H. = 3*5-4-5, G. = 3*45— 3*60 and higher.

Luster vitreons, inclining to pearly. Color shades of roa»-red; yellowish gray, fawn-colored, dark red, brown. Streaii white. Translucent to aubtranalucent. Optically —.

Comp.—Manganese protocarbonate, MnOO, = Carbon dioxide 38*3, roaugt^ «ese protoxide 61'7 = 100. Iron carbonate is usually present even np to 40 p. c, as in manganoeiderite; sometimes the carbonate of calcinm, as in man-ganocalcite, also magnesium, zinc, and rarely cobalt.

Pyr., eto.—B.B. ctiaiiKee to gray, brown, and block, and decrepitates elrocgly, but fa infusible. With salt of pbo^homs Bnd borax in O.F. ^ves an amethystiae-colorwi bead. In R.F. becomes colorless. WiihsodaonplaCiDum foilabluiBh.greenmaugaii&te. DissoWes wftli effervesceace in wnm hydrocblorlc acid. On ezpMure to the air changes to brown, and sone bright rose-red Turlelles become paler.

dS.—Cbaiacierieed by Its pink color, rhombohedral form and cleavage, efferresceDCS in acids.

Oba,—Occur* commonly la Teins alone with ores of eilTer, lead and copper, and witi other ores of maoganeie. Found at Schemultz and Kapnlk Id Hungary; NBKyag In TiansylTania; at Fieiberg in Baiony; at Diez near Oberneisen in Nassau; at Kukdea, Bbeinprovinz; at Uoet-Foataine in tbe Ardennes, Belgium. In the U. 8.. at Brantjiville, Conn.: in New Jeree^, with frauklinile at Mine Hill, Franklin Fumacs. In Colorado, at tbe John Reed mine, Ancante, Lake Co., in beautiful clear rliombobedruns; also at the Oulay mjue, near Lake City. In Montana, at Butte City. Abundant at the sUver mines of Atutin, Nevada, At Placentia Bay, Newfoundland.

Named rhodothroiiie from jioSov, a rott, and ;[pai<r[f, color; and dialogic, from Siakuyif, doubt.

BMITHBONITiJ. Calamine pt. Zfnkspatb. Dry-bone Minor: Rhombohedral. Aiis 6 = 0'8063. rr' = 72° 20'. Rarely well crystallized; faces r generally curved and rough. Usually reniform, botryoidal, or atalao-titic, and in crystalline incrustations; also grannlar, and sometimes impalpable, occasionally earthy and friable.

Cleavable: r perfect. Fracture uneven to imperfectly conchoidal. Brittle. ■ H. = 5. G. = 4'30-4-45. Luster vitreous, inclining to pearly. Streak white. Color white, often grayish, greenish, brownish white, sometimes green, bine and brown. Subtranaparent to translneent. Optically —.

Comp.—Zinc carbonate, ZnCOi = Carbon dioxide 352, zinc protoxide 648 = 100. Iron carbonate is often present (aa in mottheimiie); also manganese and cobalt carbonates; fnrther calcinm and magnesium carbonates in traces; rarely cadmium and indium.

Pyr., etc.—In tbe closed tube loses carbon dioxide, and. If pure, is yellow while hoi and white on cooling. B.B. Infusible; moistened with cobalt solution and heated in O.F. gives 8 (freen color on cooling. With soda on charcoal coats the coal with the oxide, which is ydlow while hot and white on cooling; tbia coating, moiatenei} with cobalt solution, gives a green color after heating In O.F, Soluble in hydrochloric acid with effervescence.

DIS.—Disllngulshed from calamine, which It often closely resembles by its efiervescence in acids.

Obs,—Found both in veins and beds, especially in compaay with galena and sphalerite; also with copper and Iron ores. It usually occurs in calcareous rocks, and is generally associated with calamine, and somellmes with llmonlte. It Is often produced by the action upon line sulphide nf carbouated walers.

Found at Nerchinsk in Siberia; at Dogoaczka in Hungniy; Blelbei^ and Baihel la Carimhin; WIcaloch In Baden; Moreenet m Belgium; Altenberg, In tbe province of Bnntander, Spain, at Pnente VIesgo. In England, at Roughleu QUI, Alston Moor, near Matlock, in the Mendip Hills, and elsewhere; in Ireland, at Donegal. At Lauriou, Greece, varieties of many colors.

,ab,GoOgIc

In the v. Sutea. in Ann., at Lancutcr ftbuDdaut, the rar. called "dry-bone"; at the Veberrolh mine, iiear Bethlehem. In Kslenohedron*. In WtMeonntt, at Mineral Point, BhullaburK, etc., pteudomorphe after ipbalerite and calcite. In Mirmetola, at Swing's diggluge. N. W. of Dubuque, etc. In soutb-weeteni Mittcniri aaaociated with Bphalerlte aud caUmiue. In Arkantat, tX Calamine, Lawrence Co.; fn Marlon Co. A pink coballlf-crou« vartetj occurs at Boleo, Lower Calltoraia.

Named after James SmlihBon (17S4-I82B), wlio founded the Bm<tb«onlau Instllutlon In Washington. The name calamine la frequently used in England, cf. calamine, p. 446.

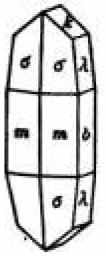
Spharooobaltita, Cobalt protocarbonale, CoCOi. Eobaltspatb Qtrm, Rhombo-hedral. In email apherlca! masses, with crystalline surface, rarely In ctTBIKLi. G. = 4'Oa-4'IS. Color roM-red. From Schneeberg, Saxony.

2. AragoDite Group. RCO,. Orthorhombio. For list of epeciea, see p. SSa ARAOOHITB.

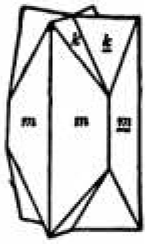
Orthorhombic. Axes &:l:i = o'6: mm'", no Alio = 68* 48'.

: ĉ = 0·62244 : 1 : 0·72056

708.



709.



Crystals of tea acicular, and characterized by the presence of acute domes or pyramids. Twins: tw. pi. m commonly repeated, pro-d a c i n g pseudohexagooal forms (see p. 127, Figs. 398, 399 and 710). Also globular, reniform, and cornlloidal shapes; sometimes columnar, straight or divergent; also atalactitic; incrusting.

Cleavage: b distinct; also m; k (Oil) imperfect. Fracture subconchoidal. Brittle. H. = 3-5-4, G. — 2-93-2'95. Luster vitreous, inclining to resinous on surfaces of fracture. Color white; also gray, yellow, green and violet; streak uncolored. Transparent to translucent. Optically —. Ax. pi. || a. Bi X c. Dispersion p> v small. 2E^ = 30° 64'. /S^ = 1-6816.

Comp.—Calcinm carbonate, CaCO, = Carbon dioxide 44'0, lime 56'0 = 100. Some varieties contain a little strontium, others lead, and rarely zinc.

.. „ „ . . also 8d*

flbroiiB witb silky luster, {e) Ma^ve.

Sbiiaelitie OT ttalagmilU: Either compact or fibrous in structure, as with calcite; Bpni-fUUtein is stalactltic from Carlsbad, Caralloidal: In grolipinKS of delicate interlaclug aud coalescing ▪terns, of a snow-white color, and looking a little like cornl: often called Flot-f^rri (ElaenblDtbe Oerm.). TamowitxiU Ie q kind containing lead carbonate (4 to 8 p. c), from Tarnowilz in SileBia; with O. = a'B8.

Pyr., eto.—B.B. whitens and falls to pieces, and sometimes, when containing strontia, imparls a more intensely red color to the flame than lime; otherwise reacts like calcite.

I^ft—Dlstinguished from calcite by higher specific gravity and absence of rhombohedral cleaviige; from the zeolites {e.g., nalrolite), etc.. by effervescence in acid. Slrontianlle and witherile are fusible, higher in specific gravity and yield distinctive flames B.B. The resinous luster on fracture surfaces ia to \>e noted.

Oba.—The most common repositories of anigonlle are beds of gypsum; also beds of iron ore, ns the Styrlan mines, where it occurs in coralloidnl forms, and Is denominated pn-ferri, "JUrarer of iron"; in basalt: occasionally it. occui-s in lavHs: often ussocUieil v '" copper and iron pyrites, galena, and malnchile. It constitutes the pearly li

T of sbellH.

Ftnt diMOTered In Angou, Spain (wbeoM Its name), at Hollna and Valmcla. In six* aided prUmB, witb ijynum. PronuDent localltlM are Bllln, Bobemla; Leogacg Id Salzburg, AuBtriu; HtrrCLgruud, HuDgwyi with aulpUurfaBicUr in flue prUmsi also al Aklou Hoor, flue lapering crjBlaU.

lu flbrouB cruBii at Hoboken. N. J.; at BdeDtine aud BoBsle. K. T.; Wood'B Hlne, LaDcaBt«r IJ»., Peuu.; Wanaw, 111., lining geodei; Hine-la-Hotte, Ho., in crystals. Flat-ftrri lu tiie Organ Hts., New Mexico.

WITHBRITB.

Orthorhombic Axei A: I-.6 = 0-6032 : 1: 07303. Crystals always repeated

711. twins, aimulating hexagonal pyramids. Fig. 711 (cf.

a h Fig, 557, p. 227). Also masaive, oolamnar or granalar.

Cleavage : i distinct; m imperfect. Fracture

oneven. Brittle. H. = 3-3-75. G. = 4-2r-4'35. Luster

J vitreous, incliniDg to resinous od surfaces of fractnre.

Color white, yellowish, grayish. Streak white. Snb-

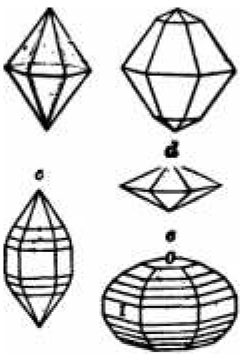
transparent to translucent.

Comp.—Barium carbonate, BaCO. = Carbon dioxide 22 3, baryta 777 = 100.

Pyr., eto.—B.B. fusei at 3 10 a bead, coloriug the flame yellowUh green; nfier fuBion reacts alkaline. B.B. on cliarcoal wtlh soda fuses easily, and U absorbed by tbe coal. S<iluble in dilute bydrocbloHc acid; this solution, even when very much diluted, gives with sulphuric acid a white precipitate wblcb Is iDBoluble In acida. I Diff—Disllnguished by its bigb specific gravity; etfer-I vescence in acid; ysr^sa colonulon of tbe flame B.B. Baiite Is Insoluble in bydrocbloric add.

Oba.—Occurs at Alston Moor in Cumberland, with galena; at lUlowfleld near Heibam In NorCbumberlaud; Tamowllz In Silesia- Leogaiig iu Sals-burg; near Lexington, Eentuctcy, with berite. In a silver-bearing vein near Babbit Ut., Thunder Bay, L. Superior.

Bromlits. (Ba.Ca)CO,. In pseudohexagonal pynmlds (Figs. SS8, 060, p. 227). Bromley Hill, near Alston, Cwnberland.



STRONTIAHmi.

Orthorhombic Axes &:l:i = 06090 : 1 : 0'7239.

Crystals often acicular or acute spear-shaped, like aragonite. Twine: tw. pL VI common. Also columnar, fibrous and granular.

Cleavage: tn nearly perfect; & in traces. Fracture nneven. Brittle. H. = 35-4. G. = 3'680-3 714. Luster vitreous; inclining to resinous on faces of fracture. Color pale asparagDS-green, apple-green; also white, gray, yellow, and yellowish brown. Streak white. Transparent to translucent. Optically —. Ax.-pi. I b. Bx_Lc. Dispersion p < v small. 2E,= 12" 17'. ,

Comp.—Strontium carbonate, SrCO, = Carbon dioxide Sflil, strontia 70'1 ■ = 100. A little calcium is sometimes present. j

Pyr,, et«.—B.B swells up, throws out minute Bprouts, fuses only on the thin edges, and :

colni-B tbe flume Blrontls-red; tbe assay reacts Hlkalloe after ignition. Hoistened wiih '

hydioflhloric acid and treated either B.B. or in tbe naked lamp gTves an intense red color. ■

Soluble In hydrochloric add; tbe dilute solution when treated with sulphuric acid girea a ' while precipitate.

Dlff,—Differs from related mlnemls, not carbonates, in effervescing with adds; has a ,

higher speciflc gravily than aragonite and lower thnn witherite: colors the Uame red B.B. .

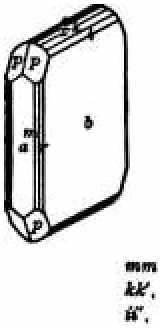
Obs.—Occurs at Btronlian in Argyllshire; in Tarkabire, England; Clausthal In tbe Harz; BrKunadorf, near Freiberg, Suony; Leogang in Salzburg; near Brixtegg, Tyrol

>t the WilbelmiDs n

^ea^eioltrol^lianitt)■. to flue crjslala near HuDm, Westpballs: I AlUhleo, Wespliallft.

lu the U. Slates, occurs at Scbobarie, N. Y.; al MuacalODSe Lake; Cbaumont Baf and Tberau, In JaSenoD Co., N. T.. Hifflin Co., Penik.

OBRnBSrm. White Lead Ore. Welasblelere Qerm. Orthorhombic. Axes a:h:i = 060997 : 1 : 0-72300. 71 a, 713. n*.



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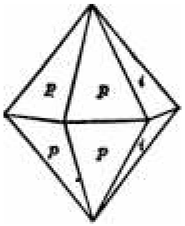


Simple crystals often tabular { b, priamatic Q d; also pyramidal. Twius: tw. pi, m, very common, contact- and penetration-twins, often repeated yielding six-rayed stellate groups. Crystals grouped in clusters, and aggregates. Rarely tibroua, often granular maseive and compact; earthy. Sometimes stalactitic.

Cleavage: m and i (021) distinct; b and x (012) in traces. Fracture con-choidal. Very brittle. H. = 5-3-5. G. = 6-46-6-574. Luster adamantine, inclining to vitreous, reeinoua, or pearly; sometimes snbmetallic. Color white, K^yi grayish black, sometimes tinged blue or green (copper); streak uncolored. Transparent to subtranslucent. Optically—. Ax. pi. Jo. BxJ.a Dispersion p > V large. Indices and axial angles, Schrauf:

a /3 7/ 2V 2E

Line D 1-80368 207638 207803 .-. 8° 14' 17" 8'

Coup.—Lead carbonate, $PbCO$. = Carbon dioxide 16-5, lead oxide 83-5 = 100.

Pyr.. etc —Id ilie closed lube decrepltarea, loeeH carboD dioxide, turas Brat yellow, and at a higber temperature dark red, but becomes again yellow on coollog. B.B. od charcoal fuses very eacily. and In R.F. yields meiallic lead. Soluble in dilute nitric acid with cfFerTetccDcc.

SiS —Chnraclerlzcil by higb spociflc gravity sod arlamanline luster; also by yleldlug lead B.B. Unlike anjilesile. it effervesces with nitric ncid.

01».—Occurs in connection with other lead minerals, and is formed from galena, which. as tt passes to a siilpbate, may be chau^^d to carbonate by means of solutions of calcium hkarbonate. Il is fouarl at Johauugeorgeustadl in benutifiil crystals; Motite Ponl.

SardiDlai Friedriclissegen. Nassau: Badenweiler, Bhden; at Clniisthiil in the Harz; si Bleiberg Id Carinthia; in Englao'l, in Cornwall; nt E Tamar mine. Devonshire: nenr Mullock and Wirkswortb, Derbyshire: at Leadhllls and Wanlocklicad. Scotland.

Found in Penn.. at Pbeniiville. In Virginia, at Austin's mines. Wythe Co. In If, Carolina, In King's mine. In Wisconsin and other lead mines of the Doribwesteru Slates. rarely la crystals; at Hazelgrern, crystals coatiDg galena. In Colorado, at Leadville, and elsewhere. In Ai-i*ona, at the Flux mine, Pima Co., in large crystalllue masses; In crystals at the Red Cloud mine, Tuma Co.

BARTTOOALOITB.

Monoclinic Axes a:h:d = 0-7717 :1 : 0-6354; >» = 73" 52'. In oryBtals; also massive.

Olsavagfi: m perfect; clesa so. Fracture uoeven to subconchoidal. Brittle. H. = 4. Q. = 3'64-3'66. Luster vitreons, inclining to resinone. Color white, grayish, greenish or jrellowish. Streak white. Transparent to translncent.

Comp.—Carbonate of barium and calcinm, BaCOi.CaCOt = Carbon dioxide 29-6, barjta 51-5, lime 18-9 = 100.

PjTT., etc.—B.B. culora the flame fellowish gieeu, and at a high temperature fuaes on the IhiD edges and assumea a pale green color; the aeaa,y reacts alkaline after IguilioD. With the Huzea reactB for manganeBc. Witb goda ou charcoal the lime is separate iia uu infusible mass, while the remainder Is absorbed by the coal. Soluble in dilute bjidri)-chloric acid.

Oba.—Occurs at Alston Moor iu Cumberlaud, in llmeBlotie with baiile and fluoille.

BUmntosphlLrlte. Bi.(COi)i.2Bi,0i. la spherical forms with radiated struclure. O. =7'43. Color yellow to gray or blackish brown. From Scbueeberg, Saxony. Also sparingly at Willimantlc and Portland, Conn., as a result of the alteratloa of bismutblnile.

Pailsite. A fluocarbonate of the cerium metals. In acute double heiagonal pyramids. H. = 4*5. Q. = 4'868. Color brownisb yellow. From the emerald mines of the Huso valley. U. B. Colombia. .

BaitnilHte, Hamartlte. A fluocarbonate of the cerium melals (RF)COt. Color wax-yellow to reddish brown. From the BastnlU mine, Riddarbyttan, Sweden. Also as aa alteration product of tysonlte io the granite of the Pike's Peak region in Colorado.

^OSaBHTTB.

Tetragonal. Axis d = 1 0876. Crystals prismatic; sometimes tabular \ c.

Cleavage: m, a distinct; alsoc. Rather aectile. H. = 275-3. G, = 6'0--i6"3. Lnster adamantine. ColoV white, gray, and yellow. Streak white. Transparent to translucent. Optically +.

Comp.—Chlorocarbonate of lead, (PbCl),CO, or PbCO..PbCl, = Lead carbonate 49'0, lead chloride 51-0 = 100.

Pyr., eto.—B.B. melts readily to a yellow globule, which on coollug becomes white and crystalline. On charcoal In R.F. cives metallic lead, with a white coaliug of lead chloride. With a salt of phosplinriis bead |>revioiD!ly saturated nith copper oxide gives tbe chlorine reaction. DImoItcb witb effervescence in dilute nitric acid.

Obi.—At Cromford near Matlock tu Derbyshire; at Glbbas. Monte Pont and Honte-vecchio io Sardinia.

Northnplt«. McCO,.Na,CO,.NaCI. In isometric octahedrons. White to yellow or gray. From Borax Lake, Ban Bernardino Co., California.

B. Acid, Basic, and Hydrous Carbonates.

)Dium carbonate, HNHiCOi. In yellowish to white deposits of Africa. Patagonia, the Chiocha Islaodt.

ICAI-AOHITEI.

Monoclinic. Axes A:i:i = 0-8809 : 1 : 0-4012 ; ji3 = 61° 50'.

Crystals rarely distinct, nsually slender, acicular prisms (mm''' = 75° 40'), grouped in tufts and rosettes. Twins: tw. pi. a common. Commonlv massiTe or incrnsting, with surface botryoidal, or stalactitic, and strncture divergent; often delicately compact fibrous, and banded in color; frequently granular or earthy.

CfeATage: c perfect; Jleasso. Fracture subconchoidal, uneven. Brittle. H, = 3-5-4. G. = 3*9-4'03. Luster of crystals adamantine, inclining to

▼itreona ; of fibrona yarietiea more or less ailky ; often dull and eartbjr. Color bright green. Streak paler green. Tranalncent to snbiraaslucent to opaque. Comp.—Baaic cupric carbonate, CuCO..Cu(OH), or 2CuO.CO,.H,o = Carbon dioxide 19-9, cupric oxide Tl'9, water 8-2 = 100.

Pyr., ate.—la tUe cloMil tube bluckeiu aod yields wWer. B.B. fuMS&t 2, colorlug the Same emerald-green; on cliarcoal !b reduced to metallic copper; wilb the fluzei rmcb like cuprite. Soluble la acids witli e&erTesceDce.

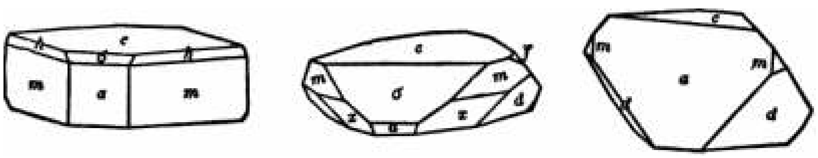
Diff.—Characlerized bj ^eeu color aud copper reactions B.B,; differs fromolber copper ores of a greeu color in Ita (Effervesceuce wiib acids.

Obi.—CouimoD with oiber ores of copper mid as a product of Ibeir allenttlon ; thus as a pseudomorpb after cuprite and B^iirlie. Occurs iibuudautly lu tbe Ural; at Clieaay In France; Id Cornwnll and in Cumberland, England; RUelnbrcltlMch; Dllleuburg, Nassau: Beliidorf near Siegeu. At Ibc copper miJiea uf Nizhni Tugilsk; witb the copper ores of Cuba; Chili; at Ibe Cobar mines and elsewhere iu Nen Soutb Wales; South Australia.

Occurs in y. Jerteg, at Schuyler's mines, and at New Brunswick, In Pennnlvanta, at Cornwall, Lebanon Co.; at the rerklomeu and Plienlxville lead-mtnes. In l^Mcoririn, at tbe copper mines of Mlueral Point, acd elsewhere. Abundantly In Qdc masses and acicular crystals, with calclte at the Copper Queen mine. Bisbee, CocliiseCo., Anxma; also in Grabain Co.. at Horencl (6 m. from Clifton), in alalactitic forms of malncbiU and azurite in concentric bands. At tbe Sauta Kita mines. Orunt Co., and elsewhere in JVine Mexico, Tiniic district, Utah. Named from ftaXazt}, matlom. In allusion to the green color.

Eupfarlaaur Germ. Monoolinic. Axes : d:$i 6 = o 8501 :

15; yS = 87"3



«'.

\ llo = B0*41'.

\ 001 = »r w.

\ 131 = 44° 4ff. \ 028 = 60* 4r.

P]f. 031 A (^1 = ISO" 47'. em. 001 A 110= B8'10". ed, 001 A S43 = M" 28'. hh', aai A 221 = 78' W.

Crystals varied in habit and highly modified. Also tnassiTe, and presenting imitatiTe shapes, having a columnar composition; also dull and eartliy.

Cleavage: p (031) perfect but interrupted; a less perfeet; tn in traces. Fracture conchoidal. Brittle. H. = 3-5-4. G, = 3-77-3-83. Luster vitreous, almost adamantine. Color various shades of azure-blue, passing into Berlin-blue. Streak blue, lighter than the color.

Transparent to subtranslucont.

Comp.—Basic cupric carbonate, 3CuCo,.C«(oH), or 3Cuo.2CO,.H,o = Carbon dioxide 25-6, cupric oxide 69-2, water 5-2 = 100.

Pyr., etc,—Sume ns in malachite.

^ff.—Characterized by its blue color; effervescence In nitric acid; copper reactions B.B.

Obi.—Occurs In splendid crystallizations at Chessy, near Lyons, whence It derived Ihe name Cheug Copper or chettyUte, Also in flne cryeluls in 8i')eHft; Moldawa in ihe Banal; at Wheal Buller, near Redrulli in Cornwall; in Devonaliire and Derbyshire, England; Cobar mines and elsewhere in New South Wnles; South AuslraliFi.

Occurs in Penn., nt Pbenixville, in crystals. In tf. Jeney, near New Brunswick, In Wi*e«ntin, near Hluerol Point. In Arinma. at the Longfellow and other mines in Gmliam

Co.: wiiL lualachite Id beautiful cryBUls at tbe Copper Queen miue, BIsbee. In Omut Co., N»vi Mt!ti£o. At the MauiinutU mine in tbe Tintic dUulct, Vtah. In California, Caliiverua Co., ui Hugbcs'a miue, iu cryBtals.

Auilchalclte. A basic carbonate of zfnc aud copper, 2[Zl],Cu)COi.3(Zo,CuXOU),. In dnis/ iuci'UHiatiuna. ti. = S'54-B 64. Luater pearly. Color pale green to akj.blue. From tbe Allali CheMy, uear Lyous: UezU&nya, Huu^ury; sjid eUtswliere. In Uie \j. b., ut IriLucaater, Pa.; tlie Santa Caterinii Hib., Arizoua; Beaver Co., Ulab.

Hydrozlnclta. A basic zinc ciirbouate, perbaps ZnCOt.2ZD(011),. Musfve, fibrous, enrtby or tompact, aa Incrustfttiona. G. = aiSS-88. Color wbite, grayiah or yetlowisb. Occura at xa\uvt of zinc, as a result of alleralioii. In great qunntiiies ai tbe Dolores mine, Sanlander, Spain. In tbe D, S., at Friedenaville, Pa.; ul Linden, In Wisconslu.

Hydrocenuatte. A basic lead carbonate, probably 2PbCo,.Pb<oH),. In Ibin colorless bexBgonal plates. Occura aa a coating on native lead, at L&ngbsu, Sweden; witb galena at Wanlockbead, Scotland.

Dawionlta. A basic carbonate of alumluluni and sodium, NB|AKCo.)i.2At(oH),. In tbiii lucriistalions of white radiating bladed crystals. O, = ^'4U. Found on a feldspatblc dike near HcQlll College, Montreal. From ilie province ol Siena, Plan Caatagnaio, Tuscany,

TtaannoiMtriU. Hydrous aodium carbonate, Na,CO, + H,o. Q. = 1-5-1 -6. Occam Id vnrious Iskes, and as an efflorescence over tbe soil in inuny d.y regions.

Neiquetaonita. Hydrous magnesium carbonate, HgCOi + 8H,o. In radiating groupft of prismatic crjatala. Q. ~ 1-88-185. Colorless to while. From a coal mine at Nesque-boning, Schuylkill Co , Penn. Bee lonsfordlte. p. 367.

Natron. Hydrous sodium carbonate, NaiCOi -f- lOHiO. Occurring In nature only Id solution, aa in the soda lakes of Fgypt, and elsewhere, or mixed witb tbe olber sodium carbonates.

Plnaonita. CaCOi.NatCOi.SEiO. In prismatic crystals, orthorhombic-hemimorpblc. Colorless to white. Borai Lake, San Bernardino, California.

OATXnSSITB.

Monoclinic. Axes d : J : d = 1-4897 :1:1-4443;. >3 = 78° 27'.

'!»■ '20. mm'", 110 A liO = in* IV.

^~ «■. Oil Aoil = 109°80'.

m#, no A on = 43° 81'.

rr', il3Aii3= 68° 28'.

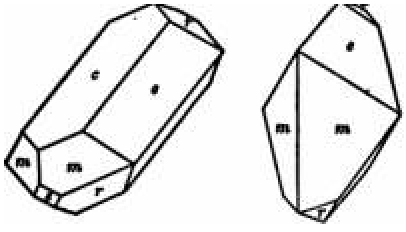
Crystals often alongatedj &', also dattened wedge-shaped. OleaTage: m perfect; e rather difficiilt. Fracture conchoidal. Very brittle. H. ^^ 2-3, G. = 1-93-1-95. LtiBterTitre-ous. Color white, yellowish white. Streak ancolored to grayish. Translucent.

Comp—Hydrous carbonate of calciam and sodium, CaCO..Na,COi + 5H,0 = Calcium carbonate 33-8, sodium carbonate 35-8, water 30-4 = 100.

Pyr,, sto.—Heated In a closed tube decrepitates and becomes opaque. B.B. fuses easily to a white enamel, and colors tlie fiame intensely yellow. Dissolves in acids wllb a brlslc cfferveacenco; partly soluble in water, and rediieng turmeric paper,

Obs.—Abundant at IJngiinilla. near Merlda. in Venezuela, in crysinlx dlsHeminated At the bottom of a amall lake, in a bed of clay, covering urno. Also abundant in LIttie Salt Lake, or Soda Lake, in tlie Carson desert near Raelown, Nevada, deposited upon tbe evaporation of tlie water. Named ikfter Qny Lussac. tbe French chemist (1773~I8S0).

Lanthanlt*. Lh,(COi)i -f 9H,0. In tbin tabular crystals; nlso granular, earthy. G. = 3003. Color graylab while, pink, yellowish. Pound coating cerite at p—-—-



TRONA. Urao.

MonooUnio. Axea: d: X ; i = 3-8460:1: 2-9700; fi = 77° 2S'. ea, 001 A 100 = 77' Sff. 731.

«, 001 A ill = 70° Mi'. 00", ill Alii = «° 861'.

Often fibrous or columnar musiTe.

Cleavage: a perfect; o, c in traces. Fracture

uneven to subconchoidal. H. = 2'&-3. Q. = S'll-

2-14. Luster vitreous, glistening. Color gray or yellowish white. Trsnaln-

ceut. Taste alkaline.

Comp.—Na.C'O..HNaCO,-f 2H,0 or 3Na.0.400,.5H,0 = Carbon dioxide 38-9, Boda 41-^ water 19-9 = 100.

Chatanl esLiiblUbed tlie above composition for nrao, and showed thai troiia. somellracs c&lled " sesquicarboDHte of soda," li an Impure form ot ibe tame compound.

Pyr., ate. —Id tUe closed tube yields water and carbon dioxide. B.B. Imparts an Intenselj jullow color to the flame. Boluble in water, and eflerresces wliii acid*. Reacts alkaline witli moistened test-paper.

OIm. —Found [□ the pro^nce of Fezsan, Africa, forming tliln superficial cnisia; nt tba bottom of a lake at Lagunilla. Venezuela, 8. A. Efflorescences ol trona occur near the Sweetwater river, Rocky Mountains. An extensive bed In Churcliill Co., Nevnds. In floe crystalB at Borax lake, San Bernardino Co., California, with liankBlte, glauberlte, thenaralte, etc.

HydromaKiwdto. Basic magnesium carbonate, 8HgCo,.Hg(oH}, + 8H,o. Cryslals small, tutted. Also amorphous: si chalky crusts. Color and streak white. Often occur* with serpentine; thus at HrubschUiz, in Moravia; at Kraubat, Btyrla, etc Also similarly near TeiBfl, Pm. ; Huboken, N. J.

Hydroglobvtito. MgCO,.Hg(OH)i + 3H,0. In light gray spherical forma. From the neighborliood of Pollena. Italy.

Laiuferdlta. 8HgCO,.Mg<OH), + 21H,0. Occurs as small atolactltes in the anthracite mine at Nesquehoniug near Lansford. Schuylkill Co., Penn.; changod on exposure t4>

nesquehonlte.

Zarattt*. Emerald Nickel. NICO. SNI<oH), + 4H,o. In mammfllary Incrustations: also nmsalve, compact. Color emerald-green. Occurs on chromlie at Texas, Lancaster Co.,Pa.; at Swinauess, Unst, Shetland, and elsewliere.

Ramlvtonit*. A hydrous cobalt carbonate. A rose-colored incrustation, soft and earthy. Vioia a copper mine near Finksburg, CHrroll Co., Maryland.

Tangmita. A supposed yttrium otrbonate. In white pulverulent coating*. On gado-linlte at Ytterby. A similar mineral is associated with tbe gadollnlte of Llano Co.. Texas.

BUmntlt*. Wismulhspalh Oerm. A basic bismuth carbonate, perhaps BI,oi.Coi.H,o.

■ iDcnisling, or eartliy and piilvenilent; amorphous. G. = B86-B-9 Breilh.: 7-67 Rg. Color

white, green, yellow and gray. Occurs at Schreeberg and Johanngeorgenstadt, wllh nalive

bismuth, and at Joachlmsthal. etc. In the U. 8., In Bo, Carolina, al Brewer's mine; In

Gaston Co., N. C-, etc.

DranothaUlte. 2CaCO,.U(CO,)i.lOH,o. In scaly or Kmntilar crystalline aggregates. Color siskin-green. Occurs on uranlnite at Joachlmsthal, Bohemia.

lilFbigtt*. A hvdmus carbonate of uranium and calcium. In raBmmlllary concrelioos, or thin coatings. Color apple-green. OccnrH on uranlnite near Adrianople, Turkey; also JobauDireorgensladt and JoacblmsthBl.

Toirllte. A hydrous carbonate of uranium, calcium and cooper. In aegregntions of rrvMnlllnp ai-alea. Cdor emerald-green to bright grass-green. From the Ellas mine, near Joachlmsthal. on uranlnite.

Oxygen Salti. 2. SHJOATES.

The Silicates sre io part Btrictly anhydroaB, in part hydrous, as the zeolites and the amorphous clajs, etc. Fnrtliermore, a large number of the silicates yield more or lesa water upon ignition, and in many cases it is known that they are, therefore, to be regarded se baeic (or acid) silicates. The line, however, between the strictly annydroua and hydrona silicates cannot be sharply drawn, since with many species which yield water upon ignition the part played by the elements forming the water la as yet uncertain. Furthermore, in the cases of several groups the strict arrangement must be deviated from, since the relation of the species is best eihibited by introducing the related hydrous species immediately after the others.

This chapter closes with a section inoludine the Titanates, Silico-titaoates, Titano-niobates, etc., which connect the Silicates with the Niobatee and Tantolates. Some Titanates have already been included among the Oxides.

Section A. Chiefly Anhydrous Silicates. I. Diiilioatea, Folysllloatei. n. MetaiiUcatei. ni. Orthoiilicatei. IT. Subiilioatei.

The DisiLlCATES, BSi,0„ are salts of disilicic acid, II,Si,0„ and have on oxygen ratio of silicon to bases of 4 : 1, as seen when the formnla is written after the dualiatic method, EO.SSiO,,

The PoLYSiLiCATEs, H,Si,0„ are salts of polysilicic acid, H,Si,0^ and have an oxygen ratio of II: 1, as seen in 3R0.3SiO..

The Metasilicates, ESiO,, are salts of nietasilicic acid, H,SiO„ and have an oxygen ratio of 3 : 1. They have hence been called Msilicates.

The Orthobilicates, R.SiO., are salts of orthoailicic acid, H,8iO„ and have an oxygen ratio of 1: 1. They have hence been called unisilicatet. The uiajdrity of the silicates fall into one of the lost two groups.

Furthermore, there are a number of species characterized by an oxygen ratio of less than 1 : 1, e.g., 3 : 4, 2 : 3, etc. These basic species are grouped as SuBSiLlCATES. Their true position is often in doubt; m most cases they are probably to be regarded as basic salts belonging to one of the other groups.

The above classification cannot, however, be carried through strictly, since there are many species which do not exactly conform to any one of the groups named, and often the true interpretation of the composition is doubtful. Furthermore, within the limits of a single group of species, connected closely in all essential characters, there may be a wide variation in the proportion of the acidic element. Thus the triclinic feldspars, placed among the polysili-cates, range from the true polysilicate, NaAlSi,0,, to the orthosilicate, CaAl,8i,0., with many intermediate compounds, regarded as isomorphous compounds of these extremes. Similarly of the acapolite group, which, however, is included among the orthoeiljcates, aiuce the majority of the compoanda observed approximate to that type. The micas form another example.

L BUlloates, B8i,0,. FolyiUloatei, BjBi,0,.

Monoclinio. Orystala rare (castorite). Ueaally maeaive, foliated clearable (petalite).

Cleavage: c perfect; o (201) easy, z (905) difficult and imperfect. Fraotare imperfectly conchoidal. Brittle. H. = 6-6-5. G. = 3-39-2-46, Lnater vitreous, on c pearly. Colorless, white, gray, occasionally reddish or greenish white. Streak uiicolored. Transparent to translucent.

Co«p—LiAl(Si,o.), or Li.O.Al,o,.8SiO, = Silica 78 4, alamina 16-7, lithia, 4-9 = 100.

Pyr., etc.—Gsutly haaledemiu a blue phoaphoreHXHt light. B.B. on charcoal becomes glasBy, BubtrHnspareDt, and wblie, and mella only on Ihe edgas: gives the reaction for utliia. Wltb borax It forms a, clear, colorleas glnss. Nol acted on by acids.

Obt.— Petalite occurs at the Iron mine of UlO, Sweden, wltb lepldollte, tOurmallnQ, •podumene. and quartz; on Elba {etutoriU). Id the U. S., at Bolton, Hau., with scapoHte; at Peru, Haine. wiih epodumene }a albil«. The name ptialitt la from nfrakor. a Itttf, alluding la the cleaviige.

Milarito. HECa,Al,(S[,o,),. In hexaEODal prlams. H. = S'tMI. G. = 3'65-2'68. Coloi'lew to pale grseu, glassy. From Tal Qiuf, QrlsoDB. Switzerland.

Bndldymlts. HNaBeBI.O., In wbite, glassy, twinned crystals. Ubular ta habit H. =6. G. = 3'55S. Occurs very sparingly In elffiollte-syealte on the island Ovre-ArO, in the Langesundfiord, Norway.

Bpidldymita, Same composition as eudldymlte. Orthorhombic Bouthem.QreeDi&Dd.

OrthooIaM

Soda-Ortboolase Hyalophanr

Kiorocline

Soda-microcline AnorthoelaM

Feldspar Group.

a. JfonocHnfc .Section.

i:i KAISLO. 0-6585 :1;

J (K,Na)AlSi,o,

i (Na,K)AlSi.O. (K„Ba)AI,Si,o„

I 0-5554

0-6584 :1: 0-6512

/I. THctinU Section.

EAlSi,o,

(K.N.jAlSi.O,

(Na,K)AlSi,o.

Alblie.Muirthit« Serlc Ptagioelate Ftldtpvn.

Albit« Oli^odue

Labradorite

Asorthite

Celiian

HaAlSi.O,

0-6335 :1: 0-5577 94° 0-6321 : 1: 0-5524 93"

116" 29' SS" 9' 116° 23' 90° 5'

/MNaAISi.O, l^mCaAI,

.o.)

CaAl,Si,o. B»Al,Si,o,

0-6357:1:0-5521 93° 23' 116° 29' 89'59'

0-6377:1:0-5547 93° 31' 116° 3' 89°54i'

0-6347 : 1; 0-5501 93° 13' 115° 55' 91° 12' 90i°

,ab,GoOgIc

DBSCBTPTiyK UINEBALOGT.

The general chsracten of the species belongmg in the Feldsfab Gboup are aa followa:

1, Crystallization in the monoclinio or triclinic systems, the crystals of the different species reeembliDg each other cloBely in angle, in general habit, and in methods of twinning. The prismatic angle in all cases differs but a few degrees from 60" and 120°.

2, Cleavage in tvo similar directions parallel to the base c (001) and clino-pinaeoid (or brachypinacoid) b (010), inclined at an angle of 90° or nearly 90°. 3, Hardness between 6 and 6'5. 4, Specific Qravity varying between 2 5 and 2'd, and mostly between 2*55 and 2'75. 5, Color white or pale shades of yellow, red or green, less commonly dark. 6, In composition silicates of aluminium with either potassium, sodium, or calcium, and rarely barium, while magnesium and iron are always absent. Furthermore, besides the several distinct species there are many intermediate compounds having a certain independence of character and yet connected with each other by insensible gradations; all the members of the series showing a close relationship not only in composition but also in crystalline form and optical characters.

The species of the Feldspar Group are classified, first as regards form, and second with reference to composition. The monoclinic species include (see above): OaTBOCLASE, potassium feldspar, and SoDA-obthoclase, potassium-sodium feldspar; also Hyalophane, barium feldspar.

The trich7iic species include; Microclink and Akobthoclasb, potassiam-sodium feldspars; ALBtTE, sodium feldspar; Anobthite, calcium feldspar; Gelsian, barium feldspar.

Also intermediate between albite and anorthite the isomorphons sub-species, eodium-calcium or calcium-sodium feldspars: Oligoolase, Andesine, LabbA'

DORITE.

a. Monoclinic Section.

ORTHOOI^BB.

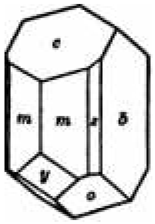
Monoclinic. Axes & ;

: d = 0-6585 : 1.: 0-5554; ft = 63° 57'.

(J7)

,110 A 110 = 61° Iff.

180 A 130 = 58* 48". 001 A iOl = 50* 16i'. 001 A 501 = W 19.



\^n

001 A 031 = 44° 861'. .'. 031 A Oai = 8»° 68'. , 001 A 110 = «7° tr.

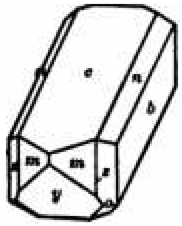
001 A ill = 35'14i'.

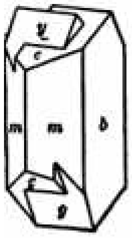
Twins: tw. pi. (1) a (100), or tw. axis i, the common Carlsbad twins, either of irregular penetration (Fig. 727) or contact type; the latter usually with b aE com position-face, often then (Fig. 728) with c and x nearly in a

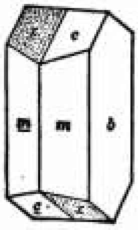
plane, but to be distin^ished by luster, cleavage, etc. (3) n (p^l)* the Baveno twins forming nearly square prisms (Fig. 739)> since en = 44 56^', and hence cc = 89° 53'; often repeated as lourlings (Fig. 417, p. 139), also in square prisms, elongated Q a. (3) c (001), the Manebaeh twins (Fig, 730), usually contact-twins with c as comp.-face. Also other rarer laws.

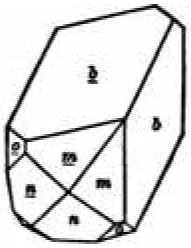
Crystals often prismatic 1 I; sometimes orthorhombic in aspect (Figs. 723, 7S5) since c and x are inclined at nearly equal angles to 6; also elongated | d (Fig. 736) with b and c nearly equally deTeloped; also thin tabular | b: rarely tabular \ a, & face not often observed. Often maasiye, coarsely cleavable to granular; sometimes lamellar. Also compact crypto-crystalline, and flint-like or jasper-like.

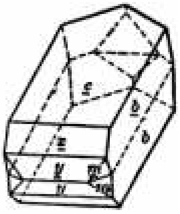
Cleavage: c perfect; b somewhat less so; prismatic tn imperfect, but usually more distinct parallel to one prismatic face than to the other. Parting sometimes distinct parallel to a (100), also to a hemi-orthodome, inclined a few degrees to the orthopinacoid; this may produce a satinlike luster or schiller (p. 190), the latter also often present when the parting is not distinct. Fracture conchoidal to uneven. Brittle. H. = 6. G. = 2'57. Luster vitreous; on e often pearly. Colorless, white, pale yellow and flesh-red common, gray; rarely green. Streak nncolored. 737. 728. 72».







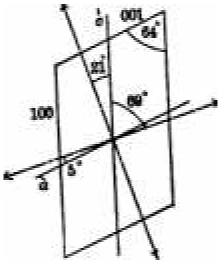




Optically negative (Bx, = 0) in all cases (Fig. 731). Ax. pi. usually _L *, ijj^ sometimes || b, also changing from the former to the latter on increase of temperature (seep. 335). For adiilaria (Dx) Bx„ A ^ = - 69" 11', Bx^w A (! = — 69° 37'. Ueuce Bx, and the extinction-direction (Fig. 731) inclined a few degrees only to ", or the edge b/c; thus -|- 3° to + 7" usually, or . up to-[-]0° or-)-12° in varieties rich in Na,o. Dispersion p> v; also horizontal, strongly marked, or inclined, according to position of ax. pi. Axial angles variable. Birefringence low, y—a = 0-007 — 0005. For adularia (5x).

Qr = l-5100.)9,=1-58S7, rj- = l'5280, . ■. 2Yf = W 43-, 2Er = 121° 6'.

Compn Tar. —A silicate of aluminium and potassium, EAISi.O, or K,0.Al,0,.6Si0, = Silica 64-7, alumina 18-4, potash 16-9 = 100. Sodium is often also present, replacing part of the potassium, and sometimes exceeds it in smonnt; these Tarietles are embraced under the name Boda-orthoclam (NatroDorthoklas Oerm.).



The promloeDt varieties depend upon crynallioe habit and method of occurrence more tban upuD dLSereuce of compositloD.

1. Adularia. The pure or nearly pure potaaalum silicate. nBually in cryaiala. like Fig. T3Jf in liabit; often with viclual planeei Baveuo twina common. G. = 2-565. Transparent or utariy so. Often with a pearly opalescent reflection or Schiller or a lielicale play of colors; so'iie mooiuU>n« is here included, but the remainder belongs to iilbile or other of tlie Iricltiiic feldspars. The original adularia (Adulari is From the St. Qolliard region iu Swlizeriund. Vaieiteianttt, from the silver mine of Valencia, Msxlco. is adiilaria.

2. Sanidine or glany fald^ar. Ocoura in crystals, often trauspareui nnd gliusy, embedded in rbyollle, trachyte (iis of the Siebeugebirge). phonolile, etc. Habit ofien tabular | b (hence named from <Tavi%, a tablet, or board); also In square prisms (A, e); Carls-bftd twins common. Hoet varieties contain sodium as a promineiit constituent, and lience tMsiong to the aoda-orthoclase,

Shyaeolite. Sit*patli Werner. Occurs in glassy crystals at Konte Somnu>: named from pvai, itream (lava stream).

8. Ordinary. In crystals, Carlsbad and other twins common; also massive or cleavable, varying in color from white to pale yellow, red orgreeu. translucent: aomelimes sventuriue. Here iKlongs Ihe common feldspar of granitoid rocks or graulie veins.

Usuiilly contains a greater or less percentage of Bodalsoda-ortUoclaae). Compact cryptocryaialline orthoclase makes up the mass of much felslte, but to)i greater or less degree iiduiixed with quartz: of various colors, from wliite and brown to deep red. Much of what baa been called ortho-clase, or common potash feldspar, has proved to belong to the related triclinic species, microcline. Cf. p. 874 on the relations of the two species. Clie^terliie and Amazxin stone are microcline; also moat aventurine orlhoclase. Loxtxlaie contains sodium in considerable amount (7'6Na,0). From Hammond, St. Lawrence Co., N. Y. JfureAuonite is a flesU-reil feldspar similar to perthite{p. 873), with gold yellow refleclions in a direction x 6 and nearly parallel to 701 or 801 (p. 371). Prom Dawlisb and Exeter, England,

The spberulites noted in some volcanic rocks, as in the rhyoiite of Ubsidlnn Cliff In the Tellowstone Park, are believed to consist essentially of orthoclase needles with quartz. These nre shown in Figs. 733 and 73il (from Iddlugs; much magnified) as Ibej api)enr iu]X)larized liglit (crossed nicols).

Pyr., etc.—B.B. fu-esat5: vnrtelies containing much soda are more fusible. Loxoclase fuses at \. Not acted upon by acids.

Diff —Cbarnc tori zed by its crystalline form and the two cleavages at riglit angles to each other; harder than tiarite and calclte: not attacked by acids; difficultly fusible. Massive corundum is much harder nnd lins a higher specific gravity.

Dislinguialied in rock sections bv its low refraction (low relief) and low interference-colon, which Inst scarcely rise to white of the first order—hence lower than those of quartz; also by its liiaiial cliaracler in convergent light and by the distinct cleavages. It ia colorless in ordinary light and may be limpid, but is frequently Inrbid and brownisb from the presence of very raiuule scales of kaolin due to alteration from weathering; this change is especially common In the older granular rocks, as granite and gneiss.

Oba.—OrthoclHse io Its BevL-ral Tarielies belongs especial]]' to the crystalline rocks, occurring aa an esseolial cODstituent of granite, gnelsB, syenite, also porpliyry, further (var., »anidiiie) trachyte, phuuolite. etc. In the niasaive grauituiii rocks ii is seldom in distinct, well-fnrmed, separable crystals, except iu veina and cavities; such cryaials are more common, however, lu TolcaDic rocks like trachyte.

Adularia occurs in the crystalline rocks of the central and eastern Alps, associated with emobj' quartz and nlbite. also litauite, apatite, etc.; the crystals are often cc&ted with chlorite: also on Elba. Fine cryalals of ortboclase, often Inius, are obtained from Baveno, Lago Maggiore; the Fleimathal, a red variety; ValUoriana; Bodenmais, Carlsbad and £lDi3£en iu Bohemia; Btriegau, etc., in Silesia. Also Arendal in Norway, and near Shait&ask lu the Ural; Land's End and Bt. Agnes In Cornwall; the Mourne Mts., Ireland, with beryl and topaz. From Tamag&ma Yama, Japan, with topaz and smoky quartz. MoontUmt is brought from Ceylon.

In the U. Stales, ortboclase is common in the crystalline rocka of New England, also of States south, further Colorado, California, etc. Thus at tbe Paris tourmaline locality. In JV. Hamp., at Acwonh. In Mam., at South Royaiston and Barre. In Conn., at Haddam and Middletown, in large coarse crystals. In 2f. York, in 8t. Lawrence Co., at Bossie; at Hammond {loxoctate); In Lewis Co., in white limestone near Natural Bridge; at Amity and Edenvilie. In i^n., in crystals at Leipervilie, Mineral Hill, Delaware Co.; sunatone In Eennett Township. In ilT. Otr.. at Washiugtnu Mine, Davidson Co. In ColoraiU). at the summit of Sit. Antero.CtaaSee Co., in fine crystals, often twins; at Gunnison; Black Hawit; Kokoma. Summit Co., also at other points. Also similarly in Nevada and California.

Ortboclase is frequently altered, especially tliiough the action of carbonated or alkaline waters; the float result is often the removal of the poiaah and the formation of kaolin. Steatite, talc, chlorite, leucile, mica, laumontite, occur as pseudomorphs after ortboclase; and CBSsiteriie and calcitu often replace these feldspars by some process of solution and substitution.

Pkrthitb. As first dfscribed, a flesh-red nventurine feldspar from Perth, Ontario, Canada, odled a sodii-orlhocinse, hut shown by Gerhard to consist of inter laminated ortho-clnse and alblte. Many similar occurrences have since been noted, as also those in which microcline and albite are similarly intetlnminalcd, the latter called mKrorline-perUiile, or microcline-albile-perthile; this is true in part of the original pcnhite. When the structure is discernible only with the help of the microscope It is railed micrcptrtliite. BrOi'ger lias investigated not only Ihe microperthltes of Norway (Orthoklaamikropeithit, Miktoklin-mihroperthit). but also other feldspars characterized by a marked Schiller; he af-sunies Ibe existence of an extremely flue inlerlnminalion of nlbite and ortboclase | 801, not discernible bxthe microscope (cryploperthlie), and connected with secondary planes of parting 1100 or I 801. which is probably to be explained as due to Incipient alteration.

Hyalophane. (K,,Ba)A1,(8iO.)t or E,O.Ba0.2AliOi.88iO,. Silica 61'6, alumina 31-0, bnrytii 16'4. potash lO'l = 100. In crystals, like aduiaria iu habit (Fig, 735, p. S70): also mas>ive. Cleavage: e perfect; 6 somewhat less so. H. = 6-6'5. G. = 3 805. Occurs in a granular ilolomtte in the Binnenlhal, Switzerland; also at the manganese mine of Jakobs-berg. Sweden. Some other feldspars containing 7 to 15 p. c, BaO have been described (cf. also celsian, p. 381).

/3. Tri<^inic Section. BUOROOLINB.

Triclintc. Xear orthoclase in angles and habit, but the angle be ~ about 89° 30'. Twins: like orthoclase, also polyaynthetic twinning according to the albite and pericline laws (p. 375), common, 734.

producing two series of fine lamellie nearly at right angles to each other, lience the characteristic grating-structure of a basal section in polarized light (Fig. 734). Also massive cleavable to granular compact.

Cleavage: c perfect; 6 somewhat less a M (110) sometimes distinct; m (110) also sometimes distinct, but less easy. Fracture uneven. Brittle. H. = 6-6-5. G. = 2-54-2-5'r. Iiuster vitreous, on c sometimes pearly. (Wor white to pale cream-yellow, also red, green. Transparent to translucent.

Optically —. Ax. pi. nearly perpendicular (82"-83") to b. Bx^ inclined 15° 26' to a normal to 6. DiBpersion p < v about Bxo. Extinction-angle on e, + 15° 30'; on S, + 5° to 6° (Fig. 739, p. 375). 2H„ = 88° to 89°, Dx.

The eBWjulIa! idenllly of OTlboclttBe and microcllne baa been urged by Mallard and Micliel-Levy ou tlie ground that the propeitlea of the former would belong to an aggregate of Bubmlcrostopic twinnmg lamellK of the latter, accurding to the alblte aud paricliiie laws. Comp., Tar.—Like orthoolase, KAlSi.O, or K,O.Al,0,.6SiO, = Silica 64-7, ainmina 18'4, potaah 169 = 100. Sodiam is usually present in small amount: sometimes prominent, as in soda-microcline.

Pyr.^As for orthoclaae.

I>iff.—Ketembles ortfaoclase but diatinguished bj optlcai characters («.^..tlie grating structure in polarized light, Fig. TSl); also often abowB flue twlnniDg-strUtions on a basil surface ^albite law).

Ob^—Occure under the same cundllions as much common orthoclase. The beautiful amoMontlene fi'om the Ural, aUo that occurring in fine groi-ps of large crystals of deep color In the gninlle of Pike's Peak, Colorado, is microcline. CkeslerliU from Poorhouae quarry, Chester Co., Penn.. and the aienturlne feldspar of Mineral Hill, Penn., belong here. A pure variety occurs at Magiiet Cove, Arkansas. Ordinary microllne la common at many points.

AnorthooIaM. A triclintc feldspar nitb a cleavage-angle, be, varying but little from 00°. Form like that of the ordinary feldspars. Twinning as with orthoclaae; also poly-synthetic according lo the i^btte and perlcllne laws; but In many cases the twinning liiminie very narrow and hence not diatinct Rhombic section (see p. 875) Inclined on 6. 4 to 6* to edee b/e. O. = 3-67-a'60. Cleavage, hKrdnees, luator, and color as with other membera of the group. Optically —. EillnctlnnHmgle on e, + 8° W lo -(- 2°; on b, 6° lo 9°-8. Bs. nearly ± J. Dlsporsfon p > •; horizontal distinct. Aiial angle variable with temperature, becoming in part monoclinic In optical symmetry between tffl° and 3M* C, but again triclinic on cooling: this is true of those coiilaioing little calcium.

Chietly a soda-poinab feldspar, N.iA18i,0, nn.i KAISI.O* the sodium silicate usually In larger proportion (3:1.8:1, etc.), as If consisting of ulblte and orlhoclaie molecules. Calcium (CaAliBliOi) is also preseut in relatively very small amoutit.

These triclinic soda'potash feldspars are chietly known from the andetltlc lavas of Panlelleria. Host of these feldspars come from a rock, called pantellerite. Also prominent from the auHte-syenite of Bouthern Norway and from the "Rbomben-porphyr',' near Chriatlania. Here is referred also a feldspar in crystals, tabular | e, aud twinned according to the Hanebach and less often Baveno laws occumug in the litiiophyses of the rhyolyte of Obsidian Cliff, Yellowstone Park. It shows the blue opalescence In a dlraction parallel with a at«ep orlhodome (cf. p. 071).

Alblt«.ADortblt« Series. FUigiodaM FMtpon.* Between the isomorphous species

Albite NaAlSi.O, Ab

Ak«hthite CaAl,Si,0, An

there are a number of intermediate subspecies, regarded, as urged by Tscher-mak, as isomorphous mixtures of these molecules, and defined according to the ratio in which they enter; their composition is expressed in general by the formnla Ah,An«. They are;

0LIGOCLA8E Ab,An, to AbiAn,

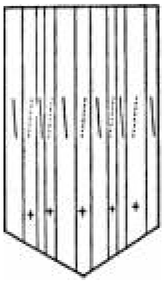
Andesinb Ab.An, to Ab,An,

Labradobite Ab,AQ, to Ab,Ani

and Bytownite Ab.An. to Ab,An,

From albite through the successive intermediate componnda to anorthita

with the progreBfiive change in composition (and specific gravity), there is also



a correspoDdiD^ cbange in crjetallographic form, and ia certain fundamental optical properties.

Crystalline form. The axial ratios and angles eiveo on p. 369 show that these triclinic feldspars approach orthoclase closely id form, the most obvious difference being in tne cleav ^^^ ^^^

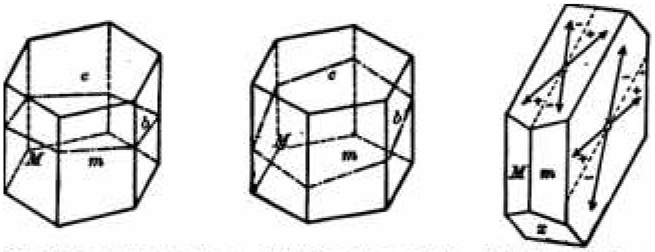
age-angle Ic, wBich is 90" in orthoclase, 86" 24' in albite, and ^b" 50' in anorthite. There is also a chan^ in the axial angle y, which is 88° in albite, about 90° in oligoclase and andesine, and • 91*^ in anorthite. This transition appears still more strikingly in the position of the "rhombic section," by which the twins according to the pericline law are united as explained below. Plagloclnae wiih twinoing lumellw, Fig. 735 secllon I o

T,ri„nino Thn nlatrin '^" "l'o"'f"J vlbrftHoti-dlreclionB (cf. Fig. 7SB), ordi-

twinned in accordance with the Carlsbad, Baveno, and Manebach laws common with orthoclase (pp. 370, 511). Twinning is also almost nniversal according to the alfyite law — twinning plane the brachypinacoid; this is nsu-ally poly synthetic, i.e. repeated in the form of thin lamellte, giving rise to fine striations on the basal cleavage surface (Figs. 735, 736). Twinning is also common according to the pericline law —twinning axis the macrodiagonal -axis h; when polysynthetic this gives another series of fine striations seen on the brachypinacoid.

The compodtloQ-plane f u this pedcllae twinning la a plane paaalng tbiough the ciystal la sucb a direclioD tluLl its Intersections witli the priamntlc faces and the bracltypiuacold make e^ual plane angles with eacholher. Thepnsition ol this rhombic section and the consequent direction of the atrfations on tbe brach^nioacoid chauge rapidly with a small varialiuu la the angle y. In general It may be said to be approximately parallel to the base, but In albite :l is inclined backward (+. Figs. 737 and 789*) and in anorthite to the front (-, Fig, 788); for the iniermediate species iU position varies progressively with the composition. Thus for the angle between the trace of this plane on the brach^Iuacoid and the edge b/e, we have for Albite + 23° to + SO"; for Oligoclase + 9° to + W; tor AndeslDe + 1' to -2°; for Labradorite - 9° to - 10°; (or ADonblte - 15° to - 17°.

737· 738· 739·



Rhombic section in albite. 738, Same in anorthite. 739, Typical form + and − extinction-directions on c (001) and b (010).

plcal form showing

e often lettered as follows: e (001) = i>, ft (010)

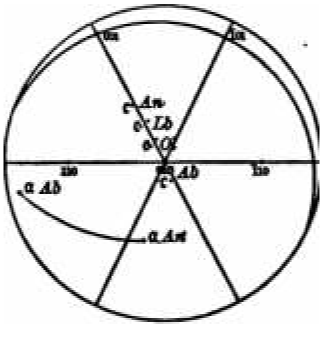
.dbyGooglc

If the compoittlon-plsne is M riglit angles lo the twinning ui* in the pericHne twinning. the polysfDtlieiic lamellge thttn show promiaently iu a basal sectioD, together with those due to the albite tniunlag. Hence the grating structure characteristic oF mlcrocline.

Optical Characters. There ia also a progressive change in the position 'of the ether-axes and the optic axial plane in passing from albite to anorthite. 740. This is most sinipf; exhibited by the position

of the planes of iight-vibration, as observed in sections parallel to the two cleavages, basal c and clinopinacoidal b, in other words the extinction-angle formed on each face with the edge b/c (cf. Pig. 739). I The approximate position of the ether-axes 1 for the different feldspars is shown in Fig. 740 1 (Schnster). The axis c does not vary very ,' much from the zone be, but the axis a varies* widely, and hence the axial plane has an entirely different position in filbite from what it has in anorthite. Farther more albite is optically positive, that is c = Bx, while anorthite is negative or Q = Bx; for certain andesines the axial angle is sensibly 90°,

The following table gives the percentage composition of the various molecular compounds of albite and anorthite, with the calculated specific gravity (Tschermak), and also certain of the optical characters connected with them. These latter values were calculated bv Schnster from an equation deduced by Mallard, in which certain observed Tafues were asanmed as fondamentol :*



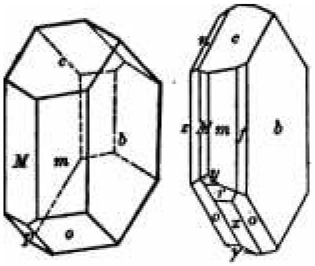
DIS.'—In rock sections the plagioclsse feldapsrs are distiogulsbed bj their lack of color, low refractive relief, and low interference-coloi-s, which In gond sectliins are mainly clarli gray and scarcely rise into white of the first order; also by their biaxial character Id converging llgbt. Id the majority of coses they are easily told by the parallel tjandg or fine lamellfe whicli pass through tfiem due to the multiple twinning according lo the albite law; one set of bands or twin lameDn exiiiblls in general a different interfere nee-col or from the other (cf. Figs. 735, 786). They are Ibus distinguished not only from quartz and

• See Tschermak. Ber. Ak. Wlen, 60 (I). .^66.18Q0; Schuster, Mia. Mittb., 3. 117, 1881. 6. 189, 1883; Mallsrd. Bull. Soc. Min,. 4, 96, 1881. Also Michel-L6vy and other authors referred lo on p. 212i further, O. F. Beclter, Am. J. Sc. 6, p. 819, May 1898.

orthoclase, with nhich the; are often kssocinted, but from all the common rock-making mioeralB. To distiiiRuisli Ibe diSereut species and Bub-EpecJeB from one iinotber, as albile from iabradorile or aniiesiiie, is more (litHcult. In sections liaving a detiDlIe oHcntutlou (| e (001) aod I ft (010)) (his can gencraliy be done by determining the ejtliiclion unBlea (ef. p. fflB and Fie. 789i. In general in rock sections speciiil meltiods are required: these are diacuBsed bj ue authors referred to Id the uote on p. 876.

0-5577; a = 94° 3', /3 = lie" 29',

741.



AI.BITEI.

Triclinia Axes £ ih -.i — 0'5335 : 1

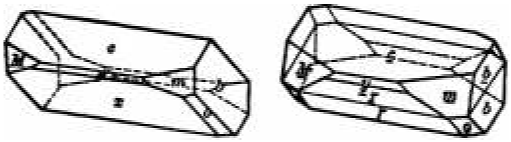
J- = 88° 9'.

be, 010 A 001 = 86*S4'. mM. 110 A liO = 69° 11'. bm, 110 A 010 = 60° aff. em, 001 A 110 - OO" ir. eX, 001 A liO = 68° lO*. «. 001 A iOl = 58° 16'. - Twins OB with orthoclase; &laa very common, the tw. pi. 6, albite law (p. 375), nsuall; contact-twins, and poljayn-thetic, consisting of thin lamellae and with consequent fine Btriatioos on c; tw. azie I, peridine law, contact-twins whose com position-face is the rhombic section (Figs. 737 and 745); often poljsjnthetic and showing fine striations which on b aro inclined backward -|- 22 to the edge b/c.

Crystals often tabular || b; also elongated j aiis h, ae in the variety peridine. Also massive, either lamellar or granular; the laminte often curved, sometimes divergent; grannlar varieties occasionally quite fine to impalpnble. Cleavage: c perfect; b somewhat less so; m imperfect. Fracture uneven to conchoidal. Brittle. H. = 6-6-5. G. = 2-62-2-65. Luster vitreons; on a cleavage surface often pearly. Color white; also occasionally bluish, gray, reddish, greenish, and green; sometimes having a bluish opalescence or play of colors on c. Streak uncolored. Transparent to subtranslucent.

Optically+. Plane (S) _L to Bx,, inclined 100° to 102° to con acute edge ft/c. Extinction-angle with edge b/c = + 4° 30'^to 3° on c, and = + 20° to 15° on b (Fig. 737). Dispersion for Bxu p < v; also inclined, horizontal; for Bio, P > "; inclined, crossed, Dk. 2H„ = 80° to 84° Dx. Birefrin-

744·



, NaAlSi.O. or Ka,O.Al,o,.

Periciiiie. gence weak, y — a = 0-008,

Comp.—A silicate of alumiuinm and sodini 6SiO, = Silica 687, alumina 19 5. aoda ll'S = 100. Calcium is usually p'res'-ent in small amount, as anorthite {CaAl,Ri,o,), and as this increases it graduates through oligoclase-albite to oligoclase (cf. p. 376). Potassium may also be present, and it is then connected with anorthoclase and microcline.

Var.— Ordinary. In crystais nnd massive. The crystals often (nbular | 6. Tlie massive forms !ire usually nearly pure white, and ofleo show WNyy or curved Inminn!. FeriaUiite is a whilish adularia-iike albile, slightly iridescent, mimed from jieoKTrepd. pigeon. Awnlurin* and maontione varieties also occur. Pericline from Ihe clilorjiic schista of the Alpa

tbebnxis, aa shown hi Figa. 744 nnd 740, and coiiimunlyiwiDued with tbisM ihe twinning axis <perlcline law).

Pyr., etc.—B.B. fuses at 4 to a colorless or white glaBS, imparling an intense yellow to the flame. Not acted upon by acids.

Diff.—Resembles barlte in some forms, but Is harder and of lower spedflc gravil]'; does not effervesce with ucid (like <»lcite). Dlstinguislied optically and by the cotnoiuu twinning strlikliona on e from onbuclase; from tbe otber triclinic feldspars pariittlly by specillc gravity aad btitter by optical means (see' p. 370).

OIm. —Albile Is a constituent of many leneous roclcs. especially those of alkaline type. as granite, eleeolite-syenite, diorlte, etc.; aTso in tlie correspoudiug feldapalhic lavaa In psrtliiU {p. 373) It la Interlamioated with orthoclasu or micrucline, and similar aggregatlons, often on a microscopic scale, are common la many rocks. A)bite is commun hIso lu ^eiss, and sometimes in tbe crystalline schists. Veins of albitlc granite are often repoallorlea of the rarer minerals and of floe crygtallizattons of gems, Inctudlng beirl.

tourmaline, allanite, columbile, etc: It is found In disseminated crystals In granular limestooe.

ls In tbe granite smoky quartz, amllel position

upon the orthoclase. Thus tu the St. Qotliard region; Roc Tourug near'Modane. Savoy; onUt. Skopi(pen^i7M): Tavetschthati Sclimim, Tyrol; also Ffllach, Kauris, the Zillerthal, Krlml, Schneeberg In Paaseir in simple crystals. Also in Dsuptiing in similar association; Elba. Also HirschberK In Silesia; Penig in Baxony; with topaz at Muislnka in the Ural and near Mlask iit tbe Ilmen Mts.; Cornwall, England; Mourne Hts. In Ireland.

Id the United States, in Maine, at Paris, with red and blue tourmalines. la Mat*., at ChesterSeld. in lamellar masses (filtaiDtltinditt), slightly bluish, also fine fcranular. lu New Samp., at Acworth and Alsiead, In Gonn., at Hsddnm; at the Hiadletown feldspar quarry; at Branchville, In fine ciystals aod massive. In if. Zwi, at Moriah, Essex Co., of a greenish color. la Penn., at Unlonville, Chester Co, In Virginia, at tbe mica mines near Amelia Court-House in sp!endid cryatallizationa. In Colorado, In the Pike's Peak region with smoky quartz and amazon-stone.

The name aXbiU la derired from olfrtM, white, in allusion to Its common color.

Otigoolase.

Triclinic. Aiea, see p. 369 he, 010 A 001 = 86" 32' Twins observed according to the Carlsbad, albite, and pericline laws. Crystals not common. TJgtially maasive, cleavnble to compact.

Cleavage: c perfect; & somewhat less so. Fracture conchoidal to nneven. Brittle. H. = 6-6'5. G, = 2'65-2 67. Lueter vitreous to somewhat pearly or waxy. Color usually whitiBfi, with a faint tinge of grayish green, grayish white, reddish white, greenish, reddish; sometimes aventurine. Transparent, Bubtranalucent. Optical characters, see p. 376.

Comp., Tar.—Intermediate between albite and anorthite and corresponding to Ab.An, to AbjAn,, but chiefly to AbjAn,, p. 376.

Var.—1. Ordi'n.ry. In crystals or more commonly massive, cleavable. The varieties conliiinlnr soda up to 10 p. c. are called oligoelau-albilt. 2. Aventitriiie oligoclate, or sun-ttow. is of a grayish-wblte to reddisb-eray color, usually the latter, with Interoal yellowish or reddisli flre-like reflections proceeding from disseminated crystals of probably either hematite or gOthite.

P;^.. etc.—B B. fuses al 3 5 to a clear or eoameMtke glass. Mot materially acted upon by acids.

Dia.—See orthoclase (p. 873) and albite (p. 877): also pp. 870. 378.

Obs.—Occurs In porphyry, granite, syenite, and also in dlffureot effusive rocks, as audeslle. It ia sometimes associated with orthoclase in granite, or other granite-like rock. Among UB localities are Daovlhs-Zoll nenr Stockholm: Pargas in FiaTand; Bbaltansk, Urut; In syenite of the Vosges: at Albiila in the Grisons; Harienbad. Bohemia; Chalanches in AUeinoat, and Bourg d'Oisaus, Dauphiu6; as tuntlon* at Tvedestrand, Norway; at HitterQ; Lake Baikal.

Id the UtilMd States, at Fine aud Macomb, St. LuwreQce Co., K. Y., In good crfttaki «t Danbuij, Ct., with onboclsse aoJ d&nburlte; Usdilam, Ct.; at the emery mine, Chester, Mass., granular; at Uuiouville, Pa., with euphjUite aud corundum; Miueral Hill, Delaware Co.; at Bakenville, N. C, Id clear Klaasy masBea, ahonlug cleavage but no twinaiag. Named In 18:i6 by Breithaupt from okiyoi, liitit, aod K\daii, fracture.

Andoiliie.

Triolinic Axes, see p. 369. he, 010 A 001 = 86° 14'. Twins as with albite. Crystals rare. Ueually maasive cleavable or graoular.

Cleavage: e perfect; h less bo; also M sometimes observed. H. = 5-6. Q. = 3-68-2'69. Color white, gray, greenish, yellowish, fiesh-red, Lnster BubvitreoDS to pearly. Optical characterg, see p. 376.

Comp.—Intermediate between albite and aaorthite, corresponding to Ab: All in the ratio of 3:2, 4: 3 to 1:1, flee p. 376.

Pyr., eto.—Fuses fu thtii Bpllntert before the blowpipe. Imperfectly Kituble in adda. Obi.—Observed {□ many granular and volcanic rocKs; Ihi» occur* in the Aodei, at Harmaio, lU an ingredient of tbe rock called anduiU; !□ the porphyry of I'Esterel, Dept. du Var, FriLDcei In tbe eyenite of Alsace In ihe Vosges: at Vapoefiord, Iceland; Boden-mais. Bavaria. Baaford, He,, with vesuvlanite. Common in the Igceout roclu of the Rocky MlB.

XiabradoTit*, Labrador Feldspar.

Triolinic, Form near that of andesine, but not accurately known (p. 369). Cleavage angle ic = 86° 4'. Forma and twinning similar to the other plagio-clase species. Crystals often very thin tabular! i, and rhombic in outline bounded by cy or ex (Fig. 435, p. 131). Also massive, cleavable or granular; sometimes crjptocryetalline or hornstone-like.

Cleavage: e perfect; b less so; M (llo) sometimes distinct. H. = 5-6, G. = 2*70-2"72. Luster on c pearly, passing into vitreous; elsewhere vitreous or aubresinouB, Color gray, brown, or greenish; sometimes colorless and glassy; rarelyporcelain-white; nan ally a beautiful change of colors in cleavable varieties, especially | h. Streak uncolored. Translucent to snbtrans-lucent. Optical characters, see p. 376.

Piny of colors a common character, but sometlmeB wanting as In some colorlesa crysIsIb. Blue and green are the]>rodoiiiinaDt colnra; but yellow, fire-red, and pesri-gray also occur. Vogelsacg regards the common blue color of labradorite as an luterference-plienomenon due to its lamellar structure, wblle tbe golden or reddish schlller, with tlie other colors, is due to the presence of black adcular microlit«s aud yetlowish-rcd micro. scopic Inmells, or to the combined efiecl of ibese with the blue reflections. Scbrauf has examined the [nclusions, their position, etc.. aud given tbe aaxaee mieroplakHe aud n>iien>-fkylliU to two groups of tbum. (See references on p. 142.)

Comp., Tar.—Intermediate between albite and anorthite and corresponding chiefly to Ab : An in a ratio of from 1 : 1 to 1 ; 3, p. 376.

The feldspars nbicb lie between labradorite proper and anorthite have been embrftced by Tschermak under the name bj/toienite. The original bytownlte of Thomson was a greenish-while feldspathic mineral found In a bouTiler near Bytowu (now Ottawa) lu Ontario. Canada.

Pyr., «to.—B.B. fuses at 8 to a colorless gloss. Decomposed with difficulty by hydro, chloric acid, generally leaving a porllon of undecomposed minerni.

DiS.—Tbe benutlful play of colors is a common but not universal character. Otherwise distill guiabed ns are the oiber feldspars (pp. 870, 87fl).

Obi.—Labradorite U an essential constituent of various Igneous rocks, especially of the basic kinds, and usually associated with xome member of tbe pyroxene orampbibole groups. Thus with hyperstbeiie in uorile, with dlailage in gnbhro, wftb some form of pyroxene la diabase, basalt, dolerite, also audeslte. tephrite, etc. Labradorite also occurs In other

kinda of Uvn, nod is sometimes found in tliem in glassy cryetKls, u in those of Etna, Vesuvius, thu Siiudwicb Islnods at Eilautra.

Tlie lubredoritic massive roclcs uro most common among the formatiotiB of tbe ArcheMU era. Sucli are part of those of Britisti America, nortliem New Yurlt. PeDnajlvania, Arkausaa; tliose of Qreenland, Norway, FiuUnd, bwedeo, and probably i>(Ibe Vosges.

On tbe coast of Labrador, labrndorite is aseoclaled with liorubiende. hyperstlirne, and miiguelite. It is met witb in many places in Quebec. Uciurs iitiundantly tbrougii tbe ceniral Adirondack region in northern New York; in tlie Wlcbila Mis., Arkansas.

Labradorite was Urst brought from the Iste of Paul, oq the coast of Labrador, by Hr. Woife, a Moravian missionary, about the year 1770.

HAflKBLTMiTs. In cotorlesB isotropic graius In meteorttei; composition near labradorite.

ANOSTHTTB. lodiaDiie.

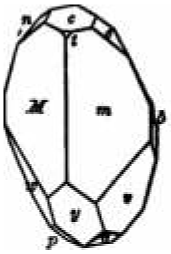
Triclinic. Axes S : B : i = 0-6347 : 1 : 0-5501; a = 93° 13', 6 = 115° 55i', y = 91° 13'.

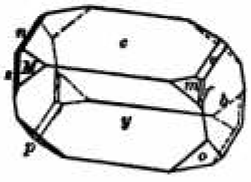
be. 010 A 001 = 86° Bff. cm. 001 A 110 = 86° Sy.

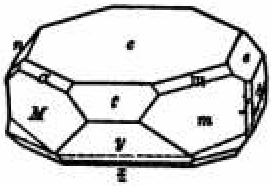
mM, no A lIO = 60* 2V. eM, 001 A lIO = 69° W.

bm, 010 A 110 = 68° 4'. ey, 001 a 201 = 81° U'.

746. 747. 748.







Twins as with albito (p. 375 and p. 377). Crjetals uanallv prismatic | 6 (746, also Fig. 338, p. 108), leas often elongated || ft, like pericline (Pig. 747). AIbo massive, cleavable, with granular or coarse lamellar strncture.

Cleavage: c perfect; 6 somewhat less bo. Fracture conchoidal to nneven. Brittle. H. ^ 6-6-5. G. = 2-74-2 76. Color white, grayish, reddish. Streak uncolored. Transparent to translucent.

Optically —. Ax. pi. nearly _L e (021), and its trace inclined 60° to the edge r./e from left above behind to right in front below. Extinction-angles on c, — 34° to - 42° with edge b/c; on 5, — 35° to - 43° (Fig. 739, p. 375). Dispersion p <v, also inclined, 2H„ = 84° 50', Birefringence stronger than with albite, y — a = 0-013.

Comp.—A silicate of aluminium and calcium, CaAl,Si,0, or CaO.AI 0 .2SiO = Silica 43-2, alumina 36 7, Hme 20-1 ^ 100. Soda (as NaAlSi.O.) is usually

Eresent in amall amount, and ae it increases there ia a gradual transition through ytownite to labradorite. Var. — AnoriJiiU was described from tlie gbisay crystals of Somma: nii<l cfirittianiU and biotine are the same mineral. Tltionauite is itae same from Iceliiud. IjidianiU je a white, grayish, or reddlsli grBniilnr nnnrlhite from India, where it occurs as ibe gnogue of corundum, first described In 1803 by Count Boiimon, Cydopite occurs In small, Iran»pii rent, and glassy crystals, tiibuliir \b, coating cavilies in the dolerite of the Cyclopean ^landa and near Trezza on Etna. Ampliodeiite, lepoliU. latrobitt also belong to nnortliite.

Fyr., eto.—B.B. fuses at 5 to a colorlesa glaaa. Anorlhite from Mte. Somma. and i&dlanite from the Oarnattc, are decomposed by hydrochloric acid, with separation of gelatinous siltcs.

Ob*.—Occurs Id aorae diorites; occMionelly Id conawtloo with gabbro and serpeutine rocks; Id some cases along iritli corundum; in matiy volcanic rocks, uudesites, buaalls, etc.; as a cooetllueot of some uieieorites (Juvenss, StaDQern),

Anurtlilte (eArulianite aud bioline) occurs at HouQt VesuTius Id isolated blocks amoDg ihe old lavas io Ibe ravines of Monte Somraa; in tbe Albaoi Hts.; on the Pesmedii Alp, HoDZoni, Tyrol, as a contact mlDcral: Aranyer Berg, TrausylvanJa, In andesite; on Iceland; near Bogoslovsk in tbe Ural. In tbe Cyclopean IslaodB (eyeiopite). In tbe lava of tbe island of Miyake, Japan.

AniyrViiU was named In 1838 by Rose from avopBiSi, oMipi4, tbe crystallization being trie) i Die.

Oalslan. BaAUSliOi, slmllai to anortblte. but coutaloing barium instead of calcium. HatBive,wlib the usual cleavages o(001) and ('(010), cA = 89° itr. H. = 0-8-5. G, = 3-87. ColorleM. Extinction: on e. V Iff; on b, &&" 45'. From Jakobsberg, Sweden.

n. UetasUioatea. ESiO..

Salta of Metaailicic Acid, H,SiO,; characterized by an oxygen ratio of S : 1 for silicon to bases. The Division closes with a number of species, in part of somewhat doubtfnl composition, forming a transitioD to the Orthosilicates.

The metasilicateB include two prominent and well-characterized gronps, viz., the Pyroxene Oronp and the Amphibole Group. There are also others less important.

Leucite Oronp. Isometric.

In several respects leucite is allied to the species of tlie Feldspar Qbouf, which immediately precede.

Lenoite KAl(SiO,), Isometric at 500°

Pseudo-iHometric at ordinary temperatures. Pollnoite H,Cs,Al,(8iO,), Isometric

LBUOrra. Amphigene.

Isometric at 500° C; paendo-isometric under ordinary conditions {see p. 230). Commonly in crystals varying in angle but little from the tetragonal trisoctahedron n (311), aometimee with a (100), and d 749.

(110) as subordinate forms. Faces often showing fine striations due to twinning (Fig. 749). Also in disseminated grains; rarely massive granular.

Cleavage: d (110) very imperfect. Fracture con-choidal. Brittle. H. = 5'5-6. O. = 2'45-3-50. Luster vitreous. Color white, ash-gray or smoke-gray. Streak uncolored. Translucent to opaque. Usually shows very feeble double refraction: oj = 1-508, € = l009 (p. 230).

Comp. — KAI(SiO.), or K;,O.Al,o,.4SiO, = Silica 550, alumina 23 5, potash 21-5 = 100.

Soda Is present only in small qiisntilles, nnless as Introduced by alteraUon; traces of litbium, also of ruliidliim and caj^iiim, have been delected.

Pyr., etc.—B.B. infusible; with cobalt solution gives a b!ue color (aluminium). Decomposed by hydrochloric airid without geUlinizalion.

Diff.—Cbaracierized by Its trnpezohedral form, absence of color, and infuslbllity. It is sorter than garnet and harder than aualcite; tbe lalter yields water and f nses.

j= cJU (i^ ^ (^(^ ^ (^ ^

}d]7 not wholly isotropic and, furtiier, Bbow complicated ajBteiUB of twinolng-lines (Fig. 749): tbe birefringence is, however, very low, and the colors icarcely rise above dark gVMj; they ara best aeea by introduction of tbe quartz or selenile plate yielding red of the Best order. Tbe ainaller leudtes, wbjcb lack this twinning or tbe Incluaions, are only to be distinguished from sodallte or analcite by cbeDilcal tests.

Oba.—Leucite occurs only in igneous rocks, and especially in recent lavaa, aa one of tbe products of crystallization of magmas rich in potash and low id silica (for which reason thia species rather tlian orthoclase is formed). The Inrger embedded crystuls are commonly anisotropic and show twinning lamella: iJie smaller ones, forming the groundmass, are Isotropic and without twinning. Found in leucitites and leucite-basalts, leucilopbyres, leucite. EhoDolites and leu cite-tepfiri tea; also In certain rocks occurring in dikes. Very rare la itruded leneouB rocks, only one or two instances betug known; but Its former presence under sucu conditions la Indicaled by pseudomorpbs, often of large si^e ipttvdoltueiU} conslstlug of nephelite and ortboclase. also of analrlte.

Tbe prominent loc&lities are, first of all, TeauTJiis and Mte. Bomma. where tl is thickly disiiemluated through the lava in grains, and in large perfect crystals; also in ejected masses; also near Rome, at Capo dl Bove, Roccn MonOEia, etc. Fui-ther In leuclte-tcphrlte at Proceoo near Lake Bolsena in central Italy; also about tbe Laacher See and at several

Elnts in tbe Eifel; at Rleden near Andernacli; al Helches Id the VoKelsgebirge; in the liserstuhlKeblrge. Occurs in Bnizll, at Pinbalzinho. From tbe Cerro de las Virginea, Lower OatilornliL. In the United Slates It Is present in a rocli in the Qreen River Basin at tbe Leucite Hills. Wyoming; also in the Absaroka range, in northwestern Wyoming: in the Higliwood and Bearpaw Mis , Montana (in part pscudoleuclte). On the shores of Vancouver island, where magnificent groups of crystals have Iteen found as drift boulders.

PBeudoleuclte(aee above) occurs In the phonolite (tlnguaite) of tie Bemi de Tiogua, Brazil; at Magnet Cove, Arkansas; near Hamburg, N. J.; Montana; also in the Cariboo DIstr., British Columbia.

Named from Xfvx6!. lehite, in allusion to Its color.

Polluolte. Essentially HiO,2Cs.0 2A1.0,.BSiO,. Isometric; often tn cubes; also massive. E. = 6'5. Q. = 3'901. Colorless. Occui-s very sparingly in the island of Elba; with petalile (castorite); also at Hebron and RumCord, Me.

Pyroxene Group.

Orthorfaombic, Monoclinic, Tridinio. Compoef 'ion for the most part that of a metasilicate, BSiO,r vith K = C»,Mg,Fe chiefly, also Mn,Zn. Farther RSiO, with R(Fe,Al),S!0„ leas often containing alkalies (Ifa,K), and then HSiO, with RAl(SiO,),. Barely inclnd-ing zirconium and titaninm, also fluorine.

a. Orthorhombtc Section.

d'.l id or h: S -.t

Emtatite MgSiO, 09702 :1 : 0-6710 1-0307 : 1 : 0-5885

Bronzite (Mg,Fe)8iO,

Hyperrthene (Fe,Mg)SiO, 0-9713 :1 : 0-5704 1-0319 : 1 : 0-5873

Tlie second set of axial ratios, with d = 1, brings out tbe similarity o(the form to tbe monoclinic spedea.

fi. 3f onooHnie SecHon.

PTTOxem 1-0921:1 : 0-6893 74^ 10*

I. Nos-ALvumouB VAsaxws:

U&lacolit«, Salite, Diallage, etc.

2. Hedenbbboite GaFe(SiO,),

Manganhedenbergfite Ca(Fe,Mii)(SiO,),

3. SCHEFPEEiTB (Ca,Mg){Fe,Mn)(8iO,),

Jeffewonite (Cs,Mg)(Fe,Mn^n)(SiO,),

II. Aluminovs Vasixtixb:

4. AUQITE

(C«f MK,Fe){SiO.).

1 with (Mg.Fe)(Ai>e).8i

,8iO, Leacangite, Faaaaite, Angite, ^girite-angite.

A: 6:6 /3

» (^girite) NaFe(SiO,). 1-0996 : 1: 06013 73° 11'

Bpodnmeoe LiAl(SiO,), 1*1238:1 : 0*6355 69" 40'

Jadaito NaAl(SiO.). 1-103 ! X: 0*613 72° 44i'

d:t:i /S

Wollartonito CaSiOi 1*0531: 1 :0-9676 84° 30'

FMtdite HNaCa,(SiO.). 11140 : 1: 0*9864 84° 40'

;'. TrteUnie Section.

a: ?: (! a 0 y

Rhodonite MnSiO. 1-0729 : 1 : 06213 103° 18' 108° 44' 81^39'

also (Mii,Ca)SiO. (Mn,Fe)8iO. (Mn,Zn,Fe,Ca)8iO. Babingtonite 1-0691 :1: 0*6308 104° 21^' 108° 31' 83° 34'

(Ca,Fe,Mn)SiO,.Fe.(SiO,),

The Ptboxene Group embracea a number of species which, while falling in different systemB—orthorhombic. monoclinic, and triclinic—are yet closely related in form. Thaa all have a fundamental prism with an angle of 93° and 87°, parallel to which there is mora or less distinct cleavage. Further, the angles in other prominent zones show a considerable degree of similarity. In composition the metasilicates of calcinm, magnesium, and ferrous iron are most prominent, while compounds of the form E(Al,Pe),SiO„ RAl(SiOi), are also important.

The species of the pyroxene group are closely related in composition to the corresponding species of the amphibole group, which also embracea members in the orthorhombic, monoclinic, and triclinic systems. In a number of cases the same chemical compound appears in each gronp; furthermore, a change

=:i,:cc ..Google

br paramorphism of pyroi^etie to amphibole Ib often observed. la form also

the two groupB are related, aa shown in the axial ratio; also in the paralUl

KTOvth of crjatals of monoclinic amphibolfl upon or about those of pyroxene

(Fig. 430, p. 131). The axial ratios for the typical monoclinic species are;

Pyroxene d : i : <) = 1-0921 :1 : 0-5893 /S = 74" 10'

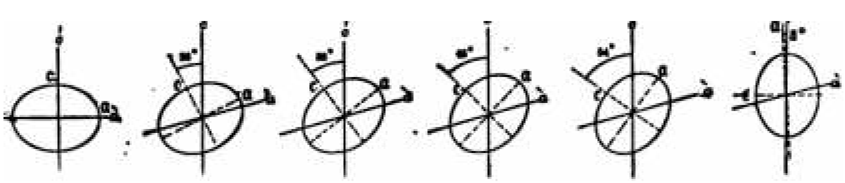
Amphibole A:it:i= 1-1022 :1 : 0-5875 /9 = 73° 58'

See further on p. 398.

The optical relations of the prominent members of the Pyroxene Group, especially as regards the connection between the position of the etber>azes and the cryetallographic axes are exemplified in the following fignres (Cross). 7B1.

in. m. IV. V. TL

4-



A corres] group,

responding exhibition of the prominent amphiboles is given under that <, Fig. 785, p. 398.

. Orthorhambte Section.

SHSTATITB.

Orthorbombic. Axes d : I 78fl.

0-9702 : 1 : 05710. 110 A liO = 88° 16-. rr'. 22S A 323 = 40' 181.

= as-16-.

= 41" 41'.

II.

Twins rare: tw. pi. h (014) as twinning lamelln; also tw. pi. (101) as stellate twins crossing at angles of nearly 60°, sometimes six-rayed. Distinct crystals rare, habit prismatic. Usually massive, fibrous, or lamellar. Cleavage: m rather easy. Parting! 6; ^Isoo. Fracture uneven. Brittle. H. = 5 5. G. = 31-3-3. Luster. Biitnle. a little pearly on cleavage-surf aces to vitreous; often

metalloidal in the bronzite variety. Color grayish, yellowish or greenish white, to olive-green and brown. StreaJc nncolored, grayish. Translucent to nearly opaque. Pleochroism weak, more marked in varieties relatively rich in iron. Optically+. Ax.-pl. Ijfi. BxJ_c. Dispersion p < ti weak. Axial angle large and variable, increasing with the amount of iron, usually about 90° for FeO = 10 p. c. /Sj = 1'669; y- a = 0-009.

Comp., Tar.—MgSiO, or MgO.SiO, = Silica 60, magnesia 40 = 100. Also (Mg,Fe)SiO, with Mg : Fe = 8 : 1, 6 :1, 3 : 1, etc.

Var.—1. With litlU or no iron; BtutatiU. Color white, yellowish, fcraylsh, or greenish white; luster vltreoua to pewly; G. = 810-318. Chladn&e (BLepardlie of Rose), which

.dbyGooglc

./

EuBtatlte (BroDzlte). Hyperathene.

2, Ferriftrmu; Bronttie. Color gravlih green lo ollve-greeD h.aA broiTD, Lu«ter 01 cleftvsge-Hurface often adaiii an line-pearly to siibmetalUc or brouso-llke: Uib. however, li usiully or secoodsry origin aod la not esaenllnl. With the Increase of IroD (above 12 to 14 p. C.I broiizile pasaes to liyperslliene, tlie oplic uxiiil angle cbauging bo tbat in the latter a = Bk, and Bx, l a. Tbla fa UlualrBted by Figs. 753, TS4.

758.

7BS.

7B7.

Pyr.. etc.—B.B. almost infuaible.belngonly sllgbtly rounded on ihe tbin edges; P. = 6. Insoluble in bydrocUloric ucld.

Oba.—Enntntlte (iucl. bronzite) tsa common conilituentof perldotiteaandthe Ferpentlnes derived from them; it alio occurs in cryslalline scbietB. It is oflen asaoclaleii In imrallel growtb witb ft moDOclinIc pyroiene, e.g., diaiiuge (Figs. 755. T5S). A common minei-ftl In meteoric siooea ofien cccurrlnK in chondriiles with eccentric radiated structure (Fig. 7S7).

Oi curs near Alovslhnl In Horavln. in serpentine; at Kupferberg in BfiTnrla: at Basle in IbeHarz (proU^milite): tn tbe so-called olivine bombs of the Dreiser Weihcr In the Elfel; in immense crysUls, tu part altcreti, at the apatite deposits of KJOrrestad near Bamle, Norway; iu tbe peridotile Basoclated wiih the diamond depoaita at South Africa,

In the U. S., in New York at tbe Tilly Foster magnetic mine, Brewster, Putaam Co., with cLondrodite; ntEdwaidn, K. Y.

Named from eyardrrf?, au opponent, because so refractory. The name bronttta has priority, but a bronze luster Is not essential, and is far from univenal.

BTPBKBTHBNB.

Orthorhombic. Axes (i:h:i = 0-9713 :1: 0-5704.

mm"'. 110 A liO = 88°20'. oo"\ 111 A HI = 58* Sff.

hh\ 014 A Oil = 16° w. UU-". asa a 252 = w sv.

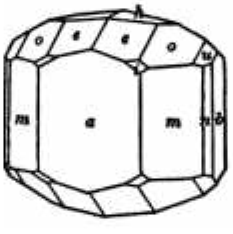
.dbyGooglc

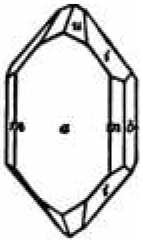
Crystals rare, habit prismatic, often tabular Q a, lesa often \ b. Usually foliated massive; sometimes in embedded spherical forms.

Cleavage : b perfect; m aud a distinct but interrapted. Fracture UDeveo. Brittle. H, = 5-6. G. = 3*40-350. Luster somewbat pearly on a cleavage-

769.

760.





surface, and eometimes metalloidal. Color dark brownish green, grayish black, greenish black, pinchbeck-brown. Streak grayish, browuiBh gray. Translucent to nearly opaque. Pleochroism often strong, especially in the kinds with high iron percentage ; thns \a or d brownish red, f or J reddish yellow, c or (^ green. Optically —. Ax. pi. || 6. Bx J.*!, Dispersion p > v. Axial angle rather large and variable, diminishing with increase of iron, cf. enstatite, p. 384, and Figs. 753, 754, p. 385, (i = 1-708; y — a = 0 013.

Hyperethene often eacloaes mlimte tabular acales. uauiilly of a brown color, tirraoped moally parallel to Ihe busal plane (Fig. 700). also leas frequeullj venical or locliuei) 30° lo t; tliey may be brookite (gOtLiie, bematlle), bu[Ibeir true iialure ia doubtful. Tliey ate-tbe cause of the pecullai' metiilloidal luaier or srhlller, and are often of secondary origiti. being developed aloug the so-called " solution-planes " (p. 149).

Comp, Tar.—(Fe,Mg)SiO, with Fe:Mg= l:3(FeO = 167 p. c), l:3(FeO = 21-7 p.C.) to nearly l:l(FeO = Sl-O p. c). Alumina is sometimes present (up to 10 p. c.) ana the composition then approximates to the aluminous pyroxenes.

Of the orthorhombtc mngnealtira-troQ m«iasillcatea. tbose with FeO > 12 to IR p. c. are usually to be clasaed with hyperstbeue, wblcli la further characteriled by being optically negative aud havW diaperaioD p> t.

Fyz., etc.—B.B, fuses to a blacli enamel, and on cbarcosi yield* a magnetic maaa; fuiea more easily with iDcreaaing amouDi of iron. Pariiallf decouipoat.'d by hydro-chloric acid.

Ob*.—HypeiMbene. associated wiih a iHclinlc feldspar (labrodonte), is rnmmori in certain granular eruptive rocks, as norile. hyperite. gabbro, also in B<ime andeallra {hyper-tOumt-a'rUUnU), a rock recently shown to occur rutber extensively in widely letmruted regions.

It occura at Isle St. Paul ; Labrador; In Greenland; at Farsund and elsewhere in Norway; Elfdalen In Swedea; Penlg in Saxony; Kiiuaberg in Bohemia: tbeTyi-ol; Neurode In Silesia; BodenmaU, Bavaria. Amblytttgile is from the Laacber See. Siuboile occurs. with paeudobrooktle and tridymite, In cavities Id tlie aodesite of tbe Arauyer Berg, Tran■ylvnnla, and elsewhere.

Occurs in tbe noritea of the Cortlnudt region on llit Hudson river, N. Y.: also commoD with labrndorlte in the Adirondack Archiean rei^lon of northern New York and northward iu Canada. In the byperslbune-andesiies of Mt. Shasta, California; Buffalo Peaks. Colorado, ond other poinls,

Hyperithtne is named from vitip and trOfyoi, wry tirong, or tough.

Bastite. i>r Schiller Si'ab. An nlti'red enaiallte (or brouzile) hiiving approximately

inular eruptivo

tbe composilioD of serpviit

1 foliiiti'd form hi ct'tliiin granui

.dbyGooglc

rocks ftod I* cbaracteiized by a bronse-Hke raetalloldal luster or scbllier on the cblef cleaTSge'face (b), nhlcli "schllleiizaiiuii" {p. 100) Ib of secondary origin. H. = 8'S-4. 0. = 3-5-a'7. Color leek-green lo oliva- and pUtacbio-green, and piiiclibeck brown, Pleo-cbroiam not marked. Optically —. Double refraction weak. Ax. pi. | a (hence normal to tliat of eusiaiite). Bx l b. Diaperalou p > s. Tlie oHgiual bastite was from Baste near Harzhurg in the Harz; also fi-om Todtmoos in the Schwurzwald.

PacKHAMiTK. 8(Mg,Fe)8iOi.(Mx.I^e)8iO.. Occurs In rouuded nodulea In the meteorite 4>t Eilherville, Emmet Co., Iowa, Mny 10, I87Q. O. = 3St8. Color light greenish yellow.

PTROXEMB.

Honocli^io.

/S. Monocttnie Section,

Axes d:$:6~ 10921:1: 0-5893; fl = 74° 10'. 001 A asi = 48" W.

; 110 a iio = »a"60'.

001 A 100 = 74° Itf. 001 A iOl = 81° W. on A oil = 89° 6'.

oai Aoai =97'11'.

001 A 111 =

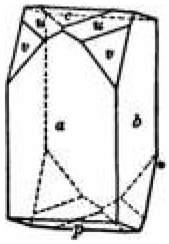
;° 491'.

em, 001 A 110 = TO'9^'. «, 001 A ill =42" y. uu'. III A lil = 48°a»'. <•', ill A ill = 69° 11'. BO', 531 A 2ai = 84° 11'.

^

w

764.

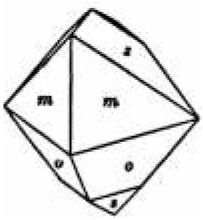


f^^

MJccJ'

Twine: t-v. pi. (1) a, contact-twins, common (Pig. 769), sometimes poly-synthetic (2) G, as twinning lamelle producing atriations on the Tertical faces and pseudo-cleavage or parting Ij c (Fig. 770); very common, often secondary. (3) tf (101) cruciform-twins, not common (Fig. 421, p. 130). (4) W (133) the vertical axes crossing at angles of nearly 60°; sometimes repeated as a siz-rayed star (Fig. 420, p. 130). Crj^stala nsually prismatic in habit, often short and thick, and either a square prism (a, i prominent), or nearly square

766.



^(^^

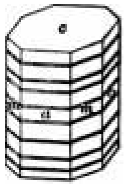
\^ K^ ^^

,<^^

(93°, 87°) with m predominating; sometimes a nearly symmetrical S-sided

f)ri8m with a, b, m (Fig. 770). Often coarsely lamellar, J c or a. Also granu-ar, coarse or fine; rarely fibrous or columnar.

Cleavage: m sometimes rather perfect, but interrupted, often only observed



green, as i:

in thin sections X i (Fig. 771). Parting I c, due to twinning, often promi-□ent, especially in large crystals and lamellar masses (Fig. 7TU); also {| a less distinct and not so common. Fracture uneven to conchoidal. Brittle. H. = 5-6, G. ~ 3-2-3'6, varying with the coni' position. Luster vitreous inclining to resinons; often dull; sometimes pearly I c in kinds showing parting. Color usually green of various dull shades, varying from nearly colorless, white, or grayisn white to brown and black; rarely bright 1 kinds containing chromium; also blue. Streak white to gray and

f ravish green. Transparent to opaque. Pleochroism usually weak, even in arK-colored varieties; sometimes marked, especially in violet-brown kinds containing titanium.

Optically +, Birefringence strong, (y - a) = 0-02 — 003. Ax. pi. | b. Bx, Ai = CAd— + Z6" in diopside, to -j- 52° in augite (wh. see), or ce = 20° to 36°, the angle in general increasing with amount of iron. For diopside from Ala (Dx.): 2E, = 111" 20'. Also (Flink) for white diopside from Nordmark (2-49 p. c. PeO):

Bx.Ai 2V, 2V, 3V^ /J, /S, /S„

+ 38° 81' SB'ff 68° S3' 68° 40" IMBTS 169359 r69869

Comp., Tar.—For the most part a normal i calcium and magnesium, also iron, lees often manganese and zinc. The alkali metals potassium and sodium present rarely, except in very small amount. Also in certain varieties containing the trivalent metals aluminium, ferric iron, and manganese. These last varieties may be moat simply considered as molecular compounds of Oa(Mg,Fo)Si,o, and (Mg,Pe)iAl,Fe),SiO., as suggested by Tsdiermak. Chromium is sometimes present in small amount; also titanium replacing silicon.

The name PyrMtne is from ffOo. firt, and ieyoi, »trangar. and recorda UaQy'e idea that the mliienit was. as he uxpressei) It. " h atranKer in the ilomiiiu of Sre," whereao. jn fact.il Is, ni-xt

to the feldsparg, the most universal coastilueut "

of i go eons 1 ocks.

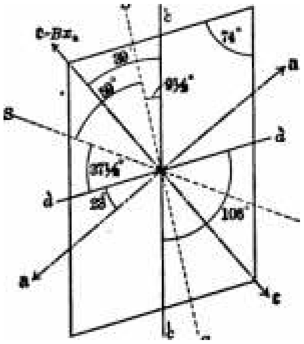
'I'be varieties nre numerous and depemi upon varialiona In composition chiefly; the more prominent of the varieties properly rank as aub-apecies.

I. Containing little or no Aluminium.

1. Diopside. Malacolite, Alaiite. Calcium-magnesium pyroxene. Formula CaMg(SiO,), = Silictt 5.'r6, Hme 259, magnesia 185 =100. Color white, Yellowish, grayish white to pale

green, and finally to dark green and nearly black; sometimes transparent and colorless, also rarely a fine blue. In pris-

letaailicate, RSiOi, chiefly of



matic crystals, often slender; also granular and colnmnar to lamellar massive. o. = 3-2-3-36. Bx. A (i =, + 36° and apwardg. y — a = 0-03. Iron is present usually in small amount as noted below, and the amount increases as it graduates toward true hedenb«rgite.

Tbe rollowing beloDg liere: Chrome-diopiidt, codUIdb chromium (1 to 2'8 p. c CriOi), ofteo a bri^bt green.

Malaeohte, aa originally (leKiibei). wis a pKleK»lored tntDsluceDt varietf from Sala, Sweden.

AtuUte occurs In broad rlKfat-angled prUms, colorleai to raint greeDJah or clear green, from tbe Hiusa Alp !□ tbe A^ valley. Piedmont.

TraterteiiiU, trom Traversal la. Is similar.

VMan Is a line blue diopaide from 81. Marcel, Pledmool, Italy; occurring la prismatic crystals and massive.

CanaaaiU Is a giaylsh-white or bluiah-wblte pyroxeoe rock occurring with dolomite at Canaan. Conn.

Lavnniit Is a pyroxene, colored green by vaoadtum, Trom tbe neigbborhood of Lake Baikal, in eastern Siberia.

Diojmdt Is named from Sii, twice or dovbl^, and oiiii, appearance. Malaeolite is from /laXatedi, tt^t, because softer t^an feldspar, nllh ivblcb 11 was oasoclaied.

2, Hedbnbebgite. Calciuvi - iron pyroxene. Formula CaFe(SiO,), = Silica 48-4, iron protoxide 29 4, lime 23-3 = 100. Color black. In cryetale, and also lamellar maaaive. G. = 3'5-3-58. Bi, A ^ = + 48°. Manganese is present ia manganhcdenbergite to 65 p. c. Color grayish green. G. = 355.

Between tlie two eilremea. diopaide and bedenbergite, tbere are numerous trnnaitions conforming to tlie formula Ca(Hg,I'e)SiiO>, As tbe nmount of Iron Increases the color changes from light to dark green to nearly black, tbe apeciflc gravity tucreases from 8'3 10 8'6, and Ibe anJle Bx. A i also from S6° to 48°.

The following are varieties, coming under these two sub-apecies, based in part upon ■truciure. in pnri nn peculiarities of composition.

Saiite (Bahliie). color graylsli ereen to deep green and black; sometimes grayish and yellowish white; in crystals; also lamellar (parting | e) and grauulnr massive; from Sala In Sweden, Baikalite, a diirk dingy green variety, In crystals, with parting | e; from Lake Baikal. In Siberia.

CoceoUte is a granular variety, embedded In calclte, alao forming loosely coberent lo compact aggregates; color varying from while to pale green to dark green, and then containing cousldenihle iron; the latter tbe original coccolite. Named from m'uVk'u!, a ^'iii'n.

DiALLAOB. A lamellar or thin-foltalea pyroxene, characieriied by a fine lumellar lure and parting I a, with also parting 1 b. and less ofltn | e. Also a fibrous struciure Twinning) a. often polysyntbetic; mterlamlnattoD with an oriliorhomblc pyroxene noD (Fif^. 755 and 756. p. 886). Colnr gniylsh green to bright grassgreen, and deep green; also brown. Lunter of siirrace a often pearly, eometlmcs metalloldal or exblhiliug Schiller and resembling bronzite, from the presence of microscopic Inclusiona of secondary origin. Bx»A<!=+'88 to 40°; /! =)B81; y - it = 0-0a4. H. = 4; G. = 3'2-8S5. In composition near dlopside, but often containing alumluit nnd sometimes in considerable amount, then properly to be classed with tlie augites. Often changed to ampbtbole, see smaragdlte. p. 401, and urallte. p. 401. Named from SzaXXayn, difference, in allusion to the dissimilar planes of froclure. This is tbe cbanicterlstlc pyroieue of gahbro, and other related rocks.

Omphaate. Tbe granular to foliated pyroxenlc constituent of the garnet-reck called ecloglte, often Interlaminated with ampliibole (smaragdite); color grosa-green. Contains some AliOi.

3, ScHEFPERiTE. A manganese pyroxene, sometimes also containing much iron. Color brown to black.

In crystals, sometimes tabular | e, also with p (101) prominent, more often elongated in the dtrecdun of the eone b: p (101), rarely prismatic, j i. Twins, with a as tw. pi. very common. Also crystalline, massive. Cleavage prismatic, very distinct. Color yellowish brown to reddish brown; also black (iTon-tehrffcritc). Optically +. Bin A i = t A i = 44* 25}'. Tbe iron-scbeffente from Pajsberg Is black in color and has t a ^ = + 49° lo 59° for different xonci in tbe same crystal. Tbe brown iroo-scbefferite (vrbanite) from L&ogban baa { a ^ = 69° 8', It resembles garnet in appearance.

Jt^erioaiU la a mangftoese-zlnc pyroxene from PraokllD FuroBce, N. J. (bnt Lbe due mar be due to tiupurity). In large, coktm crystals with edgM loundml and facea unereu. Color greenish black, on the expwei surface chocolattsbruwD.

II. Aluminous.

4. AuQiTE, Aluminous pyroitene. Composition chiefly CaMgSi,o, with - (Mg,Fe)(A),Fe),SiO^ and occasionallj also containing alkalies and then gradn-ating toward tegirite. Titanium is also eometimes present. Here belong:

a, LKrCAnaiTB. Color wlifte or grayish. Coutuma aluinlns, with lime and ntngtieaia. aud little or do Iron. Looks like dlopaide. H. = 6-5; Q. = 319. Named from Xevicoi,

b. Famaitb. Includes the pule to dark, someiimes deep green crystals, or piatachio> green and Ibea resembling epfdote. (Pig. T6fl|. The Bluinlnoiis kinds of diallage alao belong here. Named from the locality in lbe Fassalliul, Tyrol. J^gomialiom xvpyaaua,

e. AUOITE. Includes tlie greeuiab or brownish black aud black kinds, occurring mostly in eruptive rocks. It is usually In tihort prisniiiUc crystals, tlifck and stout, or tAbuiar I a; often twins (Figx. T67-T69). Ferric iron is here present, in relatively large amouut. and the angle Bx, A i becomes + 60" to 53°. j8 = P717; y - a = 003a. TiO, is present la some kinds, which are then pleochrolc. Named from avy^, luilrr.

d. Alkali-auoitb. Here belong varieliea of auglte characterized l>y tlie presence of alkalies, esiieclally soda; Ihey approijmalc in compusl-"3. tlon and optically to acmiie and tegiriie (Bi, f\ i = 60°,

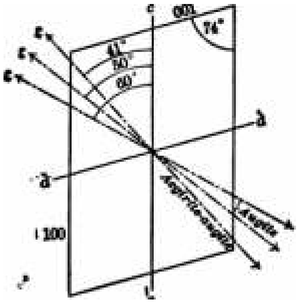
Fig. 778), and are sometimes called eegirite-auglle (cf. Fig 776, p. 882). Known chieflv from rocks rich in alkalies, as elteolite-syenite, phonollte. leucitlte, etc.

Pyr., ote.—Varying widely, owing to the wide Tarlstions In compoaltlon la the different varieties, and often by insensible gTadations. Fudblllty, 8'75 In diop-slde; 8-0 In saiite, baikalite, and omphaclte; S In jeSer-lonlte and auglte; 2'6 In hedenberglie. Varieties rich In Iron afford a magnetic globule when fused on char> coal, and In general the fusibility varies with the amount of Iron. Uany varieties give with the fluxes reactions for manganese. Host varieties are unacted upon bjr acids.

Di^—Characterized by monoclinlc crystallization and the prismatic angle of B7' and US', hence yielding nearly square prisms; these may be mistaken for scaxto-Ilte if terminal facea .are wanting or Indistinct (but scapollte fuses easily B.B. with intumescence). The oblique parting (| e. Fig, 770) often distinctive, also the cci mm on dull green to gray and brown colon. Amphlbole differa in prismatic angle (5fi)° and 124^°) and cleavage, and in having common columnar to Sbroos varieties, which are rare with pyroxene. Bee also p. 808.

The common rock-forming pyroxenes are distinguished In Ihin sections by their high relief; usually greenish to olive tones of color; d»tlnct system of Interrupted cleavage-cracks crossing one another at nearly right angles in sections 774. X h (Fig. 771); high interference-colors; general lack of pleocbrolsm; large extinction-angle, 85° to 50°and higher, for seciions 16 (010). Tlie last-named , sections are easily recognized by showing the hiebeBt interference-colon; yielding no optical figures in convergent llKht and having parallel cleavage-ci-acks. the latter in the direction of the vertical axis. See also sgirlte. p. Vt2, A znnal banding Is common, the succesBive lamlnfE sometimes differing in extinction-angle and pleochroism; also the hour-glass structure occasionally disliuct (Fig. 774. from Lacroix).

Oba.—Pyroxene Is a common mineral in crvatalUne limestone and dolomite. In serpentine and In volcanic rocks; and occurs also, but less abundantly, in connection with granitic rocks and metamorphic schists; sometimes forms large beds or veins, especially In ArchKan rocks. It occun also in meteorites. The pyroxene of Umeetoue Is mostly white and light gieen or gray in color, falling under dioptidt (malacolite, sallte, cocoolite); tltat of moat other



metamotphfc Tock* ia aometlmei white or colorless, but luually gieen of diflereot shades, from pale groen to greenish black, and occajdonaUy black; tbat ol serpeutiiie fa aomeliines Id floe crystals, but often ol the foliated green kind called diallagt; that of eruptive rocks is usually the black to greenish-black av^ite.

In limestone the aaaociatlons are often amphlbole, scapollte. Tesurlanlte. garnet, ortlio-doae, titanlta. apatite, ptalogoplte, and sometimes brown tourmaltne, chlorite, Utlc, zircon, spluel, ruiile, eic.; and la other metamorplili: rocks mostly tlie same. lu eruptive rocks it may be fn disllnct embedded crystals, or lu grains without exleraal crysUlllue form; it often occurs with similarly disseminated chrysolite (oliviue}, crystals of ortbocUse (sani-dine), labradorite, leucite, etc.; also wltb a rhombic pyroxene, amphlbole, etc.

Pyruiene. as an essential rock-making mineral, is especially common in biislc eruptive rocks. Thus, as augite, with a tricllulc feldspar (usually labradorite). magnetite, often Cbrysollte, lu basalt, lissaltic lavas and diabase; lu andeslte; also in trachyte; In peridotita aud pikrile; wiih nepbelite lu phonollte. Furtlier with elfeolite, ortlioclase, etc.. In elKolite-syenile and augile-syeaile; also as diallage in gabbro; In many peridotites and the serpentines formed from tbem; as diopslde (mulacolile) In crysiallioe schists. In llmburgite, Bugillte and pyroxeuite, pyroxene ts present as Ibe prominent constituent, while feldspar is absent: it may also form rock masses alone nearly free from associated mlneials.

Dioptide (alalitc, mussite) occurs in fine crystals on the Mussa alp in the Ala valley in Piedmont, associated with garnets (bessonile) and talc iu veins traversing serpentine; in fine crystals at Tiaversella; at Zermatt in Switzerland; Schwarzenstein in the ZlUertbal; Ober-Sutzbachthnl and elsewhere in Tyrol and In the Salzburg Alps; Reicbenstelu; Rez-1>snya, Hungary; Achmatovsk lu the Iirul with almandite, clinochlore; L. Baikal (patkaUtt) in enslern Sluerla; Pargiis In Finland; at Nordmark, Sweden.

He^nbergite is from Tunnberg. Sweden; Arendal, Norway. Manganhedentierglte from Yestcr Sllfberg; Khefferitt iramlAngtMa. Sweden.

Augite (lucT, fasaalte) occurs on the Pesmeda alp, Ht. Monzoni, and elsewhere in tbe Passftthal. as a cnntact formation; Truversella, Pieamont; tbe Laacher See and the Elfel; Sasbiicb in the Kalserstuhl; VesuviuB. white rare, green, brown, yellow to black; Frnscall: Etna; tbe Azores and Cape Verde Islands; the Saodwicb Islands, and many other regions of volcanic rocks.

In N. America, occurs in Maine, at Rnymond and Itumford, diopslde, sallle, etc. In VtrmotU, at Thelford, black augite, with chrysolite, in bowlders of basalt. In Conn.,aX Canaan, white cryst., oflen exteruallv cbangtd to tremolite, in dolomite: also tbe pyroxenic rock called eanaantU. In N.. r^rh. at Warwick, fine cryst.; Iu Westchester Co., > white, at tbe Slug Sing (lunrries; in Orange Co.. in Monroe, nt Two Ponds, cryst., often large. In limestone; near Greenwood furuace, and also nsar Edenville; in Lewis Co., at Diana, white and black cryst.; !n St. Lnwrence Co., at Fine, In large cryst.; at De Kalb, fine diopslde; iilso at Qouverneur, liossle, Russell, Pitcaim: al Honnh, coccolite. In limestone. In y. JtneSi Franklin Furnace, Sussex Co., good cryst., ».\ki jefemonite. laPenn., near Attleboro', cryst. and granular; In Pennsbury, nt Burnett's quarry, diopaide; at the French Creek mines, Chester Co., cbieSy altered to Sbrous amphlbole. In Tennettet, at the Ducktown mines.

In Canada, nt Calumet I.. gmyish-green cryst. In limestone: In Bathurst. colorless or while crvst.; at Orenvllle, daik green cryst., and granulai; Burgess, Lanark Co.; Renfrew Co., with apaiite, titanite. etc.; Orford, Bberbrooke Co., white crystals, also of a chrome-green color with chrome garnet; at Hull and Wakefield, white crystals with ueoriy colorless garnets, honey-yellow vesuvlanlte, etc. At many other points in the Archtean of

Quebec and Ontario, especially In connection with the apatite deposits.

Pyroxene undergoes alteration In dIHerent ways. A change of molecular constitution witbout essential change of compositlou, i.e., by paramorpM»m (u^g tbe word rather broodly), may result In the formation of some variety of amphlbole. Thus, tbe wliiie pyroxene crystals of Canaan, Conn., are often changed on tbe exterior to tremolite; similarly with other varieties at many localities. See uraliie, p. 401. Also changed to steatite, serpentine, etc.

Aoanrs. .£oibitb.

Monoclinic. Aiea: a:t:i = 1-0996 :1 : 0-6012; fi = 73" U'.

Twins: tw. pi. a, very common; crystala often polysyntbetic, with encloeed twinning lamella. Crystals long priematic, vertit^all; striated or channeled; acnte terminationa very characteristic.

The above appIlM to ordfoarr aemiie. For agiriu, ciysUlR prlnnattc. bluotlr tenm-775. 77Ba. Dated: IwioB DOl common; also in groups or tafta of aleuder

^^ aclcular to capUlarr crjaUJi, and ia flbroua fornia.

/^\\ Cleavage: m distinct; b less bo. Fracture uneveD.

Brittle. H. = 6-6-6. G. = 3-00-3-55 Bgr. Luater vitreoas, incliniiig to resinous. Streak pale yellowish gray. Color browuiflh or reddish brown, green; in the fracture blackieb green. Subtraneparent to opaque. Optically —. Ax. pi. || J. Bi, A (i = a A (5 = + 2 J° acmite, to 6° tegirite. p, = 1-808; y — a-= 0052.

Var.—Include* aemite Id gharp-polnled cryfllala (Fig. 775) often twins. Biu a * = H°-8°- Alao irginte (Fig. 775(i) in crystals bluDtlj terminated, twini rare. Bx. A i = ^°-^'. Aemite. jEglrile. Crystals of acmtie oftea show a marked zoDal siructnre,

green within and brown on ibe exterior, particularly \a,b.p (iOl). j (ill). Tbe brown portion (aemite) U feebly pleoclirolc, Ibe green («girite) strongij pleochrolc Both have abaorptioD ii>t>c, but tbe former baa a light brown wilh tinge of green, b greeniab yellow with tinge of browu, c browi;lah . .

fellow; the latter has a deep graai-green, 6 lighter grasa-green, c yellowish brown to yellciwish.

With some aulbora (vom Rath, etc.) (= (Oil) and o a i = - 2° to -6°, aa in Fig. 776a. Fig. 776 ahows the optical orieDtailou according to BrOgger.

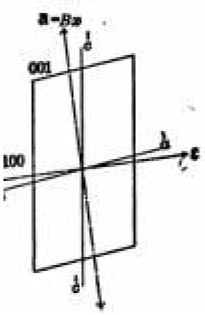
ni Comp. —EBBontially NaFe (SiO,),orNa,O.Fe,0,. 4SiO,= **" Silica 53'0, iron aeeqijioxide 34-6, soda 13-4 = 100. Ferrous iroD is also present.

Pyr., etc.—B.B. fuses at 2 toa luElroua black magnetic globule, coloring tbe flame deep yellow ; with tbe fluxes reacts for iron and sometlmea mangsneae. Sligbtl; acted upon by ncida.

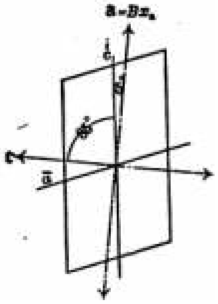
Diff.—.^girite U characterized Id thin aectiona by its grdsa-green color; strong plec chroism la tonea of green and yellow; Ibe small extinction-angle In sections | b (010). Distinguished from common green hornblende, wlili which It might be confounded, by the fact that in such sections the direction of extinction lying near the cleavage Is negative (a), while Ibe same direction In hornblende Is positive (t).

"" "" iriglnal aemite occnra at Rundemyr, east of the little lake called Rokeberg-

776.



776a.



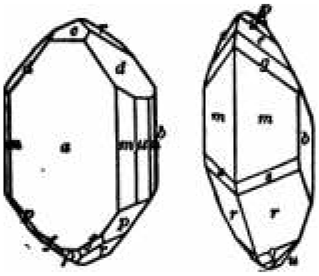
Oba.-

skjeru, in the parish of Eker, near Kongsbers. Norway, in a pegmatite vein; It U in slender cryatala, sometimea a foot lone, embedded in feldspar and quartz.

jl^irite occur* especially in Igoeovia rocks rich in soda and conlaioing iron ; thus in tegirite-granite, nephelite-syenite, and some varieties of phonoiUe ; often in such cases Iron-ore grains are wanting In the rock, their place being taken by agirite crystals. Id tbe sub-variety of pbonolite called tinguaite. the rock has often a deep greenish color due to the abundance of minute crystals of egirile. Large crystals are found iu the pegmatite

mineot American occurrences are tbe following: Magnet Cove, Arkansas (large rrystiils): Montreal: Salem, Mass : Libertyvllle. N. J. (dike); Trnna Pecos disirict in Texas (OaaTin); Black HilU; Cripple Creek, Colorado: Bearpaw MU. and Judith Mts. (Pirsson), and the Crazy Mrs. (Wolff) In MontnnH.

Armite is nameil from aieun. point, in allusion to tbe pointed extremities of tbe crystals; ^girite is from .^Egir, the Icclan<iic god of the sea.



Trlpliane.

Monoclinic. Axes: a •.1:6 = 1-1238 : 1 : 06355; p = 69° 40'. Twins: tw, pi, a. Crystals prismatic (mm''' = 93°0'),ojten flattened | a; the vertical pltmeB striated and furrowed; crystals sometimes very large. Also massiTe, cleavable.

CleaTage: m perfect. A lamellar structure \ a sometimes very promioeat, A crystal then separating into ^7^ ij^g^ 779,

thin plates. Fracture uneven to suDconchoidal, Brittle. H. = 65-7. G. = 3-13^320. Luster vitreous, on cleavage surfaces somewhat pearly. Color greenish white, grayish white, yellowish green, emerald-green, yellow, amethystine purple. 8treak white. Transparent to translucent. Pleochroism strong in deep green varieties. Optically +. Ax. pi. II 6. Bx, A £

= -f 26" Di., = 24° to Zbi" Norwich. Maaa. HWdenile. Hlddenlte.

Greim. Dispersion p> v, hon-lontal. 2H„ = 64° 58^'; ^^ = 1-669; y - a = 0-016.

IKddtniU tuu a jellow-jcreea to emerald-greea color; the bller variety U used as a gem. In samll i\ In, to 3 inclies long) deader priamstic crystals, faces otl«D elcbed.

Coup.— LiAI(SiO,). or U,O.Al,0,.4SiO, = Silica 64-5, alumina 27-4, lithia 8-4 = 100. Generally containB a little sodium; the variety hiddenite also chromium, to which the color may be dne.

Pyr., etc.—B.B. becomes white and opsque, swells up, imparts a purple-red color Oithla) to tbe flame, aod fuses at 86 to a clear or white glass. Tbe powdered mineral, fused with a mis'.ure of potassium blsulphste and fluorite on platinum wire, gives a more iDteone lithia reaction. Hot acted upon by acids.

Diff —Characterized by its perfect ortbodlsgonal parting (in some varieties) as well as by prismatic cleavage; has a higher specific gravity and more pearly luster than feldspar or scapolite. Qives a red flame B.B. Less fusible than smblygonlie.

Ot«.—Occurs on the island of Uts. Sweden; nt KlUIney Bay, Ireland; in small truQS-parent crystals of a pale yellow in Brazil, province of Mioas OeraEs.

In the U. 9., In granite at Goahen, Mass.; also at ChcBterfleld, Cheater, Huntington (formerly Norwich), and Sterling, Mass.; at Windham, Maine, with garnet aod siaurolite; at Peru, with beryl, triphyllte, pelalile. In Conn., at Branchville, the cryalola often of Irnraense aize; near Stony Point, Alexander Co., N, C. (fiiddemU); in South Dakota at tbe Etta tin mine in Pennington Co.

The name a^dumene Is from <ricoSi6i, ath-tol&rtd. SiddentU is named tor W. E. HIdilen of New York.

The apodumene at Goshen and Chesterfield is oiteaslvely altered; pseudomorpbs occur of cymalolite (an Intimate mliilure of albite and muscorite with wavy fibrous structure and silky luster), killinite (pinile), muscovite, ^bite, quartz, and of "vein granite." Similar a Iteration-products occur at BranchviUe.

JADBrm.

Monoclinic. Axes, see p. 383. Cleavage and optical characters like pyroxene. Usually massive, with crystalline atrncture, sometimes granular, also obscurely columnar, fibrous foliated to closely compact.

Cleavage: prismjitic. itt angles of about 93° and 8l°; also orthodiagonal. diificult. Fracture spliutery. Extremely tough. H. = C'.^-7. G = 3-33-3-35. Luster subvitreoua, peaily on surfaces of cleavage. Color apple-green

jcbyGoOgIC

to nearly erne raid-green, bluish green, leek-green, greenisli white, and nearly white; Bometimea white with spots of bright green. Optically biaxial, negative. Bx. A <) - 30° to 40°, 2H»j. = 83° 48*. Streak unoolored. Translucent to Bubtranslucent.

C«mp,—Essentially a metasilicate of sodinm and alnminium correBponding to apodumene, NaAl(SiO,), or Sa,O.Al,o,.4SiO, = Silica 59-4, alumina 25-2, soda 15-4 = 100:

GhlorotrulaiiiU Ib a dark greeD to nearly block kind of Jadelte (hence the nune), codulId-fu;; Irou Besquioxide nnd not confoTOiing exocUy lo the above formula.

Pjrr., et«.—B.B. fuses readily M a transparent blebby glass. Not attacked by acids after fusion, and thus dUIering from sausBurfte.

Ob*.—Occurs chiefly In eaatern Asia, thus in the Mqgoung distr. In Upper Burma, iD a valley 25 miles soulhwest of Heiukhooui, in rolled masaeBin a reddisU clay; in Yuugchang, province of Yunnnn, southern China; in Thibet. Much uaceriainty prevails, however, as lo Ihe exact localities, since iadeite and nephrite have usually been confounded together. May occur also on the American contlncDt, In Mexico and South America ; perhaps also in Europe.

Jadcite hna lone t)een highly prized in the East, especially In China, where it is worked Into omamenls and utensils of great varluly and beauty. It is also found with the relics of early man, tliiiB in the remains of the 1 like-dwellers of Bwitzerlaud, at various tx>iats in Fiance, In Mexico, Greece, Egypt, and Asia Hlaor.

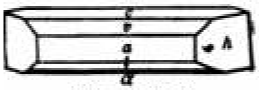
A pyroxene, resembling Jadeite in structure and consisting of the molecules of jadeile, dlopside, and scmite In nearly equal proportioDB, occurs at the tnangaoese mines of St. Marcel, Iu!y (Penfleld). .

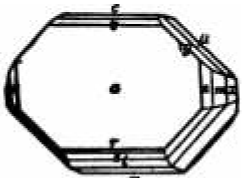
Jade is a gener^ term used to Include various mineral subslaaces of tougb compact texture and nearly white to dark green color used by early man for utensils and bmamenta. and still highly valued in the East, especially in China. It includes properly two species only; nephrite, a variety of amphibole (p. 401), either tremolite or actluoltte, witli O. = S'SE^'O, &0& jadcite. of Ihe pyroxene group and In composition a soda-apodumene, with O. = 8'!(-S'35; easily fusible.

The Jade of China belongs to both species, so also that of the Swiss lake-habitat ions and of Mexico. Of the two, liowever, the former, nephrite. Is tlie more commoi: and makw the jade (ax stone or Punamu stone) of the Maoris of New Zi'Sland: also found in Alaska.

The name Jade is also sometimes loosely used to embrsce other minerals of more or less eiinilnr characters, and which have been or might be Birnilarly used—thus silllmaulte, pec-(olite, serpentine; also vesuvianile, garneL Boweulte Is a jade like variety of serpentJne. The "]ade teoace " of de Saussure Is now called sausaurlte.

WOIJiASTOHITE. Tabular Spar. Tafelspath Oerm. Monoclinic. Axes H\%:6= 10531 : 1 : 0-9676; /3 = 84° 30'.


Diana, N. Y.


Santorin.

Usually cleavable maBsive to fibroua, fibers parallel or reticulated; also compact.

Cleavage: a perfect; also c; / (lOl) lees ao. Fracture nneven. Brittle. H. = 4'5-5. G. = 2-8-3'9. Luster vitreous, on cleavage surfaces pearly. Color white, inclining to grav, yellow, red, or brown. Streak white. Sub-transparent to translucent. Optically —. Bi, a (^ = + 37° 40', Dispersion p> V weak; inclined Btrong. Ai. pi. | 6. 2E, = 70° 40'; /S = 1-633; y - a = 0-014.

C«mp.—C&lclum metasilicate, CaSiO, or CaO.SiO, = Silica 61-7, lime 48-3, = 100.

Pyr., vto.—lu Ibe matrass do change. B.fi. fuses easily on Ibc edges; witli some soda, a blebby gluss; wilL more, swells up nud is lufuaiWe. Willi hydrocbloric ncid decomposed Willi Beparatloa of tiltca; most Tarletles eQervesce sllgbtly fiom tbe presence of cal-cite. Often pbospboresces.

Obs.—Wollusioolte is found especially iu gramilar limestone, and in regions of grentte, as u contact formallon; also In ejected masses in GODoeclion with basalt aud lavas. It Is orien associated wilb a lime garnet, dlopsfde, etc.

Occurs In the copper mines of Czlklowa in Ibe Banat; at Orawitiui at Dognaczks and Nagjag; nt Pargas in Finland; at HsTzburg in tbe Uarz; at Auerbacb, in granular limestone; lit Vesuvius, rurely in fine crystals; on Elba; ou Banlurln.

In Ibe U. S.. in N. York, at Willsborougb; Diana, Lewis Co.; Bonaparte Lake, Lewis Co. In Penn., Bucks Co.. 8 m. w. of Attleboro'. In Canada, at OrenTllle; at St. J^rOme and Horin. Quebec, with apatite.

Kamed after Ibe English chemist, W. H. Wollaslon (1766-1826).

PEtoTOLrra.

Monoclinic. Axes: d.:h:6 = 11140 :1 : 09864; jff = 84° 40'.

Goronionly in close aggregations of acicular crystals; elongated || t, but rarely terminated. Fibrous massive, radiated to stellate.

Cleavage: a perfect; c also perfect. Fracture uiieyen. Brittle. H. = 5, G. = 2-68-2-78. Luster of the Burfaoe of fracture silky or subvitreons. Color vhitieh or grayisli. Subtranslucent to opaqne. Optically -{-. Ax, pi. and Bx,Xfti Bx, nearly J.rt; 2H„ ^ 143°-145*.

Comp., Tar.—HNaCa,(SiO,), or H,O.Na,0.4Ca0.6SiO, = Silica 542, lime 33-8, soda 93, water 2-7 = 100.

s: occBsioDaily in _ , Corstorpbine Hill

ivmlkgrilay. I. 8)tye. Also at Mt. Bsldo and Ut. MoDZonriii tbe Tyrol; at Niederkirchen, Bavaria iomndite).

Occurs also at Bergen Hill and Palerson. N. J.; Lehigh Co., Peon.; compact at Isle Boynle. L. Superior; at Magnet Cove, Ark., in eleeolite-syenlle [manganptettilite wiib 4 p. c. MnO); compact, massive in Alaska, where used, like jsoe, for implements.

RoMnbnaehlte. Near pectollte, but contains lirconlum. From Norway.

WOhlorito. A ilrconiiim-Bllicate and niobale of Ca, Na. etc. In prismallc, tabular crj-stals, yellow to browtj. Occurs in elKOllte-syenile, on several islands of the I^ngesund fiord, nejir Brevik, in Norway.

Uivanlte A complex zircon)urn-silicate of Hn, Ca. etc., contaiDlnR also F, Ti, Tn, etc. In vellow 1o brown prismatic crystals. Found on tbe Island L&ven In the Langesuod fiord, BOiilhem Norway; also elsewhere In eleeolite-syenite.

y. Triainic Section.

SHODONITD.

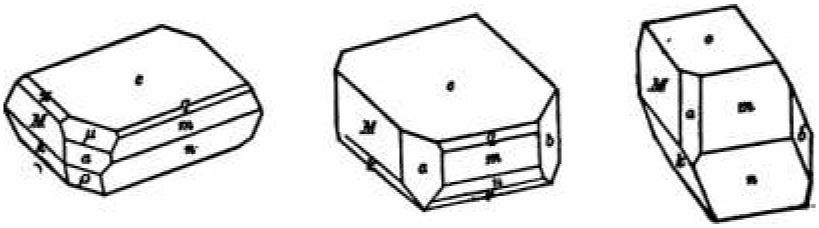
Triclinic. Axes a : S: ^ = 107285 :1 : o-6213; a = 103" 18'; A = 108" 44'; y = 81° 39'.

Crystals usually large and rough with rounded edges. Commonly tabular Q c; BonietinieH resembling pyroxene in habit. Commonly massiTe, clearable to compact; also in embedded grains.

.dbyGooglc

Cleavage: m. If perfect; c leu perfect. Fracture conclioidal to nneTen^ very tongh when compact. H, = 5"5-65. G. = H'4-3'68. Luster Titreous; on cleavage-BurfaccB somewhat pearly. Color light brownish red, flesh-red, rose-pink; Hometimea greenish or yellowish, when impure; often black outside from exposure. Streak white. Transparent to translucent.

Comp., Tar.—Manganese metasilicate, MnSiO, or MnO.SiO, = Silica 45-9, manganese protoxide 54'1 = 100. Iron, calcium (in buatamile), and occasionally zinc {in fowleriie) replace part of the manganese.



FntoUin Furnace, N. J.

ab. 100 A 010 = 04° 26'. mX, 110 A lIO = 92° 2d,'.

ae. 100 A 001 = 73° 86i'. on, 001 A S5l = 78° 52".

be. 010 A 001 = 78° 421'. «*. 001 A 2^1 = 62° 2B'.

am, 100 A 110 = 48° SS*. in, 221 A 2^1 = 86' !>'.

Pyr., ate,—B.B. blackens and fusei with sliKbt tntumeecence at 2-&: with the fluxes eives resctlona for maugRDese; fowlerlte glvei witti Boda on charcoal a reaciloD for zinc. Blightlj acted upon b; nclda. Tlie calciferoiiB vnrieties often efferresce from laechnniuil admixture of calcium carbonate. la powder, partij'diseolyes in hydrochloric acid, and the Inaoluble part becomes of a white color. Dsrkena on expoHure to the air. and sometimes becomes aearly blnck.

DtS.—Characterized by its pink color; distinct cleavages; fuaibilfly and manganese reactions B.B.

Obi.—Occurs at LSngban, Wennland, Sweden, in iron-ore beds, in broad cleavage-plates, and also granular massive; at the Pajaberg iron mines near Filipstad (paMergite) sometimes in small brilliant cryBtals; in the district of Ekaterinburg in the Ural iitassive like marble, wLctice it is obtained for ornamenlai purposes; with tetraheilrite at Rapnik and Rezbduya. Hungary; St. Harcel, Piedmont; Mexico (/nutamiU, containing CaO).

Occtirs in Cumminston, Mass.; on Osgood's farm. Blue Hill Bay, Maine; favsleriU (containing ZnO) nt Mine Hill, Franklin Furnace, and Sterling Hill, near Ogdensburgh, N. J., usually emlMtlded in calclle and sometimes in fine crystals.

Named from fioSov, a rou, In allusion to the color.

Klioduiiitc is often altered chiefly by oxidation of the MnO fas in mareeane. (^im»it«): also by hydration {itratopeite, nsolocite. etc.); further by introauction of CO, (aitagite. pltotieite, etc.).

Bablngtonlte. (Ca,Fe,HD)8iOi with Fe,(S10i)t. In smalt black tricllDlc crystals, near rhodonite In angle (axes on p. 888). H. = 5-5-0. O. = 8'S5-3-S7. From Areodal, Norway; at Herbornseelbach. Nassau; at Baveno, Italy.

Hlortdahllte. EEseulially (Ma..CaXSi.Zr)0i, with also fluorine. In pale yellow tabular crystals (tricUnic)! Occura spaxingly on ac island in the Langesund'flord, southem Norway.

3. Amphlbole Oroap.

Orthortaombic, Moaoclinic, TricUnic

CompoBition for the moBt part that of a metasilioate, KSiO,, with B = CB,Mg,l'e chiefly, also Mn,Na (KJ,H,. Further often coDtaining alumiDiDm and ferric iron, in part with ukuies as NaAl(SiO,), or NaFe(SiU,),; perhaps also containiDg RB,SiO,.

a. OrthorhomMe Section.

AntfaophTllit« (M:g,Fe)SiO, 0*5138: 1

Gedbiib {Mg,Fe)SiO, with (Mg,Fe)Al,SiO.

0. JfonocHnic SecHon,

a :h -.i a

Amphibole 0-6511 : 1 : 0-2938 73^ 68'

I. NosALUttiNova VABtsrraa.

1. Thbmolitb CaMg,(SiO,).

2. AcTiNOLiTE Ca(Mg,Fe),(SiO,),

Nephrite, Asbestua, Smaragdite, etc. Cummingtonite (Fe,Mg)SiO, Daniieniorite {Fe,Mn,Mg)SiO,

QruDerite FeSiO,

3. RicHTERiTB (K„Na,Mg,Ca,Mn),{SiO,),

II. ALvmsQua VAiurriBs.

4. HOBNBLEHDE

KeHe and \ ^'"^^y Ca(Mg,Fe).(SiO.\ with

cSl Hornblende r^^MSiO.), and (Mg.Fe).(Al,Fe),Si.O..

Glancophane NaAI(SiO.)..(Fe,Mg)8iO,

&:h:i /?

Siebeekite 2NaFe(SiO.),.^eSiO,0-5475 : 1 : 02935= 76" 10'

Crocidolite NaFe(SiO,),.FeSiO,

Arfredwnit* Na.(Ca,Mg),(Fe,Mn).,(Al,F6),Si„o„

0-5509 : 1 : 0-3378 = 73° 2' y. TVicMnfc Section. £ni^atite.

The only species inclnded under the triclinic section is the rare and im< perfectly known unigmatite (coaayrite).

The AnPHiBOLE Gaoup embraces a number of species which, while falling In different systeme, are yet closely related in form—as shown in the common prismatic cleavage of 54° to 56°—also in optical characters and chemical composition, Ab already noted (see p. 383), the species of this group form chemically a series parallel to that of the closely allied Pyroxene Group, and between them there ia a close relationship in crystalline form and other characters. The Amphibole Group, however, ia less fully developed, including fewer species, and those known show leas variety in form.

The cliief dUUnetioTu between pyroxene and amphiboie proper are tie following:

PiUmnlic angle witb pyroxene 87° uiid a°; w<lh anipbiliule 50° and 131°; the prismatic cleavage being mucb more distinct in tlie iHtter

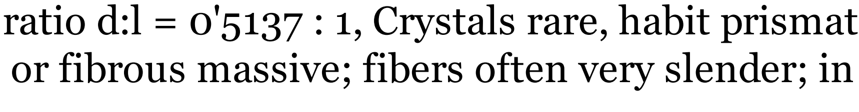
With pyroxene, cryMaU usually abort prlamaliciiud often complex, structure of niasaive kinds mostly lamellar or granular ; wItb ampbibole, cryBlale chletly long piiBuiiitic and simple, columnar and fibrous massive kiuda Llis rule.

Tlie specillc gnivity oF most of tlie pyroxene vurjetlesIsbigher than of tbe like vnrielies of amphiboie. In composition of corresponding kmds, magneslnm Is preseut in larger amount In ampblbole (Ca : Mg = 1 : 1 In diopside, = 1 : it in ttemollte); alkallea more frequently play a prominent part In ampblbole.

The. optical relations of the prominent members of the group, as regards the position of the ether-axes, is exhibited b; the following figures (Cross); compare Fig. 751, p. 384, for a similar representation for tlie corresponding members of the pyroxene group.

7BB.

L n. m. IV. V. V3.



a. Orthorhombie Section. AHTHOPHTIJJTEI.

Orthorhombic. Aiial ratio d:l = 0'5137 : 1, Crystals rare, habit prismatic (mm'" = 54° 23). Commonly lamellar, or fibrous massive; fibers often very slender; in aggi'egations of prisma.

Cleavage: priaraatic,perfect; oless so; a sometimes distinct. H. = 5*5-6. G. = 31-3'3. Luster vitreous, somewhat pearly on the cleavage-face. Color brownish gray, yellowish brown, clove-brown, brownish green, emerald-green, sometimes metalloidal. Streak unoolored or grayisli. Transparent to sub-translucent. Sometimes pleochroic. Uanaliy optically -f ; also + for red, — for yellow, green. Ax. pi. always j b. Bx, usually JL <■", also _L c for red, J. a for yellow, green. Axial angle large. ^ =■ rC42 ; y — a = 0 024.

Comp., Var.—(Mg,Fe)SiO., corresponding to eiifitiitite-bionzite.hyperstbene in the pyroxene group. Aluminium ia sometimes present iu considerable amount. There ia the aame relation in optical character between anthophyl-lite (-J-) and gedrite (—) as between enstatite and hyperstbene (cf. Figa. 753, 754, p. 385).

Var,— Amthophtli-Itb, Mg : Fr = 4: 1, 8 : 1, etc. For 8 : 1, tbe percentage composition is: Silica 55'S. iron protoxide 16-6, magnesia 27-8=100. Atithophyllite sometimes occurs in forjtis resembling asbesttis.

At-wminous. Oedrite. Iron Is present In larger amount, and also nluminium: it bence corresponds nearly lo a hyperstbene. some Vfirieties of whicb are bigbly aluminous.

Bydrout anthophyliitei biive iKtn repeatedly described, but in mo-', cases iliey have been shown to be bydmted monocHnic amphiboles.

Pyr, etc.—B B. fuses with difficulty to a black magnetic enamel: with tbe flnies gives reactions for Iron: unncled upon byncide.

Oba.—Anlhupbylliteoccura tn mica schist near Kongsberp in Norway; al Hennaun-.Bchlag. Horavia. In tbe U. S., at the Jeoks corundum mine, Frtiukliti. Miicon Co., N. G.

Named trom anlAo-

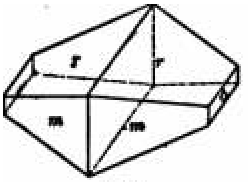
/S. Manodinic Section. AMPHIBOUI. Horabl«D{le.

Monoclinio. Axea a : 5: <t = 0-5511: 1 : 0-2938; /3 = 73° 58'. mm"', no A liO = S5° 49*. rK.OU a Oil = Bl* SB".

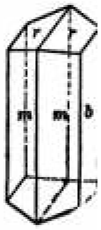
ea, 001 A 100 = 78° 68'. H. 081 a 06l = SO" 83".

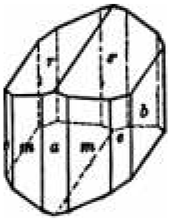
ep. 001 A iOl = 81° 0". pr, iOI A Oil = 84° Sff.

Twine: (1) tw. pi. a, common as contact-twins; i-arely polysynthetic. (2) c, as tw. lamellie, occasionallj producing a parting analogous to that more common with pyroxene (Fig. 430, p. 131). CryatalB commonly prismatic; aanally terminated by the low clinodome, r (Oil), sometimeH by r and p (loi) equally developed and then snggeating rhombohedral forma (as of tourmaline). 786. 7B8. 789. T9a



787.





Also colnmnar or fibrous, coarse or fine, fibers often like fiaz; rarely lamellar; also granular massive, coarse or fine, and usually strongly coherent, bat some-times friable.

Cleavage: m highly perfect; a, b sometimes distinct. Fracture subcon-choidal, uneven. Brittle. H. = 5-6, G. = 2'9-3-4, varying with the composition. Luster vitreous to pearl;^ on cleavage-faces; fibrous varieties often silky. Color between black and white, through various shades of green, inclining to blackish green; also dark brown; rarely yellow, pink, rose-red. Streak iincolored, or paler than color. Sometimes nearly transparent; usually sub-tranBlucent to opaque.

Fleochroism strongly marked in ail the deeply colored varieties, as described beyond. Absorption usually c > b > a. Optically -, rarely +. Ax. pi. | b. Extinction angle on b, or t /\ i = -\-16° to 18° in most cases, but varying from about 1° up to 37°; hence also Bi» A rf = — 75° to — 72°, etc. See Fig. 791. Dispersion p < v. Axial angles Tariable; see beyond.

Comp., Tar.—In part a normal metaBilicate of calcium and magnesium, RSiOi, usually with iron, also manganese, and thus in general analogous to the pyroxenes. The alkali metals, sodium and potassium, also present, and more commonl;^ sO than with pyroxene. In part also aluminons, corresponding to the aluminous pyroxenes. Titanium sometimes is present and also rarely fluorine in small amount.

TLe ahirainlum Is Id part present as NaAKSIO.),, but. many nmphlboles cortafninij aluminium or ferric Iron are more basic than n normiil metasllicate; Ibey may sometimes 1« eiplaiaed as contalnlog R(A1,Fe),8iO,, but tbe exact onture of the cotupouod Is often

{lyroxene. ThuB, for most tremolUe and fkctiuolfle, Ca: Hg(Fe) = 1:8, aoil heuce ti ite is CaMg,Bl,o,„ wbile dlopstde 1b CaMgHi,o„ etc.

RammelsbeTK baa Bhowa that the cotnpoaitiuii uf most alumluoug urnpbiboles mar b

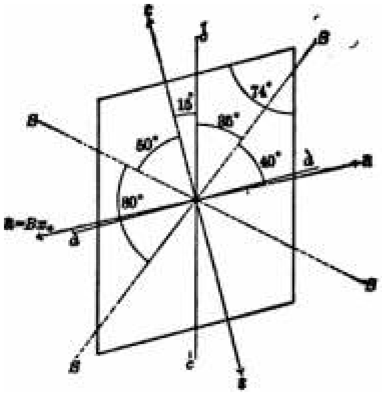
,_^ I (lie geoetal form mRS10i.7iAl,0,; wbile ScLarizat, modityiitg ibis

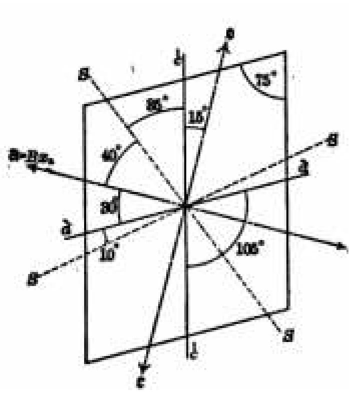
proposes to regard Ibe ampbiboles as molecular compounds of Ca(Hg,Feji&COit (ac^no-

ez pressed i

lite), and tbe orthosllicate (Ri,R)tBi8fiOii, for which he uses Breltbaupt's Dame tt/tUag. natilt, oiiginallj gLveu to tbe Tesuviaa honibleiide.

791. 791a.





Tbe ciyatallograpblc positlou here adopted is that suggested by Tscbermnk, which best exhibits the relaiioc beiweec anipblhole and pyroxene. Some aiitbors retnlo tbo former positioLi, according lo which p = (001), r = (ill), etc. Fig. 79la shows the correapcndiog optical or!eutattoo.

I. Containing little or no Aluminium.

1. Trbuolite. Orammatite, nephrite pt. Calcium-magnesium ampJiiboU. FormulaCaM:g, (SiO.), = Silica 577, magnesia 28'9, lime 13-4 — 100. Perrons iron, replacing the magnesium, present only sparingly, up to 3 p c. Colors white to dark gray. In distinct crystals, either long-bladea or short and stout. In aggregates long and thin columnar, or flbrous; also compact granular massive (nephrite, p. 40L). 0. = 3'9-3'l. Sometimes transparent and colorless.

Optically —. Extihction-angle on S, or c A (^ = + 16° to 18°, hei = - 74"* to - 72°. 2V^ = 80° to 88°. 0j = 1'621; >' - a = 0 0

027.

B Bi, A (!

2, AcTiNOLiTE. Strahlstein Oerm. Calctum-magneaium-iron ampkibole. Formula Ca(Mg,Fe),(SiO)|. Color bright green and grayish green. In crystals, either short- or long-bladed, as in tremolite; columnar or fibrous; grannlar massive. G. = 3-3'2. Sometimes transparent. The variety in long bright-green crystals is called glassy actinoUte; the crystals break easily across the prism. The fibrous and radiated kinds are often called nsbeatiform actinolite and radiated actinolite. Actinolite owes its green color to the ferrous iron present.

Ploochroism distinct, increasing as the amount of iron increases, and hence the color becomes darker: c emerald-^een, b yellow-green, a greenish yellow.

Absorption c> ti > a Zillerthal, Tschermak. Optically —. Eztinotion-angle ou A,c A<! = + 16° and Bx. A'J=-75". 2V, = 80"; p<v; y!, = l-627; y — a = 0025.

Niiined octlQulite from dtcTir, a ray, Bod kiVoi, lUme, a trauBlation ol tbe Oemua StraklilciH or niifiiilMt jfoii«. Nune chuuged 10 aeiinott by HnQy, vltliout reuon.

Nephkite. Jtule pt. A tougli, coDiiMCt, flue-erainiid Iremolite (or acttnolite), bre&klng villi a B|)liul«ry fracmre uud gliatenlo^ lusler ~ ~ - r, «.«» „., «....,.

a »iip[)osi;il elHcucy lu diar ' *'■" '—'

trblie ttreiuulile) Lo durk green fticiiaoiiH!/, m Lue iiuier iniii proioxine oeiDK preseni up lo 6 ui 7 p. c. TLu latter kind BoiDetlmea eucloses distinct priamatlc cryslHlB of actlnolite. A deritaiitiD fi'uiii an original pyroxeuic mlDflrul has been suggested lu some cases. Nephrite or jadu was broiigbt lu tlie form of carved orDamcots from Mexico or Peru soon after the discovery of Aiutricst. A similar atooe comes from Eastern Asia, New Zeslaod and Alaska See jadeite, p. 8U8: jude, p. 8S4.

AsBBfiTDB. AsliestuB, Asbvst Oerm. Tremollte, acllnollte, and otber Tarielles of sniphibale, exceptiu^ those coDtalniog mucli alumina, paas Into fibrous varieties, the flben of which are EOmetimes very lung, flae, flexible, aod easily separable by Ibe flneers. and look tike tliii. TbB!<e kinds are culled oAetUu (fr. the Greek for ineombvUbU), The color* vary from 'wbile to greeu and wood-brown. The name amianthut is applied usually to the flner and more silky kinds. Hiicb Ibut is popularly called asbestus Is chrytotUa, or flbrotu ■erpeollue, conlaiufng 12 to 14 p. c of water. Byuolitt is a stiff fibrous variety.

Mountain UaVter is in thin flexible sheets, made of interlaced fibers; and mottntain eorlt the same in thicker pieces; both are so light as to float on water, and they are often hydrous, colur white lo gray or yellowisli. Xountain wood U compact flbrous, and gray to brown In color, looking a little like dry wood.

Smaiuqditb. a thin-fojlated variety of ampUibole, near acilnolite in compoeitioD but cnrtyiiig snine iiliimlna. It baa n light gross-green color, resembling mucb common green dialfnge. In many cases derived from pyroxene (diallagc) by uralitizatlon, see below. It retains much of the structure of the disllage and also often encloses remnants of the original mineral. It forma, along wiili whitish or greenish saussurlte, a rock called sauesudte-gabbro the euphoildeof the Alps. The original niluernl is from Corsica, and the rock is the VfTiU di CvTvica duro of the arts.

Ubalite. Pyroxene altered to amphibole. The crystals, when distinct, retain the form of the oilsinal niinerul, but bave Ibe cli'iivage of ampbibole. 'Ihe change usually commences ou the surface, transforming the ciuttr layer Into an aggregation of slender amphibole prisms, parallel lu poitiiidn lo each oiher and to the p»r«nl pyroxeue (cf. Fig. 760, p. 386). Wbcu the change la complete tliu euiiro crretHl Is made up of a bundle of amphibolu needles or Ubers, The color varies from white (Ireuiolite) to pale or deep gr<en, Ihe latter Uie mote common. In composltliiu uniliie appears to conform nearly tu ai liunlile, as also lu optical characieis. The most prominent change in conipositlou in pusslug fioni the original pyroxene Is that corresponding to the difference exisiing between Ihe two speiles In general, ihnl is. an increase In Ihe miigni'slnm nnd decrease In calcium. The clmuee, therefore, is not strictly a case of pnrnmnrpbian), nltboiigb usually so designated. Unilil^ was originally deacribed by Rose lu a rock from the Urn). It has since been observed from many localities. The microscopic study iif rocks bus shown the process of " uralltizalion " to be very common, nnd some niitbais lejriu'd many homblendlc rocks and schists lo represent altered pyroienic rocks on a large scnle.

CiTMMiDaTONiTE. Ampblbole-Anihopliyllite, Iron - Magnttium Ainphe>ola. Here Iwlong curtain varieties of amphibole re.ieniblinc imthopbyllite and eosentially identical with it in composition, but optically mouoclinic. From Kongsberg; Greenland. The original tommiagtnniU is gray to brown in color; usually fibrous or Gbio-lamellar, often radiated. " = f51-!!'33; frnm Cummingtoti, Mnss.

D. . . . .

Colui Sweden.

OrOherite. Iron-Amphibole A=be8iiform or lamellar-fibrous. Luster sDky; color irown; G, = 8-718. Formula FeSIO.

3. RicHTERlTE. Sodium-Magnesium-Manganese Amphibole. (Ki^a„Mg, <;a,Mn),(SiO,)..

In elongated crystals, seldom terininaled. G. = 8-09. Color brown, yellow, rose-red. Transparent lo lran»Uicent. t a i = + 1T°-20°; 0, = 1'68: y-a = 0-fm. From Pnjs-Iwrc nnd LADgban. Sweden. Characterized by the presence of mangaoen and alkalies In Telaiively large amount.

II. Aluminous.

4. AldHIITOUS Auphibole. Hornblende. Gontaina alamiua or ferric iron, and usually both, with ferrous iron (Bometimea manganeBe), inagiieBium, calcinm, and alkalies. The kinds here included range from the light-colored edenite, containing but little iron, through the light to dark green pargasite, to the dark-colored or black hornblende, the color growing darker with increa:je in amount of iron. Eitinction-angle variable, from 0° to 37% see below. Pleochroism strong. Absorption usually c < b < a.

Edehitb, AlKininwu Magnttium-Calcium AmphiboU. Color white to gny fturt pale BTMD, and alio colorless; Q. = 3*0-3 DG9. BcBembles autbophylliteaudtreiiitilite. Named from tbe locality at Bdenrille, N. Y. To tlils variety belong various pa1e-colored amphl-facles. having less than 6 p. c, oF iron oxides.

KokikaTomte is a vnriety from tbe neigbbortaood of L. Baikal named after the Russian mfiieralogist, N. too Kokibsrov.

CouMuH Hornblende, Pasoasitb, Colors bright or dark green, aud bluish green to

f ravish black and black. Q. = S'0fi-8'4T. Pargata» is usually made to ioclude green and luiah-green kinds, occurriag in stout lustrous crystals, or gnmular; and Common hornbUnde the greenisli-block and black kinds, whether la stout crysials or longblailed, columDar, Sorous, or massive granulur. But no Hoe can be druwn between them. Tb« extinction-angle on i, or c a * = + 16' lo 25° chiefly. Ahsorplloti t > 6 > a.

PiM'gatHi occurs at Pargas, Finland, la bliiUL-green and grnyUli-blnck crystals, c A ^ = -f 18°; P = 164; y — a = O'OIQ; aV = 58°. PleochtolBm: c greenish blue; S emerald-greeu; a gm. yellow.

The dark brown lo black ttornbltniUt from basaltic and oilier Igneons rocks vary toniewhat widely Id optical churacters. Tbe angle c A i = 0° to + 10° chiefly; /J = 1-735; y -a — 0 072 (mnitmum). Pleochroism: c brown, 6 yclliiw. a yw. green, but variable.

The EataforiU of Norway (BrOgger) has (a i = 30° lo 60°; absorplion S > t > a; pleochroism: c yellow, b violet, ayw. brown; li. approilmales toward arfvedsonlte (p. 405).

Kupfferitt. from a graphite mine in tbe Tunkinsk Hts,, near L. Baikal, is a deep green amphibole (aluminous) formerly referred to nnthopbylKle. Syntagmatite Is the black hornblende of Vesuvius.

BtTgamatkiSe Is an iron-amphibole couluiDing almost do magnesia. FromMoDle Altlna, Province of Bergamo, Italy.

Eaerfititt is a tilanlferous ampblbole from Eoenut, Umanaks flord. North Greenland. Hiuti'liinU Is an amphibole low In silica and high in iron and soda, from the nephelite-syenite of Dungannon. Hnsllngs Co., Ontario.

Pyr. —Essentially the game as for the corresponding varieties of pyroiene, see p. 390.

Diff.— Diatlngidsbed from pyroxene (and tourmaline) by lis distinct prismatic cleavage,

yielding angles of 5<t° and 124°. Fibrous and columnar forms are much more commoa than

with pyroxene, lamellar and foliated forms rare (see also pp. 800. 398). Crystals often long,

792 slender, or bladed. Differs from rhe fibrous zeolites tn

not gelatinizing with nclds. Epidote has a peculiiir

green color, Is more fusible, and shows a aiSerent

cleavage.

In rock sections amphibole generally shows distinct W no colors, green, sometimes olive or brown, and is strongly

pleochroic. Also recognized by lis high relief ; generally nilher high interference-colors; by the ¥ery perfect system of cleavage-cracks crossing at angles of 6S* and 124° in sections i h (Fig. 792). In sections |& (010> (recognized by yielding no axial figure In convergent ligiil, by showing the hiehest interference-colors, and by having parallel cleavage-cracks, I i), the extinction-direct ion for common hornblendes makes a small angle (12°-15°) with the cleavage-cracks (is., with i); fuvllier. this direction la positive c (different from common pyroxene and Ezirite, cf. Fiin. 772 anil 77C). 6 6

Ot».—Amphibole occura tn many cryslaltlne limestones, and granitic and schistose locks, and sparingly in volcanic rocks. TrmioliU!, tbe maguesla-llme variety, is especially

commoQ Id Umnloties, parttculurly magoesiau or ilolomlttc; acUtulUt (ftim nephrite), (be magnesia-lime-iron TaiHety, iu steatltic rocks and witli BerpeDtioe; and dark greea aud black AerTMtade, iu chlorite scliUt, mica scbist. gneUs. aud in Taiioua other rocke of which it forms u MniBtitiient part; brown to black hornblende occurs In trachyte and uLher eniptlve rocka. Asbintiia la often foiled in coDQection with serpentine.

HorrMtiuie-Toek, or ainplJbolite, conalsiB of massive hornblende of a dark greenish black or black color, and hiie a granular texture. Occasionally the gretn hornblende, or nctiuii-lite, occurs in rock-maasea, aa at Bt. Francis, in Cimada. HoTitbUnde-iehUl baa the sniiie compoaiiion iia amptalbolite, but Is schistose iir shity in structure. It often contains a litile feldspar. In some varieties of ll the hornblende is In pari In minute needles. Uraniie and syeiiile often eontufii horiililende, and with diovite It is a common constituent. This la

o true of the corresponding forms of gneiss. Iu these cases It ia uaunlly pitssent in small.

regular masses, ofteu tlbrous in atriiclure : also as rough bladed crystuls.

Prominent foreign localities of amphibole are the following; Tremolitt (grammiitlte) in dol'imite at Campolnngo, Switzerland; also nt Orawltza. Itezb&nyn, Hungary; OulsjQ, Wermland, Sweden. Aetinoiite in the crystalline schists of the Central and Bnateru Alps, especially at Oreiuerlu theZlllertbal; at ZOblitz In Saxony; Arendal. Norway, A^eMlu* at Sterzing, Zillerthal. and elsewhere In Tyrol; in Savov; also In the island of Corsica. Paraatite iil Furgas, Finland: Sauaipe in Carlnthla. llombUnde.nt Aremlal and Kongsberg, Norway; in Sweden and Finland; atVesvifius: AussigandTeplitz, BubemliL;etc. JV^n'te, whicb In the form of " jade" ornameuta and utensils is widely distributed among the relka of early man (see Jade, p. SM), Is obtained at various points in Central Asia. The most important source Is that in the Karakash valley In the Eueu Luu Hts, on the soutliern borders of Turkestan; also other localities in Central Asia. In New Zealand. Nephrite has twen found in Europe as a rolled mam at Schwemmsal aear Leipzig; In Swiss Lake habitations and aiinllarly elsewhere.

In the United States. In Maine, black crystals occur at Tbomaalon; pareasite at Phippsburg. In VerToont, actlnolite in the aleatite quarries of Windham and Sew Fane, In Mom., tremollie at Lee; black crystals at Chester; asbeslus alPelham; Bummins/lonile nt Cummington. In Conn., in large flattened while cryslala and in bladed and fibrous forms (tremollte) in dolomlle, at Canaan. In N. York Warwick, Orange Co.; near Edenvllte; near Amity; at the Stirling mioes. Orange Co,; in short green cr7Blala at Gouvemeur, St. Lawrence Co.; with pyroxene at RuaselT; a hlnck variety at Pierrepnnt; at Macomb; Pitcalm: trcmolite at Fine; In Rosaie, 2 m. N, of Oxbow; In large white crystals at Diana, Lewis Co,; asbestos near Greenwood Furnace, In N. iTcrMj/. tiemolttc or gray amphfbol« in good crystals al Bryam, and other varieties of the species at Franklin and Newton, radlat^ actloolile. In Pmin.. actlnolite nt Mineral Hill, in Delaware Co,; at Unionvllle; at Eennett, Chester Co. In Maryland, nctinollle and nsbeatns at the Bare Hills in serpentlne;^ asbestUB Is mined at Pi'lesville, Harfonl Co, In Virginia, actlnolite at Willis's Mt,, la Buckingham Co.; aabestus at Bamet's Hilla. Fauquier Co, Nephrite occurs in Alaska.

In Canada, tremollte la abundant in the LFiurentlan limeatones. nt Calumet Palls, Litchfield, Ponilac Co., Quebec; also at Blylhlield, Renfrew Co., and Dalbousle, I^nark Co. Black hornblende at various localities in Quebec and Ontario with pyroxenf. apatite, titanite, etc.. ns in Renfrew Co. Aaliestus and mountain cork at Buckingham, Ottawa Co., Quebec; a bed of actlnolite at St. Francis, Baauce Co., Quebec; nephrite has been found in British Columbia and Northwest Territory.

OLAnOOFHANE,

Monoclinic; near ampfatbole in form, Cryetals prismatio in habit, usually indistinct; commonly maaBive, fibrous, or columnar to granular.

CIcaTRge: m perfect. Fracture conchoidalto uneven. Brittle. H. =, 6-6'5. G, = 3-103-3'113. Luster yitreoua to pearly. Color azure-bine, lavender-blue^ bluish black, grayish. Streak grayish blue. Transloceut. Pleochroism Btrougly marked: c aky-blue to ultramarine-blue, ti reddish or bluish violet, a yellowish green to colorless. Absorption C > b > o, Optically -f-. Ax. pi. \b. C A f = 4*' to 6", rarely higher values. 2E^, = 84° 42'. ^ = 1-6442 fgastaldite); y ~ a = 0-033.

Comp.-Esaentially NaAI(SiO,),-(Fe,Mg)SiO,. If Mg : Fe = 3 : 1, the formula requires: Silica 57'6, alumina 16'3, iron protoxide 7-7, magnesia 8'5, soda 9-9 = loo.

Ob*.—Occure as tlie liornbltridic couBlItueul of certain crjatalltae scbUla, called ffUtveo-pJiaiu-achiili, or glaucopliaDite; ulso more ur less promiueut la mien scblsta, nmplilboiltea, gaelss, eclogltes, etc. 11 is oHna associiited willi mii^ii. esruet, diallage and omphncile, epidote and zdeite.etc. Rrst deKribed frucn Ibe UJand of Syra, ODe or uik Cyckdes; sinca showi lo bu rather widely ilislribated, ub on the aoutlieru ulupe of the A.\\>a IgoMialiiitt), Corsica. Jupaa. eic. BlioduHte U a fibrouB variety from ibe Is. Rbodiis.

Ill Ibe U. B., glaucopLane Bcbists biive beeu described from Ibe Coast Riiiiges of Call-foriiin. IIS al Sulpbur Bmik, Lake Co.

Qlttucopbiitie is oamed from y^ctvKoi, bhiiA grean, and 0aiv(a&'H, to appear.

Monoclinic. Aies a:t:i= 05475 : 1 : 0-2925; /3 = 76° 10'. In embedded prismatic crystals, longitudinally striated. Cleavage: priamatic (56°) perfect. Luster vitreous. Color black. Pleocliroisin very atrongly marked: C green, b (= fc) deep blue, it (nearly || r.) dark blue. Optically —. Extinc-tion-angle small, a f\ d = ^"-b" (±?). Aiiai angle large.

Comp.—Essentially 2NaFe(SiO,),.FeSiO, = Silica 50-5, iron sesqDioxide 26'9, iroD protoxide 12-1, soda 10-5 = 100, It corresponds closely to acmite (tegirite) among the pyroxenes.

ObB.—Origioally described from tlie granite and eyeaite of llie bland of Socotra in Ibe Indlim Ocean, 120 m. K. E. of Cape Guardaful, Ibe eaalern eilrcmllj of Africa; occuib in groups of priginatic cryslaU, ofteu radlatiug and cloMly resembling tourmaline; also in crano-pbyrc blocks found at Ailsa Cidg and at other points in BcoUhdJ and Ireland. A similar amphibole occurs at Mynydd Mawr, CarnarvoDsliire, Wales. Alto another in granulite In Corsica. A so-called arfvedsonlte from BC. Peler's Dome, Filie's Peak region, El Paso Co., Colorado, occurring witli astropbylllte and zircon, is shown by Lacroiz to be near rlebeck-iie. Extinction-angle oab, a a ^ = 8° to 4°.

OROOIDOLITB. Blue Asbestus.

Fibrous, asbeatas-Iike; fibers lon^ but delicate, and easily separable. Also massive or earthy. Cleavage; prismatic, 56°. H. = 4. G. = 3'20-330, Luster silky; dull. Color and streak lavender-blue or leekgreen. Opaque. Fibers somewhat elastic, Pleochroism: c green, b violet, a blue. Optically +. Extinction-angle on b, inclined 18° to 20° with 6. 2E = 95° approx. y — a = 0-025.

Comp.—NaFe(SiO.),.FeSiO, (nearly) = Silica 49-6, iron sesquioxide 32-0, iron protoxide 19'8, soda 86 = 100.

Magnesium and <^lcium rcplncc pari of Ibe ferrous iron, and hydrogen part of the

Pyr., etc.—In the closed tube yields a small amount of alkaline water. B.B. fuses easily with In tumescence to a black magnetic glass, coloring tlie flume yellow (soda). With the fluxes gives reaclions for iron, Uuftcted upon by acids.

Oba.—Occurs in South Africa, in Qrlqualand-West, north of the Omnge river, in a range of quartzose schists called the Asbestos Mountains. In a micnceous poqihyiy near Pnimont, in the Vosges. At Golling in Snlzburg. In tbe U. 8., a! Beacon Pole Hill, near Cumberland. R. I. Emerald Mine, Buckingham, and Perkin's Mill, Templeiou, Ottawa Co., Ontario, Canada.

AbriimhaniU is an earthy amorphous form occurring in the Abrlacban district, near Loch Ness, Scotland. Crocidolite is named from KpoKii, voof. In allusion to its fibrous

The South African mineral is largely altered by lioth oxidation of the Iron and Inflltra-tion of silica, resulting in a compact siliceous stone of delicate fibrous structure, chaloyaut luster, and bright yellow to brown color, popularly called (^^ar-*^ (also C"l's-eye and yaaerquarz, Tigerauge. Palkeuaiige (bluish var.) Germ.). Many varieties occur forming

ARF VBDSONITB.

Monoclinio. Axea i:b:i = 0'6669 :1 : 0 2978 ; /S = 73° 2'.

Grjatals]ong prisms, of ten tabtilar Q J, but seldom diBtinctly terminated; angles near those of amphtbole; also iu prismatic aggregateB, Twins: tw.pl. a.

Cleavage: prismatic, perfect; b teas perfect. Fracture uneven. Brittle, n, = 6. G. = 3*44-3'45. Luster vitreous. Color pure black; in thin scales deep green. Streak deep bluish gray. Opaque except in tliin splinters. Pleocbroism strongly marked: c deep greenish blue, b lavender, a pale greenish yellow. Absorption c > b > a; sections || a are deep greenish blue, |j i olive* green, fi = 1'707; v — a = 002T. Extinction-angle on b, with d, = 14°.

Comp.—A slightly basic metasilicate of sodium, calcium, and ferrous iron chie&y; an analysis by Lorenzen gives:

Q. 8iO, A1,0. Fe,0, FeO MnO M■■O CsO N«,0 K,0 H.O ERiigerdluarfmk8'44 43-85 4'4S StlO S8-48 0-45 ' 61 465 815 1 (W 015= lOO'SO

Tbe supposed ftrfvedsoDlte from Oreenlaad analyzed by von Eobell, Itbg.. etc.. bas been sliowu to be Kgirite; Ibat from Pike's Peak, Colorado, analyzed by Koenig, hu been rererred to rlebeckiie.

Pyr., etc.—B.B. fuses at S with Intumosceuce to a black magnetic globule; colors the flame yellov (soda); witb the fluxes g^vea TeactioDs for Iron and mutignQeee. Not acted upon by acids.

, Ob*.—ArFvedsoolte and amphiboles at similar chanicter, coalainiDg much iron and soda, are common constUueuts of certain igueous rock wbicli are rich in alkalies, as uephe-lite syenite, phonolite, etc. Bhrge tiiid dlsllnet crystals are found only in ihe pepmatite veins iu sucli rocks, as at Eungerdluarsuk, Greeiiluud, where the auociated mineniis are Bolalite, eudialyte, feldspar, etc. Arfvedsoniie occurs also \a the nepbelile-syeniieB and related rocks of Ihe Cbristituita vegion iu soiitlieni Norwar: on the Sola peiiiosiila in Russian Lapland: Dungaonon township, Onlnrloi Trnns Pecos district, lexas. Ihe related brownish pleochrDlc ampbiboies (cf. barkevlkfte) occur in similar rocks at Montreal, Cauadn; Red Hill. New Hampabire : Saletii. Mass.; Miignet Cove, Ark. ; Black Hill£, Bo. Dukoia; Sqiiaru Uultc, Montana, etc.

C^rnfntf is a soda-ampLibole near arfvedsoniie (7'62NatO) from a rock in tbe ueighbor-Looii ot Sail Francisco.

BARKEViitiTB. Au ampblbole near arfvedsonite but more basic. In pilsmatlc irys-t:ds. CWvage: prismatic (.15° 44i'). G, = 3-428. Cidor deep velvet-black. PIcocbroiBK> marked, colors brownish. Bitioction-anrle with i on i = 12^°. Occui-aat tbe "Ohierile locality near Barkevlk, on tbe Langesund fiord, and elsewhere iu soulbern Norway.

Snlgmatita. Cossyrlte. Es^ntinlly a titnno-sillcate of ferrous iron and sodium, but containing also aluminium aud ferric Iron. In prismatic tricliuic cryetals. Cleavage: prismatic, disliuct (88°). G. = 8'74-8-80. Color bliick. ..DiiigmBtile is from tbe sodaiile-syenite of Tunuudliarfik aud Kaugerdluarsuk, Greenland. Couvrite occurs In minute crystals embedded in Ibe liparile lavua of Ihe island Pantellaria (ancient name Cossyra).

BBRTIi.

Hexagonal. Axis d = 0-4989.

Crystals usually long prismatic, often striated vertically, rarely transversely; distinct terminations exceptional. Occasionally in large masses, coarae columnar or grannlar to compact.

Cleavage: c imperfect aud indistinct. Fracture conchoidal to uneven. Brittle. H. = 7-5-8. G, = 2-63-3-80; usually 2'69-2T0. Luster vitreous, Fonetime resinous. Colors emerald-green, pale green, passing into light blue.

ie-Tci. Streak white. Tranaparent to fiabtruu-lucent. Dichroiam more or less distinct. Optically—, Birefringence low.

fellow and white; also pale iicent. Dichroiam more o: Often abnormally biaxial, oo =

1'5830, e = 1*5765 aqnamarine.

|<^^^S (^^^^

ep. 0001 A 10!l ■= S»' 664',

00, 0001 A 1122 = ae- sr.

et, 0001 A ll2l = 44° 58'.

jip'. loii AOiii sas'sii'.

V«r.—1. Bmeratd. Color bright emerald-greeo, due to tbe pi'eseuce of a little chro-tniuiD ; highlj prized as a geni whan cle&r Htid free From flnwB.

2. Ontinarj/; Beryl, ^iierally ia itexngoonl prisms, oflvn coarse and large ; green the COminnn color. The prlaclpal kinds are : (a) colorless; {}>) bluish green, ci\\)eAaqriiunariiie;

ie) apple-creen ; (d) greenish yellow lo irou-yellow and lioney-yalliiw ; sometimes a clear irlght yellow as in tlie gtHden btryl; (e) pnle yellowisb green ; (/) clear sapphire-bliie; {g) pale sky-blue ; (A) tbe pale violet or reddisli ; (i) the opaque brownish yellow, of waxy or greasy hiswr. The oriental emerald of Jewelry is emernldjcoiored sapphire.

Comp.—Be,A],(8iO,), or 3BeO.Al,0..6SiO, ^ Silica 67-0, alumina 19-0, glucina 14-0 = 100.

Alkalies (Na.O, Li,0, C8,0) a to 5 p c. : also cbemically combined n H,Be.AliSi,iiO„.

Fyr.. etc.—B.B. aloae. unchanged or. If clear, becomes milky white and clouded; at a high temperature the edu;ea are rounded, and ultimatelj a Tesiciilnr scoria is funned. Fiisihillty = S'S. but Eomenlint lower Tot beryls rich lu alkalies. Olass with borax, clear nnd coUirless for beryl, a Hue greeu For emerald. Unacted upon by acids.

DM.—Characterized by its greeu or greenish-blue color, glaasy luster aud heiagooal form ; rarely massive, then easily mistaken for quartz. Dlstiuguirfied From apatite bj its liarduess, not beiog scretchi.'d by a liuife. also harder than green tourmaline ; From cliryso-beryl by its form : from euclase and topaz)>y lis Imperfect cleavage.

Obi.—Beryl is a common accessory mineral In granite veins, especially in those of a pegmatltic character. Emeralds occur in clay slate, in isolated crystals or in nesta, near Muso, etc., 73 m. N.N.B. of BogotA, Colombia. Emeratdaof lessbrauty, but larger, occur iu Liberia, oo the river Tokovoya. N. oF BliatertDburg, embedded Id mica 8chl»'t, Emeralds of lui'ge size, though doi of uniform color or free From flaws, have been obtained in Alexander Co.. N. C.

Transparent beryls are found In Siberia, India and Brazil, In Siberia they occur at Mursinka and Shaliaukii, near Ekaicrinburg : u^r Miask with topaz : iu tbe mountains of Aduu'ChnloD with topaz, in E. Siberia. BfautiFul crystals also occur at Elba: tbe tiu miui^s of Ehrenfrfedersdorf lu Saxony, and Bchlnckenwald iu Bohemia. Other locniities arc the Mourne Mts., Ireland : yellowish green at Rubialaw, near Al>erdeen, Scotland {davidMniU): Limoges iu France ; FInho and Broddho iu Sweden ; Tamela lu FiDland: Pfilsch-Joch, Tyrol ; Bodeniiiaia and Robcnslein in Biivnrla ; iu New South Wales.

In the United Stales, l)eryl8 of gigantic dimensions have been found in N. Hamp., at Acwcrth andOiaflou, and in JfTM..at Royalslon. In J/xi/10, at Albnuy : Norway : Bethel: at Hebron, a casium beryl (CsjO, a 6U p c), aasociiiled with pollucite ; in Piuis. with black tuurmallue; at Topsiiam, pale green or yellowish. In Jfau.,at Barre; at'Oashen(^A'niie<), and at Chesterfield Id Conn., at Haddam, and at the Middlctown mid Portland feldspar quarries; at New Mllford, of a clear golden yellow 10 dark amber color; Branchvtlle. In

Fenn., nt LelpervDle Bud Chester; M Hiaenl Hill. Id Virginia, at Amelia Court-House, ■nrtietlmed white. Ia2f. Oaratina, In Aleiaoder Co., near Stonj Point, flue emernlds ; iu

MiicUell Co.: Morguiiou, Burke Co., aud elsewhere. la Alabama, Coosa Co., of u light yellow G»l»r. Ill Colorado, near tlie summit of Ht, Aotero, beautllul aquamariues. Iu & Dakoi/i, ill the Black HllU Iu turge crystals.

Endlalyta. Essenllully a metasilicate of Zr,Fe(Mn},Ca.Na, etc In red U> biowD Ubiilnr or rhombobedral crystals t also massive. H. = 5-5'5. G. = 2-9-3-0. Opilcally+■ i'rom Kaugordluarauk, West Qreenlajid, etc., with acfvedsonite and sodalile; nl Lujaor on ilie EoIh peiiiusula, Russian Lapland, iu eltenlite-syenite, there forming a main constituent of ihL- rock-mass. BiteoUU, from Islands of the Liiugeauud fiord in Norway, is similar (but (ipticall; ~). Eudlalj-te and eucolite >i1so occur at Hagnet Cove, iu Arkansas, of a rich criiuaoD lo petich-blosBom red colore in feldspar, with elteoliie and ngiritc.

Elpidite. Nu,0.ZK)i.fl6iOi.SH,O—Massive, fibrous. 0. = 2-54. Southero Green-

The following are rare species of complex composition, all from the Lange-sund fiord region of southern Norwaj.

Oatapleiite. H,(Nat,Ca)ZrSi.Ou- Id Ihlu tabular hexagonal prisms. H. = S. G. = 28. Color light yellow lo yellowish brown. Natron-eala^eiiU, or soda-calapleilte, cod-tRins only sodium ; color blue lo gray aud while; on healing tlie blue color disappears.

Oappolenita. A boro-i^ilicute of yltrium and barium. Iu greenish-brow d hexagonal

Melanocerite. A Buo sUicait of the cerium and yttrium metals aDd calcium cblefly (also B, Ta. etc.). !□ browu lo black tabular rhomboheclnil crystals

Carjroceilts. Near melauucerile, contalnuig ThOi.

Stbkenbtbdpine (from Greenland) is allied to the two last-named species.

Trltomlte. A fluosilicate of thorium, the cerium and yttrUim metals and calcium, with boron. In dark brown crystals of acute triangular pyramidal form.

The following are also from the same region:

Leno<q>luuiita. Na(BeF}Cn(BIOt)]. In glaasj greenish tabular crystals (orlhorhomblc-sphenoidal). H. = 4. G. = 2M.

Meliphanlte. A fluosllicale of beryllium, calcium, and sodium near leucophsnlt In low square pyramids (tetragonal). Color yellow. H. = B-6-6. G. = 801.

lOUTB. Conlierite. IHcbroite.

Orthorhombic. Axes a:l:f! = 0-5871 :1 : 0 5585.

Twins: tw. pi. wi, also d (130), both yielding pseudo-hexagonal forms. Hahit short prismatic (mm''' = 60° 50') (Fig. 299, „5

p. 94^. As embedded grains; also massive, compact. '

Cleavage: b distinct; a and c indistinrt. Crystals f^

often show a lamellar structure || c, especiallj when ulightly altered. Fracture subconchoidal. Brittle. H. - 7-T5. G. = 2-60-3-66, Luster vitreous. Color various shades of blue, light or dark, smoky blue. Transparent to translucent, Pleochroism strongly mai'ked except in thin sections. Axial colors variable. Thus:

Bodenm^s <(=5l dark Berltn.bliie t(=<i) light Berlin-blue a (= ^} yellowtih wbite

Absorption c (i) > b («) > a {6). Pleochroic halos common, often bright yellow; beat seen in sections | 6, Exhibits idiophanous figures. Optically —, Ax. pi. | n, Bx. X ». Dispersion feeble, p < W. 3V = 70° 23' (also 40° to 84°). p, = 1549; y - or = 0008.

Comp.— H,{Mg,FG).Al.Si„0„ or H,O.4(Mg,FeO).4Al,O,.10SiO If Mg : Fe = 7 : 2, the peroent&ge composition is: Silica 49'4, ammJaa 33*6, iron protoiide 5*3, magnesia lO'S, water 1'5 = 100. FeironB iron replaces part of the magQesiam. Calcium is also present in small amoant.

Pyr.. ato.—B.B. losea tTnuspareDcy and fuses U SS'B. Oa\j partially decomposed by aclda. DecompoHed on fusion wUli alkaline carbonates.

DlfF.—Cbaracterlsed by lu vitreous luster, color and pleocbrolsm; fusible on tbe edges unlike quartz; lesa hard IJjan lappbire.

Recognized in tbln sectious by lack of color; low refraction and low loterference-colors; it is very simitar (o quarts, but dlstingulahed by Its bluiial cbaracter: In voloiuic rocks conimoDly sbowa distinct crystal outlines aud a twinning of three tiidlTlduals like ameoti-[te. Id the gneiasea, etc.. It la Id formleBs grains, but the common occurrence of iDcluaions, especially of sillimanite needles, tbe pleocbroJc lialos of a yellow color aivund small Inclu-slouH, particularly zircoDS. aud tbe constant tendency to alteration to micaceous pluite seen aloDg cleavagea, help to diBtingulah it.

Obi.—Occurs In granite, gneiss (Mrdierite-gneitt), bomblendic, cblorltic and talcose achiat. nnd allied rocks, with quartz, orlhoclase or albite, tourmaline, horobieude, andalu-aite, silllmanite, garnet, and sometlmea berji. Leas commonly in or connected witb igneous rocks, thus forroeil directly from the magma, as in andesiie, etc.; also In ejected maaaes (la frngmeuts of older rocks); furtber formed as a contact-miDeral Id cODnection witb eruptive dikes, as in slates adjolomg graolte.

Occurs Rt Bodenmala, Bavaria. In granlle, witb pyrrholite, etc; Orijarvi, iu Flnlnnd {ateinhtiliU); Tuunberg, In Sweden; in colorless crystals from Brazil; Ceylon affords a tninspaient vnriety, the laphir d'eav of jewelers.

In Ibe U. B.i nt Haddam, Conn., associated with tourmaline <" a granitic Tein iu gneiss. At BrimSeld, Mass.: at Richmond, N. H.

Named loUld from lor, doUt, aud XBoi, ttone; Diehroite (from Sixoaoi, Iwo-eobyrtd). from its dichroism ; Cordierite, after Cordler, the Freocb geologist (1777-1B61).

The alteration of iollle lakes place so readily by ordinary exposure, that the mineral is most commonly foimd in an altered state, or euclosed in tne altered tollte. This cbange may be a simple hydration ; or a removal of part of Ibe protoxide bases by carbon dioxide ; or Ibe inlrodiiclioa of oxide of Iron; or of alkalies, forming pinile and mica. The Urst siep tn the cliange consists In a division of tbe prisms of lollte Into plates parallel to tbe iMnv, and a pearly foliation of thesurfacesof these plates: with h cbange of color to grayish ^reeii and greenish gray, aud sometimes brownish gray. As the alteration proceeds, tbe foliaibu becomes more complete; afterward It may be lost. The mineral lu this altered (»nditiou hns many names: os hydrotit ioliU (inc). bontdorfflU and auraliU) from Alio, Finland; fiilituniU from Falun. Sweden, also jiyrargilliu from Helslngfors; etmarkiU and prat«olitt from near Brevik, Norway, nlso raumiU fiom Riiumo, Fiulaiid, and pepUtlile from Itains-berg, Sweden: cMorophyllUe from Unity, He.; a»paiioliU; and polyehroilite from KragerO There are furtberalkallne kinds, ha pinite, ea(atpiliU, giganiotiU, ^nte. XnAonj^ag to tbe Mica Group,

The following are rare lead and'barium silicates: BaiyslUtc. Pbi8i,0i. In embedded mnsses with curved lamellar at

age: I'nsiil. H. = 3. G. ^ eil-BS.'i, Color white; tarnishing on exposure. From

tbe Hiirstig mine, Pnjaberg, Sweden.

Oanomalit*. Pbi8l,07.(Ca.Mn),SiO.. In prismatic crv«tals (tetragonal); also massive,

fmnuliir. H. = 3. G. = 574. Colorless \o gray. From L&ngban, Sweden; also akobslx'rg. HyaloteUts. Approximately (Pb,Ba,CaVB,(810,)ii. Massive : coaraely crystslline. H. = 5-5-5. G. = 3-Bl. Color wliite to pearly gray. From L&ngbau, Sweden.

BaiyUte. Ba.Alt3i;0,i. In eroups of colorless prismatic crystals. H. = 7. G. = 408. Luster grcnay. Occurs with bcilypbaiie iu crystalline limestone at L&ngban, Sweden.

BoeblingiU. 5(H,CaSiOt|.3(CaPbSO,). In dense, white, compact, crystalline masses. H. = 3. Q. = 8-438. From Frankliu Furnace, N. J.

m. OrthoBUiofttea. R,8iO..

Salts of OrthoBilicio Acid, H,SiO,; obaracterized b; an oxygen ratio of 1 : 1 for Bilicou to bases.

The following list includes the more prominent groups among tbe Ortbo-silicates.

A. number of bulc orlboalltcatee nre Lere fucluded. whicb yield wiiter upon l^ltion; also oiliers wLkh ai« more or lata bBsic tljau u nnrmal ortboslllcale. but whicb are of necessity Introduced here Id the clasaiflcution, because of tbeir rebiliouBliip to olber Dorinal Bilra. Tbe Mica Ohoop is ao clowly related to many Hydrous Silicates tliat (wUb also Talc, KaoHuiie. nod some otbera) it is described later with iheui.

Nephellte Group. Hexagonal. Scapollte Oroup. Tetragonal • py-

Sodalite Qroup. Isoiretrio. ramidal.

Helvtte Qroup. Isometrio-tetrabe Zircon Group. Tetragonal.

dral. Daiibiirite Group. Orthorboinbi&

Garuet Group. Isometric. DatoUte Group. Uonoclinic.

Cbrysolite Group. Orthorhombic. Epidote Group. Honoolinic Pheuacite Oroup. Tri-rbombohe-

dral.

Nephellte Group, Hexagonal.

Typical formula RAISiO..

Hephelite K,Na,Al.Si,o„ i = 0-8389

Soda-nephelite (artit.) NaAlSiO. Enoryptit« LiAlSiO. KaliopMUte KAISiO,

Canorinite H,Na.Ca{NaCO,),Al,(SiO,), 2i = Q 8448

aicrosDmmite (Na,K),,Ca,Al„Si,.o„SGl. 2<! = 0-8367

The species of tbe Nbphblite Group are hexagonal in crystalltiation and have ill part tlio typical orthosilicate formula EAlSiO . From this formula iiephelite itself deviates somewhat, though an artificial soda-nephelite, NitAlSiO., conforms to it. The species Cancrinite and Microaommite are related in form and also in composition, though in the latter respect somewhat complex. They serve to connect this group with the sodalite gronp following.

NEFHELITB. Nepbeltue.

Hexagonal-bemimorphic (p. 73). Axis i = 083893.

In thick six- or twelve-aided prisme with plane or modified summits. Also massive compact, and in embedded grains; structure sometimes thin columnar.

Cleavage: m distinct; c imperfect. Fracture snbconchoidal. Brittle. II. = 5-5--6. Q. — 2',^5-2'65. Luster Titreous to greasy; a little opalescent in some varieties. Colorless, white, or yellowish; nlao when massivp, dark green, greenish or bluish gray, brownish rod and brick-red. Transparent to opaque. Optically —. Indices; <y, = l'042, e, = 1'538.

Var.—], JfepheliU. dltiMy.—Usually In Bmall glassy crystals or grelDS. trnnspuieut vitb Tilreous luster, first found ou Mie. Soruma. Cliaracterlgtic particulurly ot yuuiij^r eruptive rocks atiil lavas. 2. Elaolite.—la large coarse cryslala. or more co.iiiiioiily uiua-sivt, nitli a greasy luster, aiid reddisU. greeniah. browaiHli or gray in color. Usually clouded by minute inclusions. Characteristic of granular crystalline rocks, syenite, etc.

Comp.—R.Al,Si,0,.; if R = Na:K = 3:1, this is equivalent to3NaO.K,0. 4A!0..9SiO, = Silica 44*0, alumina 33-2, Bodii 16-1, potash 7-7= ICO. Id most analyses Na : K = 4 : 1 or 5 : 1.

Syntlieiic experinieLts, yielding cryelals tike sephellte with the composition NnAISiOt, lead to the codcIusIod tliat a uaturul Boda-acplielltc! would be an ortljusilicuEe with this formula, while the higher silica lu tlie potash varieties m]iy be explained by the presence, hi molecular combination, of EAlSiiOi or EtO.AIiOi.4SiOg (= leuciie). Tlie other species of the group Lire uormal orthoxilictites.viz., eucrypUli: LIA.ISiO,, and kaliophillle, KAlSiOi.

Pyr,, eto. —B.U. fuses quietly ut Jt'5 to a colorless glaas. tielatiniiies wiib ui'ids.

Diff.—Distluguisbcd by its gelatini^ing with acids from scapoUte and feldspar, as also fnim apatite, from wblch it differs loo in its greater hardness. Massive varieiies have a cliarncjleristic Ereaay luster.

R^'cogiiizca iu tbiu srcllons by its low refraction; veiy low interference-colors, whlcb scarcely rise lo gray; parallel exliuclion when in crystals; ftdnt negative uniixial croat yielded by biiaal secllous in converging light. The uegulWc character is best told by aid of the seleuile pbite (see p. 201). Mlcro-cbemical tests serve to distinguish uon-chui-aiteristic particles from eimilnr ones of iilkali feldspar; liie section is treated with dilute acid, and Ibe lesiiluiut gelatinous silica, which coats the nepbellte particles, etalned with eosiue or othfr dye.

Obs.—Neplielite I3 rather widely distributed (as shown by the microscopic study of rocks) in igneous rocks as the product of crystal I izalioii of a magma rich in sodn and at Ibe

Bame time low in silica (which last prevents the soda from being used up in the foimalion of albite). It is thus an essential component of the nepbeliie-syeiiites and pbonolites where it is associated with alkali feldspai's chiefly. It is also a constituent of more basic augitic rocks such as nepbeliuile. uepbelile-basalts, neplielite-tephrites, lliernlite, etc., most of which are volcanic in origin. The vuriety eUrolite is associated with the granular plutonic rocks, while the name nrplulitf was originally used for the frisli glassy (;rjBtai8 of the modern lavas; the terms have in this sense llie same relative siguiGcauce as orthoclase and eanidlne. Hoderii usage, however, tends 10 drop the name elaolite.

The original ntphelite occurs in crystals In the older lavas of Mte. Somma, with mica, vesuvianile. etc.; at Capo di Bove, near Rome; in Ihe Imsalt of KaUenburkel, near Heidelberg; Aussig in Bohemia; Ltfliau In Saioiiy. Occurs also In mascive forms and targe course crystiils {elaoUte) in Ibe nephelile-syenltes of Southern Norway, especially along the Langesund fiord; sitni'nrly in »«it Qreenlnnd; the peninsuhi of Eoln; Miask in the Itmen Mis. (in the rock miateUr): Sierra Monchlque. Portugal (\n the rock/o^aito); Ditr6, Hungary (in the rock (ii(ro/rt); Pousac, Prance; Brnsil: South Africa.

Elicolite occurs mas.slve nnd cryslalllxed at Litchfield. He., with cancrinite; Salem, Mass.; Red Hill. N. H.; in tlie Ozark Mts.. nciir Hiignet Cove, Arkansas; elKoli1e-syenit« Is also found near Beemersville. nortlieru N. J.; uenr Montreal, Canada; at Dun cannon township, Ontario, in enormouB cryslnls. Neplielite rocks iiisn occur nt various poinis, as tlie Tninspecos diatr.. Texas : Pilnt Butte. Texas; also In western N. Americti, as in Colorado at Cripple Creek; in Monlimn, in tlie Crazv Mi«., the Higbwood, Bearpaw and Judith MU ; Black Hills in So. Dakota: Ice River, Brilisli Columbia.

Named nepheliU from rfipfXrt. "■ 'loud, in allusion to its becoming cloudy wheD immersed in siniug acid; etixoUU is from eXaCi^v, oil. In allusion to lis greasy luster.

Qieieekitt Is a pseudomorph after nephelite. It occurs in Greenland >n six-sided green-iah-grav prisms of grenay tusier; also at Diana in Lewis Co., N. Y. Tyytynla-ibiU from DiaDii is similar to gieseckite. as is also lUb«neriU. from the valley of Fleims, in Tyrol. See further Ptnite under ilie Mica Group.

BuorypUte. LiAISiO,. In symmetrl'-ally arranged cryatala (hexagonal), embedded In albite and derived from the alteration of apodumcne at BrHQchvllle, Conn, (see Fig. 474, p. 141). Q. = 3-667. ColorlesH or while.

KaUophilite. KAISiO,. Phacelllle. Plincellte. Facetllle. in bundles of slender scicniar crystals (hexaeonal), also in fine threads, cobweb-like. H. = S. G. = 2 498-2003. Colorless. Occurs in ejected masses nt Mte. Sorama.

OAHOBUnTB.

Hexagonal. Axifl i = 0"4224; and mp = 64°, pp' = 26" 58'. Rarely in priBmutic crystals witli a low terminal pyramid. Usually massive.

Olearage: prismatic (m) perfect; a less bo. H. = 5-6. G. = 3'42-S'5. Color white, grny, yellow, green, blue, reddish. Streak iiucolored. Laster subvitreous, or a little pearly or greasy. Tratiaparent to translucent. Opti< cally uniaxial, negative.

Comp—H.Na.Ca(NaCO.).Al,(SiO.),or3H,0.4Ka,O.Ca0.4Al,0,.9SiO,.2CO, = Silica 38-7, carbon dioxide 6-3, alumina 39'3, lime 40, soda IT 8, water 3 9 = IW.

Pyr., ate.— Id the closed [ube gives water. B.B. loees color, and fiiees |F. = 3) with IniiiuieBceuce Ion white blebby gliiw, ilie very eiisy fuBlWlity diatingnisbing it readily from uepliellie. EBervesces witb hydrochloric aciil, and fiiriUB a jelly ou lientins, but uot before.

Dlfi.—Recognized In ibin seciloiig by its low refraction', quite blgb ioierfereQce-color* anil negntive iiolaxial cbnracier. Its common as.wciaLioD with nepbelile, sodalite, elu. are valuabli' cbamcti'rixlica. RvoliitloD of CO, with acid dlatiDgulshea it from ail other min. erals except \\>e carboaates, wbicb abow much biglier interference-colors.

Obs.—Cancrinile occurs oul; in Igneous rucks r>f the nepbelile-syenile nnd related rock yroH]is. Ii is 111 part Iwlievcd lo be original, i.e., formed directly from the molten magma; ID part held lo be secondary and formed at the expense of nepbellte by infillratinE waters holding calciiini carbonaie In solutiou. Prominent locilitiesarc Minsk in Ibellmen Mts., In -Goaivegniliiei) Dephelite-syenite; slnillarly at Bnrkevik and olber localities on ibe Laoge-■iiiiil Uiird in Eouihern Norway; In the parish of KnolajSrvi In norlhem Fluhind (where, associated with orllioclase. (eglHle and oepbeliLe, ii composes a mass of cancrlnite-syenite); at Dilr6, Transylvania, etc.; in nephelite-syenite of Sttrna and AlnO In Sweden, nnd in Brazil; also in small amoutit as an occasional accessory component of many pbonolitic rocks at various localities.

In the United St-ites at Litcbfldd ami We!>.i Qanliucr, Me., with elKolite and blue sodo-llle. Nameil after Count Ciincrin, Itnsaian Minister of Finance.

Hiorosonunlte. Near cane finite; perhaps (Na.E^iDCaiAliiSlnOifBClt). In minute colorless prismatic orystols (hexagonal). Fitini Vesuviun (Mocte Sooima). H. = 6. G. = 2-42^2 53.

Davtnb is in part at least microsommlle. From Mte. Somtoa.

Sodalite Group. Isometric.

fiodaUte N«,(AlCl)Al,(SiO,),

Hafiynite (Na„Ca),{NaSO,.Al)A],(SiO.),

Hoselite Na.(NaSO..AI)Al,(SiO,),

lazurite Na,{NaS,.Al)Al,(SiO.),

The species of the Sodalite Group are isometric in crystallization and perhaps tetrahedral like the following group. In composition they are peculiar (like cancritiite of the preceding group) m containing radicals with CI, SO and S, which are elements usually absent m the silicates. These are shown in the formulas written above in the form suggested by Broggef, who shows that this group and the one following may be included with the garnets in a broad group characterized by isometric crystallization and a close resemblance in composition. See further under the G.vrnkt Group proper, p. 414.

The formulas are also often written as if the compound consisted of a silicate and chloride (sulphate, sulphide)—thus for sodalite, SNaAlSiO, + NaCI,

SODAUm.

Isometric, perhaps tetrahedral. Common form the dodecahedron. Tvins: tw. pi. o, forming Deiagonat priama by elongation in the direction of an octahedi^ axis (Fig. 368, p. 133). AIbo mosaiTe, in embedded grains; in concentric nodules resembling cbalcedacy, formed from elteolite.

Cleavage: dodecahedral, more or leas diatiiict. Fi-acUire conchoidal to nneven. Brittle. H, = 5'5-6. G. = 2-14^2*30, Luster vitreouB, sometimes inclining to greaer. Color gray, greenish, yellowisli, white; sometimes blue, laveuder-blne, light red. Transparent to translucent. Streak uucolored. tiy = 1-48S7 Na.

Comj.—Na,(AlCl) Al,(SiO,). = Silica 37-2, alumina 31-6, soda 25-6, chlorine 7'3 = 101-7, deduct (o = 2C1) 1-7 = 100. Potaasium repkces a email part of the sodium. The formula may also be written 3NaA!SiO. + NaCl.

Fyr.. ttc,— Id Ihe closed tube the blue varieties become white and opaque. B.B. fuses with uilumescence, at 8'5^, to a colorleu glass. Decouiposed by hydrochloric acid, witb MpsrHliun oi gelatlDOUS silica.

I>ifF.—Recogoized in thin EecUoua by Ita very low rerractiou. Isotropic character aad lack of good cleuvage: also, in most caaes, by its lack of color. Diallngulalied from much annlcite. leuctle nnd haUyoitc by chemicnl tests alone; dissolvfug the miueml in dilute ultric acUi iind tesliaK for cbloriue is Ibe simplest and best.

Oba.—SodsTlle occurs only in igDGOus rocks of tbe nephellte-syenite and related rock groups, either directly, as Is commonly tbe case, ds a product of the crystal Hz a lion of a magma rich Id soda; also as n product associated with enclusFcl masses and bombs ejected wItb sii' !i magmas in tbe form of lava, as at Vesuvius. Ofieii a'<soc!ated wiih nephelite (or elxolite), cancriulta and eudialyte. Witb sanldiiie It forui a todnUtt-iraeltyte at Scar-nipata In Iscbia, iu crvslala. In Sicily, Val dl Nolo, with nephelite and iiiialcite. At VcsuviiiB, Id Itombs on Afonle Sonima in white, tmostuceut. dodecahedral crystals; massive and of a gray color al tbe Kaiseratiihl; also near Lake Loach. At D[lr6, TmnsylvaDln. in an elsolile.syenlle. In liie foynile of soutbern Portugal. At Minsk, in the Ilmeu Mts.; lo'tlie AUglte-syenitc of the Langesund-flord region)u Norway, Further in West Green-hkud iu sodalite-syenllc; Ihc peninsnla of Kola.

A blue massive variety occurs at Litchfield and West Gardiner. He. Occurs Id the theralite of the Crazy His., Montana: also at Square Butte, HIgbwood Mis., and la Ihe Bearpaw Mts., Id liiiguaile. Occurs also Id the elseolite-syenlte of Brome, Brome Co., and of Montreal and Belteil, province of Queliec; at DuDgannon, ODIarlo, In large blue masses and iu sumll pale pluk crystals.

HADTMITB. IlaOyne.

Isometric. Sometimes in dodecahedrons, octahedrons, etc.

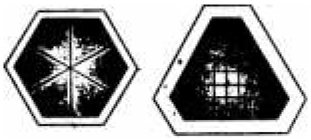
Twins: tw. pi. e; con tact-twins, also polysynthetic; pen strati on-twins (Fig. 367, p. 123). Commonly in rounded grains, often looking like crystals with fnsed surfaces.

Cleavage: dodecahedral, rather distinct. Fracture flat conchoidal to nneven. Brittle. H. = 55-C. (i. =■ 2'4-2'5. Luster vitreous, to somewhat greasy. Color bright blue, sky-blue, greenisii bhic; asparagus-green, red, yellow. Streak slightly blnish to colorless. Subtransparent to translucent; often enclosing symmetrically arranged inclnsiona (Fig. 7'JT). ji, = 1'4961.

Comp.-Na,Ca(NaSO..Al)Al,(SiO.),. Tliis is antilogous to the garnet formtila (Brogger) where the place of the R, is taken by Na,', Ga and the group Na-0-SO,-0-Al. The percentage composition is: Silica 33"0, sulphur trioxide US, alumina 27-2, lime 10-0, soda 16-6 = 100. The ratio of Na,: Ca also varies from 3 : 2; potassium may be present in small amount. The formula may also be written 2(Na„Ca)Al,(SiOJ, + (Na,,Ca)SO..

Pyr.. etc.—In ihe closed tube retatos its color B B. in Ihe forceps fuses at 4'5 to s white ghiss. Fused wilb soda on Wiarcnal ntfords ii KUlphide. wliieh blackens silver. I>ecom[>osed by bydrocUloric acid with sepuialiiiD uf gulaliuuus silica.

I Melfl, on Mt. Yullur. Naples; ia tliu Invus uF the CBtnpsgon, Rome, also



Section of crjsUla of liaujnite (ftfrer HOhl). In the peperino near Albano; at NIedermendig. Id tbo Eifel; the plionolltes of HobeDt-wiel.

Hoaellta or Noseau. Near bft&yDite, but coutaius little or no lime. Color grayisli, 1j1u<!>Ii. browuisb; sometimes nearly opaque from Ibe preseoce of iucliisloiiB (cf. Fig. TOT). Noi uiicommou in phoDollte. At AaderDach. Ibe Laaclier Bee, &Dd elsewhere.

LAZURrm. L apis-La ZULI. Lnaurlle.

laometric. In cubes and dodecahedrons. Commonly massive, compact. Cleavage : dodecaliedral, imperfect. Fracture uneven. H. = 5-5'5. G. = 2-38-3'45. Luster vitreous. Color rich Berlin-blue or azure-blue, violet-blue, greeiiisli blue. Translucent.

Comp.— Essentially N'a.(NaS,.Al)AI,(SiO), (Brogger), but containing also in molecular combination haiiynite and sodalite. The percentage composition of this ultramarine compound is as follows: Silica 31'7, alumina 2ti'9, soda 2r-3, sulphur 16'9 = 102-9, or deduct (0 = S) 3-9 = 100.

The bL'lerogeueou3ChiiractcrornLalbndloni;piLBsediiBa simple mluersl iiaderlhe Dnme Lnpis-luKuli was shown by Fiscber (1889), Zirkel (1873), and more fully by Vogelaaag (1878). Tlie oi'iliiinry natural lapi» Intuit (Lasiirsieiii) is sbowu by BrOgger aud B^ckstrOm lo cou-tain taziiriie iir baQjniie iBnraelimes cbaiiged to a ztolile), a diupside free from Irou, nmpbi-Imle (boksbaro ite). mica (miiscovite), cnlcitc. pyrlle: alfo in some varieties in relaliveiy small amount stapolite, plagioclase, orihodase (microperthite?), apatite, tltauite, zircon, and nn nnileiennjiied mineral optically + and probably uniaxial. Regarded by BiCggeras a result of contact melnmorpbism in lime=toiie,

Pyt., etc.—Heated in ilie closed tube gives off pome moisture; the variety from Cbill gions with ft bcplle-green llgbt, but Uio color of the mineral remains blue on cooling. Fu^es easily (3) n<[h intumesrcnce to a white gliiss. DiTomposed by bydrocbloric acid, Willi aepnratioii of gelatinous silica and evniuiinn of bvdrogen sulpliide.

Obs.— Occurs In Badakahan in ttiH valli'y of lb'- Kokcha. a brancli of tbe Oxus, a few miles a)>ove Firgamu. Also at the snulh end' of L. Baikal. Further, in Chili in tbe Andes of Oviille. In ejected masses at Monle Simima. rave.

The richly colored varieties of lapii lawili are bicblv estoemed for cosily vases and omamoiital furniture; also employed in the manufacture o(nio'aics; and when powdered constitutes the rich and durable paint called ultramarine. 'I'bU bas been replaced, however, by artidcial ultramariae. now an iui|)ortaiit commercial product.

Helvlte Group. Isometric-tetrahedral. Helvite (Mn.Fe),(Mn,S)Be,(SiO.),

Sanalite (Fe,Zn,Mn),((Zn,Fe),S)Be,(SiO,),

Eulytite Bi.{SiO,).

Zimyite (AI(OH,F,Cl),),Al,(SiO,),

The Helvite Group includes several rare species, isometric-tetrahedral in

crystallizatioQ and in composition related to the species «f the Sodalite Gbouf sod also to those of the Oabnet Qbocp wbicn follows:

Isometriotetrahedral. Commonly in tetrahedral crystals; also in spherical masses.

Cleavage: octahedral in traces. Froctare uneven to conchoidal. Brittle. H, = 6-65. G. = 3*16-3 36. Luster vitreous, inclining to resinous. Color boae;-yellow, inolinine to yellowish brown, and siskin-green, reddish brown. Streak uncolored, Subt ran a parent, n = 1'739. Pyroelectric.

Comp.—(Be,Mn,Fe),Si,o„S. This may be written (Mn,Fe),(Mn,S)Be,(SiO), (Brogger), analogous to the Garnet Group, the bivalent gronp -Mn-S-Ma taking the place of a bivaleot element, B, and 3Be corresponding to 3A1, cf. p. 415. Composition also written 3(Be,Mn,Fe),8iO..(M:n,Fe)S.

Pyr., etc.—Fuses at S In R.F. with liitiimescetjce Lo a yelluwiBh-brown opnque bead. becomluc darker in H.F. Willi tbe fluxen gives the mniigmiese reacllon. Dicunipo&ed bj' hydroi^bfoHc ncid, with cToliilloii uf bydrcc^n sulpliidu and sepBtntlou of gelBtiuoua silica.

Ob».—Occura at ScliwBricolierg und Breiieuhriiiin, iti Saxony; at Knpiijk. IIun;ciiry; also In tlie pegmatite veins 'if tbe niij^lte-sjenite n(Die Lniie<^Bund fiord; Iti tlie lluieu Mrs. Deiir Minsk in pcgmalile. In Ibe U. S., witb spesBHrtlte at the mica miiiea near Anieila Court-House, Amelia Co.. Va.; etc. Named bj Werner, In allusion to its yellow color, from ^\toi, Iht ijin.

DanaUte. (Be,Fe.Zn.KD)iSliO,i8. In oclabedroosi usunllT maaslve. H. = 55-6. O, = 3437. Color fleab-red to gniy. Occurs In smnll KHLiDS in tlie Rockport gniulte. Cape JLdu, Mass.: at tlie Iron mine iit Bartletl, N. H.: El Paso Co., Culurodu.

Bulvtitfl. Bi,8ito.i. Wlammhblende, Kieselwiamutb 0-rm. Usually in mioiiie tetrahedral cryeuds; also lu spherk-al forms. H. = 4-5. Q. = 5-106. Color dark hair-browD to grayisli, atraw-feliow. or colorless. Found with native bismutb near Schnec-berg, Saxony; also at

JoiiunngeorgeuBladl In crystals on quartz.

Zunylte. K highly basic orthnslllcale of aluraintiim, (A.l(OB.F.CI>i)tAl,SliO„. Id minute transparent tetrahedrons. H.= T. 6.=^ 3'875. From the Zu&l mine, near Bilver-ton, San Jaan Co., and on Red Monnlain, Ouray Co., Colorado.

4> Garnet Group. Isometric E.E,(SiO.), or 3BO.R,o,.3SiO,.

E = Ca,Mg,Fe,Mn. B = Al,Fe,Cr,Ti. Oftrott

A. Gbossulabite Ca,Al,(SiO.), D. Spessartite Mn,Al,(SiO,),

B. Pyropb Mg,Al,(SiOJ, E. Andradite Ca,Fe,(SiO.).

C. Almandite Fe,AI,(8iOJ, Also (Ca,Mg),Fe,{SiO.)„

Ca,Fe,{(Si,Ti)o,), F. UvABOViTE Ca,Cr,(SiO,), Sohorlomite Ca,(Pe,Ti).C(Si,Ti)o,),

The Garnet Group includes a series of important sub-species inclnded tinder the same specific name. They all crystallize in the normal gronp of the isometric system and are alike in habit, the dodecahedron and trapezo-hedron being the common forms. They have also the same general formula, and while the elements present differ widely, tbere are many intermediate Tarieties. Some of the garnets incltide titanium, replacing silicon, and thus

the; are connected with the rare apecies soborlomite, which probably also has the same general formula.

Closel; related to Ibe Gabnkt Gnovr proper are the species ot the Bodallte and Helvlte Groups (p. 411, p. 413). All are cbaractcrized by Isometric cry stall! zalion, uad all are orthoaillcates, with aimilar cliemical itructure. Thus llie formula ot the Garuet Group is

U|Rt(S1o,)i; lo this Sodallte conforms if wr biraleot radical AlCl are equivalent In Ri; si[i>f the hivalent group Na8oi-AI is esauined,

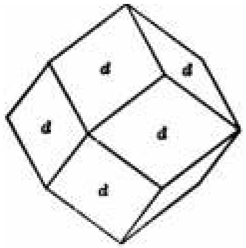
111 the Helvlte Group, whlcb is cbaraclerlzcd b; the tetrabednd character of the species (perhaps true also of the Sodnlites), the cheniical relation is leas close but probably exists, as exhibited by nrUing the formula of Helviie (Mu,FexHQ,a)Be.(SiO.)i. where the bivaleDt group -8-Mu-8- euLers, aud 8Be may be regarded as tuklug the place of 3A1.

QASNET.

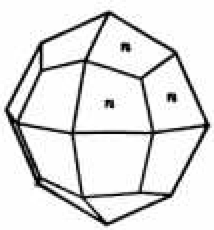
Isotnetric. The dodecahedron and trapezohedron, n (211), the common simple forms; also these in combination, or with the hexoctahedron « (321). Cubic and octahedral faces rare.

Often in irregular embedded grains. Also massive; granular, coarse or fine, and sometimes friable; lamellar, lamellae thick and bent. Sometimes compact, crjptocrjstalline like nephrite.

7&8.



801.



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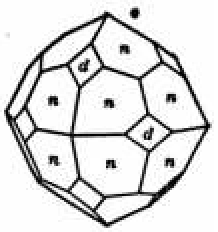

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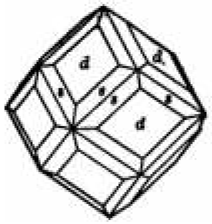
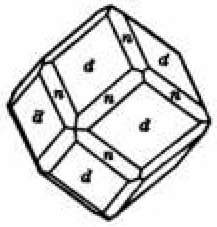




Parting: d sometimes rather distinct. Fracture subconchoidal to uneven. Brittle, sometimes friable when granular massive; very tough when compact crjrptocrystalline. H. = 6*5-7'5. G, = 3'15—1'3, varying with the composition. Luster vitreous to resinons. Color red, brown, yellow, white, apple-green, black; some red and green, colors often bright. Streak white. Transparent to eubtranelncent. Often exhibits anomalous double refraction, especially grossularite (also topazolite, etc.), see Art. 411. Befractive index rather high, thus n, for:

Groawilarite 1-7646, Pyrope 1-T77«, Almaudlte 1-7716.

.dbyGooglc

Comp^ Tat. —An orthosilicate having the general formnia R,U,(SiO^), or 3RO.R,Oi.3SiO,. The bivalent element may be calcium,.magneHium, ferrous iron or manganese; the trivalent element, alnmininm, ferrio iron or chromiam, rarely tttauiiim; further, silicon is also sometimes replaced b;^ titanium..

Ibere are three pTominent groups, and various Bnbdivisions under each, many of these blending into each other.

I, Aluminium Garnet, including

A. Gbossulakite Caloinm-AlumiDiam Garnet Ga,AI,(SiO,),

B. Ftbope Magnesium-Aluminium Garnet Mg,Al,(SiO,), o. Almanditb Iron-Aluminium Garnet Fe,Al,(SiO,), D. Sfbbsartite Manganese-Aluminium Qamet Mn,Ai,(SiO,), IL Iron Garnet, including

K Ahdeaditb Oalcium-Iron Garnet G»,Fe,(SiO^),

(1) Ordinary. (3) Magueaian. (3) Titaniferous. (4) YttriferouB. III. Chromium Garnet,

F. Uyabovitb Calcium-Chromium Garnet Ca,Cr,(SiO.).

The Q&me Oftroet U from the Ln[f d granahis, roeauiDK lik« a grain, aod directly from jMmegranalt, the seeds of whicL are small, numerous, ana red, in allusion to tbe upect ot the cryBtale.

A. Grosbdlaeite. Eaaonite or Heasonite. Cinnamon-stone. Calcium-nluminium Garnet. Formula 3CaO.Al,0,.3SiO, = Silica 40 0, alumina 22 -7, lime 37'3 = 100. Often containing ferrous iron replacing tbe calcium, and ferric iron replacing aluminium, and hence graduating toward groups 0 and E. G. = 355 to 366. Color (a) colorless to white; (i) pale green; (c) amber-and honey-yellow; (rf) wine-yellow,brownish yellow,cinnamon-brown; (e) roae-red; rarely (/i emerald-zreeu from the presence of chromium. Often shows optical anomalies (Art. 411).

Tbe orlgiDsl groirularitt {miuitt pt.) Included Ihe pale green from Siberia, and was so named frum the botnnlcal Dame for Ihe cooseberryi 0- s 3-43-9'72. CinnamoH'ilont, or euoniu (niore properly hutonite). Included a cinnamon-colored variety from Cey)6n, there called hyaeintli; but unjler this n^une tbe yellow nnd yellowish-red kluda nre iiauaUT Included: named from r/a-a-ay, inferior, because of less liarduesB llinn Ihe true hynctntn which it resembles. SueeiniU is an amber-colored kind from the Ala valley. Piedmont. BomanzaniU is brown.

Pale green, yellowisb, nod yellow-brown garnets are not invariably groRsiilariie; some (Including topazolite. demaniold, cic.) belong lo Ibe group of Calcium-Iron Onruel, or Andredilc.

B. Pyhopb, Precious garnet pt. Maqnesiam-alumhiium Garnet. Formula ;i.MgO-A!,0,.3SiO, = Silica 44 8, alumina 25'4, magnesia 29-8 = 100. Magnesia predominates, but calcium and iron are also present; the original

Eyrope also contained chromium. G. = 3'T0-3-75. Color deep red to nearly lack. Often perfectly transparent and then prized as a gem. The name pyrope is from nvpa>7i6i, fire-like.

HIiodoliU. of delicate ahndea of pale rose-red and purple, brilliant by reflected light, correaponda iu couiposItioD to two pans of pyrope and one of almandite; from Macon Co.,

C. Almandite. Almandine. Precious garnet pt. Common garnet pt. Iron-aluminium Garnet.

Formula 3FcO,Al,0,.3SiO, = Silica 36-3, alumina 20-5, iron protoxide 43'3 = 100. Ferric iron replaces the aluminium to a greater or less extent. Magnesium also replaces the ferrous iron, and .thus

it graduates toward pyrope, of. rbodolite above. Q. = 3'9-4'3. Color fine deep red, transparent, in precimis garnet; brownish red, translucent or Bab-translucent, in common garnet; black. Part of common garnet belongs to A nil indite.

Tlie AlatintidkcnrbuDCleaof Pliuy were so culled because cut and polished at Alabacda. Heuce tbe oamo atmuudiiie ur ftlmaiJdile, uuw in use.

D. Spessartitb. Speasartine. Mangatiese-chtminiiim Garnet. Formula 3MnO.AI,0,.3SiO, = Silica 36-4, alumina 20-6, manganese protoxide 4S0 = 100. Ferrous iron replaces tlie manganese to a greater or less eitent, and ferric iron also the alnminium. O. = 4*0—1*3. Color dark hyacintb-red, sometimes with a tinge of violet, to brownish red.

E. Andradite. Common Garnet, Black Garnet, etc. C'afciwm-iron Gamei. Formula 3CuO.Fe,0,.3SiO, = Siiicii 35-5, iron sesquioxide 31-5, lime 33'Q 1= lUO. Aluminium replaces the ferric-iron; ferrous iron, mauga-nese and sometimes magnesium replace the calcium. G. = 3-8-3'9. Colors various: wine-, topaz- and greenish yellow, apple-green to emerald-green; brownish red, brownish yel'ow; grayish green, dark green; brown; grayish black, black.

NoniEii AndradiU after tlie Portuguese mlneralnglsi, d'Aodrada, wLo lu 1800 dcsrHbed and iiniiied oue of ibe incliuied subviiiieties, Allcwliroiie. Cbenileally tbere are ibe following vurifiiea;

1. Simple Calciiijn-iron Qnrnei, In nljich tlie protoxides are U'liully or tilinoet wLolly Hme. Include*: (u) Tupatolite, baviog the color and ttans|>iiri.iicy of Inpiiz, -"' ' -

snmetimei gri'en; cryhiaIs often Bboning a vicinal heiDCIabedron. X/emantoid, a Eniss-)tieeii to enierald-green varleij wlili brilliant dinmoDd-like luster, used as a crm. (b) Colopl-onite, a coarse granular kind, browuUh yellow lo dnrk reddieh brown ia color, rcaiiiniis in luster,

_ .. _iually wiih Iridescent liuee; iinmed nfier tbe resin colophony, (e) NaU-vilt (fi'<i___. ji^Xai, bl'iek), black, eltber dull or lustrous; but nil bluck gsrnel is i.oi here included. I'urentiie U graylsli black melniilte. (d) Duvk green garjiet, not distiti^uibbable (I'um some allorbmite, eicept by cbemlcid Iriiils.

S. Manganiuiart Calcium-iron Oarittt. (o) Sothiygile. The ovlginal atlofkroi

igitiiesiaD irou-gnrnel oi browu or reddisL-browu color, and uf flue-gniinid r

. Hot/iome, from LSiigUiin, is dinilar, yellowish browu to llv "

kinds of Tnungancsiaii iroti-garnet are ligLt nuil dark, dusky gie

Uothomfe, from LSiigUiin, is siniilar, yellowish browu to llvet-bronD Olbcr

Linds of Tnungancsiaii iron-garnet are ligLt imd dark, dusky giecii nod black, and

often in crystals. PoCymletphiU is a miissive browuisb-ytllow iiud, from Franklin Fiiniuc

N. J. Brtdbtrffile, from Sa\a. conlains a large amount of magnesia, <A) Aplcme (prnperiy

..___, ,___=._^.. . . ., ,..:,. _„., --■-■--■' -Hi, wliei.ce Hat-

sluipler iban ll dudecahedroD. he gdvi; it a mime derived froui dnXun', simple. CuIot oi Ibe oi'lgfiul

iiBplome) bas lis dodecaliedrai faces sirialed imnillel lo tlie sborttr diagonal, wlienci inferred Ibat the fundamental form was tbe cube; iiml as tbis form U sluipler iban Ibe

.... . e (of unknown locality) dark browu: nlso found ^ellowlsb green and bvowuisb green at Scbwarzeiibei'g iu Siixony, and ou tlio Lena in Siberia.

3. TUanifermiii. CoutaJna thauinm aud probably liotb TiO, and Ti.Oi; formula hence 8Cao.(Fe.Tr,AI),O,.3(8l,Ti)o,. It Ibiis graduales toward seliorloniile. Color black.

4. yttr^erimt Caleiam-iron Qarnet.-Ttlergranal. Conlains yltria iu small amount;

F. UvAROViTE. Ouvarovifce. tJwarowit. Calcium-cltromium Garnet, Formula 3CaO.Cr,o,.3SiO, = Silica 35'9, chromium sesquioiide 306, lime 33-5 = 100. Alamininm takes the place of the chrominm iu part, H. = 7*5. G. = 3'41-3'52. Color emerald-green.

Pyr., ato.—Moat rarielles of gurnet fuse easily lo a ligUt brown or blnck glass; F. = 8 In almandlte, spessartite, groaaulnrite, and allocbroite; 8'S tu pyrope; but uvarovite, Ihe I-11 route-gurnet, is almost Infusible. F. = 6. A.ltocbrolte and altnanillte fuse to a magnetic globule. Re:ictions with tbe flnics vary wftb llie bases. Almost all kinds react for Iron; Btr>iig ninngiineM reaction in spe'sanile. and less marked iu other varielies; a cbrumium re:tciioii In uvarovite. and in most pvropt. Some varieties are partially decomposed by iidils* all except uvarovite are after ignition decomposed by liynrocblnric acid, and generally with separation of gelatlnoiit silica on evapop,tion. Decomposed on fusion with i.liuiliiio carbonates.

Tlie dcDsIty of gurnets is largely dimluisbed bj fuaion, Tbus a GreenlaDd girnet fell from 3'90 to 8'05 on fusion, and ii Vilui gro-isularite from 8-63 lo 3'95.

DUE,—Characterized by isometric crystullization, usuidly in isolated crystals, dodecahedrous or trapezobedrons; massive forms rare, then usually granular. Also disliogulsbed by hardaess, vitreous luster, and in llie common kinds tbe fusibility, Veeuviaoile fuses more easily, zircon aud quartz are infusible; the specific gruvity is higher tbsn fur tourmuline, from nbich it differs la form; it is much hBrder than spbalerite,

Distlogulslied in tbiu sections by Its very high ivllef; lack ul cleavage; isotropic character; usually sbona a pale pink color; t^ometimes not readily told from some of ihe sninels,

letamorpliosed i nWomorphic pro

commouly found in the contact zone of ioli-uded igneous rocks nod in the cryslallioe schists. AlmaruiiCa Is characteristic of tbe mica schists and metamurpbic rocks contaiciog alumina Bod iron: it occun also la some Igneous rocks as the result of later <lynniiiic aod metamor-pbic processes: it forms with smamgdite tbe rock eclogite. Pyropa is especially characteristic of sucb basic Igneous rocks as are formed from magmas contaloiug much magnesia and iron with little or uo alkalies, as the peridolites, dunltes, etc.; also found in the serpeutines formed from these rocks; then ofteu associated with spinel, chromlle, etc. SpaiarliU occurs in granitic rocks, in quartzite. In wbetslouu schists (Belgium); it haa beeu iioted with topaz in lithopbysea in rhyolite (Colorado), Tbe black variety of andradite, melanile, is common in eruptive rocks, eapecialiy with uephellte, leuclte, thus In phouolitea, g_. leucitopbyres, neplieliuites: in sucb casus often titanifer-

^^ ous or Biisociated with a tilaiiiferous garnet, sometimes in

zonal Ititergrowib; it also occurs iis a pnxiuct of contact metamorphUm. Demantoid occurs iti serpentine. Uvatv-viU btloiigs paiticuliivly with chromlle iu serpentine; it occurs also in granular llnestoile,

Ganiet crystals often contain Inclusion!! of foreign matter, but only in part due to alteration;)i , vesuvianiie, calcite epidote. quartz (Fig. 4T2, p. 141); at times tbe garuellsB mere shell, or perimorph, surrouniliDg a nucleus of another species. A black giruet from Areodni, Norway, contains both calcite nnd epidote; crystals from Tvedestrand nre wholly calcile within, there being but a tbiii crust of garnet. Crystals from East Woodstock, Maine, are dodecabedroos with a thin shell of citiD;k-mou-sloue enclosing calcite; others from Baymund, He, show successive layers of garnet aod calcile. Many such cases have hern noted.

Garnets ute often altered, thus to chlorite, serpeniini:: even lo limoiiite. Crystals of pyrope are sometimes surrounded by a chlorltic zone (kelyphite of Scbrauf) not homogeneotiB. as shown in Fig. 804,

Among promluent foreign localities of garnets, besides Iliose already mentioned, are the following—GiLOSHui.AHri'EL: Fine eiiinaraon-tloat comes from Ceylon; on tbe Hussa-

Alp Id tbe Ala vnlley iu Piedmont, with clinochlcire and diopaide; atZermatl; paleyellowal Auer-bach; brownish {romamovUt) at Kimilo in Finland; honey-yellow oelalitdTont in El In; pale greenish from the banks of tbe Vilui in Siberia, in serpentine with veauvianlte: also fi-om Cziklowa and Orawiiza iu Ihe Banat; with vesuvlanlte and woliaatoulte in ejected masse.'! hi Vesuvius: in while orcolorlcss crystals in Tellemark, in Norway; also dark brown at Mudgee, New South Wales; dark honey-yellow al Guadslcazar, aud clear pink or rose,red dodeca-hedrous nt Morelos, Meilco.

Pykupe: In serpenti[ie (from perldotlte) near Meronltz and the valley of Krema, in Bohemia (used as a gem); at ZOblitz in Saxony; in the Yosges; in tbe diamond diggiugg of South Africa ("Cape rubles"), Aluanditk: Common in granite, gneiss, eclo^te, etc., in many localities in Saxony, Silesia, etc.: at Eppenreuth near Hof, Bavaria: in large dodecahedrons at Falun In Sweden : hyacinth-red or brown in tbe Zillerthal. Tyrol. Precious garnet comes in line crysinls from Ceylon, Pegu. British India, Brazil, and Greenland, Sfbbsartitb: From AscbaSenburi; in the Speaaart, Bavaria; al St, Marcel, Piedmont; near Chnoteloube, Hauie-Vienne. etc.

Andradite: The beautiful green dnnantotif or"UrHlIaoemendd"occurs in transpnrent greeniab rolled pebbles, also in cryslais. in the gold washings of Nizlmi-Tagilsk in the Ural; green crystalsocRur at Schwarzenberg, Saxony; brown to green at Morawitza and Dognacaks; emerald-green al Dobschau; in the Ala valley. Piedmont, tbe yellow to greenish topaaatitt. AlioehroiU, apple-green and yellowish, occurs at Zermatt; black crystala (mtlaattt), alio

browD. at VmutIu* oh Hie. Somma; near Barigef Id tlie Hauies-PyrSnSes (pgreiitila), ApU^me occurs at BcbwarzeDberg in Haiouy, io bruwu to black cryBtals. Other localllIeB are WlMlilhul, Tjrul; LAugbaii, Sweden; Pitfearjuia, Finlaod; Areudni, Norway. Uvakotitb: FuuDil at SHraiiovskiiyit Dear Bisersk, also in Ihe viclulty of Kyeblymsk, Uriil. iu clirumlc iroB; lit JordansmOh], Slleala; Pic Posets near VSnuaque In the Pyrenees ou cbitinilte.

In N. Amtrlcfi. in Maine, benutlrul cryetals of cinnamou-stOQe Ivilh TVBuvlaiilte) occur at PnnonBfleld. Phippsburg. nud Ruinron). In N. Hamp., at HaooTer, amall clear cryMala it) gneiss; iit Warren, ciDUiimon gurnets; at Qraftun. In Vmnont. at New Fane, ia clilorile Ntaiu. tn itfiiu , iu guciM iit Bmokfleld; iu flue dark red or nearly black tnipezoliedral cryainls >it Riissell, gomeilmes very large. In Conn , trapezobedrous, In mica Blute. al Reading 1111(1 Monroe; dodecaliedroiia at Boullibury; at Bodilam, crystals of Bpessarrlle. In iV. York, bruwn crvHlals al Crown Polut, Essex Co,; cnloplionite aa a large vein at WIllHboni, Essex Co.; in MidtDetown, Delaware Co.. large brown cryst.; a clnniimou variety at Amity. In N. Jerteg, at Franklin, black, brown, yellow, red, ami green dodecahedral gurnets; also near ibc Franklin Furnace (polyadeiphiie). Iu Penn., In Chester Co., at Peunsbury, fine dark brown cryaiaJs; near Kuauertown; at Cliestflr, brown; In Concord, on Green's Creek, reaembling pyrope; in Leiperville. red; at Mineral Hill, fine brown: at Avondiile quarry, fine Le'isonile; uTarovlte at Woods' chrome mine, Lancaster Co. In Virginia, lieaullfu) transpareut speasartite, used aa a gem, at the mica mines at Amelia Court-House. Id N. Carolina, fine clniianioii-slone at Bakersvltle; red Karneta in the gold washing of Burke, McDowell, and Alvxaiider counties; rhodolite In Macon Co.; also mined ncnr Horiraiitown Hud Warlich, Burke Co., to be used as "emery." and as "garnet-paper." In iSsnlitcky, fine pyrope iu the peridotite of Ellis Co. Iu Arkatua*. at Magnet Cove, a titaniferous melanite with schorlomit« Large dodecaliedral cryslalB altered to cbloriiG occur ut the Spurr Mt. iron mine. Lake Buperlor. In Colorado, at Natbrop, flue spessaniie crystals in liihophyBBs iu rhyollLe; in largedodecohudral crystals at Buby Mr., Salida. Chnilee Co., tbe cxlerior altered to chlorite. Id Artnna, yellow.green crystals In the Gila caflon; pyrope on the Colorado river In tbe western part of the territory. New Mexieo, fine pyrope on the Navajo reservation with clirysnlite and a clirome-pyroxene. Iu Caltfomia. green with copper ore. Hope Valley, El Dorado Co.; uvarovjle, in ciyMnls on cbromiie, at New Idria. Fine crystals of a rich red color and an inch or morb In diameter occur In tlie mica schists at Fort Wmngell, mouth of tbe Btiikcen R., In AUuhi.

In Canada, at Marmora, dark retl: at Grenvllle, a cinnamon-stone; an emerald-green cbrome-gnrnet, at Orford, Quebec, with mlllerlle and calcite: fine colorless to pale olive-green, or brownish crystals, at Wakefield, Ottawa Co.. Quebec, with white pyroxene, honey-yellow vesiivianlte, etc., also others bright Ki'een cnrrylng cbroroltim; dark red garuet Iu the lowDshlpi of Vllleneuve (spessarlite) and 'Templelon.

achorlomlte. Probably analogous to garnet. 8CaO.(Fe.Ti},Oi.S(8l,Tl]Oi. Schorlamlt. Uauallv massive, black, with conchoidat traclure and vitreous luster. H. = 7-7B. G. = 8-81-8-68. From Magnet Cove, Arkansas.

Partachinite. (MD,Fe),Al,Si.O„ like apeasartile. In small dull crystals (monocUnlc). H. = 6-S-7, O. = 4-006. Color yellowish, reddish. From the auriferous sands of OIAbpian, Transylvania.

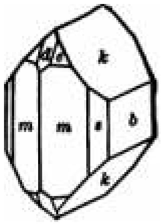
Anlcollt«. Same a* for eulytlte, Bi.SftOi,, but moDocllnic. In globular or »euU globular forms. From Jobanngeorgenstadt.

The Chrysolite Group includes a eeries of orthoailicateB of magneBiam, calcium, iron and maugaiiese. The;^ all crvstallize in the orthorhombic Bystem with but little variation in axial ratio. The prismatic angle is about 50 , and that of the unit brachjdome about GO"; correBponding to the latter threefold twins are observed, 'i'he type species is chrysolite (or olivine), which contaioB both roaguesium and iron in varying proportions and is hence intermediate between the comparatively rare mugjieBiuni and iron silicates.

Ill form llie species of the Cliryaoliie Gioup. B.SiO., sre closely relnted iu nngle to ChrjBoberyl, BeAiiO,; ulso somewhat lees closuly lo ihe species of Ihe Diospore (Troup, H,AI,o„ uic. Cr. UrOgger, Zs. Kryst., 18. :)T7, IHOO. There Is also au interesting relalfOD betweeu Uie chrysolileB and the bumites {see p. 443)

oBRT8oUTB. OlivlDe. Peridot. Orthorhombic. Axes &:h:t = o46575 : 1 : 0-5865. 805. 806. ram'", HO A 110 = 40° 57*.

m", 120 a 120 = o4° 4'. dd\ 101 A iOl = 108" 6'. kk. 021 A 021 = W V. *)'". Ill A III = 40" 6'. JT" 181 A l5l = 73' 18". Twins rare: tw. pi. h (Oil) with cc = 60"* ", penetration-twine. eometimeB repeated; tw. pi. w (013), the vertical axes crosEiitg at an angleof about ;iO°, since cc- 32° 41'. Crystals often flattened || (x or A (cf. Fig. 62, p. 3T), less commonly elongated Q 6. Massive, compact, or granular; in embedded grains. Cleavage; & rather distinct; a less so. Fracture conchoidal. Brittle. H. = 65-7. G. = 32i-337, increasing with the amount of iron; 3'.'>7 for hyalosider-ito (30 p. c. FeO). Luster vitreous. CoJorgreen— commonly olive-green, sometimes brownish, grayish red, grayish green, becoming yellowish brown or red by oxidation of the iron. Streak usually uncnlorcd. rarely yellowiBh. Transparent to translucent. Optically -i-. Ax. pi. [c. Bx J. n. Dispersion p < v, - ■'- "" -"■■>-'" yi^ = 1-678. Birefringence high, y — a = 0-036.



weak. 2H,^, = 105° 58'.

—PreciDV*.—Of a psie yellowisL-greeu color, and liau spa rent. Q. = 3-441, 8351. lally seen la mitsaes us >arge as "u turkey's egg." but usually much snialler. It been brniigbt from Ihe Ijeviiul for Jewelry, but the exact locality is Dot known.

" ■ " bottle-green. G.= 8 2S-3-40.

Var,

Occusioi

Common; OiiMfie.^Duik yellowish green to oiive-Dlsseininnted in ctystals m graius iu basic igneous rocks, basalt and basaltic lavas, etc. Hyalotiderite is a highly ferruginous variety.

Comp.—(Mg,Fe),SiO. or 2(Mg,Fe)0,SiO,. The ratio of Mg : Fe varies widely, from 16 ; 1, 13 ; 1, etc., to 2 ; 1 in hyalosiderite, and hence passing from fosterite on the one side to fayalite on the other. No sharp line can be drawn on either aide. Titanium dioxide is sometimes present replacing silica; also tin and nickel in minute quantities.

Pyr., eto.—B.B. whitens, but is Infusible In most cases; hyalosiderite and other varieties ricb in irOD fuse 10 a black magnetic elobule: sninu kinds turn red upon heating. With the lliixe^ gives reactions for iron.

e vnrfptlcs eive rpacttons

for tltaniuin uid inuigsDese. Decomposed b; hydrochloric and sulphuric ocida with ■epar&tloQ of gekliooua Blllt^

Diff —Characterized bj its infuglbilitj, the jellow-green color, granular form and cleavaf^e (quartz has noue).

Reoognixed in tblu eectloDS bj Its high relief; lack of color: lis few but marked rough cleavage-cracks; high interferfiQce-colora, which are usually the brilliant aod proDouuced tones of the secoud order; parallel extinclfoQ; biaxial character; characterlsiic oi^tllDes 80a 809. 810.

lU/^W

(usually with acute terminations) when in distinct crystals (Figs. 807-809). its frequent BsaocIalioD with iron ore and aagiie, and its very common alteration, in a greater or lesser degree, lo serpentine, the first sCiiges being marked by the separation uf livn-ore grains sluiit; the lines of fracture (Fig. 810].

bbs.—Chrysolite folivlue) has two distinct melboils of occurrence: {a) In Igneous rocks, as hasull, formed by the crystallizallon of uiagmaa low lu silica and rich in magnesia; from an accessory componeat in auch rocks the oliviae may increase In atnouDt until It is llie miiio rock couslEtuent aa in the duultes; alao {b) as the product of melamorphism of cerlaia sedimentary rucks contulaing imignesia and silica, as in impiiie dolomites. In tUe duuiles and peridotitesof Igneous origin the chrysolite is commonly associated with chnimite, spinel. pyrope, etc., wblch are Tolnable indicmions also of the origin of serpeniiues deriTi'd from olivine. In the metamorphic rucks the above are wanting, and carlionates, as dolomiie. brcunnerite, magnesite, etc.. are the common associations; chrysolitic rocks of Ibis latter kind may nlito occur altered lo serpentine.

Chrysoliie also occurs in grnlns, rarely crystals, embedded in some meteoric Irons. Also present Id meteoric atones, frequently la spherical forms, or chondrules, sometimes made up of a multitude of grains with like (or unlike) optical orientation enclosing glass between (Pig. 811). *^*'

Among tUe more prominent localHiea are: Vesuvius in lava and on Monte Sorama in ejected masses, with Hiigite. micii. etc. OlBerved In [Ue so-called S'lnidiiie bombs at the Laacher Bpe; at Forstberg near Mayen In ihe Eifel and forming the mass of "olivine liomb8"Tn the Dreiser Weilier near Daun In the sameregion' at Sasbach In the Kalsei'siul.l. Baden IhyalatidiHU). In Sweden, with ore-deposits, as at LSngban, Palsberg. Pereberg. etc. In Berpeiitiua at Snarum, Norway. In large crystals, themselves altered to the same mineral. Common in the volcanic rvicks of Sicily, llie Sandwich Islamls. the Azoroi. etc.

In the U. 8,, in Thetford and Norwich, Termont, in boulders of coarsely cryat. basalt, the crystals or mosses seveuil inolies through. In olIvinB gnbbro of Waterville, In the White Mis N. H.; at Webster, in Jnck-on Co., N. C. witli serpentine and chromite; with chromlte in Loudon Co.. Va.; in Lancaster Co.,

Pa. In small clear olive-green grains with gamel al some pninis in Arizona and New Mexico. In hasnlt In Canniln, Hear Montreal, at Rougemont and Mounts Royal and Montarnlle. and in eruptive rocks at other points.

Chrysolite r-hondrule from the Knynliinya meteorite (XlOdiam.).

.dbyGooglc

Alierntlon of cbrysolite often tnkes place through the oxfd&llon of the troo; the mioerkl becomes Urunnisli or reddish bruwn aud irldeaceui. The process may eud In tearing ibe cavity of ilie crystid filled wiih liujoiiiie or rtd oxide of Irou. A very commoD kiud of ' o the bydmua liiagDesiiim ailicnte, serpenliue, with the psnial removal uF the ' ■ ■ ■ ' ■■ ; this

..,._^ ^ ^„_ ___.^ , _r7.

Ciirysiiliie is tie iied from xiauo-o's. gold, and AilSuS. The tiyaloeiderile, from ,

Siat^a,ni\ o-/j;/puC, I'run. Tiie chryioiU/ittt of Pliuy was probably our lop&z; aad hia top/a

Iddinosite. From the rock carmeloite of Carmelo Buy, Cailfomia; a riilcaie reaetnbllng anelU'rcdchrysoille, exaclcompositiunuudetermiued. Ortborbombic, follatedftudcle«vable. G, = a-838. Color brown,

Tim iixial raiios of the other members of the Chrysolite Group are given In the table od p.

41U. TIte apei'ies are hriedj characlerized as follows:

Monticellite. CiiMgSio4. Occurs in colorless to ^'ray crystals on Mie, Somma : Id iiiasses (b-ilrac'iiUi ou Alt. Monzool, I'yrol; iu ci-ysials or grains fn iimestone at Magnet C.ive, Arkainos. G. = 3-03-3-25.

Fonterit«. Mg,SiOi, Occurs id while crystals at Vesuvius; iu greenish or yellowtsh embedded grains nt B<dIon, Ma&9. Ipetlonile). G = 8-2i-S'88.

HortonoUte. (Fe.Mg,Ma),S;o,. In rough dark-colored crystals or massea. Occurs at the ii-ou mine of Monroe, Oninge Co , N. Y. G. = BM,

Fayalite. Fe,SiO.. Fnuu the Moiiine MIh., Irelaud; the Azores; the Yell ovfstoue Park; Rockport, Mass., etc. Crystals and mnssive, brown to black on exposure. Q. = 4'1,

KnabeUte. (Fe,Mn),StO.. From Danueinora, and elsewhere in Sweden, G = 41,

Tephroite. MdiSIO,; alao with zinc, In the vaAely rotpperite. From Sterling Hill and Franklin Furnace, N. J.; also from Hweden. Color flesh-red to Hsh-gray. G. = 41.

Pfaenacite Group. R,SiO,. Tri-rhombohedral. ■ rr' i

WUlemite Zn,SiO, 64° 30' 0-6775

Troostite (Zn.Mn),SiO.

Phenacite Be,SiO, 63° 24' 0-6611

The PfiENACiTE Group includes the above ortbosilicates of zinc (man-ganeae) and beryllium. Both belong to the tri-rhombohedral group of the trigonal division of the hexagonal system, and have nearly the same rhombo-hedral angle. The rare speeiea trimerite, MnSiOj,BeSiOj, which is psendo-bexagoual (tricliuic) is probably to he regarded as connecting this gronp with the preceding Chrysolite Group.

The following rare species are related:

rr' i

Dioptaee H.CnSiO,

FriedeUte H,(MnCl)Mn.(SiO.).

Pyroimolite H,((Pe.Mn)Cl)(Fe,Mn),(SiO,),

These species are very near to each oilier In form, aa shown In the above axial ratios; they fiirlhar approximate lo Ihe Bpecles of the Phenacite Group proper. They are also cloaely related among Ihemaelves In composllion, since they are all add orthoeillcaleo, and have the general formula H,R8IO, = H.R,(8iO,)4. where (a.g. for FriedeUte) to the latter form the place of one hydrogen atom Is taken by the univalent radical (MnCl).

Tri-rhombobedral. Axis i = 0-6776; rr' = 64° 30'; se" = 36° 47'.

In hexajE:onal prisms, sometimes long and slender, again short and etont; rarely showing subordinate faces distributed according to the phenacite typo. Also massive and in disseminated grains; fibrooB,

Cleavage; c easy, Moresnet; difficult, K J.; a easy, N.J. Fracture con-choidal to nneven. Brittle. H. = 5-5. Q. = 3-89-4-18. Lustet Titreo-

reeiuous, rather weak. Color white or greeuish yellow, wben purest; apple-grt-eii, flesli-red, grayish white, yellowish browo; often dark brown when

f^X ^^

H^

a 11 a 10.

Figs. 812-814. New Jersey, e (Oil2) * (1138), u (3118), i (SiSl). inipiiie. Streak uncoloied. Tranaiiareiit to opuque. Optically +. Birefringence iiigh.

Comp Zinc ortlioailicate, Zn.SiO^ or ~'ZnO.SiO, = Silica 27-0, zinc oxide

73'0 = 100. Manganese often replaces a considerable part of the zinc (in troosttte), and iron is also present iu small amount,

Pyr., «tc.—B.B. in the toieeps glows and fuses wilh difflcully lo a white ennmel: the varieties fnun New Jersey fuse from 8'5 to 4. Tlie powdered minenil on chari'oal in R.F. gives iL coHtiDg, yellow while hot and wbile oo cuuliof!, which, moistened wiih soliiUoo of cohalt. and lieati:tl in O.P., Isiolored bright green. With soda the dialing is more readily obtained. Decomposed by hydrocliluric acid ulih Mparntlon of Kelalinons sllira.

Oba—Proin Alteubeig iieur MoreBuei: al Siolberg, oeor Ali-ln-Chapeile. In New Jereey at Mine Hill, Franklin Furnace, nud at Slerlinj; Hill, two miles dismnt. Occurs wilh zincite and franklinite, varying in color from white M> pale hooey-yellow and light green to dnrk ash-gray and flesh-red; aomeiimen in large reddish crysialf {trootliU). Rare at the Merritt mine, Socorro Co., New Mexico: also at Ihe Sedalia mine. Sallda, Colo. Named by Levy afler William I., King of the Netherlands.

PHENAorm.

Tri-rhombohedral. Axis i = 0-6611; rr' = 63° 24'.

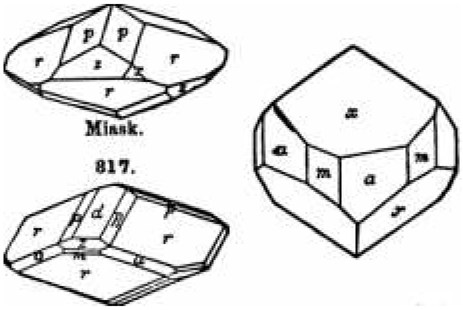
Crystals commonly rhombohedral in habit, often lenticular in form, the prisms wanting; also prismatic, gjg g^g

sometimes terminated by the riiombohedron of the third series, X (pee further, pp. 80-82).

Cleavage: a distinct; r imperfect. Fracture conchoidal. Brittle. H.= 7-5-8. G. = 2-97-300. Luster vitreous. Colorless; also bright wine-yellow, pale rose-red; brown. Transparent to Bubtranslucent. Optically -I-. ooj = 1-6540; e, = l-66fli, Framont.

Coup.—Beryllium orthosili-rate, Be.SiO. or 2BeO.SiO, = Silica 54-45, glucina 45 55 = 100.

Pyr., eto.—Alone lemnins nnallered;



Miask.

817.

Florissant. Colo. Ml. Antero, Colo , Pfd,

: fuica wilh extreme slowness, unlesa

DEBCKIPnTE HINBEALOOT.

puWeiized, to b tronaparent glasa. With soda aflords u wbita enamel; wilh more, Intn-niesctn BD(1 becomes iufuslble. Dull blue witli cobalt scluliuD.

Oba.—Ocoiirs at liie emerald and clirywberyl mine of Takovaya, 80 strela E. of Eka-lerinbnrg; alui JD tile Ilmeu Mts., near Miask; Dear Framont in the Voigea Hta.; at tbe Cerro del Hercado, Durango, Meiico.

Id Colorado, uu amazou-stone, at Topaz Butle, near FlorisBant, IS mileB from Piki's Peak; also on quariz and bervl at Ht. Aatero, Cbafiw couuly. Named from ip4raZ, a dteeiwr, in allusion to Its having been mistaken for quuts.

Trimnit*. (Hii,€ft)iSiO..Bc:,BiOt. In iblck tabular prismatic crystals, pseudo-hexagonal (trlcllnlc) iu form aud angle. H. =6-7. Q. =3 474. Color aalmon-lrink to nearly coknleHhi vomll ciTati^*. From the Harsiig mine, Wermlaud, Sweden.

Dtoptoae. H,Cu8iOi or H.O.CnO.BiO,. Commooly In prismatic 819.

crystals (m* = 84° SS)'). Also in crystalline aggregates; massive. Cleav yf-'^

age: r perfecl. Fracture conchoidal to uneven. H. = 5. Q. = B'28- y/^/ ^S. 8 85 Luster vitreous. Color emerald-green. /•jl • j

Occurs iu druses iil welldefioud crystals on quartz, occupying seams // "V^ / Id a compact limestone west of the iilll of Altyu-Ttlbe in the Klrshese i' ^St/

Steppes: iu the gold woshiugs at several points In Siberia; at Kczbanya. Hungary. Prom C()pU|>o, Chill, on quartz with other copper ores. In " « "

Hue crystals al the Aline Mindouli, tno leagues east of Combn, in the J.

Preneh Congo Stale, Also nt Iho copper miuea of Clifton, Gtaliam Co., >'^\^_^ / Aiizoua. l^ , ^"^

rVedalite. H,(HoCl)Mii.Si40,.. Crystals commonly tabular | e; ^'^./'^ also massive, cleavsble to closely compact. H. = 4-6. O. = 8'OT. Colcr rosored. From the mangauese mine of ^-dervlelle. vallee du Lourou, Hautes Pyrenees.

Fyrosmallte. HT((Fe,Mi))CI)(Fe,HD).Si.O,.. Crvstala thick bexagonal prisms or liiliuliir: also massive, foliali'd. H. =4-4-6. G. = ^'l>6-3'ig. Color blackish green to pule liver-browD or gray.. From the Iron mines of Nordmark in Wermland; Danuemora, Sweden.

Scapolite Group. Tetragonal-pyramidal. Helonite i = 0-4393 Hiszooite, Dipyre <i = 0-4424

SarcoUte ^6 = 0-4437

Tbe species of the Scapolite Oboup crystallize in the pyramidal ffronp of the tetragonal system with nearly the same axial ratio. Tliey are white or grayish white in color, except when impure, and then rarely of ^ark color Hardness —- 5-6-5; G. — 2-5-2-S. In composition they are silicates of aln-minium with calcium and aodium in varying amounts; chlorine is also often present, sometimes only in traces. Iron, magnesia, potash are not present unless by reason of JDclusions or of alteration, which last canae also explains the carbon dioxide often found in analvsis.

The ScapoliCes ai-e analogous to the Feldspars in that they form a series with a gradual variation in composition, the amount of silica increasing with the increase of the alkali, soda, being 40 p. c in meionite and 64 p. c. in marialite. A corresponding increase is observed also in the amount of chlorine present. Furthermore there is also a gradual change in specific gravity, in the strength of the double refraction, and in resistance to acids, from the easily decomposed meionite, with G. = 2'72, to marialite, which is only slightly attacked and has G. — 2'63. Tsohermak has shown that the

Tariation in composition may be eiplained by the aaBamption of two fnnda-mentid end componnda, viz.:

Meionito Ga,Al,Si,0„ Me

Marialite Na.AI,Si,0,.Cl Ma

By the isomorphoiiB combination of these compounds the composition of the species mentioned above may be explained; no sharp line can, however, be drawn between tbem,

Opticallv tbe writB i* cbu&cierlzed by the decraaae lu the streugili of tfae double refrac-(k>D in pHsalDg from meioDUi: lo marialite. Thus (Lacrois) for melonlte co — f = 0 080; for typical wurnerile 008-002; for dlpyre 0 015.

The tetragonal species melilite and gehlenite are near the Scapolites in angle. The more c ■ ■. ■ . . . i

nivianite is also related.

bqhohttb.

Tetragonal. Aiia i = 0-43925. In prismatic ciTBtalB {Fig. 179, p. 60)^ either clear and glassy or milky white; also in crystalline grains and massive. Cleavage: a rather perfect, m somewhat less so. Fracture conchoidal. Brittle. H. = 5'5-6 G. = 2-70-2-T4. Luster vitreous. Colorless -to white. Transparent to translucent; often cracked within. Optically —. Double refraction weak. Indices, Dx.: m, = 1'594; e, — 1'558.

Comp.—Ca,Al,Si.O„ or 4Ca0.3Al,0,.6SiO, = Silica 40-5, alumina 344, lime 25'1 = 100.

Tlie varieties Included here range from uearly pure melonlte to tlioae consUling of meiotiii« and mftiia)iie in the ratio of 3 :1, ■«.. He : Ma = 3:1. No Bbarp line can be (Irau-ii between mciotille nud tbe following species.

Obs.—Occurs in amall crystals in cuvities, iisuolly in llmestoDe bUwka, ■ Soinnia. Also in ejected mnsseB at llie Lancher See.

WERNEIRITB. Common Scapolite.

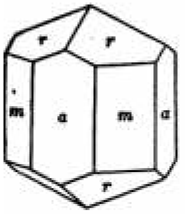
Tetragonal-pyramidal. Axis i = 0-4384.

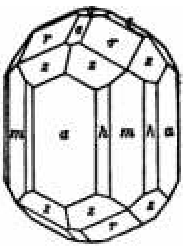
Crystals priBmatic, usually coarse, with uneven faces and often large. The svnimutry of the pyramidal group sometimes shown in the development of the faces «(3U) and 2,(131). Also massive, granular, or with a faint fibrons appearance; sometimes columnar.

«,'", 311 A 311 ^ 29° 48.

Cleavage: « and m rather distinct, bnt interrupted. Fracture siibcon-choidal. Brittle. H. = 5 - 6. G. = 2"66-2-73. Lnster vitreous to pearly externally, inclining to resinous; cleavage and cross-fracture surface vitreous. Color white, gray, bluisli, greenish, and reddish, usually light; streak uncolored. Transparent to faintly subtrans-lucent. Optically—. Birefringence weak. Indices: tt>r = 1*566, €,= 1 "545 Arendal.

Comp., Tar.—Intermediate between meionite and marialite and corresponding to a molecular combination of these in a ratio 3 :1 to 1:2. The silica





varies from 46 to 54 p. c, and as its amount increases the soda and chlorine alao iucreHse. Scapolites with silica from 54 p. c. to UU p. c. are classed with mizzonite; they correspond to Me : Ma from 1 : 2 to 1: 3 and upwards.

. The percentage composition for a common compound is as follows: He : Hb 8 : 1 StO, 4610 Al.O. 80-49 CaO ISIO Na,0 S-G4 CI 1-01 = 100^

Pyr.. ato.—B.B. fuica easily wlih fntumesceoce to awhile blebbjr glaaa. Imperrectl/ decomitoseil by hydrochloric rciiI,

Difi.—Cliaracterized b? iU square form ood prUmalic cleavHge (90°); resembles feldspar ^licii iDsssive. but bas a clisroctedstlc Sbrous appeaiaDce on tba cleavage surface; it Is stso more Fusible, iind bu a biglier specific gravity; also dUllnguistied by fustblliij with Intu-iiieacence from pyroxene (w)i. see, p. 887).

Rucoguized m tUin sectlous by iis low refraction; lack of color; ratber bfgb Inlerfcrence-colors reaclilng tbe yellows aod rcda of ttie first order, seclions showing which exliogiiisti pnnillul to tlie cleavage; by the distinct negative axial cross of basal sectloos which show the c!eavne«-CrackB crosalog at right angles.

Obi.—Occurs it) metamorphic rocks, nnd snoct abuodantly Id granular llmestoDO near its jiiDciion with tbe nssocinted gmnitlc or allied rocks; somellmes in beds of magpetite iiccompauylng llmestoue. It is often associated with a light-colored pyroxene, amphibola, giimel, and also wiih apalite, (ItaDlte. zircon; ampbibole is a. less commou aasoclute than

Kyroxeiie, but in some ciises bus rvsulted frnm the alleration of pyroxene. Scapolile hna eeo shown als'i lo be frequently h coniponeat of bnsic igneous rocka, especially Iliose rich iu plii|;luclase!4 conlninlng much lime; It is regarded lis a secuiuliiry product Ihiougli a, certain kind of slieration.

Pronilneul locitllties are ut Parras, Ftnlani. trbere It occurs in llmeslotic; Arendal iu Norwiiy, and MalsjO in WermlnmT, where ii occi:rs nitb magnetite In limestone. Pat-4auile is from Ubernzell. nenr Pneeuu, in Itnvaria. Thi> pale blue or grey Fcspolite from L. Baikal, Bibfrin, is called glawotitt. In the U. S.. occurs In Vermont, at Hnrlborough, massive. In Ma*i., at Bolion; at Cbelmsford. In N. York, in Orange Co., Essex (S3., Lenls Co.; Orasse Luke, Jefferson Co.; at Gouverneur, in llmcEtone. Id N'. Jertey, at Franklin and Newion. In iVnn.. iit Ibe ElizatxMb mine. French Creek, Chester Co.

In G'inada, at 0. Cnluniel Id., massive; at Orenville; Templetun; Wi.kcfleld, Ottawa Co. Scapolite rocks occur nt eevcrel piiinls.

Hiazonlta. Dipyre, HiTi! are included scapolitea with 64 to 67 p. c. SlOt, correapond-1i;g 10 a molecuUr c^mlilniitiin from Me : Ma = 1; 2 to Me : Ha =: 1 ; S. JVMwntt* occurs iu cliAr crystals Id ejected masses on Mte. Somma.

Dipyrt occurs in f loiigated square prisms, often slender, sometimes large and coarse. Id limeBtoDe and crystalline schisls. chieSy from tlie Pyrenees; also in diorile at BaDile, Norway; Baiut-NHZiure, France; Algeriii. Couteraniia from the Pjreneea is a more ur less nl.ered form of dipyre.

Marialite. Tlieorelicitlly Na.A>iBI.0»C1. see p. 426. The actual mineral corresponds to Ale : Ma = 1; 4. It occurs In a volcanic rock called piperno, at Planura, near Naples.

Baroolita. (Ca.Na,)iAI,{BiO,)i In small tetragonal crystals. H. = S. G. = 2645-3 033. Color Sesb-red. From Monlc Sommu.

bsblujtb.

Tetragonal. Asis ({ = 0*4548. IlBually in short square prisms (a) or octagonal prisms {a, m), also in tetragonal tables.

Cleavage: c distinct; a indistinct. Fracture conchoidal to uneven. Brittle. H. = 5. G, = 2'9-3'10. Luster vitreoua, iutilining to resinous. Color white, pale yellow, greenish, reddish, brown. Pleochroism distinct in yellow varieties. Sometimes exhibits optical auomaliea. Optically —. Birefringence low. Indices:

Ilumbotdtilite »; = 1-6812 0»j = 1-6838 f, = 16263 f, = 1-6891 Henniger

Comp.—Perhaps R R,Si,o„ or Na,{Ca,Mg)„{A],Fe),(SiO,;i, for molilite. If Ca : Mg =^ S : 3, and Al : Fe = 1 :1, the percentage composition ia: Silica 37'?, alumina T'l, iron eosquiozlde 113, lime 313, magnesia 8*4, soda 4'3 = 100. Potassium is also present.

With the fluxei n

Pyr., Bto.—B.B, fuses at 8 to a yellowish or green'sh glasi iroD. Decomposed by hydrochloric &<'iii with gelnilulzatiou.

DIff. — Disiingulshed m thin seciioas hy lis muderalb refraction; ve;y low Jnterfereuo^ colore, sbuwiiig cifteti the " ultra blye" (Ciipo di Bovu); parallel exiiuctioa; ueg&tiTe character; u-iial developnieiit In tables parallel to the bnse slid very common "peg siniclura" due to ptirallel rod-likeJDcliiaioDB peueiraliDg the crystal from the bas&l plsjiesiuward: this, liowKver, is not always tiiBily sten.

Obs.—Melillie Is n compnuenl of certaiu tgiieoiis nicks formed rrnm magmas very low in silicii, rather dcficicut la iilbullcH, aud iiiuiaiuiitic cou side ruble llnii; iimt alumina. In Midi <'iists nielilile appears to crystallize lu the place of lite more acid plaginclnse.

UtUliU of yellow iiud brownish colors is fmind at Onr»> di Bove. nvar ItoniL-. in leiicito. tdiyrc with iiephelile, niigile. 1iornblend<i; at Vesuvius In dull yellow crystals {lomtrrUlxuy. mil iiDCOinmon in certain basic eruptive rocks, as the melilite-batalU of Hoclibohl near Owau iu WhrliembiTc, of the Schwnbian Alh. at OOrlilz. the KrzgebiTfre: also in ihe iieplielile bHfflitis of the iTcgau, of Oabu, Sandwich Islands, etc.; perovakile is a counnoii associate. CuuiiuoM in riiniiirc shifts. Uelilile Is iinrnvd from ueli, honty, in aUuslon to the color.

NumbeldtiliU occurs tii cavernous blmiks on Monte Somma with greeiiisli nilca. also apatite, aiiglie; the iTysials are often rather liirge, and covered with a calcareous coatins;) <-ss common in [ratispnreiit lustrous cryslala with iiephelile. sarcolite. etc., in an augltic ri>ck. Z'irlite is impure humboldtiliie.

Oehleulta, CniAliSiiO.t. Crystals usually short square prisms. Axis J = 0-4001. O. = 2-9-3 07. DiOtuuI shades of grayish green to liver-brown. From Mount Honzonl, la the FasBBlhal, In Tyrol.

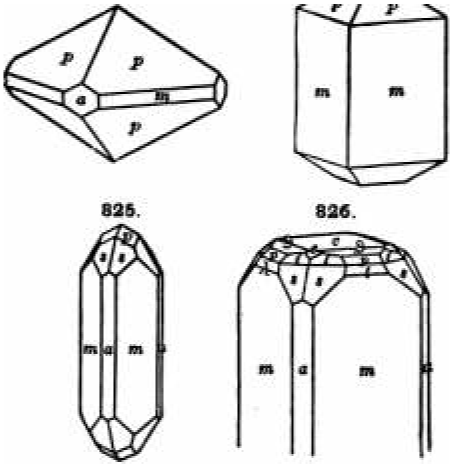
VEBTJVIAinTB. Idncrase.

Tetragonal. Axia 6=0-5372.

M. 001 A 101 = 29° 15".

ep, 001 A 111 = 37° I3i'.

ct, 001 A 881 = 06° 18'.



pp'. 111 A 111 =60°8«'. «•". SUA all = 31"B8'.

I<^^\ f^>\

Often in crystals, prismatic or pyramidal. Also masBive; columnar, straight and dirergent, or irregular; granular massive; crjptocryatalline.

CleftTftge: m not very distinct; a and c atill leas so. Fracture aabcon-choidal to uneven. Brittle. H. = 6 5. G. = 3-35-345. Luster Titreous; often inclining to resinous. Color brown to green, and the latter frequently bright and clear; occasionally sulphur-yellow, and also pale blue. Slreak white. Subtran8parent to faintly aubtranelucent. Dichroiam not UBually strong. Optically—; also-f-rarely. Birefringence verv low. Sometimes a b-normiilly biaiial. Indices: a>^ = 1-7235, e^ = 1-7236 Ala, Osann.

Comp.—A basic calcium-aluminium silicate, but uf uncertain fonnula; perhaps Ca,rAl(OH,F)]Al,(SiO A. Ferric iroti replaces part of the aluminium and magneemm the calcium. Fluorine and titaninm may be present. The following ai-e typical analyses (Jannaach):

810, Tie, A1,0, Fe,0, FeO MnO CftO MgO N«,0 L1,0 H,0 F,

1. Vesuvius, 188-98 — 16-70 2 89 2 01 057 85 67 8 68 0 48 008 1 82 108 = lOOW

8, VIlul. 86-17 1-80 laas 316 1« 016 85-81 6-05 045 — 072 0-22B,O, 281=89-68

Pyr,, etc.—B.B, fu»e« at 3 with intumescence \o n ffreenlsh or browuUli glass. Hacnus Mates that the density after fusion Is li-93-2-94S. Wtlh tlie fluxes gives leactlons for Iron, and some vsrietles a strong mangiinese reaction. Cyprine. a hliie viiriety. (jItcb a reactloo for copper with suit uf pbospbonis. PartiBlly decomposed by liydrocbloric fcid, and completely when the mlnenU lias been previoiialj ignlled.

DM—Cbamcleriiied by lis tetragonul form and eusy rusibilily. Resembles some brown variettes of garnet, tourmiillne, and epidoie.

Recognized In tUin sectious by Its high i-efractlon producing n very strong relief and its extremelj low birefriugence; * also in guiieml by Its color, pleochroism, nnd uniaxial nega* live character; Ihe latier, on account of (he low birefringence, being difficult lo determine. The low birefringence, however, uida in diMingulshlng It from epidute, with which at times it may Iw confounded.

Om. —VesiiTinuile was Hrst found among the nucieut ejections of Vesuvius and Ihe dolomilic blocks of Monte Bomina, whence ha nnuie. It commonly occurs he h conlaci mln-eml from the alternlion of impure liitiestoni^!i, then nsunlly a-sociiited with lime gurnet (grossiilarile), plilogopite, diopslde, wollnstoDile; also "pidoie; also in serpintine, chlorite schist, gneiss and related rocks.

Prominent localities are Vesuvius; the Albaul Mts.: the 3Iussn Alp in the Ala valley, ia Piedmont; Ht. Moiizoni in the Fiis.'mthnl; at Omwllza and Do^aczka; Hoalnu near £ger in Bohemia {egeran); near JordnnsmQlil, Sile»iiii; on the Vilui river, near L. Baikal (some-limes eitlled tnfui'I'or vilulte. like the gixmsular garnet from the same region]; at Arendal, " tolophonite"; at Egg, near CliristiiiUKand.

• In N. America, in MaineaK Phippsburg and Rumford; at Bnudford. In N. Hampthirt, at Warren with cinuanioji-stone. \n N. York. \ m. S. of Amity. In Ifew Jm-my. at Newion. Id Califomi-i nenr San Carlos in Inyo Co. In Canada, nt Calumet Falls. Litch-field, Pontlac Co.; at Orenville in calciie; at Templeton, Oltawn Co., Quebec

Zircon Group, RSiO,. Tetragonal.

Zircon ZrSiO. 6 = 06404

Thorite ThSiO, i = 0-G4O-3

This group includes the orthosilicatcs of zirconium and thorium, both

alike in tetragonal crystallization, axial ratio and crystalline habit.

The e species are sometimes regarded as oxides and then included in the Rdtilb Group (p. 343), Vi which they approximate closely in form. A similur lorui belongs also to the

" Frisiuently mluerali. which, like vesuvianiie, melilile nnd ziiisite, aredmibly refmctiug but of exiremcly low birefringence (and possibly, where Ihey are positive for one color but negative for another), do not show a gray color between crossed nicols but a curious blue, nt times nn intense Berlin blue, which Is quite disCinct from the other blues of the color ■cale and Is known as the " ultra bint,"

zntooN. Tetragonal. AxiB <! = o'Mo37.

m'. 101 A on = 44- SO". «■'. 101 A iOl = 66° 16", pp". 111 A in = 6eMoJ-. uu', 831 A S31 = 83- V.

mp. no A 111 = 4r BO". mu, 110 A 831 = 30° 13^'. EE'", 811 A 811 =82° 67. ax. 100 A 811 =81° 43*.

83B.

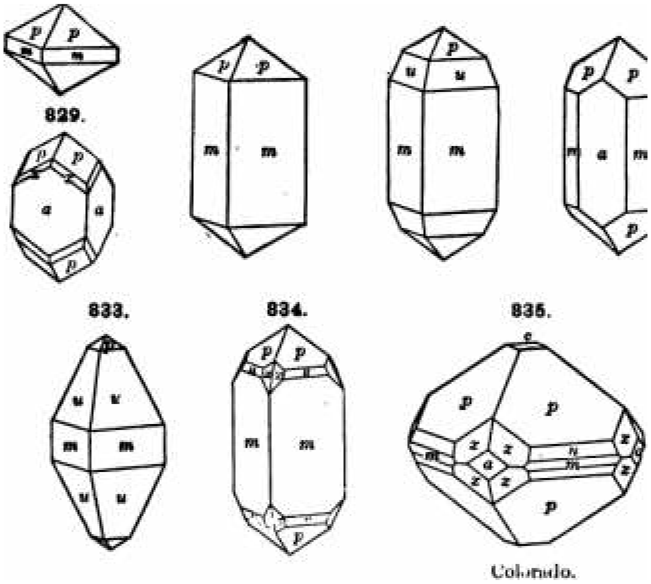
830.

831.

832.

f€^ o\ (fO\

\p'



829.

833.

834.

835.

Colorado.

Twins: tw. pi. e (101), genicnlated twins like rutile (Fig. 374, p. 124). CoQimonly in Bqaare prieniB, sometimeB pyramidal. Aleo in irregular forma and grains.

Cleavage: m imperfect; ^(111) less distinct. Fracture conchoidal.

Brittle. .H. = 7'5. G. = 4'68-4'70 moat common, but varying widely to 4'2 and 4'86. Luster adamantine. Colorless, pale yellowish, grayisli, yellowish green, brownish yellow, reddish brown. Streak uncolored. Transparent to subcranslncent and opaque. Optically -(-. Birefringence high, qj, = 1'9239, €j =^ 1*9682, Ceylon. Sometimes abnormally biaxial.

Hyacinth is the omnge. i'e<1(Iiali nnd browiiisli trniiBpnreut kind used for gems. Jargon is a D«me given In ilie colorliiss or amokj zlrci— " •■■-..i— ■—ii.._.._ ._ .t._ .___^ ..... while resembling the d' " '" ' ■'^--

1 lusler, they a

C«Mp.—ZrSiO, or ZrO.SiO. = Silica 32-8, zirconia 67-8 iron (Fe,o,) is nsnally present.

= 100. A little

.dbyGoogle

Pyr., «t«.—lufuaible; the colorless var[et[eB are uaalleml. tbe red become colorlm,

wbile dark-colored varieliea are made while; some Tsrletles glow aud lucrease ia di'usiij by Igultion. Nol perceptibly acted upon by salt of phosphorus. lu powder decompuaeil when fused wllh soda ou the platinum wire, and If the product Is dissolved lu dilute hydtn-chloric itcid it gives the oruuge color charucteristic of zircouia wlieu leated wlib luriiieri(: paper. Not acted upuu by acids except in Hue powder with concentrated Bulphuiic »cid. Decomposed by lueioD with alkaliue carbonates and bisulphaies.

Dlff'—Cliaracterized by the prevuiliug square pvtumid or square prism ; also T>y [Is iidamaiitiue luster, hardness, lilgU specific j^vity. and lufusibillty; the diamond isoplicnlly laolnipic.

Recognized Id tliin sections by its very iilgU relief; very high Inlerference-colors, which approach white of the higher urder e^icept in very Ililu sections; positive uoitixial uharncter. It Is distinguished from ctissiierite and rulUe only by Us lack of color, and frum the latter also in many cnses by melii< d of occiirreDce.

Obi,~A common constituent iif iknieous rocks, especially those of the more acid feldspalhic groups and parlicularly llie Itlurls derived froui magmas containing much sucla. Is generally present in uiinuie i-ryataU, l>ut iu pegmalltic fades often in lar^e and trellfonnett crystals. Occurs more r.irely elsewlierv, as In granular limestone, diloritic nad other schists ; gneiss : sumellme-' in Iroii-ote beds. Crysuils are common in most anrifeniui sands. Sometimes found lu volcanic rricbe. pmbiibly In part us incluslous derived from older ri>cks.

Zircou in distinct crystals Is so common iu the pegmatilic forms of the uephelite'evenite and allgltc-syeiiile oF eonlbern Norway (willi tpgirite. etc.) that Ihla rock Uiere auJ elsewhere bassomeiimes been called a "zircon-syenite."

Found in alluvial aands in Ceylon ; in the gold regions of the Ural,Bt Laurvik. Norwav: at Arendiil, in the iron mini-s: at FiedriksvBrn. and In veins in tlie au^lte-syenite of il'ie LangesundHord; PfilBchilial, Tyrol; in lava al Niedermendig In tlie Elrel, red cryaliils: eic.

In N. Amerlcii, in Xaint. at LltclifictiU In N, York, In Mnriah, Essex Co . clnuaniun-red; near llie outlet of Two I'onds, Orange Co., with scapolile. pyroxene and lilanlle; Ht Warwick, cbocolate-brown, near Amity; in tSt. Lawrence Co., in the (own of Haminoncl; at Roasle. Fine, Fliotlrn. In Ptnu., near Reading. In N. Car,, abundnnt in the gnid Mnds of Burke. McDnwcll. Polk. Rutherford. Henderson, and other countlea. Iu Coloi-: do. with aslropliyllile, etc . in the Pike's Peak region in El Paso Co.; at Cheyenne Mi. In California. In auriferous crnvpls.

In CaTtada. at GrenvUlu. Argenteuil Co.; In Templeton and adjoining townships In Ottawa Co., Quebec; la Renfrew do., aotnetimes very large; in North Burgess, Lanark Cn.

Malaeonis an altered zircon. C//rlolite Is related but contains uranium, yttrium and other rare eitments.

Thoiita. Thorium silicate, ThO,, tike zircon in form; uaunliy hvdmted. blnck in color, and then with G. = 4 &-5; also omnge-yellow and with Q. = 5'19-0<0(oranyi(e). From tlie Brevik region. Norway; also near Arendal.

Auarlite. Like ^rcoD In form; supposed to be a slllco-phospbate of tborlam. Hender-

Danburite-Topaz Orotip. Orthorhombic. RR,(SiOJ, or (BO) RSiO,.

Danbnrite CaB,{SiO,), i:l:i= 05444 : I : 04807

Topas [Al{P,OH),]AlSiO, d:h:6= 0-5285 : 1 : 0-4770

Andaladte (A10)A18iO. ih:d:ii = 0-5070: 1 :0 4749

or S:h:i = 0-9861: 1: 07035

SilUmanito Al,SiO, Orthorhombic S:i = 0970:1

Cyanite Al,SiO, Triclinic

d:h:d = 0-8994 : 1 : 07090; a = 90° SJ', j8 = 101° 2', y = 105° 44^'.

/p^=^

SILICATES. 431

OANBURtTB.

Orthorhombic. Aies d:b:i = 05444 : 1 : 0-4807.

836. mm'", 110 A HO = 57° 8'. dd'. 101 A lOl = 83" 88".

a. 120 A iaO = 8!>° 8". mif. Oil A 041 = ISO" «.

Habit prismatic, resembling topaz. Alao in indietinct embedded crystals, and dissemiDated masses.

Cleavage: c very indistinct. Fracture uneven to subcon-choidal. Brittle. H. = T-T'So. G. = 2-97-302. Color pale wine-yellow to colorless, yellowish white, dark wine-yellow, yellowiah brown. Luslur vitreous to greasy, on crystal surfaces brilliant. Transparent to translucent. Streak white. Cump. — CaB,(SiO.), or CaO.B,0,.2SiO, = Silica 48-8. boron trioside 28'+, lime 22-8 = 100.

Pyr., •!«.—B.B. fuses xt 80 In a colorless g\tMB, and Imparts a green color to the O. P. (boroD). Nul.ilL'composed b; liydroclilorlc acid, but sufflcieutly atlftcked for the soluliou III givB llie reaction of boric acid wiih lurmeric paper. WhenpreTlouBly ignited gelatinizes witU hydrocliloric ncid. Phosphoresces on beiiling, ^vlng a reddish light.

Oba. —Occurs at Danbury. Conn., with mlcrocHiie and ollgoclase in dolomite. At Russell. N. Y , Id doe crystals. On the PIz Viilatsch&, the northern spur of Ht. BkopI south of DisseDlls Id eastern gwilzerUnd, In slender prUmHCic cryslals.

TOPAZ. Orthorhombic. Axes i:l:i = 0-52804 : 1: 0-47698.

m m t

rid',

48° 87i'. ff, 031 A 021 = 8r 18'.

CryBtals commonly prismatic, m predominating; or ^ (130) and the form then a nearly sqnare prism resembling andaUisite. Faces in the prismatic zone often vertically striated, and often showing vicinal planes. Also firm columnar; granular, coarse or fine.

Cfeavage : c highly perfect. Fracture subconchoidal to uneven. Brittle. H. = 8. G. = 3'4-3-6. Luster vitreous. Color straw-yellow, wine-yellow, white, grayish,greenish, bluish, reddish. Streak uncolored. Transparent to snbtranslucent. Optically +, Ai. pi. \ b. Bx X ". Aiial angles variable, 2E, = 112° to 120"* 40'. Eefractive indices, Brazil (Miihlheims):

For D a = 1-62986 (I = 1-68077 r = 1-8S747 -■. aV = 49° 81'

Tar.— Ordinary. In prUmallc cryatsls usually colurlins or pale yellow, less often pale blue, piuti. etc. The yellow of the Bmzilmu cryaials is obaaged by Lealiug io a pula Tose-pluk. Orieu coDtaiua iucluaioas of liquid CO..

PhyiaiiU, ur pyroplij/MoliU, i» u coarae uearly upaque variety, from Finbo; iaiumescea Wliuu heated, lieoce its name fiucii tf/v<ra\ii, bvbblt, and nCp.fira. Pye'iiU lius n cuhim-nnr. vtry compact structure. Row made out tliat tlie cleavage was tbe same, and ihe form prolmbly the same; aud Dea Cloizeaux showed that the optical characlera were those of topaz.

Comp.—(AlF),SiO,; usually eontainiog liydroxyl and then [Al(F,0n)],SiO, or as given on p. 430. The former requires Silica 32-6, alumina 55*4, fluorine 20-7 = 108-7, deduct (0 = 3F} 8-7 = 100.

Pyr., ato,—B.B. iufuslble. Fused In the closed tube, with previously fused and pulverized salt of phogphoruB, etches llie glass, glvlug oS silicon fluoride, which forms a Hog of SiOi above. Willi cobalt solution the pulverized mineriii gives a flue blue on beating. Only psrllally attacked by sulphuric acid. A variety of tupax from Bmzll, wheu Iteated, »asum;8 a pink or red hue, reBembliog llie Balas ruby.

Diff.-H!haracterized by its prismaiic crystuU wiih anKles of 56° (124°) or 87* (88°); also by the perfect basal cleavage; hardncsi: furusibillly; yields fliioTine B.B.

Oba.—Topaz occurs especially ia the highly acltl igneous rocks of the granite family. 03 granite nnd'rhyolile. Id veias nud cavities, wiiere It appears to be the result oF fumarule action iifier the cryslalliEalion of the marina; sometimes also In the surroundiag schiala, gnelase-. <^t'•., as a result of such action. In these occurrences oflen accompanied by fluor-

FJu<- Lii|]:i£ comes from the Urals, from Alabaahka. in the region of Ekaterinburg: from Minsk in the Ilmeu Mts : also the giild-wasUinga on tbc R. Saoarka, In Govt. Oreubiirg: in Nerchinsk, beyond L. Baikal, in the Aduii-C'halon His., etc.; In the province cif Minas Gcraea. Brazil, at Ouro Pi-eto and Villii Rica, of deep yellow color; at the tin mines of Zinnwald and Ehrenrriedersdorf, and smaller .cryBlals at Schneckenalein and Alteoberg; sky-blue crvslals in Calrngorin. Aberdeenahire; Uic Mimrne nioumalDS. Ireland; on the island of Elba. Phy»'iUI« occurs iu crystals of great size, at Possum, Norway; Flnbo, 8we<len. Pyeniti is from the tin mine of AltcDlHTg in Siixoiiy; also of Sc blacken wait). Zinnwald, etc. Fine crypfd* occur at Duraugo, Mexico, with tin ore; at San Luis Potiiai in rhyolite. Mt. Bi-choB. Tasmania, with tin ores; similarly in New South Wales. In Japnn in pegmatiie from Olani-yaina, Province of Omi, near Kioto.

Io the United Stales, In Maiitt, at Stoneham. in albitlc gmnlle. In Oonn.. at Trumbull, with fluorite: at Willimaiilic, In N. Car., at Crowder's Alouutain. In Cdlorado, m floe crystals colorless or pale blue from the Pike's Peak region; at Nathrop, Chaffee Co., in wme-colored crystals with spessariite !n litliophyses in rhyolUe; similarly in the rhyolite of Chalk Mt. In Ut'th. in flne transparent colorless cryslali wilb quanz and aanUhne in the rhyolite of the Thomas Ranire, 4(1 miles north of Sevier Lake.

Tiv e topaz is from r.iirit'Sios, nn island in the Red Sea. as staled by Pliny.

But

by Pliny and earlif

ANDAI^nSITE.

Orthorhombio,

a well as by many later, under Ihe ni

Axes &:l: (!=0-9861 :1 :0-'r0245. 842.

e ehrfftoliU,

mm'", 110 A liO = 89* 13". u\ Oil A Oil = 70' 10". TlBUftlly in coarse prismatic forms, the prisms nearly square in form. Massive, imperfectly columnar; sometimes radiated and granular. •

Clpavajre: m distinct, sometimes perfect (Brazil); a leas perfect: b in traces. Fractnreuneven, aubconchoidal. Brittle. H. = 75. G. = 316-320. Luater vit-reons; oftea weak. Color vhitish, rose-red, flesh-red, violet, pearl-gray red-

\U^

,ab,GoOgIc

^iah brown, olire-ereen. Streak nncolored. Transparent to opaque, usually BubtranBlaoent. Fleocbroism stroug in some colored varieties. AbBorptioB strong, a > b > c Sections normal to an optic axis are idiophanooB or show the polarization-brushes distinctly (p. 219), Optically — Ax pi B d Bii.c. 2H,= 96° 30'Brazil; /9, = l-6as; >/-ff = 0011.

Cliiatlolite, or Maelt la a Turiety in stout crystuU Itaviug ,^,

tlie III is iiDd QDgles of a dlflerenl color from tLu rtsi. owiug "•■•

lo a regular arruufemeiit of ctkrbou&eeoua Impurities tliioiigE a=Bx

ibe ioterior, nad aeuce exhibiliiig a colored cross, or a Itn-ceiiited uppeHtance lu a liacsTerae sectiou. Fig. 644 ibows sections uf a crystal.

CoBip.—A!,SiO. = (A1o)A18iO, or Al,o,.8iO, = Silica itC'8, alumina 63-3 =^ 1oo. Manganese is sometimes present, as in manganandalusite.

F]rr.. elo.—B.B. infusible. Witb cobalt Bolutton gtves a blue rolor after ignition. Not decomposed by ttcids, De-GOinpo>ied on fusion witli caustic alkulles and alkaline carbons Ids.

Diff.—Cbaracteriiied by the nearly square prUm, pteo-cbrniam, bardiiess, Infualbtlity; reacliou fur alumina B.B.

Distinguished in ibln sections by Its bigh relief; low Interference-colors, which arc ouly slightly above those of a

quarts: negaiive biaxial cbiiracter; negaliTe extension of

the cryabtli (diff. from silUmanite); rather distinct prismatic cleavage and the constant

parallel estinclion (diff. from pyroienes, wbicb have also greater birefringence); aliobylta

844.

characteristic amingemcnt of impurities when these are present (Fig. 844). Tbe pleo. chraism, nliich is ofteu lacking, is when present strung and cLaractorlstlc.

Ob*.-~Most common In argilluceous sciiist, or other schists Imperfectly cryatalllne; alao in gueiss, micii schist und reluted rocks; rarely in connection with serpentine, Tbe variety cbiusiolite ia commonly a contact mineral in cliiy-slntes, e.g., adjoining granitic dikes. Sometimes associated wich ailllmnnite nitb parallel axes.

Found in Sp^u, in Andalusia: in the T^rol, Lisena Alp; in Saxony, at BrHunsdorf;

e of Uinaa Geraes, in fine crystiila and u

Bavaria, at Wunsiedel, etc. Id Brazil, proi rolled pebbles.

In N. America, In Maim, at Siandlafa. ti. Hamp.. Wblte Mtn. Notcb; Uau., at Weat-ford; Lancaster, both varieties; Sterling, chiastolite. Conn..at Litcbfleld and Wosbiugtoa. I'tnn,., in Delaware Co.. nesr Leiperville, large crjat.; Upper Providence.

Named from Andalusia, tbe first localiiy nolea. Tbe name fnaeU is from the Latin mac'iia. a spot. Cblostolile is from ;t'<x'o'ro!, arranged diagonalty, and hence from thi, the Greek name for the letter X..

srrjtJMAwrm. Fibroiite.

Orthorhombic. Axes d:ti = 0-970 :1. mm''' = 88" 15', M' (230 A 330) = 69°. Prismatic faces striated and rounded. Commonly in long slender (Crystals not distinctly terminated; often in close parallel groups, passing into libroua and coinmnar massive forms; sometimes radiating'.

Cleavage: ft very perfect. Fracture uneven. H. = 6-7. G. = 3-23-3-24. Luster vitreous, approaching subadamantine. Color hair-brown, grayish brown, grayish white, grayish green, pale olive-green. Streak uncolored. Transparent to translucent. Pleochroism sometimes distinct. Optically +.

Doable refraction strong. Ai. pi. | 6. Bt X c. DiBpenion p> v. SE, = 44°. /S= 1'661; J/ -« = 0021.

Pyr.—Same as BndaluBlte.

TUB. —Cbaracturlzed bj Ita fibrous or columnar form; perfect cleBvsge; infudbility;

reaclioa furalutnlDa,

In thin sections recognized bj Its form, usually witli traiiBversB fractures; parallel extfDCtloD: bigb iuterrerence-colars.

Obi.—Orien present in the quanz of gnefssea aod sometimes granilei [q very slender, minute prisms cotnmuDly aggregaled together and sometimes lutergvown with andalusite; lolile is also a common aasociaLe; rarely as a contact miuerni; often occurs with corundum.

Observed in manj localities, thus near Muldnu In Bohemia {Fattrkieatiy, at Fassa in Tyrol (JueA^rifc); in the Carualic with corundum {JtbroiiU); at Bodeumais, BaTBria; Freiberg, Saxony; in France, near Ponirlbaud and other points in Auvergne; forms rolled masses in the dlamantlferous sands of Hiuaa Geraes, Brazil.

In the United States. In JfoMOcAbMld, til Worcester. In Cbnn«ea«uf, near Norwich, with zircon, monazite and corundum; at Wlllimantic. In N. York, at Yorblown. West-Chester Co.; In Hotiroe, Orange Co. {monroliU). In Ptnn.. at Chesterou the Delaware, near Qiieeosbury forge; in Delaware Co.; Dtlaaare, at Brandywlne Springs. With corundum in N. Oarolina.

Named j!&roIif« from the fibrous massive variety (Germ., Faaerklesel}; titUmanilt, after Prof. Benjamin Sllliman of New Haven (1779-1864).

BamliU, xenaliu, adrtiUtt probably belong to sililmanlte; the last la altered.

OTANrm. Eyanlte. DIathene.

Triclinic. Axes d:lU = 08994 :1 :0-7090; <r = 90° 51', 0 = 101°2% sy = 105" 44f. ac, 100 A 001 = 78" 30'; be, 010 A 001 = 86M5';

84fi. Usually in long bladed crystala, rarely terminated.

Alao coarsely bladed columnar to snbfibronB.

Cleavage: a very perfect; ft less perfect; also parting U c. H. = 5-7-25; the least, 4-5, on a || rf; 6-7 on a U edge a/c; 7 on 6. G. = 3-56-3-67, Luster vitreona to pearly. Color blue, white; blue along the center of the blades or crystals with white margins; also gray, green, black. Streak uncolored. Translucent to transparent. Pleo-chroism distinct in colored varieties. Optically —. Ax. pi. nearly J_ a and inclined to edge a/b on a about 30°, and about 7t on 6. 2H..r ^ 99" 18' Pfitschthal. Cemp.—Empirical formula Al,8iO, or Al,0,.SiO„ like andalueite and silli-manite. Perhaps a basic metasilicate, (A10),SiO,.

Pyr.,ete.—Sameasfor andalusite. At a bIgb temperature (lS20°-lSS0')cyanite assumes the pbvslcal characters of slllimanile.

Difi.—ClianiMerlzed by the bladed form; common blue color; varying haTdoeas; infiisi-bllity; reaction for alumlnii.

Obi.—Occurs prlacipally fn gneiss and mica schist (both the ordinary variety with muscovite and also thai with paragonlle) often accompanied by garnet and sometimes by siaurolite: also la eclogile. It Is often associnled wllh corundum.

Found in transparent crystals at Monte Campione in tbe 8t. Golbard region in Switzerland in paragoulte schist; on Mt. Gi-elner. ZiMerthal, and in the Pfitscbthnl (rfiatiiite. while) In Tyi-ol; In ecloglle of the Saualpe, Caiinihia; HorrsjOberg in Wermland, Sweden; Villa Bicn, Braill, etc.

In Mat$., nl Chesterfield, with garnet in mica schist. Id Conn., at Litchfield and Wasliineton. In Vtrmonl, at Thetford. In Penn.. Id Chester Co. and In Delaware Co. In Fi'r^inia, Buckingham Co. In JV. CaroHta, with rulile. lazulile, etc., at Crowder'a Ml., QastOD Co.: In Gaston and Rutlierford counties associated with corundum, damourile; beautiful clear green In Yancey Co. Named from Kvavoi, Hiu.

Datollte Oroap. Monoclinic.

BasicOrthoeilicatee. HBHSiO.or B,B,(SiO.),. OxygenratioforEiSi = 3:2. R = Oa,Be,Fe, chiefly; E = Boron, the yttrium (and ceriam) metale, etc.

DatoUt* 0-6345 :1: 1-2657 89° 61'

HCaBSiO. or Ca{BOH)SiO, HomlUt* 0-6249 :1 : 12824 69° 21'

Ca.FeB,Si,0„ or Ca,Fe{BO),(SiO,),

EndiM 0-6474 :1: 1-3330 79° 44'

HBeAlSiO. or Be(A10H)SiO, &

OadoUnito 0-6273 :1 ; 1'3215 89° 26^

Be,FeY,Si,0„ or Be,Pe(YO),(SiO.),

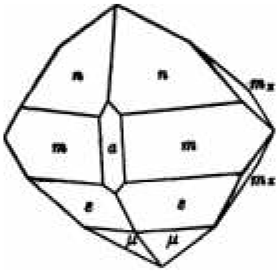
The species of the Datolite Group are usually regarded as basic ortho-silicates, the formulas being taken in the second form given above. They i^ crystallize in monoclinic system, and all but Enclase conform closely in axial ratio; vith the latter there is also a distinct morphological relationship.

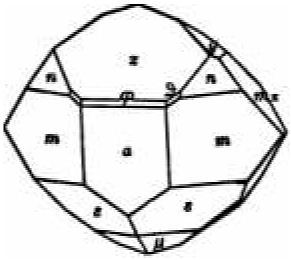
DATOUTE.

Monoclinic. Axes it : % mm'". 110 A liO = ac 100 A 001 = a*. 100 A 101 = «r'. 013 A 0i2 = jBiW. Oil A Oil =

Crystals varied in habit; usually abort prismatic vith either mar m^ predominating; sometimes tabular jj x (201); also of other types, and often highly modified (Figs. 846-849). Also botryoidat and globular, having a columnar structure; divergent and radiating; sometimes massive, granular to compact and crypto-crystalline.

840. 847.





Bergen Hill. Cleavage not observed. Fracture conchoidal to uneven. Brittle. H. = 5-5"5. G. = 2-9-30. Luster vitreous, rarely Bubreeinous on a surface of fraoture. Color white; sometimes grayish, pale greeo, yellow, red, or amethystiDe, rarely dirty olive-green or honey-yellow. Streak white. Transparent to translucent; rarely opaque white.

wbile on A Oil = IHI° itr, etc. 2. Compact moMtiee. Wblte iipiiquE (.-reaiii-culor«d. t<ii>k; breuKiiig wiib llie surfnce iir porcelulu or WedgewcKni ware. From tlie L. Biiperior re|[i"u. 8. Botryoidal; BotryolUe. RHdiuied coliimQar, baviug a. bolryoidal surface, Hud cuuiaiiiliig more WAler tbuu tLe (jrystalii, but upllcuillj ideutical.

Comp.—A baaic orthosilicate of boron and calcium; empirically HCaBSiO, or H,0.20aO.B,0,.28iO,: this may be written Oa(I30H)SiO. = Silica 37-6, boron trioxide 21'8, lime 35-0, water 5-6 — 100.

nitli iuIumeBceuce v:\l\i LydrocLloric itcid.

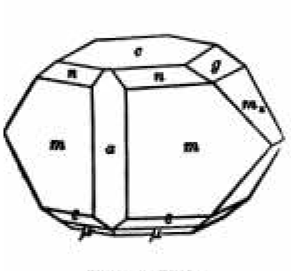
cryMaU; easy fusibility and green

.r glass, coloring the flame bright creen. (

DUf.—Churocterizedby its glassy, greunish, ciin flaino B B.

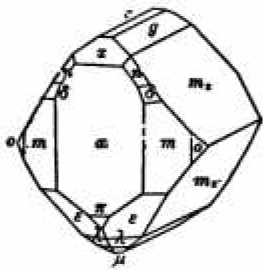
Oba.—Datolite is found cblpfly as a setnodary minenil In velus and rnvitfes ia basic eruptive rocka, often aasociatcd with calcite, prelinite and varinus ZL'otltea; lomeiimes aasociated with dauburile; also in gnelu, diorite, and aerpenline: lu metallic velni; sonae-

848.



Bergen Hill.

849.



Andreasberg.

ADdreosberg.

timea Id beds of Iron ore. Found In Scotlaod, tn trap, at the Eilpatrlck Hills, etc.^ in a bed of maEnetile at Areodal in Norway (bofrvofife); at UtO tn Bweden: at Aiidreaaber)^ inillnbasenod in veins of silver ores: tn Bheniah Bavaria (tbeAutnAaMtfiO'at the Seiaser Alp, Tyrol, and at Thelss, near Claussen. in geodes in amygdaloid: in granite at Baveno near LiLgo Hagelore; at Toggiana In Modena. in serpuntine: Monte Catliil Id Tuacany.

Ill the 17. S. not uncommon with the diabase of Connecticut and Hsssachusetta. Tbus at the Rocky Hill quarry, Hiirtford, Conn.; at Middlefleld Falla and Roaring Brook, Conn. In N. Jersey, at Bergen Hill. In splendid crystals; at Paierson, Paasaic Co. Both crystals and the opaque compact variety. In the lAke Superior region.

Named from 6aiti<yBat, to divide, alluding to the giaoular alructure of a maastre variety.

Homillte. (Ca.Fe),B,Bi,0,0 or (Ca.Fe),(B0),(BiO.),. Cryslala often tabular | e: angtea neiir thnse of datolite. H. = S. Q. = 8:^. Color black, blackisb brown. Found on Uie Island BtokH and other ialanils. in the Langesunil fiord, Norway.

Euclaaa. HBeAlSiO. or BefAIOHISIO,- In prismatic crystals. Cleavage : 6101O)

EcrfeC H. = 7'5, Q = 806-3'10. Luster vitreous. Colorless to pale green or blue, rem Brauil. In the province of HInai Geraes; in Che auriferous sands of the Orenburg dinlrict, southern Ural, near the river San&rka; in the Oloesglockner region of the Austriaa Alps.

OadoUnlta. Be,FeY,Si,0„ or Be,Fe(TO),SiO,),. Crystnls. often prismatic, rough and coarse: commonly in masses. Cleavage none. Fracture concholdal or apllnlery. Brittle. H. = 6'5-7. G. = 40-4-5; normally 4-86-4 47 (anisotropic), 4-34-4'a8 (Isotropic and amorphous from alteration). Luster vitreous to greasy. Color blach, greeofab black.

.dbyGooglc

a)*o brown. From aesr Falun And Ytterbv, Sweden; HItterO, Norway; also in Llano Co., Texas, in nodular mawes and rough crysUle. sometimes up to 40 or SO pounds In weight.

Tbe yttrium earltis or " gadollnite-earlbt" (purtly replaced by the oxides of cerium, lanthanum itnd didymlum) lona a complex group which coutains cousldeiahle erbium, also several new elements (jtlerblum, scandium, etc.) ot more or less definite churacter.

TttrUUte. Aallicateof thorium and the yttrium metals chiefly. HasslTc; amorpboua. G. = 4976. Color on the freah fracture olive-green, changing to orange-yellow on surface. Aasoclated with the gadollnite of Llano Co., Texas.

RowUndlts. An yttrium illicate, occuTring massive with gadollnite of Llano Co., Texas; color drab-green.

MaoUntoahlte, Silicate of unoium, thorium, cerium, etc. Hassive. Color black. Llano Co., Texas.

Epidote Gronp. Orthorhotnbic and MonocliDic Baaic Ortbosilicatea, HR,E,Si.O„ or R,{ROH)R,(SiOJ. B = Ca,Fe; K = Al,Fe,Mn,Oe, etc. a. Orth&rh&mbic Section.

Zoiute Ca,{A10H)Al,{SiO,), 0-6196:1: 03429 fl. MontuMnte Section. •B^m^^ i mCa,(A1oH)Al,(SiO.), d : b : i

JtpiaoH ^ nCa,(FeOH)Fe,(8iO,). 1-5787 :1: 1-8036 64° 37'

PiBdmontite Ca.(A1oH)(Al,Mii),{SiOJ, 1*6100 :1: 1-8326 64° 39'

Allanits (Ca,Fe),(A1oH){Al,Ce,Fe),(SiO.), 1-5509 :1 : 1-7691 64° 59'

The Epidote Group includes the above complex orthoailicateB. The monoclinic specieB agree closely in form. To them the orthorhombic speciea zoieite is also related in angle, its prismatic zone corresponding to the mono-clinic orthodomes, etc Thus we have :

Zolille mm"', no A no = 68° 84'. Epidote er, 001 A lOl = BS" 42'.

vu', 031 A 031 = 68' H'. mm', 110 A IlO = 70" 4', etc

There aeema to be, however, a monocliQio oalcinm componnd, having the composition of ;oisite, but monoclinic and strictly isomorphona with ordinary epidote; it is called dinozoisite.

Orthorhombic. Axee S:i:i = 06196 :1 : 0-34295,

,mm": 110 A lIO = 68* 84'. jT, Oil A Oil = >r ESf.

df. 101 A iOl = 57° 66'. «/", 111 A Ul = 88° 34'.

Crystals prismatic, deeply striated or furrowed vertically, and seldom distinctly terminated. Also massive; columnar to compact.

Cleavage: 5 very perfect. Fracture uneven to subconchoidal. Brittle. H. = 6-6-5, G. = 3-25-337. Luster vitreous ; on the cleavage-face, 5, pearly. Color grayish white, gray, yellowish brown, greenish gray, apple-green; also peach-blosflom-red to rose-red. Streak uncolored. Transparent to snbtrans-1 a cent.

Pieochroiam strong in pink varieties. Optically +. Ax. pi. usnally f h ; also D c. BxX <^- Dispersion strong, p <v; also p> v. Axial angle variable even in the same crystal. 2E, — 4',"'-90". /S = 1-696; y — a = o'oo6.

Vaz.—l. Ordiitary. Colon graj to white and brown; also greCQ. Usually In Indistinct prlamatlc or columnar forms; also la fibrous agKKgfutes. Q. = 8'228-S'381. UnionUe ia a very pure zoislle. 3. Boie-red or T/iuliie. Fnglle; pleochrolsm Btroug. S. tompael, muMtcK. Includes the essential part of moat saussurlte («.f., In saunuiite-gabbro), which has iiHseu from !tae alierutfon of feldspar.

Comp.—HCa,Al,Si,o„ or 4Cao.3AI,o,.6SiO,.H,o = Silica 39-7, alnmiDa ' 33'7, lime 34*6, water 3*o = 100. The alumina iB sometimeB replaced by iron, thus graduating toward epidote, which has the aame general formula.

Fyr.. etc.—B.B. swells up and fuses al S-S'.l to a white blebby mass Not decomposed by aclda; when previously Ignited gelatiuizes with hydrochloric acid. Qives off water when sirongly Ignited.

dS.—Characlerlzed by tiie Columnar structure; fusibility with intumescence; resembles some ampbibole.

Dlatiuguisbed in thin sections by Its high relief and very low luterferencc'Colois; laclc of color and biaxial character. From epidote it Is distinguished by its lack of color and low birefringence: from veauvianite by its color and biaxial character. Thin sectioDa tns-quentlj show the "vitra blue" (p. 428) between crossed nicols.

Obs.—Occurs espBcIully In those cryslalline scliista which have been formed by the dynamic metamorphisin of basic igneous rocks coutaiulDg plagioclase rich in lime. Commonly Bccompauies some one of the amphibolea laclinolite, amaragdite, glaucopbaue, etc.); thus m ampbibolite, glaucophane Bchlsl, eclogite; often associated with corundum.

The original zoisite is that of the eclogite oC the Baualpe In Carinthia (laiutlpiU). Other localities are: Kauris in Salzburg; Sleizing, etc., in Tyrol; the Fichtelgebirge in Bavaria; Harachendorf in Horavla; Saasthal In Switzerland; the island of Syra, <ine of the Cyclades, in glaucopbaue schisL T^uliie occurs at Kleppau in Tellemarken, Norway, and at Tra-venella in Plednjont,

Flstacite. Fistazit, Germ. HoDOclinic. Axes A :t>:i = 1'5787 : . 110 A liO = 108° 66'.

: 1-8036; /3 = 64° 37'.

el, 001 A 201 = 89° 26". w, 001 A on = 58, 2ff. en. 001 A 111 = 75° 11'. in'". 100 A Hi = 6fl° y.

IB'", ill A Hi =70*20'. Twins: tw. pL a common, often as embedded tw, lamellse. Oryetals astially prismatic | the ortho-axis h and terminated at one extremity only; passing

001 A 100 = M° 87'.

001 A 101 = 84' 48'.

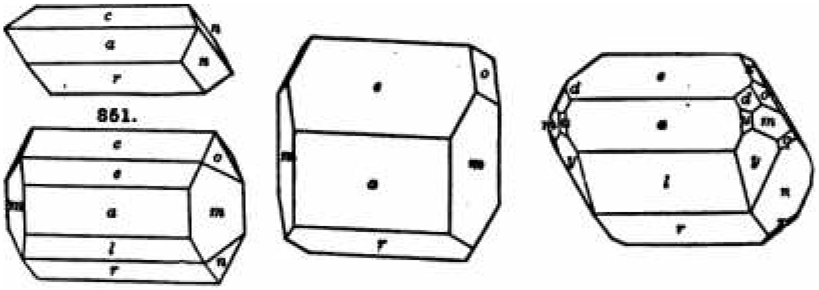
001 A iOl = 63° 42'.

100 A lOi = 61° 41'.

86a

863.

863.



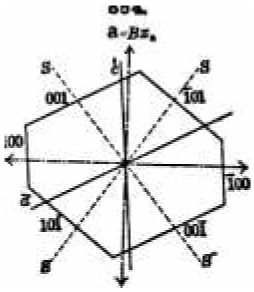
into aoicnlor forms; the faces in the zone ac deeply striated. Also fibrous, divergent or panilJel; grannlar, particles of variouB sizes, sometimes fine granular, and forming rock-masses.

.dbyGooglc

Cleavage: c perfect; a imperfect. Fractare uneren. Brittle. H. = O. = 3'35-3'5. Luster vitreouBi on c inclining to pearly or reBinons. Color pistachio-green or yellowisli green to brownish ""

.green, greenish black, and olack; Eometimes

-clear red and yellow; also gray and grayish white, rarely colorless. Stre^ unoolorea, gray-Transparent to opaque: generally enb-



transliicent.

Pleochroisin strong: vibrations | c green, b brown and strongly abmrbed, a yellow. Absorp. tioQ usnally b > c > a; but sometimes c > 6 > a in the variety of epidote common in rocks. Often exhibits idiophanous figures; best in sections normal to an optic axis, but often to be observed in natural crystals (Sulzbach), especially if flattened I r (lOl). (Seep. 318.) Optically-. Ax. pi. B 6. Bx.„ A i) = - 2° 56'. Hence c±a (100) nearly. Dispersion inclined, strongly marked; of the axes feeble, p > v, 2fi^, = 91° 20'. fij = 1-T5T02. Birefringence high, y ~ a = 0038 — 0-056.

Vm.— Epidote has ordinarily n peculiar yellowish green (pisiacblo) color, seldom found In othermtoeraU. But this color pASses lu to dark audlicht f hades—black on one side and brown on the utber; red, yellow imd colorless varieties also occur.

. Var. 1. Ordinary. Color greeu of some shade, ai described, the pistachio tint rarely absent, (o) In crystals, (i) Fibrous, (e) Granular massive, (d) Beerta is epidote sand from the gold washings la TraDsylrania. TLe Arendal epidote {Arend/tliU) Is mostly in dark greeu crystals; that of Bourg d'OlsouB Dauphlug {Thalliie, JMphiniie, OitaniU) in yellow Isli-Rreen crystals, somaiiinea trauBparent, Fute/Jdnite includes crystals from the auriferous sands of Ekaterinburg, Ural. A^itaatitt is ordinary epidote from Acbmatovak, Ural. A variety from Oarda, Hosle la., Terra del Puego, is colorless and resemliles loisite.

2. The Biicklnndite from Aclimatovsk, described by Heroiaiin, is black wiLb a tinge of

Seen, aod differs from ordluniy epidote in hnving the crystals neiirly symnielrical and not, .e other epidote, lengthened in tlie direction of the orthodlngonal. G. :^ 8 61. 8. Withnmite. Carmine-red to straw-yellow, strongly pleochroic; deep crimson and atraw-yellow. 11. = 6-6 0; Q. = 3'187; In small radiated groups. From Glencoe, In Argyle-shire, Scotland. Sometimes referred to piedmontite, but contains little UnO.

Comp.—HCa,{Al,F6).8i,0„ or H,0.4Ca0.3{Al,Fe.),Oj.6SiO„ the ratio of alnmininm to iron varies commonly from 6 ; 1 to 3 : 2. Percentage composition:

For Al: Pe = 8 ; 1 8iO, 87 87, Al.O, 24-13, Fe,0, 12M, CaO 28'51, H,0 IW = 100

Clinotoititt Is an epidote without Iron, having the composition of zoisite; fouqueiU Is probably the same from an snorthlte-gneiss In Ceylon. Pieroepidoti is supposed to contain Ug in place of Ca.

Fyr.. etc.—In the closed tube gives water on strong Ignition. B.B. fuses with Intumescence at 8~3'G to a dark brown or block mass which Is generally magnetic. Seactafor iron and sometimes for manganese with llie fluxes. ParUully decomposed by hydrochloric acid, but when previously ignited, gelatinizes with acid. Decomposed on fusion with alkaline carbonates.

Dl&.—Characterized often bv Its peculiar yellowish-green {pistachio) color; readily fusible and yields a magnetic globule B.B. Prismatic forms often longitudinally atrlated, but they bave not the angle. cTeaTage or brlttlenesi of tremolite; laurmallne has no distinct cleavage, is less fusible {In common forms) and usually shows Its hexagonal form.

Recognized In thin sections hy ita high refraction; strong Interference-colors rising into those of tbe third order in ordinary aecilons; decided color and striking pleocbrolsm; alao by the fact that the plane of the opllc axes lies transversely to the elongation of the t&iniDg much lime. It tliiig oftuu occurs iu giieissic rucks, uiics schUl. amplillxite scbiat, BerpeDtlne; no also <d (tuHrtzlles und sauilBloiiea iiltertd by neigbboring Igntious rucks. Often liccnmpsDles beds of magnetite or liemHlite Id sucb rocks. Has ulao been tounil io granite (Hobbs, Hsrylauil), aud regarded as au oiigiual miueral.

It is often asaoclated witli quartz, feldsptir, actlbolite, axiuite, chlorite, etc. It sometimes forms with quartz &u epldote rock, cHlled epidotiU. A. almiiar rockexiuLsnt Uel-boiirue in Cimadn. A gueissoid r^ck coaslsting of flesh-colored orthocluae, quartz and epidoie from the Uuak* Mts. (N. 0. mid Teon.) has beeu called unakyle.

Beautiful cryalall mil Ions come from Bourg d'Oisans, Daupbine; the Ala valley and Travcrsella. in Piedmont; £lba: Zermutt: Zllknlial in Tyrol; also Id flue crystals from the KoappenwaDd In (he Uiitersulzbacbtbai, Pinzgau, associated nith asbestus, adularia, apalite, tlianite, scbeelile; further at Stiiegau. Silesia; ZOptau, MorarliL; Arendal, Norway; the Achmatovak mine near Zlatoust, Ural.

In N. America, occurs in If. Hamp., at Praaconla. In Mau., at Hadlyme and Chester, In crystals in Knetaa; al Athol, in syenltic gneiss, in fine crystals, 2 m. S. W. of the center of the town; Newbury, In limeslone. In Coin., at Haddam, fu large splendid crystals. In N. York, near Amity; Monroe, Orange Co.; Warwick, pale yellowish green, wUbtltanite and pyroxeDe. In N. Carolina, at Hampton's, Yancey Co,; White's mill. GIsston Co.; Frank-liii, Macon Co.; in crysrals and crystalline masses In quarts at While Plains, Alexander Co. In Michigan. In the Lake Superior region, at many of the mines.

EpidoU was named by IlaUy, from the Qreek eKidoa-t<i, inereate, translated by htm, "qui & re9U un accroissement," the base of the prism (rbomboldal prism) having one side longer than the other. PittaeiU, from nttrtaKta, lh» pittachio-nvt. refeia to the color.

Pledmontita. Similar in angle to ordinary epldole. but conlalns 6 to IS p. c. Mn,0]. H. = 6'6. O. ~ S'404. Color reddish brown and reddish black. Pleochroism airong. Absorption a> 6>(, Optically+. Ax. pi. \b. Bx,.r A i=+82"84', a a ^ = - 6* to ~ 8'. Occurs with manganese ores at St. Harcel, Piedmont. In crystalline schisls on lie de Orolx, France; In glaucopbane-achist, in Japan. Occasionally in quartz porphyry, as in the antique red porpayry of Egypt, also that of South Mountain. Penn.

AUJUnTB. Ortblte.

Monodinio, Axes, p, 437. Id angle near epidote. CrTstala often taba-lar I n; also long and slender to acicnlar prismatio by elongation | axis h. Also massive and in embedded grains.

Cleavage: a and c in traces ; also m sometimes observed. Fracture uneven or aubconchoidal. Brittle. H. = 5-5-6. G. = 3-0-4-2. Luster snbmetaliic, pitchy or resiuons. Color brown to black. Sub translucent to opaque. Pleo-obroism strong : c brownish yellow, b reddish brown, a greenish brown. Optically —. Ax. pi, y b. Bi. /\i = 324° approi. ^ = 1'682. Birefringence low; V — n = 0-032. Also isotropic and amorphous by alteration analogous to gadolinite.

'Vax.—AUnnila. The original mineral waa from East Greenland, in tabular crystala or plates. Colo black or brownish black. G. = 8IS0-8-B5. BiteAiandito is anhydrous allanlte in small black crystals from a magnetlle mine near Arendal. Norwa\-. Bagration-iU occurs in black cmuls which are like the bucklandite of Acbmnlovsk (epidoie).

QrlAile included, tn Its original use, the slender or aclcular prismatio crystals, containing some water, from Finbo, near Falun, Sweden. But these graduate Into massive forms, and •ome orthitea are anhydrous, or as nearly so as most allnnlre. The name is from o/Aoi, straight. „jjj

Comp.—Like epidote HRR,8i,0„ or H,0.4R0.3R,0,.6SiO, with R = C» and Fe, and R = Al.Fe, the cerium metals Ce, Di, La, and in smaller amounts those of the Tttrinm group. Some varieties contain considerable water, bnt probably by alteration.

Pyr.. ate.—Some varletlea give much water In the closed tube.and all kinds yield a small amount on strong ignklon. B.B. ftuea easily and swells up (F. = 2'B) to a dark, bleb^y.

=:i,:cc ..Google

SILICATES.

441

nuSQCtic elaas. With the fluxes reacts for Itod. Most varieties geltUinize with hydrochluric acid, but if prevlouHly igailed are nut dccoiiipuBevI by add.

Ob*.—^Occura ia albiiic iiud cummou feldspiitbLc Kniiilta, gneiss, syenite, zlrconsyenile, porpbyry. Thus in Orceuiaud : Norway ; Stredeu ; Btriegnu, SiU-sin Also la wlilte thiiu-hIodc SB at AucrbacU on the Bergstraaae; oftbD iu mitiea of magnelic iron. Riitber coiiuiiud as an accessory coustlluent iu many rocke. as Id aDdesitt!. dioilte, daclte, rhyoUle, Ibc tDimlite of St. Adamello. tbe scaiiolile rucka uf OdcKaunleu. Nui'way, etc Sumetimes iDcloseU as a nucleus In cryatuls of tbe IsomoipliiiuB species, epidote.

At Vesuvius in ejected raasaes w!tbBauidine,sodslite, ncphelite, bombleude, etc. Biiiii-larly ia trachytlc ejected messes at tbe Laacber See {bucklandite).

Ia Mau., at tbe Bolton quarry. In N, York, Horlah, Essex Co.. with magnetite and apatite ; at Houroe, Orange Co. la N. Jtrtty. at I^Variklin FuruaDce witb feldspar aud mag-netite, Iu Ptnn., at ^. Houulalu, near Betblebem, iu large crystals ; at E. Bradford ; near Eckhardt's furnace, Berks Co-.abuudact. In Virginia, in large masses la Amberst Cn.i also in Bedford, Nelsoa. aud Amelia couulle*. In N. Carolina, at many points. At the Devil's

Head Mt., Douglas Co., Colorado.

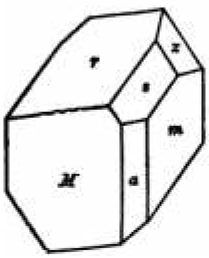
AXmiTZL

Triclinic. Area &:h:i = 04921 :1 : 0-4797 ; y « 131° 32'.

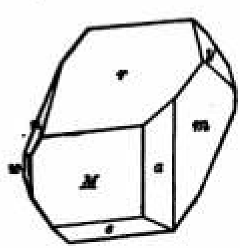
ses.

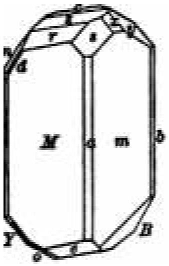
" 54', y9 = 91° 52',

855.



856.





Daupiiinfi. Poloma. Bethlehem, Pa.

am. 100 A 100 = 16* 84'. Mr. lIO A Hi = 45' 15'.

aM. 100 A liO = 38° 55'. mr, 110 A ill = M° 2*.

M, 100 A aoi = 21° 87'. ™, no A 201 = 27° 5T.

CryBtala usaallj broad and acute-edged, bat varied Id habit. Also massive, lamellar, lamellse often curved ; sometimeB granular.

Cleavage : b distinct. Fracture conchoidal. Brittle, H. = 6-5-7, 0. = 3-271-3'294. Luster highly glassy. Color clove-brown, platn-blue,aTid pearl-gray ; also hoDey-jellow, greenish yellow. Streak uncolored. Transparent to subtranslncent. Pleochroiim strong. Optically —. Ax. pi. aud Bx, approximately i, X (111). Axial angles variable. 2H„ = 87° 30' ; /9, = 1-678. Pyroelectric (p. 234).

Comp.—Aboro-silicate of aluminium and calcium with varying amounts of iron and manganese. Perhaps n,R.(BO)Al,(SiO.). (Whitfield.) R = Calcium chiefly, sometimes in large excess, i^in lu smaller amount and manganese prominent; iron is present in small quantity, also magnesium and basic hydrogen.

Analyses. 1, Wlittfleld ; 2, Genth.

G. SiO, B,0, AI,D, Fe,0. FeO M.iO OnO MgO len. 1. Bourg d'Oisans 41,S3 4 63 17flO 3»0 403 8-7fl 21-66 074 a"l6 = 100-82

3. Franklin. crjMf. 8-358 42^77 .'ilO 10-78 103 1-6(1- 18 69 18-25 0-28 0-78 = 100-16 ■ZnO, including 012 OiiO. Pyr,, •to.—B.B. fuaes r«adlly with iutumesceoce. Imparts a pale green color to the O.F.,

and fuBea at 2 to & dark green to black glass ; nitb bomi Id O.F glTce au ameibvstine bead (manguQtse), wblch in R.F. becomeii yellow (irou). Fused <nUb a mlzlure of biaufphate of potuab aud Uuur od the platiuum loop colors the flame greeu (boriu acid}. Not decomposed by acids, but wben pr<:viousl7 Igulled, gelatiolzes with hydrochloric acid.

Oba.—AiiDite occurs ia clove-browD crysiali, near Bourg d'Oisans Id Bauphfng : kt Andreaabtrg ; Striegau, Silesia ; un Mt. Skopi, In eastern SwitMrland ; Elba ; at the silver mloes of KuugsberK, Norway : Nordmark, Sweden ; near Hiask In the Ural ; In Cornwall, of a dark color, at tlie Botalfack miiie near 8t. Just. etc.

lu the U. S., at Pbippsburg, Halnu ; Franklin Furnace, N. J., honey-yellow ; at Bethlehem. Fa.

Named from dkiyt), an acu, la alludon to the form of the crysials.

Orthorhombic-hemimorphic. Axes S -.i ; 6= 08401 : 1 : 0*5549.

Distinct individual cryetaU rare; asuallj tabular | c; Bometimes priamatic mm''' = 80° 4'; again acute pyramidal. Commonly in groups of tabular crystals, united by c making broken forms, often barrel-shaped. Benifomi, globular, and stafactitic with a crystalline surface. Structure imperfectly columnar or lamellar, strongly coherent; also compact granular or impalpable.

Cleavage: c distinct. Fracture uneven. Brittle. H. = 6-6-5. G. = 2-80-296. Lnster vitreous; c weak pearly. Color light green, oil-green, passing into white and gray; often fading on exposure. Subtranaparent to translucent. Streak nncolored.

Comp.—An acid orthosilicate, H-Ca,Al,{SiO,), = Silica 43*7, alumina 24'8, lime 27-1, water 4-4 =^ 100.

Prebnile ia sometimes claased with tbe zeolltee, wllh which It is often BBSOciaied; the wnier bere, however, bas been shown to go off only at a red heat, and hence plays a differetit pari.

Pyr., «to.—In the closed lube yields waler. B.B. fuses at 2 with lotumesct nee to a blebby enamel-like gloss. Decomposed slowly 1>j hydrochloric acid without gels tin! zing; after fusion dissolves readily with gelallnization.

DIA—B B. fuses readily, unlike beiyl, green quariz, and chalcedony. lis hardness Is grealer Ihnn that of Ibe zeolites.

Obs.—Occurs cbleHy !n basic eruplive rocks, basalt, diabase, etc., as a secondary mfm-ral In vein a and cavitiec, often associated with some of Ibe zeolites, aho dalulite, pecioiile, calniie, but cnmibonly one of Ihe fli-sl formed of ibe series; alio less of leu in gtauite. gnelea, syenite, and then frequently asiociated with cpidote; sometimes associated wllh native copper. OS In the L. Superior region.

At St. Cliriaiopbe. near Bourg d'O

in Piedmont: in the Barz. near Ani „, „ „- . - -.

Norway: ^deiforsln Sweden {edelite); at Coratorphlne Hill, near Edinburgh; MoumeMls., Irelnnd.

In tlir United St«l«s. finely cirstallized a Bill. N. J.- In syenite, at Bomervflle, Mass.; < copper rerion.

Named (1790) after Col. Prebn, who brought the mineral from the Cape of Good Hope.

Haratiii^t*. An acid orthosilicate of manganese and calcium. In small colorless prismatic cryatals. B. = 60. Q. = 8-049. Prom the Baraiig mine, near Pajsberg, Werm-land, Sweden.

Onapidlns. Coninlos silica, lime, fluorine, and from alteration carhon dioxide: formula doubtful. In minute spear-shaped crystals B. = (i-6. Q. = 3-868-a-860. Color pale rose.red. From Vesuvius, in ejected masses In the tufa of Honte Somma.

17. SubsUioatei.

The species here included are basic salts, for the most part to be referred either to the metasilicates or orthoailicates, like many basic compounds already included in the preceding pagea. Until their constitution is definitely settled, however, they are more conveniently grouped by themselves as SuBSiLiCATza.

It may be noted that those speciea having an oxy^n ratio of silicon to bases of 3 : 3, like topaz, andaluette, sillimanite, datolite, etc., also calamine, car-pholite, and peraaps tourmaline, are eometimee regarded as salta of the hypothetical parasilicic acid, H.SiO,.

The only prominent group in this subdivision is the Hchite Group.

Hutnite Oroap.

Proleotite [Mg(F,OH)],Mg[SiO,],? Monodinic Chondrodite [Mg(F,OH)l,Mg,[SiO.], Monoclinic

1-0803:1:1-8861 10863:1:3-1447

l:&:6

1-0802:1:4-4033

1-0803; 1:5-6588

90"

Hamite [Mg(F,OH)],M:g,[SiO,], Orthorhombio

CUaohumite [Mg{F,OH)],Mg,[SiOJ. Monoclinic

The species here included form a remarkable series both as regards crystalline form and chemical composition. In crystallization they have sensibly the same ratio for the lateral axes, while the vertical axes are almost exactly in the ratio of the numbers 3:5:7:9(seu also belowj. Furthermore, though one species is orthorhombio, the others monoclinic, they here also correapond closely, since the axial angle y9 in the latter cases does not sensibly aifler from 90°.

In composition, as shown by Penfield and Howe (also Sjogren), the last three species are basic orthosilicates in each of which the univalent group (MgF) or (MgOH) enters, while the Mg atoms present are in the ratio of 3:5:7. The composition given for Prolectite is theoretical only, being that which "would be expected from its crystallization. In physical characters these species ore very similar, and several of them may occur together at the same locality and even intercrystallized in parallel lamellfe.

J chijsollte and chrjioberyl.

ProlecUle d: %:\h^l -0803

ChondTodlle d: t:\e = \<mz

Humlle I: 4: Ji = l-0802

Clinohumite <i: i:ie = 1080a

Clirygollle J : 2« : h = 1'0786

Chvyaoberyl i:2d: i = I-M87

: 0-8387

1:0-6170

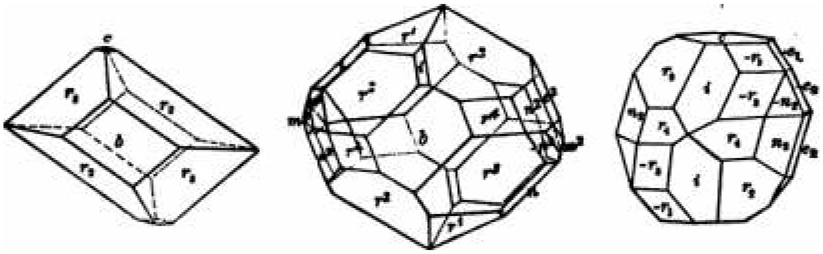
OHONDaoDrrE-HUMITB—OUNOHaMrm.

Axial ratios as given above. Habit varied, Figs. 858 to 866. Twins common, the twinning planes inclined 60°, also 30°, to c in the brachydome or clinodome zone, hence the axes croasiTig at angles near 60°; often repeated as trillings and as polysynthetic lamellee (cf. Fig. 556, p. 226). Also twins, t with c (001) as tw. plane. Two of the three species are often twinned together. \

Cleavage: c sometimes distincfc. Fracture subconcboidal to uneven. Brittle. H. = 6-6-5, G. = 3-l-3'2. Luster vitreous to resinous. Color white, light yellow, honey-yellow to chestnut-brown and garnet- or hyacinth-red. Pleocbroism sometimes distinct. Optically +.

Chondrodite. Absorpllob « > c > *. Optically +. Ax. pi. and Bn, 1 b. Bi. A 4 = a A 4 = +-5° Off Brewster: 28° 68'Kftfveltorp; SO" npprox., Hte. Bomma. (S=l-619;

= + 11°-13°; 71° approx., Brew-



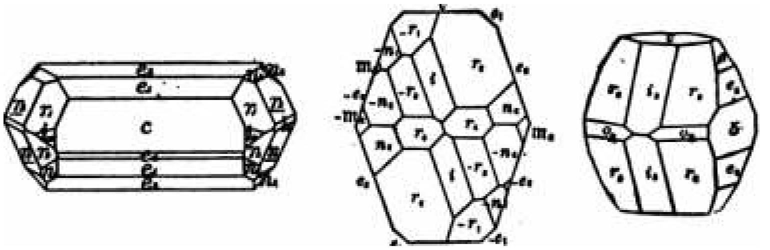
Flgi. 8S8, 8n, Ohondroditt. Brewsier, N. T.

*{018), «, (108). •, (101), r, (187), r, (188), r, (185),

861. 862.

GliondrodUe, Sweden. ,(121). n,(lll).

863.

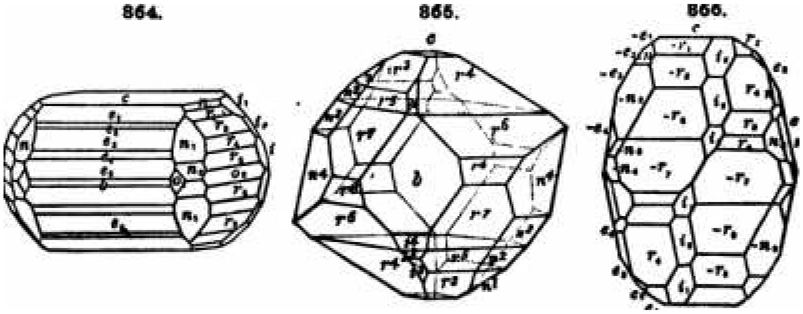


FIgi. 801, 60a, Ghmdrvdite, Ute. Bomnu.

SymboU see abore.

864. 866.

BumiU, Sweden. o,(aiO), «,(OIS),e,(o18).



Bvmit*, VsMlvlu* CUnnJi'imiU. Brewsttr. CUnohumitr, Mie. Snmmft.

(.(Oil), r, (2 1-10), r, (316). t",(o14|, i',(0l2!. <, (1081, «,(101). r.{i27). r.(i23).

r.(313). n,(I13), n,(MI). r. (12.'.). r. (121).

Comp—Basic flaoeilicates of magneBium with related formulas as shown in the table above. Hydroxy! replaces part of the fluorine, and iron often takes the place of magnesium.

Analyses bj Peu field:

. Coogic

P7T., ato.—B.B. lofiulble; loiiie vsrletla blacken and llieu bum wblW. Fused wiib potBaaliiin biaulphniB in the closed tube ^veg a reactlun for fluorine. With tbe fluxei & reaction for iron. Gelatinize* nlth acids. Beated witb sulphuric add gives uS silicoa fluoride.

Oba.—Chondrodite. bumlle, aud cllnobunilU: all occur at Vesuvius in tbe ejected maiMS both of limestone or feldspathic type found on Honte Somma. Tbey are associated witb chrvsultte, bioUte, pjroxene, magnetite, spinel, vesuvlauile, calcite, etc; also less often wiln sanidine, meionite, nephelite. Of the Ibree species, bumite Is the rareat and clinubumite of most frequent occurrence. Thej seldom all occur logvlber In the same muss, and only rarely two of tbe speciea (as humlte and cllnobumile) appear logelber. Occasiocally ciinohumite In terpen etmtea crystals of bumlle, and parallel iutergrovrlbt nilh clirysolite hnve also been observed.

CAondrodile occurs M Mtc, Bomma, as above noted: at Pargas, Finland, honey-yellow la Hniestone; at Kafveltorp, Nya-Kopparberg, Sweden, associated with chalcopyrlte, galena, sphalerite. At Brewster, K. Y., at tbe Tilly Putter nisgnetlc iron mine in deep

Sroel-rMl crjBtala. Also probably at numerous points where tbe occurrtnce of " (hon-odite" bas been reported.

HvmiU alga occurs at the Ladu mine near FiUpsiadt, Sweden, wilb magnetite In crya-talline limestone. In crystalline-IImesioue witb cbnohumlte in Andalusia. AIeo Id large. coarae, parity altered crystals at the Tilly Foaler irun-miue at Biewtter, N. Y.

Clitu^umiU occuta at Mte. Bomma and in Andalusia; in irysialllne llmeslone nwr L. Baikal iu Kaal Siberia; at Brewster, N. T., in rare but highly modittd crysials.

ProleettU Is from the Eo mine, Kordmark. Sweden; very rare; Imfieirecll] knovu.

Numeroua other localities of " cbondrodlle " have been noted, cl.iefly In crytiialllne limestone; most of Ihem are probably to be referred to the Epeclts chondroillte. but the identilf in niiiny cases Is yet to be proved. At Brewster large qusntities of marFive " chondnidlte" occur iissoclated with magnetite, enslaliie. ripldollte, and fiom lie t-xlcnsive alteration serpentine bas been formed on a large scale. Tbe granular mineial Is lommon in Umeatone In Sussex Co., N. J., and Oraqge Co., N. Y., aBcociated wllb spinel, and orca-■touatiy with pyroxene and corundum. Also in Man., at Cbelmsford, wilb fcapolite; at South Lee, in limestone. In Canada, In limestone at Bt. Jerome, Orenville, etc., abundant.

Tbe name chondrodite Is from lor^fiof, a grain, alluding to the granular structure. Humlte is from Sir Abraham Hume.

f^

TLVATIE. Llevrlte. Tenlte. Orthorhombic. Axes il:h:6 = 0-6665:1:0-4427.

mm-, no A liO = 67' 33". «'. 101 A lOl = «7* 11'.

m\ ISO a 130 == 78° 45'. otf. 111 A 111 = 63' 88'.

Commonly in prisma, with prismatic faces vertically striated. Colnmnar or compact massive.

Cleavage: b, c rather distinct. Fracture ttneven. Brittle. H. = 5-5-6. a. = 399-4-06, Luster sobmetaUic. Color iron-black or dark grayish black. Streak black, inclining to green or brown. Opaqne.

Comp.—CaFe.(FeOn)(SiO,), or H,O.Cao.4FeO.Fe,o,.4SiO, 'sI^^JT^^/ = Silica 29-3, iron sesquioiide 196, iron protoxide 35-2, lime ^^^■^^ 13-7, water 2-3 = 100. Manganese may replace part of the ferrona iron.

Pyr., etc.—B.B. fuses quietly nt 3-6 to a black magnetic bead. With the fluxes reacts for iron. Some varieties give also a reaction for manganese. Gelatinizes wilb bydro-'chlorlc acid.

Oba.—Found on Elba In dolomite; on Mt. Mulatto near Predazzo, Tyrol, in granite; Schneeberg, Saxonv: FoBSum. In Norway. Reporieii as formerly found at Cumberland, R. I.; also ai Milk Row quarry, Somerville, Mass. Named Hvaitt from the Lntin name of the island (Elba).

Ardennlte. Dewalqulte^ A vanadlo-silicale of aluminium and manganese, also containing arseDic. In pHsmatic cryslals resembling IWaite. H. = 6-7. G. = 8630. Yellow to yellowish brown. Found at Salm Chflteau in the Ardennes. Belgium.

Iiui|;baiilt«. Hbd^dcm silicate with ferrous ftutlmoDBte: formula doubtful. In Itoo-black liexagoDkl prismatic crj^Bta]!. H. = 6'S. O. = 4-918. I>uater metAlllc From L&Qgban, Swt<l«D.

The following are rare lead silicatos. See also p. 408.

EeatroUt*. Probably 8Pbo.2HntO,.3810i. Id mloule prismatic crystals; often Id aheaf-like forms; nlso manlTt;. H. =0. O. = 619. Culor dark reddlah browu; black on the surface. From loutheru Chili; Liogbaa, Bwedeti.

Melanotakita. aPbo.aFe,o,.88iO, or(Fe.O.)Pb.(8iO.). Warren. Orthorhombic: prismatic. UaasiTe; cleavable. H. = 6'fi. G. = 5'78. Luster metallic to greasy. Color black to blnckisb gt^- Occurs with natke lead at UDgban, Sweden. AJso la crystata resembling kentroUte at Hillsboro, New Mexico.

BertrandlU. H.Be.SI.O. or H,o.4Beo.2SiO,. Orthorhomblc-bemiroorpblc. losmall tabular or prismatic crystHls. H. = 6-7. Q. = 2'60-2-eO. Colorlesa to pale yellow. UbiioIIv occurs in feldapaitaic veiiu, often with other beryllium minerala as a result of the alteration of beryl. At the quarries of Barbin near Kantea, France; Plsek, Bohemia; HL Anterii, Chaffee Co., Colo., with pbeuacite; Stooeham, He.; Amelia Court-House, Ta.

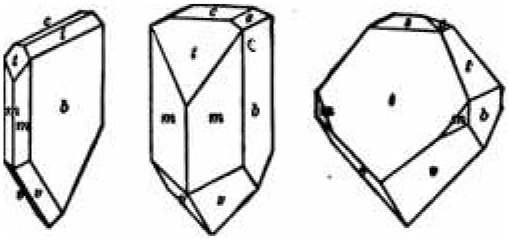
OALAMTWB. Smlthsonlte. Hemlmorphlte. Eieselzlnkerz, Oalmel pt. Oerm.

Ortborhombic-bemimorphic. Axes d:h -.i^ 0-7834 : 1 : 0-4778. 868. S69. 870.

mm'''. nOAlIO= 76* 9*. •f'', 101 A iOl = 62* 46'. It. 801 A 80I = 133* 41'.

on A Oil = sr v.

081 A 03l = 110'12''.



081.. M2i

Crystals often tabular I b ; also prismatic ; faces b vertically striated. Usually implanted and showing one extremity only. Often grouped in sbeaf-like forms and forming drnsy surface in cavities. Also stalactitic, mam miliary, botryoid^, and fibrons lorois; massive and granular.

Cleavf^e: m perfect; s (101) less so; c in traces. Fracture uneven to sob* conchoidal. Brittle. H. = 4-5-5, the latter when crystallized. Q. = 3'40-3'50. Luster vitreous; c subpearly, sometimes adamantine. Color white; sometimes with a delicate bluisn or greenish shade; also yellowish to brown. Streak white. Transparent to translucent. Htrongly pyroelectric.

Comp.—H,ZnSiO, or (ZnOH) SiO. or H,0.2ZnO.SiO, = Silica 25-0, zinc oxide 67'5, water 7-5 == 100. The water goes off only at a red heat; unchanged at 340'' C.

Pyr,, ate.—lu the cldBcd tubt decrepitates, whitens, and gives off water infusible (F. = 6). On charcoal with soda gives a coatiDK which is yellow wiilta on cooling. Holsleiied with cobnlt solution, and heated Id O.F. assumes a bright green color, but the Ignited mineral itself becomes blui with acids tven when previously ignited.

Dlff.—Characlerized hy itsinfusihtlity; reacllon foreinc; gelatiniaalion with'aclds. Resembles some smitlisonlte (which cffcrvegces with acid), alsn prehnlle.

Obs.—Calamine iind smlthsonlte are usually found ftssoclated In veins or beds in stmlibed cnlcareous rocks accompanying sulphides of zinc, Irou nnd lend. Thus at Aix-ia. Cliivpelle; Raibel and Bleiberg, in Carintliis; Moreinet in Belgium; ReKb&nva, Srhemnltz. At Itoughti^ti Oil!, in Ciimbcrlnnd; at Alston Moor, white; near Matlock, lu Derbyabire; Leadhilis, Scotland-, at Nerchinsk, In easleru Sibi^ria.

In the Uulted States occurs at Sterling Hill, near Ogdensburg, N. J.. In fine clenr crystalline masses. In PetiDsylvania, at the Perklomeu and Phenlzville lead mlnei; at

B.B. almost

hlle hot, and

this coaling

Qclatiuizes

.dbyGoOglC

FriedeDaTtlle. Abuodftnt in Virginl*. at Aiulfn's mines Id Wythe Co. With the zino deposiiH of southweaterD Htssouri. eapeclallf &bout Qranby, both sa crysUllized and niusive calamiDe. At tlie Emma mine, Cottonwood Cafion, Utah.

The name Caiamint (with Gaimei of the Germanai la commouly auppoaed lo be a coiniptiou of Cadmia. Agrlcola aaya it U from ealamut, a reed. Id allualoa to the aleoder forma (atalaotiticj pommon !□ the eadmiafomatMm.

011tioh*diit«. UiCaZuSiOi. HoDOcllnlc-clinohedral (aee Flga. 881, SSlo, p. 104). H. = 5'&. O. = 8'3S. Colorleaa or while to ainetbystlne. From Franklin Furnace, N.J.

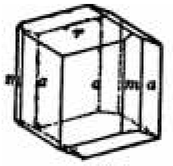
Oaipholitfl. H.HdAIiSIiO,,. Id radiated and stellated tufts. O. = 3-980. Color straw- to wax-yellow. Occurs at the tin minea of CkAlackenwald; WIppra, In the Hbtz, on qoaitE, etc.

Lawaonlte. E,CaAl,BliO,(. In priemaUc ortborhonnblc crystals ; mm''' = 87° 16'. O. = S-09. Luster vitreous to greasy. ColorleBs, pale blue to eroyisli blue. Occurs in cryatnllline achista of the Tibum peninsula, Harin Co., California; also In the schists of Ponigibttud and New Caledonia.

Oerita. A silicate of the ceilum metala chie^, with water. CrrtUls ran; commonly massive; graDular. H. = O'S. G. s 4*66. Color between clove-Drown and cherry-red to gray. Occun at BastoBa, near Kiddarhyttan, Sweden.

TOURMAUNB. Turmalin Oerm.

Rhombohedral-hemimorphia Aiia i = 04477. er, 0001 A lOil =^ 2r 20*. tt*, lOil a ilOl = 46° 68'. eo, 0001 A OsSl == 45° 5T. od, OaSl A 2021 = 77" C, 871. 873.



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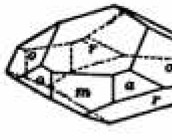

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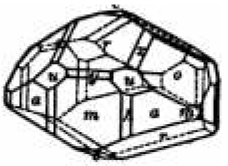

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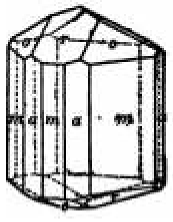
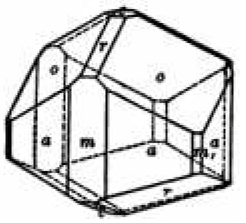
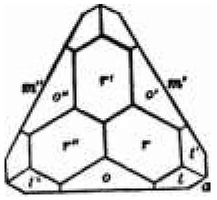






Crystals usually prismatic in babit, often slender to aoicular; rarely flattened, the priam nearly wanting. Prismatic faces strongly striated Tertically, and the crystals hence often much ronnded to barrel-shaped. The crosB-section of the prism three-sided (m. Fig. 877), six-sided [a], or nine-sided (m and a). Crystals coai-monlj hemimorphic. Sometimes isolated, but more commonly in parallel or radiating groups. Sometimes massive compact; also columnar, coarse or fine, parallel or divergent.

Cleavage: a, r difficult. Fracture anbconohoidal to uneven. Brittle and often rather friable. H. = 7-75. G. = 3'98-3-20. Lnater vitreous to resinous. Color black, brownish black, bluish black, most common; blue, green, red, and Bometimes of rich shades; rarely white or colorleas; some specimena red InterDMlly and green externally; and others red at one extremity, and green, blue or black at the other. Streak unoolored. Transparent to opaque.

Strongly diohroic, especially iu deep-colored varieties; axial colors vailing widely. Absorption for cu (vibrations J. i) much stronger than for e (vibrations jj ^); thus sections || 6 transmit sensibly the extraordinary ray only, and hence their use (e.^., in the tourmaline tongs (pvlSl)) forgiving polarized light. Exhibits idiophanons figures (p. 219). Optit^ly ~. Birefringence rather high, aa — e = 0-02. Indices: at, = 1'6366, e, = 1-6193 colorless var.; CO, = 1'6435, e, = 1*6222 bL green. Sometimes abnormally biaxial. Becomes electric by friction; also strongly pyroelectric.

Tar.— Ordirtary, In crystals as above deK;ribed; black much the most commoo. (a) RubaUile; the red, sometimes transpareiil: the Siberian is mosttj violet-red [ribaite\ the Brazilian roae-rod; Ihat of CheaCerfleld naA GoalieD,4tasB., pale roae-rcil sud opaque; that of Paris, Me., fine ruby-red and traiispareat. (fi) Ittdicolitt. or indigotitt; the blue either]>ali> or blui^ black; named from the indlgo-bhie color, (e) Brarilian Sappfiire (In jewelry): Berlin-blue and transparent, (d) Bratilian Emerald. Chrytolite (or Peridot) of

Bratil; green and IranspareDt. («| Peridot of Ceylon; bouey-yellnw. (/) Arhroite; colorless tourmaline, from Elba, (g) Apliritite; black tourmaiiue, from ErngerO, Norway. (h) Co'uTnnai' and black; coarse columnar. Resembles somewhat common hornblende, but bus s more resinous fracture. SDd Is without ilistinct cleavage or uuything like a fibrons appearance In the texture; it often baa the appeaiaoce on a broken surface of some kinds of soft coal.

Comp.—A complex silicate of boron and alnmininm, with also either magnesium, iron or the alkali metals prominent. The oxygen ratio of Si : B is in general 2 : 3 and the formula may hence be written: R,SiO, = K,8iO^ s H,SiO.. Here E = Na,Li,K; E = Mg,Fe,Ca; E = Al,B,Cr,Fe.

The varieties hased upon comporition fall into three prominent groupc, between whiclt there are many gradatioos:

I. Alkali Tourhalhik. Contains sodium or lithium, or bolh; also potassium. Q. = 8-0-3-1, Color red lo green; also Colorless.

3. Iron Tourhauhb. Q. = 8'l-8'3. . Color usually deep black.

8 Haokebium TonRMAUNB. Q. = 80-3-09. Usually yellow-brown to brownish black; also colorless (nnal. Mi).

A chromium bntrmaline also occurs. O. = 3'130. Color dark gieea.

The following are typical analyses (RIgga) of the three varietiea:

1. Rumford. Me., rou:

HIO, TIO. W,0, A1,0, yrO MnO C»0 MirO N«,0 K,0 tl.O H,0 T 88-07 — 9-89 43-34 036 085 OSB 0-07 218 044 I*«t 4-2« 038 = 100*8»

2. Auburn, blnek:

34-99 — 988 88-98 14-28 0-06 015 l-Ol 801 0-84 tr. 8-62 — =100-01)

3. Gouveraeur, brown;

87-39 119 10-73 27-89* 0-64 — 2-78 14 09 1-73 0-I« tr. 8-88 ft-.f =100-48

■ Including 0-10 Ff,0,.

Pyr., ate.—The raaiiiiteBln varieties fuse rnther easily to a white blebby glass or slag: the Iron-maRnesia var. fuse with a strong hent to a blebby slag or enamel; [he iron var. fnse with rtifficuliy. or, in some, only on the edges; the irou-magnesia-llthia var. fuse oa the edfTPS, nnd often with great difllculty, aud some are infusible; the lithla var. are infusible. With the fluxes many varieties give reactions for iron and manganese. Fused with

.dbyGooglc

« mixlure of potAMlum bUnlpbate and fluor-spar givee a dlitlnct reaction fur boric udd. Not decomposed by ncidi.

DHL —Ciancterixed by its crjBtBllizntlon, prfsmatic forms uBiml, wblcb arc three-, hIz-, or Dlueiided, and often with rbombnhedrul lecniinations ; niBssive formi nitb columnur Uruutiirt:; also by atisence of cleavage (unlike amplilbole and epldote); iu the common bliLck kinds by the coal-like fraoture; by liurdtieas; by difficult fusibility (cummou kiuils), compared witb garnet and VeHUTlauite. The boron test Is conclusive.

Rcudily distinguished in thin sections by Us somewhat liigli relief; railier strotiK inter> feruuce colors; negalive nulaiial characler; decided colors in ordinary light iu which Itasal MCtloQs often exhibit a zoaal structure. Also, eiipccially. by its remarkable absorption wtieu the direction of crystal elongaliou is ± to the vibrMllon-plBoe of the lower uicol: this with iu lack of clciiTagu dUtlug'urBLes It from bliitito and aniphibole, nhlch alone uinong rock-m:iklDg iniaemla show sinillar strong nbaorpllon.

Obi.—Commonly found In gmnlie nod giieiMea ai a result of fumarole action or of miuenilizlDK gases tu the fluid mngma, especially in the pegmntite veins associated with such rocks; at the peripbeir of nuch mai-ses or in Iliu schisu, or altered limestones, gaeiisuB, etc., Immoiliately adjoiumg them. It niarks (specially the boundaries i>f grauitia masses, and its associate minenils us those chamcierisLlc of sticli occurrences; quartz, albite, ' micDcliue, muscovlte, etc. The vnrie'y in granular limcaiotic or dolomite is commonly brown; the bluish-black var, somelimes associated with lln ores; the brown with titanium; the litbinm variety is often astociated with lepidolite. Redurjereen varieties, or both, occur Dear BkftieriDburS in the Ural; Elbii; CsmpoIonKO in Tessin, Bwilzerlnud ; Penfg, Sutony; als > the province Minna Geraes, Biazll: yellow and brown from Ceylon; dark brown varieties from Eibenatock, Saxony; Ihe Zillerthal: blark from Arendul, Norway; Saarnin; Kmi^erQ; pale yellowish brown al Windisch Kiippel In Cariulhla; flne hiacic crystikU occur in Cornwall nt iliHerent localities.

la the o. UliUa. in Maine at Paris and Hebron, magniScent red and ^reen touruialinei with lepidolite, etc.; also blue and pink vnrielies; aud at Norway; pink at Rumford, embedded iu lepidolite; at Auburn in clear ci^stals of a ddicule pink or lilac wlib lepidolite etc.; at Albany, greeu itod black, Iti Jlati., at Cheslerfiela, red, green, nnd blue; at a islii;ii, blue and greea; at Norwich. New Braintree and Carlisle, good black crystals. In N. Htmp., Qraftoii. Acwnrth; at Orford, brownisli bliick in steatite. In Cunn,, ni Monroe, ditrk lir >,vn in inica-slate ; at Haddain. liliick iu mlcu slutc; also flue pink and green; at New

Mitford, black. In N. Tirrk. uear Gouverueur, brown crystals, with IrenioTiie, etc., in grHDiiliir limestone; black near Port Henry, Essex Co.; near Edenville; splendid black cryilala at Plerrepout, St. Lnwrence Co,; colorless and slasiy at De Ealb; dnrk brown at McCumb. In N. Jertty, at Hamburg and Newlon, black and brown crystals in limestone, wiib spiuel: also grass-green crystals tu crystidliue linieslone near Franklin Piimac. In Pen'i... lit Newliu, Chester Co.; near Unlouville, yellow; at Chester, flne bluck; Middleto»ii, black; Marple, green iu lulc; near New Hope on the Delaware, large black cryptnls. A chroine v ir, from the chromile beds in Montgomery Co., jtforv.and. In y. Car.. Alexander Cii.. in flue black crystals with emerald and hlddenlte. In California, flue groups of rubsllite in lepidolite in 8iu Diego Co.

In Caiyida, \a the province of Quebec, yellow crystals iu limestone at Calumcl Falls, Litchfield. Pontine Co.; at Hunlerslown; flue btowu crystals ut Clarendoo. Pontine Co,; black at Qreuville and Argenleuil, Argeuleiiil Co. In Ontario, Iu flne crystals at N, Burgess. Lanark Co,; Qalway sod Stonuy L. in Dummer, Peterborough Co.

The name IttmuUin from TuraratUi iu Cingalese (applied to zircon by Jewelers of Ceylon) was Introduced luto Hiillaod in 1708, with a lot of gems from Ceylon.

Domortieiita. A basic aluminium silicate, perhnps4Al|0>.8BiOi.

Ortborliomblc. Prismatic angle approxtnintely 90°. Usually iu fibrous to columnar aggregntes. Cleavage: a distinct; also prismatic. Imperfect, H. =^ T. O. = 8'26-3*8fl. Luster vitreous. Color briglit amaltblue to greenish blue. Transparent to translucent. Pleochroiam very strong: c colorless, b reddish violet, a deep ulti-aniadue-blue. Exhibits Idloplianous figures, analogous to audaluslte. Optically —. Ai. pi. \ b. Bx 1 «.

Recognized in thin section by its rather high relief; low icterference'Colois (like those of qunrlz); occurrence in slender prisma, nceoles or fibers, with negative optics! extension; parallel extinction; biaxial character and especially by its remarkable pleochrolam.

Pound embedded in feldaiiar in blocka of gneiss at Chapimost, near Lyons. Prance; from Wolfshau. near Schmiedeberg. Silesia; in the iolile of the gneiss of Tvedestrand, Norway. In the U. S., il occurs near Harlem, New York Island, in tbe pegmatoid portion of a blotile gneiss; In a qiiarlzose rock at Clip. Yuma Co., Arizona.

..Coogic

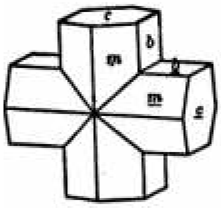
DBaCRlPTlVB MINBEALOQY.

STAUROUTB. Slaurolide. Orthorhombic. Axes d ih : i = 0*4734 : mm'", HO A liO = 50° 40". «

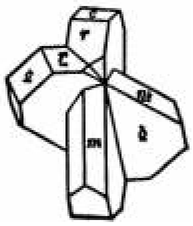
rr", 101 A 101 = 110° 83'. n

Twins cruciform: tw. pi. x (033), the crystiila crossing nearly at right alleles; tw. pi. z (333), crossing at an angle of 60° approximately; Iw. pi. y (330) rare, also in repeated twins (cf. Figs. 359, p. 132,409, p. 138,411, p. 129). CiyBtals commonly prismatic and flattened (J; often with rough surfaces. 878. 879

879.



880.



Cleavage: idistinct, but interrupted; niin traces. Fracture subconchoidaL Brittle. H. = 7-7-5, G. = 3-65-3-77. Subvitreous, inclining to resinous. Color dark reddish brown to brownish black, and yellowish brown. Streak nncolored to grayish. Translucent to nearly or quite opaque. Fleoohroism distinct: C (=^) hyacinth-red to blood-red, a, byellowish red; or c gold-yellow, 0, b light yellow to colorless. Optically -|-. Ax. pi. II a. Bx ± e. 2H„ = 113" 10'. p = 1-76, y — a = 0012. ' Comp.—HFeAl.Si.O,,, which may be written (A10),(A10H)Fe(SiO.), or H,0.3Fe0.5Al,0,.4SiO. = Silica 36'3, alumina 55'9, iron protoxide 15'8, water 3*0 = 100 Penfield. Magnesium (also manganese) replaces a little of the ferrous iron; ferric iron part of the aluminium.

SordmarkiU from Nordmark, Sweden, conlaias loaDga*

. . ^ Tnanganestaii Tsrlety, wblcli fuses eastly to a.

blaoWmaKneiicKlau. Willi the fluxes gives reaciions for iron, and sometimes for manganese. Imperfectly decomposed bj salpbuiic ai^ld.

Diff.—Cbaraclerucd bj tbe obtuse pnsra (unlike andahistte. wblch is nearly sqiiBre); by the frequency of twinning forms; hy hardness and Infuslbillt^.

Under tbe microscope, sections sbow a decided color (yellow to red or brown) and slmng-

Sleocbroism (yellow and red); also cbaracieriied by strong refraction (high relief), rntlier right iaterfereuce-colora, parallel eitinctloa and binxinl character (genemlly positive la the direction of eloneation). Easily distinguished from rutile (p. 84S) by Its biaxial character and lower interference-colors.

Oba,—Usually found in crystalline schists, ns mica schist, argillaceous schist, and gneiss, as a result of regional or contact mctaraorphisiii: ofien iissnciated witli garnet, slllimanltt:, cyanite, and tourmaline. Sometlmea encloses symmetrically arranged carbonaceous impurities like andalualte (p. 488). Other impiirilles arc also often present, especially silica, sometimes up to 30 to 40 p. c.; also garnet, mica, nnd perhaps magnetite, brookite.

Occurs with cyanite in paragonite schist, st Mt. Campinne, Switzerland: In the Zlllerthal. Tyrol; Gnldenslein in Moravia; Aschaffeiibiirc, BiitaHb; in iRrge twin crystals in tbe mic* ichisis of Brittany and Scotland. Id the province of Minas Oeroes, Brazil.

^AlOglc

Abundant throughout the mica scbisls of New Englaud. lu Maine, tX Wlndbam. In N. B'tmp., broirn at Fnncoaia; ut LisbuD; dd the shores of Hiak Poud, looae in,the soU. Id JfuM., Bt Cliesterfield. la tine cryaUla. lu Conn., at ButiOD, VerDOiJ,«(c.; Southbury witb garoets: at LItcbOeld. black ciTsIals. In S. Carolina, near Franklin, Macoo Co.; also In Madison and Clay couqIIqb. In Georgia, in Fannta Co., looee in the aoU in Sne cryaials. Named from <rTavpii, a oroti.

Koniarnpine. HeAltBiOi. In fibrous to columnar aggregntes, resembliDg ejlli-maoitQ. H. = S'5. G. = li'273konienipine; 3-S41 piismatine. Colorless to white, orliroirD.

Kornerupnt occurs at Fiskemfis oa the nest const of tireenland. Pritmattnt ie from Waldheim, Saxony.

Sapphlrina. HgiAlitSt|0<T. In indistinct tabular cirstals. Usually Id disseminated grains, or aggregations of gralDs. H. = TS. Q. = 8'13-8'48. Color pale bluo or giecOi From FiskernSa, Bouthwestern Qreeuland.

SrUOATBS.

Section B. Ohiefly Hydrona Speoies.

The Silicates of this Becond section incltide the trne hydrous compoundB, that is, those which contain water of crystallization, like the zeolites; also the hydrous amorphous species, as the clays, etc. There are also included certain species—as the Micas, Tale, Kaolinite—which, while they yield water upon igaition, are without doubt to be taken as acid or basic metasilicates, orthosUi-cates, etc. Their relation, however, is bo cloae to other true hydrous species that it appears more natural to include them here than to have placed them in the preceding chapter with other acid and basic salts. Finally, some species are referred here about whos^ chemical constitution and the part played by the water present there is still much doubt. The divisions recognized are as follows:

I. Zeolite Division.

1. Introductory Subdivision. 2. Zeolitea.

II. Mica Division.

1. Mica Groap. 2. Clintonlte Group. 3. Ctilorite Group. Ill; Serpentine and Talc Division. Chiefly Silicates of Magnesium.

IV. Kaolin Divi^on. Chiefly Silicates of Aluminium; for the most part belonging to the group of the clays.

V. Concluding Division. Species not included in the preceding divisions; chiefly silicates of the i heavy metals, iron, manganese, etc.

I. Zeolite Division.

1. Introductory Snl>diTlaioD,

Of the species here Induiled. several, as Aponhylllte. Okenlte. etc.. wblle not strictly Zkoiitbb. are rlosFJy relnted to thnni In compositinn and method of occurrence. PecloUte (p. 895) and Prehniie (p. 443) are also eometimes classed here.

I&Mito. 2(Hn.Ca)SiOi+HiO. Crysials gmall, priGmstic: also fibrous, ndbiled aoil BpLerulitic. U. =6. (i. =31129, Color roae- to flesb-nsU. Uccnra at tbe maogaDise mlLCB near Dilleuburg, Qerm&Df. BJwdotiliie Is.tlie wme Bpeclet from tbe Haratlg mice, Pttjaberg, Sweden.

OBQophyUlU. SU,0.7HdO.AI,0,.88IO,. In short prismatic crystalsi also tollBted, tnlcftceous. Color browD. B. = 4-45. O. = 384. From Ibe Haistig ffliM, near Psjs-berg, Sweden.

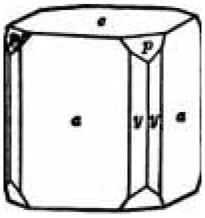
Okeiilt«. H,Ca8i.O. + H,0. Oommoijlr flbrous: also comprct. H. = 45-5. G. = 2'28-2'36. Color while, with a shade o(yellow or blue. Occurs In basalt or relsled eruptive rocks; as iu the FSrber; Iceland; Disko. Greeuland: Foods, India, etc.

QyToUte. H,Ca,Sl,0. 4- H,0. In white concretions, Inraeliar-radiate In stnicture. From tbe Isle of Skye, with atllbite, laumontlte, etc.; In India, etc. With apopbflUte of New Almadeu, CullforQlai also N. Bcotia,

APOPUI IjUTB.

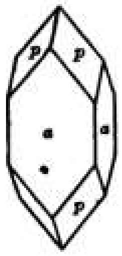
Tetragonal. Azis i =

ep, 001 A 111 = 80° 83".



ap, 100 ∧ 111 = 52° 0'.
pp', 111 ∧ 1̄11 = 76° 0'.

883.



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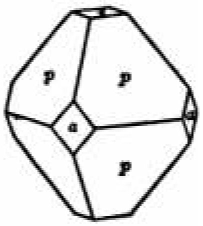
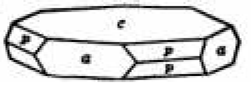


885.



Habit vnried; in gqnare ptisine (a) usaallT short and terminated by c or by cp, and then resembling a cube or cubo-octanedron; also acute pyramidal {p) with or withont c and a; lesB often thin tabular || c. Faces c often rough; ri bright but yertically striated; p more or less uneven. Also massive and lamellar; rarely concentric radiated.

Cleavage: cbighlyperfect; mleaaso. Fracture uneven. Brittle. H.=45-5. G. = 23-3"4. Luster of c pearly; of other faces vitreous. Color white, or grayish; occasionally with a greenish, yellowish, or rose-red tint, fiesh-red. Transparent; rarely nearly opaque. Birefringence low; usually +, also —. Often shows anomalous optical characters (Art. 411, Fig. 565). Indices: 00, = 1-5309 Li, e^ = 1-5333.

Comp.—H,KCa,(SiO.). + 4lH,0 or K,0.8Ca0.16SiO,.l 6H 0 = Silica53-T, lime 35-0, potash 5'3, water 16*1 = 100. A small amount of fluorine replaces part of the oxygen.

The sbove forroula differs hut little from HiCaSi.O. -|- H,0. In which potassium replaces pari of tlie himic hydroFrc'ii. The form often nccepted. H,(Ca.E)8l,0. + H|0. corresponds less well with the analyses,

Pyr.. etc.—In the closed tube eifiitiates. whitens, and yields wnler. which reacts sdd. Id the open tube, when fiisudwlib salt of phospliorus, gives a fluorine leactlon. B.B.

nfollates, colors tire flame vlolat fpotasli). and f ubm to a whtte vedculu CDunel. T. = 1-6. Decoiuiiiwed by hydrochloric acid, wIlL sepaiatioii of ellmy silica.

Dt&—CLarscteriKed by its leti'agvual furm, tlie aquure prism and pyramid Ibe commoa iiabils: by the perfect basal cleavage aud peurly luster on tLls surface.

Ob«,^Occiir« tommuDiy as a secoudai'y uiineral Id basalt xni related rocka, vitJi Tariiius xeoliles, also datollte, pectolite, otlcile ; also occasiooally in cavities io granite, gneisa, etc. Greeaknd, Iculaud, the FSrOer, aud Brllisb India aSord fine Hpecimeiis of apopbylilie to amygdaloidal bosull or diabase. Occurs also at Andreasberg, of a delicate pink; Radatithal ia tlie Uarz; at Or&witza, Hungary, with wollastonite; UlO, Swedeu; on iLe Seisser Alp lo Tyrol; GuHoajiiato, Mexico, often of a benutifiil piuk upon amethyst.

In tlie U. S.. large crystals occur at Bergen Hill, N. J.; in Ponn., at the Frencli Creek mines.

Chester Co.: at the CiiQ mine. Lake iiiiperlor regioui Table Mt. near Golden, Colo.: in California, at the mercury mines of New Almaden often stained bro^n bjbiiumeu; also from Nova Scotia at Cape Blomidon, and other poiuls.

Named bv HaQy in allusion to its tendency to exfoliate under the blowpipe, from dxu and ^OXXor, a leaf. Its irliilish pearly aspect, resembling Ibe eye of a tish after boiling, gave rise to the earlier name lehthyophOtalnite, from ixfivi.JUh, u<p6aXfiiii, tye.

2. Zeolites.

The Zbolites form a fatnil^ of well-defined hydrous ailicatea, cloeelj re lated to each other id compoBition, in conditioneof formation, and hence iii method of occurrence. They are often with right spoken of sa analogous to the Feldspars, like which they are all silicates of aluminium with sodittm and caloinm chiefiy, also rarely barium and strontium; magnesinm, iron, etc., are absent or present only through impurity or alteration. Further, the composition in a number of cases corresponds to that of a hydrated feldspar; while fusion and slow recrystallization result in the formation from some of them of anorthite (CaAl,Si,o,) or a calcium-albite (CaAl,Si,o,,) as shown by Doelter. The Zeolites do not, however, form a single group of species related in crystallization, lilce the Feldspars, but include a number of independent groups widely diverse in form and distinct in composition ; chief among these are the monoclinic Phillipsite Geoup; the rhombohedral Cdabazite Gkoup, and the orthorhombio (and monoclinic) Natrolite Group. A transition in composition between certain end compounds has been more or less well established in certain cases, but, nnlike the Feldspars, with these species calcinm and sodinm seem to replace one another aud an increase in alkali does not necessarily go with an increase in silica.

Like other hydrous silicates they are characterized by inferior hardness, chiefiy from 3o to 5-5, and the specific gnivity is also lower than with corresponding anhydrous species, chiefly 2"0 to 2"4, Corresponding to these characters, they are rather readily decomposed by acids, many of them with gela-tinization. The intumescence B.B., which gives the name to the family (from Z^iv, to boil, and \WoS, stone) is characteristic of a large part of tlie species.

The Zeolites are all secondary minerals, occurring most commonly in cavities and veins in basic igneous rocks, as basalt, diabase, etc. ; less frequently in granite, gneiss, etc. In these cases the lime and the soda in part have been chiefly yielded by the feldspar; the soda also by elaolite, eodaJite, etc.; potash by leucite, etc. The different species of the family are often associated together; also with pectolite and apophylHte (sometimes included with the zeolites), datolite, prehnite and, further, calcite.

Ptilollte. BAl,Si,pO„+5H,o. Here R = On : K, : Na, = 6 ; 2 ; 1 approx. In abort capillary needles, ajfgregeted !□ dellcnle tufts. Colorless, white. Occurs tipon a hluidi chalcedony iu cavities in a vesicular augite-anilesitc found in fragments in tbe conglomerate beds of

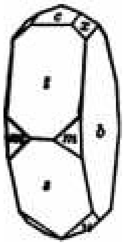
Oreen and Table mounlaius, Jefferson Co., Colorado.

Hordenlta. 3RAI,SI,gO„ -|- :jOH,o, where H = E.: Na> : Ca = 1 : 1 : 1. In minute crystals resembling beulandite in habit and nngles: also in small hemispherical or reni-

DESOBIPTIVB UIKEBALOOT.

form concretloDB with flbroua structure. H, = S-4. O. = 9'IS. Color wlilie, yellowish or piuklBli. Occurs nesr Hordeo, ElDg's Co., Nots Scotia, tn tnpj also In western Wyoming Dear Hoodoo Ht., on tbe ridge forming the divide betweeD Clark's Poric and ibe East Fork (I^msr R.) of the Yellowstoue river.

886.



HBUZiANDITB. 8tllblt« loma author*. Monocliaic Axes: d : i : d = 04035 : 1 : 0-4393; >5 = 88° 34^'.

«w»"', 110 A liO = 48" 56*. ». 001 A 501 = 66- C.

tt, 001 A aoi = 68* *)-. M. 001 A Oai = 40° 88^'.

Crystals sometimeB flatteued | h, the enrface of pearly luster

(Fig. 886; also Fi^. 3S, p. 11); form often suggestive of theortho-

I rhombic system, since the angles cs and ct di&r but little. Also

'i globular forms; graunlar.

Cleavage: S perfect. Fracture snbconchoidal to uneven. Brittle. H. ^ 3-5^. a. =2-18-2-23. Luster of b strong pearly; of other faces vitreous. Color various shades of white, passing into red, gray and brovii. Streak white. TranspareDt to suhtrauslucent. Optically -)-. Ax. pi. and Bi, J_ b. Ax. pi. and BXo for some localities nearly \c; also for others nearly _Lc in white light {Dx), Bio A (i = + 57i°. Axial angle variable, from 0° to 92'; nsnally 2Er = 52°. Birefringence low. yS = 1 "499 ; y — a = 0007.

Comp.—H,CaAl,(SiO,). + 3H,o or 5a,O.CaO.A1.0,.6SiO, = Silica 59-2, alumina 16-8, lime 9-3, water 14'8 = 100.

StroQtIum is usually present, sometimes up to 8'0 p. c. Pyr.—As with Btilbite. p. 4S7.

Obs.—BeulaDdlle occurs prlocipally in basaltic rocks, associated with cbabazlie, slil-blte and other zeolites; also in gneiss, and occasloually In metnlliferouH veins.

The finest specimens of this species come from BeruQord. and elsewhere in Icelimd; the FarOer; in British India, neiir Bnmbav; also iu railrond cutlings In the Bhor and Thiil GL&ls. Also occurs in the Eilpatrick Hills, near Glasgow; on the I. of Skye; Fassalhal, Tyrol; Andreasbi:r$(, Harz.

In the Uuited Stales. In diabase at Bergen Hill. New Jersey; on north shore of Lake Superior; with haydeuite, at Jones's Falls, near Baltimore {baaumontite). At Peter's Polut, NoTiL Scotia; alsil at Cape Blomldon, and other points.

Named nfter the Gaulish mineralOElcal collector, U. Heuland, whose cabinet was the boals of tbe clasBlcnl work (1887) of Levy.

Brswitoilta. H<(Sr.Ba,'Ca)A1,SI)o„4-8HiO. It) prismatic CiysUla. H = S. Q. =%-4S. Color while, Inclining to yellow and gray. From Strontlan In Aigyleehlre; tbe Giant's Causeway; near Freiburg In BreUgau, etc.

BpUtilMU. Probably like heulandlte. H,CaAl,ei)o.i + 8H,o. Crystals monocllntc, UQitormly twins; habit prismatic. In radiated spherical aggregations; also gmaulBr. O. =2-39. Color white. Occurs with scolecite at the Beruflord, Iceland; the FArOer; Poona, India; fu small reddish crystals, at Margaretville, N. Scotia, etc, BtiitiU Is from Sanioiln.

The above species, while crystallizing in the monoclinic system, are remarkable for the pseudo-symmetry exhibited by their twinned forms. Certain of

, Google

these twins are pseado-orthorhombic, others paeudo-tetrsgonfti and more complex twins even pseu do-isometric.

Frawulua has shown that the species of this group mav be regarded ufonning n series, in which tbt: rulio of BO : Al,o> is constuit (=1:1), aud thut at SIO, : H.O obo chieUj ' I : 1. The end coiupouude assumed by him are:

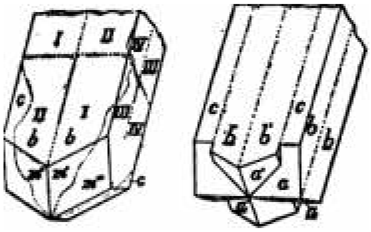
RAl.SiiO,, + 6H,o; R.AI,8i.o„ + 8H,o. Here R = Ca chleQ^, In philllpsite and sUlbitf, Ua iu iiarnioluuie, while in wellilte Ba, Ca. mid K, ure priiseuL; also in smaller amounts Nsi, Kt. The first of ibe above cotupoiiuda maj be regarded as a hydmted calcluiu albite, Ibe secuud as a hydraleil anoritilte, Pratt ana Fnoti:, liowever, show tbiit the anortbiie end compouDd more probably bas the fonnulti RAI.SiiU. + 2H]o (or this doubled). The formulas glTen beyoud are tbose comspoading to reliable imalysus vt certalu typical occurrences.

WallalU. RAliSi.Oit + 3H,o wiLh R = Ca: present iu small aDiuutit. PerceDtapie composition: SiO. 43-0. Ai.O, 24'8, BaO 6-6. CuO T-8. K.O 8-1, H,0 13-8 = 100. Monoclinic (axes p. 454u in complex twins, analogous to Ibosu uf phillllpsite and harmotome (Figs. B87, 868). Brittle. No cleavage. H. = 4-4-5. G. = S'3T8-3'36a. Luster vitreous. Colorless to while. Optically+. Bij.i(010). Bi-refriiiRence weak. ,

Occurs at the Buck Creek (Cullakauee) corundum mine in Clay Co., No. Carolina; in isolated crfatals atlacbed to feldspar, also to bombleude and corundum^ intimately associated with chabazite.

= 8:1:8; I

and Na also



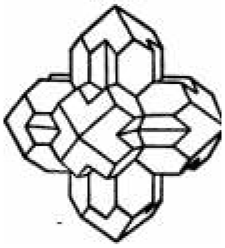
PHUiUPBITB.

Monoclinic. Axes S:$:i = 0-7095 : 1 :1-2563; fi = &5' 37'.

mm'", 110 A liO = 60* 43". em, 001 A HO = 60' BO*. uf, 100 A iOl = 34° 38'. «'. Oil A Oil = 82° 4'. CryiitHls nniformlv penetration-twins, bnt often simulating orthorhombic or tetragonal forma. Twins sometimes, but rarely, simple (I) with tw. pi. e, and \ then cruciform so that diagonal parts on b belong together, hence a fourfold striation, Q edge b/m, may be often observed on b. (3) Double twins, the simple twins just noted united with e (Oil) as tw. pi., and, since ee' Tariee but little from 90°, the result is a nearly sqnare prism, terminated by what appear to be pyramidal faces eacn with a double senes of striations away from the medial line. See Figs. 4^3-424, p. 130; also Fig. 363, p. 133. Faces b often finely striated as just noted, but striations sometimes absent and in general not so distinct as with harmotome; also m striated] edge b/m. Crystals either isolated, or grouped in tufts or spheres, radiated within and bristled with angles at surface.

Cleavage: c, b, rather distinct. Fracture uneven. Brittle. H. = 4-4-6, Q. — 2 2. Luster vitreous. Color white, soraetimes reddish. Streak uocolored. Translucent to opaque. Optically -+-. Ax. pi. and Bx^ _L 6. The ax. pi. lies in the obtuse angle of li i, and Is usually inclined to a about 15° to 20°, or 75* 10 70° to the normal toe. The position, however, is variable. 2H„ = 71 "-SI", Comp. — In some cases ttie formula is (E„Ca)Al,Si,0„ + 4^11 0 = Silica 48-8, alumina 20-7, lime 7'6, potash 64, water 165 = 100. Here Ca : K, = 2 :1.

889.



Pyr., vto.—B.B. crumbles &ud fuses at 8 to & white enamel. Qtlalfnizea wltti bydro-chloric Bc!d.

Obg.—111 irauslucent crystals in basalt, ut tbe Oinnt's Causenay, Irelaud; at Capo df Bove, neKr Rome; Ac! Caslello and elsewhere Id Sicily: among the lavas of Hie. Sorania; at BtBmpel, near Marburg; Aunerod, near Ofesseu;.lu the Kaiserelulil. with faujnsUe; S&lesl, Buheuiu; in the aocieot lavas o(thu Puy-de-Dfime.

Moiioclinic. Axes a-A-.6 = 0-7031 : 1 :1-2310; /3 = 55" 10'.

Crystals uniformly crnciform penetration-twins with c as tw. pi.; either

(1) simple twins (Fig, 890) or (2) nnited as fourlings with tw. pi. e. These double

690. twins often have the aspect of a square pnem with diagonal

pyramid, the latter with characteristic feather-like strintions

from the medial line. Also in more complex groups analogous

to those of phillipsite.

Cleavage: b ea^, c lees bo. Fracture uneven to subcon-ohoidal. Brittle. H. = 4-5. G. = 244-2-50. Luster vitreous. ' Color white; passing into gray, yellow, red or brown. Streak white. Sub trans parent to translucent. Optically 4~- Ax. pi. and. Bxb _L b. Ax. pi. in obtuse ?ngle a i and inclined about 65° to a and 60° to i. 2H,^, = 87° 2'. ^ = 1 516.

Comp.—In part H,(K„Ba)Al,Si,0„ + 4H,0 or (K„Ba)0.

Al,0,.5SiO,.5H,0 = Silica 471, alumina 160, baryta 206, potash 21, water 141 = 100.

Pyr., etc.—B.B. whitens, then crumbles and fuses without iutumesceDce at 3'5 to a white iranslucent glara. Some varieties phosplioresce when heated. Decomposed hy hydrochloric acid wiltioul gelalinizlnfc.

Obi.— Occora in basalt and similar eruptive rocks, also phoaolite, trachyte ; not 111 frequently on gneiss, and in some melalllferoiia veins. At Sironlian, lu Bcotland; iu a nieliilijferons vein at Aiidreasberg in the Harz; at HudebladI, Silesia; OberaielD, on agale In siliceous gerides; at Kongsberg, Norway.

Ill the U. 8.. in sinsll brown crystals with atilbite on the gneiss of New York island; nesr Pi. Ariliur, L. Superior.

Named tiom duttoi, joint, and r^fivtiv, to eiit, alluding to the fact tlisl the pyramid (made by tlie prismatic fnces in twinoiDg position) divides parallel to the plane that passes through tbe lermioal edges.

STILBI^B. Detmine.

Monoclinic. Axes: « : i : <! = 0-7623 : 1: 11940; /5 = 50" 50'.

Crystals uniformly cruciform penetration-twins with tw. pi, c, Z9\. analogous to phillipsite and harmotome. The apparent form a "

rhombic pyramid whose faces are in fact formed by tbe planes m and m ; tbe vertical faces being then the pinacoids h and c (cf. Figs. |

5(H.)-562, p. 22T). Usually thin tabular || b. These compound crystals are often grouped in nearly parallel position, forming sheaf-lilie aggregates witb tbe side face (b), showing its characteristic pearly luster, often deeply depressed. Also divergent or radiated; sometimes globular and thin lamellar-columnar.

Cleavage: 6 perfect. Fracture uneven. Brittle, H. = 3-5-4. |

G. — 2-09-l-2'205; 2-161 Haid. Luster vitreous; of b pearly. '

(^olor white ; occasionally yellow, brown or red, to brick-red. Streak uncolored. Transparent to translucent. Optically —. Ax. pi. II b. Bx, inclined 5° to axis a in obtuse angle a ^; hence Bx, A (^ = — 55" 50'. Ax, angle approx. 52° to 53° (blue glass); >3 = 1-498.

CoMp.—For most Tarieties H,(N'a, ,Ca) Al,Si,0,.+ 4H,0 or (Na„Cs)0. A1,0,. 6SiO,.6H,0 = Silica 57-4, alumiiia 16-3, lime 7-7, aoda 1-4, water ITS = 100. Here Ca:^, = 6:1.

Some kiadi show a lower perceaUge of «ltlcB, nnd these have been called AnwtfilMU.

Pyr., elo.—B.B. exfolintea, swella up, curvet into fan-like or vermicular forms, and fnaes to a wbite enamel. F. = 3-3'6. Decomposed by hydrochloric acid, without gel»-tinlzinK.

DUl— Characterized br the frequency of radiating or aheaf-like fortnfl; by the pearly lua'er on the dinopiuacoia. Does not gelatinize wlih actds.

Oba.—StUblle occure mostly In cavities in nmygdaloldal basalt, and almilar rocks. It U also found in some metalliferous veins, and in granite and gneisB.

Abundant nn the FarOer; In Iceland; on the Isle of 8kye,1n amygdaloid; alao In Dumbartonshire, Scotland, in red crysraU ; the Oiiint's Causeway ..Ireland; at Andreasberg in the Harz, and Kongsberg and Arendal In Norway, wilh iron ore ; on the Belaser Alp In Tyrol, and at the Puflerloch (pufierilt); on tbe granite of Striegau, Silesia. A common mineral In the Deccan Imp area of British India.

la North America, epnriogly In small crystals at Chester and at the Bomerrllle syenite

Suarrles, Mass.: at Phillipstown, N. T.; and at Bercen Hill. New Jersey ; also at the lichiplcoleu Islands, I.ake Superior. At Partridge Island, NoTa Scotia ; also at Isle Haute, DIgby Neck, Cape Ulomldon, etc.

The name itilbile is from ariXffij, lutUr; and detmitu from 64au-tf, a httuUt. Olsmondita. Perhaps CaAliSi.O,, + 4HiO. In pyramidal crystals, pseudo-letragonal. n. = 4'5. G. = S'2flG. ColorlMS or while, bluish white, grayish, reddish. Occurs id the lencltophyre of Mt. Albano, near Rome, at Capodl Bove, and elsewhere, etc.; on tlie Oonier glacier, near Zermatt; Schlauroth near OOrlitz in Silesia; Baleel, Bohemia, etc.

ZiAUMOHTmi. Leonhardlte. Caporcianite. Monoclinic Aiee ii\t:d~ 1-1451 : 1 : 05906; /? = 68" 46'. Twins : tw. pi. a. Common form the prism m (nim"' = 93" 44') with oblique termiDatioQ e, SOl (ce = 56° 55'). Also columnar, radiating and di Terse nt.

C^avaee : b and m very perfect; a imperfect. Fracture uneven. Not very brittle. H. = 3*5-4. G. = 2*25-2 36. Luster vitreous, inclining to pearly upon the face« of cleavage. Color white, passing into yellow or gray, sometimeB red. Streak uncolored. Transparent to translucent; becoming opaque and usually pulverulent on exposure. Optically —, Ax. pi. | i. Bx, A t* = + 65° to 70°. Dispersion large, p < I/; inclined,Blight. 21!, = 52° 24'.

Coup., Tar.—H,CaAl,Si.O„+ 2H,0 = 4H,O.CaO.A1.0,.4SiO,= Silica 511, alnmina 217, lime ll"9, water 15 3 = 100.

LeoahardiU Is a laumoulite which baa lost part of lis water (to one molecule), and the same is probably true of eaporeianiU. Sehneidtrita la laumontite from the serpentine of Monte Cotini, Italy, which has undergone alteration through the action of raagnesiaa sohitions.

Pyr., etc.—B.B. swells up and fuses at S-6-8 to a white enamel. Qelatlnizes with hydrochloric acid.

Obs.—Occurs in the cavities of basalt and similar eruptive rocks; also In porphyry and syenite, and occasionally In veins traversing clay slate with calcite.

Its principal localities are the FArOer; Disko in Oreenlaod; In Bohemia, at Eule In clay slate; bt. Qothard in Switzerland; the Fasgalhal: the Ellpatrick hills, near Glasgow; the Hebrides, nnd the north of Ireland. In India, in tbe Deccan trap area, at Poona, etc.

Peter^B Point, Nova Scotia, affords flne specimens of ttils species. Found at I^Ippsburg, Maine. Abundant in many places in the copper veins of I^ke 8ii|ierior In trap, and on I. Royale; on north shore of Lake Superior, between Pigeon Br j and Fond du Lac. Found also at Bergen Hill, N. J.; at the Tilly Foster iron mine, Brewster, N. Y.

I^rabanlta. Ca.AI,Si,o„ + 6H,o. Resembles sitlbttc. H. = 4'6-5. jG. = S-38. Color aaow-while. Occurs upon phillipslte in basalt at Lnuban, Slleala.

.dbyGooglc

Chabazlte Group. Bhombohedral. rr' i

Ch&buite {Ca,Na,)Al,Si.O„ + 6H,o, pt 85" 14' 1-0860 Gmeliaite (Na,Ca)Al,Si,o„ + 6H,o 68° 8' 0-7346 orj(!= 1-1017

XflTjnite CaAI,Si,o,. + 5H,o 73° 56' 08357 ^ = 1-1143

The Ghabazite G-roap inclndeB these three rhombohedral apeciee. The fundamental rhombohedrong have different angles, but, aa ehova in the axial ratios above, they are closely related, since, taking the rhomboheijron of Chabazlte as the basis, that of Omelinite has the symbol {(30S3) and of Levynitfl J(3034).

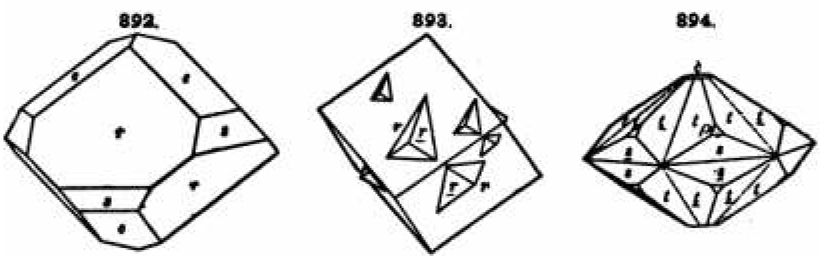
The Tarfatlon la composltton often observed in the flnt two specie* baa led to lb« rather plausible hypotliesls that they ftre to be vtewed u isomorphous mixtures of the feldapar-llke compouDds

(Ca.Na,)Al,81.0. + 4H,0. (Ca,Na,)Al,Si,o,. + 8H.o.

1-0860; 0001 A lOll = 51° SBf.

CHABAZITE.

Rhombohedral. Axis ċ = 1·0860; 0001 ∧ 10$\bar{1}$1 = 51° 25½'.



Twins: {1) tw. axis i, penetration-twins common. (2) Tw. pi. r, contact-twins, rare. Form commonly the simple rhombohedron varying little in angle from a cube {rr' = 85° 14'); also r and e (0ll2), {«' = 54° 47'). Also in complex twins (Fig. 348, p. 118). Also amorphous.

Cleavage: r rather distinct. Fracture uneven. Brittle. H. = 4-5, G. = 2-08-2-16. Luster vitreous.. Color white, flesh-red; streak uncolored. Transparent to translucent. Optically —; also -f- (Andreasberg, also hayden-ite). Birefringence low. The interference-figure usually confused; sometimes distinctly biaxial; basal sections then divided into sharply defined sectors with . different optical orientation. These anomalous optical characters probably secondary and chiefly conditioned by the variation in the amount of water present. Mean refractive index 1-G.

Var.—1. Ordinary. The moat common form Is tbe fundameotal rhombobedron, in wtiich the angle is ao near 90' that the crystals were at first mistaken for cubes. AeadialO*. from Novn Scotia (Acadia nt tbe French of last century), is a r«ddlsb chabazlte; sometimes iieiirly colorless. Uaydtnite Is a yellowish variety In small crystals from Jones's Fulls, near Baltimore, Md. 2. Phaeoliie U a colorlefw variety occurring in twins of heiagonal form (Fig. lilQ-l). Hud leiillrular In slmpe (whence the name, from tfnicii^, a bean); the orlglDal was from Lc'ipa In Bohemia, Here belongs also hertehUiU (seebachite) from Richmond, VIcloriii; the composite twins of great variety and beauty. Probably alao the origlnat burschelile from Sicily. It occurs in flat, almost tabular, hexagonal prisms with rounded termloatloQS divided Into alz lectoia.

Comp.—Somewhat uncertain, since a rather wide Tariation is often noted eren among Hpecimens from the same locality. The ratio of (C&,Na,,K,) : Al U nearly co>D8tant (= 1 : 1], but of Al, : Si varies from 1 : 3 to I : 5; the water also increases with the increase in silica. I'he compoaition usnally corresponds to (Ca,Na,)Al,Si,o -|- 6H,o, which, if calcinm alone is present, requires: Silica 47-4, alumina 20-2, lime IIJ, water 21-3 = 100. If Ca: Na^ = 1 :1, the percentage oompoaitioii is: Silica 47*2, alumina 200, lime 5*5, ioda 6*1, water 21-3 = 100.

Polauliim ts present In imall amount, alao, sometimea. bariiini aud atroutfum. t^treng explulns Ihe supposed facts moat ftBtlstactorlly by tlie bypoibesis that the memben of the group are isomorphous mixtures aualogoua to the feldspiirs, as Doled on p. 453.

FjT., ato.—B.B. iotumesces aud fuses to a blebby glass, nearly opaque. Decomposed bj bydrocbloric actii, with sepantiou of slimy silica.

Di£—Chsracterized by rbombobedral form (resembling a cube). It is harder than Gslcite aud does uot effervesce with acid; unlike calcile and fluorite In cleavBge; fuses B.B. with intumescence unlike snatcile.

Obs.—Occurs mostly in biisaltlc rocka. and occnalonally in gneiaa, syenite, mica schist, hornbleuilic schist. Occurs nl the FftrOer, Greenland, iind Icelnnd, associated wiih chlorite and Elllbite; at Ausaig In Bohemia: at Oltersteln. with harmotome; al Anuerod, near Qlessen: at the Giant's Causeway, Antrim, Renfrewshire; Isle of Skye. etc.

In Ihe U. B., In ayenlts at Someivllle, Mass.; at Bergen Hill, N. J., iu small crystals; at Jones's Falls near Baltimore (/laj/detiitt). In Nova Bcolla, wiuo yellow or fleab-red (the Inst tlie aaidiaCile), associated with heuliiudite, analclte aud caloiCe, al Five Islands, Swan's Creek, Digby Neck, etc.

Tbe name Cfiabanta la from x'^ff<"t'ot, au ancleat name of a stone.

OMBUNITB.

Ehombohedral. Axis i = 0-7345.

Crystals usually hexagonal Mt. 89S.

in aspect; sometimes p (Sill) smaller than r (lOll), and habit rhombohedral ; rr' = 68° 8', rp = 37° 44'.

Cleavage: m easy; c sometimes distinct. Fracture nueven. Brittle. H. = 4-5. G. = 3 04-2'17. Luster vitreous. Colorleas, yellowish white, greenish white, reddish white, flesh-red. Transparent to translucent. Optically positive, Cyprus, also negative, Andreasberg, the Vicentine, and Glenarm, N, Scotia-Birefriugejice very low. Interfere nee-figure often disturbed, and basal sections divided optically into section analogous to chabazite.

Comp.—In part (Na„Cft)Al,Si,o„ 4" 6H,o, If sodium alone is present this requires: Silica 469, alumina 19-9, soda 12-1, water 21-1 = 100. See also p. 458.

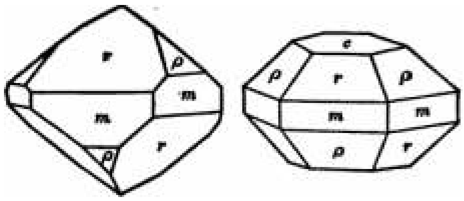
Pyr., ato.—B.B. fuses enally (F. = 3'5-8) to a wbite enamel. Decomposed by hydrochloric BCid with sejiaralion of Killca.

Oba.—Occurs in flesh-red crystals In amygdaloldnl rocks at Hontecchio Magglore; at Andreasberg; in TransylTsnta; Antrim, Ireland; Tallsker in Skye, in large colorless crystals.

In tbe United Ststes Iti fine white crystals al Bergen Hill. N. J. At Cape Blomidon. Nova Scotia {hdererite): also at Two Islands aort Five Islands.

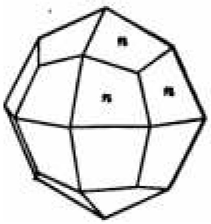
Named OmtliniU after Prof. Ch. Gmeiin of TQblngen (17Ba-1860).

I/avynlte. CaA1,8iiO,(+5H,0, In rhombohedral crystals. H. = 4-4-5. G. = S-OU-a-16. Colorless, wbite, grayish, reddiab, yellowish. Found at Olenarm and at bland

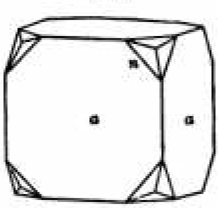


Qolden, Colorado.

897.



898.



ANAIXHTEI. Aoslcime.

iBometric. Uaually in trapesohedroiiBj also cubes with faces n (311); again the cnbic faces replaced by a riciaal trisoctahedron. Sometimes in composite groups abont a single crystal as nucleus (Fig. 351, p. 119). Also maBsive granular; compact with concentric structure.

Cleiivage: cubic, in traces. Fracture subconchoidal. Brittle. H. = 5-5-5. G. = 2-22-2-29; 2-2r8 Thomson. Luster vitreous. Colorless, white; occasionally grayish, greenish, yellowish, or reddish white. Transparent to nearly opaque. Often shows weak double refraction, which is apparently connected with loss of water and consequent change in molecular structure (Art. 411). h, = 1'4874.

Comp.—NaA18i,0,+H.O = Na,O.Al,0,.4SiO,.2H,0 = Silica 54-5, alumina 23-2, soda 141, water 8'2 = 100.

Pyr., sto.—Yields water in the closed lube. B.B. fuses at S'G to a colorless glaes. Qelstlnfzes with hydrocbloric Bcid.

mff.—ChBracterlKed by tiapezoliedral form, but is softer than garnet, and yields water B.B., unlike leucite (wbicb is also Infuaible}: fuses witbout lotumeiceDce to a clear glass unlike cbabazite.

BecogDized in tbln Becllons by its very low relief and isotropic character; often shows optical anomalies. From leucite nud sodalite surely disliDguisbed only by chemical leata, i.e., absence of cbloriue in Ibe nitric-acid test (see sodalile, p. 444), absence of mucb potash and abundance of soda in the solution, and evolution of much water from the powder in a closed glass tube lietow a red heat.

Obs.—Occurs frequently wilb other zeolites, also piehnlte, calcite, etc., in cavities and seams in basic igneous rocks, as basalt, diabase, etc; also in granite, gneiss, etc. Recently shown lo be also a rather widesprend comtwnent of the groundmass of various basic igneous rocks, at times being the only alkali-alumina Bilicnte present, as in the so-called analcite-basalts. Has been held in such casea to be a primary mineral produced bj the crystalliiBtion of a magma containing cousiderable sooa and water vapor held under

The Cyclopean Islands, near Catania, Sicily, afford pellucid crystals; also the Fassathtl in Tyrol; other localities are, in Scotland, In the Kilpntrick IJills; Co. Autriui, etc, ju Ireland; the F&r&er; Iceland; near Aussig, Uohemis; at Arendal, Norway, ia beds of iron ore; at Andreasberg, in tbc Hnrz. in silver mines.

In the U. 8., occurs tit Bergen Hill. New Jersey; Id gneiss near Tonkers. WesttAester Co., N. Y.; abundant in tine crystals, with prebnite, dalollte, and cnlcite. In the Lake Superior region; at Tabic Mt. near Qulden, Colorado, with other zeolites. Nova Scotia affords line specimens.

Tbe narae ArutletToe is from ayaXKii, weak, and alludes to its weak electric power when heated or rubbed. Tbe correct derivative is nnaUite, as here adopted for the species.

Faigasite. Perhaps H.Na,CaA1.8i,.0„ -f 1BH,0.

In isometric octahedrons. H. = 5. G. = 1883. Colorless, white. Occurs with angile In tbe limburgite of Suslucb In tbc Ealserstubl, Baden, etc.

BdingtoDit*. Perhaps BaAl,SiiO,, + 8H,0. Crystal a pyramidal in habit (tetragonal-sphenoidal); also massive H. = 4-45. G = 2ei)4. Wblle, grayish white, pink. Occurs in the Ellpatrick Hills, near Glasgow, Scotlaod, with harmotome.

HfttndiU

Natrollte Group. Orthorhombic and Monoclinic. Na,Al,Si,0,. + 2H,0 0-9785 :

Soolooite XewUte

4 il-.i p

0-9764 : 1 : 03434 89° 18'

C«(A10H),{SiO.), + 2H,0

Na,ALSi,0,. + 2H,0

2[CaAl,Si,0,.+3H,0] The ihree species ot lli« Nathoutk Gnoin" ngree closely in angle, tliougb vnrylug In crysialUue sjBiena : Natrolli« la orthohiumbic usually, a1w> rami}-mouocliDic: Scukcite ia monoclinic, perilapa hIso iu part ivlclinic: Mesolite aeems to be botli monoclinic aud irl-cliulc. FibrouB, mdialing or divergeut grou a are common to all lbe«e species.

The Matrolitu Gniiip iiicludeg ilie Bodiiim stltcate, NatroUle. witb ibe empirical rormula Na,At,Sl>o,g.2H,0i the calcium eilicaie, Scoleclie, CaA1,SI,0„.3H,0i sIbo Hecollta intermediate between tlieae anil coTTcspouding to j ^Qj^i gj o 8H O ■

= 0-9785 : 1 : 0-3536.

NATROUTE. Nadelieolitb Qtrm.

Orthorhombic. • Axes a xh -A

mm'". 110 A no = V»° «!' 8" «».

mo', no A 111 = 63° 11'. «/. Ill A ill = 37° 88'. on'". 111 A iil = 30° 471'.

Cryatnla prismatic, usually very slender to acicular; frequently divergent, or in stellate group. Also fibrou8,radiating, massive, granular, or compact.

Cleavage: m perfect; b imperfect, perhaps only a plane of parting. Fracture nneven. H. = 6-5-5. G. = 2 20-225. Luster vitreous, sometimes inclining to pearly, especially in flbroua varieties. Color white, or colorless; to grayish, yellowish, reddish to red. Transparent to translncent. Optically+. Ai. pi.] 5. Bi J, c. 3E, = 93" 28'. /?,= 1-4797; y-a = 0012.

V«T.— Ordiaary. Commonly citber (a) in groups of Blender colorless prlBmatlc crystals, varyini; but little In angle froni square prisma, often actcular, or (A) In Qbrousdirer-gent or radiated massea. vitreous In luster, or butslfgbtly pearly (these radiated forms often Tesemble those of tbomsotilte and pectolile); often also (is) solid amygdules, usually radiated flbrouB, Ktid aomewbiit silky In luster within; (d) rarely compact massive. OaiaetiU is ordinarily natrollte. In colorless needles from southern Scotland.

BergmanniU. tprtutUin, brmUite, are names wblcb bave been given to the natrollte from the augite-syenlte of southern Norwar, on the Langesund Bord. in the "Brevik" region, nhcre it occurs Bhrous. massive, and in long prismatic crystallizations, and from white to red In color. Derived Iti part from elxollle, In part frum aodallle. Iron-natrolile la a dark green opaque variety, either crystalline or smoi-pbous, from the Brevik region; the iron ia due to iriclusiiins.

Comp.—Nft,Al,Si.O,.-f 2H,0 or Na,O.Al,0,.3SiO, + 2H,0 = Silica 474, alnmina 26-8. Na,0 16-3, water 9-5 = 100.

Pyr., eto.—In the closed lube whliens and becomes opaque. B.B, fuses qule'ly at 2 to a colurleM glass. Fusible In the flame of an ordinary steartneor wax candle. GelaliniKcs with acids.

Diff — Dislingulsbed from aragonile and peclolite by Its easy fuslblllly and gelatinIzation with acid.

Obs.—Occurs in caviiies in amyi-dnloidal basiill, and other related Igneous roclts:

•Ian

9 cases the crystals seem to be monoclinic.

^Aioglc

BomellmeB fn Eeums In greoite, gDClea, and avenile. Found Al Ansaig and Teplltz la Bohe-miit; ill fine L-rystiila In Auvergiie; Fussatlial, Tyrol; KapLiik, Huugury. In red amygdules ferocalite) iu miiygtiHliiId of Ireland, Bcutlaud uiid Tyrol; tbe amygdaloid o' BLshopton {salactit«)\ at Glen Farg l/argiie) iti FIfesliire. Common in (he Bugite-sjenite of &.e Laugc-euBd Dixd, neiirBrevIk, guiilhein Norwiiy.

Ill Norb Americii, in lLh trupof Novu Bcolia; at Bergen Hill, N. J.; at Copper Fulb, Lake Superior.

Named Metoiypt by HaOy, from HtVoS, middle, and rvteoi, type, because the form of the cryBial—iiiltis viev n square piiaui—was intermediate between the forma of atllblte aud auHlcite. NatroliU, of KlaprolU, la from natron, toda; It alludes to tlie presence of soda, -wheuce also the name waa-me»oiYpt, iu contrast with scolecite, oi Unw-mMolj'jM.

SOOLEOITB.

Monoolinic. Axes h.%A = 09764 : 1: 03434; /S = 89° 18/

Crystals slender prismatic {mm'" = 88' 3Ti'), twins Bhowing a featherlike stmtion on &, diverging upward; also as peuetration-twins. Crystals iu diverfrent groups. Also massiTe, fibrous and radiated, and in nodules.

Cleavage: m nearly perfect. H. = 5-5'5. G. = 216-'J4. Lustervitreons, or silky wHen fibrous. Transparent to sub translucent. Optically —. Ax. pi. and Bx„ J, ft. Bi, a (^ = 15M6°. 2H„ = 33" 26'. /? = 1 4953.

Comp.—CuAl,Si,0,. + 3H,0 or CaO.Al,0,.3SiO,.3H,0 - Silica 459, alumina 36-0, lime 14-3, water 13-8 = 100.

Pyr.. Bto. —B,B. someltmeg curls up like a worm (whence the name from okh^Xii^, a vorm. nblcb gives tuMdU. and not icoleiile or toUtiU); otiier TiirlencK JntumeEce but sligblly, and ail fuse at 3-3 3 to a white btebby euamei. Gelatinizes with adds like nBtroitte.

Obi.—Occurs in the Beruflord. Iceland; in amygdaloid at Slaffa; in Skye. lit TuliakN: near Fisenni'h, Saxony; in Auvcrgne; common in fine crystalIfzatlong iu the Deccnn trap area, in British India. In tbe United Stales, in Colorado at Table Mountain near Oolden In cavities ip basalt. In Canada, at Black Lake, Hegaulic Co., Quebec

Mesollte. Intermediate between iiatrollte and scolecite (see p. 4S3). In acicular and capillary cryslois: delicate divergent tufts, etc. G. = 8'39. White or colorless. In amygdidoidal basalt at numerous points.

THOUBONTTB.

OrthorhomWe. Axes S : i : i = 0-9932 : 1 : 10066.

Distinct crystals rare; in prisms, mm'" = 89° 37'. Commonly columnar, Btmcture radiated; in radiated spherical concretions; also closely compact.

Cleavage: i perfect; n less so; c in traces. Fracture uneven to sabcon-choidal. Brittle. H. — 5-5-5. Q. = 2'3-2-4. Luster vitreous, more or less pearly. Snow-white; reddish, green; impure varieties brown. Streak uncol-ored. Transparent to translncent. Pyroelectric. Optically -f. Ax. pi. \ c. BxJ,6. DUpersion p > V strong. 2E, = 83-. /i^ = 1-503.

Var.—1. Ortlinary. (a) In rcguliir crystals, usiially more or less rectnnguliir in init-line, prismatic in habit. (6) Prisms sltniier. often vesiculMr lo radiated, (e) Radiated fibrous, {d) Spherical concretions, ronsisling of mdiated fibers nr slender crystals. AUo massive, gninular to impalpable, ami whiti' to reddish brown, le.'s (ifteii green ns in Unton-iU. The spherical massive forms also i-adiatcd with several cenlcra and "f varying colors, hence »f mucli beauty when polished. Otarkiie is a white masiive thomsouiie from Arkansas.

Comp.—{Na„Cs)Al,8i,o, + |H,o or (Na„Ca)O.Al,o,.2SiO,.5H,o. The ratio of Na,: Ca varies from 3 :1 to 1 :1.' If Ca : Na, = 3 : 1 the percentage composition requires: SiO, 37-0, Al.O. 31-4, CaO 12-9, Na,o 4-8, H,o 139 = 100.

Pyr.. etc.—B.B fuses with intumescence at 2 to a while enamel. Gelatinizes with hydrochloric acid.

Diff —Resembles some natrolite, but fuses lo an opiique not to a clear glut.

^~.oogIc

Obf.—Found in cavilfcB in lava in amygdaloidal igneous rocVa, somedmes wlib elteoUte as a result of lu ftltemtion. Occurs near Eilpairick, Scotland; ia tiie lavas of Somma {eomptonite); lu basalt at the Pflaaterkaute in Saie Weimar; in Bohemia, in pbooo-lile; the Cyclopean Islaude, Sicily; near Brevik, Norway; tbe PftrtJer; Iceland (carpbo-itllblte, atraw-yellow): at Ht. MonzonI, FoABatbaL

Occurs at Peter's Point, Nova Scotia. In the XI. 8. at Magnet Core (oiarkiie) in the Ozark His., Arkansas; In the amygdaloid of Grand Uorais, L. Superior, which yields the water-worn pebbles resembling agate. In part green {tinlonile); in the biualt of Table Ut. near

Oolden, Colo,

Hydion^hcUU. HNa,Al.SitO„+SH,0. Hasdve, rodUted. H. = 4-6-0. a = 2-268. Color white; also dark gray. From Utcbfield, Maine, BaitiU from the Lsngmund flord, Norway, is limllar.

il. Hlca Division.

The species embraced onder this DiTiBioii fall into three gronps: 1, the Mica Group, including the Micas proper; 2, the Clintonitb Gbodp, or the Brittle Micas; 3, the Chloeitb Group. Supplementary to these are the VermiculiteB, hydrated compounds chieSy resulte of the alteration of some one of the micas.

All of the above species have the characteristic micaceous structure, that is, they have highly perfect basal cleavage and ^ield easily thin lamiuee. They belong to the monoclinic system, but the position of the bisectrix in general deviates but little from the normal to the plane of cleavage; all of them show on the basal section plane angles of GO" or 130°, marking the rela-tive position of the chief zones of forms present, and giving them the appearance of hex-agonal or rhombohedrai symmetry; further, they are more or less closely related among themselves in the angles of prominent forms.

The species of this Division all yield water upon ignition, the micas mostly from 4 to 5 p. c, the chlorites from 10 to 13 p. c; this is probably to be regarded in all cases as water of constitution, and hence they are not properly hydrous silicates.

More or less closely related to these species are those of the Serpentine and Talc Division and the Kaolin Division following, many of which show distinctly a mica-like structure and cleavage and also pseudo-hexagonal symmetry.

1. Mica Qronp. Monoclinic, MuMOTlte Potassium Mica H,KAl,(SiO.),

ii:i:i = 0-57735 ; 1 : 3-3138 fi = 89° 54' Paragonite Sodium Mica H,KaAl,(SiOJ,

LepidoUte Lithium Mica KLi[AI(OH,F),]Al(SiO,), pt.

Zinnwaldite Litbiuro-iron Mica

Biotite Magnesium-iron Mica (H.K),{Mg,Fe),(Al,Fe),(SiO.), pt.

&:$:i = 0 57735 ; 1 : 3-2743 >3 = 90' 0' Phlogopite (H,K,{MgP)),Mg,Al{SiO,),

Magnesium Mica; usnally containing fluorine, nearly free from iron, lepldomelane Annite

Iron Mioaa. Contain ferric iron in large amount. The species of the Mica Qrottp crystallize in the monoclinic system, but with a close approximation to either rhombohedrai or orthorhombic symmetry; the plane angles of the base are in all cases 60° or 130". They are all characterised by highly perfect basal cleavage, yielding very thin, tough, and more or less elastic laminee. The negative bisectrix, a, is very nearly normal to the basal plane, varying at most but a few degrees from this; hence a cleavage plate shows the axial interference-figure, which for the pseudo-rhombohedral kinds is often uniaxial or nearly uniaxial. Of the species named above, biotite has usually a veiy small axial angle, and is often sensibly unaxial; the axial angle of phlogopite is also small, usually 10° to 12°; for muscovite, paragonite, lepidolite the angle is large, in air commonly from 50° to 70°.

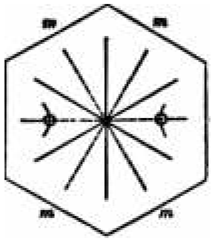
The Micas may be referred to tbe same fundamental axial ratio with an angle of obliquity differing but little from 90°; they show to a considerable extent the same forms, and their isomorphism is further indicated by their not infrequent intercrystallizaCion in parallel position, as biotite with muscovite, lepidolite with muscovite, etc.

A blow with a somewhat dnll-pointed instrument on a cleavage plate of mica develops in all the species a aix-T&yed percussion-figure (Fig. 901. also Pig. 477, p. 149), two lines of which are nearly parallel to the prismatic 9Q1_ edges; the third, which is the most strongly characterized (Leitstrahl r?erm.),isparallel to the clinopinacoid or plane of symmetry. The micas are often divided into two classes, according to the position of the plane of tbe opticaxes. In the Jirai class belong those binds tor which the optic axial plane is normal to b (0 10), the plane of symmetry (Fig. 901); in the second class the axial plane is parallel to the plane of symmetry. The percussion-figure serves to fix the orystallographic orientation when crystalline faces are wanting. A second series of lines at right angles to those mentioned may be more or less distinctly developed by pressure of a dull point on an elastic surface, forming the so-called pressure-ngnre; this is sometimes six-rayed, more often shows three branches only, and sometimes only two are developed. In Fig. 901 the position of the pressure-figure is indicated by the dotted lines. These lines are connected with gliding-pfanes inclined some 67° to the plane of cleavage (see beyond).

The micas of ih& first class include: MuBcovite, paragonite, lepidolite, also some rare varieties of biotite called anomite.

The second class embraces : Zinnwaldite and most biotite, including lepidomelaue and phlogopite.

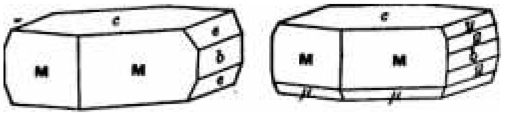
Chemically considered, the micas are silicates, and in most cases orthosili-cates, of aluminium with potaseinm and hydrogen, also often magnesium, ferrous iron, and in certain cases ferric iron, sodium, lithium (rarely rubidium and cfesinm); further, rarely, barium, manganese, chromium. Fluorine is prominent in some species, and titanium iu also sometimes present. Other elements (boron, etc.) may beipresent in traces. All micas yield water upon ignition in consequence of the hydrogen (or hydrozyl) which they contain.



B9U80oVITB. Commoo Hlca. Potash Mien. EaKglimmer ffortn.

Monoclinic. Axes d,:i:i = 057735 ; 1 : 3-3128; j8 = 89° 54'.

Twins common according to the mica-Iato: tw. plane a plane in the zone cVnormal to c, the crystals often united by c. Crystals rhombic or hexagonal in outline with plane angles of 60" or 120°. Habit tabular,passing into tapering forms with planes more or less rough and strongly striated horizontally;



Ticinal forms common. Folia often very small and i^gre^ted in stellate, plumose, or globular forma; or in scales, and scalj maasive; also crypto-crjstatline aud coihpact massive.

Cleavage: basal, eminent. Also planes of secondary cleavage as shown in the percnssioQ-fignre (see pp. 464 and 149); natural plates hence often yield

oM. 001 A 231 = M° 8(r. 6^. 001 A ill = 81' 80". MM'. 221 A aSl = W 48*. ntt\ ill A ill = 69° 1«J'.

narrow strips or thin fibers | axis h, and less distinct in directions inclined 60° to this. Thin laminie fiezible and elastic when bent, very tongh, harsh to the touch, passing into kinds which are less elastic and nave a more or less unctuous or talc-like feel. Etching-figures on c monodinic in symmetry (Fig. 481, p. 150).

II. = 'i-i-b. G. = S'76-3. Luster vitreous to more or less pearly or silky. Colorless, gray, brown, hair-brown, pale green, and violet, yellow, dar£ olive-green, rarely tose-red. Streak uncolored. Transparent to translucent.

Fleochroism usually feeble; distinct in some deep-colored varieties (see beyond).

Absorption in the direction normal to the cleavage plane (vibra< tions 1 b, c) atroug, much jnore so than transverEely (vibrations | a); hence a crystal unless thin is nearly or quite opaque in the first direction though translucent through the priam. Optically —. Ai. pi, J. b and neai'ly _L c. Bx, (= q) inclined about — 1° (behind) to a normal to c. Dispersion p > v. Axial angle variable, usually about 70°, but diminishing to 50° in kinds (phengite) relatively high in silica. Birefringence rather high, y — a = 0-033; ^y = 1-5941.

V*r.—1. Ordinary Xvieotite. la crysials ob above described, otien tabular] e, aim tapering with vertical faces rough and striated; tbe basal plane often rough unless as developed by cleavage. More commonly in platea nitbout disiioct outline, except as developed by pressure (see above); the plaiea eometimes very Inrge, but passing into Hne scales. arranged In plumose or other forma. In normal miiscovite the tbin lamins Eprlng back with force when bent, the scnies are more or less harsh to the Conch, unless very small, and a pearly luster is seldom prominent.

2, Damoukitb. Including tnargarodite, gUbtrlite, hj/dro-tmiiMuilt, and moat htdbo-MiCA in general. Folia less elastic ; luster somewhat pearlyor silky and feel unctuous like talc. Tbe scalea are usually small and it pusses into forms which are floe scaly or flbrous, OS urieiU, and finally into the compact crypto crystalline kinds called oneoniie, Including much piuite. Axial angle for damourite chieQy from 60° to 70°. Often derived by alteration of cyantte, topaz, coruadum. etc. Although often spoken of as Ayrlroiu micas, it does not appear that damourite and the allied rarletii^s necessarily contain mora water than ordlniiry muscovite; they may, however, give it off more rendily.

Margarodite, as originally named, was tlie talc-lilte mica of Mt. Qretner in the ZillerUial; granular to acaly in structure, luster pearly, color grayish white. QW>»i-titt occurs in whitish, silky forma from the tin mine of Bt. Austell, Cornwall. BerieiU is a fine scaly muscovite united in fibrous aggregates and characterized by Its silky luster (hence the name from (yrnitKo'i, tiiky.

Comp., Tar.—For the most part an orthosilicate of altunininm and potassium (H,K)AlSiO,. If, as iu the common kinds, H : K = S : 1, this becomes H.KAl.(SiO,), = 3H,O.K,0.3Al,0,.6SiO, = Silica 45-3, alumina 385, potash 11-8, water 45 = 100.

SoiDfl kinds kIts ft larger amount of dlica (47 to 48 p. c.) ibnn correapondB to a iiormal orthoallicate, and tbey bave been called phtngiU. Asalionu bf Clarke, these acid mus-oovltea caa be moBt slmplv regarded na molecular mixtures uf HiKAIi(SEOt)t and B,KA1. (81.0,)..

Iroa u UBuallJ present In small amount onlj'. Bsrtum Is rarely preteDt, an in otUaehtritt. 6. = 2-88-2-|t0. Chromium Is also preKnt infuehsilt from Bcbwamenstein, Zillerttaal, and elsewhere.

Fyr., etc.—In the closed tube gives water, which with Brazil-wood orteo reacts for fluorine. B.B. whitens and fuses on the thin edges (F. = 6'7, ▼. Kobell) to a gray or yellow glaw. With fluze* gives reacllous for Iron and souietttnea maagauese, rarely chromium. Not decomposed by acids. Decomposed on fusion with alkalme curboaates.

Dlff.—Distlnguuhed In normal kinds from all but the speci«s of thia division by Ibe perfect basal cleavsge and micaceous slructure; the pale color sepaialea it from raostliiatile; the lamina are more flexible and dasllc than those of phlogopite and still more th«n thoae of the brittle micas and the chlorltes.

In thin sections recognized by want of color and by the perfect cleavage shown by fine lines (as in Fig. 907, p.)J44) In sections 1 e. In a direction parallel to e. By reflected light under the microscope the same sections show a peculiar mottled surface with aatln-like lusler; birefringence rather high, hence interfertince-cotora bright.

Ofa«.—Uuscovlte Is the moat common of the micas. It is au essential constituent of mica schist and related rocks, and is a prominent component of certain common varielies of granite and gneiss; aiao found at times in frugmental rocks and limestones; lu volcanic tO«£s it Is rare and appears only as a secondary product. The largest and b^ developed crystals occur In the pegmatite dikes associated with granitic Intrusions, either directly cutting the granite or in its vicinity. Often In auch occurrences In enormous plates from which the mica or " iaingiass " of commerce is obtained. It Is then often associated with crystallized ortboclase. quartz, alblte; alao apatite, tourmaline, garnet, beryl, columbite, etc., and other mineral species characteristic of granitic veins. Further, muscovite often encloses flattened crvslala of garnet, tourmaline, also ouartz In thin plates betweeu the sheets; further not Infrequeutly magnetite In dendiite-llke forms following In part the directions of the perciisaiou-figure.

Some of the best known localities, are: AbUhl In the Sulz bach thai, with adularia; Rolhenkopf in the Zlltertlial, Tyrol; Soboth, Btyria; Bt. Oolhard, BInnenthal, and elsewhere In Uwitzerlaud; Mourne Mts., Ireland; Cornwall; UU), Falun, Sweden; Skutterud, Norway. Obtaiued in large plalea from Oreenland and the East Indies.

In ittiine, at Mount Mica In the town of Paris; at Buckfield, lu fine crystals. In If. Bamp., at Acwortb. Oraftou. In Mdu., at Chesterfield; South Royalalon; at Goshen, rose* red. In Oonn., at Honroe; at Litchfield, with cyanite; at the Middletown feldspar quarry; at Haddam; nt Bi-anchvtUe. with albite. etc.: New Milford. In N. Tort, near Warwick; Edenville; Edward.^. In ftnn., at Pennsljury, Chester Co.; at Unionvllle, Delaware Co., Hndat Middlelown. In Maryland, at Jones's Falls. Baltimore. In VA^'ni'a, at Amelia Courr-House. In No. Carahna. eiteusively mined at many places In the western pnrt of the stnte; the I'hief mines are Id HItcbell, Yancev, Jackson and Macon Cos. The mica mines have also iiSorded many rare species, as columbite, samarskite, hatcheltollte, uraninlle, etc.; in good ciyatnls InAlexander Co. In 8. Carolina, there are also muscovite deposits; also Iq Georgia and Alabama.

Mlcit mines have also been worked to some exteut lu the Black Hills, South Dakota: In Wrtshington, at liockford, Spokane Co.: in Colorado.

Muscovite is named from ViiTum Muteoviiicum or Muioovy-glatt, formerly a popular name of the mineral.

Finite. A general term used to Include a large number of alteration-products especially of iolite, also spodumene, nephelite, acapoUle. ft;lii»par and other minerals. In composition esaentially a hydrous silicate of aluuiinium and potassium corresponding more iir teas closely to muscovite, of which it is prohablv to be regarded as a miiaslve, compact variety, usually very impure from tbe admixture of clay and other gubatnnces. Charuciers as fol lows: Amorphous; granular to cryptocryaialliue. Rarely a siibmicaceous cleavage. H- = 2-5-3'5. G. =3-6-2-8B. Luster feeble, waiv. Color grayish white, grayish green, pea-green, dull green, brownish. reddUh. Translucent to opaque. The following are some of the mloerala classed as pinile: gigantolitt, gieuekiU (sec p. 85S), lUhtjiertie, ds»yntribite, paropMlt. TotiU. polyargUt, viiUonite. Mltinit«.

Agalmalalitt (pB)^lie)ls)lke ordinary massWe plnlte Id its amorphous compact teiture, luster, and other physical characters, but contains more silica, whicli may be from free quartz or feldspar as Impurity. The Chinese has H. = 2-2'.'l; G. = 2-785-3-815. Colors usually grayish, gniyish green, brownish, yellowish. Named from aj-aXfia, animagt;

poffodiU Is from pagoda, the Chinese corvine the boR stone Into miniature pngodss. Imager etc Part of tbe so-called sfulmatolUe ol Cnina U irue plnlte in compositioii, aootber part mpact pyropbylUte, nod still auolher steatite (see these species).

Pangoulte, A sodium mica, correspondiug to muscoviie Id com position; formula, H.KsAli (SiO.)i. la fiue pearly icBlea; also compact. Q. = S'78-2-00. Color yellowish, gtayisb. ereeaish; coosttlutesIliemassof tlierockat Moule Cumplone near Faldo in Oanton Tesain, Bwllzerlsiii], contaiDing cyauite and staurollte; cnlled paragonIte-schisl. Occura associated with tourmaline and corundum at Unioarille, Delaware Co., Pa.

IiBPIDOUm. Llthla Ulca. Litbionglimmer Otrm.

In aggregates of short priBme, often with rounded terminal faces. Crvs-t&Is sometimes twins or trillings according to the mica law. Aleo in cleavable plates, but commonly massive scaly-granular, coarse or fine.

Cleavage: basal, highly eminent. H, = 25-4. G. = 3'8-2"9. Luster pearly. Color rose-red, violet-gray or lilac, yellowish, grayish white, white. Translucent. Optically —, Ax. pi. nsnally J. 6; rarely] b. Bx, (o) inclined V 47' red, and 1 33^' yellow (Na) to normal to c. Axial angle large, from 50°-72", yj = 1-5975.

Coup.—In part a metasilicate, R,Al(SiO), or KLi[Al(OH,F),]Al(8iO,),. The ratio of fluorine and hydroxyl is variable. The following are analyses (HiggB):

SIO. A1,0, Fe,0. FeO HoO K.O Ll,0 Na,0 H,0 F Paris, SO-fti S499 0 80 0-2S (r. ll-»8 420 2-11 196 6-28=103-88 Hebron, 48-80 38-30 0'3» 009 008 13-81* 4'4S 074 1-78 4-96

[CaO.MgO 017 = 101-86

■with 0-17 (Rb,C»),0.

Pyr., etc.—In tbe closed tube gives water.and reaction for fluorine. B.B. fuses with IntumesceDce at 2-26 to il white or grayish glass, sometimes magnetic, coloring tbe flame purplish red ai tbe mumect of fualuu (lltblaj. Wiih the fluxes some varieties give reuctlotis for iron aud mangaucse. Attacked but not complelety decomposed by acids. After fusion, gelatinizes with hydrochloric acid.

OIm. —Occurs in g:ainle and gneiss, especially la granitic veins: ofiea associated with litbla. lounnaliiie: also with amblygouile, spodumene, casaiterite, etc.; scmetimea associated with muBCOvite fn parallel posillou.

Fouud near UlO in Sweden; Peiiig. Saxouy: Rozena (or Rozna). Moravia, etc. In the United States, common in the westum part of Maine, In Hebron, Auburn. Purls, elc; at Cbeslerfield, Mass.; Middleiown, Conu.: with nibellltc near San DIepo. Callfornln.

Named lepldnlite from Aeff/!, leaU, after tbe earlier German name Sdiupptnttein, alluding to tbe scaly structure of llie massive variety of Rozena.

CooEEITE Is a micaceous mineral occurring in rounded aggrccatlonq on ruhellle, also with lepidolite, tourmaline, etc.. at Hebron, Me. Composition LI[Al(OH),],(8iO.),.

Zlnnwaldlte. An Iron-lilhla mica in form near hiotite. Color pale violet, yellow to brown and dark gray. Occurs nl Zinnwald and Altenberg; similarly In Cornwall.

Cri/ophyllite is a relnlud lliblum mica from Rockport, Mass, Polylitkiimite Is a lithium mica from Kaogerdluarsuk, Greenland.

BIOTITB,

Monoclinic; pseudo-rhombohedral. Axes h:o:t ^ 0'57735 ; 1; 3-3743; y? = 90°.

Habit tabnlar or short prismatic; the pyramidal faces often repeated in ostiilliitory combination. Crystals often apparently rhombohedral in symmetry since r (l<il)and z{]33), j'(l32), whicn are inclined to c at sensibly the same'angle, often occur together; further, the zones to which these faces belong are inclined 130° to each other, hence the hexagonal outline of basal sections. Twins, according to the mica law, tw. pi. a plane in the

prismatic

xoneJ_c. Often in disMminated scales, sometimeB in massive aggregations ot cleavable scales.

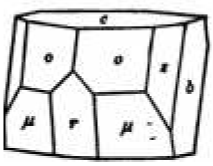
ec, 001 A US = 78" I'. w. 001 A 101 = 80' 0".

ejf. 001 A 321 = 86* 88". et. 001 A 183 = 80* O'.

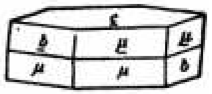
e/i. 001 A ill = 81* IB'. JfJf', 331 A 321 = 6r-4Si'. 004.

@35

905.



906.



Cleavage: basal, highly perfect; planes of separation shown in the percussion-figure; also gliding-planes p(So5), C {i'^^) shown in the preesure-fi^nre inclined about 66 to c and yielding pseudo-crystalline forms (Fig. 475,p. 148). H. = 2-5-3. G, = 2-7-3'l. Luster splendent, uiii] more or less penrly on a cleavage surface, and sometimes aubmetallic when black; liiter»] gurfiices vitreoiiB vben sinootb and shining. Colors usually green to black, often deep black in thick crystals, and sometioies even in thin iamirse, unless the lamiiw are very thin; such thin taminie green, blood-red, or brown by transmitted light; also pale yellow to dark brown; rarely white. Streak nncolored. Transparent to opaque.

Pleochroism strong; absorption b = c nearly, for a much stronger. Hence sections y c (UOl) dark green or brown to opaque; those Xc lighter and deep brown or green for vibrations | c, pale yellow, green or red for vibrations J_c. Pleochroic halos often noted, particularly about microscopic inclusions. Optically —. Ax, pi. usually { b, rarely _L />. Bi» (— a) nearly coincident with the normal to c, but inclined about half a degree, sometimes to the front, sometimes the reverse. Axial angle usuallv very small, and often sensibly uniaxial; also up to 50°. Birefringence high, y — a = 0"04 to 006,

Comp., Tar.—In most cases an orthosilicate, chiefly ranging between (H,K),(Mg,Fe). {Al,Fe),(SiO.). and (H,K),(Mg,Fe)^l.(SiO.),. Of these the Becond formula may be said to represent typical biotite. Toe amount of iron varies widely.

Biotlle U divided into two clanea by Tschermak:

I. Meroxsnb. A^iul plane I b, II. Anohitx. Az. pi. i b. Of these two kinds, meroieoe liicliideB nearly all ordiaarr biotite, wblla uiomite is. ao tat its yet obaerv«d, of realrlcted occurrence, the typical lotalilies being Greenwood Furnace, Orange Co., N. Y., and L, Baikal in E. Siberia. Meroxene 1b a name early given to the VMuviao bloUte. Ancimile Is from avufioi, contrary to law.

Himghtonile and SitUropAj/llitK are kinds of biotite containing much Iron.

Manganophyilite m a manj^aneBian hiotil«. Occurs in aggregations of thin scales. Color bronze- to copper-reii. Streak pale red. From Pajsberg and L&ngban, Sweden; Pled-nionl, Italy.

The followinK are typical analyses of biotite: 1, by Berwerth; 3, by Bammeisberg; S, by Smith and Brush.

BIO. A1,0, Fe,0, FeO UgO GaO E.O Na.O B.O F

1. Vesuvius 89-80 1605 0'4e B-4S 21'8» 0-83 7'T» 0-40 402 089

[=10108

2. Mlask.&foet 83-49 12'84 650 3018 539 - 969 088 2 43 1-fl]

[TiO, 4 03 = 100-34 8. .dniMnfte. Qieeawood F. 89*88 14-99 7-68 - S8'«9 - 911 112 1-30 0'S5

[010 44 = 9816

Borne varieties give the reaction for 907.

SILICATES.

Pyr., etc.— Id the doHcd tube gives a little wnter. fluorine ia the open tiibv; some kinds give little or no reaction for Iron with the fluxes, while others eire strong reactions for iron. B.B. whiteus and fuses on the thin edges. Compleiely decomposed hy sulphuric acid, leaving the silica in thin scslua.

DIB.—Distinguished bj its dark green to brown and black color and micaceous structure, usually nearly uniaxial.

Reeoguized In thiu sections by its hrown (or freen) color; strong pleochroisin and strong absorp-Iton parallel to the elongation (unlike touriuallDe). Sections I e are nonpleochroic, commonly exhibit more or leas distinct hexagonal outlines and yield a negalive seniibly uniaxial figure. Sections X e are strongly pleochroic and are marked by floe parallel cleavage lines (Pig. 907); they also have nearly parallel extinction, and show high polarization colors; by reflected light they exhibit a peculiar mottled or watered sheen which Is very characteristic and aids In distinguishing them from brown hornblende.

Oba.—Biotlte is on important cotistituent of many different kinds of igneous rocks, especially those formed from magmas containing considerable potash and msgnesii. Common In certain varieties of graolles, syenite, diorile, etc., of the massive granular type; also in rhyollle, trachyte, and andesite among the lavas; In miuettes, kersautiies, etc. It occurs Also as tbe product of mPtamorpbic action in a variety of rocks. It is not infrequently asaociated in parallel positlo". with muscovite, the latter, for example, forming the outer portions of plates having a nucleus of biotlte.

Some of the prominent localities of cryslalliEed blolite are as follows; Yesuvlus, common particularly in ejected limestoue masses on Monte Somma, with uugite, clirysoiile, ueplielite, humite, etc. The crystals are sometimes nearly colorless or yellow and then usually complex in form; nlso dark green to black; Mt. Monzonl in theFassatbal: Bchwnrz-eusteln, ZUIerthal: HezbSuya and Horawitza In Hungary; Schelingen and other points In the Kaisersluhl; the Laachcr See; on the west side ofX. llmen near Minsk, etc.

In the United Stutes ordinary biotite is common in granite, gneiss, etc.; but notable localities of diatincl crystals are not numerous. It occurs with tnuscovile (wh. see) as a - - ' IS prominent constituent of the pegmatite veins in the Mew Bnglsnd Stales; also

'•" ' 'Vnrlh Pjirnlina .QSbn>n£>i/;>rt< is frnm Ihs Pllrn'o PbhIe rsirliin

Section i e.

PHLoooprm.

Monocliiiic. Id form and angles near biotite. Crystals prismatic, tapering; often large and coarse; in scales and plates.

Cleaviige: basal, highly eminent. Thin lamins tough and elastic H. = ■2-5-3. G. = 3T8-286. Luster pearly, often submetallic on cleavage surface-Color yellovriah brown to brownish red, with often something of a copper-like reflection; also pale brownish yellow, green, white, colorless. Often exhibits asterismin tninsmitted light, due to regularly arranged inclusions, Pleochroiam distinct in colored varieties; c brownish red, b brownish green, a yellow. Absorption C > b > a, Burgesa. Optically —, Ax. pi. j b. Bi, nearly J_ c, ' Axial angle (3E) small but variable even in the same specimen, from 0° to 17° 25' for red. Dispersion p <v. The axial angle appears to increase with the amount of iron.

A magnesinm mica, near biotite. but containing little iron; potassium is prominent as in all the micas, and in most cases fluorine. Typical phlogopite, according to Clarke, is R,Mg.Al(SiO.)„ where E = H.K.MgF. Analyses: 1 by Penfleld; 2 by Clarke anil Schneider.

BIO, Al.O. Te,o, FaO KgO VaO K,Q V^Q H.O F

Edwnrda 2792 | 44S1 10(J7 — OBI 38-90 — 8W O'itC ola — Ign (100°) 0-M

(=10018 Burgeu SSOO 17-00 027 0-30 36-49 063 997 0'60 399 334 Ti,0 0-60

[= 100 « • wiLh 0-0e u.o.

Obs.—Pblogoplte la eipednlly cbaracteristic oC crystullioe linieatone or dolomite. It la oFttiu assoctaled wiib pyroxeae, Hinphibole, aerpenllne, etc TLua aa at Farm, Fiu-laiiit; Id Si. Lawrence Co. aad JeSersoo Co., N. Y.; also Burgess, Ontario, ood elMwkere iu CauEnla.

Named from tfiinj'mnoi, fire-like, in allusion to tbe color.

The nalerUm of pUiogopite, seen when a caodle-flame la Hewed through a tbin sheet, is a'commoQ cbanicter, parllciiiarly prominent in the kinds from Dortbeni New York anil Cannda. It bns been aiiown to be due lo miauie aclculnr IncluBlons, rutlle or tourmaline, arranged chiefly in tile dlrectloD of the rays of Uie pressure-flnire, producing a distinct six-rayed star; nlao parallel to the lines of tho percuatdoa-flgure, giving a aecondary atar, uaitally less promluent than the other.

Lepidomelan*. Npar blotlte, but characterised by the large smouul of ferric Iron preaent, Annite from Cape Ann, Haaa., belonga here. Iu small aii-slded lables. or an ugeregate of minute scales. H. = S. O. — S'0-8'3. Color black, with occosionnlly a leek-green reflection.

Alnrgite. A manganese mica from St. Marcel. Piedmont.

Rosco«llt0. A vanadium mica; formula doubtful. In roioule tcalesi structure micaceous. O. = 2-93-2-94. Color cloTe-brown to greenish brown. Occurs at the gold mine tX Qraolte Creek, El Dorado Co., California.

2. Cllntonite Group. Monoclinio.

The mineralB here included are sometimes called the Brittle Micas. They are near the niicae in cleavage, crfstalline form and optical properties, hut are marked physically hy the hrittleness of the lamiufe, aad chemically by their basic character.

In several reepecte they form a transition from the micas proper to the cblorites. Margarita, or calcium mica, is a basic silicate of aluminium aiid calcium, while Chloritoid is a basic silicate of alnminium and ferrous irou (with magnesium), like the chlorites.

MARaAIUTB. Ealkgllnimer (7«r)n.

Monoclinic. Rarely in distinct crystals. tJaually in intersecting or aggregated laminfe;

Bometimes masBiTe, with a scaly structure.

Cleavage; hasal, perfect. Laminte rather brittle. H. = 3'5-4-5, G, = 2'99-3-08. Luster of base pearly, of lateral faces vitreoas. Color grayish, reddish white, pink, yellowish. Translucent, b ubtranalucent.

Optically —. Ai. pi. X *• Bx» approximately J. c, but varying more widely than the ordinary micas, a c = -+- 6i°. Disperaion p < v. Axial angle large, from 100° to 120" in air. Refractive index /3 — 1'64-1'65.

C«mp. — H,CaAl.Si,0„= Silica 30-2, alumina 51-3, lime 140, watar i-5 = TOO.

Pyr., etc.—Yields wBler in the closed tube. B.6. whitens and fuses on the edges. Blowly tiod Imperfectly decomposed by boiling hydrochloric add.

Ob».—Awnciated commonly with corundum, and in many cases obviously fornie<l directly from it; llius at the emery deposits of Quuiuch-dngh iu Asin Minor, the ialaada Naxos. Nicaria, etc. Ocrr-s in clijorite of Mt. Greiner. Ster/.iug, Tyrol. In the U. 8., at the emery mine at Cbeate. Mnaa.; at IJnionvIlle, Cheater Co., Fn.; with corunduni In

SadisoD Co. ftod elMwhera Id North CarollDa; at Galnenllle, Hall Co., Qeorgia; UDaillej* ville. Alabama,

Idamed Marganla from /lapyapirtii, ptarL

SXtTBUUTITU, CIlntoDlle. BnuKJUte.

MoQoclinic, near biotite in form. Also foliated maeaive; Bometimes lamellar radiate.

Cleavage: basal, perfect. Structure foliated, micaceous. Laminae brittle. Percussion- and pressnre'figures, as with mica. H. = 4-6. 0. = S-Sl. Luster pearly submetolllc. Color reddish brown, yellowish, copper-red. Streak uncofored, or slightly yellowish or grayish. Fleochroism rather feeble. Opti-■cally —. Aj. pi. J_ 0 seyherlile; \ b braitdisite. Bi» nearly X c. Axial angles variable, bat not liirge. Birefringence high.

Var.—1. The Amltj lej/bertile (clintonita) Is In reddish-brown to cnpper-red brittle foliated tDBssei: tlie surfaces of ilie folia often marked with equilateral triaiiglet like wme mica aud cblorlte. Axial angle 8'-18°.

2. Braadiiil* (diUtrriie), noni tlie Fassatha), Ty<^'- ^ 'i hexaeooal prisms of a ^ellowlih.

Sea or leetgreeu color to reddish gray; H. = 6 of base; of sldea, ft-6'5. Ai. plane | b. iai angle 10 -ttU". Bome of it pseudumorphoua. after fassiiite. Cemp.—In part H, (Mg,Ca),Al,Si,o„= 3H,O.10(Mg,Ca)O.5Al.O,.4SiO.. Fyr., eto.—TIelds water. B.B. iofuslble alone, but whitens. In powder acted on t^ .concentrated adds.

o\M.—8eiil>trlilt occurs at Amity. N. T., in limestone with serpentine, nssociated with «mphibole. spinel, pyroxene, graphite, etc.; also a chlorite near leuchleuberj^ite. Brandmtt -occurs OD Mt. Honzoni in the Fasuthal, I'yrol, In white limestone, with fassaiie and black

XanthophylUU. Perhnps H.(Mg,Ca),<A1,.SI.o.>. The original xanthophyUiU is In trusts or in implanted globular forms. Optically negntiye. Ax. ADgle usually very small, ■or sensibly uniaxial; sometimes 80°. From near Zlatoust iu the Unil.

WaluewittSa the same species occurringin distinct pseudo-rbombobedral crystals. Folia brittle. H. = 4'8. G. = &'093. Luster vitreous; on cleavage plaue penrly. Color leek-to botrie-green. Transparent to transluceat. Pleocbroism rutber feeble: | h fine green; i i reddish brown. Optically -. Ax. pi. I b. Bx sensibly i c. 2B = 50°-40''. Axial angle 17° to tS,', Fonnd with perovsklte and other apecies in chloritic schists near Achma-lovsk, is the southern UraL

CHLORTTOID. Chloritspath. Ottrelile. Phyllite.

Probably triclinic. Barely in distinct tabular crystals, usually hexagonal in outline, often twinned with the individuale turned in azimuth 130° to each ■other. CryBtals grouped in roaettee. TJeually coarsely foliated maseive; folia often curved or bent; and brittle; also iu thin scales or small plates disseminated through the containing rock.

Cleavage: basal, but less perfect than with the micas; also imperfect parallel to planes inclined to the base nearly 90° and to each other about 60°; b diffi-■cuft. Lamina brittle. H. = 65. G. = 3-52-3-57. Color dark gray, greenish gray, greenish black, grayish black, often graas-greeii in very thin plates. Btreak nncolored, or grayish, or very slightly greenish. Luster of surface of cleavage somewhat pearly.

Pleocbroism strong; c yellow-green, 6 indigo-blae, a olive-green. Optically 4-. Ai. pi. nearly | ft. Bi» inclined about 12° or more to the normal to c (001). ^Dispersion p > v, large, also horizontal. Axial angles large, in air 100° to 118 . Birefringence low, y — a = 0-015.

Comp.—For chloritoid H,(Fe,Mg)Al,SiO,. If iron alone is present, thia le^uires: Silica 23-8, alumina 40'5, iron protoxide SS'S, water 7'2 = 100.

Diff.—Recosnlzed by tbe crjBtiil oiitlfnea and general micaceous sppefiniDce; high relfet; green colors: dlatluct cleavage; frequent tnioniDg; strong plileochrolsm and low iuletfer-euce-coloiB. Bjr the last characler rtsdily diitiugiiiabed from ihe micas; also by the high relief aud eitlnclion obllqno lo tlie cleavage from the chlorili^s.

Obs.—Cbloritoid (otlrelile, etc.) are characteristic of stiliuientary rocks which have suffered dyuamic me tamo rpb ism, especially in the earlier stages; Ibus found in argilliies. cod-glomemtes, etc., which bave assumed tbe schistose condition, Willi more advanced degree of metamorphism it disap[>ear3. Often grouped In fan-sbaped, slieaf-Illie forma, also in i I regular or rounded grains.

The original ehlo1^loid from Eosoibrod, uear EknlerlDburg Id the Ural, is lu lar^e curving lamiace or plates, grayish to blockish green in color, often spotted wilb yellow from mlxturs wilb limonite. Other localities are lie le Groix iMorbibau); eml>edded in large crystals at Vanlup, Shetland; Ardeunesin schists with ottreii(e;alBO from Upper UJchigau; Leeds, Canada, etc.

Si»n(mdin#(H,iFeiAli.S[.0t.)i3fTom St. Marcel; it occurs also wllh glaucophane at Zermatt in the ValaiB, Switzerland, and elsewhere.

Salmiie is a manganesian variely occurring in iiTegular masses, having a coarse sacciia-roidal structure and grayish color. O. = S'S8. From VielBalm, Belgium.

Matonite, from Kalic, R. I., is in very broad plates of a dark grayisb-green color, but bluish Kreen in very thin laminee parallel lo e, and grayish green at right angles to this; 04»>urs7n argillaceous schist.

OUrtliU is generally classed with chloritotd, though it Is not ceititlD that Ihey are identical; it seems to have tbe composition H,<Fe,Mu)AI,Si,0>. It occurs in small, oblong, shining scales or plates, more or less lieiagonAl in form and gray to black in color; iu argfl-laceouB schist near Ottrez, on the borders of Luxembiiurg, and from the Aideones: also near Serravezza, Tuscany; Tintagel In Cornwall. VenatguiU is from Venasque In tbe Pyrenees, and from Teul£. Finistire. PhyUiU is from the schists of New Bugluia.

3. Chlorite Group. Monoclinic,

The Chlorite Gbocp takes its niime from the fact that a large part of the minerals included in it are characterized by the green color common with silicates in which ferrous iron is prominent. The species are in many i-espects closely related to the micas. They crystallize in the monoclinic system, bnt in part with distinct monoclinic symmetry, in part with rhombohedral symmetry, with corresponding nniaxial optical character. Tbe plane angles of tbe base are also 60 or 120", marking the mutual inclinations of tbe chief zones of forms. The mica-like basal cleavage is prominent in distinctly crystallized forms, but the laminee are tough and comparatively inelastic. Percassion-and pressure-figures may be obtained as with the micas and have the same orientation. The etching-figures are in general monoclinic in symmetry, in part also aaymmetric, suggesting a reference to the triclinic system.

Chemically considered the chlorites are silicates of aluminium with ferrons iron and magnesinm and chemically combined water. Ferric iron mav be present replacing the aluminium in small amount; chromium enters similarly in some forms, v^ich are then usually of a pink instead of the more common green color. Manganese replaces the ferrous iron in a few cases. Calcium and alkalies—characteristic of all the true micas—are conspicuously absent, or present only in small amount.

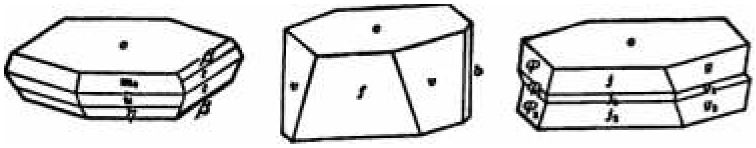
The only distinctly crystallized species of the Chlorite Group are Clinochlore and Penninite. These seem to have tbe same composition, but while the former is monoclinic in form and habit, tbe latter is pseudo-rhombobedral and tfsually uniaxial. Prochlorite (including some ripidolite) and Corundophilite also occur in distinct cleavage masses.

Besides the species named there are other kinds less distinct in form, occurring in scales, also fibrous to massive or earthy; they are often of more or less undetermined composition, but in many cases, because of their extensive oocurreoce, of considerable geological importance. These Utter forms occur as eecondary minerals resulting from the alteration especially of ferro-maguesian Bilicatea, sach as biotite, pyroxene, amphibole; also garnet, vesuvianite, etc. Tliey are often accompanied by other eecondary minerals, as serpentine, limon-ite, calcite, etc., especially in the altered forms of basic rocks.

The rock-iiiakin|: chlorites are recognized in thin sections by their characteristic appearance in thin leaves, scales or fibers, sometimes aggregated into spherulites; by their greeniiih color; pleochroism; extinction parallel to the cleavage (unlike chloritoid and ottrelite); low relief and extremely low interference-colors, which frequently exhibit the " ultra-blue." By this latter character they are readily distinguished from the micas, which they strongly resemble and with which they are frequently associated.

OIJNOOHZ.OBB. Rlpldollle pt.

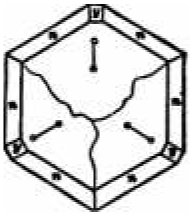
Monoclimc. Axes: a:t:i = 0-57736 :1 : 22772; /S = 89" 40'. 908. MM. 910.



PfltKh.

Scbworaenstelu.

Zlllerthal.



Crystals usually hexagonal in form, often tabular J c Plane angles of the basal section — 60° or 120°, and since closely similar angles are fonnd iii the zones which are separated by 60°, the symmetry approximates to that of the rfaombobedTal system.

Twins: (1) Mica law, tw. pi, Xcin the zone cm,; sometimes contact-twins with c as comp.-face, the one part revolved fiO" or a multiple of 60° in azimntb with reference to the other; also in threefold twins, (2) Pennin-ite late, tw. pi. c, contact-twins also united by c (Fig. 910); here corresponding faces differ 180° in position. Massive, coarse scaly granular to fine granular and earthy.

Cleavage: c highly perfect. Lamince fiexible tongh, and bnt slightly elastic. Percnsaion-figure and preaaure-fignres orientated as with the micas (p. 464). H. = 2-2'f Luster of cleavage-face some what pearly. Color deep grass-green to olive-green; pale green to yellowish and white; also rose-red. Streak greenish white to uncolored. Transparent to translucent. Pleochroism not strong, for green varieties nsnally a green, c yellow. Optically usually +. Ax. pi. in most cases | b. Bx, inclined somewhat to the normal to c, forward ; for Achmatovsk 2° 30'. Dispersion p <V. Axial angles variable, even in the same crystal, 2E = 20°-90°: sometimes sensibly nniaxial. Birefringence low. j8 = 1-588; y ~ a — O'Oll.

V«r.—1, Ordinary; jrreen clinoohlnre, piLssinK inio Wiiish c™pn: '") '^ crystnU, ns descilbed. usunlly wilh rtisllnrt monocllnic aymmelry; (h) folliitprt: le) mnsaive.

T^euehUnhrrgHe. Conlslns usuiilly little or no iron. Color wbile, pale green, yellowish; nften resembles talc. From near Zlatoiiat In ihe Unil.

Koixhvbtitd. ConlRinfl several per cent of chromium oxide. Cryslala rhombolieilrnl Id habit. Color roee-red. From the iwutbero Ural.

Achmntovak.

G. = 2-65-2-78.

Comp.—Normally H,Mg,Al,8i,o„ = 4H,O.5MgO.Al,o,.3SiO, = Silica 32 5, alumina 18*4, magnesia 3C'l, water 13*0 = lOQ. FerrouB iron uauaUv replaces a small part of the magnesia, and the same is true of manganese rarely; sometimes chromium replaces the alumiuinm,

Pyr., etc.—Yields water, B.B. lu the platinum forceps whlteuB aud fuaes with dilUculiy (III the edges io » grajisb-hlack glass. WUh boruz. a clear glass colored 67 Iron. and sometimea chromium. lu sulphuric aeld wholly decomposed.

Obs,—Occurs iu connectiou with <ililurltic imd talcoee rocks or schists and eerpenline: Bomeiiines lu parallel posltiou with biotite or phlogopiie. Promineui localities are: AclimatOTsk lu the Ural; Ala in Piedmont; tlie ZilieHhal: Zertoatt, SwilEerlaiid; MBrfenberg, Saxony; Z&ptau, UurHvla. A mangnuesiBD vnriety occuis at Pajsberg, Swedeo.

Id the U. Btates. at Westchester, Penn., in large crrstals and plates; also llDionvllle aud Texas, Penn.; at the magnetic iroa mltie at Brewster, N. Y., iu part chnoged to serpentioe.

PEIKNINITII. Peuutne.

Apparently rhombohedral in fonn but strictly pseudo-rhombohedral and mouoctinic.

Habit rhombohedral: sometimes thick tabular with c prominent, again steep rhombohedral; also in tapering '*^ six-sided pyramids. Rhombohedral faces often horizontally striated. Crystals often in created groups. Also massive, consisting of an aggregation of scales; also compact cryptocrystal-\ line.

Cleavage: c highly perfect. LamtnEe T^zaK Zermstt. flexible. Percnsai on-figure and pressure-figure as with clinochlore but less easy to obtain; not elastic. H. — 3-2-5. G. = 2-6-285. Luster of cleavage-surface pearly; of lateral plates vitreous, and sometimes brilliant. Color emerald- to olive-green: also violet, pink, rose-red, grayish red; occasionally yellowish and silver-white. Transparent to subtrauslucent. Pleochroism distinct: usually J t-p-een; J.c yellow. Optically -f .also —, and sometimea both in adjacent laminae of the same crystal. Usually sensibly .uniaxial, but sometimes distinctly biaxial (occasionally 2E = 61°) and both in the same section. Sometimes a uniaxial nucleus while the border is biaxial with 2E = 36°, the latter probably to be referred to clinochlore. Indices 1'576 and 1579 Levy-Lox.

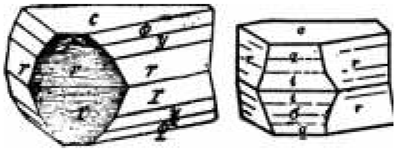
Var.—1. PmninUt, as flrel named, Included a green crystallized chlorite from the ' PeDtiinine Alps.

KAmmereeH». In hesagooal forms bounded by steep sii-Bided pyramids. Color kermes-red; peach-blossom-red. Pleochroism distinct. Optically - from L. Itkiil, Bieersk. Perm. Ruasfft: + Texas, Pa. Uniaxial or biaxial with axial angle up to 20-. Bhodo-piiyllUe from Texas, Pa., and rhodociirome from L. Itkiil belong here.

PieudophOe is compact massive, without cleavage, and resemhiea serpentine. Comp.—Essentially the'same as clinochlore, H,(Mg,Pe),Al,Si,o„. Pyr., «tc.—In the closed lube yields water. B.B. exfoliates somewhat and Is difBcullly fusihle. With the flnxea all varieties give reactions for iron, and many varieties react for chromium. Partially decomposed by hydrochloric and completely by sulphuric acid.

Obs.—OccnrB with serpentine in the region of Zermatt, Valais. near Mt. Rosa, especially in the moraines of Ihe Fiudelen glacier; crystals from Zermntt are sometimes 2 in. long and H in. thick; also at the foot of tlie Simplon; at Ala, Piedmont, with clinochlore: at Sphwnrzenstein in Tyrol; a1 THlierg in Wermland; at Snarum, creenish and fnliated.

KammereriU is found at the locaiilies already mentioned; also u«ar Miaslc in the Ural;



U Haroldswlck la Unst, SbetUDi) Isles. In large cirstiris encloded in tlie talc Id crevlcei of tbe cbrumite from Kraubat, Btyria. Abundaut at Texas, Lanciisier Co., Fa., along with cliuocblore, some crystals bdug embedded lu clinoclilore, or the reTerse. Also !o N. Can>-llaa, wlili cbromite at Ciilsage«, Hacon Co, i Webster, Jackson Oo.; and other poiiiis.

PROOai.ORITB. Ripldollte pt.

Monoclinic In six-sided tables or prisma, the aide planes strongly furrowed and dull. Crystals often implanted by their sides, and in divergent KroDpB, fan-shaped, vermicnlar, or spheroidal. Also in large folia. Massire, foliated, or grnuuliu-.

H. = 1-2, G. = 2'78-3'96. Translucent to opaque; traoaparent only in Tery thin folia. Luster of cleavage surface feebly pearly. Color green, grase-green, olive-green, blackish green; across the axis oy transmitted light sometimes red. Streak nncolored or greenish. Lamtnee dezible, not elaetic. Pleochroism distinct. Optically -}- ii> most cases. Bz inclined to tbe normal to c some 2°. Axial angle smaj, often nearly uniaxial; again 3£ = 23°—30°. Dispersion p < i-.

Corap.—Lover in silicon than clinocblore, and with ferrous iron usually, but not always, in large amonnt. Analysis by Egger:

BIO. Al.O, Fe,o, PeO MgO CrO H,o

Zfllerthal 26 03 2016 1-07 2808 16'SO 044 9 65 = 10093 '

Obs.—Like other cblodtes In modes of occurrence. Somptimes in implanted crrstals, HR at SI..Oi>lliBrd. cnvelopiDg often adulsrin, etc.; Ht. Qreiner In the Zillertbal, Tyrol; Ruurla iu Salzburg; Traversella in Piedmont; at Mtn. Sept Lacs and St. Cristophe In DiiupbinI: in Siyna. Bohemia. Also nmssfve in Corowall, lu tin velug; at Arendiil in Norway;'Salberg and Diinuemora, Sweden; Dogiincaka, HimsHry. Occatiluaally formed from at)ipbi1)ote. In Scotland at varinua piiitits. Iu tbe U. States, near '^ashiugton; on Castle Mt., BatesTille, Va., a mnssive form resembling soapstone, color grayish green, feel sreasy; Steele's mine, Montgomery Co., N, C.; also with corundum at tbu Culsagee mine, m broad plntes of a dark green color and flue scaly; it differs from ordinary prochlorile in tbe small amount of ferrous iron.

AmsTTX. H.(Hg.Fe)tAliBiO>. Silica 21-4 p. c. In beiagonal plaiea, foliated, resembling the green talc from tlie Tyrol. H.= 2 5-8. G. = 2-71. Color apple-green. Luster pearly on cleavage face. Optically 4-, sensibly uniaxial. Occurs with diaspore at Chester,

Otbbr Chloriteb. Besides the cblorites already described which occur usuallr In distinct crystals or plates, there are. ns noted on p. 4Xi, forms varying from fine scaly to fibrous aud earthy, which as already noted are prominent in rocks, In some cases lliey

J belong 1o the species before clescribed, but frequently the want of sufficient pure malerlal has left tbeir composition in doubt. These cblorites are commonly characterized by tbeir green color, disliuct pleoclirolsm and low birefringence (p. 478).

The foliowlug lire names which have been given particularly to tbe cblorites filling cavltiesorseamslu basic igneous rucks: a'phroti^nUt^iaba'atUa, ii»lettita,tpichbril«,miralite, i ehlorep/imU, hullite. \

Tl»e following are otber related minerals.

Oronstadite. 4Fe0.2Fe,Oi.SSiO,.4H,0. Occurs taperingln hexagonal pyramids; also tn diverging groups; amorphous. Cli'avage: basal, highly perfect. ThIo laminte elastic. O. = 8-84-«-3S. Color coal-black to brownish black; by transmitted light in thin scales emerald-green. Blreak dark olive-green. From Pllbram in Bohemia; also In Cornwall.

Thnringite. 8Fe0.4rAl.Fe),Oi.eSIO,.9B,0. Massive; an aggregation of minute

Karly scales. Color olive-green to plslachio-green. From nenr Siialfeld, lb Thnringla: >t Springs. Arkansas, etc.; from the metamorpbic rocks on the Potomac, near Harper's Ferry (inMnA*).

Chamobitb. Conlains iroD (FcO) wllh but little HgO. Occun compact or oOliilc wiih H. nbuiitS; G. = 3-3'4; color ereeQisb gray to bluck. From CbnmoMD, neiir Si'. Muurict;, in tbe Valuis.

Stilpnomelane. Au irou alHcate, In folbted platfa: also librous. oc as & velvety coaU Ing. G. — a'77-a-B6. Color black, giwoisli bWk. Occurs al Obergruud atid tlwwliete Id Slletiiii; ulso lu HorsTlu: Lear Weilbuig. Nusaiiu. C/ialecditt, from the Bterling Iron uiiue. iu Auiwerp, Jefferson Co., N. Y., ctUlug Ijetnatite and calcite, ts Uie saine miuerol in velvety coating of niico-like Bcalea wiib a broaze color.

Btrigovltv. H.Fe,(Al,Ff)iSj,o. In nggregutious of miuul« crysUtls. Color dark

freeii. Occurs as a fine coaling over Ibe iiiiuerala in cavities in the groalta of Striegau la lleiiia. Rumpfite, H,iHgTAli«BlitOii. HaKive; granular. consiatlDs of vsry floe Kales. Color greenlab wliiie. Occurs with talc near St. Hicliuel tu Upper Stjria.

APPENDIX TO THE MICA DIVISION.-VERMICUUTES.

TLe Vbrhicolite Group Includes a number of micaceous minerals, all hydrated silicates, in pari closely related to the chloriles, but varying scimewlirit widely in compod-tiou. Tliey are tilteraiion-products cbleti; of tlie micas, bioiite, pblogoplte, elc.,aiid r^aln more or less perfectly tlje micaceous cleavage, anil often show tlie negative optical character and small iixiiil angle of the original species. Kany of tlieni aie of n more or less ludefluile chemical nature, and the composition varle> with tbat uf tiie original mineral and with the degree of iilteratiou.

The lamtnn iu general are soft, pliable, and Inelastic; the luster |>early or bronze-like, and tlie color varies from while to yellow and brown. Heated to 10u°-110° or dried over sulphuric acid most of tlie vermiculiles lose considerable water, up tii 10 p. c, which is probably hygroscopic: at itOO* nnothei' portion la often ^ven oS; and ai a ri'd heat a some' what large!' amount is expelled. Connected with the loss of water upon ignition is the common physical cliaraccer of exfoliation; some of the kinds especially show this to a marked degiee, slowly opeolng out, when heated gradually, Into long worm-like tbreada. This character has given the name to thegrono, from the Iiatin Dermieulari, to bread uormt. The minerala Included can hardly rank as distinct species and only their names can be given here: JafferiiOa, wrmieaiiU, euitageviU, k«mt», Itnjtilile, AoUtU, phOaMpAUt, taalitt, maamila, dvdityilt, piftvteler&t.

III. Serpentine and Talo Division.

The leading species belonging here. Serpentine and Talc, are closely related to the Chlorite Group of the Mica Division preceding, as noted beyond. Some other magnesium Bilicates, in port amorphons, are included with them.

SEBPBNTINII.

Monoclinic, In distinct crystals, but only as psendomorphs. SometimeB foliated, folia rarely separable; also delicately fibrous, the fibers often easily separable, and either flexible or brittle. Usually massive, but microscopically finely fibrous and felted, also fine granular to impalpable or crjrptocrystalline; slaty. Crystalline in structure but often by compensation nearly isotropic; amorphous.

Cleavage 6 (010), sometimes distinct; also prismatic (50°) in chrypotile. Fracture usually conchoidal or splintery. Feel smooth, sometimes greasy. H. — 25-4, rarely 5'5. G. = 2-50-2'65; some fibrous varieties 2*3-2-3; retin^-ite, 2-36-9-55. Luster siibresinons to greasy, pearly, earthy; resin-like, or wax-like; usually feeble. Color leek-green, blackish green; oil- and siskin-green; brownish red, brownish yellow; none bright; sometimes nearly white. On exposure, often becoming yellowish gray. Streak white, slightly shining. Translucent to opaque.

Pleochroism feeble. Optically—, perhaps also-]-io chrysotile. Double reflactiou weak. Ax. pi. | a (100). Bx (a) J. b (010) the cleavage surface; c || elongation of fibers, biaxial, augle variable, often large; 2V = 20° to 90°. Indices:

Anligoriit « = JOflO /S = 1IS70 7- = 1-571 r -'r = 0011 Lfivy-Lcx.

V*T.—MsLy UDSuslBiaed Bpecies linve been m^a out of urpeDllDS, illfferlug Id sUuc-

lure (muMivti, elaty, foliated, Hbroua), or, as supposed, in chemical composition; and these

DOW, ill puTt, stHud as rarietles, alutig witli some otbers based on varlationa iu textuie, etc.

A. In Crystalh —PsKtiDOMcsPHB. The most common have tlie form of chrysolite. Other kinds are pseudoniorpha after pjruzeue, aoipbibole, spinel, chondrodlte, gartiet, pblogupite, etc. BoMtiU ot tkhiiUr Spur la euetatite (hypentbeoe) altered more or lea* complettil/ to serpentine. See p. SSfl.

B. Mabbite. 1. Ordinary maitint.- (a) Predtnu or JiebU Serpentine is of a rich oil-greeu color, of pale or dark shades, aud translucent even when in thick pieces. (A) Ckmtmon Serpentine Is of dark shades of color, and Bubtranslucent, The former baa a hardness of 2-5~li: the laller oFteii of 4 or beyiind, oning to impurities.

Seiinoui. JielinaliU. Hassive, houe^'-yellow to iTgbt oil-green, waxy or resIn-Uke

Bowenite (Nepbrite Botnen). Haasive. of very fine granular tenture, and much resembles nephrite, and naa long so called. It Is apple-greeu or greenish white In color; Q. = S'5U4-2'7»7, Boweu; and itbastlie unusual hardness 5-5-6. From SmiLhBeld, R. I.; alaoaaim-ilnr kind from New Zealand,

C. Lamellar. Antigmie, tbtn lamellar in structure, separating into translnceot folia: B. =

2"); O = 2'622; color bronuish green by reflected light; feel smoolh, but not greasy. From Auligorio valley. Piedmont.

I). Thin Poliatbd, Murmoiile, tbiu fitliuted; the lamlns brittle but i^parable. Q. = 2'41: colors greenish white, bluish while to pale aspiiragus-green. From Hiibuken, N. J.

E. FiBBOua. ChrytolUe. Delicately hbrous, ibe hhers usually Qexible and eHsily separating: luster silky, or silky nielnllic; color greenish white, green, olive-green, yellow and brownish: G = 2'21B. Often conslilutts seuins in serpeniiue. It includes moat ol the silky iimianaiut ot serpentine Tocks ntid mucli of wliaC is popularly called atbettut (asbestos). CI. p. 401.

Picroiile. coUiinnar, but fibers or columns not easily flexible, and often not easily sepantble. or nfferding only 11 apliutery fructure; color diiik green to mo ud lain-green, gray, brown. The ori^iial was from Tuberg, Sweden. BaltimoriU Is plcrolile from Bare Hills, Md.

F. SBHPBNTinB RoCH8. Serpentine often constitutes rock-masses. It frequently occurs mixed with more or less of dolomite, magnesite. or culcite, making a rock of clouded green, somelimea veined with wbtle or pale green, called mtJ antique, ophiolitft, or opMeaMte. SerjientiDe rock is sometimes mottled with red. or has something of the aspect of a red porphyry; the reddish porlioos coDtainliig an unusnal amount of oxide of iron. Any serpentine rock cut Into slabs and polished Is called t«rpe)itine marble.

Microscopic examination has established the fact that serpentine In rock-masies has been largely produced by the alteration of cbrvsollte, and many apparently homogeneous serpentines show more or less of tliis original mineral. In other casee it has resulted from the alierstion of pyroxene or amphibole. Sections of the gi^

aerpentine derived from chrysolite often show a peculiar structure, like the met<bes of a net (Fig. 614): the line* marked by grains of magnelile also follow the original cracks ana cleavage directions of the chrysolite (Fig. 916, a). The serpentine from amplilbole and pyroxene commonly shows an analogous structure; the Iron particles following the former cleavage lines Hence the nature of tlie original mineral can often be Inferred. Cf. Fig. 915, a, b. e (Plrasoa).

Comp.—A magnesium silicate, H,Mg,Si,o, or 3Mgo.3SiO,.aH,o = Silica 44-1, magnesia 43-o,

water 12*9 = 100. Iron protoxide often replaces a small part of tbe mu^ nesinm; nickel in small amount is sometimes present. The water is chie^ expelled at a red heat.

Pyr., etc.— Id the closed tube yields water. B.B. fuses on the edges with diffloully.

F. = 6. GWea i:

acldB. From cbrysotife tbe silica la left in floe lll>erB.

Diff. —Characierlzed by Boftness, absence of cleavage anii feeble nsxy or oily luater; low specific gravity; by yteldiug mucb water B.B.

Readily recoguized iu tliin sectloDs by its greecUli or yellowlsta-gretQ color: lo* relief and aggregate polarization due U> Ita fibrous Btructure, Wbea the flbera are parallel, (be

916. a h e

a, Berpeutine derived from chryBollte; b, from amphibole; e, from pyroxene.

Interfereace-colors are not very low, but tbe coufused aggregates may show the " ultra blue" or even be Isotropic. The conatant associatlua nftli otber magnesia benring minerals like chrysolite, pyroxene, hornblende, etc.. U also cbaracteristic. Tlie presence of lines of Iron parllclea as noted above iFii;. 916) is cbai-acledstlc.

Obs.—Serpentine la always a secondary mineral resulting, us nored above, from tbe alteration of silicates coutaluiiig magnesia, pankiilarly cb)ysoUl«, ampbibole or pyro.xene. It frequently forms large rock-maoses, then being derived frani the aheralion of peridoiito. duultes and otber basic rocks of Igneous orlcm: also of amphibolites. or pyroxene and chrysolite rocks of metnmorpblc origin. In tbe first case it is usually Bccom]mnied by spinet, garnet, cbrnmlce and sonieiiuiea nickel ores; lu tbe second case by various cni'boDiites such as doloinile. miignesite, breunnerile. etc.

Crystals of serpeuliue. pseudomorphous after monticellllte. occur In tbe Fnssalbal. Tyrol; near Miask at Liike Ausbkul. Barwvka, Ekaterinburg, itud elsewhere; In Norway. at Siiiiruni; etc. Fine precious serpnnlines come from Falun and Gulsjo In Sweden. Ilie Ihle of Mnu, the neigbborbood of Foitsoy in Al^erdeensblre, the Lizflrd in Coruwall, Uor* sIcB. Slberi'i, Saxony, etc.

In N. America, in Maint. at Deer Isle, precious serpentine. In Vrrmont. at New Fnne, Rozbiiry, etc. In Mau . fine at Newburyport. In H. Uland, at Newport; boweiiile nt SmiChlield. In Gonu., uear New Haven and Milford. at the verd-antique quurrlcs. In N. York, at Port Henry, Essex Co.; nt Antwerp, JelTeraou Co., in crystals; in Oouver-neur, St. Lawrence Co , in crystals; In Cornwall. Monroe, and Warwick. Oranire Co.. somelimcs in large crystals nt Warwick; and from Richmond to New Brighton, Richmond Co. In N. Jerity, at Hobokeu. with bnicite. magnesite, etc.; nt Mootville, Morris Co., cbvysotlle and retiunlite. wiib common serpentine, produced by tbe nllemtinn of pymxcne. Iu Penn., ma.'jsive, fibrous, and foliated, at Texas. Lancaster Co.; nt West Chester. Chester Co., icilliaiiiale; iil Mineral Hill, Newtonn. Marple. nnd Middlelown, Delaware Co. Id

Maryiand, at Bait; Hills; at Cooplown, Harford Co., wiih diallage. In California, nt various points in tbe Cotist Ranee.

Ill Canada, abundant iimoug the metamorphlc rocks of the Eastern Townships and GaspS (leninsuln, Quebec; at Thetford. Coleraine. BroiigbtOD. Orford. S Ham. Bolton. Sliiplou, Melbourne, etc. Tbe tibrous variety cfarysotile (asbeslus. bostonlte) ofien forma seams several Incbes In tbicknois lu ibe massive mineral, and is now extensively mine<l for technical purposes. Massive L'lurentinn serpentine also occurs in Qrenville, Argenteiiil Co..

guebec. nnd North Burgess, Lanark Co.. Ontario. In N. Bruntwiei, at Crow's Nest in ,>rtl.ind. The names 8eTpenlint. OphiU, ZapU eolubrinia, allude lo the green acrpent-like cloudings of tbe serpentine mnrble. lUtinaliU is from '^leric^. rtHn; PktoUU. from triKpoi, bitter, En nlluiiion lo the magnesia (or Bitlererdei prfseut; Thermophyliite, from 6€tiUJj. heal, nnd tpvWnt; leaf, on iiccouut of the exfolinlion when healed; ChrytotiU. from jiriro'u?, ffo'den, and liKoi.jUrrov,!; MeUiiila, from itfra^a, silk; Marmolila, from iiapnuiiJia, to thine, in allusion to its peculiar luster.

I>«w«7Ute. A mfttnieriaii silicate near serpemtnfl but with more'vater. Formula perhupi 4Hg0.8^iOi.SH|0. Amorphous, resembling Kum arable, or a resin. H, = 9-3-5. G. = 20-aa Color wliitUh, ;ellowlab, reddish, browiii»L, Occurs with serpentine In llie Pleimalhul. Tyrol; also at Texas, Peuu., aud Uie Bure Hilid, Ud, Qymnite of Tbcmsou, namci from yvtivoi, naktd. In allusiou to tlie locality at Ban; Hills, Md., is the lame species.

Owttblte. NiclEel-Ovmnile. A gfmnlte with part of the magnesium replaced b; nickel. 2Ni0.2MgO. 8S10,.6U,0. AmorphuUB. with a delicate stalaclitic surface, inc^ua^ log. H. = 3-4; sumelimea very soft. G. = 3'4MI. Luster reslnouB, Color pale apple-green, or yellovriah. From Texas, Lancaster Co., Pa., In thin crusts on cbromlte.

Oamierita. Nouraeite. An important ore of nickel, consisting eHsentlally of & hydrated silicate of magnesium and nickel, perhaps Hi(MI.Hg)SiOt -f aq, but very variable In composition, particularly as regards the nickel aud mugueslum; not always homogeDeoua. Amorphous. Soft and friable. G. = 2-8~3'8. Lusuir dull. Color bright apple-green, pale green to nearly while. In part unctuous; sometimes adlteres to the tongue, (^ura In serpeoiiiie rock near Noumea, capital of New Caledonia, associated with chromic iron and steatite, where it is extensively mined. A similar ore occura at Blddle in Douglas County, southern Oregon; also at Webster, Jackson Co., N. C.

TAXiO.

Orthorhombio or tnonoclinio. Rarely in tabular crystals, hexagonal or rhombic with prismatic angle of 60°. Usually foliated massive; sometimes ia globular and stellated groups; also granular massiTe, coarse or fine; fibrous (pseudomorphous); also compact or cryptocrystalliue.

Cleavage: basal, perfect. Sectile. Flexible in thin lamiofe, but not elastic Percussiou-fignre a six-rayed star, oriented as with the micas. Feel greasy. H. ^ l-l'o. G. = 27-2'8. Luster pearly on cleavage surface. Color apple-green to white, or eilvery-white; also greenish gray and dark green; sometimes bright green perpendicular to cleavage surface, and brown and less translucent at right angles to this directiou; brownish to blackish green and reddish when impure. Streak usually white; of dark green varieties lighter than the cojor. Subtransparent to translucent. Optically negative. Ax. pi. y a. Bx J, c. Axial angle small. ^ — « = 0035-0-050.

Tar.— FolinUd. Talc Conslala of folia, usually easily separated, haviug a greasy feel, and presenting orilluarily llglil fjeen, greeulsli nbite, and wliite colors. O = 2'K5-2-78.

MnttiTe, Steatite or Sonpilone (Si>eckBteiD Oerm.). a. Coarse granular, grayish green, and brownish grsy In color; U. = l-SC. Pi}t-*ti>ne ia ordinary soapslone. more or less impure, b. Fine granulfir or cTyptocrystalllne, and solt enough to be used as chalk; as the Freneh ehalk, which Is mllk-wbile with a pearly lualer. e. Indvraltd tale. An Impure alaty talc, harder than ordinary talc.

Ptevdomorplunu. a. Fibrous, fine to coarse, altered from ensttitite and tremolite. b, JlimiMlaerite, having the form of pyroxene from northern New York and Canada.

Corap.—An acid raetasilicate of magnesium,H,Mg,(SiO,),or H,0.3Mg0.4SiO, = Si]ica,63-5, magnesia 31'7, water 4'8 = 100. The water goes ofiE only at a red heat. Nickel is sometimes present in small amount.

Pyr., ate.—In the closed tulw B.B.. when Intenaely Ignlled, moat varieties yield water. In the platinum forceps whiuns. exfoliates, and fuses with difQculty on the thin edges to a white enamel. Moistened with cobalt aolulioti, assumes on ignition a pule red color. Not decomposed by acids. Rensselaerlte Is decomposed by concentrated anlphuric odd.

Diff.—Characterized by extreme softness, soapy feel; common foliated structure; pearly luster; it Is flexible but inelastic. Yields water only on iuiense ignition.

Obs.—Talc or steatite is n very common mlnoml, and In the Intter form conslitutps extensive beds in some tepiona. It In often aagociated with serpentine, lalrose or chloritlc Kcbist, and dolomite, and frequently contains crystals of dolomite, brcunnerlte, also asbestua, actiuolile. tourmaline, magnetite.

Steatite is the material of many pseudomorphs, among which the most common are those after pyroxene, hornblende, mica, scapoltle, and spinel. Themsgneslan mineral are tbweffhlch commouly ufFord steatite by alteration; while IhowHIie BcapolfleBndnepbelite, wlifch contain soda and no magnesia, most frequently yield pIultG-like pseudoaiorplis. Tlieie nm uIhu ste&tilic peeudomorpbs after quarts, dolomite, topaz, cliuistoltte, Hiaurolite, cyanlte, garnet, veauviaulle. cbiysotile. gehlealte. Talc in the fibrous form Is pseudomorpb after enstatite atid Iremolite.

Apple-L^reeu talc occurs at UL Orelner in the Zlllerthal, Tyrol; Id the Valals and St. Ootliard III Snltzerlaud; Id Cornwall, near Lizard Pcdot, with serpeuUue; the Slietland Ulauds.

In N. America, foliated talc occurs in Maine, at Dexter. In Vermont, at Bridgewaler, handsome green talc, with dolomite; Newfane. In Mau., at Middlefield, Windsor, Binnford, Auiluver, atid Cheater. In B. hland, at Bmlthfleld, delicate green and white in a CTjstiilline limestone. In N. York, at Edwards, St. Lawrence Co., a due fibrous talc {agalite) associated with pink tremollte; on Staien Island. In N, Jartey, Sparta. In Ftnn., at Texas, Nottlngliam, TJtiluiiville; in South Mountain, ten miles south of Carlisle; at Chestnut Hill, on tbe Schuylkill, tolc and also soapstone, the latter quarried eitenslTely. Id Maryland, at Cooplown, of green, blue, aud roae colors. In N. Cur., at Webster. Jack. son Co. In Canada, in the towusljips Bolton. Sulton, and Potton, Quebec, with steutite in beds of Cambrian age; In tbe towiuhip of Elzevir, Hastings Co., Ontario, an impure grayial) var. in Archtean rocks.

SBPIOLTTZt. Meerschaum Q&rm. L'&sume de mer Fr.

Compact, with a smooth feel, and fine earthy texture, or clay-like; tXm rarely fibrous. H. = 2-2-5. G. = 2. Impressible by the nail. In dry masses fioate on water. Color grayish white, white, or with a faint yellowish or

reddish tinge, bluish green. Opaqne.

Comp.—H.Mg,Si 0,. or 3H,0.2Mg0.3SiO, = Silica 60-8, magnesia 2T-1, water 12-1 = 100. Some analyses show more water (2U,0), which is probably to bo regarded as hygroscopic. Copper and nickel may replace part of the magnesinm.

Pyr., etc.—In the closed tube yields first hygroscopic moisture, and at a higher temperature gives much water and a burnt smell. B.B. Booie vjirietlea blacken, then bum white, and fuse with difflcully on the thin edges. Wiib cobalt solution a pink color on Ignitiou. Decomposed by hydrochloric acid with gelaliuizuiion.

Obi,—Occura in Asia Hmor, in masses in Etratified earthy or alluiial deposits at tbe

glains of Esklbi sber: at Unibscliilz in Horavia; in Morocco, called ic French Pierre de awn de Maroe; nt Vallecas In Spain, in extensive beds.

A flbious miuernl, baving llie composition of sepiolile, occurs in Utab.

Tbe word meericliavja is Oermau fur tea-froth, iind alludes ii> lis liglitness and color. Sepiolile Glocker Is from cryjzia, euUle-fith, the bone of,whicb Is llgbl aud porous; and being also a production of the sea, " dclnde jpumotn marinam sigtilQcubat," sa_i s Olocker.

GoDDaiite, A hydrous nickel silicate, perhaps H,N[,8iiO,s. In small fi-oglle gisins. O. = 3'4S9-3'S19. Color yellowish, green. From RSttis, in Saxon Votgtlnnd.

Spadaite. Perhaps 5Mg0.6SiO|.4H,0. Massive, amorphous. Color reddish. From Capo di Bove. near Rome.

SAPOHITEI. Plotine. .

Massive. In nodules, or filling cavities. Soft, like bntter or cheese, but brittle on drying. G. = 2-24-3'30. Luster greasy. Color white, yellowish, grayish green, bluish, reddish. Does not adhere to the tongue.

CoBp.—A hydrous silicate of magnesium and alnminium; but the material is amorphous and probably always impure, and hence analyses give no uniform results. Contains SiO, 40-45 p. c, AI,0, 5-10 p. c, MgO 19-26 p. c, H,019-21 p. c; also Fe,0„ FeO, etc.

Fyr., etc.—B.B. gives out water very readily and blackens; thin splinters fuse with difficulty on the edge. Decompased by sulphuric acid.

Obs.'—Occurs in cavities In basalt, dlabfise, etc.; also with serpentine. Thus at Lizard Point, Cornwall, in veins in serpentine; nt various localities In Scotland, etc.

Saponile la fn»D Mipo, toap; and piotlne from iciorifi, fat.

Caladonlta. A silicate of Iron, magDeelum and potasaium. Earthy or In mioute Males. Very soft. Color green. From cavities in amygdaloid at MU. Biildo tieat

OUuconit«. Essentially a bydrouB atllcate of iron and potassium. Amorphous, nud Tesembliiig aartby cliloiite; either in cavities !□ rocks, or loosely Krauular massive. Color dull green. Abundant Id tbe "green sand," of tbe Clialk formatloD, sometimea constituting 75 to M p. G. of tbe whole,

PhoUdoUtc, Corresponds approiimntely to 5H|O.E,0,13(Fe,Hg)O.Al,0..18BiO.. In minute crystalline scalea, G, = S'406. Color grayish yellow. From Taberg in Werm-land, Sweden, with garnet, dlopside, etc.

IV. Kaolin Division.

KAOUHITEI. EaollQ.

Moaoclinic; in thin rhombic, rhomboidal or hexagonal scales or plates with snglea of 60° and 120°. Usnally oonBtituting a clay-like mass, either compact, friable or mealy.

Cleavage: basal, perfect. Flexible, inelastic. H. = 2-35. O. = 2-6-3-63. Luster of plates, pearly; of mass, pearly to dull earthy. Color white, grayish white, yellowish, sometimes brownish, bluish or reddish. Scales trauaparent to traiislticeut; usually unctuous and plastic.

Optically biaxial, negative. Bz^ ± b. Bx. and ax. pi. inclined behind some 20° to normal to c (001) Dick. Axial angle large, approx. 90°.

Tar.—1. KaoiinitB. In crystalllae scales, pure white and with a satin luster lu the masa. 2. Ordinary. Common kaolin, in part in crystalline scalea but more or lesa Impure including tbe cumpari lithomarge.

C*«p.—H,Al,Si,0„ or 2H,O.Al,0,.2SiO, = Silica 465,alnmina 39-5, water 14"0 = 100. The water goes off at a nigh temperature, above 330°.

Pyr.p ato.—Tields water. B.B. Infusible. Gives a blue color wUb cobalt solution. Insoluble In acids.

DilF,—Cbaracterized by uDCtuoua, soapy feel and tbe alumina reaction B.B. Resembles Infusorial earth, but readily diBtinguisbed under tbe tnicroscoiie.

Oba.—Ordinary kaolin is a result ot tbe decompoBitton of alumiuoua minerals, especially the feldspar of grauitic aud gneissoid rucks and porpbyries. In Bome regiuoB wheii: tbeae rocks have decomposed on a large satle, Ihe reaiiltlng rluy remains in vast beds of kaolin, uaualiy more or less mixed with free qunrlz, and sometimes with oxide of Iron from some of tbe otlier minerals present. Pure kaolinlle In scales often ocuura In conneciioii with iron oree of tbe Coal formation. It sometimes forms extensive beds in the Terlitiry forma' tiou. as near Richmond, Va. Also met with accompanying diaspore and emery ot corundum.

Occurs in the coal formation in Belgium; Schlan in Bohemia: in argillaceous schist at Loddve, Dept. of HSraiilt, France: as kaolin at Diendorf (Bodenmaia) in Bavaria: at ScbemnitE; with fluor at Ziiinwald, Yrieii, near Limoges, is Ihe best lociility of kaotiu in Europe (a discovery of 1760): it affords niaierial for the famous Sevres porcelain manufactory. Ijirge iiuantltiee of clay (kaolin) are found in Cornwall ami West Devon. England.

In the U. States, kaolin occurs at Newcastle and Wllmioglon, Del,; at various localities In tbe limonile region of Vermont (at Brandon, etc.), MaasachnsettB, Peunsyt-yanta; Jacksonville, Ala.; Edgefield, S. C: near Aurusta, Oa.

The name Kaolin is a corruption of the Chinese Katiling, meaning /^iBh■ridgt. the name of a hill near Jaucbau Fu, where tbe material la obtained.

Pholetlta Near kaolinite, but some analyses give 10 p. c. water. The original wu from tbe coal mines of Fins. Dept. of AUier, France.

BAIXOTSTTB.

Massive, Clay-like or earthy.

Fracture conchoidal. Hardly plastic. H.= 1-2. G. = 2'0-2-20. Luster

BOmewh&t pearly, or waxj, to dull. Color white, grayisb, greenish, yellowish^ bluish, reddish. Translucent to opaque, sometimea becoming translucent or even transparent in water, with an increase of one-fifth in weight.

Var.— Ordinary. E&rthj or waxy [a lusrer. aEi<l opaque niMsive. OalapeeU'it li liallojs-ite of Anf;lar. PteudotttaUU of TbomaoD & BInney la ad Impure vurleiy. dark j^roen in color, with H. = 3-26. O. = 2'46i>. Itidianaiit \a a white poi-celulD clay from Luwreace Co., ludiana, wbere It occura with allophane in beds four to ten feet thick.

Simetile Is greeulah. aud iu certaiu atalea of humidity appears tranepareut aud almost gelatinous; it is from Condi, near Houdan, Frsuce.

Bole, iu pnrt, may beluug here; tUat is, those colored. UDCtuoits clays coutalolug more or less iroD oiide. which also have about 34 p. c. of water; the Irou gives Ihem a browniah, yellowish or reddish L-olor; but they muy be mixtures. Here beiongaBergteift (niouutaln-soap).

Cornp.—A silicate of aluminium (Al,0,.3SiO() like kaolinite, but amorphous and containing more water; the amount is somewhat uncertain, but the formula is probably to be taken as H,Al,Si,0,+ aq, or 2H,O.Al,0,.2SiO,+ aq = Silica 43-5, alumina 36-9, water 19-6 = 100.

Pyr., eto.—Yields water. B.B. iafutible. A toe blue with cobalt solution. Decom* posKd by acids.

Obi.—Occurs often In veins or beds of ore, iia a aecoiidarv product; also In grtuite and other rocks, buiog durived from the dccompoaitiou of some nlumiiious minerals.

Newtoalt*. HuAliSiiOii-l-nq. In soft white compact masses resembling kaolin. Fouud on Sueed's Creek in the oortUeru purt of Newton Co., Arkansas.

Oinollte, A hydrous silicate of aluminium. 2AUOi.9810,.SHiO. Amorphous clay-Itke, or chalky. Very soft. O. = 2-18-280. Color white, grayish while, reddish. Prom the isltiud of Argentiern (Elmolos of the Greeks),

HontmoriUonlte. Probably H,AltS<.Oji + n aq. Massive, clay-like. Very soft and tender. Luster feeble Color white or gray Isli to roBe-re<l, and bluish; also pistachio-green. Unctuous Munimoriilonite, frnm Montmorllinn, France, is rose-red. Gonfolensile is paler mte-red; fr. Coufolens, Dept. of Cbareiile. ai Bl. Jean-de-CAle, near Thlvlera.

StolptniU is a clay from the basalt of Btolpen. Suponitt of Nicklte la a white, plastic, soap-tike clay fiom the fn^nite from which issues one of the hot springs of Plombi^rea, France, called Soap Spring; It was named tmegmatiU by MaunDaun.

PYROPHTLLTTD.

Monoclinic? Foliated, radiated lamellar or somewhat fibrous; also grana-lar to compact or cryptocryatalline; the latter sometimes slaty.

Cleavage: basal, eminent. Laminse flexible, not elastic. Feel greasy. H. = 1-2. G, = 2-8-2-9, Luster of folia pearly; of massive kinds dull and glistening. Color white, apple-green, grayish and brownish green, yellowish to ocher-yellow, grayish white. Sub transparent to opaque. Optically —■ Bi X cleavage. Ax. angle large, to 108°.

Vai.—(1) Foliated, aud often rniliated, closely resembling talc in color, feel, luster and structure. (2) Compact mauine. white, groyish and greenish, somewhat resembling compact steatite, or French chalk. This compact variety Includes part of what has gone under the name of agalmatollte, from Cliina; it is used for slate-pencils, and Is sometimes called p«neU-^il«ne.

Comp.—H,Al,(SiO,), or H,O.A],0,.4SiO, = Silica G6-7, alumina 28-3, water 5-0 = 100.

Pyr.. etc.—Yields water, but only at a liigli temperature. B.B. whitens, and fuses w!th difficulty on the edges. The ludiated viirietles exfoliate in fan-like forms, swelling up to many times the origjnnl vnliime- of the assay. Heated und moistened with cobalt solution gives a deep blue color (nluminn). Partially decomposed by sulphuric acid, and tompletety on fusion with alkaline carbonates.

nut—BaMmblM tome talc, but distinguished b; tlM mctloD for tJumiiu with cobalt solution.

Oba,—Compact pyrophylllte Is the materinl nr base of some schistose rocks. The foliated variety Is ofteu tLe ^&ogui! of cjtttilte. Occurs ia the Unl; at WeatauA, Sweden; □ear Otlrez, Luiembourg; Ouro Prelo, Brazil.

Also !□ white stellate H^gregatious in Cottonstoae Hin., Heckleoburg Co.. N. C ; in Chaalerfleld Dist., B. C, witli lazulile and cyanlte; in Lincoln Co., Oa., on Qiaves Utn. Tbe compact kind, at Deep Rtver, N. C, is exlensively used for making alaie-peocils and reaemblea the so-called agalmatolile or pagodite of Ohina, often uted for omBmenlil earrings..

AIXOPBANB.

AmorphonB. In iooruBtations, asaally tbio, with a nammillaTy surface, and hyalite-like; aonietimea Btalaotitic. Occasionally almost pnlTernlent.

Fractnre imperfectly conchoidal and shining, to earthv. Very brittle. H. = 3. ■ G. = l-85-l'89. Luster yitreous to aubresinoos; bright and waxy internally. Color pale sky-blue, sometimes Kreenish to deep green, brown, yellow or colorless. Streak nncolored. Tran^ucent.

Comp.—Hydrous aluminium silicate, Al,SiO,-|- SH,0 = Silica 238, alumina 40-5, water 35*7 = iOO. Some analyses give 6 equivalents of water = Silic» 22-2, alumina 37'8, water 400 — 100.

Impurities are oftvn present. The coloring matter of tbe blue varietj Is due to trmc«s of chrysncolla. nnd substances Intermediate between allopbane and chrjsocolla (mixtures) are not uncommon. The green variety Is colored by malachite, and the yellowish stHl brown by iron.

Pyr., ato.—Yields much water In tbe closed tube. B.B. cnimbiei. but Is infusible. Qlves a blue color with cobalt solution. Qelatlnizes with bydr ochloric scld.

Obs.—Allopbane ia regarded as a result of the decomposition of some aluminous silicate (feldspar, etc.); and it often occurs incnisting fissures or cavities in mines, especla]!; those of copper and limonite, and even in beds of coal.

Named from aXXoS. other, and i/Mtiyf<j€ai, to apptar. Id allusion to Its change of appearance under tbe blowpipe.

OoUyiits. 3AliOi.8iO,.9HiO, A clay-like mineral, white, with a glimmering luster, greasy feel, and adberiug to tbe longiie G. = 3-3-15. From Ezquerra In the Pyrenees.

BohrBttarits. 8AliOf8aiOi.8DH,0. Resembles allopbane; sometimes like ^m in sppeaiance. H. = 3^'G, Q. = 1-05-3 OG. Colorpale green or yellowish. FromDulUu-

gvc mountain, near Freiensteln, In Styrla; at the Falls of Little River, on tbe Sand Htn., herokee Co., Alabama. The following are claylike minerals or mineral substances: Sioopile, smectite, catlinite.

OnuMita. H.Cat(T,Er),C8i.0n. Color yellowish brown. From HhterO, Norway.

Thanmaslte. CBaiO>.CBCOi.CaSO,.16H,0. Haesive, compact, cirstalline. Cleavage in traces. H. = 8 6. Q. = 1*877. Color white. Occurs fllling cavftits and crevices at Uie BJeIke mine, near Areskuta, Jemtlaud, Sweden: nt first soft, but hardens on exposure to tbe nlr. Also in fibrous crystnlliiie masses at Paterson. N. J.

Uranophane Uranotil. Ca0.3U0..2SiO, +6H1O. In radiated aggrentions; massive, fibrous. Q. — 3-81-8-90 Color yellow. From tbe granite of Eupfetberg, Slle^ Uranotil occurs at Wslsendorf, Bavaria; Mitchell Co., N. C.

OHBTSOOOIXA.

Cryptocrystalline; often opal-like or enamel-like in texture; earthy. In-crasting or filling seams. Sometimes botryoidal.

Fracture conchoidal. Rather sectile; translucent varieties brittle. H, = 2-4. G. = 2-2 238. Luster vitreous, shining, earthy. Color moiintaiQ-green, bluish green, passing into sky-blue and turquois-blue; brown to black when impure. Streak, when pnre, white. Translucent to opaque.

Comp.—True chrysocoUa appears to correspond to CnSiO,-|- 2H,0 = Silica

34'3, copper oxide 45-3, water 205 =: 100, the water being double that of dioptaBe.

CompositloD variei much tliTOUgh impultles; free bHIcr, sIbo iilumlna, black oxide of copper, oxide of iron (or llmonlte) luid oxide of munguneee m&y bu preaeuti Ihe color con-Beqiieotl; varies rnDia bluish green lo blown and black.

Fyr , etc.— Id the closed tube blackeoB uod yields water, B.B. deci«|)itBt«*. colon the fiame ernernld-green, but la Infualble. With the Uuxes gives the reactioDB for copper. Wiih soda and charcoal a globule of metallic copper. Decompoaed by acids without gelalinizatlon.

Oba —Accompanies other copper ore«, occurring especially in the upper part of Teios. Found ill copper mines la Cornwall^ Hungary; Siberia; Saxony; South Australia; Chllf,

In the n. B., similarly at the Schuyler's mloes, New Jeney; atHorgantowa, Pa.; at the Clifton mines, Qrabam Co., Arizona; Kmma mine, Utah.

C^rt/toeoBa is from ;[f>u(TDS, foM.and K6\Xa,glvt,aii<l was the name of a material used Id Bolderlug gold. The name is often applied now to borax, which Is so eniplttyed.

OHLOROPAL.

Compact massiTe, with an opal-like appearance; earthy. H, = 2-5-4-5. Or. = l-727-l'870, earthy variettoB, the second a conchoidal Bpecimen; 3105, CeYlon, Thomson. Color greenish yellow and pistachio-green. Opaqne to buo translucent. Fragile. Fracture conchoidal and splintery to earthy. Feebly adhering to the tongue, and meager to the touch.

Var.— Ohtoropal has the above-mentioned characters, and was named from the Hungarian mineral occurring at Unghwar.

Jfanirouiit is pale slraw-yBllow or canary-yellow, and RTpenlsh, with an uucluons feel; flattens and grows lumpy under' tlie peatle. aud is polisTied by friction; from Noiilron. Dept. of Dordogne. France. Pinguite Is siskin- imd oil-green, eitretflely si>fl. like new-made soap, witli a sli^hlly resinous luster, not adhering to the tongiie: from Wolkenstein in Saxony. QraminUe hns a graas-green color (whence the name), iind occurs at Meiixen-berg, in the Siebengeblrge. In thin Dbrous seams, or as di'licate lamella.

Corap.—A hydrated silicate of ferric iron, perhaps with the general formula H.Fe.fSiO,), + 211,0 or Fe,0,.38iO,.5H,0 = Silica 41-9, iron sesquioxide 37-2, water 20'9 = 100. Alumina is present in some varieties.

The water and silica both vary much. Tlie Hungarian cliloropal occurs mixed wUh opal, and KTaduates into it, and this Recounts for the hitrh silica of some of irs tinnlysea.

Obs.—Localltiea mentioned abo»e Gh/oropal occurs also at Meenser S1 elnberg near GOttinRen; pinguiUi at Sternberg, Moravia. On Lehigh Mt., Pa., soiilh of Allenlown, occurs In counecilon with Iron depislts.

UmPERiTB. An iron silicate near ciiloropal. Color green. From Kfitz, Bohemia.

Hlaingarita. A hydraled ferric silicate, of uncertain composition. Amorpboiis. compact. Fracture conchoidal. H.=8. G. = 2-5-3 0. Luster (rreaay. Color black lobrown-ish black. Streak yellowish brown. From Riddarbyttan, Tunaberg. Sweden; Liogban, etc., Norway.

The following are hydrous manganese sllicatet. Bementit

gillie. G.

ye. N. J.

OaryoplllU. Approximately 4Mn0.38iO. 3H,0. In stalaclltic and renIform shapes. G. = 2-83-2-9I. Color brown. From the Haratig mine near Pajsberg, Sweden.

Heotoclte. A hydraled silicate of manganese and Iron, of doubtful compoailion, usually derived from the alteiatlou of rhodonite. Amorphous Color black to dark browD and Uver-browD.

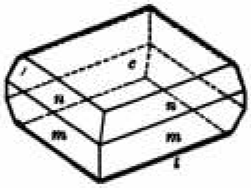
TITAHO-8ILICATES, TITAITATZS.

This BectioD ineludeB the common calcium titano-eilicate, Titanite; alao a nnmber of silicates which coDtaia titanium, but whose relations are not altogether clear; further the titanate, PeroTskite, and niobo-titanate, Dysanalyte, which is intermediate between Perovskite and the species Pjrochlore, Micro-lite, Koppite of the following chapter.

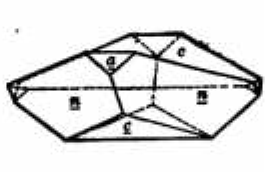
In geaeral tbepart played by lltanium in the many silicates In which it enters is more or leaa uucertain. It is probably la most cases, ss shown in the preceding pages, lo be taken as replacing the silicon ; In others, however, it Beema to play tlie part of a basic elemeuti in schorlomite (p. 419) it may enter In both relations.

$b : c = 0{\cdot}7547 : 1 : 0{\cdot}8543$; $\beta = 60° 17'$.

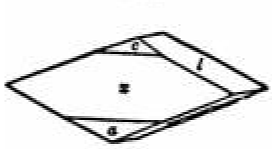
916.



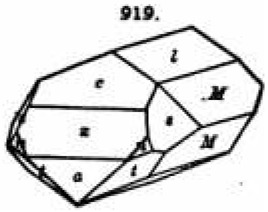
918.



917.



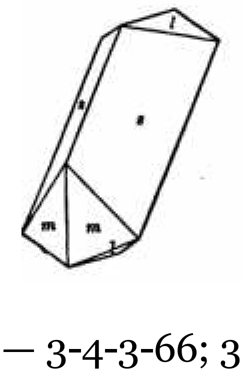
919.



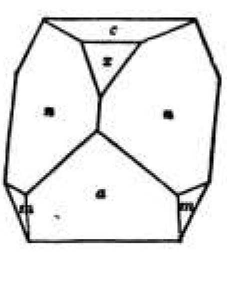
Twins: tw. pi, a rather common, both contact-twins and cruciform penetration-twins. Crystals very varied in habit; often wedge-shaped and flattened) e; also prismatic. Sometimes massive, compact; rarely lamellar.

Cleavage: m rather distinct; a, I (Il2) imperfect; in greenovite, » {111) easy, t (111) less so (Dx.). Parting often easy \ fj (221) due to twinning

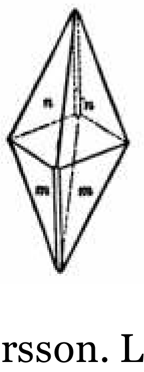
920.



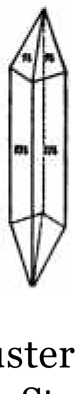
921.



922.



923.



lamellffi. H. = 5-5'5. G. — 3-4-3-66; 3-54I Chester, Pirsson. Luster adamantine to resinous. Color brown, gray, yellow, green, rose-red and black. Streak white, slightly reddish in greenovite. Transparent to opaque.

Pleochroism in general rather feeble, but distinct in deep-colored kinds: c, red with tinge of yellow; b, yellow, often greenish; a, nearly oolorless. Optically +. Ai. pi. i b. Bx nearly X x (102), i.e., Bx A li = + 51°. Diapersion p > V very large, aud hence the peculiarity of the axial interference figure in white light. Axial angles variaW 2E, = 50° to 90°. /9, = l-fe94. Birefringence high, y~ a = o'121.

Vai.—Ordinar]/. (a) TitaniU; brown lo black, tbe original belag Ihus colored, also opaque or Bublrauslucent. (bj Sp!tent (named (rom <Tipf'/r, a tBtdge); of Ifglit shniln>, as yellow, greeulsh. etc., and often translucent; tbe orlghiiil was yellow. Ligunlaia ild ajiple-greeu spheue. Spiailiere (ur tiemcline) a greenish klud. LedtiiU is brown, opaque, tii' sut>-traoslucGut, of tbe form in Fig. 916.

JitanomorphiU is a white mostly granular altcraiton-prodiict of ruttle attd llmenite, not uncommon in lerlalu crystalline rocks; liere ulso belongs most leucoxeue (see p. UD7).

Maitgatuaau; Qreemmte. Red or rose.coloi'ed, owing to tbe pieseuce ul a little manganese; from Si. Marcel.

Containing ylirium or eerium. Here belong grotbile, aUliedlte, eucollle-tllaiiile.

Comp.—CaTiSiO, or CaO.TiO,.SiO, = Silica 306, titanium dioxide 40-8, Jime 28'6 = 100. Iron is present in varying amonnts, eometiniee manganese

and also yttrium in some kinds.

Pyr., etc.—B.B. some varieties change color, becoming yellow, and fuss at 8 with latumescence, lo n yellow, brown or black glass. Wilh borai: ihey nfiord a clear ycllowlsb-greett glass. Imi>erfectly soluble ii) lieated bjjdrochloric acid ; and if Ibe solution he concenlriited along witb tin. It becomes of u Une violet color. Witb salt of phosphorus in R.F, gives a violet bead ; vurlotiea containing mucL iron require lo be treated witb the flux on cbaicoul wilh metallic tin. Completely iJccomposeil by sulphuric and bviirofluoric acids.

Diff.—Characterized by Its oblique crystal liiation, a wedge-gbapeil tana common ; by resinous (or adamiinline) luster ; bardneas less tlian that of stauroliie and greater than Ih&t of aplialerite. The reaction for lltanium Is dtaliuctive, but less eo in vaiieties coDtaluing much iron.

Dintlugulshed In thin sections by Its acule-angled form, often lozeDge-ahaped ; lis generally pale brown tone i vtry high relief and remarkable birefi-ingence, causing Ibo section to stinw wbile of tbe bibber order; by its biaxial cburacier (showing many lemniscale curves); and by lie great dispersion, which produces colored liyperbolus.

Ob«.—Tilanito, as an nccesaory component, Is widespread as a rock forming mineral, though confined mostly to tbe acidic feldspalhic Igneous rpcks; tt Is much more common \a the plutonic granular types than In the volcanic forms. Thus It is founii In tbe more basic bornblende granites, syenites, and dioritcs, and is especially common and characteristic in the nepbelile-syenites. It occurs also in tbe metamorphic rocks and especially In the schists, gneisses, etc., rich In magnesia and Iron and in certntn granular limestones. It is also found in beds of Iron ore ; commonly afsoclsled minerals are pyroxene, amphtbole, chlorite, scapolite, zircon, apatite, etc. In cnvitiee In gneiss and gr&nite, It often accompanies adularia, smoky quartz, apatite, chlorite, etc.

' Occurs at various points in "the Orisons, Switzerland, associated with feldspar and chlorite; Tavetsch; in the Bt. Golhnrd region: Zermatt in tbe Yalais; Maderanertbai In Uri; also elsewhere in the Alps; in Dauphin^ {tjiintfii^e): at Ala, Piedmont {liffuriu); at St. Marcel, in Piedmont: at Bchwdrzeusiein and Rothenkopf in the Zillerthai, Pfllsch, Tyrol; ZOpIau, Moravia; near Tavistock: near Tremailoc, in North Wales; in titanic Iron at Arendnf, in Norway; with magnetite at Nordmark, Sweden: Achmatovsk, Ural. Occasionally found among volcanic rocks, aa at Lake Laacb itemtlint) and at Andemacb on the Biiiiie.

In Mainr, in flne crystals at Sandford. In Matt., in gneiss, In the east part of Lee: nl Bolton wlili pyroieue and scapolite in limestone. In N. York, at Roger's Rock on Idike George, abundant in small brown crystals; at Qouvemeur, in black crystals In granular liniestODe; In Diana near Natural Bridge. Lewis Co , in larM dark brown crystals, among which is tbe variety UdrriU; at Rossie, Fine, Pitcairn, St. Lawrence Co.; in Orange Co , In limestone; near Edenville, in light brown crystals In limestone; at Brewster, at the Tilly Foster iron mine. In N. Jeney. at Frnnklln Furnace, honey-yellow. In Penn., Bucks Co.. three miles west of Attlehoro', associated with wollastoniu and graphite. In N. Carolina, at Statesville, Ii edell Co., yellowish white with suostone; also Buncombe Co.. Alexander Co., and other points.

OccuTi In Giniubi. stOrenrille. ArgenleutlCo.; also BucttlDgbsm. TompletoD. Wakefield. Hull, Ottawa Co.: tit N. Surges^ haiiey-jellow: near Eganvllle, ReDfrew Co., Ontario, in very large dark brown crystal* with apatfle, amphibole, zircon.

Keilhanite. A titano-silicate of calcium, aluminium, ferric Iron, ami the yttrium metals Crystals near titanite In hnblt and angles. H. = OS. O. = 8-09-8-77. Color bluwniafa black. From near Arendal, Norway.

QnarinlU. CaTiSlO.. u for titaulle. In minute tliln tnbles, flattened | b (010), nearly tetTBgoual in form. H. = 6. G. = 8-487. Color lulpliur-yellow, boney-yellow. Found io a grayisli trachyte on Monte Booinu.

TcchflSUnlte. A tltanoallicaie of Ibe cerium metals, iron, etc.. Iiut an alteration-product, more ot less heterogeneous, and (lie compo«ltlon of the original mineral is very tincerlain. Haaslve, amorphous. H. = 5-S-O. o. = 4-S08-4'Mil Color velvel-hlack. From the Ilroen mouDlains In tbe Ural. Also from 8. Indiit. probably KHnjonutlai Hill, Salem distr. Au Uolated moss weighing 30 lbs. has beeu found on Hat Cre^. near Hna-ale'B Hills. Nelson Co , Vlrgluia; also found, south of this poiut. in Bedford Co.

ArtrophTlllU. Probably K,R,Tl(BiU,). >vlib H = H, Nu, E, and R = Fe. Hn cbiefly, iacluding also Fcid. In elonguted crystals; also in Ihln strips or bUdes; sometimes la stellate groups, Cleavase: 6 perfect like mica, but lamlDee brilile. H. = 8. Q. s 8 3-8'4. Luster submetallic, pearly. Color bronze-yellow to gold-yellow.

Occurs 00 tlie small islsuds in the Langeaund fiord, near Brevik. Norway, In elsoljte* syeuiLe, embedded In feldspar, with catnpleiite, eegirtte, black mica, etc. Similarly at Kaueerdluarsuk, Oreeniand. Also with arfvedsouite and zinwu at SL Peter's Dome, Pike's Peak. Ul Paso Co., Colo,

Johnstraplta. A silicate of the cerium metals, caldum and sodium chiefly, with titanium and fluorine. In prismatic crystals. O. = S-29. From near Barkevlk, Norway.

Mosandrita. Near jobaslrupile In form and composition and from the same region.

Rinkite, also near johnstruplle. Is from Oreenland.

Neptiinite. A titRno-silicate of iron (niantninese) and tbe alkali melals. In prismatic monoclinic crystals. H. = 5-6. O. = 8-38. Color black. Southern Greenland.

PBROTSKITB. Perofskite.

Isometric or paeu do-isometric. Crystals in general (Ural, Zermatt) cubic in habit and often highly modified, but the faces often in-egularly distribnted. Cubic faces striated parallel to the edges and apparently penetration-twins, as if of pjritohedral individuals. Also in reniform masses showing small cubes.

Cleavage : cubic, rather perfect. Fracture Uneven to aobconchoidal. Brittle. H. = 5-5. G. = 4 017-4-039 Zermatt. Luster adamautine to metallic-adamantine. Color pale yellow, honey-yellow, orange-yellow-. reddish brown, grayish black. Streak colorless, grayish. Transparent to opaque. Usually exhibits anomalous double refraction.

Geometrically considered, perovsklte conforms to the isometric system; optically, however, it is uniformly blailal and usually positive. Tlie molecular structure (also as developed by eichiug. Baumbsuer) seems to correspond to onhorboniblc symmetry. Cf. Art. 411.

Comp—Calcium titanate, CaTiO, — Titanium dioxide 58-9, lime 41-1 = 100. Iron is present in small amount replacing the calcium.

Pyr.. etc.—In the forceps and on cbnrcoal infusible. Willi salt of phosphorus In O.F. dissolves easily, giving a greenish bead while hot, which becomes colorless on cooling; in H.P. the beiid changes to grayish green, and on cooling assumes a violet-blue color, j Unllrely decomposed by lioillng Bulphuric acid, I

Ob(,—Occui-s ill small crystnts, associated with chlorite, snd magnetic Iron In chlorlle i slate, at Acbmatovsk. near Zlnloust, in tbeUrnl: at Schellngen in the Kalserstulil.in graniilnr timeslone: in tbe valley of Zermatt, near Ibe Findelen glacier; at Wildkreuzjucb, between Ptilsi'b and Pfuuders In Tyrol, SpmelimeB noted in microscopic octahedral crystals iis a rock coiistiliicnt; ilius in nephellte- and melilite-basalts; also in serpentine (altered perido-tite) lit Syracuse, N, T.

Eiiopit«. Near perovakltc but costaluB cerium. In blitck iaometric cirttala. From AluQ, Sweden.

Dywuialyto. A tilaDo-oiobate of calcium and Iron. lu cubic crjstala. From the ranular limeitoae of Vo ' ' " ' ■ ■ ■ ■ " ■ ■" ... ...

, eroTsklte, but is in fac pyrocblore and koppile.

A reluted minerul, wbich has tlso long passed a* perovshlte, occurs with m brookite, niille, etc., at Magnet Cove, Arkansas. It U io octabedrona or cubo-octa black or brnwniah black in color and Hubmelallic in lusl«r.

Bee also tlie allied litanate, blibylte, mentioned on p. S48.

OeikiaUU. HuKnesium tltanate, MgTiO.. Hassive, as rolled pebbles. G. = 4, Color bluuta or brownish black. From Ceylon.

Oxygen Salts. 8. NIOBATBS, TANTA^^TES.

The Niobates (Golumbates) and Tantalates are chiefly salts of metaniobio and m eta taut alic acid, BNb,o, and RTa,o,; alBoinpartPjron!obateB,R,Nb,o„ etc Titanium is promiDeDt in a number of the species, which are hence intermediate between tiie niobates and titanates. N^iobiam and tantalum also enter into the composition of a few rare silicates, as wohlerite, laTenite, etc.

The following groups may be mentioned:

The isometric Ptrochlobe Group, including pyrochlore, microlite, etc The tetragonal Fkhgusosite Group, including fergusonite and aipylJto The orthorhombic Columbitk Group, including colnmbite and tantalita Also the orthorhombic Sauabskitb Gbouf, iQclading yttrotantalite, samarsfc ite, and ^snerodite.

The species belonging in this class are for the most part rvio, and are hence but briefly described.

PTROORLORB.

Isometric. Commonly in octahedrons; also in grains. Cleavage: octahedral, sometimes distinct. Fracture conchoidal. Brittle. H. = 5-5'5. O. = 4'2-4'36. Luster vitreous or resinouB, the latter on fracture surfaces. Color brown, dark reddish or blacltiab brown. Streak light brown, yellowish brown. Subtranslucent to opaque.

Comp.—Chiefly a niobate of the cerium metals, calcium and other bases, with also titanium, thorium, fluorine. Probably essentially a metaniobate with a titanate, RNb,o,.R(Ti,Th)o,; fluorine is also present.

The followlDg ate aiuilyseB bj Ranimelsberg :

G. Nb,o, TIO, ThO, Ce,o, CaO FeO MgO NaO, P Mlask 4-859 f 58-19 1047 TM 7-00 14-21 1-84 0 22 SOI ~

FredriksvBrn 4-228 47 18 18 62 — 780 15-84 10-03 019 3 13 2-SO

[fgn. 1-39 = 101-52

Oba.—Occura In elEeotlte-ayeuite at FredriksvBrn and I>iurvlk. Norwnv; od the iiland L5vo. oppoaileBrevIk, aod at several points in the Lujpesuud fiord; uearHiaak In tbsUral. NuDied from nCp, fin. aod jfAiupdS. green, because B.B. it becomes yellowisli green.

Kopplla. Bssentiailj a pjroDiobste of cerium, calcium, etc., near pyrochlore. In miuute brown dodecahedrons. O. = 4-45-4-50. From Scbellngen, Eaiserstuhl, embedded In llmeEtoue,

BatclMttollta. A tantalo-niobale of uranium, near pyrochlOre. In octahedrons wllb a (100) and n> (811). G. = 4-T7-4'90. Color yellowlBli brown. Occura wllh samai-sklte, at the mica mioea of Hitchell Co., North CaTofiaa.

BUorolite. Essentially a calcium pyrotantalate, CaiTaiOi. but contalnin); hIm niobium, fluorine and a variety of bases In small nmount. Isometric. Habit octahedral; Cfyalals often very small and highly modified (Fig. 109, p. 40). H. = 5 5. G. =5-486-5-562; 8 18 Virginia. Color pale yellow 1o browo, rarely byacinth-red. From Cbesterfleld, Hbbs.. in albite: Brancbvllle, Coun.; UtO, Sweden. Also in fine crystals up to 1 in. in diameter at the mica mines at Amelia Court-Houae, Amelia Co., Ya.

Ptrkhitb. Probsblf a mlcrolita. Occore In minute orange-yellov In ihe Ural.

FEIRanBOHITB. Tyrite. Braglte.

Tetragonal-pyramidal. Axis t = 1'4643. OrTStals pyramidal or prismatic in biibit.

GleATage: j|[lll) in traces. Fracture snbeencboidal. Brittle. H. = 5'5-6. G. = 5'8, aiminiahinK to 4*3 when largely hydrated. Luster externally dull, on the fractare brilfiantly ritreouB and Bubmetallic. Color brownish black; in thin sc^es pale liyer-brown. Streak pale brown, Subtranelucent to opaque.

Comp,—E^entially a metaniobate (and tantalate) of jrttrium with erbinm, cerium, uranium, etc., in varying amounts; ^bo Iron, cslciam, etc. Qeneral

formula K{Nb,Ta)o, with R = T^Er.Ce.

Water U usually preBent and sometimea In conaidenble amount, but probably not an orlgiDai conatituent; the epeclflo grarity falls as the amouut Increaaes. Aualyses by Bammebberg;

G. NbiO. Ta,0. UO, WO, SnO, Y.O, Er.O, Ce,o, FeO CbO H,o Greenland, F»g. S-sn 41-46 680 3-58 0-lB 0-47 24-87 981 7-6S* 0-T4 O'Sl 1'49

[= WIO Ttterto, yw. 4-774 38-14 27-04 213 — — 24-46 S-M — 072 417 613

[=100-03

• iDcl. G'U T>t,0„U,Oi.

Oba.—Prom Cape Farewell In Qreeulaad, In quarU; also at Tlterbv, Sweden, and E&rarfvet. Tyrit» ia associated with euxeulte nt Hampemyr on Ibe lalana of TromO, aod Helle on the mainland; bragite la from Eelle, Narestn, elc, Norway.

Found Id the U. S., at Kockport, Mass., In granite; in the Brindlstown gold district,

Slpyllta. A niobate of erbium chiefly, also the cerium melala, etc., near fergusonite In form. Rarely In octahedral cryatala. IJaiially In Irregular niasaea. G. =: 4*89. Color bTOwnish black to brownish orange. Occurs sparingly with allanlte In Amberat Co..

Virginia.

COIiUMlUTXI-TAHTAUrXI.

Orthorhombic Axes d:h:i = 0-8286 :1 : 0-8898.

W", 210 A 210 = 45'" 0'. et. 001 a 031 = 60° 40*.

mm ", 110 A liO = 78' IT. ao. 100 A 111 = 61' 18'.

ffg', 130 A I80 = 43" W. en, 001 a 138 = 48° 48'.

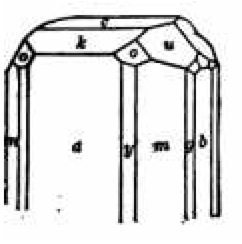
ek, 001 A lOS = 19- 43'. ««', 138 a 188 = 29' ST.

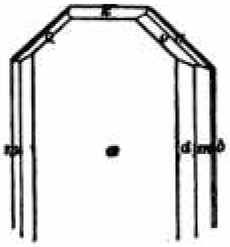
eg, 001 A 038 = 80° 41'. w."\ 188 a iSS = 79* 64'.

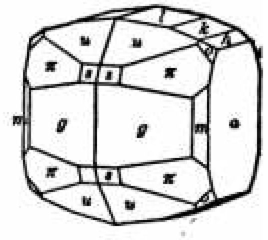
Twina: tw, pi. e (021) common, nsually contact-twin a. heart-ahaped (Figs. 347, p. 118), also penetration-twina; further tw. pi. g (053) rare (Fijr. 404, p. 281). Crystals abort prismatic, often rectanenlar prisma with the pirjacoida, a h c, prominent; aho thin tabular || a; the pyramida often but sliffhtly deyeloped, aometimes, howeyer, acutely terminate by « (133) alone. Also in large groups of parallel crystals, and maaaiye.

CleaTage: a rather distinct; 6 leas ao. Fracture anbconchoidal to nneven. Brittle. H. — 6. Q. = 5-3-r-3, varying with the compoaition (see below). Luster submetallic, often very brilliant, sub-reainous. Color iron-black, grayidi

and brownish black, opaque; rai-elj reddiah brown and tranalncent l frequentlv iridescent. Streak dark red to black.







Comp^iTar.—Niobate and tantalateof iron and manganeee, (Fe,Mii)(Nb,Ta),0^ paseiug by insensible gradations from normal Ooluhbite, the uearl; pure niobate, to normal Tantalite, the nearly pure tantnlate. The iron and manganese also vary widely. Tin and wolfram are present in small amount. The percentage composition for FeNb 0, = Niobium pentoilde 82'7, iron protoxide 17-3 = 100; for FeTa,0, = Tantdum pentoiide 861, iron protoiide 139 ^ 100

In aome varieties, mattffanoeolumbiU or manganctantaiiie, the Iron is largely replaced b;

Tlie coonectloD belween the specific gravity and the percentage of metalllcacids 1b ahowD in the [ollowing table :

a. Ta,o. Q.

6-86 3-3 Bodeumals G-93

G'66 ia-8 flnddam 6-09

S'TO 18-8 BodcDinalB 9-M

6-74 13'4 Haddam 618

5-86 10-0

Tantalitt 7-08

Gre«o1aad Acworlh, N. H. Limoges

Bodenmals (JXaniU) Bad dam

Tb,o. 271 30-4 8S4 815

«S'S

Diff. — DlstinguUbed (from black tourmaline, etc.) by orthorbomblo crrstalllzation, rectangular forms common; high specific gravity; submetalllc luater, often with Iridescent surface: cleavage much less distinct than tor volframlte.

PyT.,eto,—For (aii((ii((«.B.B. alone unaltered. With salt of phosphorus dissolves slowly, glvJDg an iron glnss, which In R.F, is pale yellow on cooiing; treated with tin on charcoal It becomes green. Decomposed on fusion with putasalum bisulpbate la the platinum spoor, and gives on treatment with dilute bydrochlorlc add a yellow solution and a heavy wbl e powder, which, on addition of metallic zinc, assumes a smalt-blue color; on dilution with water the blue color soon dlsappean. ColTimbite. wlien decomposed by fusion with caustic potash, and treated with hvdrucliloric and sulphuric acids, gives, on the addition of zinc, a blue color more lasting than with tnntallte. Partially decomposed when the powdered mineral Is evaporated to dryness with concenlrnted sulpliurlc add. Its color is changed to while, light gray, or yellow, and vfher boiled with hydrocblortc acid and metallic Bine it gives a beautiful blue.

Obs —ColumbilB occurs at Ribenateln and Bodenmala. Bnvnrla. in granite; Tammela. in Finland: Chnnteloube. near LImogea. in (le^matite wlili tnntnlile; near Miask, In the Ilmen Mis., with samarskite; in the eold-washings oT the Sanarka region in the Ural; In Oreeiiland. In cryolite, at Ivlgtiil (or EvigtokV In hrllHant crystals.

in the United aiates, Id Maine, at Standfsh. in splendent cryalals in gmnlle; also at

Stonebam with cassltcrito. etc. lu N. Bnmpthir*. at Acworlb, at the mica mine. In Ma*».. at Chesterfield; Northfleld, Mass. In Conneeiieut, nt Haddnm, in a granite vein; near Hlddletown: at Branchvilie, Fairfield Co., In ft vein oi albltic granite, in lar^e crystals and aggregates of crystals, also In minute translucent crystsls {manganeeolambils). upon ■podomene. In H. Tork, at Greenfield, with chrysoberyl. In F»nn., Hioeml Hill, Dela-

ware Co. Id Virginia, Amelia Co., In fine Bplendeiit cnsUtli witli mlcrolite, moDUlte, etc Id JV^. Carolina, with Mmsrabite at tbe mica mitiM of MilcLell Co. Id Colorado, od micro-cliue ai the Pike's Pe&k region; 'I'urkey Creek, JeSeraoii Co. In 8. Dakota, lu Ube Blsck HilJe regiou, commoo in tbe granite veiDS. In California, Eiog'B Cnek dLBtr., Fresno Cu.

Mangantantalile (NordonskiOld) from UtO, Sweden, occurs with petftUle, lepidollte, microUte, eio. Hanganotantalitt (Arzrunl) Is from gold-wuhings la tbe Buivka region in the Ural.

MssmTe tantalite occurs tn Finland, in Tammela, at HSrlcBsaari tiMr Torro; In Ktmlto, at SkogbOle; in Somero at Eaidiuuo, snd in Euortane at Katlala, with lepidollte, tourmnlioe, and beryl; In Sweden, neiir f^luD, at Broddbo and Fliibo; in France, «t CLanteioube near LimogiM, lu perniatlte. In llic V. 8.. In Taocey Co., N. C; CoomCo.. Ala.; also in Ibe Black Hills. 6. Dakota.

SzoaaOLiTK is esaentiallT FeTaiOi, like normal tant&lile, but occura in prismatic cryslals of diSereut anflesi the prum is near that of samartkile. From HfitkBatari Id Tammela, Fiulandi also from SkogbOle fu Elmlto. Ixiolitb, from Skogiifile, Is a nlotro-tanlalate of Iron and manganese: also coalaiulng tin; relailoua doubtful.

Tapiollta. Fe(Ta,Nb),Oi, Like tantalite, but occurring In square oclahedroDS. G. = 7 496. Color pure black. From tlie Eulmala farm, Tammela, PiDUuid.

TTTROTAHTAU^.

' Orthorfaombic Axes &:l;l! = 0-5413 : 1: I-I330. Crystals prismatic, mm''' = 56' 50'.

Cleavage: b very iodistiDct. Fracture email conchoidal. H. = 5-5*5. G. = 5'5-5'9. LnBter snbmetallic to Titreons and greasy. Color black, brown, brownish yellow, straw-yellow. Streak gray to colorless. Opaque to 8nb-translucent.

Coup.—EBsentially RR,(Ta,Kb),0„ + 4H,0, with R = Fe, Ca,°H =Y, Er, Ce, etc. The water may be secondary. Analysis by Rsmmelsberg:

Ta,0, Nb,0. WO, SnO, T,0, Er.O. Ce.O, UO. FeO CaO H,0 O. = 5-436 I 46'25 12 83 3S6 112 1002 6-71 3-23 1-61 8 BO S-78 6'31

[= 98 95

Tbe so-called yellow yttrotantallte of Ttterby and Elrarfvet belongs to fergusonite. Obs.—Occurs in Sweden at Ytterby, near Vaxbolm, in red feldspar; at Finbo and Broddbo, near Falun.

SAMARSKITS,

32, Orthorhombio. Axes <l:h:i = 0-5456 : 1:0-5178. Crys-

tals rectangular prisms {a, b), with e (101) prominent. Angles, mm''' = 57° 14'; ee' = 87°. Faces rongh. Commonly massiTe, and in flattened embedded graius.

Cleavage: b imperfect. Fracture conchoidal. Brittle. H. = 5-6. G. = 5-6-58. Luster vitreous to resinous, splendent. Color velvet-black. Streak dark reddish brown. Nearly opaque.

Comp.—R,'R,{Nb,Ta),o„ according to Rg., with R = Fe,

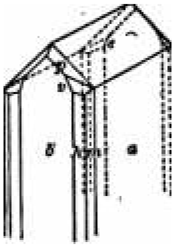
Ca, UO,. etc.; R= cerium and yttrium metals chiefly. Analyses by Rammelsberg:

3. Ta.O. NJi-O, 8dO„WO, UO, Cf,o,* T,o, Er,o, FeO TiO,

N. Carolina 5-839 u'si 4107 016 lOW 337 610 10-80 14-61 0-5ff> = 100-98

Miask 5-673 f — 56-84 033 11-94 488 8-80 8-83 14-80 108 = 99-88

• Inol. EUtOfl-atO,. ■■ IdcI. SIO,.



. . _ _ 11 emerald-

graeii bead. With todii yields a nmngsueBe reocllon. DecuDipoBed oo fusiim with poiasaium blsulpbatc, yieldiag ik yelluw uuaa which oo treatoieiit witli dilute hydmcbloric ftcid eeparalea while laotalic acid, and un boiling with metuUic zluc gives a Uae blut color. Id powder sti&lcieiilly decoiiipoEeil od boUiug with coDcentruted Bulphuric acid to give the blue rerluctlnu test when ibe acid fluid is treated with metallic zinc or liu.

Obi.—Occurs !□ reddish brown feldspar, wilh eescliynile aud columhite !□ the Ilmeu Diounimtis. near Miask. In the United Stulea, rntber sbundunt and sometimes in large DiMses, up to 30 lbs., ut the mica mluee in Stllchell Co., N. Carolina, iDtlmalely sasucluled ■ -with columbite; sparingly slsewhere.

AnnarlSdlU. Esaenlially a pyro-siobate of unuluinand yttrium. lu prismatic crystals. ofK'n resembling columblte. E. = 6. 0= 0'7. Color black. From tbe pegmatite vein at Aunerddi uearHoss, Norway.

Hlolmito. A Stan no-tan ts late (and nfobate) of yttrium. Iron, mauganese, calcium. Crystals (orthorhombic) usually rough; massive. O, = 6'88, Color pure black. From the EfirwfTet mine. Fulun, Btveden.

JEiohynlts, A niobate and litauaie (thoraI«) of the cerium metals chleUy, also In smal'i amount iroa, calcium, etc. Crystals prismulic. oitliorhombic Fracture small conchotdat-

Brlltle. H. =5-e. G. = 4 93 HillerS; SIBS Hiask. Luster submetalllc to resinous, nearly dull. Color nearly black, luclinlng to brownish yellow when trunslucent. Analysla by Rainmelsberg

Nb,o, TiO, ThO, Ce,o..r^(Di,)o, Y»o.,(Er,o,) PeO CaO G. = 6108 33 51 aiaO n-5a 1»-41 ■ 8-10 8 84 2-50 = 99 61

From Uiask in the Ilmeu Hts.. in feldspar with mien aod ztrcou; also with euclase in llie >!Old sands [>f the Orenburg District. Southern Ural. From HillerS, Korway. Named from aia^xvvi'i. thame, by Beraeliiis. in alliisiou to the inability of chemical science, at the time of its discovery, to sepsrale some of its constituents.

Polymignita. A utobate and titnnatc (zirconnle) of the cerium metnts, iron, oalcium. Crystals slender prisms, vertically striated. O. = 4T7-48IJ. Color black. Occurs at Frederikavam, Norway.

Eoxanlte. A niobate and titanale of yttrium, erbium, cerium and uranium. Crystals rare; commonly massive. H. =85. G. = 4 7-5-0. Color brownish black. Analysis by Rammelatwrg.

Nl>,o, TiO, T,o, Er.O, Ce,o, UO, FeO H,o

■ " ■ = 9009

Alve 500 8609 ai'lQ 37-48 840 817

Occurs at JOlster lu Norway; near Tvedestrand; ut Alve, < Poljrorue. A niobate and titniiate of yttrium, erbhin

near Arendal.

_, j^^..u,>,, ^.„,„.„. „c luiu, uranium,

like eiixenlte. Cryslals thin prismatic, cirthorliomblc. Fracture cmcholdal. H. = 6-6. G. — 4 97-5-04. Luster vitreous to resinous. Color black, browuisb In splinlerd. Analyses: 1, Mackintosh; 2, Hidden and Rimmels-berg.

NDjOt T«,o, TiO, T,o, Er,o, 0,0, UO, F*o H,o

HitterO 30-86 400 26-69 3888 7-63 2-81 7-70 8-73 4 03

Henderson Co., 19 48 — 29'81 27-6B' — — 18-77 SS^ Sll

{=98-16

- At. "(rht. 11!. 6 UO,.

From HiLt«rO, Norway. In gn.i>iiewlih gadolinite: at SWitSkra. Smftlaod. Sweden. In the U. Slalea, in N. Carolina, in the gold-washinm on Davis Innd. Henderson Co. with zircon, monazite, xenolime. magnetite; also in 8. Carollua. four miles from Marietta in Greenville Co. Named from xokvi, many, and Kfidtrti, mialurt.

Oxygen Salts.

4. PHOSPHATES, ARSKBTATES, VANADATES, AlVTIMONATES.

A. Anbydrous Phosphates, Arsenates, Vanadates, Anitmonates. Kormal phosphoric acid ia H,PO^, and consequently normal phosphates

have the formulas E,POj, B,{PO,), and RPO„ and similarlj for the arsenates, etc. Only a comparatively small number of species conform to this simple formula. Most speciee contain more than one metallic element, and in the prominent Apatite Oroup the -radical (GaF), (CaCl) or (PbCl) enters;

in the Wagnerite Group we have similarly (RF) or (ROH).

Tetragonal Axis i =: 0-6187, a 33'.

930.

z' (111 A 111) = 55° 30', zz" (111 A III) In crystals resembling zircon in habit; ^, ^^ sometimes compounded with zircon in parallel position

/Wty^ /fXX. (Fig- 314- p. 131). In rolled grains. <"^»-/l fV^^^ Cleavage: m perfect. Fracture uneven and splintery. Brittle. H. = 4-5. G. = 4 i5-4 56. Lnster reainons to vitreons. Color yellowish brown, reddish brown, hair-brown, flesh-red, grayish white, wine-yellow, pale yellow; streiik pale brown, yellowish or reddish. Opaque. Optically 4-.

Coinp.—Essentially yttrium phosphate, YPO, or

*<:s^>y VS-^ Y,O..P,0. = Phosphorus pentoiide 38 6. yttria 61-4

^\X^ ^V**^ ~ '00, The yttrium metals may include erbium in

large amount; cerium issometimes present; also silicon

and thorium as in monazite.

Pyr.p «to,—B.B. Infusible. When mnlsreneil wllb sulphuric ncld colors tbe flftme bluish

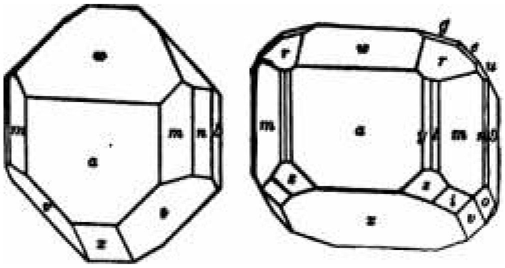
^reeu. Dlfflciillly mliib'e In snlt of phtHplionis. Ingoltihle in ncids,

Diff—Resembles zircon in its (etnigonal form, but disUiiguished by inteHor Imnioen and perfect prismntic cleavage.

Obi.—Occurs as an accessory mineral in griinite veins: somelimes in minute embedded crystnla genenillj distributed in RTnaitic nnd gneiasnld rocks. Fnund at HilterQ; nt Hnss, KragerS. anil from pegmatite veins (it ntber points in Norway; nt Ttterby, Sweden; the FIbitt Berg. S.W. from St. Golhard and tbe Binnenthal. Switzerlaud. An accessory cod-Etituent in the miiBcoTite-graniles of Brazil.

Id the United States, in the gold washings of Ctorksville, Georgia; In N. Carolina, Burke Co.. Henderson Co . Mitchell Co.; In brilliant cry-tals in Alessnder Co. wilb nitiie, etc.; with tysoDite near Pike's Peak, Colorado; rare on New York laland.

933·



Norwich, Ct.

BwltUTlMld.

BSOHAZITXI. MoDocitnic. Axes a-A: 6 = 0-9693 :1: 0-9256j fi = 76° 20'.

mm", 110 A 110 = 88° 84'.

OM. 100 A 101 = 8»° I2i'.

a'x. 100 A 101 = 58* 81',

ftr", on A Oil =88*56'.

rr". Ill A lil=i»0"40'.

vtf, ill A iil =78*19'. Crystals commonly small, often flattened || a or elongated | axis b; eome-times prismatic br extension of V (111) (Fig. 334, p. 103)i uIbo large and coarse. In masses yielding angular fragments; in rolled

Cleavage: c sometimes perfect (parting?); also, a distinct; h difficnlt; sometimes showing parting { c, m. Fracture conchoidal to uneven. Grittle. H. =■ 5-5'5. G. = 4-9-5'3; mostly 5'o to 5"2. Lnster inclining to resinons. Color hyacinth-red, clove-brown, reddish or yeliowish brown. Snbtransparent to Bubl ran sin cent. Optically+, Ax. pi J. 6 and nearly [a. Bi, A<-' = 4-1° to 4°. Dispersion p < v weak; horizontal weak. SE, = 29° to 31°.

Coup.—Phosphate of the cerium metals, essentially (Ce,La,Di)FO,.

Host uiitlfBes show ibe pre«eDce of TbOi luii] SiOi, usually, but not alwayt, Id thft

«roper nmouDt lo fonn lUoiium silicate; thiit this U nriechaulcsllj present is not c«rlBln ut possible, lyplcal Baalyeea: 1, Blomatnodi 2, Peofield.

G P.O. Ce,o, La,o, TrfErj.O. 810, TbO,

1. Arandal SIS 37-65 39-30 26-20 882 I'86 057 X3'84 = 100 6O

2. Burke Co., N. C. 610 2B-2S 8188 8088 — 1-40 S'49)gDo-30= 9968

X = Fe.O,118. CaOo 89. H,Oo 53.

_ rt.. rto.—B.B. Inl the ^

coolfuR: s satunlecl be«d becomes eQamel-white od flaming. Difficultly soluble luibydra chloric SCld.

Ob«.—Ratber ubundnntly distributed as an accesaoiy coDStltueul of goelssoid rocks ia reruln re^oos, thus Id Norlb Cnrolinii and BrHZil. Occurs uear Zlatiiusl In the Ilroen Hts.,ii) ^niDlte. In Norway, near Arendnl. and at AnnerOd. In brisII yellow or brown crystsla (tuTTierite) in Dsuphine sod Switzerland., Foued also <q the gold wasliingsof Aoiioqnia: in the diamond gravels of Brazil.

In the United Stales, formerly found with the sl]IImanite of Norwich, Conn.: also at Yorktown, N. Y. In laree coarse cn'stnls nnd mauet in albitic ^ninlio with nilcn)liie. i-lc, at Amelia Court-Ho use, Virginia. In Alexander Co., N. CarollnA, in splendent cryaislsi in Hitcbell, Hadison, Burke, and McDowell counties, obtained in large quautiiies in rolled groins by washing tlie eravels.

Monazlle Is named from /loyaf^fir, to be tolitarf, In allusion lo its rare occurrence.

Cryptolita occurs in wine-yellow prisms and grains in tbe grsen and red apulile of Arendal, Norway, and is discovered on putting the apatite In dilute nitric acid. It is probably monazlte.

Beizellite. R,As,o,(R = Ca.Mp.Mn). Isometric, ufually mnssiTe. G = 4 08. Color

MonlmoUU An antlmonate ot lead, iron, and sometimes calcium; in part, R,Sb,o,. UBUftlly in ocUihedrona; massive, locniating. G. =«88. Color yellowish or brownisli gtixa. From llie Haratig mine, Pujaberg.

Oarminlte Perbaps Pb,As,o.. lOFeAaO,. In clusten of Sue needles; also In spberol-dal forms. G. = 4 106. Color carmine to ille-red. From the LuUe mine at Horhau«n.

PucheriU. Bisroulli Tanadate, BITO,. la small orthorhomWo orysUls. H. =4. O,' = e 24». Color reddish brown. From Uie PueLer Mioe, Schoeeberg, Saxony.

Triphylite Group. Orthorhombic

d:i:i TriphyUte Li{Fe,Mn)PO. 04348 : 1 : 0-5865

LithiophUite Li(Mn,Pe)PO.

SatrophiUta NaMnPO.

Orthophoaphatea o(an alkali metal, lithium or sodium, with iron and maa-ganese.

TRIPBTUTB-LITHIOFHIIjITa.

Orthorhombic. Axes d:B:i = 0-4348 :1 : 0-5265. Cryatala rare, nenally coarse and faces uneven. Commonly mafigiye, cleavable to compact.

Cleavage: c perfect; ft nearly perfect; nt interrupted. Fracture uneven to subconchoidal. H. = 4'5-5. G. = 3-43-3-56. Luster vitreoua to resinoua. Color greenish gray to bluish in tripbylite; also pale'pink to yellow and clove-brown in lithiophilite. Streak nncolored to grayish white. Transparent to translucent.

Comp., Tar.—A phosphate of iron, manganese and lithium, Li(Fe,Mn)PO,, varying from the bmish-gray tkiphylite with little manganese to the salmon-pink or clove-brown lithtophiute with but little iron.

Typical Tripkylile Is LiFePO. = Pho"ph(irus pentoiide 4B'0, iron protoxide 45-.'S, lilliia 9-5 := 100. Typiciil Lithiophilite is LlMnPO, = PlioepboniB pentoi:ide 45-8. maDgaoese proloiide 45-1, lilhin 9-8 = 100. Both Fe and Mti nre always preaeut.

Pyr., •tc,—lu tiie closed Lube sometimte decrepUatee, turns to a dark color, an'i gives oatriioes of water. B.B. fuses at \H, coloring the flame beauiifiil lilhia-red In streaks. with a pale blutob green on tlie exterior of ibe cone of flame. Wilh the fluxes reacU for iron and manganeae; the iron renclion is feeble in pure lithiophilite. Soluble in hydrochloric acid.

Q\a-—Trip\ylH« Is often assoclnipd wl'h mwdunipnp; occurs a' RnbenstHn. near Zwiesel, in Bsvftrfa; KellyO. Fliilanrt; No»wich Mas*.; Ppru. Me : Gmfto", W. H Nnmed from rpii, thretfoid. and i/iuItJ. ffmilj/. in nllusioo lo Us contalninff tbr'e phoanhaio^.

LMiiipMtiU occurs at BmnchTllle, Fairfleld Co . Conn., In a vein of nlMHc granite, with spodiimene, mans^nese phosphates, etc.; also at Norway, Me. Named from lithium and ipi\oi, friend.

Natrophillt*. NaMnPO,. Near triphyllte in form. Clileflv massive. elpavaWe. H. = 45-5. G. = 8-41. Color deep wine-yellow. Occura sparingly at Bmnchville. Pair-field Co., Conn,

Berylloiilte. A phosphate of ▪odium and hpryllllnm, NaRePO,. Cryntals abort prismatic to tabular, oiltaorliomblc. H, = 5'5-A. G = SM-I. Luster vitreous: on e pearly. Colorless to white or pale yellowish. From Sloneham, Maioe.

Apatite Group.

General fomnla R.(F,Cl)[{P,Aa,V)o.], = (R{F,C1))R,[{P,A8,V)oJ,;

Apatite (CaF)Ca.(PO.), Flnor-apatfte " <! = 0-7346

or (CaCl)Ca.{PO.), Chlor-apatite

Pyromorphite (PbC])Pb,{PO,), 07363

Himetite (PbCI)Pb.{AsO,), 0-7234

Tanadinite (PbCl)Pb.(VO,), 0-7183

lex, tlicre are alsu cerlain iutermediate compounds conlaln-ill) pbospLoriis ami arsenic, or anuQlcaod Tanadiuin, ua re culcium nvaeiiate, Svnbittt, also seeras to belong In this

III iidditiOH to llic ubove api lug lead ftiid calcium 1 others noted beyond. Ftirlher tbe i group.

The species of the Apatite Group cryBtallize in the hexagonal system, but nil show, either by the Biibordinnte facca, or in etching-figures, that they belong to the pyramidiil group (p. 71). 'I'licy are chemicnlly phosphates, arsenates, vanadates of calcium or lead {also iimtiganese), with chlorine or fluorine. The latter element is prob:ibly present as a univalent radical CaF (or CiiCI), etc., in general RF {or RCl), replacing one hydrogen atom in the acid R,(PO,)„ so that the general formula is (RF)R,(PO,)„ and similarly for the arsenates. This is a more correct way of viewine the composition than the other method sometimes adopted, viz., 3R,(PoJ,,RF„ etc.

APA'lTfU. Hexagons-pyramidal. Axis i = 0-7346.

933. 934 93G 936.

^^

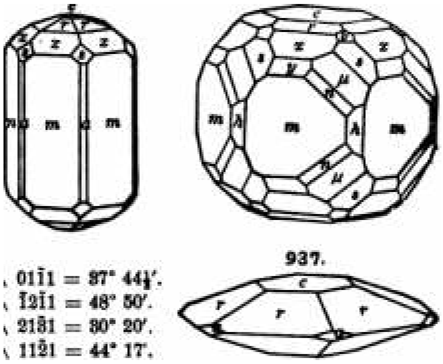
f^S>

fr, 0001 A 1013 = 22' SV.

fx. 0001 A lOit = 40° 18'.

/T/. 0001 A 2021 = Se° 36'.

rr'. 1013 A 0113 = 23° SI".



, 01̄1̄1 = 87° 44½'.
, 1̄21̄1 = 48° 50'.
, 2131 = 80° 20'.
, 1121 = 44° 17'.

937.

. lOil A Olil = SJ' Mi'. , 1131 A l3il = 48° BC. (, 1010 A 3181 = 80° 20". , 1010 A nSl = 44° ir.

Crystals varying from long prismatic to short prismatic and tabular. Also glohnlar and reniform, with a fibrous or imperfectly columnar structure; massive, stmcture granular to compact.

Cleavaee: c imperfect; wi more so. Fracture conchoidal and uneven. Brittle. H. — 5, sometimes 45 when massive. G. = 3'17-3-33 cryst. Luster vitreous, inclining to Hubresinoiis. Streak white. Color usually sea-green, bluish green; often violet-bine; sometimes white; occasionally yellow, gray, red, Besh-red and brown. Transparent to opaque. Optically—. Birefringence low, OJj ^ 1-6461, 6j ^ 1"6417.

Tip.— 1. Ordinary. Cryslullized, or cleavible aud gnuiulsr maBBlve. Colorleu to green, blue, yellow, fleah-red. (o) Tlie a»paragui-ttone, origiQallj from Hurcts. Spulu, is yellowlBh green. MoroxiU, frum AreDiliiJ, is in greeuUh blue und bluish crjslals. (b) LaruravaiUe in a sky-blue varieiy wiiU iMpig-liiziili in Siberia, (e) FrancoUu, from Wheal Fraucu, near Tavistock, DevonBhire, occura iu BUiall cryalulllne stalactilic a^usBes aud io minute curviug crysliils.

Ordinary apatite w fluor-apatUe. containing Uuorlne often with only a trace of chlorine, up to O'S p. c; rarely chlorine preponderates, aud someilmes flunrine Is enilrtly absent

3. MangaTutpatUe contains munguuese replacing calcium to lU'G p. c. HuO; culur durk bluish erecu.

8. Fibrout, eonerttionm-y, ttaUetUie, PhotphoriU iucludes the fibrous cuocrelionar;

i partly scaly mineral from Eslremadura, Spain, and elsewhere. EvpvrehroiU, fio "~'nt, N.T '•-' ■— " • ---■- ' - -■-

Crown Point, N. T., iwlongs here; it is concentric in airucture. .. _

Ing the phosphorite of Sl^el in bolryoidol, renifonn, or sialactitic'masses, flbroua aud radiating. Seep. 469.

i. Earth]/ apatite; OiUolile. Mostly altered apatite; coprolilea are Impure calcium phosphate.

Comp—For Fluor'apatile (CaF)Ca.{PO),; and for Cklor-apatile (CaCl) Ca,(PO,),; also written 3Ca,P,o, + CaF and 3Ca,P,o. + CaCl,. There are alao intermediate compounde containing both fluorine and chlorine. The percentage composition for these normal varieties is as follows:

Flaor-apalilB P,o. 42 8 CaO 55-5 F 8-8 = 1016 or Ca.P.O, 82 25 CaF, 7 75 = 100 GhUnr-apaliU P.O. 410 CaO 58 8 CI 68 = 1018 or Ca.P.O. 8»-4 OaCl, 108 = 100

Fluor-apatite !s much n the Alps, Spain, St. Lawre iuent are rare; Ibis is true of some Norwtgian kinds,

Pyr., etc.—B.B. in tlie foreeps fiiues vilh difficulty on llie edges (F. = 45-5), coloring the flame rediiiBb 3-ellow; moistened with sulphuric acid and heated colors Ibe flame pale bluish green (phosphoric acidi; some varieties reatt for chlorine wiih salt of phosphorus, when.tlie bead lias been pveriouBly saturated with copper oxide, while others give fluorine when fused with this salt in an open glass lube. Otves a phosphide with the sodium test. Dia'wlvcB in hydriichloric snd nitric acids, yielding with sulphuric acid a copious precipitate of calcium sulphate; the dilute nitric acid solullon gives with lead acelate a white precipitate, which B.B. tin chnrconi fuses, giving a globule wlih crystnllloe facets on cooling. Some varieties of apatite phosphoresce on heating.

131ff~ChHraclerfzed by the common hixngonul form, but softer than beryl, being scratched by a knife: does not efli^rvcsce in arid (like cnlcite); difficultly fusible: yields a green flame B.B. after hein^ moistened with sulphuric acid.

Recognized in thin sections by lis mndirately high relief; extremely low birefringence (hence not often showiuR a dislinct axial flgure in basal sections}, llie Inlerference colors in ordinary sections scaroely rising above gray of the first order; parallel extlncUon and negative extension; columnar form: lack of color and cleavage; and by the rude cross parting seen as occasional cracka crossing the prism,

Oba.—Apatite occurs In rucks of vai-ious kinds and ages, but Is most common in metamorphlc crystalline rocks, especially in granular limestone and in many metalliferous veins, particularly those of tin. in gneiss, syenite, hornblendlc gneiss, tulca schist, beds of Iron ore; occaslonRlly In RPrpentine. In tlie form of minuie microscopic crystals it has bd atmnst universal distribution as a rock-forming mineral. It is found in ail kinds of igneoiia rocks and Is one of the eariiest producW of crystallization. In Inrger cryslalB it isespeciuily characteristic of the pegmatite fiicies of igneous rocks, psrticularly the graniles, and occurs there associated with qiiariz. feldspar, tourmaline, muscovite. beryl, etc. * '■ ■"•"—■—— prweot In ordinary sttatifled limestone, beds of sandstone - -■-'- ~' •'-iferoua, Jurassic. Cretaceous, or Tertiary. '" "" ' '

of wood. . L TT

Among Its localities sre Ehrenfrledersdorf in SBxony: BchwarzenBlem, the Knappeo■wand In Unteranlzbachlhnl in the Tyrol ; Rt- Qothard, Tavelscb. etc.. in Switzerland; MuBsa-Alp in Hedmont, while or colorles': Zinnwald and Schlackenwald n a.hemla: id England. In Cornwall, with tin ores; in Cumberland, al Carrock Pells; in Devonshire, cream-colored a' Bovey Trncpv, «"d at Wlipr.l Franco [fmneoliU). The atparag^uilojit or wpairgtitltin of Juroilla, In Murcla, Spain. Is pale yellowish green in color. Large quantl-

ties of ap&tfte are mined Id Noiycay at EnigerO; also at Odegurd, near Bamle, and

elsewhere.

In Maine, on Long IslaQd. Blue-hill Bny. In JT. Hamp., WeslmorelHiid. !□ Mau., at Norwicb; at Bolton ubundaui. Id Conn., at Bniuchvllle (manganapatiu), aitio greeolBh witite and colorleas. In Nme York, commoa iu Bt. Luwreuce Cu., in grauukr Ittiiestoue: nl.to Jefferson Co.; Stuidford mine. Eiibl Horialj, Essex Co.. in magtielltt:; Dear Edeovtlli:, Orange Co. In Penn., at Lelperville. Delaware Co.; iu CLeater Co. In N, Carotina, at Slouy Point, Alaxander Co., etc.

In extensive beds in tlie Lauremian gneiss of Ciinada. usually aa»ociat«d nllh Jiraestoue, and iiucomiMiiied by pyroxene, ampbilrole, litiinile, zircon, gurnet, vesuvianiie iiud many Dtber species. Prominent minta are in Ottawa County. Quebec, in Ibe townslilpa uf Buck-iugbiim, Tampleton. Portland, Hull, and WakeQekl. Also iu Itenrrew county, Ontario, and ill Lan.irk. Leeds, nod Fri>nteni\c counties.

Apatite was ntimed by Werner from diraTo^iv, lo deeeice, older miuerulogiHts baving refeireil it to aqnAmarlne, clirysullte, araetbyst, Uuor, scborl, etu.

Besides tbe deUuite mineral photpliala. Including normid apatite, pbosphorite, etc., there are also extensive deposits of amorphous pliUBphutes, consisting largely at "bone pliosphatc" (CaiPiOi), of great economic importiince. ihougb not biiving a dennite clieml-cal composition and bence not strictly belonging to pure mineralogy. Here belong the pboapbatii: nodules, coproliles, bone beds, gU!iuo, elc. Kxlenalve pliuspbutic deposiia also occur ia North Carolina, Alabama and Florida. Oiiano is boue pliospbale of lime, mixed wi'h till hydrous phospbalea. iind geuerally wllh some calcium carbouule, and often a little magoesia, alumina, iron, silicu, gypsum and other impurities.

Stafpklite. a carbonated calcium pbospliale. Occurs incrustiog tbe phospliorlle of StaSel, In biitrjoldnl ur slalacillic masses, nbrons and riidlatiiie; It is the result of th« action of carbonated waters. U. = 4. Q. = 8 123 Color leek to dark green, greenish yellow. DahUiU, from Barale. Norway, is similar.

PTROHORPHITB. Green Lead Ore. Ortlubleierz Qerm. Hex agonal-pyramidal. Axis i = 0 7362.

CryBtak prismatic, often in rounded barrel-shaped forms; also in branch-ing groups of priamiitio crystals in nearly parallel position, jjg^

tapering down to a slender point Often globnlar, reniform, "— ■

and botryoidal or verruciform, with usually a subcolumnar I

structure; also fibrous, and granular.

Cleavage: tn.x{\i)\\) in traces. Fracture 8Ubeencholdal, '

uneven. Brittle. H. = 3-5-4. G. = 6-5-7-1 mostly, when |

pure; 5 9-fj'5, when containing lime. Luster resinous. Color green, yellow and brown, of different shades; sometimes wax-yellow and fine orange-yellow; also grayish white to milk-white. Streak white, sometimes yollowish. Subtransparent to siibtranslncent. Optically —. t

Var. —1. Ordinary, {a) /« erytiaU as descril>ed : sometlmea yellow and in rounded forms resembling camnylite {p»«udo-campylHe). (b) In nekular and WHM»-(»t< aggregations. Id) (»nflj'e(i«n"-y groups or masses of crya-tnis, linving ti>« surfuce angular, (rf) FiSroxu. (e) Granular mauit». (/) Earths ,* inctusiiig.

3. Foiytpharite. Containing lime: color brown of different shades, yellowish gray. pale jellow to nearly while; streak white; G. = 5-89-e-44. Rarely in aepnrate cryalala; usually ill groups, globuliir. miimmillnry, verruciform. Mietite. from Mies in Bohemia, is a brown variety. NumieriU is similar and impure, from NiisslSre, near Beaujeu, France; color yellow, greenish or grayish; G. =6-043. 8. CliTamiferous; color hrillinnt red and orange. 4. Arien\f»rou»; color green to white; G. = 55-88. 5. J^eudotnorphmit; (a) after galena; lA) cenissite.

Cemp.—(PbCl}Pb.(PO,). or also written 3Pb,P,0..PbCl = Phosphoms pentoxide 13-7, lead protoxide 82'3, chlorine 2-6 = 1005, or Lead phosphate 897, lead chloride 103 = 100.

TUe plinspbonis is often replncert by arsenic, and as the amooDt Increases the species puiMS iuiu iiiiiiiuiilt!. Culclutn also tepliLces ibe lead to a cuDsiderable extent.

Fyr.. etc.—lu Uiu closed tube ^ives a wljlte sublimate of lead chloride. B.B. la the forci-ps fiis.s easily (F. = l."!), colmiiig the flame bluish greeu; on charcoal fuses without reduction lu » globule, wblcbon cooling assumes a crystalliue polyhedral form, nhile the coal is coined wbiie from cbloride and, uearer the assay, yellow from lead oxide. With stiila iin charcoal yields inetidlic lend; some varielies contain arsenic, and give the odor of garlic iti K.F. ou charcoal. With salt of phosphorus, previously saturated wltli copper .oxhie, (jivcs iiD nzure-blue color to the flame when treateid in O.F. (chlorine). Soluble in uitiic mid.

Diff,—Distinguished by its hezagoDul form; high specific gr&vityi resinona luster; b!ow[Hp4! cliariiciers.

Obs.—Pyromorjiblte occurs principally In.veins, and accompauies other ores of lead. Al Puulluoueu nud Huelgoel in BriUany; at Zschopnu and other places in Saxony; Ht Pfibrnni, Bldsudt. in Bohemia; In fine cryslab at Ems, Braubach, in Nassau; also «t Dernbiich in Nassau; Berezov in Siberia; in Che Nerchinsk mining district; Cornwall, grt-en aud bronii; Dtvon. gray; Derbyshire, green and yellow; Cumberland, golden yellow, in EiiEluud; Leudhills, red and orange, lu Scntlitud.

lu the v. S.. has been found very fine at PheDixTille, Pa.; also In Maine, at Lubec and Lenox; In New York, a mile south of Sing Sing; in Davidson Co.. N. C, also iu Cabarrus and Caldu-ell Cos.

Named from itvp, fire, nofiipij, form, alluding to the cryslallfne form the globule assumes on cooling. This species passes Into mlmelile.

HIMBTim.

Hexagoiial-pyram idal. Axis i = 0-7324.

Habit of rrystula like pyroiuorphite; sometimee ronnded to globnlar forniB. Also ill muiiiiuillur; crusts.

Cleavage: a-(1011) imperfect. Fracture uneven. Brittle. H, = 3'5. O. = 7'0-7'25. Luster resinoue. Color pale yellow, passing into brown; ■orange-yellow; white or colorless. Streat white or nearly so. Subtrans-parent to ti-ajisluceut.

Var.—I. Ordinm-y. (a) In ery»lnlt, nsfiaX^j \n rounded aggregates. (6) Capillary or Blainenious, especially marked in a variety from St. I'rix-sous-Beuvray, France; somewhat like asbestus, aud straw-yellow in color, (e) Concretionarp.

Campylite, Irom Drygill in Cumberland, has Q. = 7'218. and is io barrel-shaped crystals (whence the name, from KtitmvKoi, euTwd), yellowish to brown and brownish red; contains 3 p. c. PtOi.

Comp.—(PbCl)Pb,(A8o,)., also written 3Pb,A8,o,.PbCl = Arsenic pent-oxide 23'2, lead protoxide 74*9, chlorine 3"4 = 100'5, or Lead arsenate 90'7, lead cbloride 9-3 = 100.

PhosphoruB replaces the arsenic in part, and calcium the lead, EndUckite (p. 501) la intermediate between mimetite and vanadinite.

Fyr., etc —In the closed tube like pyromorphite. B.B. fuses at 1, and on charcoal give.' Ill R.F. an arsenical odor, nnd Is easily reduced to metallic lend, coating the coal al first with lead chloride, nnd Inter with arsenic Irioxide and lead oxide. Gives (he chlorine reaction as under pyromorphite. Soluble Id niirlc acid. ■

Obs.—Occurs near Rt'drulb and elsewhere in Cornwall; Beer Alston. Devonshire; in Ciimlicrlarid; near Pontgtbaud. Puy-de-Ddme; al Johanngeorgensliidl. in line yellow crysials; at Nerchinsk, Siberia; at Zlnnwalcl; L&ngbau, Sweden; at the Brookdale mine. PheMixville. Pn.

N:Lmed from iii/i?/T^i, imitator. It closely resembling pyromorphite,

VANADINITE.

Hexagonal-pyramidal. Axis i = 07122.

Crystals prismatic, with smooth faces and sharp edges; sometimes cavernous, the crystals hollow prisms; also in ronnded forme and in parallel groupings like pyromorphite. In implanted globules or incruBtatione.

Fractnre nneven, or flat conchoidal. Brittle. H. = 2-75-3. G. = 6-66-7*10. Luster of snrface of fracture resinous. Color deep ruby-red, light

brownish yellow, straw-yellow, reddish brown. Streak white or yellowish. Subtranslucent to opaque.

Comp.—(PbCl)Pb.{VO,),, also written 3Pb,V,0..PbCl, = Vanadium pent-oxide 19-4, lead protoxide 78-7, chlorine 2'5 ~ 1006, or Lead vanadate 90-2, lead chloride 9-8 = 100.

Phosphorus is sparingly present, also sometimes arsenic, both replacing vanadium. In endlichite tbe ratio of V : As = 1 : 1 nearly.

Pyr., atc^lD the closed tube decrepitUea and yields a fulut white subliuute. B.IJ. fuses easily, and on cb&rconl lo a black lustroua maas, irblch !□ R.F. jlelds metallic luuil and a co&tlDg of lend chloride; nfter completely oxidizing tbe lead lu O.F. tlie bl:i(;k residue eivn with ult of phosphorus an emerald-green bead in R.F., which becomes light yellow ID O.K. QWea the chlorine reaction with the copper tear. Dvcomposeil by hydrochloric acid.

Ob«.—First discovered at Zlmnpan In Mexico. Later obt^ned at Wanlockhead iu Dumrriesahlre; also ai Berezov lo the Ural, wltb pyromorphite; and near Eappel lu Csrtntbia, lo crystals; at UudenBa, BQlet. Sweden. Id the Sierra tie C6rdoba. Argentine Bepubllc

Id tbe U. States, sparingly near Sing Sing, N. T. AbuDdant In the mining regloDS of Arizona «id New Mexico, ofteD associated with wulfenlte and desclolzite; in Arizona, nt tbe mines Id Yuma Co., In brillipiut deep red crysials: Vulture, PbiEuix, etc.. in Maricopa Co.; the Mammoth gold mine, near Oracle. Pinal Co. In New Mexico, at Dike Valley, Sierni Co. {eacUiehiUy, aud tbe MImbres mines near Georgetown.

Hbdtphanb. From L&ngbau, Swedeu; has ordinarily been Included ns a calcium variety ot mioietlte, but is dow made moooclinlc. Massive, cIeavable. Color yellowish white.

SvaUt«. A calcium arsenate, related to the species of the ApalUe Group. Crystuls hexHgoDid prisms; colorless; i = 0-7143. H. = 6. G. = 8-53. From the Harstig mine, Pajsberg, Sweden.

Wi^nerlte Group. Monoclinic.

a:h:d 0

Wagnerite (M:gP)MgPO, 1-9145 :1 : 1-5059; 71" 53'

Tripbte (Rr)RPO„ R = Fe : Mn = 2 :1,1: 1, etc.

■ftipbidite (ROH)RPO., R = Mn:Fe = 3:l 1-8572 :1 : 14925; 71M6'

AdeHte {MgOHjCaAsO. 2-1978 : 1: 1-5642; 73" 15'

Tilasite (Mgr)CaA8o.

Barkinite (MnOH}MnABOj 2-0017 : 1: 1-5154; 62° 13^'

.dbyGoogle

Phoepbates (and srsenates) of maEneaium (calcium), iron and mangaceBA containing flnonne (also hydroiyl). PormnU B,FPO, or (B1")RPo„ etc.

WAGHEBmi.

Mouoclinic. Axes, see p. 501. Crystala Bometimes large and coarse. Also massive.

Cleavage: a, m imperfect; c in traces. Fracture uneven and splinter;. Brittle. H. = 5-5-5. G. = 307-3-14. Luster vitreous. Streak white. Color yellow, of different shades; often grayish, also flesh-red, greenish. Translucent.

Comp.—A fluo-phosphate of magnesium, (MgFjMgPO, or Mg,I\o,.MgP, = Phosphorns pentoiide 43'8, magnesia 49'3, fluorine ll'S = 1049, deduct (o = 2F) 4-9 = 100. A little calcium replaces part of the magnesiain.

PjfT., oto,—B.B. ill the forceps fuses al 4 to ngreeiiish-gray slasa; iitoisteDed with ■iilpliiiiric acid colurs the flame bluisli green. With borax leaclE for itdd. Ou fusion with soda efFervesci^, but is uot completely dissolved; g\jea a faint maugauese reactioo. Fused witb Bait ut pbnspliorus in an open gliua lube reucts for fluorine. Soluble in nitric aud hydrochloric acids. Witli sulphuric acid evolves fumes of liydrofluoric acid.

Ob*.— WagneriU (tu small bigbly moditled crystals) occurs in the vaJley of HOllen-graben. neiir Werfen, in Salzburg, Auslrin. E^^~<Ufina (musaivi!, cleavable; auo in coarse crystals) is from KJOrreetod, near Bamle, Norway.

Bpodloalts. A calcium fiuo-pbosph'ite, perhaps (CaF)CaPOi. In flattened prismatic crystals. Q. = 294. Color ash-gray. Prom Ihe Kraugrufva, Wermlaud, Sweden.

TRIFUTB.

Monoclinic. Massive, imperfectly crystalline. Cleavage: uneqnal in two directions perpendicular to each other, one much the more distinct. Fracture small conchoidal. H. = 4-55. G. = 3'44-38. Luster resinous, inclining to adamantine. Color brown or blackish brown. Streak yellowish gray or brown. Subtranshicent to opaque.

Comp., Tat.—(RF)EPO or B,PX)..EF, with R = Fe and Mn, also Ca and Mg. The ratio varies widely from Fe : Mn = 1: 1 to 2 : 1 (zwieaelite); 1:3; 1:7.

TnlktripiiU is a variety from HorrsJOIwrg; coulaius magnesium and calcium In larga

Pyx., eto.—B.B. fusee easily nt 15 lo a blaclc magnetic globule: moistened with Bulpburic acid ciilors Ihc flame lihiisli green. Wltli borax in O.F. gives an smelhystinc-colored gloss (maugnuesL'): !□ R.F. a strong reaction for iron. With soda reacts for miiugimcse. Wllh sulphuric acid evolves hydrofluoric acid. Soluble in liydrooliloric ncid.

Oba. —Found by AUuaud at Limoges iu France; Helslagfors, Finlnud: Stnneham, Miiliie: nrnnchvillc, Codu. ZurittfUU. a ciuve-browu variety, is from AalwDstein. near Zwlesel in Bavaria.

Griphitb. a problemallcal phosphate related to tHpItle occurring In embedded reni-form uinsses. From (lie Riverton lode near Harney City, Pennington Co.. 8. Dakota.

TriploidltB. Like Irlplile. but with Ihe F replared bv (OH). Commniily In crys'alline aggregnten. Fibrous lo columnar. H. = 4-5-5. O. = 3687. Color yel'owish to reddish brown. From Braochville, Fairfield Co.. Conn.

Adellta. (MgOHK^aAsO.. MonocHnic. Axes, see p Ml: aiso massive. H. = 5. G. = 8'74. Color gray or grayish yellow. Prom Nordmark and LAnghan, Sweden.

Tilasits. Like ndelite, but contains fluorine. From L&ngban. t

SarklnltB. (MnOHlMnAsO,, In monoclinic crystals; al=o In spherical forms. G, -^ 4 17. Ci'lor rose-red. flesh-red, reddish yellow. From the iron-manganese mlnen of Pajs-berg. SwedpD. Polyantnite from the 'B]6 mine. Grytb^t« parish, Orebro. Sweden, is essentially the same.

Berdvrit*. A fiuo-pboepli&te of beryllium uud calcium, (CaF)BePO,nltb(CBOG)BePOt. In priamiitic crystals, monoclinic wltli complex twimilug. H. = 5. Q. = a-9B-8'01. Luitur viireouB, Color yellowisli uitd KreeuisL wlilte. From tbe tiu mlaeH of Eliren-fiit.'dtirsilurf, Sulouy; also at Stoueliaui, Auburn and Hebrou, HalDS.

Hunllnite. A basic phosphate of alumiuium and atronlium. In colorless riiombobedral crysiutii. fl. — 40. Q. — U-16-tt'!8. Occurs witb berderile, bertiaadite, etc.. at Slone-ham. Maine.

Dar*Dgit«. A fluo-ai crj»iala. Q. = "'"' ' ""

AUBLTOONITXI. HebrooUe.

Triclinic. Crystals large and coarse (Fig. 20, p. 10); (orine rarelj distinct. Usually clearable to columnar and compact masaWe. Polysyntbetic twinning laiuellsB common.

Cleavage: c perfect, with pearly luster; a somewhat less so, vitreous; € (03l) sometimes equally distinct; M (lIO) difficult; ca ^ 75° 30', ce = (4° 40', cM=9-i° iO'. Fracture uneven to snbconchoidal. Brittle. H = 6. G. = 3'0l-3'09. Luster vitreous to greasy, on c pearly. Color white to pale greenish, bluish, jollowish, grayish or brownish white. Streak white. Sob-transparent to traufilucent.

Comp. — A fluo-phosphate of aluminium and litbinm, Li(AlF)PO, or AlPO.-LiF = PhosplioniB peutoxide 47!), alumina 3'14, lithia 10 1, flnorine 12 9 = 105-3, deduct (0 = 2F) 5-3 = 100 Sodium often replaces part of the lithium, and hydrosyl piirt of the fluorine.

Pyr,, sto —In t1ic HowkI tulie yields water, whicli nt a high brat Is acid and corrodes thu glass. B.B. riises eaaily (iit i) with liitumesceuce, and becomes opuque while on c<>oliug. Colors Ibe fliitae yellowlBli red with trncea of green; the Hebron variety gives nti iuteusa litbia-red: moistened with siilpbiirio ncld gives a bluish green lo the tiame. With boniz and suit of phospliorua forms n iraospareiit colorlass glass. In Hue powder ilisBClves easily 111 sulphuric acid, more slowly hi liydrochlorlc acid.

nff —Diatingufahed by Its easy fusibility and by yielding n red flame B.B., from feld-spsr. barite. calcite, etc.; alao by the acid water In the lube ffom apodumene.

Obi.—Occurs near Penig in SuKony; Arendal, Nomay; Moutebras. Creuze, Frauce. In the U. States, iu Maine, at Ilebrnu; also at Paris, Peru, etc.; Branchville, Cono.

The name ambipgonite is from d/i(S^ti, Hunt, and yoyv, anglt.

B. Basic Phosphates. This section includes a series of well-characterized basic phosphates, a number of which fall into the Olivinite Group. Acid phosphates are represented by one species only, the little known monetite, probably HCaPO., see p. 507.

Ollrenlte Group. Orthorbombic.

OUvenite Ca,(OHlAsO, 09396 : 1 : 0-6726

Libethenite Cn,{OH)Po. 0-9601 i 1: 0 7019

Adamite Zn,(OH)AsO. 09733 : 1 : 0-7158

DeKloizite (Pb,Zn),(OH}VO,

S\l:ii = 0'6368 : 1 : 0-8045 0T^:hi{: = 0-9552 : 1 : 0-8045 Cnprodescloizite (Pb,Zn,Cu), (OH)VO,

The Olivenite Group includes several basic phosphates, arsenittes, etc., of copper, zinc, and lead, with the geneml formula (BoH)EPo.,{BoH)ItA8o.,

etc. They crystallize ia the orthorhombic Bystem with similar form. It is to be Dotad tDBt this ^oup correspoods io a measure to the mouocliiiic Wagnerite Group, p. 501, which also includes basic members.

OIiIVENlTB. Orthorhombic Axes dilii- 0-9396 : 1 : 0-673f

m'". no A lio = ee- ar. >, 101 A ioi = n° iif.

«•, on A oil = 67* 51'. w, 101 A on = 47- 34'.

Or^etale prismatic, often aciculsr. Also globular and reniform, indistiDCtlr fibrons, fibers straight and divergent, rarely irregular; also curved lamellar and granular.

Cleavage: m, b, e (OH) in traces. Fracture conchoidal to

uneven. Brittle. H. = 3, G. = 4'l-4'4, Luster adamantine to

^/ vitreous; of some fibrous varieties pearly. Color various shades of

'V_J^^ olive-green, pasaing into leek-, siskin-, pistachio-, and blackish

green; also liver-and wood-brown; sometimes straw-yellow and

grayish white. Streak olive-green to brown. Sub transparent to opaque.

Vw.—(n) Oyi(«U«»ii. (6) FSirouM; finely and divergenlly fibrous, of grttu, yellow, brown and gray, to white colors, wtth Ihe surface Bomeiiuies Telrety or aciciilari found (□vesting the common varlsty oi paBslng into U; culled itoodcopper or taood aTtenaU. (c) Earthy; Dodular or maMlve; sometimes soft eoougli to eoll the Uagers.

Comp.—Cn,As,0,.Cu(OH), or 4CuO,A8,0,.H,0 = Arsenic pentoJide 40-T, cupric oxide 561, water 3'2 = 100.

Fyr., etc.—In tlie closed tube gives wnter. B.B fuses nt 2. coloHuf; the flnine bluish

SreuQ, and ou conllug tbe fused moss sppenra cryslalllnG. B.B. on cbnrco&l fuses with Bflngrstioo. gives off arsenical fumes, aud yields s mclnllic niBcnlrle which with soda yields a globule of copper. With the fluxes reacts for copper. Soluble In nitric acid.

Obs.-—The ciTBt«lli«eil varieties occur in Cornwall, at various mines; Tavistock, in Devonshire: fa Tyrol; tha Banat; Nizhiif Tagiisk lu the Ural; Chili. Id the U. S., Id Utah, at the American Esfie and Mammoth nilueB. Tlutic district, both in crystals and The name olTvenlte alludes to the oUve-green coloc.

Orthorhombic. Axes &:l:6= 0-9601 : I : 0-7019. mm'", no A lio = %r iV <»'", 111 A 111 = 59° 44'.

ftj', on A Oil = '0° y. «', m a in =er47j'.

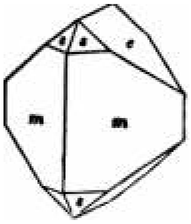
In crystals usually small, short prismatic in habit; often united in druses. Also globular or reniform and compact.

Cleavage: a, 6 very indistinct. Fracture snbconchoidal to uneven. Brittle. H. = 4. G. = 3-6-3-8. Luster resinous. Color olive-green, generally dark. Streak olive-green. Translucent to subtranslucent.

Comp. —Cu,P,0,.Cu(OH), or 4CnO.P,O.H,0, = Phosphorus pentoxide 29-8, cupric oxide 66-4, water 3'8 = 100.

Pyr.. etc.—In Ihe closed lube yields wiiter nnd turns black. B. B. fuses at 8 and colon the flame emerald-iTeen. On chnrconl with soda Kives metallic copper, somellmea also nn anienicsl odor. Puced with raetnllic lead on cliarconl Is reduced lo metallic copper, with tbe formation or lend phosphate, wliich treated In R.P. gives a crystalline polyhedral bead on coolliip. With the Buies reacts for copper. Soluble in nitric acid.

Ohs.—Occurs with clialeopyrite st Libelben. near Neusohi. Hunpiiy; at Rlieinbi«ilen-bacb and Ehl on the Ithine; at Nizhni Tagilsk In the Urul; In small qunntilies in Cornwall.



Adamite. ZuiAs)0>.Zd(OH)i. Id rmsll crysl&ls, often grouped in crusts tud graDular ■ggregutiona. H, = Si. U, = 4'34-4-3S. Color Loney-yellow. TJolet, rose-red, green. cuJutltss. From Cbafi&rcillo, Chili; Cup QuroDue, FraDcei at the undent zinc luiiiea of Idiuriou, Q recce.

DeiclDizlta. R,V,O..B<OH), or 4RO.V,Oi.H.O; R = Pb, Zn chleflj, and usually Jii tbe ruiio 1: 1 tipproK. Id small crystsU. oricn drusy; also massive, fibrous nidimed wiih mamniillary

surface. U. = S'5. ti. = 5'ft-B'2. Color cherry-red and brownisli red, to liglil or dark brown, black. Streak orange lo browuish red or ^ellowbh gray.

From the Sierra de Cordoba, Argentina; Kappel in CannlhJa. Abuudant at Lake Viilley. Sierra Co., New Mexico, also near Oeorgetown; in Arizona near Tombsloue; iu VaTHpai Co.; at tbe Maminolh Gold mine, near Oracle, Final Co,

A lUflsiiiTe variety, contiiiuiug copper (0-5 to.9 p. c), in ciusIb, and reuiform masses with radiateil structure, occurs iu Siii Luis Poiosi, also iu a vein of argentiferous ^lenn in Zncalccas, Mexico; il lias been vnriously named Irilochorilt, evprodetelointe, ramirttt. A diuilnr variety (11 p. c. CuO] uccurs as an Incrustation on quartz at tbe Lucky Cuss mine. Tombstone, Cochise C'>., Arizona.

EcsTNCHiTB may be identical with deacloizite, HoaalTe: hi nodular, staUctltlc forms. G. = 6 596. Color yellowish red, reddish brown, greenish. From Hofsgnind near Freiburg in Baden. The same may be true of armoxtn« from Dahn near Nieder-Bchletteubacli. Rhenish Bavaria,

Dbchknitb. Composillou usually accepted as PbV.Ot. MaasiTe, borryoldal. nodular. G. = 5 6--j*81. Color deep red lo yeliuwish red and brownish rod. From Nieder-Schlet-teubach iu the Lauterthiil. Khenlsh Bavaria.

Oalclovolborthite, Probably (Cu,Ca).ViOi.(Cu,CaKOH),. In thin greeu tables; also gray, fine cryslalline granular. From Friedriclisrode, Thuringla.

Brackcbiuchita. Near descloizite (monoclinlclj. From the State of Cordoba. Argentina,

Paittacinite. A vanadale of lead and copper, from the Silver Star District, Hoiitana. In liiiti coatings: also pulverulent. Color siskin- to oKve-green.

MoTTRAMiTii:. A vanadate of lead and copper; possibly Identical with psittaciuite; in velvety black incrustallouB. From Mollram St. Andrew's, Cheshire, EugUnd.

OUNOai.ASrrai. Eilnokloa. Aphanfse.

Monoclinic. Axes A : J : ^ = 1-9069 : 1: 3-8507; j8 = 80° 30'. Crystals prismatic (m); also elonfjated Q i; often grouped in nearly apherical forms. Also massive, hemispherical or reniform; Btructnre radiated fibrous.

Cleavage: c highly perfect. Brittle. H. = 2-5-3. O. = 4-19-4-37; 4-37 Utah. Luster: c pearly; elsewhere vitreous to resioouB. Color internally dark verdigris-green; eiternally blackish bine-green. Streak bluish green. Sub transparent to translucent.

Comp.—Cn,As,0..30u(OH), or 6CnO.As,0..3H,0 = Arsenic pentoiide 30-3, cupric oxide 62-6, water 7-1 = 100. Pyr., etc.—Same as for oliveiille.

Obi. - Orcurs in Cornwall, with other ores of copper. In Umh, TIntIc district, at the Mammoth mine. Niimed in al!ii«Ton to tbe basal cleavage beina; oblique to the sides of the prism.

Brinlt*. Ca,As,0..2CufOH), In mammillnted rryatalllne groups. Color fine emerald-green. From Corn wall; also the Tintic district. Utah.

Dihydrlte. Ci]iP,Oi.3Cu(OH)i In dark emerald-green crvslals (monoclinic). H. = 4-5-.^. G. = 4-4-4. Prom Elil near Linz on the Rhine; the Ural eic.

Piaudomalachlte. In part Cn.P.O. SOnfOHl- Mnaslve. refembliiiB malachite In color and structure. From Rhelnbrei ten bach: Ntzhtit Tngilak, etc. BMile Is closely allied.

Ohoadraisentte. Perlinpa MniAS|0.,8Mn(0Hl,. In small embedded grains. Color yellow to ri'ddish yellow. Prom the PajsWrg mines. Sweden.

X*WTH*ReBKiTB Nenr fhondrnrsenile. but contains more water. Iu sulphur-yellow grains; majsive. From the 8j& mine, parish of Orylhytle, Sweden.

DUFSBNTTXI. Eraurile.

Orthorhombic. Crystals rare, small and indistinct. Usaally i nodules; radiated fibrous vith drnsj surface-Cleavage: a, probably also b, but iudistinct. H. = 3'5-4. G, = 3"2-3"4. Luster silky, weak. Color dull leek-green, oliTe-green, or blackish green; alters on exposure to yellow and brown. Streak siskin-green. Subtranslucent to nearly opaque. Strongly pleochroic.

Comp.—Doubtful; in part FePO,.Fe(OH), = 2Fe,0,.P,0,.3H,0 = Pho8-phoruB pentoxide 2T'5, iron sesquioxide 63-0, water 10'5 = 100.

Pyr., ate.—Same as for Tivianite, but lesa w&Ier Is giveo out in tbe closed tube. B.B. fusen easily to a alag.

Oba.—Occureiiifar Aselar, Dept. of Haute Vieuue, and at Hlrschbei^ lu Westphalia; from tbe KotblSufclieD mfLe near Waldelrmes; St. BeDlgDa, Bobemia; EasI Curnwall. lu tbe United States, at Alleotown, N. J.; in Rockbridge Co., Vs., in radiated coenelf

IiAZULmt.

Monoclinic: Axes A : J : t^ = 09750 : 1 :1-6483; /? = 89° 14'.

M4. at. 100 A 101 = 80° 24'. a^, ill a ill = 80* W.

fpp". Ill A lit = TB" 40'. pa. Ill A 111 = 82* Sff.

Crystals usually acute pyramidal in habit. Also mass^ ive, granular to compact, Cleayage: prismatic, indistinct. Fracture uneven. Brittle. H. = 5-6. G. = 3-057-3'122. Luster vitreous. Color azure-blue; commonly a fine deep blue viewed along one axis, and a pale greenish blue along another. Streak white. Subtranslucent to opaque. Comp.—EA],(OH),P,0, or 2AlP0,.{Fe.Mg)(0n). with Fe : Mg(Ca) = 1 : 13,1 : 6, 1 : 2, 2 : 3 (Eg). For 1 ; 2 the formula requires: Phosphorus pentoxide 45*4, alumina 32 6, iron protoxide 7"7, magnesia 8'5, water 5"8 — 100. Pyr., Bto.—In tlieclnseil tube whitens and yieliia water. B B. wilb cobaltsolutinu tbe blue color of Ibe mioenil U restored. In llip fortepH » hitens, trucks open, Bwells up. and without fusion falia til pfccca, coloring Ihe flame bluish green. The green color ia mnde mote intense bv rooialeninf; tbe assHy with sulphuric scid. Willi the fluxes gives an iron glass; with soda on charcoal iin infu.sibie mass. Uuucled upon bytields, relaiulug perfectly Its blue color.

Oba,—Occurs near Wevfeu in SnUbiirg; Krieglacli, lu Slyrln: also Horrajfiberg, Swt-deu. Abundant with corundum at Crowder's Ml., Gaston Cu., N. C.; nod on Oraves Mr,, Lii:co1n Co . Qn., witb cvaalt«, riitile, etc.

Tlie nume iazulite is derived from an Arabic word, ami, meaning Ammk, aud alludes to the color of lliemiiiHriil

Taviktooklta. CaiP,0|.SAl(OH)i. In microscopic acicular crystals, sometimes Stellate groups. Color while. Prom Tavistock. Devonshire.

Oiirollte, Perhaps C«,A1(P0.),. AKOH].. Compiici. G. = 3-08. Color pale yellow. Occure at the iron mine nt Westaufi, in Scaniii, Sweden.

Ananioaidartta, CaiFe(AsO,)i.8Fc(OH)i. In yellowish brown fibroua concretions. O. = 8-530. From Romaneche, near Mficon, France; also at Schneebcrg, Saxony,

Allaotita, MniAs,0..4Hn(0H)i. In smull brownlsb-red prismatic crystals. From tbe Hoss mine, Nordmark. and ai L&ngban, Swedeu.

Bynadelphite. 2(A1.1d.D)AsO, 5Mn(0H),. In prismnllc crystals; also in grains. G.= 3-45-a-!H). Color brownish black to lilack. From the Moss mine, Nordmark. Sweden.

FlinUts. MnAsO,.2MB(OH),. Id minute ortborhombic crystals, labular | e\ grouped

in feather-like aggregatea. O. = 3-87. Color greeolsh brown. From the Hsnttg miiM, Pajsberg, Sweden.

Bemak>lit0. Perhftpi (Al,Hn}A£0..4Mii(0U),. In rhomboliednl crysUU. O. =: 3'80-8 40.

Color brownish red, black on the surface. From the Hoia mine, Nordma^ 8we<leD.

Retslui. A bade arseoate of Ihe ytlriuni eartbB, maDganese and caldum. In ortho-rhombic ciystala. H. =4. Q. = 4'IS. Color cliocolule- lo cheslnul-brown. From lb« Hum iiiiue, Nonliiiarh, Sweden.

Ananiopleita. Perliaps U,R,lOH),(AsO.).i H = Hu, Ca, also Pb. Ug; K = Mu.

also Fe. HiisbItc, cleavabU. Color brownUli red. Uccurs at ihe SjO mlue, Qrythytta pariah. Sweden, wltb rhod'inlte iu crystalline limeslone.

Hangaaostlblit*. Hemntoalibilte. Highly banic manganese antimouales. Iu embedded gntiuB. Color black. Maj^anotliSult occurs at Nordmark, Sweden; htmatotlibiite la from Ihe 8J6 mine, Grytliytte parish.

Atalestita. Basic bUmiitb arsenate. HiBI.AsO.. In minute tabular crystals. O. =: 6'4. Color sulphur-yellow. From Schoeeberg, Saxony.

C. Normal Hydrous Phosphates, etc.

■taut group t monoclinic Vivianite Gaoop.

StmTits. Hydrous ammoDium-miigneslum ptiosphate. In orlhorbombic.hemlmorphlc crjBtnls (Fig. 307. p. 9S'; white or yellowUh; slightly soluble. From gunno deiwsils.

OoUophaiiite. CaiPiOi + H,o. In layers resemhllng gymnite or opal. Colorless or snow-whlli,-. From the isliind of Somlirero. Monite U aimllar. fmin the Islnnds Moiia and Monetaiu (heWest ludies, where It Is associated with monftUe, HCaPOi. occurring in yellow-Isb-while tricllulc crystals

PVBOFHOBPHORITB!. Mg,P,o, + 4(Ca,P,o, + Ca,P,o,). Massive, earthy. Color SDOW-wliite, dull. From the West ludies.

. . s 7.inc rliMphitle. Zn,P,o,-f H,o. In minute prismatic

crystals. Also in reniform masses. G. = 3"6-285. C<t!or grayish wliiie. Found in caTiiies is cilainiDB at the zinc miues of Allenberg, uear Alxla-Clnpelle. The composition given is that of tLu urtlflrliil mlueriil.

DioWnsonil*. 31,P,o, + H,o wiih R = Mii, Pe, Na, chiefly, also On, K„ LI, Id

tiiliuliir, psemlo-rliomljoheilral cryatsls; commonly follsleri to micaceous. G = 3538-

3 843. Color olive- to oil-greeii, grass-green. From Branchville, FnirfieUi Co., Coun.

Fillowit«. Formula as tor dickinsonite and nlao from BraucliTille, but differing In

„„io T., 1... „ iu„= .„„„~, Q _ 8.^ (.(jIjjj. wai-yel!ow, yellowish lo red-

Tlie three followiag tricllnic species are related in composition and mar be in crystalline form.

(Ca,Co,Mg),As,o, + 2H,o. In small crystals; often in druses aod spherical aggregates. Q. = 8-5-3 6. Color light to dark rose-red. From achiieelwrg, Saxony.

BrandUte. Ca,MnAs,o, + 3H,o. In prismatic crystnU; cryatsls often united in raiiiated groupa. O. =3671-3-673. Colorless lo white. From the Hntstig mine, near Pajsberg, Sweden.

Fair£eldlta. A hydrous nhospbale of calcium and mangnnese, Ca,MnP,o,4- 3H,o In prismatic crystals; usually in foliated or flbrnua rryatalline ngirregates. G. = 8-07-8'16 CoIr)r white or greenish while lo pale stmw-yellow. Prom Branchvllle, Fairfield Co., Uonn.; Kabenstetn, aa,va.nA {leiiaomanganiu).

Reddiiiglt«. HoiPiOg -|- 8HtO. lu orlhorliombic crystals near Bcorodltc En angle; also graoiilar. Q. = 810:!. Coloi pinkish while lo yellowish while. From BroDchTille, CotiD-

PicrophormacoUte. R>A«,o. + 6H,o, niih R = Ca: Mg ^ o : 1. Id small apliericul formB. Coloi wbite. From Biechelsdorfj Freiberg; Joplia, Ho.

Tricludclto. CuiAsiOg -f 5H,o. Il radiaied gioups, columnar; deodtitlc. Color Terdlgria-greeti. From the Turgiusk copper mine.

Vivlaoite Group. MoDOclinic.

Vivianlte ' , + 8H,o a:t:i = o-7498 :1 :o-7015 yS = 75° 34'

Sympleaite). + 8H,o o7806:1:o-6812 72= 43'

Bobierrite), + 8H o

HffinieBite o.+ 8[l,o

Brythrite 3, + 8H,o o-75 :1:o*70 75"

Aimabergite), -f-8H,o

Cabrerite),Ab,o. + 8H,o

Kbttigite o. + 811,o

The ViVlANlTE Grodp includes hydrons phoBphatea of iron, magnesium, cobttlt, nickel and zinc, all with eight molecules of water. The cryat^lization is monocliiiic, and the angles so far as kuo"i correspond closely.

VmANITE.

Monoclinic. Crystals prismatic {mm''' = 71° 58'); often Ju stellate gronpa. Also reniform and globular; structure divergent, fibrous, or earthy;

also mcrusting.

Cleavage: d highly perfect; a in triices; also fracture fibrous nearlyX"-Fleiible in thin lamiiiffi; sectile. H. = 1-5-2. G. = 2-58-2-68, Luster, 6 pearly or metaliic pearly; other faces vitreous. Colorless when unaltered, blue to green, deepening on exposure. Streak colorless to bluish white, changing to indigo-blue and to liver-brown. Transparent to translucent; opaque after exposure. Pleochroism strong.

Comp,—Hydrous ferrous phosphate, Fe,P,0, + 8H,0 = Phosphorus pen-toxide 28-3, iron protoxide 43-0, water 28*7 = 100.

Hnny analyses sb<>w tLe presence of iron sesquioxide due to alteration.

Pyr., etc.—lu tlic closL-iI tube yields ncutnil water, whileas, sod exroliatea. B.B. fuses at I'S, coloring tLe flinuo blu'sn green, to n grayish black inugDeilc globule. Wiih the fluxes reads for iron. Soluble in hydrochloric acid.

Oba,—Occurs nssocialcd wiili pyrrhotile aud pyritc In copper and lin vi^ius; someiimea 111 narrow veins with gold, travursing graywucke; bolh friable and cryatallizvd in beds "t clity. and sometimes assocluled with ifmoiiiic, or bog iron ori^; urtcn in cavities of fossils or buried bones.

Occurs at St. Agnes and elsewhere in Cornwall; nt Bodenmais; llie gold mines of Yerespatiik in Traosylvnuiik. The Siirtby vuriely, sometimes called blae iron-mreh or nad'w Pruuian blue I'Fer azure), occurs in Greenland, Cariuihia, Cornwall, fic.

In N. America, In Seie Je-wy, at Alleiitown. Monmoutli Co., bolb crystallized, in nodules, ood eariliy; at Mullica Hill. Gloucester Oo (muUieitt), lu cylindrical m:issea. lu Virginia, in Siii&ord Co. In Ktniuelcg, nenr Eddyville. In Cajuida, with llmonite itt Vaudreuil.

SymplsBlte. Probably FeiAsiOi -|-8H,0. In small prismatic crystals acd la radiated spliericul aggresales. G. = S'SST. Color pale indigo, izicliued to celundine-green. From Lobenstein in Volgtland; HUtteuberg, CarintUia.

Bobierrite. H.ifiPiOi-f ^I^iO. In nggrcgates of minute crystals; also massive. Colorless to wlilte. From tlie guano of Mexillones. on tlie ChiliaD coast. Haulffewillite b like bobierrite, but contains culcium. From Bamlc. Norway.

Hcsmealte. HgiAs,Oi + SHtO. In crystals resembling gypsum; also columnar; Btel I a r-foliated. Color snow.while. From llie Banat, Hungary.

BBTTBmTB. Cobalt Bloom. Eobultbifithe a«rm.

Moiioclinic. Crystals prismatic and vertically striated. Also in globular and reuiform shapes, having a drusy surface and \i columuar structure; Bome-times stellate. Also pulverulent and earthy, iiicrustitig.

Cleavage; fi highly perfect. Sectile. II. = l-b-'4-b; least on 6. G. = 3-948. Luster of b pearly; otJier faces adaTiiiititine to vitreous; also diil), earthy. Color crimson- and peach-red, sometimes gray. Streak a little paler than the color. Transparent to subtmushicent.

Comp.—Hydrous cobalt arsennte, Co,A8,o, + 8H,o = Arsenic pentoiide 38-4, cobalt protoiide 375, water a4'l = 100. The cobalt is sometimes reT>laced by nmkel, iron, and calcium.

Pyr,, eto.—lu tlie olosed tube jIcUb watur Ht a geiilleLeat and turnsbluiali; nt n lil^lier liciit gives off urscalc trinxlde. wliirb cumleiiaes iu cryBlalsou I he cool glass, and ibe rMidue bus n dark gray or black color. B.B. iu llie foiceps fuses at 2 to a gruy bead, and colors (he flame light blue (arseuic). B.B. on cfaiircoal gives au aisenical odor, and fuses lo a diirk gmj :irseiiide, which with borax gi^es the deep blue color chai act eristic of cohall. Soluble: in hydrochloric aciil, giving u ruse-red suluiiou,

Oba.—Occurs ut SchuL-eberglu Saxony, iu iiileuceoii»scales; Wolfach iu Baden; Modum

III the U. S., iu Peon., sparingly near Philadelphia: hi Nevada, at Lovelock's stallou. In C'liliforiiia. Named from fijv$fiui, red.

Annabergita. NliAS|o, + HHjO. Ih ciipillitrj crystals; also tnasBlveand disseniinaied. Color line apple-greeu. From Alleiuoul hi DnuphinS; Atinaberg nad Schueeberg; Riechelsdorf; in Colomdo; Nevada.

Oabrerite. {Ni,Mg)iAs,o. + eH.O. Like erylhrite in bnblt. Also fibrous, radiated; reuiform, granular. Color apple-green. From Ibe Blerra Cabreni. Spnlo: al Laurlon, Greece.

KfttUgito. Hydrous zhic arjenaic, Zn>AfiOi + 8H,o Massive, or in crusts. Color light carmine-and peach-blossom-red. Occurs with unaltlte at the cobalt miue Dauiel, near Scbneeberg.

Htaabdopbanlte. Scorlllite. A hydrous phosphate of the cerium and yttrium melnls.

Massive, small mamillary: as an iocruslaiion. O. = 8't>4-4'01. Color brown, pinkish or j-ellnwiab while, tthabdophanite is from Coruwall; SeovUiiU is ritim the Scoville (llDionite) ore bed ig Salisbury, Coon.

Ohnrohitfl. A bjdroua phosphate of cerium and calcium. As a tliiu coating of mluttte crystals. o. = 8 14. Color pale smokc-giay tinged with flesh-red. From Cornwall.

SOOHODlTti. »*» Orthorhombic. Aiea ll:l-A = 0-8658 : 1 : 0-9541.

*f, 130 A l20 = 60' 1'. pji'. Ill A ill = 111° 6'.

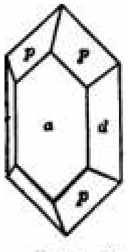
pj/ 111 A 111 ='"!°8' pff.ni fym= 65*20'.

Habit octahedral, also prismatic. Also earthy, amorphous. Cleavage: d imperfect; n, b in tnices. Fracture uneven. Brittle. H. = 3-5-4. G. = 31-IV3, Luster vitreous to sub-adamantitie and subresinous. Color pale leek-green or liver-brown. Streak white. Subtransparent to translucent.

Comp.—IIvdrouB ierric arsenate, FeAsO, + 2H,0 = Arsenio pentoxide 49'f<, iron sesquiojide 34 6, water 15'C = 100.

_,.., —In the closeii liil* yields neutral water and turns yellow. B.B. fuses

«aaiW, coloring Ibe-Unmv blue. B B. on charcoal gives arsenical fumes, and with soda a black magnetic scoria. With the fluxes reacts for iron. Soluble in hydri)chloric acid. OIm.. — Often associated with arseuopyrlle- From Schwarzeoberg, Saxooy; Demhacb.



Pyr.. etc

.dbyGoogle

Nassau: LOllIag, CariothU: Nerchinsk, Siberia, in flne cryiials; leek-green, in tbe Corniih mluea.

Occiii-B near Edeuville, N. Y., with araenopvdle; in Umb, Tintic dlitrict, at th« Haiti tuoih iiilue ou enarglte. As sn tncrusialiou on BiliceuiiBsiatev of the Yellousluue geysers.

Named from criediJoSoy, garlic, Hlludlug to tlje odor before tlii; blowpipe.

Strengita. PePOi + 3HiO. Crj'slala rare: lu habll and augli- nmr scorodiie: gi-neralljr III spberival and botryoidnl forms. G. = 2'6T. Color jwle red. From iron miues dcht Qlessen;

also in RiickOridge Co.. Va.. wtlh dufreuite.

PhoBphoaldarlte. SFePO, + S1H,o. Au iron pliospbutc oeiir Btreut;iie, but wjtb 8iHiO. From the Blegea luinlDg district, Qermiiny.

Bairandlta (Al.Pe)FO(+ SH|o. Id ipberoidal coucretiun«, color pitle shades of gniy. From Bohemia.

Tarlictte. AlPOi + SUiO. Commonly in crystalline aggrt^tes and IncniBiatloDS witli renifnnn surface. Color greeo. From Mesebach in Siixou voigtlaDil; Homgomer^ Co., Arkansas, ou quart/.; iu uodulnr masses from Utah.

Oallalnita. AlPO,+34HiO. Massive; wax-like. Color apple- to emerald-green. From a Celtic grave Id Lockmariaquer.

Zephuroviohlte. A1P0< + SHiO. Cryslalliue to compact. Color yellowish or grayish Tblie. From Treolc Id Bohemia.

Add Hydrous Phosphates, etc. .ooum.

Monoclinic. Crystals rare. Commoiily in delicate silky fibers; also botryoidal, stalactitic.

Cleavage I 6 perfect. Fracture uneven. Flexible in thin lamioie. H. = 2-25. G. = 3'64-2-73. Luster viti-eous; on b inclining to pearly. Color white or grayish; frequently tinged red. Streak white. TranBiucent to opuque.

Comp.—Probably HCaAfiO, + 2H,o = Arsenic pentoiide 53-3, lime 25-9, water 2U*8 = 100.

Obs.—Fouod with arsenical ores of cobalt and silver, also with arsenopyrite: at AndrciLiliert; fn tbe Hurz; Riecheistlorf lu Hesse; JoachlmstLal iu Bohemia, etc. Named from 0aiiU'iKor, poison.

Haidingortto. UCaAaO, 4- IliO. Ill niliniio crystal aggregates, botryoidal and drusy. G. = 3 848. Color white. From JoiicLimsllial with pbarmacnjlle.

Wapplarita. HCnA'iO, -\- 3JHtO. In minute crystals; also in incrustatioDS. Colorless lo wliite. Fimiid wiib pliarmucollie at Joacliimellial.

Bruihlte. HCiiPO. f 3H,o. In smnll slender prisms; coticretiotiHry massive. Color-le.ts to pile vellonisn. Occurs in guano. Motabnuhlte, similnily B&suciated, is aHCuP0.4-8li,o.

Martinite. H,('a,(PO.>, -|- iH,o. From pbospliorite deposits (from guano) in ibe islaiul iif CLir990ii, W. Indies.

Newberylte. HMgPOi-f 8H,o. In white onln'rlioiniilc crystals. From guaoo of 8kit>toii Ciives, Victurta. Haanaylt*, from same li (iilUy, is a hydrous phosphate of amiiKiiiiuin and tnngnesium.

Stercorite. Microcosmic salt. HNb'NH.)PO. + 4H,0. Phoaphoraalz Germ. In while crystalline masses and nodules in giiatio.

Hursanlits. H,Mut(PO,),-{-4H,0. lo short pHsmntIc crystals (monoclinic). Also miiast e. compact, or imperfectly flbmua. Color yellowish, orange-red, rose, ffreylib. From Limoges, commune of Bureaux, France, In tlie U. Biates. at BrancbTille. Codd.

ForbesiU. H,(N1.Co),Ab,Oi + 8U.0. Structure flbro-crystalline. Color grayfsb while. From Atucama. •

laooluito. CaiPiO,.C&(OH)i.4H,0. In miunle white cijstah; aleo columnAT. From Joacblmstlial.

Hcmafibrite. MiiiA«iOt.8Hn(OH), + aHiO. Commonly In apheilcal ndiated sroupa. Color brownjgb Md to garnet-red, bvcomiag black. From the Hoes mine, Noromark, Sweden.

SITOHROITB.

Ortliorhombio. Habit prismatic mm'"= 63° 40'. Cleavage: m, n (Oil) IQ traces. Fracture Bmall conchoidai to UDeTen. fiather brittle. H. = 3*5-4. G. = 3 389. Luster vitreouB. Color bright emerald- or leek-green. Transparent to trauBlucent.

Comp.—Cu,A8,0..Cu (0H),4- 6H,0 = Arsenic pentozide 34-3, cnpric oiide 47-1, water 187 = 100.

Oba.—Occurs in quartzoae mica alaie at Llbetben hi Uungnry, In crjsiale of couslder. able size, having much resemblance lo dloptase. Named from fvxiioa, btaut^ui color.

Oonlchalolte. Perhaps (Cu,Ca)iAj,Oi.(Cii.Ca)(OH), -\- \R,0. Reulform and massive, resembllDg mitlachite. Color pistachio-greeu to emeiald-grveu. From Audulusia, Spun; Tintlc district. Utah.

Bayldonita. (Pb Cu)iAsiOi.(Pb,Cii)(OH)i -|- H,0. Id mamjllarj coucretious, drusy. Color green. Fiom Cornwall,

Tagilite. Cu>P,O..Cii(OH),+ 3HiO. In renirorm or spheroldsl concretloDS; earthy. Color verdigris- to emerald-green. From Ibu Ural.

Iiaucocluloita. Probably CuiAsiO..Cu(OH)i + 3K,0. In white, silky acicular crys. tals. From the Wilhelmiue mine in Ibe Spcssarl, Germany.

Volborthlte. A bydroiis vanadate of copper, bnrium. and calcium, lu small six-sided tables; in globular forms. Color olive-green, cilroo-yellow. From (lie Ural.

Oornw»lIit«. Cu,4s,0..2Cu|0H), -|- H,0. Massive, resembling malnchile. Color emerald green. From Corownll.

TyroUto. Tirollt. Kupferschaum Germ. Perhaps Cu.A8,0..3Cu(0H), -f 7HiO. Ua lally in fan-sliaped crystnlline groups: In fo1iate<l aggregates; alsi> massive. Cleavage

Cirfucl. yiL-Kling soft tliin flexible bmiinte. Color pale green inclining lo sky-blue. From ibeihen. Hungary; Nercliinsk, Siberia; PalkeoBtein, Tyrol; etc In the U. States, lu the Tintlc <il9trict. Utah. Borne analyses yield CaCOi, usiiully regarded as an Impurity, but It may be essential.

OHAIiOOPHTIXim.

Rhombohedral. Axis l = 2-5538. cr = 71° 16', n

In tabular crjratals; also foliated massive; in druses.

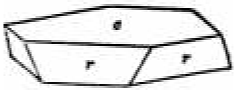
Cleavage: c highly perfect; r in traces. H. = 3. G. = 2'4-3-C6. Luater of c pearly; of other faces vitreoaa or subadamantine. Color emerald- or grass-green to verdigris-green. Streak somewhat pater than the color. Transparent to transhicent. Optically —.

Comp.—A highly basic arsenate of copper; formula uncertain, perhaps 7CuO.As,0,.14H,0.

Pyr., eto.—In the closed lube decrepitates, yields much water, and gives a residue of olive-green scales. In other respects like olivetiite. Soluble In nitric acid, and in

' = 110° 12'.

946.



WAVELLITE.

Orthoihombic. Axes d:h:d = 05049 : 1 : 0 3751. Crystals rare. Usually io nggregutes, hemispherical or globular with crystalline surface, and radiated structure.

Cleavage: p (lOL) and b rather perfect. Fracture uneven to Bubconchoidal. Brittle. H. = 3-35-4. G. = 3-316-2-337, LuateryitreouB, iDcliningtopearly and resinous. Color white, passing into yellow, green, gray, brown and black. Streak white. Translucent.

Comp.-4A]PO,.2Al{OH), + 9H,o = Phosphonia pentoiide 35-2, alumina 38-0, water 26-8 = 100. Fluorine is sometimes present, up to 2 p. c.

E*yr.. eto.—lu tlie closed tube gUcB o& much water, the last portions of which met acid imd color Binzil-wood pu|)er yellow (Uuorioe), uud also etch the tube. B.Il. in Ihe forceps swells up aotl aplits iclo Hue Infusible pnrticles, coloring Ihe Uame pnle green. Gives It blue wilL cobalt soliitioti. Ueated with sulphuric acid givtrs off fumi-s of hyilro-fluorl<: aciil, which olch glass. Sulable iu hydrochloric ncid, and als > in cauKtic polash.

Ob«.—From B:irJisiaple in Devoushire; at Zblrow in Bohemia; at FninkenUerg, Saxony; Mliias QeracB. Brazil, etc.

In the United Stales at tlie slate quarries of York Co., Pa.; White Horse StalloD, Chester Valley R. R., Pa.; Ma^et Cove, Arkansas. ohwite. AiPO,.Al[OH), + 2£H,o. In cruUs. Color green. From Nizhui Tagilsk in the Ural.

Peganlt*. Al<PO,).AI(OH)i + 11H,o.' Occurs In green crusU, of aniall prismatic cryslaU. at Striegis, near Freilwrg, Saxony.

TITRQUOia. Turquoise.

Massive; amorphous or cryptocrystalline. Reniform, stalactitic, or in-crusting. In thin seams aud disseminated grains. Also in rolled masses.

Cleavage none. Fracture small oonchoidal. Bather brittle. H. = 6. G. — 2'6-2 83. Luster somewhat waxy, feeble. Color sky-blue, bluish green to apple-green, and greenish gray. Streak white or greenish. Feebly sub-translucent to opaque.

Comp, —A hydrous phosphate of aluminium colored by a copper compound, A1P0,.A1(0H), + 11,0 = Phosphorus pentoxide 326, alumina 46-8, water 20-6 = 100. The copper salt probably has the composition 2CnO.P,0,.4H,0.

Pyr.. etc.—In Die closed lube decrepitates, yields water, and turns brown or black. B.B, Id Ihe forceps l>ecomea brown and assumes a glassy appearance, hut does not foae; colors the Same green; inoisteaud with hydrochloric acid the color is at first blue {copper chloride). Wltli the fluxes reacla for copper. Soluble in hydrochloric acid.

Ob«.—The highly prized oriental liiniuois occurs in narrow seams (8 to 4 or even 6 mm. in thickness) or in Irregular pnichea in the breccialed portions of a porpbyrltlc trachyte »nd Ibe surF-oiinding cky slate In Persia, not far from Nlshlpfir, Eliorassan; in the Megara Valley. Sinai; Iti the Kiira-Tnbe Mis. in Turkestan. .50 Tcrsla from Samarkand.

In the U. Stales, occurs lu the Los Cerlllos Mis., 20 m. S. E. of Santa Fd, New Mexico, 111 a tracliytic rock, a locality long mined by the Mexicans and in recent years reopened and extensively worked; in the Burro Mts., Grant Co., N. M.; pale green variety near

Colitmbin. Nevadn.

Nntural tnrquois of inferior color Is often arllllclally treated to give it the tint desired.. Moreover, manv atones which are of a fine blue when fir^t found retain the color only so long aa Ihey are kept moisi, and when dry they fade, become a dirty green, and are of liUlo value. Much of the lurquoia (nn[arlificinli used in jewelry in former cenluHes, as well a" the present, and thai described In Ibe enrly works on minerals, was boiu-turguoi* Icalled also othntolile, from oSoiii, Uiotfi). which Is fossil bone, or tooth, colored by a phos-|ihale of iron. Its organic origin becomes manlfesl under a microscope. Moreover, tnie lurquols, when decomposed by liydmehloric acid, gives a fine blue color with ammonia, which is not true of the odontollte.

SidiNtlU. Perbftpa4AIPO,.6Al(OH}i. In globulnr druaj concretlODS. Color light gray, bluhb. From oenr Si. Beulgiiu, Bohemia.

LiakMirdito. <Al,Fe]AsO,.2i Al,Fe)(UH|i + SH,0. la ihic iDcruating layers, white or bluUli. From LUkeard, Corowall.

Evaniite. 2AIPO,.4AI(UII|i + 12H,0. Mssslve; reniform or botryoidal. CoIorle«S, or milk-white. From Zseii'zuik, Uungury.

CticitULEOLACTiTB. PcrhiipB iiAl|Oi.2P|Oi.lOH,0. Ciypto-cryslalliDe; milk-while to light copper.blue. Froui near Katzenellnbogeu, Nassau; also East Whitelood Township, Cbesler Co., Penn.

Augellte. 3Al,0i.P,0>.SH,0 In Ubiilar nionocUiic crystals sod masdve. O. = 27. Colorless to wbile. From ibe inm mine of Wc:staii&, Sweden. Tbe same locality has also yielded ilie following aliiiiiiniuin plioaphutts.

Bebuh[tk. 2Ar,0, 2P,0, H,0. Compact, masalve. G. =2-64. Colorless to grayish

Trollgite. 4A1,0>.3P,0(.8H,0. Compact, iDdiatlnctly cleavable. G. =810. Coloi p&k- gi'eeii.

Attacolitb. P,O,.Al,0,,Mn0,Ca0,Hi0, etc.; formula doubtful. Massive. G. = SOS. Color salmoD-red.

PHARMAOOSIDIIRrTB.

Isometric-tetiahedral. Commonly in tubes; also tetrahedral. Rarely granular.

Cleavage: a imperfect. Fracture uneven. Bather 947.

sectile. H. = 2'5. G. = 2'9-3. Luster adamantine to greasy, not yery distinct. Color olive-, graas- or emerald-green, yellowish brown, honey-yellow. Streak green tn brown, yellow, pale. Subtransparent to sub-translncent. Pyroelectric.

Comp.—Perhaps 6FeAs0..2Fe(OH) + 12H,0 -Arsenic pentoxide 431, iron sesquioxide 40-0, water 16-9 = 100.

Pjrr., etc.—Same hs for srorodite.

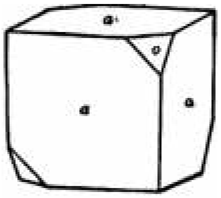
Obi—Obt! lined Hi the mines In Cornwall, with ores of cop-pc-r; at Sdinceberg and BrhwjirzpLibere, Saxony; at Kftuigsbert, gary. In Uiab, at Ihe Mimimoth mine, Tintlc district. Named fi «Dd <TiSTj/}as, iron.

Iiudlamite. liFe,P,0, Fe(OH), + 811,0. Occurs In small green tabular crystals {monoclinic), iie:ir Truro, Cornwall.

Oaooxenita, Kakoxen Oerm. FePO..Fe;OH), -|- 41H^0. In radiated lufta of ft yellow or brownish color. From near St. Beuigun in Bobcmla; Laucaster Co., Pi'nn.

Berannlte. Pm-hnps SFePC.FKOH). -|- 31H,0. Commonly in druses and in radiated glolmlesand cniuls. Color reddieli brown to dark liyacfnlh-red. From Si. Benlguii, near Beraun, in Bohemia BUonoriU. in tabular cryslAla, is the same mliiemi. From the Elentiore iniiie nenr Oiessen.

Globobitk, PiCiTE, Dkltauxite are other hydraled ferric phosphates.



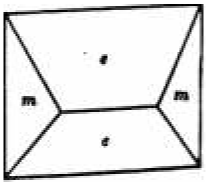
, near Schemnitz, Hun
rom φαρμακον, poison,

OHILDRBNITB. Orthorhombic. Axes till: mm''', no A lio= 7.V4n'.

80 : 1 : 0-52570.

rr''', 131 A l2l =]fl6° V. m''. lai A 131 = 46° 56i'. Only known in crystals. Cleavage; aimperfect. Fractureuneven. H. = 4'5-5. O. = 3.'18-3-24. Lnster vitreous t.o resinous. Color yellowish white, mle yellowish l>rown, brownish black. Streak white to yellowish. Translucent.

CoBp.~In general 2AlPO,.3Fe(OH}, + 2H,0. Phosphorus pentfliida



30-9, alumina 22-2, iron protoxide 313, water 15-6 = 100. Manganese replaces part of the iron and it hence graduates into eoephorite.

Pyr.. etc.— Id tbe closed tube givea off iieulral waler. B.B. awells up into ramiflca-tloBB, and fuses on tbe edges to a Wack mass, coloriDg the flame pule green. Healed on charcoal turns black and LiecomeB magnetic. WUh soda gives a reactiuu for manganese. With borax and salt of phosphorus reacts for iron and maugaDei>e. Soluble iu bjdro-chloric acid.

Ob*.—From TavistoGk, Devonshire. In U. States, at Hebron, H«.

Boaplioiite. Form and compoallion as (or chlldrenite, but coDtaiuiu^ chiefly maiiEBiiese Instead of Iron. In prismatic crystals; also massive. Color rose-pink, yellowisb, etc. From B ranch ville, Conn.

HaaaplUte. CaiFe,(AsO.),.SFeO(OH)+ SH,0. In slender prismatic crystals. G. = 8'M7-3-588. Color blsck. From Maznpil. Meiico.

Oaloiofenita. Oa.Fe,(PO.),.FeiOHii.8H,0. Occurs in yellow to green nodules In clay at Battenberg, Rhenish Bavaria,

Borlckito. PerhaiM Ca,Fe,(P0.)..13Pe(0H)i-|-«H,0. Reniform massive) compact. Color leddUh brown. From Leoben in Syria; Bohemia.

RicKBLLiTK. Perhaps4PeP,O..Fe.OPi(OH)i-|-86HiO. Massive,compactorfoliated. Color yellow. From Rlchelle, Belgium.

UBOOONTTB. Monoclinic. Axes i 949.

CrygtalB reaembling rhombic octahedrons. Rarely granular. Cleavage: m, e indistinct. Fracture Bubcon* choidal to uneven. Imperfectly sectile. H. = 2-2-5. G. = 2-8S2-2'985. Luster vitreoua, inclining to resinous. Color and streak sky-blue to verdigris-green.

Comp.—A hydrous arsenate of aluminium and copper, formula uncertain; analyses correspond nearly to Cu,Al(A8O.),.3CuAl(OH),.20H,O = Arsenic pentoxide 289, alumina 103, cupric oiide 35-9, water 24'9 = 100. Phosphorus replaces part of the arsenic.

Pyr., etc.—In tbe closed tube gives rnuch water and turns olive-^reeu. B.B. cracki opeu, but does not decrepltnte; fuses leaa readily lliau olivenlte ton dark gray slag; on charcoal cracks opeu. dedagralea, and gives reactions like oUventte. Soluble in nitric acid. Obi,—Prom Curuwall; Herrengrund in Hunirary,

Ohansvixita. Perhaps Cu,<Feo>,As,O,-(-3H|o. Massive 10 compact. Color dark green to greenish yellow. From Cornwall; UImIi,

Hbkwooditb. a hydrated phosphate of aluminhim and copper. In botryoidal globular masses. Color tunjuois-blue. From Cornwall.

Ohalooalderlte. CuO 8Fe,o,.2P,o,.gH,o. In sbeaf-llke crystalline groups, as in-cruslatioUB. Color llglit slab In-green. From Cornwall. AnDBEWHiTS, also from Cornwall. Is near chalcosld^rite.

Eshoelts. A hydiKted phosphate of aluminium, zinc, etc. Massive. Q. = 2 34. From Galenii, So. Dakota.

Qoyaslto. Perhaps Ca.Al,iF>oii.9H,o. In small rounded grains Color yellowish white. From Hinaa Geraes, Brazil.

Plambognmmlt*. A hydrated phosphate of lend and alumlohim. Resembles drops or coalings of gum; as iDcrustatlona. Color yellowish, brownish. With galena at Huelgoet, Brittany, and elsewhere.

PHoBPEATB8, ARSENATES, ETC.

TJrauite Group.

TOBBBRNITB. Copper Unmite. EapfBruraoit Qerm.

Tetragonal. -Axis 6 = :^-9361. Crystals usually square tables, sometimes very thin, again thick; less ofteu pyramidal. Also foliated, micaceous.

Cleavage: c perfect, micaceouB. Lamiuse brittle. H. = 2-2'5. G. = 3'4-^'6. Luster of c pearly, other faces subadamautine. Color emerald- and grass-green, and sometimes leek-, apple-, and aiskin.green. Streak paler than the color. Transparent to eubtranslucent. Optically uniaxial; negative.

Comp.—A hjdroua phosphate of uranium and copper, Cu(UO,),P,o,-(-8H,o = Phosphorus pentoxide 15'1, uranium trioiide 61'2, copper d'4, ivatet 15"3 = 100. Arsenic may replace part of the phosphorus.

Pyz., etc.—Ta Ibe cliwed lube yields wnter. In ibe Torceps fuses ut 30 to a blackish masa, and colors the flsme green. Witb salt of pboapbonis gives B green bead, which with tia on cbarcosJ becomes on coollag opnque red (copper). With soda on charcoal' gives a globule o[copper. Soluble lo nitric acid.

Oba.—Froui Qunnis Lake add elsewhere lu Corownll; Bchneeberg, etc., Saxouy: Joacblmathal, Bobemia.

Zennerite. Cu{U09)iAsiO.-|- 8H|0. Id tabular crj'Stala resembllDe torbernlle Id form nod color. G. = 8-2. From Schneeberg, Saxonyj Dear Joachlmsthal; Cornwall.

Lime Uranite. Ealliuranit Qerm. Orthorhombic. In thin tabular crystals, nearly tetragonal in form and deviating but slightly from torberuite in angle; also foliated, micaceous.

Cleavage: basal, eminent. Lamiuse brittle. H. = 2-2-5. G. = 3'05-3'19. Luster of c pearly, elsewhere su bad am an tine. Color lemon- to sulphur-yellow. Streak yellowish. Transparent to translucent. Optically —. Ax. pi. \b. Bx J. c. ^ = 1-572.

CoBp. —A hydrous phosphate of uranium and calcium, probably analogous to torbernite, Ca(trO,),P,0, -|- 8H,0 or CaO.3U0,.P,O..8H,O = Phosphorus pentoxide 15-5, uranium trioiide 63-7, lime S'l, water 15-7 = 100.

Borne analyses give 10 and others 12 molecules of wnter, but It is not certain that the additional amount is esseutial.

Pyr., ate.— Same aa for torberniie, but no reaction for copper.

Obs.—With uranioiie, as at Johanngeorgenstadt, Falkenstelu. In the U. States, at Middletowii and BranclivUle, Conn. In N. Carolina, at mica mines In Sfitchell Co.; lu Alexander Co,; Black Ilills, 8. Dakoln.

Unnosptnlte. Probably Ca(U0i)]As90i -|- 8H,0. In thin tabular crystals rectangular in outline. Color si skin-green. From near SchDeeberg, Saxony.

Uranoclrclts. Ba(UO,)<PiO, 4- 8H,0. In cryaUla rimltar to auluulte. Color yellow-green. From Falkeneteln, Sniou Voigtiand.

FhoaphuranyUt*. (UO.liPiO. -j- SHiO. As 8 pulverulent IncrustattoD. Color deep lemon-yellow. From Mitchell Co , N. C.

Tiiigerit«. (UO.)iAs,Oi + 13H,0, Id Ihin druses of tabular cryslals. Color lemon-yellow. From near Bchneeberg, Suiony.

WalpnrgltB. Probably BI,0(TIO,),{OH)„(AsO,).- In tbin yellow crystals resembling gypsum. Q- = S-78. Color yellow. From near Scbneeberg, Saxony.

Rhaglt«. Perhaps 3BlAaO,.SBI(OH)i. In cryatalltne aggregates. Color yellowish green, wai-yellow. From near Scbne^rg, Baiony.

Mlzlte. A bydrated basic anenate of copper and bls'^'Uth, formula douhlfni. la aclcular crystals: as an Incrustation, Color green lo whitish. From Joachlmsthal: WillicUen, Baden; Tinlic distr., Utah.

Antimonates; also Antimonites, Arsenites.

A number of an ti mo nates have been inclnded in tbe preceding paces among the phosphates, arsenates, etc

Atopite Perhaps culciiiin pyroADlimonaie, CiiSbiOi. Id bometric ocUhedroDS. H. = 5'5-«. <i. = 503. Color yellow to resin-broiTD. Prom LAogbaD. Sweden.

Bindhaimlte. A bydrouB auliruonaie of Irani. Amorpbous. reniform: also earthy or iuciLisiiug. Color gniy, lirowuisb, yellowish, A result of Ihe decomposillon of otber aDlimuiiiul ui-ex; tliiu ul Hurbiiiiaen; lu Corawall; Sevier couDty, Arkanns.

Romeite. An anllmonllo of cnlcium, perlinps CaSbaO.. Id groups of minute square ociaIie<iroua, H. above 5-5. G.= 4 7]3. Color byacJDtb- or boney-yellow. From St Martel, Piedmont.

Nadorito PbClSbO,. lu onhorbomWc crywals. H. = 8 6-4. G. = 702. Color browoisb jellow. From Djebel-Nador. CotiBtantioe, Algeria

Elcdemlt«. Hellopbylllie. Perbapa Pb.Aa,0,.2PbCI,. In crystnls. maasWe, and as an IncruBlation. O. = 6*8B-7-14. Color brigbt yellow to green. From LAogbao, SwedeD; also PnjsLierg {fieiiopk^UiU).

OohroUte. Probably Pb,Sb,0,.3PbCI,. In smrcll cryslals, united lu diverging groups. Color Bulphur-yellnw, From Pajsberg, Sweden.

TilpplMite. E«sentlally an araenlte of copper. In small blulsh-ffreen, tetragonal crya-tals. From CopUpo. Cblll.

Tripnhylte. An iron antimonnle. 2Fe0.8bi04. In mlcrocrystalllDe aggregates of a dull green isb-yellow color. From Tripuby. Brazil.

Darbylita. An aulimii-litanate of iron. In prismatic, ortborbomblc cryBlals. H. = 6. G. = 4-53. Color black. Tripuliy, Brulil.

Lewisite. SCa0.2TiOi.SBbiO(. In mfnuie yellow to brown Isometric ociabedrona. Tvlpiiliy.

Brazil.

Mauielllle. A titaniMintimonRte of lead ao<l calcium, related to lewisite. In dark brown isometric oclnbedrons. Jakobslierg. Sweden.

Ammiiiutk. A doubtful antimonlle of mercury; forming a scarlet eartby mass. From Chill.

Phosphates or Arsenatea -with Oarbonatea, Sulphates, Borate*.

Slafelile and Dahilitt (p. 4S9) may be!ong here.

Diadoohlte. A hydrated pboaphnte and sulphate of ferric Iron: Thuringia. Dettinetitt Issimilnr; from Belgium.

Pitticiie Ahydrnted arsenate anrl sulphate of ferric Iron. Renlform and nias.'ive. Yellowish and redoish brown. From Saxony, Coruwall, etc.

Svanbargit*. A hydiated phosphate and sulphate of aluminium auil ratcium. In rhombobedral crystals. Color yellow to yellowish brown, rose-red. From Hormjftberg, Sweden.

Bendantit*. A pbospbiite or arsenate with sulphate of ferric Iron and lead: formula doubtful In rhomhohedral crystals. Color green to brown and black Prom Cork; Dernbach and Horhausen, Nassau.

UndackeTltv. Perhaps 3Ni0.aCuO.S0.2As,0,.TBiO. In roiettee, and In reniform masses. Color venligris- to apple-green. From Joachlmsthal.

Lilaebarglte SMgO.RiOi.PiOi 8H,0. Id flattened masses, flbroua to earthy stmc-' ture. From LOnebiirg. Hannover.

A hydrous iron arsenate and lead aulphate from Laurion, Greece.

The NitratM being largely solnble in vater play bnt an animportant r<Jle in Mineralogy.

BODANTrBB.

Rhombobedral. Axia i = 0-8276; rr' = 73° 30'. HomcBomorphona with calcite. TJenally iu massive form, as an incruetation or in beds.

Cleavage: r perfect. Fracture conchoidal, seldom observable. Rather sectile. H. = l'6-2. Q. = Z-M-2'29. Luster yitreouB. Color wbite; also reddish brovn, gray and lemon-yellow. Transparent. Taste cooling. Optically-. c^ = 1-5874, ej= 13361.

Comp.—Sodium nitrate, NaNO, = Ifitrogen pentozide 63*5, soda 36-5 = 100. Pyr., otc —DeflagnOei on cbarcoal wltb 1«n violence tbao niter, cauaing a yellow light, and alu) deliqueuea, Cotora the flume iDtenaely yellow. DlsEolvi'a Id three pnrtl of water at 60' P.

OIm.— Prom Tarapaca, northern Chill, and alao the nelghborliig parta of Bolivia; aim 111 Humboldt Co., Nevadu; nenr Cnllco, Ban Bernnrdluo Co., Gal.

Hlt«T. Fotasdum nlirate, ENOt. In thb white cniata and silky tntta.

Nitrooalolt*. Hydroiu calelum nitrate, CafNOOi ->- nH,0. In efQoreicent silky tuft* aod maasei. In oiBiiy llmeitone caverns, as tbow of Kentucky.

HitramagneeiU. Mg(NOi), + nH,0 In eflloreacences tn limestone eaves.

Nitrobuito. Barium nitrate. Ba(NOi),. iBometrir-letartobedral. Prom Chili.

Oarhardtite. Basic cupric nllmte, Cu(NO,>„SCu{OH), In pyramidal orthorhomblc crystals. 0. = 8426. Color emerald-green. Prom Ihe coppermlDeB nt Jerome, Arizona.

DarapakiU. NuNCNa.SO. + H,0. In square .taouma, Cliilf.

NitroglanberiU. 6NaNO,.3Na,80..8H,0. Prora

Iiaatarit* Calcium lodnte. Cs'IOO.- In prismatic ciyslals, colorleas to yellowish. From the sodium nltrale depnslts of Atacftma.

Dletseita. A calcium lodo-chromate. Monocllnfc; commonly fibrous or columnar, H- = *-*■ Q. = 8-70. Color dark gold-yellow. From the same region aa lauCarite.

Oxygen Salts. 6.

The alumlmtteB. ferrates, etc., allied cbemleally to tbe borates, betTO been already latroduced among tbe oxides. Thej Include the specie* of tbe Spinel Group, pp. SS7-341, klso CbryBobeijl, p. 842, etc.

Id fibrous seams or veins. H. = 3. G. = 3'43. Luetor silky to pearl;. Color white with a tinge of pink or yellow. Translucent.

Comp.—HRBO,, where R = Mn, Zn and Mg = Boron triozide 34'1, manganese protoxide, 41*5, magnesia 15*6, water 8*8 = 100. Here Mn (-{- Zn) : Mg =: 3: SJ.

Pyr., etc.—In Ibe closed tube darkena in colot and yields neutral water. If turmeric paper is moistened with tliis water, and tUen with dilute hydrocliloric acid. It assumea a red color (boric acid). In tbe forceps fuses In tbe flame of a candle (F = 2), and B.B. in O.F. yields & black crystalline mass, coloring the flame Intensely yellowish green. With the fluKCB I'eaclH for manganese. Soluble iu hydrochloric ncid.

ObB.—Found on Mine Kill, Franklin Furnace, Sussex Co., N. J., with frankllQlte, Eiocite, wtllemite, elc. An Intimata iniitiire of zhicile and catcite, not uocommun at Mine Hill, Is ofien mistaken for sussexlte, but the ready fusibility of tbe genuine mineral Is distinctlTe.

Lndwigite. Perbajia 3MgO.B,0, + FeO.Fe.O,. In finely flbrous masses. G. = 391-4-02. Cnlor blackjsb green lo nearly black. From HorawilEa, Hungary.

PlnakdoUte. KMgO.B,0, + MnO.Hu,0>. !□ small recUingular crystals. H. = 6. G. = 3-881. Luster metHllic. Color black. From Laugban, Sweden.

Nordenakiaidlne. A calcium-tia borate, CaSn(BO,),. In tabular rhombobedral crystals. H. = S'S-S. G. =4'20. Color sulphur-yellow. From the LangensuDd fiord. Norway.

Jeremejerlte. Eichwaldiie. Aluminium borate, AlBOi. la prismatic liexagonal 'crystals. H. = 6S. G. =328. Colorless to pale yellow. From Mt. Soktuj, AduD-Clialun range in Eastern Siberia.

Hamberglte. Be,(OH)BO,. In greyish-white prismatic cryslalB. H. = 7 5. G. = 2'34T. From Langesuud-fiord, southern Norway.

Szaibeljrite. 3Mg,B,0,,.8H,0. In small nodules; white outside, yellow within. From Rezbanyn, Hungary.

BOBACITE.

Isometric and tetrahedral in esternal form under ordinary conditions, but in molecular structure orthorhombic and psendo>iaometric: the strnctnre becomes isotropic, aa required by the form, only when heated to 265". (See Art. 411.)

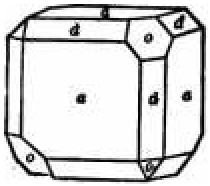
Habit cubic and tetrahedral or octahedral; also dodecahedral. Crystals nsnally isolated, embedded; less often in groups. Faces o bright and smooth, 0, dnll or uneTen.

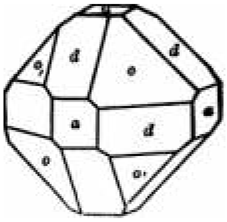
Cleavi^e: 0, 0, in traces. Fracture conoboidal, nneyen. Brittle. H. = 7

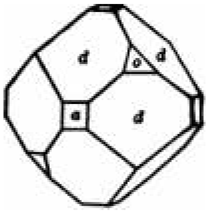
in crystals. G. = 2'9-3. Luater vitreouB, inclining to adamantine. Color white, inclining to gray, yellow and zreen. Streak wliite. Subtransparent to translucent. Commonly shows double refraction, which, however, disappeara upon heating to 265", when a section becomes isotropic. Refractive index,

- a = o 0107.

949.







Strongly pyroelectric, the opposite polarity corresponding to the position of the+ aud — tetrahedral faces {see pp. 234, 235). The faces of tne dull tetrahedron a, (ill) form the analogous pole, those of the polished form o (111) the antilogous pole, Kose.

Comp.—Mg,Cl,B„o,. or 6MgO.MgCI,.8B,o,= Boron trioxide 63-5, magnesia 31-4, chlorine 7-9 = lOrS, deduct {o = CI) 1-9 = 100.

V>r.—1. Ordinary. In crysliila of varied lialjit. 2. Maiticf. with eometlmes a sub> columnar structure ; itattfurtiU of Robc^. It n»«u>blt;s a Une-g^rBlntd wblle msTble or grHDular llmesloue. Faratite of Yolger in llie plumotte luleiior of some ci^Hlale of boraclte. S. £^rM(a(^urtiJ« coDtninsBome Fe.

Pyr., etc.—The massive variety gives water lu the closed tube. B.B. bclh varieties fuse at 2 with lulumfeceDCt: 10 a wblte cryslBlline pearl, coloring the flame green: beated after moIstealDg with cobalt solution nseunies a dtep pink color. Mixed with niide of copper and beated on cbnrcoal culora tbe Same deep azure-blue (coppei chloride). Soluble In bydrocblonc acid.

Alters very slowly on exposure, owing to llie magDeslum cbloride present, which lakes up water. It is the frequent presence of il is deliquescent chloride in the massive niaeral, tliUB originating, that led to the view Ibnl tliere was a hydrous boracito (atsBBfurtlle), ParitiiU of Vo1i;er Is a result of Ibe sfinie klod of alteration lu the interior of crystals of boniciie; Ibis alteration giving It lis somewhat plumose character, and IctroduciDg water.

Obi.—Observed In l^ds of anhydrite, gypsum or salt. In crystals at Ealkberg aud Scbildslcin in LOneburg, Hannover; at Segeberg, near Kiel, In Holstein; at LunevilTe, La Meurthe. France: massive, or as part of the rock, also In crystals, at Blassfurt, Prussia.

Ascharite. A hydrous magnesium borate. In white lumps wfih boracile. From Asclierslelien, Germany.

Rbodlsite. A borate of aluminium and potassium, with cnsium and rubidium. T^mctrlc.tetrahedml: in white, trauslucenl dodecahedrons. H. = 8. Q. = 8'41. Found on red inurinaline from the vicinity of Ekaterinburg in the Ural.

WarwicUt«. Perhnps eMpO.PeO 2TIO,.3B,0>. In elonjiated prismatic crystals, G. = 8'38. Color dark brown to dull black. From Edenrllle, N. T.

HowlitB, A sillro-boTate of calcium, HiCatBtBlOu. Id small white rounded nodules; also earthy. From Nova Scotia.

Idgonita. Fe.Oi.SBiOi.SHiO. Ad IncrustatloD at the Tuscan lagoons.

LardanUlU. (NH,)i0.4B,O,.4H.0, From tbe Tutcao lagoons:

OOLBMANTTEI.

Monoclinic. Axes h-^b : 6 = 0-7748 : 1 : 0-5410; yJ = 69" 5'. Crystals nsnally short prismatic (mm'"= 72" 4'). Massive oleaTable to granular and compact.

cr>N

Cleavable: b highly perfect; c distiDct. Fracture aneven to eubcon* chotdal. H, = 4-4'5. G. = 2i2. Lneter vitreons to adamantine, brilliaDt. Colorleaa to milky white, yellowish white, gray. Trauspareot to translucent,

Comp Ca,B,0,,.5H,0, perhaps HCa(BO,),+ 2H,0 = Boroo trioxide 50-9,

lime 27-2, water 21-9 = 100.

Pyr.—B.B. d«crepltHtea, exfoliates, sinters, and fuwa Imperfectly, coloring the flame yellowiBh green. Soluble In hot liydrocLlorlc acid with separattoD of boric acid on cooling.

Oba.—First discovered El DchUi Valley, loyo Co., CaliforDia; later In Calico district. Sao BernardtDO couuiy.

pRicmTB. Hear colemaiiite. HassJTe, fdahle aad chalky. Color suow-wbile. From Curry Co., Oregon. PandermiU is similar; in compact nodules from Asia Minor.

Plnnolte. HkB,0..8HiO. Tetrsgonul-pyramidal. Usually ia nodules, radiated fibnius. Color sulphur- or straw-yellow. From Stassfurt

BBintEite. Hinlzelte. EBlil>orlte. A bydrous borate of magnesium and potassium. In small crystals, someilmes aggregated togeUiep H. = 4-S. O. = 3'18. Colorless to white. From Leopolds ball, Stassfurt.

BORAX.

Monoclinic. Axes A : t: i = 10995 : 1 : 0-5632; /? = 73° 25'.

ea. 001 A 100 = 7Z° Sff. «. 001 A 531 = 64° ff.

mm'", 110 A lio = 98° 0". . a/, lU A ill = 67° 27. eo, 001 A ill = 40° 81'. «", §21 A ^1 = 88° 28'.

Crystals prismatic, sometimes large; reEembling pyroi-eue in habit and angles.

Cleavage: n perfect; t» less so; i in traces. Fracture coDchoidaf. Rather brittle. H. = 2-2 5. Q. = 1-69-1-72. Ltister fitreous to resinous; sometimes earthy. Color white; Bometimes grayish, bluish or greenish. Streak white. Translucent to opaque. Taste sweetish-alkaline, feeble. Optically-. Aipl. J.J. Bx.X*- Bi„ A** = - 56° 50'. /3 = 1 -470. 2E, = 59° 30'.

Comp Na,B,O,.10H,0 or Na.O 2B,0,.10H,0 = Boron trioxide 366, soda

16 2, water 47-2 = 100.

Pyr., eto.—B.B. puffs up and afterward fuses to a tranpparent globule, called the glass of borax. Fused wilb fliioilte and poiaasium blsulphate, It ciilors tbe Baine arouuJthe assay s clear green. Soluble iu water, yielding a falutly alksUne solullou. Boiling water dissolves double Its weigbt of this salt,

Obs,—Obtained from the lalt lakes of Tibet; Ihe crude mineral is called lineal. In California, abundant in Lnke Co., iit Boihi Lake and Hnchlnbiimn, two small alkaline lakes In ilie Immediate TlHuity of Clear Lnke; present in Kolutlon in tbe lake waters, and obtained also in targe quantities In flne crystals embedded in the lake mud and the surrounding marsby soil; also found in fire largfi clear crvstnls st Borax Lake, Ban Bemar-diini Co.: at Death Valley, Inyo Co. Also Rbodes Hnrsh. etc.. Esmeralda Co.. Nevada.

Named borax from tbe Arabic iuro?. wbicb Included also the niltr (sodium carbonate) of ancient writers, tbe natron of the Egyptians. Borax was called chrysocolla by Agricola because used in soldiring gold.

UIiEZTTE. Borons) rocalci I e. Natron borocalctle.

Usually in rounded masses, loose in texture, consisting of fine fibers, which are acicular or capillary crystals. H. = 1. G. = 1'65. Luster silky within. Color white. Tasteless.

Comp.—A hydrous borate of sodium and calcium, probably NaCaB,0,.8H,0 = Boron trioxide 43-0, lime 13'8, soda 77, water 35-5 = 100.

\^

,ab,GoOgIc

]^T.,ato.—TleldB water. B.B. fuses M 1 wltb Intuniesceace to aclear blebby glue, coloring the Ukioe deep yellow. Molatened with sulpburic Kid the color of the flame U rooineuiarlly vluuiged lu deep lereea. Not soluble in ciild wnier, and but Utile so in hotj the aolutjon alkKliue Id lt« rcaclioiia.

Ofaa.—From the dry pttiliw or Iquique, Cbtll. In Nevada, la large quantitiea in the •alt marshes of the ColumbuB Mining District, Esmeralda Co.

Named after the Oermao chemist, G. L. Ulex

BeoUllt*. CaB,Oi.4HtO. In crusts, as a deposit from springs In Tuscany.

Hydroboraoita. CbM);BiOii.0HiO. Itesemblea fibrous and foliated gypsum; color white. From the Cauciisiis.

Uranatei.

ITRANINITB. Clevelte. BrQggerite. Nlvenite. Uraupecbera Oerm. Isometric. In octahedrons, also with dodecahedi^ faces {d); lees often io cnbes with 0 and d. Crystals r^irc. Usually massire and botryoidal; also in grains; Btmctnre sometimes columnar, or curved lamellar.

Fracture conchoidal to aneveii. Brittle, H, = 5'5. G. = S'OtoO'T of crystals; of massive altered forma from ^'4 upwards. Luster submetallic, to greaay or pitch-like, and dull. Color ffrayish, greenish, brownish, velvet-black. Streak brownish black, grayish, olivo-green, a little shining. Opaque. Oomp.—A uranate of uranyl, lead, usually thorium (or zirconium), often the metals of the lanthanum and yttrium groups; also containing the gases nitrogen, helium ami argon, in varying amounts up to 2'6 p. c. Calcium and water (essential ?) are present iu small quantities; iron also, but oiilyas an impurity. The relation between the bases varies widely and no definite formula can be given.

Tar.—Tiie minerals proTiafonally included under the name urautulte are as Tollows:

1. Crytlaltiteri. DVonrtio*iW'mm Norway. la crystals, iisuaDy octahedral, with G, varying for liie most part from 9 0 to 0'7 ; occurs as an originiil constituent of coarse gratiitcs. The variety from Brancbville. wliich is as free fToro alicratiou as any yet exiimiiieii. cuutuiiis chiefly L'O, with a relatively sniHll amount of UOi. Thorln Is prom-ineiii. whitv till: earihs of tlic inntliuDum nnd yltrlum groups uru oiily sparingly reprcseuted.

Bro-igtrite, as nuulyzed by Hillebrund, gives the oxy^'cn ratio dF UO, to other bases of ubonr 1:1; it occurs in octahedral crystals, also with d ond a. G. = 80S.

OleMUe add iiineniU coutaiu UOi in larger amounL than tlie other Tarieties mentioned. aiul are charucterized by coDtaiuiog about 10 p. c. of tlie yttrium eavtlig. Clevelte is ft variety from tLe Arendai region occurring in cubic crystals modified by tbe dodecahedron and octubedrou. Q. = 7'49. It is particularly rieh iu Ihe gas helium. Nivenile occurs iiias-sive, with Indistinct cryBtallizalinn. Color velvet-black. H. = SS. Q. = S'Ol. It is more solitbie than other kinds of uranltilte, beiog completely decomposed by the action for one liour of very dilute sulphuric acid nl 100°.

3. ifouAis, probably nmorphous. Pllchblende. Uranpecherz 0«mi. Coutains 00 thoria; the rare earths also aljsent. Water Is prominent and the specific gravity is much lower, in some cn<«s not above 65; these last diSei'ences are doubtless largely due to altei'nlloii. Ili-re belong the kinds of pitchblende which occur In metnlliferous veins, with sulnhideaof silver. Ipad. cobalt, nickel, iron. zinc, copper, a-a that from Jolinnngeorgenetaitt, Pribram, etc.: probably al«o that from Black Ha»k. Colomilo (Hillebraud).

Pyr.. etc.—B.B. Iiifuaible, or only sliglMly rounded on the edges, sometimes coloring the outer flame green (copper). With borax and salt of pliosphonis gives a yelliiw bead In O.F . becoming creen In R.F. (uranium). With soiln mi charcoal gl^ea a coaline of lead oxide, »ud frequently Ibe odor of HTsenic. Many specimens give reactions for Rulphur and arsenic In the open tube Soluble In nitric and sulphuric acids; the solubility differs widely In different varieties, being greater in those kinds containing the rare earths. Not Attractable by the magnet.

Ob*.— Ab DOted kbove, unninlte occurs either m a primsir conatilueDt of granittc rocks

or as II secondsrj minenl witL ores of sllTsr. lend, copper, etc. Under the latler condition ll ia found at JohanDgeoigenatudl. Uarieuber)^, and ticnneeberg id Saxooy, at Joochimithal and Pfibrem Id Botiemla, and Rezbaoya in HuuKurv. Occuib In Norway Id pegmsiilc TeiuB at Bcverai poluls uear Mosa, viz.; AuDerttd (briggarite), Elvestad, etc; also oeax Areudal at the Oarta feldspar quarry (titteite), aaauciated wtlh orlliUe, fergiuoolte, thorite.

pi'giimiite veil], as Bmall uctalitdral crjatuls, euibediled in alblLe. In N. Carolina, at th« Flat Rock mlue and other mica miuea In Mitchell Co., rather abundant, but usually altered, in part or entirely, tn guiuiDiie and uranopbsoe; tlie crystala are Bometimes an inch or more across and cubic in hnbtt. In S. Carolina, al Marietta. In Texas, at the gadolinile Incalily In Llano Co. (ninsnde). In targe quuutities at Black Hank, near Central City, Colorado. Rather abundant in the Bald Mountain district. Black HIIIb, 8. Dakota. Also vi'Uh inonazlt', etc., at the Villeueuve mica veins. Ottawa Co., Quebec, Canada.

auinmlta. An alteration-pro duct of urauinlte of doubtful compoaiiJoD. In rounded or Uiitttned pieces, looking much like gum. G. = 8-e-420. Luster greasy. Color reddish yellow to orange-red, reddish brown. 3^om Johnnngeorgenstadt, also Mitchell Co., N. C.

Yttroocmmitb. Occurs with cleveite aa a decorapoaltion-product

Thosoolmhitb. Occurs with fergusonite, cyrtollte, and other species at Ibe gadoli-nite locality lu Llano Co., Texas.

tTruioBpliaTlt«. (BiO)',U.OT.8H(o. In half-globular aggregated fomu. Color orange-fellow, brick-red. fVom near StJineeberg, Saxony.

Oxygen Salts.

6. SUIfHATES, OHROMATES, TEUASRATEB.

A. Anhydrous Sulphates, etc.

The important Babite Group is the only one among the anhydrons Boi-phates and chromatea.

BCuoagnlt*. AmmoBium aulphaU, (NH,)]SO,, Usually In cruBta and italaclltlo forms. Uccunt aUiut volcunoes, ns ot Etua, VnuvUts, etc.

TaylotiU. 3E|SO,.(NH.)i80,. Id Hmull compact lumps or coDcrettons. From ths g'jntui of ibe Clilticba Islaads.

Thsnardlt*. Aiiiiydrous swllum sulpbale. NiiiSO,, In orlhorhomblc crjatals, pyramidal, short prismuli ■ or labiiiar: also ns twins {Pig. 846. p. IIS). Wliile lo brownlab. Soluble Id wnter. Ofti-ii observed !□ connecllou wiib salt lakea, us od the sbor«e of Lake B.'ilkhash, C«ulral Asia; similarly cUi'Wlitrc; also in B. America in Tarapaca. Id tbe U. S. forms uxtCDsive depo:jita on Lhe Rio Verde, ArizoDii. In Caliruroia, at Borax Lake, Saa BeTuardimi Co.

AphtUtallt*. ArcaDlte, (E.Na),80i. RboinbobeclTal; also massive, (d crusts. Color wbite. Protn Veauviiu, upon lava; atDouglaaballnearWesturegelD in blOdUe; Rocalmuto, Sicily.

aLAUBBRTTB.

Monoclinic. Axes A:t:i= 1-2200 :1 :1-0275; /3 = 67° 49'. ea. 001 A 100 = 87' W. et. 001 a HI = 48° ^. .„

mm", 111 A 111 = «6° 58'. em, 001 A 110 = K' 30*'.

In crystals tabular | c; also prismatic.

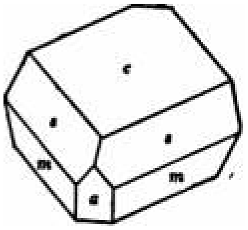
Cleavage: cperfect. Fractnreconchoidal. Brittle. H. = 20-3. G. = 2 7-2-85, Luster vitreous. Color pale yellow or gray; sometimes brick-red. Streak white. Taate slightly saline. On the optical properties (see p. 225).

Comp.—Na,SO..CaSO. = Snlphur trioxide 57-6, lime 20-1, aoda 223 = 100; or. Sodium sulphate 61-1, calciam sulphate 489 = 100.

Fyr., ato.—B.B. decrepltatea, liima wlifte, and fusea at 1-5 to a wbite enamel, coloring the flame latenseiy yellow. On nliarcoa) fuses In O.F. to a dear bead: In R.F. a portion ia nbaorbed by tbe cbarconl. leaTlng iin infiiaible hepatic residue. Soluble la hydrochloric iicld. lu water it loaea its tranapareDcy. Is pnrlfally dlasolved, leaving a reddue of calcium BulphatA, nnd in n large excecs this Is completely diiwnlveil.

Oba.—In crystals Id rock (alt at Tllla Rnbla, In New Caallle, Spain; alao at Aussee, Upper Austria; Berchteagaden, Bavaria; Westeregelu: Btassfiirt. In crystals la the Kio Verde Valley, Atizona, with Ibenardlte, mirabillte, etc.; Botax lake, San Bemardluo Oo., California.

I.aiifb«bilta. E|Hri<SO.)i. laometrfc-tetartobedral. In highly modified colorleai crystals. O. = 9'8.^ From Wetteregeln. Oermauy.



Barlte Group. RSO,. Orthorhombic.

The Bakite Group includes the sulphates of barium, slroiitium, and lead, three species which are closely isomorphouB, agreeing not only in axial ratio but also it) crjHtalline habit and cleavage. With these is also included calcium sulphate, anhydrite, which has a related but not closely similar form; it differs from the others conspicuoualy in cleavage. It is to be noted that the carbon* ates of the same metals form the iaomorphona Araqonite Gkoup, p. 353.

BAHTTB. Heavy Spar. Baryici. Scbwerspath Oerm. Orthorhombic. Axes d:h:i = 0-8152 ; 1:1-3136.

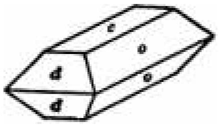
mm'". 110 A liO = T8' 38i'. ed, 001 A 103 = 83° 51i'. CO. 001 A Oli = 62° iz:

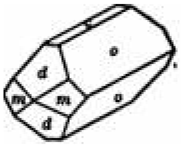
M'\ 103 A 105 = 103' IT. eo', on A Oli= 74'84'. ct, 001 A 111 = 64° W.

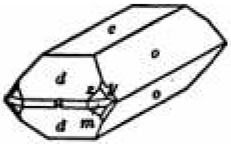
966. 967.

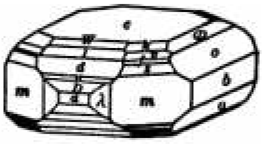
^

/f3









Crystals commonly tabular \ c, and united in diverging groups havinf; the axis h in common; also prismatic, most frequently Q axis J, d (102) predominating; also I axis i, m prominent; again || d, with o (Oil) prominent. Also in globular forms, fibroos or lamellar, crested; coarsely laminated, lamina

coDvergent Hod often curved; granular, resembling white marble, aod earthy; colors sometimea banded as in stalagmite.

Cleavage: c perfect; m also perlect. Fig, 954 the form yielded by clearage; also 6 imperfect. Fracture uneven. Brittle. H, = 3-5-3-5. G. = 4-3-4-e,-4'489 cryst. Luster vitreous, inclining to resinous; sometimes pearly on c, leas often on m. Streak white. Color wttite; also inclining to yellow, gray, bine, red, or brown, dark brown. Transparent to translucent to opaque. Sonietimes fetid, when rubbed. Optically +• Ax pi. \ b. BiX**- SE, = 63° 6', p, = 1-6371, (see further p. 224).

Y»x.-—Ordinary, {a) Crystals UBually broad or atout; aiimeiituea very large: again In ■leader ueedles. (A) Crated; massive a^gregutious of labular ciytlals, tbe cryitala project-iai; nt surface ID 10 cresl-lIke forms, (c) Coiumnar; tlie columns often coaise and tnosely aggreguled, and eilber radiated or parallel: larrly fine fibrous, (d) In globular or nodular coucrtiloDB. Bubtlbrous or columaar witbiu. Bologna lslon4 (from ueur Boloena) is here iiicludeil; it was early a source of woudtr btcaiise of ibe pbuHphorescence ii eiuibiied after heating mltb cbarcoal. "Bologna pliuspborus" «'iia made from it. (s) Laoiellar, eiiher atraigbt or curved; the latter sometiiiies as »g(jregiilious of curved scelC'like plates. (/) Orauular. (g) Compact or cry piocrys lull Inc. (/<) Earthy. (0 Stiilaclitic itod slaliig-mltic; similar In structure and origin to calcnreous etuiactiiea and stalagmilea aud of niucb iMiiuty wbeu polished. (A) Fetid; so called fioiii llie odor given ofi vheu struck or vbin two pieces are rubbed together, which odor may be due 10 carbonaceous matlers present.

The bBL'ite of Muzsaj, Hungary, and of Betier. uenr Rosenau, was early <.'nlled Wolnyn. Cawk [a the ordlDary barite of the Derbyshire leaii mines. Drtetitt, supposed lo be ihoni-boJiedral, ta simply barite. Miehel-levyte from Ptrktii's Mill, Templelon, Quebec (deecrlbed aa moDOclitiic), is peculiiiir lu its pearly luster on m, twinning strialions, eic

Comp Barium sulphate, BaSO. = Sulphur trioiide 34-3, baryta 6B-7 = 100.

StroDliiim sulphate Is often present, also calcium sulphate; further, aa Impurllles, silica, clay, bituminous ur carbonaceous subBlances.

Pyr., etc.—B.B. decrepitates and fuses at 8, coloring the flame yellowfeh fCTtta: the fused mass reacts alkaline with lest paper. On charcoal reduced lo a sulphide. Wllb soda gives at tlrst a clear penrl. but on continued blowing yields a hepatic niaM. which tprends out and soaks into the coal. This react>< for sulphur (p. 20S). loEoluble in acids.

Dlff.^Characterized by high specific gravity (higher thnn celealite. aiagonite. niblle, cslcite, gypsum, etc.) : cleavage; insolubility : griei^ coloration of the blowpipe flame. Alblte is harder and calcite eServesces vnith neid.

Obfl.—Occurs commonly in connection vith beds or veins of metallic cres, eFpecielly of lead, also copper, silver, cobalt, manganese, as part of the gnnguc of the ore; also often ai^companies stibnite. Sometimes present la massive forms with hemallie deposits. It is ini:l wiib In secondary limestones and sandstones, sometimes forming distinct veins, and la the former often In crystals along with cnlclte and celcsliie; lu ihe latter often with copper ores. Sometimea occupies the cavities of nmyednloldat basalt, porphyry, etc.; forms eaitliy masses in beds of marl. Occurs aa the petrifying material of fossils and occupying caviiiea in them.

Pine crystals are obtained at the Duflon lead mines, Westmoreland, England; also In Cumberland and Lancashire; in Derbyshire, Staffordshire, etc.; Cleator Moor: Alston Mont. In Scotland, In Argyleahlre, at Strontian. Some nf the most Important of the many

European localities are PelsObfinya, Nngybinya, Schemnitz. and Eremnilz, in Hungary, often with stibnite; HCitenbern, Carinthin; Freiberff. Marienberg. in Saxony; Cliiusllial In IheHarz; Ffibram, Bohemia; wllh the manganese ores of Ilefitd, (Ehrenstock, elc: Auvergne.

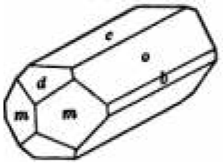
In Hie U. States, formerly In Conn., at Cheshire. Intersecting the red sandslone In veins with cbalcocite and malacliite. In N. Turk, nt I'illar Point, opnoaite Sackttl's Harbor, ma'^lve: at ScohaHe. fibrous; in St. Lawrence Co., crystals at De Kalb; the cre^ti'd variely nl Hammond. In Thnn., in cryatala st Perkiomen lead mine. In Virginvj, at Eldririge a jrold mine in Buckingham Co. In N. Carolina, white mnsaive at Cmwilers Mt.. Qaslon Co., PIC. In Tenn , on Brown's Creek: at Haysboro', near Nashville; In large veii)B in sandstone on Ihe W, end nf I. Royale, h. Superior, and on Spar Id., N. shore. In 3lit»tmri, not uncommon with the lend ores: In concretionary forms ni Salina. Ballne Co., Kansas. In Colorado, at Sterlini;, Weld Co ; ApTslinpa Creek; also In El Paso and Fremont Cos. In fine crystals, near Fori Wallace, New Mexico.

In Oulario. Id Bathurat, and N. Burgew, Lanark Co.: Gslnaf. Peterboroueh Co.; u large veina on Jarvli, HcEellaT*, and Pie Ulande, In L. Superior, and near Fort Wflllam. Tbunder Bay. Ill Nova Scotia, Id velna In tbe alales of But Riv«r of tbe Five Islaoda, ColcLester Co.

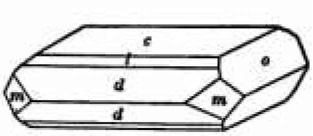
Named tiaai fiapvi, AMny.

OELEffrrm. Ccsleatine. Orthorhombic Axes S:h:i = 0-7790 :1:1-2800,

966.



967.



mm''', 110 A lIO = n° no: ed, 001 A lOa = 89° 241'.

et. 001 A 104 = 2i° aC. 60. 001 A OH = 62' 0".

GrystalB resembling those of barite in habit; commonly tabnlar | c or prismatic Q axie d or S; also more i-arely pyramidal by the prominence of the forms ip (133) or x (1^)- ^^ fibrous and radiated; sometimes globular; occaeioDally granular.

Cleavage: c perfect; m nearly perfect; b less distinct. Fracture uneven. H. = 3-3'5. Q. = 3'95-3'9i. Luster vitreous, sometimes inclining to pearly. Streak white. Color white, often faint bluish, and sometimes reddish. Transparent to subtraaalucent. Optically +, Ax. pi, lb. BxJ. a. 2E, = B9° 36\ ^j = 1-6237.

V«r.—1, Ordinary, (a) In crjBtaU of varied habit as noted above: a tinge of a dellcnie blue Is very cominna and eometimea belongs to only a part of a crystal. The variety fmm MnDttnartre. r-allsd apoioTnt. \% prismatic liy extension of o 'Oil) aod doubly terminated l>f tbe pyraiiiilil it (IDS)- {*) Fibriuis, either parallel or radiated, (e) Lamellar; of rare ocpur-iBOce. idi Orauulur. {») Coucreiiooary. (f) Saitiiy; impure usually with carbonate of

Comp.—Strontium sulphate = SrSO, = Snlphur trioxide 43*6, etrontia Ei6'4 = 100. Calcium and barium are sometimes present.

Pyr., etc.—B.B. frequently liecrepltalea, fuses at 8 to a wblte pearl, coloring the Same stroutiii-red; llie fused muss resets alkaline. On cbar&Tal fuses, and in E.P. U converted Into :i dilHciLltly fusible hepulic mass; this treated with hydrochloric acid and alcoli"! gives iiQ inteiisi'ly red flume. With soda on clinrcoal reacts like barite. Tnsoluble in acids.

Diff.—Characterized by form, cleavnge, high speciSc gravity, red coloration of tbe blowi>i|>e ll^ime. Does not effervesce with acids like the carbonates (e.g., stroDtianite); specilip gravity lower than that of barite.

Obs.^Usu lily associated with llmeatone, or sandstone of various ages; occasionally with metaltiferotia ores, as with galena and splinlerite at Condorcet, France; nt lte7.1iiiiv», Hiiagiiry; nlso in beds of gypsum, rock salt, as at Bei, Swilzerlsnd, laobl. Austria. Liioe-Iwrg. Hannover; sometimes fills cavities in foasile. e.g., ammonites; with sulphur in some volcanic regions as at Qirgentl, Sicily.

Specimens, finely crystaltized, of a bluish tint, are found In limestone about Lake Huron, particularly on Drummond Isiaod, also on Btrontian Is., Put-in-Bay, L. Erir-, and at Kingston In Ontiirlo, Canada; Chaumont Bnj. L. Ontario, Schoharie, and Lnchport, N. Y. A blue fibrous oelestite oeciim at Bell"- Mills. BInIr Co . Peon. In MinemI Co.. TT. Virginia, a few miles south ot Cumberland, Md., in pyramidal blue ciyslalf. In Texas,

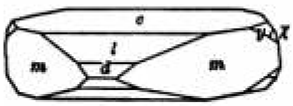
BL Idmpoau, large crystals. WItb coletnaaltA at Death Valley, Bac BeniArdliiO Cu., Califoruia. lu Cauoda, m cryatuiltne masBea at Kingston, Froatenac Co.; Lansdowu^ Leeds Co ; In radiatlnj^ fibrous musses in llie Laureutlnn of Renfrew Co.

Named from ealtttu, aU*Ual, in uHusIod to the faint shades of blue often piesent.

Airai^SITE. BlelTltrlol, VHriolblelerz Germ. Orthorhombio. Axes &xh\i = 0-7852 :1 : 13

Orthorhombic. Axes $\breve{a} : \bar{b} : \dot{c} = 0{\cdot}7852 : 1 : 1{\cdot}2894$.

968.



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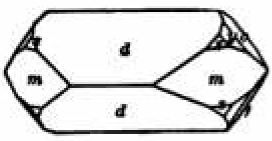

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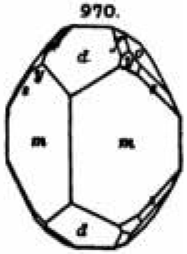


mm''', 110 ∧ 1$\bar{1}$0 = 76° 16½'
cl, 001 ∧ 104 = 22° 19'.

cd, 001 ∧ 102 = 39° 23'.
co, 001 ∧ 011 = 52° 12'.

Crystals Bometimes tabular | c; more often prismatic in habit, and in all the three axial directions, m, d, o, predominating in the different cases; pyramidal of varied types. Also maasive, granular to compact; stEilactitic; nodular.

Cleavage: c, m distinct, but interrupted. Fracture conchoidal. Very brittle. H. = a'70-3. Q. — 63-6'39. Luster highly adamantine in Home specimens, in others inclining to resinoua and vitreous. Color white, tinged yellow, gray, green, and sometimes blue. Streak uncolored. Transparent to opaque. Optically +. Ax. pi. [J. Bx J. a. 2H^, = 89° 53', Di. Indices measured by Arzrnni:

2V

1-86061 1-87709 1'6»H9 1-87838

1-87539 187260

SV (calc.)

™i*

100.

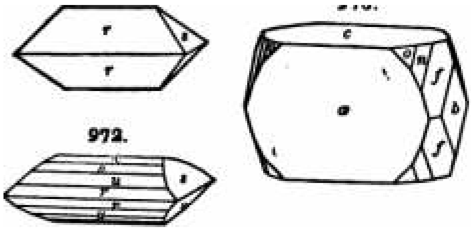
Comp.—Lead sulphate, PbSO, = Sulphur trioxide 26-4, lead oxide 73-6 =)o.

Pyr,, eto.—B.B. decrepitates, fuses in ilie flame of a candle (P. = IB). On cbarcosi Id O.F. fuses to a clear pearl, wblch on cooling becomes milk-white; in R.F. Is reduced with efferrescBncB to metallic lend. With soda on charcoal in R.F. gives metallic lead, and the soda is absorbed by the cnal. DifUcultly soluble in nitric add.

XMff. —Cliaracterized by high speciflc gravity adamantine lusler; cleavage; and by yielding lead B.B. Cerussite effervesces In nitric acid.

mine in Angleaea; at LcadhiUa; In Derbyshire and in Cumberlsnd in crystals; CInustbal, Id the Harz; near Slegen In Prtissla; Bchapbach and Badenweller In Baden: FelsObfinva and elsewhere In Hungarv; Nerchinsk, fllberiai and nt Mnnte Poni, Sardinia; Oranada; massive in Siberia. Andalusia: In Auatrnlln, whence It la exported to England. In the Blerra Hoja'la. Mexico, In Immense qnnntities moetlv mnosive.

Id the United States In cmtals at Wheatlcy's mine, Phenizvllle, Pa.; in Missouri lead mlues; in ciystala of varied habit at tbe Mouniain View rolue, Carroll Co., Maryland. In



Colorado at TftriouB poiuU. but less connuon than ceruaalle. At the Ceno Oordo miaea of CeKforuU large□ liferous galeoa). wUli other lead mlueraU. In Aiixoot,, In the mines 01

the Castle Dome district, Tuma Co., and elsewhere.

Named frum tbc locailly, Aiiglesea, nhere it was flrit found.

ANHTDRITB.

Orthorhombio. Aiea d:h:i = 0-8933 :1:1-0008.

t^. Oil A Oil = 90* 8* io. 010 A HI = W* 18*

Twins: 1, tw. pi. d (012); 2, r (101) occaaioD&lly as tw. lamellfe. Crystals oil not common, thick tabular,

^'^3 also prismatic | itiia h. TJsn-

ally massive, clearabie, fibrous, lamellar, granular, and sometimes impalpable.

Cleavage: in the three pin-acoidal directions yielding rectangular fragments bnt with varying ease, tbus, c very perfect; b also perfect; a somewhat less so. Fracture uneven, Wl, 97a, Stastfurt, Hbg. V3S, Ausaee, Id. sometimes splinterv. Brittle.

H. = 3-3-5. G. = 2-899-2-985. Luster: c pearly, especially after beating in a closed tube; a somewhat greasy, b vitreous; in massive varieties, vitreous inclining to pearly. Color white, sometimes a grayish, bluish, or reddish tinge; also brick-red. Streak grayish white. Optically +. Ax. pi. o J. Bx ± a. SE^ = TO. /3 = 1-576.

Vat. —1. Ordinary, (n) Crysiallized; crysiiils rare, more commoul; massive and cleav-able in ils Ibree reetauguiar directiona. (6) Fibrous; either pm-allel. i-adiated or plumose.

ie) Fine graaular. (d) Scaly granular. Vulpiniit is a scnly granular kind from Vulpino n Lomliard)'; it is cut and jiolisbed fnr ol-nanitntnl purposes. A kind in contorted coucretioDary forms is the iripestone [OeirdtsUin or SfJilnngejuilabatier). a. Pitudomorphout; in cubes after ruck-salt.

Comp. —Anhydrons calcium sulphate, CaSO, = Sulphur trioiide 588, lime 41-3 = 100.

ID enainpl-vriih schIa lloes not fuse to a clear globule, and is uot aiisorbed by the coal like be'ritr; is, liowevir, decompi'sed. niid .vields a muss which binckpns silver. i>oliible in hydrochloric atid.

riff.—Chitrncteriieil by its cleavage in Ihi-ee reclsnguliir dlTeclions {pseudo-cubic tii napeon: harder than gyraum; doesnrt effervesce with acids like the carbonates.

Oba.— Occurs in tockb of various nges. especinlly in limestone stmla.aDd often the sniiie that conlniii ordinary gypsum, and also very commonly In beds of rock-salt: at llie salt mine near Hall In Tvrol; of Bex, Switzerland: iil Aussce, cryBlulllzcd and massive; Lnneburjr. Hannover; Eapnik in Hungary; Wieliczka In Polsnd; Ischl in Upper Aiislria: Berchlexgnden in Bavaria; Slassrurt. In line crystals, embedded fn kieserile; In cavities in lava at Sant'Hn.

In ilieU. State*. MLockporl. N, T.,flneblue. Id geodes of black limestone, wilL calcile and gypsum; in limestone at Nashville, Tenn., etc In Nova Scotia it forms extensive

Anhydrite by absorption of moisture changes to gypsum. Extensive beds are sometimes thus altered In part or throughout, as at Bex, In Switzerland, where, bydigginj: down 60 to 100 ft., the unaltered nnliydrite may be found. Sometimes specimens of anhydrite are altered between the folia or over the exterior.

Zinkoalte. ZnSO,. Reported as occurrtng at a mine In the Sierra Almngrera, Spain.

Hrdrocranite. CuSO.. Fouod at Vesuvius as a pale green to blue Incrustation after the eruption of 1868.

3ULPHA.TS8, CHBOHA.TES, STO.

OROOOITB. Rothblelerz, Oerm. Monoclinio. A^es & :i li: =

: 1 : 0-9159; 0-11"

974·

Crystals nauall; prismatio, habit varied. Also imperfectly columnar aod granular.

Cleavage: m rather distinct; c, a less so. Fracture small con-choidal to uneven. Sectile. H. = 2-5-3. 6. = 6*9-6'l. Luster ndamantioe to vitreoue. Color various shades of bright hyacinth-red. Streak orange-yellow. Translucent.

Gomp.—Lead chromate, FbCrO. = Chromium triozide 31'1, lead protoxide 68-9 ^ 100.

Pyr , •to.—lu the closed tube decrepitates, blackens, but recovers Its ■irij^iuikl color on cooling. B.B. Fuses At 1'5. and on cliarcoal U reduced to iiiKinllic lead with deflagrnliuii, leaviiig a residue of chromium oilde, and giving a lead coultng. With salt of pboapborus ^Ivcs an cmemld-green bead In both flames.

Ob*.—First fouud at Berezur, lu cryatnlB In quartz veins; also at HiirslDka and near Nizhni Tugilak In tbe Urjil; in Brazil, at Couffonliaa do Campo; at Rezbfinju In Hungary, Holdamii in Hungary; on Luzon, one of the Philippines; from Tasmania; in the Vulture ilistric, Haricopa Co., Arizona.

The name Oroeoite is from Kfioiciii, saffron.

Phonloochrolta. Pbceniclte. A basic lead chTomate, 9Pbo.2CrOi. In crystals and massive. Color between cochineal- and byacintb-red. From Berezov Id the Urol.

if lead, perhaps 3(Pb,Cu)CTO,.(Pb,Cu),PiO.. la Color green to brovn, Frou) Berezov In the

Sulphates with Chlorides, Carbonates, etc.—In part hydrous.

¥.H A T MTTT ,T .r FW

Monoclinic. Axes lt:%:i = 1*7476 :1 : 2-2154; >3 =

\ 101 =

«, 001 A lU = 68° 31'. w, 001 A 110 = 80° 64'.

Twins: tw. pi. m, analogous to aragonite. CrystalB commonly tabular p c.

Cleavage: c very perfect; a in traces. Fracture conchoidal, scarcely observable. Rather sectile. H. = 2-5. G. = 626-6'44. Luster of c pearly, other parts resinous, somewhat adamantine. Color white, passing into yellow, green, or gray. Streak nncolored. Transparent to translucent.

Comp.—Sulphato-carbonate of lead, pertaaps 4PbO.So,.2CO,.H,O=Sulphur triozide 7-4, carbon dioxide 8-2, lead oxide 827, water 17 ~ 100.

Pyr., ate.—B.B. Intiimescea, fiisea at 1'6, and turns jellow; but becomes white on cooling. Easily reduced nn charcoal. With soda affords Ihe reaction for sulphuric acid. Efferretces briskly In nitric acid, and leaves white lead sulphate undissolved. Yields water III tbe closed tube.

Obe —Found at Leadhills, vrlth other ores of lead: Red Gill, Cumberland; at Matlock Derbyshire. From the Haiti Calxeltn lead mine near Ig1esla.s. Sardinia (mamle). Observed from Arizona, at the Scbuk gold mine with wulfentte, vansdinlte, cenualle; partly altered to cerussiie.

SoBAKiHTB. Regarded at one lime as rbombohedral and dimorphous with leadhllllte, but probably only a modlflcation of that species. From the Busantia mine, LeadhUls, la Scotland.

. ,._ 8N&iSo(.SNaCl. Id pale greenisli yellow dodecahedrODB. From Bonx

lake. Bun Benurdtno Co., Cal.

Ouaoollta. Perhapi Pb(OH)CI.NaiBU«. Ab s cryatalllne iDcnuUtioD. Colorleat.

From Atucftuia.

Kalalta. UgSO..KCl + 8U.o. UbuqUj granulu m&ssive ind Id crusU. Coloi wliile to d&rk Beali-i-ed. From StHsefurt; Kulusz, Gulick.

omoatone, Arizoaa, SN&i8o..2NB,COt.KCI. lu liexa^iiBl priams, abort priamatlo to taUulari bIbo Id guartzoids (Figs. 202, 20S, p. 60). Color vhitu to jellow. From Bomz Lake, San BernBrdtao Co., California; also from Death Valley, lajo Co.

B. Acid and Basic Sulphates.

In Bllkjr fibers of & white color.

BROOHANTFTB.

Ortborhombic. Axes ^-.1:6 = 07739 :1: 0-4871.

In groups of prismatic acicnUr crystals (mm''' = 75° 28') and drusy crusts; maeeive with reniform structure.

Cleavage: b very perfect; m in traces. Fraotare nneven. H. = 3'5-4.

G. = 3'907. Luster vitreoii?; a little pearly on the cleavage-face b. Color

emerald-green, blackish green. 8treak paler green. Transparent to transiocent

Comp.—A basic snlphate of copper, CuSo..3Cu(OH), or 4CuO.SO,.3H,o =

Suljihiir trioiide 17-7, cupric oside 70-3, water 12'0 = 100.

Pyr., etc.—Ylc-ldB water, and at b higher leinpemtnre sulphuric add, in tlie closed tube, ami becomes bisck. B.B. tofea, and on charcoal affords melaltic copper. Willi soda gives the reaction for aulpluiric acid.

Oba.—Occurs in the Urni; the kOnigloe (or ki/nigiU) was from Qtlmesfaevsk; near Ronghlen Gill, in Cumberlnnd; in Cornwnll (in nnn teaHngUmiU); tit Kezbinjra: In small hedH at EriBiivIg In Iceland (kriruiiiffitey. in Mexico (bronffnartinti; AtBcama. In Ibe U. IJlBleB. At Monarch mlDC, Chaffee Co., Colorado; In Uinb, Tlnllc district, at the Mam> moth mine.

Iianarklte. Basic lead siilpbaie. Pb,SO|. In mnnocllulc crystals. Color greeuisk white, pale yellow or gray. From Leadhiils, Scotland; Blberia; the Harz.

Dol*rophanlta. A basic cupric sulphate. CUiSOt(?). Id small brown monocllDle cryslats. Frum Tesuvlus (eruption of 1869|.

OalAdonits A basic siiipbate of lead and copper, perhaps 2(Pb,Cu)O.SOi.H,0. In Bmall prismatic crystals. Color deep verdigris-green or bluUb green. From LMdblls; Bed Qili, CumberinDit. elc: Inyo Co.. Cal.

Unarite. A basic Bulrhate of lead and copper. (Pb.0u)80,.(Pb,CuX0H)i. In de^ blui^ monoclinlc crystals. From Leadhiils; Cumberland; the Ural, etc. Also Inyo Co., California.

AKTLnRiTE. Perhaps 3CuS0..TCu(0H)i. In light green soft lumps. From the Antler mine. Hohave Co., Arizona.

Alnmlan. Perhapa Al,Oi.3BOi. White crystalline or msaatve. Bleira Almagrem, Spain.

C. Nonnal Hydrous Sulphates.

Three vell-cbaracterized groups are included here. Two of these, tha EP80U1T8 GuotJp and the Mklantbiute Ghodp, have the same general formnU, KSO, -|~ "^^fii hut in the first the crystallization is orthorhombic, in the second monoclinic. The species are best known from the artiticia' cryattila of the laboratory; the native minerals are rarely cryatallized. There is also the isometric Alum Qbocp, to which the same remark is applicable.

Glauber Suit.

Monoclinic. CryBtaU like pyroxene in habit and angle. Usually ia efflorescent cmsts.

Oleavage: a perfect; c, A, in traces. H. = 1-5-2. G. = 1'481. Luster vitreous. Color white. Transparent to opaqae. Taste cool, then feebly saline and bitter.

Comp.—Hydrous sodinm sulphate, Nft,SO, + lOH.O = Sulphur trioxide 24-8, soda 19'3, water 55-9 = 100.

Pyr., rto;— Id the closed tube much water; gives an Intense yellow lo ttae Bame. Very loluble <n water. Loses Its water on exposure to dry nlr and falls to powder.

Obs.—Occurs at Isclil. Hallstndt, huJ Auasee fn Upper Austria: also fn Huncary, SwilEerlaod. Imlv; nt the bot sprlugs at Csrl-^bad, etc. Laige quantities of this sodium Biilpbate are oblaliii'd from the waters of Qreat Salt Lake, Utnb.

Klaserlte. MgSO. + H,0, Usually massive, (jranular to compact. Color white, gmyisb, yellowish. From StassFurt; Hallstadli ludla.

SuniUt*. HuSO, + H,0. StalacUllc. WhItUb, reddisb. From FelsOb&nya, Hungary.

OTPSUM.

Monoclinic Axes ii:$:6 : =:(>•

mm'", no Alio = 88° SO*.

ed. 001 A 101 = 28" ir,

et, 001 A lOl = 88* 8i',

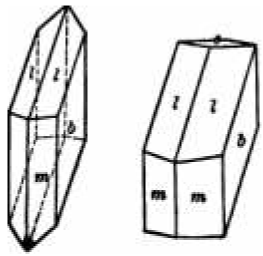
ft), 001 A 103= 11° aff.

w*. on A Oil = 44* 17V,

»7S. B7«,

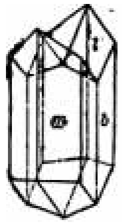
:1:0-41S4; /? = 80'«'. le. Ill A 111 =86° ly. n< 111 A 111 = 41° 20'. ml. llOAlll =48' V. mn. 110 a ill =69° ly.

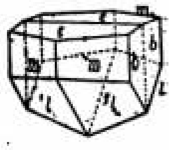
»77.



^^

Hs^





Grystala nsnall^ simple in habit, comtnoD form flattened | b or prismatic to acicalar | i; again prismatic by extenaion of I (111'). Alao lenticnlar by

rounding of I (111) aud e (l03). The form e (103), whose faces are nsitally rough and convex, is nearly at right angles to the vertical axis (edge m/m'''), hence the apparent hemimorphic character of the twin (Fig. 979), Simple crystals often with warped as well as curved surfaces. Also ^liated massive; lamellar Bteliate; often granalar moasife; and sometimes nearly impalpable. Twins: tw, pi. a, very common, often the familiar awailow-tail twins.

Gleavuge: b eminent, yielding easily thin polished folia; a (100), giving a surface with conchoidal fracture; n (111), with a fibrous fracture [t (TOl); a cJeaviige fragment has the rhombic form of Fig. 549, p. 322, with plane angles of 66" and 114°. H:.= 1-5-3. G.= 3-314-3-328, when in pure crystals. Luster of J pearly and shining, other faces subvitreous. Massive varieties often glistening, aometimea dnfl earthy. Color usually white; sometimes gray, Hesh-red, honey-yellow, ocher-yellow, blue; impure varieties often bTack, brown, red, or reddish brown. Streak white. Transparent to opaque.

Optically +. Ax. pi. | J, and Bi A t! = -i- 52^° (at 9-4° C), (cf. Figs. 549, 550, p. 222}. Dispersion p > v; also inclined strong. Bi, a Bit, ^ 0° 30'. 2Er ^ 95° 14' at 20". /S, = 1-5226, y — a := 0-009. On the effect of heat on the optical properties, see p. 225,

Var,—1. Ory»tallittd. or SeUnite/ colorless, Iranspareot: in distinct crystala. or broad folia, often large. Usually flexible and yieldlDg a fibrous fracture | t (101), but the variety from HoDtmartra rather brittle.

2. Fibrou*; co&nc or Sue. Called Batin tpar, wben flne-Sbrous. with peuly opal-

8. MastUe; .JIoAoffer. aflne-grAiaed variety, wblteor delicately sbadedi earthy qt rodt-gyptum, a dull-colored rock, often Impure with clay, calcium carbonate or silica. Also, in caves, curious curved forms, often grouped la rosettes and other sliapee.

Com p.—Hydrous calcium sulphate, CaSO, -f 2H,0 = Sulphur trioxide 46-6, lime 32-5, water 20-9 = 100.

' Pyr,, etc.—In Ibe closed tube gives off water and becomes opaque. Fuses nl 2-5-3, coloring the flame reddish yellow. For other reactions see Abhtdritk, p 528. Ifnited at a temperature not exceeding 290° C, it again combines with wnler wlien moislened. and becomes firmly eolld. Soluble in hydrochloric acid, and nl>o in 400 to 600 parts of water.

Dfff_CliaracteT'ized by Its softness lu nil varieties, audbyclcHviigesfn crystallized kinds; Udoes not effervesce wlih ncidslikecalcile, nor gelatinize like the zeolites; harder than talc nnd yields much water In llie tube.

dbs,—Gvpsum often forms pxtensive beds in connection wilb various stratifled rocks, especially limestones, and msrlltes or clay beds. It occurs occasionally in cryaialline rocks. It Is also a product of volcanoes, occurring about furaaroles. or where sulphur gases are escaping, being formed from ihe sulpburic acid genertitert. and the lime afforded by llie decomposing lavas. It Is also produced by the decomposition of pyrilo when lime is present. Oypsiim is also deposited on the evaporation of sea-water and brines, in which II exists In solution.

Fine specimens are found in the salt mines of Bex In Switzerland; Hall in Tyrol; ilie sulphur mint^ of Sicily; In the Hay of Sbnlover Hill, near Oxford; and large lenticular crystals at Montmartre, near Paris. A noted locality of alahasier occurs at Cnsielino. 8.') m. from Leghorn, whence it is taken lo Florence for the manufacture of vosea, flgures. etc.

Occurs in extensive beds in several of the United State", and more panicularlv N York, Oiiio. Illinois, Virginia, Tennessee, and Arkansas, and is usually associated with salt springs, also with rock salt. Alao on a large scale In Nova Scotia, eli^.

Handsome solenile nnd suowy gypsum or-cur in N. York, near Lofikport In limeslime. In Maryland, liirge grouped orystals on the Bt, Mary's in clay. In Ohio. large transparent crystals have been found at Ellsworth and Canfleld. Trumbull Co. In Tenn., seleuire nnd alabaster In Davidson Co. In Kentucky, in Mammoth Cave. It has the forms of rosettes, or flowers, vines, and shrubbery. Also common In Iso'aled crystals and mosses. In Ihe Cretaceous clays in the we'itern U. S. In enormous crystals, several feet iu lengili, in Wayne Co.. Uiab. In Jf. Scotia, in Susaax, Kings Co.. large single and grouped crystals, which iliostly contain much symmetrically disseminated sand.

Named from yv'poi, the Greek tor the mluenil, but more especially (or Ihe ealeintd min-ewl. The derivmiou ordioarilf BUgeMled, from yt^. earth, aud fipfiy, U>eook, correapondi with tbU, ilie inoM common use ot Uie word amuog the Qreeke.

Burnt gypsum la called Ptrultref-Parii, because the Montmartre gjpaum quarries, uear Paris, are. and have loDg beeo, famous for affordiiig It.

DsaKe. (Ma,Zii,Fe)SOt + 4HiO. lb loosely adherent aggregates. Color clear greea. From Colorado.

Eptiomlte Group. RSO. + 7H,0. Orthorhombio.

EpMmite MgSO. + 7H,0 d:h:i = 0-9902 : 1: 05709

(Fe,Mg)SO. + 7H,0 Oodarite ZnSO, + 7H,0 0-9807 :1: 0-5631

Ferro-goslarite (ZTi,Fe)SO, + 7H,0 Morenoiite NiSO, + 7H,0 0-9816:1: 05655

EPSOMTTB. Epsom Ball.

Orthorhombio. Usaally in botryoidal masses and delioately flbrons crustB. Cleavage: b very perfect. Fracture conchoidal. H. = 20-2'5. G. = 1'751. Lnster vitreous to earthy. Streak and color white. Transparent to translucent. Taste bitter and saline.

Comp.—HydroQs raagneBium enlphate, MgSO, + 7H,0 = Sulphur trioxide 32-5, magnesia 163, water 51-2 = 100.

Oba.—Common In mineral waters, and as a delicate fibrous or capillary efflorescenoce ou rocks, in the galleries of mines, and elsewhere. In tlie former slate it exists at Epsom, England, and at Bedlltz aad Snidschltz (or SaidschQIz] Iti Bohemia. At Iclris iu Curnlola It occurs In silky fibers, aud is hence calleil hnirialt by ttie workmen. AIeo oblidned at Ibe ;>yp8um quarrleaof Hontmartre, ncarPnris. Also fouoil at Vesuvius, at the eruptions of lysO aod 1850.

The floors of the limestone caves ot Kentucky, Tennessee, aud Indiana, are In many Instances covered with epsomlte, in mintile crystals, mingled with the earlL. In ilie Mammoth Cave, Ky., it adheres lo the roof in loose msases like snowballs.

OoaUrlte. ZnSO. + 7H,0. Commonly massive. Color while, reddisli, yellowish. Formed by the decomposition of sphalerile. ami found In the passages of mines, as at tlic Itammelsberg mine near Ooslar. in the Hnrz, etc. In Montana ut the Gagnon mine, Bntte. Fenv-ffaitarite (48 p. c. FpSO.) occurs with spiialerite at Webb City, Jasper Co., Missouri.

MorenoaltB. NIBO.+ 7H,0. In acicular crystals; also fibrous, na an efflorescenn. Color apple-green lo greeuisli white. A result of the allemtioQ of utckei ores, as mat' Cape Horicgal, in Gnlicla; Rlechelsdorf, in Hesse, etc.

Cupromagnoaite (On,Mg)SO, + 7H,0

Chalouitbite CtiS0,+ 5H,0 TricUnic

d:h :i = 0-5656 : 1 : 05507; a = 82° 21', /S = 73" 11', y = 77° 37'

The species here iucluded are the ordiimrj vitriole. They are identical in general formula with the species of the Epsomite group, and are regarded as the Slime compound essentially under oblique crystallizatioD. The copper Bulpliate diverges from the others in crystallization, and contains but 5 of water.

HEL&NTEIRITB. Coppeiu.

MonocliTiic. Usually capillary, fibrous, atalactitic, and concretionaryj also massiTe, pulverulent. Cleavage: c perfect; m less so. Fracture eon-choidal. Brittle. H. =2. G. = 1-89-1-90. Luster vitreous. Color, various shades of green, passing into white; becoming yellowish on exposure. Streak uncolored. SnbtrauBparent to translucent. Taste sweetish, astriiigent, and metallic.

Comp—Hydrous ferrous sulphate, FeSO, -f 7H,0 — Snlpbnr trioiide28-8, iron protoxide 25*9, water 45'3 = 100. Manganese and magnesium sometimes replace part of the iron.

Ofa«.—Proceeds from tbe decompi>ait[ou of pyrlte or marCBaite: tUus near Ooslar In the Hftrz; BodeaiDBii Id Bnvariu; Fslua, Bneileii, atid elMwbere. Usunlly accompialFB pytfte in tbe U. States. ■■ bd eBiorescence. LuekiU (IB p. c. MuO) ia from the " Lucky Boy " mine, Butterfleld Cnfiou, Utali.

Mkllardlts. HnSO*-|-7H,0. Fibrous, miiMive; colorlew. From the mloe "Lucky Boy," south of Salt Lske, Utali.

Pisuiite. (Fe,Cu)80* + 7H,0. CuO 10 to 16 p. c. In concrellonsry and aUlactltio forme. Color blue. From Turkey.

Baltaooiute a copper-iron vitriol near piuulte. From tbe ealvador mlti« QueteUR, Cbili.

BleberiU. CoSO. + THiO. Usually In stalactites and crusts. Color flesh- and rooe-nd. From Bleber, tn Hesse, etc. CapromaffOMiU Is frum Vesuvius.

OHAI^OANTHTFE. Blue Vitriol. Kupferrllrlol Oerm.

Triciinic. Crystals commonly flattened | p (111) (Figs. 339-341, p. 109). Occurs also massive, stalactitic, reniform, sometimes with fibrous structure. '

Cleavage: M,m,p imperfect. Fracture conchoidal. Brittle. H. = 3'5. G. = 2'12~2-30. Luster vitreous. Color Berlin-blue to sky-blue, of different shades; sometimes a little greenish. Streak uncolored. Subtransparest to translucent. Taste metallic and nauseous.

Comp.—Hydrous cupric sulphate, CuSO^ -\- 6H,0 = Sulphur trioxide 321, cupric oxide 31'8, water 36'1 = 100.

Pyr., etc. — Id the closed tube yields water, and at a higher tempemtiire Ru'phur Iri-oxide. B.B. witli adds od charcoal yields roetslllc copper. With tbe fluxes rencta for copper.

Soluble In water; a drop of Ibe solulton plscod on a surface of ii-on cnat» it with

; Parys mine, Anglesen: at various mines In Co. of Wlcklow; Rio Tiiito mine. Spain. Trom tbe Hlwnssee copper mine, alan In larice quan-tltlea Ht other mines, in Polk Co., Teimeaaee. In Arizona, near CUftou, Graham Co.. and Jerome, Tavapal Co.

SyngMilta. KaUiaztte, CaSO,.R,gO. + HiO. In prlsmaltc (monocllDfc) eryitala. Colorless or milky-white. From Ealusz, Qalicla.

Xittwalt*. HgSO,.Nai80t + 3iH,0. Massive, clWTable. Color paUvellow. From Ischl, Aiturin.

BlSdita. Hg60<.Niii60i + 4HiO. Ciystals abort priaoi&ttc, monocllDic; also massive gmnular or coinpscl. Colorless lo greenUb, jellowisb, red. From the salt mines of lacbl; «t Uallsladl (rimoraiiley, at Slassfurt; tie salt lakes of Aslrakbao iaiWalianiU), Asia; lodia,' Cbili. tic.

Itsonlte. Hg80,.Et8O. + 4HiO. In monocllnic crystals from Westeregela and Leopolilsbiill. Germtiny.

Boosaliiganltlte. (KH,),SO..Mg804 + 6H,0. From the boric acid logoonl, Tuscany.

Piciotneiita. MgBO,.E,BO, + eH|0. As a whils cTTStalline Incnislatlou. From TesiiTiiis witb eyanoehroitt, iin isomorpboiis species la nblch copper replaces the mag* Desium. Also at liilassfurt {lekotuitt); at Ascberslebea; Galusz la JCast Galicia.

Polyhalite. gCaSO, MgSO..E.SOt + 3H.0. Usually In compact fibrous or lamellar inasses. Color flesb- or brick-red. Occurs at tbe mines of Ischl, HalUtadt, etc. Id Austria; BurchlesgadeQ, Bavaria; Slassfitrt.

Alum Oroup. Isometric.

RA1(S0.), + 12H,0 or R.SO..AI,(SO.). + 24H,0. Sali&ite Potash Alum EAI(SO,), + 12H,0

TMli«niiigito Ammonia Alum (NH,)A1{S0.), + 12H,0

Xendozite Soda Alum liaAl{SO.), + 13H,0

The Alums proper are isometric in cryatallizatioD and, cheroioally, are faydrona sulphates of sItimiDium with an alkali metal and 13 (i.e., if the formula is doubled, 24) molecules of water. The speciea here included occur very spiiringly in nature, and are best known in arttfioiol form in tbe laboratory.

The IIalotrichites are oblique in crystallization, very commonly fibrous in structure, and are hydroua sulphates of aluminium with magnesium, mang* anese, etc.; tbe amount of water iu some cases is given as 23 molecules, and m others 34, but it is not always easy to decide between the two. Here belong:

Plckeriaglte, Mngntata Alum. MgSO,.AIi(SOt), + 22H,0. Id long fibrous mauei; aod iu efflorescences.

Halotrlchlt*. Irnn Alum. PeSO,.AI, 80.).-f a4H,0. In yellowish silky fibrous

Aptohnlte. Mhii!;.i"c<4I' Alum. MnSO. A1,(So.)i + 94H,0. Bitsbmantte cod< Isint McO- In flhrnns or ntb'stiform mas.iea; also as cntstsftn_d efflorescences. Diatilohite. (Zii.FB.Mti)So,.A1,iSo,1. + 32H,0. MiiHKiTB. A flbrous alum from Egypt supposed to contain a new element, maarlum.

Ooqnlmblta Fps'SO,^, -l 9H-0, 'Rhomhohedral. Oranular manlTe. Color white, yellowish, hrnwuinh, fVom Ihe Tlerra Amarilla n«ar Coptapo, Chill (not from Coqnlmbo.)

Qnmstwltlte. Fti,l80,)i+ 10H,O. Tn reddish tabular crystals. With coqolmb-lie Chill.

IhlBlto Fp-'80.)iH-IZHiOT An orange yellow efflorescence on graphite. Prom Hmrran. Bobemin.

AlnnorBn AI,'EI0,1,+ 18H,0. Uniift'l'- In dellcnle flbmn« masseB or cnistn; mass!v«. Color while, or tinged with yellow or red. From near BIlin,Bahemb; Bodemnkia; PnU«r< tlttl, Tyrol.

Philufitx. Perhaps CuSo,.Fe,(80,)> + nH,0. In blue fibrous mBues. Chill. Found at the copper miuea in the Curdillenu of CJoDdcs, proviace of Santiago, Chili.

ForronatriU. 8Na,So,.Fei(So,)i+6HiO. Rarely !□ aclcular crralala; nauall; la cpbsrical forma. Color greenlBli or gny to white. From Sierra Gk>rda near C&raculee,

Cbili.

Basic Hydrous Sulphates.

Langlto. Near brochaQtite. CuSO,.SCu(OH}, + H.O. Uauall; in flbro-lamellar, COD ere lion Brf crusts. Cnlor blue to greKnlsli blue. From Cornwall.

HerrengnmdlU. 3(CuOH),SO,.Cu(OH), + SH.O wltli one-fifth of the copper replaced b7 cnlciutn. lu tbin tabular crystals; usually in apberical groups. Color emerald-green, bluiBli green. From Uerreagrnnd, Hungary.

Eamorezlte. A. hydrous baatc copper sulphate from Latirion, Greece.

Oyanotrlohlta. Lettsomite. PerhapB4CuO.A],0,.BO..eH,0. InTelvet-lIke dmaeg; in spherical forms. Color bright blue. From Moldawa in the Banat; Cap Qaronne, iSiance. In Utah aud Arizona.

oopiApmr.

Monodinic. Usnally in loose aggregations of crystRlIine scales, or granalar massive; iBcmsting.

CleavBge: ft{010). H. =35. G. = 2'103. Luster pearly. Color snlphnr-yellow, citron-yellow. Tranalticeiit.

Comp.—A basic ferric sulphate, perhaps 2re,0,.5SO,.18H,0 = Sulphur trioxide 38-3, iron sesquioxide 306, water 31-1 = 100.

Miiy ia an old term, which lias been somewhul vngntly applied. It seems to belongin pnrt htre and In part nlso to other relured s|iecies. '

pjT., eto.—Yields water, and at a higher temperature sulphuric acid. On charcoal becomes magnetic, and with soda affords the reaction for aulphurlc add. With the fluxes reacts for iron. Soluble In wnler. nnd deromposed by boiling water.

Ob«.—The original co[iiaiiito was fiom Cnpiapo, Chill. Other hydrated ferric sulphates:

Outanlta. Fe,0, 290,.8H,0. Color chestnut-brown. From Siorra Gorda, Cbili.

ntahite. 3Fe50..2SO,.7H,0. In aggregates of fine scales. Color omnge-yellow From the Tintic dlstr.. Utah.

Amaratitit*. FeiOt.880,.7H,0. Usually in columnar or bladed ma.<ieB, also radiated. Color amaraDth-red. From near Caracoles. Chili. Echmannite la the aame partially altert'd; this Is prohihly nlso true of paponle.

FIbrofarrite. Pe,0,.2S0. IoH,O. Id delicntely fibrous aggregates. Color pale yellow, nearly white. From the Tierm Aniarilla neiir Copiapo, Chili.

Balmondite. 2FegO,.3SOi TU,0. In thin alx-sided tables. Color between honey- and oclier-yellow. From the itn mines of Ehrenfriedersdorf; mines of Bolivia.

OarphosldeTlte. 8Fe.O,.4SOi.10H.O, In reiilform masses, and incmstations: also in micaceous InmellEB. Color atraw-yellow. From Greenlnnd,

OIookBrlta. aFeiOi.SOi.flH.O. Mnsrfve. apnrrv or enrtliy: stslacUtlc. Color ttrowa to ocher-yellow to pitch black; dull green. From Goslnr nnd Modura, KaoxvUIite. A, hydrous basic snlphate of chromium, ferric iron, and aluminium. In rhombic plates. Color greeniah yellow. From the Redbgiou mercury mine, Enoivill^ California.

ftBDnroTOinTE. A hydrous chromium aulpliate, in tiaeiy flbroiu maum of a palt^ purple color. Same localltf as knox*i1Ule.

Oypnulto. Perhaps 7Pe,O,.AI,O,.10BO..14H,O. An aggregation of microscopic crystuls. Color yellowfsii. From the IslBod of Cyprus.

Alnniliiite (Websterite). Al,0>.SO,.eH,0. Usuallj io white earthy reoiform musea, compact. From near Halle, la clay: also at Nenhav^n, Suasei. aud elsewhere.

Paraliiinliilts. Near alnminite. but supposed to be 2AI,0,.B0..15II,0. i

F«ls6buiylte. 2Al,Oi.SO..10H|O. Uaaairei-lD seal; concretioQe. Color snow-white. Prom neiir FelsCbfiuya, HuDgarf.

Fe.O. 4S0..18HrO. Usuallj Id reuiform and botrvoii I, Sweden: ^sofrooi Pen

SlderoaatHte. 2Na,0.Fe,0, 4SOi.7H,0. Fibrous, masslTe. Color yellow. From the province of Tampncfi, Chill. Also ou the Urus plateau, near Sitrakiiyu, on the island, Cht-lekeii, In the Oiispiun Set, (vnitilei,

Voltaite. Pi'rhaps 5<K,.Pe)O.2(AI.Fe),O,.10SO..lGH,O. In octahedrons, etc. Color dull oU-green to browu or black. From tlie solfnlars uear Naples; also Persia.

MatsToltise. Perhaps 6|Ki.Na,.Fe)O.SPe,0..1SS0..18H,0. In aggregates of minut« yellow scikleB. Occurs vrlth Toliuitu in Persia.

AIiUNTTB. Alumstone. AhiunBleln.

Rliombohedral. Axis 6 = 1'3520. In rhombofaedrons, resembling cubes (rr-' = 90° 50'). Also massive, having a fibrous, granular, or impalpable texture.

Cleavage: c distinct; r in traces. Fracture flat conchoidal, nneven; of massive varieties splintery; and sometimes earthy. Brittle. H. = 3-5-4. G. = 308-2'T52. Luster ol r vitreous, basal plane somewhat pearly. Color white, sometimes grayish or reddish. Streak vrhite. Transparent to subtranslucent. Optically positive.

Comp. -Hydrous Bnlphate ot aluminium and potassium, K,0-3A1,0,.4S0,. 6H,0 -Sulphur trioxide 386. alumina 37-0, potash 11'4, waterl3 0= 100. Tlie formula may be written K(AIO),(SO.), + 3H,.

Pyr,, etc.—-B.B. decrepitates, and is Infusible, In the closed tube yields water, sometimes also aminoulum sulniiate. and at a higher temperature sulphurous nud sulphuric oxides. Heated with cobalt solution sffotils a fine bine color. With soda and charcoal infusible, but yields a heputic mass. Soluble in stitphuiic acid.

Ohi.—Forms seama in IracLytlc and allied rocks, where it bas been formed as a result of the alteralloD ot the rock by mnnns of siilphiirous vnnors; as at Tolfn, nenr Civira Vucchia; in HiiQcary; on Milo, Grecian Arcliipelago; at Ml. Dore. Prance. In tbc U. 8„ associ:iled with Ulaipore, in rhombohedral ciyslals, tabular through-the presence of e (0001) lit the Rosila Hills, Custer Co., Colorado,

JAROSTTB. OelbelseDers.

Rhombohedral. Axis 6 = 1-2492; rr' = 90" 45', cr = 55° 16'. Often in druses of minute crystals; also fibrous, granular massive; in nodules, or as an incrustation.

Cleavage: (J distinct. Fracture nneven. Brittle. H. = 25-3 5. G. = 3'15-326 cryst. Luster vitreous to subadamuntine; brilliant, also dull. Color ocher-yellow, yellowish brown, clove-brown. Streak yellow, shining.

Comp.—K,0.3Fe,O,.4SO,.6H,O = Sulphur trioxide 31-9, iron aesquioxide 47-9, potash 94, water lO'S = 100. The formula may be written K(FeO> (80 > + 3H.0. '■ *"

Ob«.—The original Oelbeisendrz was from Luschitz. between Eolosomk and Bllin, Bohemia, lu brown coal; and Inter from Modum. Norway, in alum slate. The iarosite waa from BarraDCoJaroso, Id the Sierra Almagrera. Spain: also from other points. In the U.S.. on quartz In tlie Vulture mine, Arizona; In ChaOee County, Col.; Tiutlc district, Utah.

Lttwiflto. F«TbapBKtO.8&.1,O..4S0..9H,O. la rouoded

«luDii«. Found in a coal bed at Tabrze Id ll[)per Silesia; also witli aluoite at Tolfa.

Bttringlt*. Perliaps eCaO.AUOi.SSOi.SSHjO. !□ mlnate colorless acfcular crysUlt. From limeBioiteiDClusfonB is lava, Ufui Hayen, Rlienlsh Prussia.

Quetonita. HgO.Fe,0,.3SOi.l8H,0. HassiTe, Id Indistinct cirslals. Color reddiih browu. Fi^im Quetena, Cliill.

Zinoalumlnita. 3ZiiS0..4 lolor wliile. bluish. From L

Johannlta. A brdrous sulpLate of uranium and copper. In druses or raDiform maisM of a green color. From JoHChimatlia].

DnnopiUta. Perhaps CaUtStOii.25H]0. Id velTety IncnurUtlODS; yellow. From Johanngeoi^en itad t.

ZiipgaUt, mogUar^, ttraeonitt Are uncertain uranium sulpbateo, also from Joachlmrthal.

Tellorates; also TellnilteB, Selenltes.

Bi,0,.TeO,.2B,0 In earthy incrustations; yellowish to whlU. From Bightand, Moalonn, with tetradymite.

Bmmoaalta. Probably a bydrated ferric tellurite. In thin yellow-green scales. Prom near Tombstone. Arizona.

Dnrdsnite. Hydrous ferric tellurite. Fe,(TeOi)i + 4H,0. In small mammtllary forme; greenbh yellow. Honduras.

Obaloomenlte. Hydrous cupric selenite, CuSeOi + SH,0. In small blue monocllnic 'Crystals. From the Cerro de Cacbeula. Argentina, with silver, copper selenides.

MoLTBDOMENiTB is lead selenite and CoBuyrouBKim probably cobalt aelenlte, from the same locality as cbalcomenfte.

Oxygen Salts.

7. TUiraSTATES, XCOLTBDATEB.

The monoclinio Wolframite Group end the tetragonal Scheelite Group are included here.

Wolframite Hiibnerite

Wolft^mlte Group.

(Fe,MD)WO, a:'b:i = 08300

I : 0-8678 ft = 89° 23' 0-8362 : 1: 0-8668 89" 7f

WOU'RAMTTEI. Wolfram.

Monoclinio. Axes: a-Azi =0-8300 : 1 : 0-8678j /?= 6 mm"'. 110 A lIO = 78* aff. aj/, 100 a 105 = fla" M'. at. 100 A 102 = 81* 54'. /', Oil A Oil = 81' M'.

/G\

Twins: (1) tw. axis i with a as comp.-face; (2) tw.

f\. k (033), Fig. 419, p. 130. Crystals commonly tabntar a; also priBmatic Faces in prismatic zone vertically striated. Often bladed, lamellar, coarse divergent columnar, granular.

Cleavage : b very perfect; also parting Q a, and It (102). Fracture uneven. Brittle. H. = 5-55. G. = 7-2-7-5. Luster submetallic, Color dark grayish or brownish black. Streak nearly black. Opaque. Sometimes weakly magnetic.

Comp., Tar.—Tungatate of iron and manganese (Fe,Mn)WO,.Fe ; Mn = chiefly 4 : 1 {FeO 189, MnO 4-7 p, c.) and 2 : 3 (FeO 9 5, MnO 14-0).

Pyr., ate.—Fu'fS B.B eaillj (F. = 2 6-8) to a globule, wblcli Lu a cryMalllne aurfkre and !■ niKgiietic. With inlt of pliiMplionie f^iveB a clenr recldigb yellow glut while boi. which Is paler od cooling; Id 1{.P becomea ilHrk red; oo chnrcoal wllb tin, if not too antiirnlril, the bead aaaumsB on cooline t, green color, which continued trealnieiil In R F. «biiiig«s to reddish jellow. Wllb snda and niler ou platiniim foil fuset to a bluish grriii niaiiraoate. Decomposed by aqua regia wttli separation of tungstlc acid ns a yellow powder. 8uiBc[«Dt1r decomposed by coDcenimteH sulphuric acid, or even hydroclitnrlc aclil, to give a colorless solution, which, treated with metallic zinc, b«comes Inlsnsely blu«, but soon bleaehea on dilution

Oba.—Wolframite Is often associated with tin ores; also in qnarti, wflh natlTe blsmnlh, •cbeeltte, pyrite, Ea1eIl^ sphalerite, etc. In flne crystals at Bchlnckenwald, Ziimwalil; Schneeberg, Freiberg, Alteoberg; at Nercliltisk, Siberia; Ghantaloup, near Llmnges, Fmnce: near Redruth and elsewhere In Cornwall with tin ores. In S. America, at Oniio in Bolivia Wilfa tin stone at variouB points tn New South Wales.

In tlifl n. States at Lane's mine. Monroe. Conn.; Flowe mine, HecUenburg Co., N. C. with scheellte; in Missouri, near Mine la Hotte.

HUbnwlU. Near wolfiamlte, bat eontalnlns 20 to 2S p. c. MnO. Uanally in bisdid form*, rarely in distinct terminated crystals. Color brownUi red to bidr-browo to nearly

..Ca>o'

QIC

block. Streftk yellowtah brown, greenlah gnj. Ofteo tnuuilucrat. Uammotb dist, Nevftda; Oanj County, Col.; neat Bilveruxi, Sui Juan Co.; Bl&ck Hills, 8. DnkoU, etc. Alio in Peru, and In rboUoobrosite at Aderrlelle in tb« Pyreneet.

Bcbeelite Oronp. Tetrsgouol-pyramidal.

pp' (111 A ill) = 79° 55i' i = 1-5360

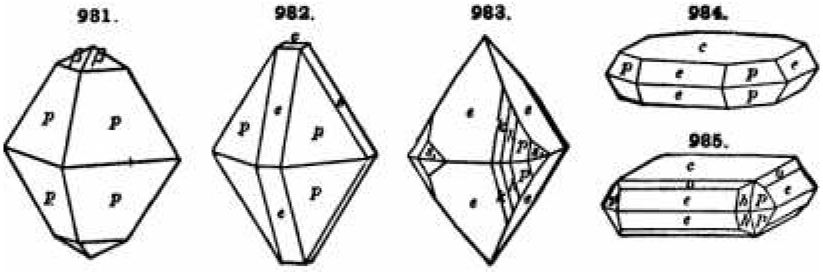
80" 1' 6= 1-5445 80° 15' 6 = 1-5667 80° 23' i = 1-5T71

The ScaEELiTE Group includes the tangBtates and molybdatea of calcium and \ead; also copper. lu cryBtalUzation they belong to the Pyramidal Group of the Tetragonal System. Wulfenite is probably hemimorphic.

Tetragonal-pyramidal. Axis i = 1'5356.

ee', 101 $\wedge$ 011 = 72° 40½'.
ce, 001 $\wedge$ 101 = 56° 56'.

pp', 111 $\wedge$ $\bar{1}11$ = 79° 55½'.
cp, 001 $\wedge$ $\bar{1}\bar{1}1$ = 65° 16½'.



Forms: o (102), e (101), β (118), p (111), k (515), h (313), s (131).

(lOaj, it(IOI). (5(118), p(lll), *(51S), A (813). 1,(131).

Twins: (1) tw. pi, a, both contact- and penetration-tvins (Fip. .'ITS, p. 125). Habit octahedral, alao tabular. Symmetry shown by faces k, h, k (E\g- 983). Also reniform with columnar structure; massive granular.

Cleiiyage; p (H^ most distinct; e (101) interrupted. Fracture nneyen. Brittle. H. = 4-5-5. G. = 5'9-6'l. Luster vitreons, inclining to adamantine. Color white, yellowish white, pale yellow, brownish, greenish, reddish. Streak white. Transparent to translucent. Optically-)-■ Indices: oa^ =: V9\9. e, = 1 934.

Comp.—Calcium tungstate, CaWO, = Tungsten triozide 806, lime 19-4 = 100.

Molybdenum is usually present (to 8 p. c.). Copper may replace calcium, see cupro-gcheelite.

Pyr., ato,—B.B, Id the forceps fuses at S to a semi-transpaTent glass. Soluble with borax l» a traaspareut glass, wbicb afterward b^comei npnque and crystnlllDe. With itiilt of pliciaplioruB forms a eIbss. colorless in outer flume, lu inner green when bot. aud fine blue wLeu cold ; Tarleties cootainiug iron require to Iw treated on charcoal with tin before

,i,:cc ..Google

inNOSTATES, MOLTBDATBS.

the blue color appeals. Id hydrocblorlc or nitric acid decompoBed, letkTlng a yellow powder soluble In ammonlii.

Ob*.—bcheelite Is lUkinUy aaBOc!ated willi cijalallltie rocks, and U commoutj found In coDDCctloD with caasiterile, lopaZ; fliiorite, npallle, mutybdeulte, or wulfninille, lu guartz-nlso associated with guld. Thus at Schlacketiwald and Zliiuwiild, Bohemia: AlCenbers, Saximy; Kieseuf^ruud Id tbe BleEeiigebiri^: the Kuappenvvuiid in Ibe UuterBulzbiK'hlhal, Tyro); Ciirrock FkIIb in Cuiuberlaml; Tmversella iu Piediiioiii; Meyniiic, Corrfif. France (L'ouiaiuingTHiOi)' Swt-deu; Pilkfimiita in Finluiid. In New Bouib Wales, at Adiiloag, from a gold mine; New Zealuud, niiuaive: Mt. Kanisav, Tasninnia, wtlb cassiterite.

It) the U. Slaies, at Lxue's Mlui;. Mouroc. and iit Trumbiill: Flowe.miae. Mecklenburg Co., N. Caroliua; the Maiiimoib mining districl, Nevada; wilb gold at ilif Chnrily mine, WiLrren a. liluho; Lnke Co., Coloiiido. In quuriz veiuB in RlBboiough and Hiirlow, lleimce county, Quebec.

OuprotuDgstite Cupric tungsiiite, CuWOi. From Ihecoppcr mines of Llamuco. near Sautiago. Cbili. Cuprobchbeutk. from Ibt vicinily of Lb Paz, Lowet Caliroruin. ig iCii.CuJWO,, with 6 a p. c. tJuO; color green.

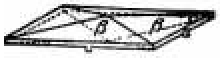
Powellite. Calcium molyhilate wiib ciilcium tungftnle (10 p. c. WO.), Ca(Mo,W)o,. Ill minuie yellow Icirsgonul pyramlilB. G, = 4'84tt. From western Idalio; Houghton Oi.. Mich.

Stolzita. Lead tungstate, PbWO,. Iu pyramidal tetragonal crystala. H. = 3-7B-8. G. — 7 8T-SI3. Color green to gray or brown. Zinnwald.

Rasplte. Has lie aame cotnposilioji iib slolzite, liut ia referred to the nionoclioic system. In nm]ill tabular crystals. Color browoisli yellow. From the Broken Hitl mtnei. New Soutl> Walea.

WniJ'BNITXI. Gelbblelerx, MolybdAiibleispath. G'rm. Tetragonal-pyramidal; hemimorphic. Axis i = 1-577I.

986.



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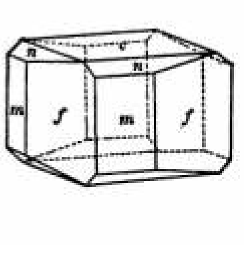

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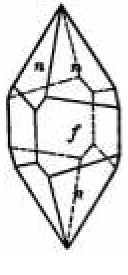

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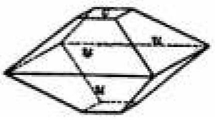


ca. 001 A 102 = 38'IB'. uu', 103 A 012 = 51° 58'.

et. 001 A 101-67° 87. teT, 101 a Oil = 78° SC.

en, 001 All! =65° 61'. nn', 111 a ill = 80° 28",

CrystalB commonly square tabular, sometimes extremely thin; less fre-qnently octahedral; also prismatic. Hemimorphism sometimes distinct. Also granularlj massive, coarse or fine, firmly cohesive.

Cleavage: n (111) very smooth; c, s (113) less distinct. Fracture subcon-choitial. Brittle. H. = 2'75-3. G, = CT-T'O. Luster resinous or adamantine. Color wax- to orange-yellow, siskin- and olive-green, yellowish gray, grayish white to nearly colorless, brown; also orange to bright red. Streak white. Suhtransparent to siibtransfucent. Optically negative. Indices: (Wr = 2-402, e, = 3'.304.

Conp. —Lead molybdate, PbMoO = Molybdenum triozide 39'3, lead oxide 60'7 = too. Calcium sometimes replaces the lead.

PTt. , Bto,—B.B. decrepiUtea atid fii3« below 2. WitU nit of phospUorui !n O.F. elfa a jel I o wish-green glau, wtilcb in R.F. beconieH ilurk greeu. WilL ioA& un charccul jields iiieliillic leiiif. Decompoaed on cv&poratiuu vriili liydrodilorlc &cid, witb Ibe fumutlou of lead chloride nod mol>bdic oiidc; on moisleniDg llic residuu wlih water aud iiddiog meUHic liuc, it gives un iolenie blue color, vhicli dots not fade oil dilution of the liquid.

Obi.—Occurs Id tcIiib witli otiier ores of lead. At BleilnTg, Cariniliia; HezMiiyo, Hungary: PNbram; Uoldawn in the Baaat; Aaaaberg, Sclineeberg. ctc.

Ill tbe U. Stiiles, apiiriiigly at the SoutliamptOD Itail mine, Maa^., nod uearHing Slug, N. Y.; uenr PhenUTille, Pa.; at the CotnBIocii lode inNeviida; In liirge lliin orange-yellow tables at liie Tecomali mine. Utah. In New Hl'xIco, pute yell<w ory&lals lu tlie Orean His. In Arizona, large deep red crystals at the Hamburg and olber mines, YiimiiOo., ofien will) red Tanadlulte; also at the Castle Dome dislrlci. HO miles dlsiant; at tLe Mnm-motb gold mine near Oracle. Pinal Co., with vnuadlnlte auil desclolzlle.

Named after the Austrian mineralogist WOireo (1TS8-180C).

Rdnlt«. FenouB tuugstate, FeWO.. Id blackish-brown tetragonal pyramida, perbftpt paeudomorphous. H. = i. G. = 6-64. Eimbosan, Japan.

B*lonMlt«. Perhaps HgHoOi- In minute acicular crystals at YesuTlus.

yH. SA1.TS OF ORQAJSnO AOIDS.

Oxalates, Mellates.

WhawelUte. Calcium oxa}ate, CaCtO, + HtO. In small colorleaa moaoclinlc cryi-tals. Prom Boxony, nlth coal.

Oxammita. Ammonium oxalate, (NH«)iCiOi + 2H|0. From the guano of the Guafiape Islands, Peru.

HnBLboldtiiie. Hydrous ferrous oxalnie, 3FeC,0i + 8H,0. Color yellow. From Dear'Blliu, Bohemia.

Hellita. Hydrous aluminium raellate, AliCnOn -f IBHiO. In square pjrrtunlda; also laaslve. granular, q. - — ■—'" ■ „„.,.. , ■ ™,

rlogla, Bohemia. etc

massive, granular. Q. = l'S5-l'6C. Color honey-yellow. Ocean Id brown coal in Tbu--"--■-Boheir'- -'-

ym. ETDROOARBON OOMFOUNDB.

1 The Hydrocarbon compouodi In general, with tew exceplions, are noi homegaiuotu , tubttantet, bul mixtures, wlilcli bj tbe aciiou of sulveuis or by fmctioual dbiMlntioQ maj ibe separated tuto two or mure compoDeot parts. Tlie; are hence not definite miuuml ape-' clea nnd do not strlctlj belong to pure Mlucntlogf, ralfier, wiib tbe recent guma and reslua, to Cliembirf or, so far u they are of pracCloil tuIuu, to Economic Geology. Id the following jiagea they are treated for the must port nlih great brevity. >

1. Kmple Hydrooarbona. Chiefly memben of the Paraffin SerieBG.Hhi + i.

ScHXBKXRiTB. In wbltlali monocllclc cryalAls. Perbsps a polymer of marsh-gaa (CHi). Pound fn brown coal at Usnacb, Bwltzerlaod.

Hatchettitk. Mountain Tallow. In tbin plates, or mnsilve. Like soft wax. Color yeltowisb. Iteiio of C to U = uearly 1 : 1. From the Coal-measnres near Merthyr-TydrU iu Olamorgsnslilre, England.

Parutfih. a nslive cryBlalllzed paraffin lias been described as occurring En cavltiea In baaultic lava near Palerao, Sicily.

Ozocerite. HinerHl wax pt. Lilce wni or spermaceti In appearnncB anil consistency. CnlorlesH to white when pure: ofien leek-grteu, yellowUh, orownish vellow, brown. £s»t:iilj:Ll7 a piiniffln, and conslatine cblflly of one of tbe blicher membe'rs of tlis series. Occurs In beds of coal, or ossocUted biiuniinoua deposits, as at Slanik, MoldiiTla; Boryalaw lu the OarpatliUuB. Also occura In soutliuru Utslj on a large scale.

ZintrinkiU. Chritmalile. Frp«(/iil« ore near .izocerlte.

FiCiiTBLiTB. Ill wliUc moii.iclinic labulur crysliiK Perhaps CtHi. Occurs in tbin li^-ers of pine wood from peai-beds near Uedwltz. In the Flcbtelgebirge, Bavaria. Uartita lius a siiuilar occurrence.

2. Oxygenated Hydrooarbons.

Amber. BcmsteJD, Qtrm. In irregular masses, with concholdai fracture. H. = 2-S-S. G. =1096. Luster resinous. Color yellow, sometimes rrddlsh, brownish, and whilUh. ortuii tloudtid, somelimcs fluorescent. Transparent to tninelucent. Heated to ISO* begiu to soften, and finally mclls at 380°-300", Ratio for C, H, O = 40 : M ; 4.

Fart of tbe so-called amber is sepiLrated niiueralogically as tueriniU (yielding anccioio acid). Other reluted fossil resins from many nlher regions (e. g . the Atlantic coasl of tho United Btiites) hare been uoteil. Some oF Ihem have been called retinitt, gtdaniU, gltttit*, rumdniU, tinuUU, tfnntzile, chemawiniu, etc.

Amber occura abundantly on tlie PrussinD const of tbe Baltic from Driiiizig to Memel :* also on tbe coasts ot Denmark, Sweden, and the Russian Baltic proTinces. It !s mined eitensively, and is also Tnund on the sliores cost up by the waves after a heavy storm. Amber and tbe similar fossil resins are of vc.t'etable orif^in, altered by fossiliziition : Ibis ia inferred both from Its native situation with cual. or fossil wood, and from the occurrence of insects Incased In It. Amber was early known io the ancients, and called ^kfKrpisv, eleclmm, whence, on account of its electrical ausceptibilUies. has been derived the word eUetriaty.

CoPAUTB. or Hlghgale resin, is from the London bliieclay. It is like the resin copal Id hardness, color, lusler, transparency, and difficult aolubiUiy in alcohol. Color clear pale yellow to dirty gray and dirty brown. Emits » resinous aromatic odor when broken.

The following are oxygenated hydrocarbons occurring with coal and peat dL-poslls. etc.:

Bathtillitb. Occurs in dull, brown, porous lumps In the torbaolle or Bngbead coal (of the Carboniferous formation) adjoining the lands of Torbane Hill, Bathvllle, ScotUnd.

It Diuy be »□ altered rosla, or else material which has filtrated loto the cavity from the aurrounJiDg torbsnite.

Tasmanite. In miaute reddish brown acalee disseminated through n laminated ahale; average diameter of acales about 0'U3 in. Not dlsBolved at all by alcohol, ether, benzene. turpeutioe, ur carbon diaulphide, even when heated. Iletnarkable as yielding 5 B p. c sulphur. From the river Mersey, north side of Tasmania; the rock is culled eombutttdU

Dye Aoiilysis guve 3'Sl p. c. sutphur and 1'? p. (bicily, Hud elsewhere.

Oeockrite. a white, wax-like substance, separated from the brown coal of Qesterwliz, neuf Wuiaseufels. QeomyridU and geoeenilUe are other products from the lame source.

Leccofetritb. Also from the Gesttrwiti brown coal. Between a resfn and was in physical cUai'aciera.

PvKUHETiHiTB. From brown coal near Aussig, Bohemia.

DoppLERiTB. In elsslic or partly jelly-like masaea; brownish black. An acid sub-Biaiire. or mixture of different acids, related to hiimie acid. Italio for C, H, 0. nearly 10 : lli: ,'). From pent beds near Aussee in Styria, etc.

iDRtAUTE. Occurs wiih the ciunabarof Idria. In the pure state white andcryslnlliue In stt-uciurp. In nature fiiund only impure, being mixed with cinnabar, r.lny. aiid some pyriie and gypsum In a brownish-black earthy maleHal, called, from lis combustibility aud llie presuuce uf uierciivy, infiamfnablt cinnabar {QuMkti'Uwbrander*).

FoBuPMYTK. Dccun in Lard, brittle plates or nodules, light greeu in color. From Ifae Great Weitiern mercury mine, LakeCo., California. See also napollie, p. M8.

The followio^sresllll more complex native hydrocarbon compounds of great importance from an economic standpoint.

PelxoleDm. Napbtha; Pbtrolbux. Mineral oil. Eeroaene, Erdfil, BergSl, StelnOl, Qerm. *

PiTTASPBALT: Maltha. Mineral Tar. Bergtheer Otrm.

Liquids or oils, in the crude state of disagreeable odorj raryjug widely in color, from GiilorlesB to dark yellow or brown aud nearly blauk, tbe greenish-brown color the most comiiioti: also in consislency from thin flowing kinds to those that are thick and viscous; aud in apeciflc gravity from 0'6 lo 09. Petroleum, proper, passes by insensible gradations htio ptIfatpAaH OT mallfia (vlaciA bitumen); aud the latter as luaensibly Into (up/iaf(or solid bitumen.

Chemically, petroleum consists for the most part of mem bets of the pai-offln series, Cntlin-1-1, Varying tram minih gns, CUt, to the solid forms. The olefines, CbHih, are Tihn preaeDl in smaller amount. This is especially true of the American oils. Those of the Ciuii':i!>ii.4 have n higher deiisliy. the volatile coasiituents are less prominent, they distill at abi>ut 150° and couiaiu the benzenes, C>,Hin'«, in consideinble amount. There are present also membei-s of the series CnH,»-.. Tlie Gerinao pelnileiim is iniermediiile between the Amnrlcim iind the Caucasinn. ThuCnnmllan petroleum isespechill^-richln the solid paraffIna.

Petroleum occors In locks nr deposits rif nenrly all geological ages, from the Lower Silurian lo the present'epiich. It is Hssnclaled most nbundiuitly Willi argillaceous shales, sands, and sandstones, but is found also permeaiing limestones, ^Iviiig them a bituminous ciilor, and rendering ibem sometlines n confiderahle source of oil. From these oleiferous shales, saods and limestones the oil ofteo exudes, and sppears floating on the streams or lakes of the region, or rises iu oil springs. It also exists collected in subterranean cavities in certain rocks, whence it issues In Jets or fountains whenever an outlet is made by boring. The oi! which fills the cavities has ordinarily bten derived from the subjacent rocks; for the strata in which the cavities exist are frequently barren sandstones. The condition a requireil for the production of such subterranean accumulations would be therefore a bltn-mlnou' oil-bearing or else oil-producing stratum at a greater or less depth below; cavittea in receive the oil; an overlying stratum of close-grained shale or limestone, not allowing of the ea«y escape of the naphtha vapors.

The two regions which now furnish the chief part of the petroleam Bt«, flist Id linportance, western Pennsylvania, with parts of New Tork and Ohio, and, second, the Baku region on the Caspian Bea, at the eastern end of the Caucasus. The oil Las been known to

IB localUiea where it . .

Stales. lu Ciiaaiia, oil ii produced in Lttuibton couDty, Ootario. Other oll-priHluciDg regiouH are found lu Burma, Jupau.tNew ZealEuid, etc.

Aiphaltmn. Mioeral Pitch. Asphalt, BerKpecli, Erdpech, Germ.

Aspbulium, or mlueral pitch, is a mixture oidtflerent liydrocarboni, part of which are oxygtualed. lis ordiuarj characters are as foUuns ; Amorphous. O. =<l-l'8i Home-tioies higlier fmin impurities. Luster liho that of lilacii pitch. Color brownish black and blat^s. Odor bitumlaous. Melts ordluarlly at B0° to 100°. aud burns with a bright flame. Buluble mostl/ or wholly iu oil of turpeutiue, and partly or wholly in other; commonly partly in alcohol. The more solid kiods graduate into the plttosphaltB or mlueral tar, and through these there is a gradation to petroleum. The Suid kinds change luto Lhe solid by the loss of a vaporizable portloa on exposure, aud also by s process of oxidation, which L-unsJsts flnt In a loss of hydrogen, and fiually Id the oxygenation of a poriioD of the mass. Tbe action of heat, alcohol, eiher, naphtha and oil of turpemtne, as well as direct aoalyscs, show that the ao-called asphaltum from different localities is veij various in composition. ,

Aspbaltuiii belongs to rocks of no particular age. The most abnndaDt deposits are superficial. But these are generally, if not always, connected with rock deposits containing some kind of bituminous material or vegetable remains. Borne of the noted localities of asphaltum are the region of the Dead Sea, or Lake Aspbaltltes, whence the most of tbe aspbiitlum of iiucient writers; a Inke on Trinidad, 1} m. in circuit, which Is hot at the center, but is solid and cold townrd the shores, and has its borders over a breadth of } m. covered w llh the hardened pilch with trees flotlrishlag over it; at various places In South America; Iti California, near the coast of Si. Barbara; also in smaller quatituies, elsewhere.

Elatbrits. Elastic Bitumen. Mineral Caoutchouc. Soft, elastic, sonistimes much llfee India-rubber; occasionally bard and brittle. Color usually dark browu. Found at Castletou lu Derbyshire, and elsewhere.

Albbhtite. Differs from ordinary aspbaltum In being only partially soluble in oil of turiieuliue, aud in lis very imperfect fusion when heated. H.= 1-2. G. = I-097. Lusier brillliint. pitoh-like; color jet-black. Occurs fllllng au irregular fissure in rocks of the Lower Curbouireroiie iu Nova ticolia.

Gbahamitb. Resembles albertile III Its pitch-black, lustrous appearance. H. = 2. G = 1-.115. bdluble mostly lu oil of turpeuiltie; partly In ether, uiiphtba or benzene; not at iilt. iu alcohol; wholly lu chloroform and carbou disulphlde. Melts only Imperfectly, and with a decomposition of tbe surface. Occui's in W. Virgiuio, ubout 30 m. S. of Parkcrsburg, ailing a dssure in a Cnrboniferous saudsloiie.

UiLBONITK,alsocalledf7i"(eit/it{«or Ulntalte. A variety of asphalt From near Ft. Duchesne, Utah, which has fouud muny applications In the una. Occurs in uiassea several Inches iu diameter, with cuncholdalfrocture; very brittle. H. =2-25; G. - 1 ■085-1'070. Color black, brilliant and lustrous; sireaknud powder a rich brown. Fuses easily In tbe flame of ii candle and burns with a brilliaul flame, much like sealiug-nux. Hamed after Mr. S. H. Gllson of Suit Lake Cliy.

Blinarol Ooal. Compact massive, without cryslalllDe structureorcleavage; BOmelimcs breaking with a degree of regularity, but from a jointed rather than a cleavage eiriiclure. SoroeiimtfS lamiuuied: oFien fidntly and deiiciueiy banded, successive layers differing Bliglillv iu lUBler. Kmclure concholdal I" uneven. Brittle: rarely somewbat sectlle. H. = 0-5-3-5. G. = l-I 80. Luster dull to brilliant, and either earthy, resiaouB or sub-metallic. Color bliick. gmylaii blnck, brownish black, aud occasionally Iridescent; also sometimes dark brown. OpiKpie. Infusible to subfuslble; but often becoming a soft, pliant or paste-like mss<< wlien heiited. On dialllalion most kliids afford more or less of oily and tarry subslaiices, which are mixtures of hydrocarbons and parafBo.

The varieties recognized depend partly (1) on the amount of the volatile ingredients afforded on destructive dktlllntiua; or (2) on tlie nature of these volatile compounds, for Ingredients of similar composition may differ widely in volatility, etc,; (8) on structure, luster and other physical characters.

Coal Is In genenil lhe result of lhe gradual change which bos taken place In geological history In organic deposits, chiefly vegetable, and Tla form and conipoeltlnn depend upon the extent to which this change has gone on. Thus It passes from forms which sllil retain the original structure of the wood ipeiit. lii;nllel and through tliose with tetts of volatile or bituminous mailer to antbraclte and further to kinds which approach graphite.

^AlOglc

1. Ahthbacitb. muczkohle Q«rfn. H. = 2-2-S. G. = l'82-l-7. Luster brigbt. ofUu BUbmetaliic, iroD-black, aud frequeotlj Iridescent. Fracture concboldKl. Volatile malter after drying 8-6 p. c. Burns with ^ leeble flame of a pule color. Tbe anlhrai-'ites of Peunsjrlviiiihi cotitaiu

ordinarily 8a-B3 per ceut. ol carbon; those of South Wales, SS-95i of France, 80-88; of 8aiony, 81; of uoulherii Russia, sumetlmea 9i per cent. Aulbmcite gradiiiLles tlirougli aemi-auUiracile iulo bitumiauua coal, becoming less bard and coniaiuing more volatile mutter; and an lulermediate variety la ci\\et\ frt»-l>uming anthracite.

3. BlTUUiKOTTS Coal. Burua in tbe fire with a yellow, smokj tiame, and gives out on distil I atiou hydrocarbon oils or Ltir; heuce tbe uame Mfumtn^u*. TheonftTiitry blluiiiinniis coals contain from 5-iS p. c. (rarely IH or 17) of oxygea (ash excluded); while Ihc so-cnlled bromn coal or lignite conWins from 30-86 p. c, after the expulsion, at 100°, of 15-86 p. c. of water. The amount of hydrogen iu each is from 4-7 p. c. Both have usually a brigbl, pitcby, greuiy luster, a Qrm compuct texture, are rather fragile compared with antbracitc, and have U. = 1'14-1*40. The broten coals have often a brow Dish-black color, nheuce tbe name, and more oxygen, but in these respects and others Uiey shade Into ordinary bilumlu-ous coals. The ordinary bituminous coal of Peonsylvania has O. = l'2S-]*87; of Newcu-tle, England, 137; of Scotland, ia7-l-8a; of France, 1*2-1 83; of Belgium, lOT-lB. Tbe moat prominent hinds are the following :

(aj Caking or Coking Coal. A bftumTuous coal which softeas and becomes paa^ or semi-Tlsciii in the fire. This softening takes place at tbe temperature of incipient decomposiiloD, and 1b attended with the escape of bubbles of gas. On Increasing the heat, the volatile products which result from tbe ulliraale decompoBilioc ' ' •- ■ j ._ . .™

and a coherent, grnyish-black, cellular or frltlea mass (or part not volatile! varies from 50-85 p. c.

(b) Nan- Caking Coal, Like the preceding in all external characters, and often la ultimate comnosltlon; but burning freely without softening or any appearance of incipient fusion. There are all gvadatluns between caking and uou-caking bituminous coals.

{e) Cantul Coat (Parrot Coal). A variety of bituminous coat, and often caking: but differing from the preceding in lextiire, and to some e\ti.-nt in composiliou. as sbowu by iu products on distillation. It is compact, with little or oo luster, nod wjtboiit anyapi>earaiice of a banded structure; and ii breaks with a conchoidal fraclure and smooth surface; color dull bkck or gi-ayisli black. On distillation it affords, after drying, 40 to OS p. c. of volatile mutter, and the material volatilized includes a large proporilon of burning ami tubri-caliiig oils, much larger than tbe above kiuda of bituminous coal; whence it Is extensively used for tlie manufacture of sucb oils. It giitduates iulo oil-pradudng coaly shales, the moi'e compact of which It much i-esemhles. Torbanileia a vniletyof cannel coal of a dark -brown color, from Torbane Hill, near Baibgale, Scotland; also called Boghrad Cannel.

((f) Brown Coal (Bi-annkobie Oenu., Lignite). Tbe, proniliienl cbnracterlstlcs of brown cnal bave already beeu mentioned, Tliey are non caking, but nfford a large proportion of volatile matter; sometimes pUch-black. but often rather dull and browiiiah black. G. =

]'|,')-1'S. Brown coni is often culled ligniU. But ibis term is sometimes restricted to moRsesof coal which still reiuin the form of tlie original wood. Jet is a black variety of brown coal, compact in texture, and taking a good polish, whence its use in jewelry.

Coal occurs in beds. Inters trail Ited with shales, saudstones, and cou glome rales, and sometimes limestones, forming distinct layers, which rary from a fraction of an inch to 30 feet or mure iu thickness. In tbe United States, the anthracites occur east of the Alleghany range, in rocks lljat have under^ue great contortions and fraclurings, while the biluininous coals are found extensively m many Stnles farther west, inrockn that have been less disturbed; and this fact and other observations have led geologists to tbe view that the anthracites have lost their bitumen by the acliou of heat. The origin of coal is mainly regeliible, though animal life hnsconlribuled somewhat to the result. The beds were once beds of vegi'latioLi, analogous, in most respects, iu mode of formation to the peut beds of modem limL's. yet In mode of burial often of a very different character. This vegetable origin is proveii uoL only by the occurrence of the leaves, stem^ and logs of plants Tii the coal, but also hy the presence throughout its texture, in many cases, of the forma of the original lil>em; also by the direct observation thut pent is a transition state between unaltered vege-liiblc debris and brown coiil, bt:iiig sometimes found pasalug completely into true brown coiil. Peal differs from true coat In want of homogeneity, It visibly containing vegetable flbers only partially altered; and wherever changed lo a fine-textured homogeneous material, even though hardly consolidated, it may be true brown coal.

For au account of the chief coal fields, asal-oof (he geologicalrelationiof tlie dlfleient Goal deposits, reference is made to works on Economic Qeology.

APPENDIX A.

ON THE DRAWING OF CRYSTAL FIGURES AND OF PROJEOTIONS.

Ik tbe repreaentatlon of cryaials by drawing, the object maybe eitLer to show tlie entire form Id perspective or to give Bimply a projection of the faces u^n a aiagle plajie. The flrst of these coses is the more Imporliint, and must be treated here m some detajl. Two points are to be uoled In rea^ard to it. Id the llrst place, in the drftwinga of crystals the polul of Tiew is supposed to be at an lufiulte dislance. and it follows from this tbat aJI Hoes which are parallel on the crystal appear parallel In ihe drawing.

Iq the second place, iu all ordinniy cases, it It the complete ideal crystal which Is represented, that is, tlie crystal with Its full geometrical symmetry as explained ou pp. 9 to]l{cf. noteonp. 11).

Fhojection of tbb Axes.

The projection of the axes of a crystal Is the flist step preliminary to the drawing of the form of the crystal itself. The projection of the aies In the Isoiuocric system, which are equal and intersect at right angles, la here &rat given. The projtictloa of the axes In the other systems, witli the exception of the bexagODal, may be obtained by varying the lengths of the projected isometric axes, and nlao, wbcu oblique, their inclinations, as shown beyond.

Itometrio System.—When the eye Is directly Id fionl of a face of a cube, neither tbe sides nor top of ttie crystal aro visible, nor the faces that may 989.

be situated ou the latermediate edges. Ou liiruing the crystal a few degrees from right to left a side lalerul face Is brought In view, and by elevating tbe eye slightly the termi-iiai face becomes apparent. In tbe fallowing dcmonslratioD the angle of revolution la designated 3, and the angle of the elevation of the eye, e. Fig. 989 represents the normal position of the horizontal axes, suppii»iiig the eye to be in the direction of tlie axis BB: BB U seen us a mere point, while CC appears of its actual leni;th. On revolviQK the whole throuKb a number of degreea equal to BUB'(5] the axes have the position exhibited in tbe dotted Hues. Tht projection of the semlaxls MB is now lengthened to HN, and that of the semlaxls MC U shortened to MH. _

If the eye be elevated (at any angle, e), the lines B'N, BM, and C'H will be projected respectively below N. H. and H. and the lengths of these projections (which we may designate 6'N. iM. and cH) will be directly prDporlioual to the leugihs of the lines B'N, BM. and CH.

II is usual to adopt such a revolution and such an elevation of the eye as may be ex-

Bessed by a simple ratio between the projected axes. The ratio between the two axes, N : WU, as projected after tbe revolution, is designated by 1 : r; and the ratio of A'N to MN by 1 : s. Suppose r to equal 3 and i to equal 2, Ibeu proceed as follows :

Draw two lines A A'. H'H (Fig. 9ft0), luterset ling one another at right angles. Make MH = MH' = b. Divide HH' into 3 ir) parts, and through the points, N, N', thus delermlned. draw perpendiculars to HH'. On the left hand vertical, set oS, below U', a part U'R.

equal t

1 .

r-H'M; and from R draw RM, and extend the same to the vertical N'. B'B

is tbe projection of the front horlzoiital axis.

Draw BS parallel with MH' and conned 8M. From the point T fn which SM Intersects BN. (Ii-aw TC parallel with MH. A line (CC) drawn from C through M, and extended to the left vertical, is the projection of the ^de horizontal axis.

Lay off OD the rl^l venical a part HQ eqtial to — MH, and make HA = MA' =^ MQ;

^ B

liero, r = 8, ftDd (= 2, tlieo 8 = 18° %V. and e =9* 2S'. lor cot 6 = T, and cot f = rt.

It is dtsirable logo thruugli Ilie alwive construction wilU cHre lo iUBUre all pusBible Bi-cumcy. The axes thus oliluliied, tit.y Iwice Ibe leugLL lieie represeuted, mny be dnwn on n auliuble curil anil |)reiM;rTed for (ulure use. Wlitnever neisded, ilie; oiu be readily tratiafened [o a slieei of paper by priikiiig Ihraugh tlie lerriiiiia! And cenirul [xiIiiIB. In i-iicL ciisc, before Ibe axes so oblaiuedure ueed, Uiey bIiuuIiI be tested lo muke BureiliiLt tlie respective seniiaxeseiiher Bld:jof the centnit point M lire iqual.

Tetragonal and Orthorhombic SyateiiiB.—Tbeaies AA', Cff. BB'. conatnitied In ilie miiiiner d<t«ril>ed, art equal and ni righi angies lo eacli ctlier. Tbe pro-

t^cLiuiL of tbe axes of a letrvgonHi crystnl is oblidned y simply iiiyiuy off. with a scale of proportions! ports, on MA and MA' taken as units, the value of the vertical iixis (i*! furl be given species. Tbus forElrcoD. where i — O'M, we must lay off 0'84 of MA above M an<i i he same length below.

For an orlhorborahic crystal, where tli^ three axes iire unequal, the length of i must before be laid off above una below from M. ami that of li in front i It Is usual to make the side axis MC — 6=^i.

Monocllulo System.—The axes t and d In the monocllnic system. other at an oblique angle = ft. To project this iiicHnalion, and thus adapt the isometric axes lo a moiioclinlc form. Iny off (Fig. 991) on the axes MA, Ma = HA X cos 0. and on the axis BB' behind H, TSb=WBx siii ff. From the points b and a, ilraw tines parallel respectively wiih the axes AA' and BB', and from their Intersection D", draw through M. D'D. making MD =MD'. The line DD" la the ciinodiagonal, and the lines AA, CC. DD' represent the axes In a monocllnic solid in whicha = £ = e = 1. The points a and b and the position of the axis DIV will vary wilh the angle ff. The relative values of the axes may be given them as above explained; thai is, if J = 1, layoftft the direction of MA and MA' a Hue equal to i, and In the direction of MD and HD' a lioe equal to d, etc.

Tricllnlo Bystam.—The vertical sections through the horizontal axes in the triclinio system are obliquely in-clinedi also the Inclinacion of the axis a in each axis b and e, is oblique. In the adaptation of the isometric axes to the trictiulc forms, it Is tlierefore uecesBary. ii le length of J I ind behind H,<

B inclined to one a.

J^^

Brst place,

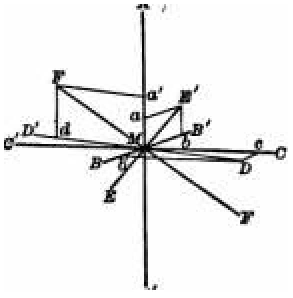
place, to give :liDattoii ofthi

.the requisite 992, obliquity to the mutual InclIDatton of the vertical eec-

lioDS, and afterwards to adapt tbe horizontal axes. The tncliualion of these socIIodb we may desijrnHte A. tind as heretofore, the angle between a and b, y, and a nod e, (8. BB' is the analogue of the brachydiiponal. and CC of the mncrodiagonal. An oblique inclinntion may be given the vertkiii sections, by varying the position of either of these sectiuDS. Permitting the bntchydiag-onal section ABA'B' to remain unallered. we may vary the other section as follows r

Lay off dig. 892)on MB, M'/ = MB X cos A. and on the axis CC (to the right or left of U. nccording as the angle A la to the right or lefti. Mc =. MC X sin A: completing the pandlelogram M£'D>!. and dntwin^ the diagonal HD, extending the same tn D' bo as to make HD' = MD. we nbuin tbe line DD'i Ibe vertical section isinit through this line lathe correct mncrod is con al ,A section. The Inclination of a to the new macro'iiag-

onal DIV is still a right angle: as also Ihe Inclination otatoi, tlieir oblique Inclinalions may be given them aa follows : Lay off on HA (FI^



B92), Ho:

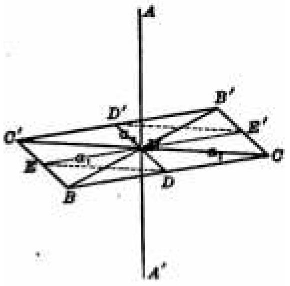
K cos o, and o

the projected bnchjiUagooal. Agtia iay oft on HA, Ha' = HA X cos n, and on HIX, U tbe left, Md = HD' X sia a. Draw tines from a' and d parallel to MD and HA; V, the 1dleiaectioD of tbeae linea, U one extremltT of the macrodUEOnal; and the Hoe FE*, in %vhlch HF = HF', la the macrod[agonal. Tne TertlcaJ axis AA' and the borizoolal axes EB* (brachydtagonal) and FF* (macrodlagonal) thus obtained, are the axes la a tricllnlc form, in which a =6 = tf = 1. Diileient valuea maj be given these axea, accoidlDgioihe method heretofore illustrated.

Hsxagonal Bjrat«in.—The simplest method of obiaininK tbe axes for the hexagonal sjsteui iB as follows : We start with tbe isometric axial crosi (Fig. 060) and change it so thai the front axis (MB, fig. 998) shall have a length equal io 1782 (= f^) times its original length. When the extremities of the litiee CC and BB' are Joined a rhomb will be formed having the angles at C and C equal to 120*. Now draw through the middle po!nIs of HB, HB' lines parallel to CC, and the resulting figure, CDEC'D'F', will be a regular hexagon. The lines Joiningits ancles, namely, CC', DD', BB', will be the lateral axes r^ quired; these are shown lu Fig. 90i, repeated from p. 60, It only remains lo ^ve the vertical axis the length required by the case In b&ud.

9M.

993.



DRAWING OF SIMPI

Jlis

ABD CUMPLBX CrTBTAU.

a beeu constructed tor tbe given species, the oi 090.

;eby

^:_.

htdronh. .. _ ._ _ .

mid la the other systems are obtained a joining the extremities of each of tbe lateral a: with those of the Terlicul axii This is illustrated for LLe Isometric system by Fi^. DBS Here, as in all cases, the lines wbicb fall in front are drawn Btrongly, while tboee beliiud are simply dotted.

For the diamttral prism draw Ihrough B, B', C. C, of the priijected axes of any flpecfes (Fig. 9»5|, lines parallel 'o the axes CC, BB', uatll they meet; Ihey make tbe pnrnllelnEram.

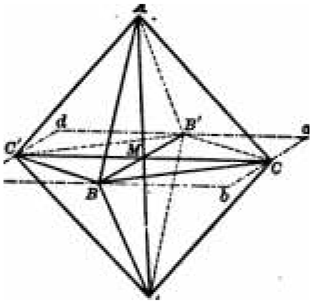
abed, which is a transverse section of the pHsro, parallel to the base. Through n, b, e. d draw lines parallel and equal to the vertical axis, making tbe parts above nod hclow these points equal to Ibe vertical seml-Hxls. Then, connect ibe extremities of these lines by lines parallel to ab. be, ed. da, and the figure

will be that of the diametral prism, correspond ^■

ing lo the axes projected.

In the case of the isometric system (Fig. 996), Ibia diametral prism Is the cube whoae faces are represented by the letter a (100), Fig. TO, p. S4; in the tetragonal system It is the prism a (lOCi). c (001), Fig. 1*9, p. 54; iu the oilhnrbomblc, monocliutc aod tricllnic syslema tbe faces have tbe symbols a (100), 6 (010), e (001), as shown in Figs, 276, 812, 888.

The ynit vertical pri»m in the tetragonal, orlhorhomblc. and cllnometric systems may bo projected by drawing lines pai«11el to tbe vertical axis AA' Ihrough B, C, B', C, maklog



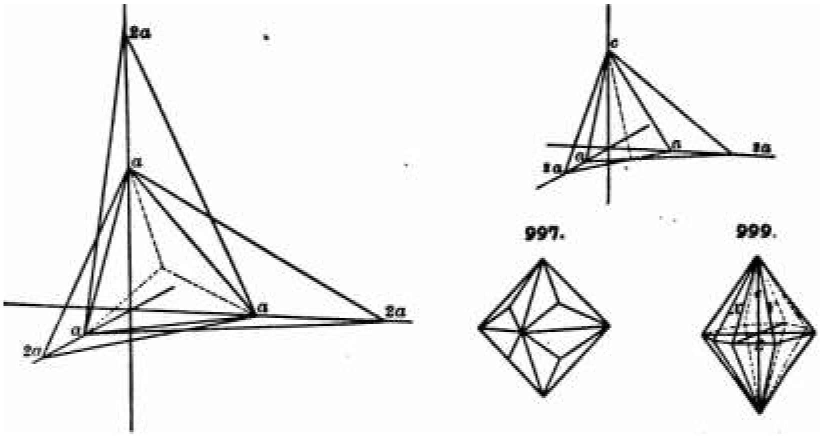
the pBTlaaboTe and below theae pointa equal, and then coonectlDg* the eztremlties of theae Hues bj^ lioee parallel to BC, CB', B'C, vB. The plane BCB'C Is a traoEvene secttoti of «iich a prUu parallel to Ita base. This priam la bounded by the faces in (110), e (001). Gf. Figs. 160, 276, 813,

Oibtr prisma in the orthorhombic, moDoctinlc and trlcllnic sjstems, as (310). (120), etc., are ilrawti in tlie aame way, ouly that Ihe lateral axes must t>e adapted to each case. Tlius tui (210) Ihe uxls b has double the unit value characteristic of llitj giveD species; for (UO) it lius half this value (or, otherwise expressed, the azia a la to be doubled), and so on.

lu the teiragooal ajatem the prisms (810). (310), etc., have eight faces (cf. Fig, IB2, p. 64). TImrefare, e.g. for i210), first draw ia the pluue of the lateral axes Hoes from tlie unit leuglb of each axla to the double of thnt adJoiiilDg (+ and —) : the intersectlana of these eigui lloi-s arc poluta through which I lacs must be drawn vertically (parallel lo ^>, correspond iug lo the edges lettered n in Fig. 1G2. For the hL-iagonal system the conalructiou of liie three prisma la so similar to those described as to eeed do fuKher explanation.

Oiticr simple forms are constructed on much the same principle. The points are first lo be deteruiliied at which the respective faces cut tlie axes. Then light cooatructiun linea are drawn iu each of the axial planes counectlug these points, audat Lbesame lime the Id terscctiou-points noted for endi pair of adjoiuiog faces. Fi-om these last the actaal Inier-secliUD lines of the given form are obtained.

996. 998.



Jlim MA tn om will aerve as illustrations Tlie form Fig. WT is the trisnclahedro (S2S'^ThTth?eefro"t4l^'faces of this have the symbols 381, 21^ 122 (cf Fw 88, , 88). For them the axial Intersections are (see the e>;planation on pp. 28, 24) as follows :

Here the axes a,, a,, a, are. as always, taken in the a, Fig. 896 shows each of the three planes projected lirm-edges " *-■'" ^ --'"

, order (cf. Pig. 85. p. 88). ..jd their respective inlersec-tlie points lettered a. The

sccu HI uu-;"^'"■'-Ihe dotted li..- -o - . , , „ ,.

..,..,pletion of llie llgnre involves no further dilHculty. It ia lo be noted, however, Ibal it is not necessary lo repeat the full ronrtruction for each octant, since he principle of symmetry with respect to the three nxial planes, lliat Is, along lines parallel to each of the axes. ComM lu to simplify the work. In practice, it is well to construct the front half »"£"« 'be aymmetrv to complete the part behind, which is uaually drawn In dotted linea. The symmetry. In any case, is a most vnluable check nn ihe accuracy of the work.

Another illustration la given by Figs. 998. 099 of the ditetragonal pyramid (122) of the tetraeon«l STStem (cf. Fin. 166, p. 58) Thia requires no addilional explanation.

Oomplei Ponin.-When it ia required lo draw not only the faces of a singe form K .... symbol, but also those of a num^r of forms modifying one embraced under the a

■uotlier, ft somewhat different process U found desirable. It Is possible, indeed, 1o con- slruci a. cumplex figure iu tlie way just mealtoned, e&ch plane belo); laid off on the giveu Hxes, UDit its inleraectiou-edges witb adjoinlnji planes determined by two points, always In Ibi: aziKl sectlous, which it has iu commou with each of tbem. In this way. however, the Bgure will soou become so complex as to be extremely perplexing, ncd Ibus lead to error •ud conaequeut loss of lime.

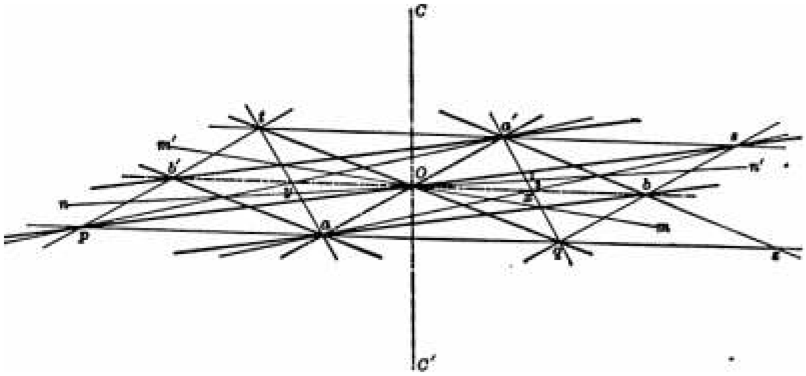
The process of determining the direction of the intersect!on-edges is much simplified If Ihe ezpreGsion giving the ratio of the iutercepls on the axes for each plane ia so tranaformed (by dividing by the coefflcieuL of the verticul axisi that the value lot the vertical axis shall be unity (that fa, [□ general equal to ij. The extremity of the vertical axis (-f or —) U then OM point of intersection for any two planes, and the other point will always be in the plane of the lateral axes.

As an einmple of the traneformalion culled for, suppose 834 to be the symbol of a given face, lis intercepts on the axes a. b, e would be (Art. 84) ia : Ifr : ie. This put Into thu form required for the present purpose becomes (by muptiplyiug by 4), ia:2b:c.

It will be noted that the expression inus obtained is not ordinarily that which corr^ sponila lo the Naumaun symbols, Tor with them the length of a lateral axis (usually a) is taken as the unit.

Example.-—The explanation of Ihn method' of drawing cryslala can beat be described by use of a concrete example. Suppose Uiut it is reijuiied iu aruw an ortborhombic crystal (HuduluBiK!) of pristuutic Lnbil (Fig. 1000), showing the fiicea a (tOO), e (001), m (110), f (101), »(()11), o(111). f (121). It Is evident that an ItideSuiie number lOOa

of tignres may 1>e niado, including the faces mentioned, tind yet of very different appearance according lo the relative size of encb. It Is usually desirable, however to represent the actuiil appenrnnce of Ibe crystnl i[i nature, only in idenl symmtlry, hencu it is Important in all cases to bnve H sketch of the crystal to be represented, showing the relative development of the different fnces. If this sketch Is made with a little care, so as to exhibit also the parallelism of the Interaectlon-edges In the occurring zones, it will elve material aid. The zones, it Is lo be noted, are a great help in (irawing figures o(crystals, and they should be carefully studied, since the common direction of the Intersection-edge, once determined for nay two faces in it, will answer for all others.



The first step la to take the Isometric axial cros-s. already dntwn on a suitable card, aod of a conveniently large scale, and pierce il through on to the paper to be employed, and then adapt It to the lequlrcmeuta of the species Tq hand. For andalualte the axial ratio U u :&: i = 0-M : 1 : O'TO. Hecce the vertical axis muac be 0-7 of its isometric length, but (Id this case) the lateral axia calls for no change.

The next atep is to draw on the plane of the lateral axes (Fig. 1001) a line giving the

trace of each face as it Is Deeded. Each line Is obtatoed from tlie expreailoD of the azt&l Intei'ceptB trnnsformed In tha manner tireadf explained, so that Ibe value for i shall be uuitT. For tlie faces of tbe prism, m(llO). the required lluea are pt and at (Fig. 1001). Obviously their intersection-edges are parallel lo ibe vertical axis, vrblle their Interaectlona with tbe base c (001) are parallel to pt uud ;(. Simllarlj the mutual iuierecclloii-edges for tbe faces of tbe prism k (£10) and the pioscoid a (100> will be panillel lo CC

Furtber, the correspondlog Hues for the upper faces of the macrodome, cr, thsl Is, 101 and lOl, are pq and It: those of tbe faces of the cUtiodome ((Oil) are gt and pi; tlinse of the faces of the pyramids o (111) are ab, ba', a'i/, b'a; those of the pyramid e(121). whiise Intercepts In the required form are la: JA: le, areas, ga', a'p, ta. Each of Ibr planei mentioned passes also through C, the extremity of the vertical axis. Therefore, wlintevcr tutersectlon-edge Is called for is given at once by tbe figure. For eieniple, tbnt for the fac«s ■ (331) aud « (Oil) Is the line joining C with >, since (be lines at and g* repreMiiiin^ these planes intersect at« and all planes pass through C \ further, the ssme direction is tbnt of theiutecsectiou-edgeot ffl(tlO), f (llil), since the trace of m (110) also passes throueb the point I. So also the intersection-edge of o (111) and s (121) will be the line join lug C and a. aud tbe same line Is that required for r (101) aud 0(111); that of r and r'^ElO) Is given by the Hue Joining C and i. since the trace of k", or fun' (Fig. 1001 ; cf. Fig. 1002), ir produced, meets that of r (101) orp^at s.

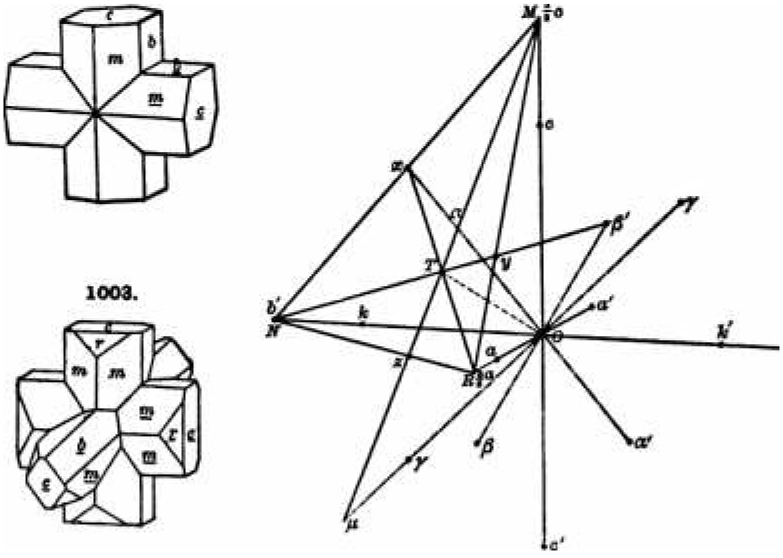
The above eiphioatlon will show bow tbe required iDleraectioD-edges cbd be obtained as needed. In the practical use of the method ii is cusLomary to begiu with the predomiuating forui aud tbeu add tbe modifying faces Id succestlon. That li, Id the esse tn banil. tbe prism m would he drawn teiiuiunteu by e ; then perfasps tbe pinacold a added ; then tbe prUni J:(210), and afterward Ibe-IemilDal faces.

The actual figure U usually made on the shtet of paper below the axial projecilon (Fig. 1001), the directions of the Inter si ctionidgcs being carefully transferred by menns uf a trlauEle sliding agidust Ibe dde of nnothtr triangle or a ruler. The figure should be made cunufierabty larger lliaii as finally required, since only In this way Is sufficient accuracy nttaiunble. Tbe final figure of tbe required sise Is readily accompllabed by pholo-engraviug, if tbe drawing Is done clearly and iu black llnea.

To complete tbe figure beblnd, the Intersection-lines can be oblalned Id the same way. It is to be nutbd, however, thai In tbe given case (of an orthorhombic crystal) tbe sj m> meuy can be used to simplify tbe process, or, if desired, merely to check tbe work duoe, since every point in front has a correspoDdlng eymmeirical point behind equally distant from tbe axial plane be, in the direction of ibeaxha, Tbe symmetry right and left relatively lo tlie axial plane ae also should be usid lo tesl the accuracy aa regards ibe two pities of tlie figure. When the upper half of llie figure (or. if preferred, the front half) Is completed, the symmetry, as noied, ia usually employed in the completion of Ihe remainder, since (in Ibis case) every liue in front above has one paiallel and equal to It behind below. In the case of crystals of lower grade of symm etry tbe method Isiessiimple, and in some instance* considerable iugeauity Is culled for, hut pnictlce will serve to give faclliiy.

On TEtB Drawina of Twin Crtstals,

Twlsnad Oiyatals.— Id order to project a compound or twinned crvBIal It Is generallT necessary tn obtain first the axes of Ibe second individual, or seml-individual, In the position iu which Ihev ere brought by tbe revniullon of 180'. This is accomplished In Ihe following manner ■ ' In Fig. 1008 a compound crystal of stiiurolite Is represented, Iu which twinning has taken place (I) on an axis normnl lo 1082), aud In Fig. 1008 this is shown again with also twinnlnit on an axis normal to (2321, Tbe second method of tw[oiiing being the more ireneral. is of the greater importance foi- the sake of example. Iu Fle^ IftH r^, W. *.■ repre«enl the recUnguUr axes of slsurolUe d : !: i = 0-47 : 1 : 0-68). T-he t*vlu-nlng-plane (2821 lias the position MNR. It is first necessary lo coustruct a normal from ibe center O to this plane. It perpendiculars be drawn from tbe center O to tbe llnea MN, NR, MB, they will meet rbem at tbe points *, a. i. dividing each line Into segments proportional to the squares of the adjacent axes ;• or Ni: Mi = ON' : OM". In this way the points x, y I are fixed and lines drawn from nnv two of them to Uie opposite angles R. N. or U will fljc the point T, A line joining T nod O is norma! to the plane iMNR = 28-2). Furlber-more it is nbvious that if a revolution of 180° about TO take place, that every point in the plane MNR will remain equally distant from T. Thus tho point M will take the place gtinU u, ff, St, and the common centtir O will be the new axea correit»oDdiDg to HO, NO, O. In order to obtain the unit axes coireipondlog tah.h, d It b merely neceawry to-dniw through e a line parallel to MTu, meeting xO at y, then yOr' 1b the neir Teril-


1003.

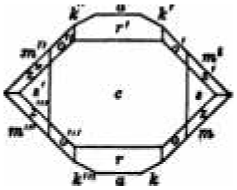
cal Hxla corregponding to eOe*; also, fiOfi'carresponAi to bOV, and oOa' correaponda to aOa!. TlieBc tlireeiiKes. then, are the axea for tlit xpcond inillvidiml Id Its twiunvd posUioD : upon tlieiii, 111 llie usual way, the new figure iiiiiy be coustructed and then ttsnaferred to Ita proper positioD with reference Ui the iioTiinil crystal.

For the second melhod ol iwianiae. wheu the iixIb ia normn) to (033\ the construction Ih more ^iiuple. It Is obvious that the axis is the line Oz, and using this, as before, thv new axun nn Fiiund ; kOk correaponds lo eO<f (sensibly colncidlug with W), since e (OOl)A (m = 45° 41'. and so on.

Ill muuy cases the simplest method Is to cocatract first the normal crystal, then dt«w through its center the twinning-pkne and the axia of revolulfon, and determine the angular points of ilie reversed crystal on the principle alluded to above : that by the revolution every point remains at the same distance from the axta, measured In a plane at right anele to the axia. Tlius in Ii'ig. 884, p. 120. nheo the scalenohedron has been drawn, since liie miiiuing-plana is the b^l plane, each angular point, by the revolution of 180*, obtains a poaitlon equidistant from this plane and directly below it. In thia way each angtdar point Is determined, aud the compound crystal ia completed iu a '

Dbawino of Projections.

Borizontal PreJeoUoiM.—It la often conveoient to have, Instead of a drawing of a complete crystal. B .ip-called horizontal proji'ction of its faces upon a single plane. The plane selected is usually thai normal to the prtiinialir zone—in other worda. that parallel to the base (if nl! crystals except those of the clinomctiic system ; Pigs. 80, 83. 84. 8«. 39, on pp. 15, 16. are ezamplei. O'Iiit planes itiny also be taken with advantage in certain cases, ai, for example, the clinodUgoiial axial plane with monocliolc crystals. Fig. 836, p. 108, represents such a projection of a crystal of epidote.



IS ua'. W repreat'til the lutarsl

t or llie pyramid, i (121). lUe

In Fig. loot) tbe dotted Hoc

:s (beiu aensibly eciuaJ). Tlii

"•(110) o

k (210). luB imea 7i7. i litius <M, u'j. u'p< uiid ^ .

The intersettlon-edgtii for aoy two planes wfll be jriven by the line drawn through e (the eslremily of Uie vertlckl axis a* projected, coniiiiun to all plaues), and also through the polot where the Uues represeDting the (jiven planesiaieraect. Thus the r&uesB &oil t are repreeenled iti the projecliou by the Ifoea i; hence the intersection-dlreclion Coi the two

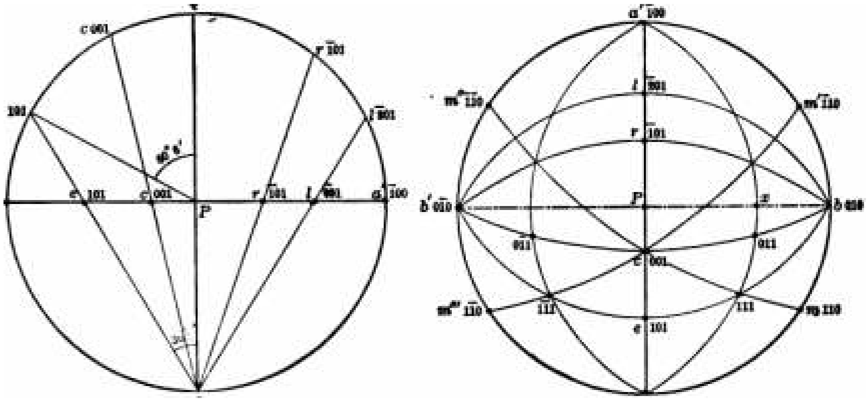
The projection shown in Fig. lOOS. when each face of a irjslal is represented by a lin« on a given plane, iiBUtilly lliAl u'lrmal to the pmmatic zone (vertical snisl, was proposed by Quenstedt, and ia known ns the (iutmUdt Pi-irieetion; It was made by hiin the buU of ui eiaboiftte system of cryBtalloRrapliy, It will be noticed lliat wioeR here are represented by poinU, since all the lines repr.'sintirijr i lie faces of a given zone must pass through tlie same point in the plane of projection ; ihis is slUl true malhematiciilly of lines which ate parnliel.

Spherical PrcJ«cUoik.—Vnrions itiotbods Imve been aiiggesled aud are in use for representing the positions nf tbe fucts of a crystiil. especially with rtspect to their zonsl rela-lions, tlie angles between them, file,: these do not, however, iitteitipl ui give a picture of the crystal itself. One of tbese—the Quenstedt pnijection—represented by Fig. 1006. has nlremly been spoken of. Another vnlnable method is thst of GoldscUmiMt. which lie makes the base o(his ingenious and practical system (see references on p. 117).

The most serviceable melhoii and the only one used in the present book Is the spiieric*! projection desciibed in Arls. SS to 42. and of which examples are given in the paees follow. fng (see Fig. 110, p. 41; 171. p 58, eic). Tbe method of construction needed hu been •xplained in Art. 40, sii far as ll applies to the orthomelric systems.

For the monoeiinie lyttem it is to be noled (cf. Fig. 827. p. 108, and Pig. 1008) lb« while the poles of the prismatic faces still lie on the clrciimfenmce of the circle aud can be fixed at once ^ilh a protractor, and while all the ortliodomes (AOO He in the diameter from n (100) to a' (100) at 00° from b (010), the base e (001) is not the middle point of the circle, as ill the projections of the orlbometrlc syatemB. The position of e can, however, be readily flied, since the complement of the angle at (100 A 001 = i3) gives its angular distance from the middle point of the dkmeter oa'(P in Fig. 1008); sud this distance od tbe

projettioii is ptuponlonal to the taogeut of halt tbls augle In lermg of tbo given ndiui. So itlso tLf pi,»iiiou of uny orthodome whose aogulftr dislnnce from a (100), o' (1001, or e (001), U known c&u be flxed on the sphere of projection In the same way.



Instead of using the tangent of the half angles with a scale of proportional parts the distances may be readily constructed witliout cnlnilBilon. Thus for epidote we have as. 100 A 101 = 38° 54'; ae. 100 A (101 = 84'"87":

tt'r, ioo A ioi = ar 41';

a'i. ioo A SOI = 25- 57'.

Draw a circle with the given rsdiua" (Fie. 1007) nnd measure oB on llie circumference from a (100) and if (lOO) the successive uiigtes given. Then jnin Ihe points m flxed with the point o, the opposite extremity of- Ibe diimieier at right angles to aPa'. which is supposed to be the position of Ihe eye in this method of projection. The roinls where these lines intersect the diameter apa^ jrive the position of g (101), e (001), r (101), I (201), to be used rortiie projection of Fig. 1008.

Wlien the positions of llie poles of Hie orlhodomes of the given crystal are fixed In t'lu diitmeter no' (Fig. 1008), nnd also those of the prieniB tn Ihe circiiDifereDce of the ci'cle. it is obvious thai the pole of any other face can be determined by dnwing ihe proper circular arcs. Thus the arc 010, 101. 010 and that 110, 001. liO together determine Ibe position of 111, and so on for any pyramid. Again, the arc 100. Ill, 100 and 010, 001, OiO determine the position of Oil. It ia to be noted, however, that for sake of scdiracy it may be better to flx the pole of Oil. or any riven clinodome, independently. It (Fig. 1008) a diameter be drawn connecting b (010) and Zi* (010), it ia dear that the angular dlMance bx and hence Pz (P* = 90°) can be obtained at once by the fnlution of n siuple rlgbtangled triiiDglu in which tlie hypolhenuse (010 a Oil or In general 001 a Okl) Is known and also the sTiifle at S—the last being equal 10 90°—oe. When Ihe point x is known the circular arc axn" dalermiaes Iha position of Oil, and so in irfneral of anv clinodome. Fig. 1007 makei it clear at once why, as stnted in Art. 40, the t"ngent of half the angle from ihe central pniutofthp sphere plves Ihe position of anv pole. Ihe radius of Ihe circle being laken as unity. It tesHen here (Pic 10O7) that the actual angle, for example eC 8'. foT?(101)ai the center Is one-half the corresponding anele'80° 8'lst the cltcnmference ; fnnher, thedlKtSDOe P- ii proportional to tan 30° ff (tnn i 80* 6'), where the rsdius aP Is equal tn unity. *

In tlie trielinie ty»ttm the spherical projection ran l>e drawn hj an extension of the iiisthod just described It Is assumed that the angles between Ihe pinacoids are known, (A. ne, he : also tlie angles of the triangle nbc which are the supplements of Ihe axial anglea a, fi, y._ In the first place the positions of a (100), 6 (010). and of Ihe prisms aie fixed bj the protractor on the circumference of the circle. How dntw through aa' k

1 and a'. A circular src drawu llirougli BB' und e (001) will t tilt! iliameler oo' at & point £, whose diitaiice from tlie center P can be oLlcuUled m a right-angled spherical triangle !□ which the hjpotheuubc (oe) and Ibe adjac«ut aiigla at a are koowu. Heoce the poHltfon of K i* flsed. Agaiu, draw the diiimeler bb', aud Ht ligbt aagles to It aooCher diameter, AA'. If L Ib the polut on blf where il is cut hy the circular arc through bel/, the dlilance PL can be aimilurly calrulated. With K and L both fixed, it is easy to draw oeo' and beV, and thus deteriiilue the podtion of e. After the zone circles aea' and M/ have been drawn, Ihe poeiliou of auy dome (Mit or OkC) cau be similarly found by a sinzle calculation, and aa the prisms have been fixed It is easy to locate any required pyramid.

On the general method of projection applicable (o triclinic crystala, see Qrolh, Pbys, . Kryst., p. 679, «t ttg., and Lleblich. QMmelr. Kryit., p. lU, el Mg. *

APPKJSDIX B,

TABLES TO BE USED IN THE DETERMINATION OP MINERALS.

ThiB Appendix coctalna % wrlei of tBblea, more or teu completQ, of miDenls arrnDged according to certain prominent ciTitallographic or physical cbaractan. Tliesc, it I* twlieved. will be of aerrice not onlv to the Htudenl. but also to the Bkilled miueralogiM. Table I,. ofMJnenli arranged accora lug to Sjritem of Crystal llzatk>n, is intended to Mabraca all null-recoguized ipeciea, IbouKh those of relatlvelj greater importance, especially >• regard* occurrence, are Indicated By being printed In heavier type.

The other tables make no claim to completeoesa, being limited often to common aitd important species.

For an exhaustive system of Determtnative Tablea based paitlcularly upon blowpipe and chemical characters, the student Is referred to the work of Professors Briufa and Penfield, meniloned'oD p. 206.

I. MINERALS ARRANGED ACCORDING TO THEIR SYSTEM OF

CRYSTALLIZATION.

The following lists are Intended to ioclude all well-recognlEad species, whose crystalllzallou is known, arranged according to the system to whicb they belong, and furlh^ classifled by tbelr luster and specific grBTliy ; tbe hardneas is also given In each case.

I. CRYSTALLIZATION ISOMETRIC*

A LUBTBR UhHETALLIC.

ShI Ammoniac (p. 8l9)

EnliQJte(p.53i))

Fauiiuite |p. 460)

Bylvlto (p. 319f

HaUUlp 818)

Hydri-phflile (|>. 821).

Sodalite (p. 41?)

Analcite (p. 460)

NosaUte (p. 418}

Niirtljiiiiite (p. 864)... Hallynite (p 4IS)....

Leucit«(p, 881)

Lazurite (p. 418)

Sulpliohfilitelp. 531).. ItaUtouite (p. 838)....

Voliaite(p. 537)

Langbejuile(p 533)...

Zuiivilc (p. 414)

FoiriicitB(p,882)

BoraclU (p. 518(

Pharmacoiiderite(p.Sl 8) Nitfiibariie (p. 61''' Flnorite (p. 830). Helvite(p. 414).. Oaniet(p, 415)., Uhod!7.ite(p. G18) Daiiiilite I p. 414). Haiieriie (p. 801), Diamond [p. 371) Spinel (p. 388)... Periclaae (p. 831).

ArsenolLte(p. 880)... Hcborlomlte (p. 419). Hercynite (p. 33B)... Sphalerite (p. 291)... Nanlokite (p. 817)...

Marahile (p. 317)

Akbnndlte [p 2B2).. PerovBkite (p. 4R7)... Berzeliiti; (p. 405).... Qabnite (p. !i89) .... Pyrocblorefp. 480)... Koppiie(p 4«9) ....

Zirkplile<|>. 846)

Halcbellolite <p. 489).

Lfwipilie (p 516)

Alopile(p. 516)

Percyliie. Bolelte(p. 822) Hnu/.eliilc (p. 516) .. Mangniiosite tp. 833).

Emboliie Ip 810)...! Oerargyrite (n- 319)

Miersite(p. 3IB)

Microliie(p. 489) ... Inil'ibromite (p. 319). Brimiyrite(p 819)...

Ouprite(p. 881)

SnlyUte (p. 414) ... Buiiseoite<p. 882).., Honin)c>lile(p.49a),.

Hauerlte (p. 801)

BpbalerlU! (p. 2»1)

Alabaodite (p. aes)

aut)uiite(p. 297)

Dyunalyte (p. 468]

StwiiiUe(p. 81G)

Ohromita(p. 841)

Biunite(p. 8P8)

TeiUMuUta(p. 318)

Tetrahadxlte (p. 81S).. Magae»io(ernii: (p. 841) PsntloDdit* (p. 398)... Polydymile (p. SWJ),...

JaCDbElte(p. 341)

Syt^liDodymite(p. 298),

Umiwlte (p. 297)

Carrollite (p. 287)

Ulxbyltetp. 843)

PyTlU{p. 800)

FnuiUiaita(p. 341)....

Magnetite (p. 889)

Boniit« (p. 297)

Oersdorfflie (p. 303)

Onprito(p. 381)

BrouRDiardiM (p. 30B)..

CorynUe (p. 803)

Argyrodit<)(p. 816)

OobalUte(p. 801)

Caiifleldite (p. 816)

nUmannite (p. SOS).... SnultiU, ChloaDthlW

(p. 301)

Skuiierudlte (p. 807)... WlllyHmite<p. 302).... Polynrgyrite (p. 316)...

Lnurlte(p. 802)

Arg«ntite(p. 288)

Iron(p. 281)

Oalen« (p. 287)

Eucalriieip. 289)

MetiiciimabBrite <p. 292) C'auatLaliie (p. 288).... NiiumaunlU ip. 288)...

AltftltB(p. 288)

TieiimnuUe (p. 392)

HoBsiie (|>. 289)

Ooppor (p. 278)

Uruinito <p. 521)

SUvorip. 278)

8i«rrylite (p. 302)

Lead (p. 279)

Pallddlum (p. 28!)

Amalgam (p."279)

PlaUnum (p. 280)

Oold(p.276)

Iridium (p. 380)

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6-4-6 U , 5-5-6

6-7-6 86 ■ 6

6-87 I 6-5

6-97 2-5

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73-7-36 2-2-5

7-8-7-8 4-5

7-4-7-6 1 2 5-8

8-2-8 5 I 2 5

8i\-8-9 I a-5-8

8 8-8 9 2-.-.-8

9-9-7 5-5

101-111 2-5-3

113-11-8 13 7-11-1 14-19 ' 15-6-19-3 I 32-6-22 8

II. CRYSTALLIZATION TETRAGONAL.

A. Luster Unmetallic.

Torbendte(p. 516)., I Trippkeitefp. 516)..

Oct^edrite (p. 346).

Rutile Ip. 345}

, Xanotlma (p. 494)... ' P.'welli(e (p, 541) ...

Thorite (p. 480) ....

P«rR.l8<inite <|.. 490) ,

Ziiooa(p. 4281

Itomeile(p. 516)

Sipyliiu (p. 490) ....

Oi>immnli1e<p. 408)..

SoheeUte (p. 540)....

PhoBgeoite (p. 364)..

OalomeKp. 817)

Wulfemto(p. 541)...

OoMiteritv (p. 344)...

Hallockile ip. 322)...

Taplolite(p. 493)....

Siolslie

8-8-a-D5 I

4-l&-4-3.'>;

4-46-4-56 4'S3 4-4-5 4 4-4-5-8

4-68-47

,ab,GoOgIc

AFPBKDIX B. B. liDBTBR HiTAij,ic (akd Submbtaluc).

Ohalcopyrlt* (p. S»7)...

Rnm«(p.M6j

t'eigUMJuitB (p. 490)...,. Hauamaimita (p. 342).., BrauniU (p. 348)

PolUDlU(p. 845)

iteluit«(p. 5«3)

Haucbecornite (p. 3B6)

TapioHle (p. 4Ba)

PlHltuedte (p. 84G)....

ni, CRTSTALIZATION HEXAGONAL.*

Rhom bo belli 111 speclea are dUdDgtilshed by a iMter R.

A. LCBTBR Umicbtalijc.

Jarosite (p. 587) R

Ifaimondlte (p. 5S6)...

Hamliulte(p. 608)R...

Pyiochioite (p. B61) R.

jKreniBjidvitetp. 61B)...

DlopUM (p. 4S4) R...

STBiibertfitc (p. 61fl) K.

Ci-onBtedlile (p. 475) R..

HemnloKte (p. 1507] R,

Counellllit! {p. 5B0)

MesltHe (p. 368) H

RhodochTOilts iHC9) R.

8vabile(p. 601)

81dm1te{p. 35«) R

RliBbclopliBulie(p.GOg|R

Wiirtziie (p. 2B5)

Conindam (p. S3.'l) R..

WlUemita (p. 452) R...

Si)l'a>rocofaa1t!le (Sfil) R.

MeluDOCBiite (p. 407) R.

Trilomite (p. 407) R...

NordeuBkiOldiiie |518) R

Csiyocerile (p. 407)6...

Parisite(p. 864)

Smithiontte (p. 3601 R.. BeudanUte (p. 516) B. .. I Pluinboguramitef(n.ai4} ' Cappeleoile (p. 407).., ai«enocUU (p. 294).. Hematite (p. 334) R... XaolbocoDite (p. 815)1

Zinoitelp. S3S)

FrouiUte ip. Sll) R...

lodyritc (p, 819)

Fluocerite (p. 323)

PyrMgyrita (p. 811) R.

Penfleldlieip. 323)

BaryeiHtefp. 408)

Ty»'.nile(p. S3I)

Pyromorphlta (p. 499) T>iiadliiita(p. 500)....

Mimetlts(p. 500)

Oinnabar (p. 393) R...

■ Some pieudo-hexlcon*! ipeciei are Included.

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8-38-8-42 8-46-3 60 I

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4-9-5 0 4-9-5-3 5-5-2

5-4-5-7

t-6-5 3-8-6 5-5-6-5

6-66-6-86 7-0-7-25 I 8-0-8-2

APPBKDIX B.

B. LUSTBB HBTAI.UO (abd Scbiotallio).

Tesobemncberfte (p. 864) Thermotiatrlte (p. 886).,

Ctiroallite (p. 822)

BtniTtlB(p. 607)

£pBomlLe(p. 688}

Ma»cagaite (p. 628)

KesqueboDite <p. MO},..

OiMlarite(p. 688)

Moieaoiite {p. 68S)

Bnlphnr (p. »78} ,

Lltidackerite(p. 610)....

Newberrite (p. SIO)

Niter (p. 617)

eideronatrite (p. 587)....

Pliielllte (p. 882) ,

H«troUt« (p. 461)

Okeiiiie?(p, 438)

Fe!Bftliauji[e(p. 587).... ThomBoalte (p. 402'....

WavelUte (p. 5I8|

Hnmbergiie (p. 518)

PirssoDlte (p. 806)

8>iirobori(e(p. 531)

PJMilierile (p. 512)

I'egiiiiile (p. 612)

Elpidileip. 407)

HowlUe?(p. 519}

Fraluiit« (p. 442)

ADhydrits(p. 538)

AraKonite (p. 301)

Spodioalte? (p. 508)

LeucopliHoile (p. 407)...

Danbotil* (p. 4S0)

T\-n)lite(p, 611) ,

HnrKtiglte (p. 442).... .

Rfdiliiigit.-(p. 506)

Bertmncliie (p. 440)....

Lftiiiliiiiiw(p. 866)

loUto(p. 4071

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Hopeile (p. 507)

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CRYSTALLIZATION ORTHOBHOMBIC. A. Luei'BR Unmbtaixio.

T«lo{p.476}

Berylloolte (p. 496)

Hftidtagerlte (p. 610}

8treDgite{p. 610)

lAwsoDlte (p. 447}

Hnlnlte (p. 448)

Aathophylllta (p. 896)..

Andalniite (p. ^)

Bnrtatit* (p. 384)

Antaiiite(p. 515)

MoDtlnelUte (p. 482}....

CbifdieatM (p. 618)

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Foratarits <p 422)

Duniorllerile (p. 448)... Konierup[iie (p. 461) ..

Zot«ite(p. 487)

Dufren:t*(p. 500)

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Giiiiiinile (p. 487)

Calaminafp. 446)

Lltbiophil[1e(p.4ft8)...

TopaKp, 431)

Langiie(p. 186)

UrsDocirciM (p. 616)..,

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Mazap[liie(p!'G14).^ Hemnfibrite (p. 611)... Ohryiobwyl {p. 842) .

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BrooUU (p. 847)

nvalta (p. 445)

Steruberelte (p. 200)... HaiiguiU«(p. 846). ..

Bnarglte (p. 815)

SUbiiit«(p. 28S)

Fanisiioite (p. 816).. .. Klaprotbulite (p. 808).. WUlicheDite(p.810)...

Eiixenlte (p. 4S3)

CliBlcosUblie (p. 808)...

Pyrolaalt* Ip. B47)

P.tlymigiiite (p.403)..

Stjl..iypite{p. 310)

MaroaaiU (p. 803)

^xclilnitc (p. 498)

Zinkanlts (p. 807)

Andorile (p. 308)

6Briurite(p. 806)

Oolnnbite {p. 490).... SiiiiiiHte(p. 308)... . Dafrenoyalte (p. 809). Olialcoeit* rp. 3601... YttrotHntallle (p. 462). JamMOnlttt (p. 808)... A.niier&(llte (p. 468)... Helanoteklle (p. 446)..

B. LUBTER UbTALLIC (ARD SCBITBTALLIO).

6-6-0 Bounioiiita (p. 810)..... 5-6-6 Bonlangarita (p. 809).... 1-1-5 Hielmile (p. 408)

Diaphoiite (p. 809)

aUDcadot(p. 804)

Anenopyiita (p. ^08]...

Kentrolilc (p. 448)

Alklulied). 810)

Stromeyerite [p. 290)....

Staphanitetp. 814)

OuanaJuiitUe (p. 384)....

Geocroolle (p. 814)

Wolfochlte (p. 804)

Bmplectile(p. 808)

HeneghiDlM (p. 813}....

BiimnthlnlU (p. 284)...

Schapbacliite (p. 806)....

AI1oclAslle(p.804)

Cosalite (|i. 806)

N«5yagita (p. 305)

Rannuelsber^clic (p. 804)

Safflorllefp. 804)

I TanUUte (p. 460)

LollJiiKi'e (p. SOlt)

Aoanltaita (p. 290)

Krenuerfte<p. 805)

Dyaoruita (p. 388)

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4'8

4 66-4-9

493; 5-17

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5 ■0-6-3 S-10

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Snssnllte (p. 852) .... LaDsfordite(p. 367).. Hniiiiayire(p 510)... ATniintLiiiie (p. 636)... Ohaloanthitfllp 681).

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Rhodonite (p. 805)

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Cbloritoid? (p. 471)....

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A.PPBNDIX B.

IL CRYSTALLINE HABIT,

I. ISOMETRIC SYSTEM.

lu ibe followlDK liaU aome Bpeciea are euumerMed whose citbUIUim lublt U often lo Diarkeil us to be a distinctive character.

Oubei.— Metallic Lcsxkb : Qaleua; Pyrlte,

UnhktallicLubtbb: Fluorlte; Cupriie; Cenr^rite; Halite; Sylvlte; Boradte; Pbar-mBc»iiiLli.-iits. Also Percjllle; Cerargjnte; Perovakite.

Cube-iikt formt occur with the lollowing: Apophyllite (tetragonal); Cryolite (motio-cliuic), AIM) with ibu rhombohedial speclea: Chabaziiei Aluuitei Calcltei rarely Quart! oud UemaLile.

Octabedrona.— Metaujc and Bubuxtaluc LuarBs: Haguetite; FrankUulle; Chro-mitu; Unmiuite. Also sometime*, Qaletm; Pyrlte; Liaatelie; Dysanalyte.

(Jnuutaluc LuaTBS : Bpluel (iiicl. Hei-cyalle aud Galiulte^; Cuprite; Diamond; Pyro-chloni uud Mlcrolite; Ralatonite; Perlclase- Alum.

Forma aumi:wtiat I'eaembliug regular octahedrons occur with BOiue tetiagoaal species, as Braiiuiie; UausmaiiDile; Cbalcopyriie; Zircoo, etc; alao with some rbombohedral apecies, aa Doluuiite.

Dodeoahedroiu.— Metaluc Lustxb : Magnetite; Amalgam,

Vnxetallic LvaTkB : (lurnet; Cuprite; Sodalite.

Trapezohadrona.— Unubtallic Lubteb ; GHruet: Leucite; Analcite.

Pyiitohedrona.— Metallic Lustbr ; Pyrlte; Cobaltlte. Also Geradorfflte; Hauerlte (subuiutallie^

Tatrahedrona.— Metallic Lustbr : Tetrahedrlte.

Ukubtallig Lubtbb : Spbaleritc; Boi'acite; Helvlte: Eulyllte; Dl&moud.

The tetragonal spheuolds ol Clialcopyrlte may resemble lelrahedrona.

II. TETRAGONAL SYSTEM.

Sqnar* Fyramlda.— Submbtallic Lubtbh : Brnuuite; Hanamanulte.

Uhmktallic Ldbtbr : Zircon; Wulfunite; VeauviauHe; Ociahcdrile; Xenotlme.

Square Frlanu.—UN metallic Lubteb : Zircon, Vesuvitiuite; Scnpoliles; Apophyllite; PhoBgenlte.

Square tabular cryslala occur with Apophyllite; Wiilfeuile; Torberolte.

Priauis nearly atiuare are noted with a number ot ortborhomblc spedca, e.g.. Topaz; AndalusUe; Danburite.

ni HEXAGONAL SERIES.

Bexagonal Prisma.— UnhbTallic Lcbtbb : Beryl; Apatite; Pyromorphlle; Vanadlnlte;

Mlmetlte (uaunllT Indistinct rounded form*. Alao Nephellte; Hilailte; TyBOoite, and othera.

Hexaennal prisma are alaocommnn witli Ihertumhoh^ralfMeiu-.Qutiti,: Calelte: Tourmaline; Wlllemlre: Phenaclte: Diopiaae, eic. Again, with the MlcaB, etc. Numeroua rare specipB could he Included here.

Many ortTutrhonMe (or mffnoeKniel ■■ppi-Iedhavinir a prismatic anzle of abont 60° (nnd IW) Blmulate thU form both In almnle crystals and atlll more aa the result of twlnnlnp Thus, Aragonltfi: Stroiitlanlte; Leadhlllte; lolite. It la alao to be noted that the itomelrif dodM-nhedron, e r.. of Oamet. has often the form of a hexagonal pyramid with trihedral lernilnntlons fcf Plfr. 443. p. 184).

Tahulnr hexacfonal prism" arp noled with various «peele!>. Thua. Metallic Lotteb : Hematlle; Tmenlfe: Pyrrliotltfi. TInmetallic Ltjbter : Tridymlta.

Hexarnnal Pvramlda.—Apntile: Corundum (rhombohedral); Quarts (rbombphedral-trappKnlipdrall: Hankslle.

This form la often almulated by Tarloiis orOiorkombU aperies. In part as the reaull_ of twionlne. For pxamnle. mktalt.ic lubtbr : Chalcoclte; Btephanile;PolybB«Ite; Jordanile, etc Alan Brooklte (Fie. SOI n M)

■Unicktallic LcffTEn : Wliherlte; Bromllte; Ceruaslte: loHte.

^Mgonal Prian.—TourmaliDe.

RhombolMdroiM.—Angle 1&' (nod lOS"); Oaldle; Dolomite; Bldeilte; Jtbodochroslte. Aoglu not far froiD SO": Cliabazlte; A.1uDite,

Sonlenohodroit*.—Calclte aod allied Carbonatea; Prousttte.

IV. ORTHORHOMBIC, MONOCLINIC AND TRICLINIC SYSTEMS.

Prlimatlo Oryatala.— Mbtallic LDBTBit; SUbnile; Arsenopyrite; BournODlte; Maoga-Dilei OOtliite, etc.

Unmi'.Xaluc Luster : (w-l/wrAomM:) Topaz; Siaurolite; Andalusite; BarttQ; Celeitlte; Danburiie. Also (monotiinic) Pvroxeae; Amphlbole; Orthoclase. and many otbera.

Epidote cry^talb are orten prfsmBlic in uapect (Fig. 8S0, p. 488).

Tabulmr Orjrrtali.—Bnrilc; Ceruulle; Calamine; Dlaspore; Wollastonlte,

Acionlar Oryitala.— Hktaluc Lubtbr : Stibnlle; Blamuthlnfte: Hillerite; JameRODite; Aikiuiie, auil oitiFt species,

UmietalijcLiibtbu: Fectolite; Nalrollle; Scolecite; Thomsonile, and otber Zeolites. Also Arugouile; Slronliuuite; leu often Caiclte. Also many oilier species.

Twin Orystals,—Tlie habit of the twins occurring with many species Is yery cliaracler-istlc. Relerence is made to pp. 118 lo 130 and tbe accompanylni; figures for a presentHtion of tills subject.

III. STRUCTURE OF MASSIVE MINERALS.

Ftbrons.— Fibwt leparahU: Asitestus (snipbibole); also the similar asbesliforni variety of serpentine (clirysotile): Crocidullte (color blue).

FOeri not leparadi*, ehiejty ilTiii^ht : Calclie; Gypsum. Also AngODite; Bnrlte; Celea-lite; Auhydrlte; Bruclte; Enatatite; WollaslODlte; Dufreolle; Vlvianlle. See also Colvmnar below.

Fibrotu-RadlAted.-~WaTelllte; ThotuwDlte; Netrollte; Slllbite, and other Zeolitea; GOtUiteiUalachlte.

Oolmnnar.— Metallic LrsTKB : Stibnlle; Hematire; Jamesonite; Zlnkenlla, etc.

Unmktallic LOBTKR : Llmonite; GOtbite; Atsgonltc; Amphlbole (tremolile. actinollte, etc.); Epidote; Zoiaile; Tourmaline; SUlinianlle; Naliolile end oiler Zeolites; Strontlnnite; Wllberile; Topaz.

Cyanlte baa often a Uadtd structure.

Fibrous and columnar varieties pass into one another.

ZdunttlI«r-BtaUata.—Gypsum iPyrophylUte.

Foliated,— Metallic Ld8tbr : Graphite; Uolybdenlte: Tetradymite; Sternbergite; NaiTfaeiie

UiTMKTALLic LusTEn : TeIc; Orpiment; Gypsum; Pjrophyllite; Serpentine: Gypsum.

Mfo«ceona.~-The MlcM. p. 468: also the Brittle Micas, p. 470. and the Chloriies, p. 472. Also Bnidte; Orpiment; Talc: Torliernite; Anlunfte.

Orannlar.— Metallic LrsTBB : Galena; Hematite. Msny snlphldes, sulpharsenitea, etc., have varieties wbicb are fine-granular to compnct and Impalpable.

TInhbtallig LrsTBR : Pyroxene (coccolite); Gomel; Caloiie; Borile, etc.

Botryoldal, MammlUary, Renlform, etc.— Mstallic Lcbtkh : Hemallte; Arsenic; Allamonilte. ™_ i j n

Unmrtaluc LrsTER : Malachite; Prebnlte; Calamine; Smlthaonitc; Chalcedony; Hyalite: Sphalerite, etc.

StalaetlUo.— Metallic Lubtbr : LImonlte: Psilomelane: Marcasite.

Ukketallic Luster : Calclte; Aragonlte; Gibbslie; Chalcedony.

IV. PHYSICAL CHARACTERS.

I. CLEAVAGE.

OuHo.— Mbtalmo Luemt: Galena, , „ „_

UmntTALLic LuaTEH : Halite: SylTiio. The cleavage of Anhydrite (alio of Cryolite) simulates this. Cf. also Corundum, p, 838.

OoUhsdral.—Fluorile; Diamond. Magnetite (aba Fraoklinlte) bu often dlitincl octft-faedral parting..

Dodeoahadrtl.—Spbalerite.

tUioinbahedral.~Calcite and other species of the same group, pp. 854-860.

Sqnare Prlamatlc (90°).—Scapolite; Ruiile; XeDOlime.

Priuaatlo.—Barlte; Celestlte; Amphlbole (64° and 136°), etc.

Batal.— Hktallig Luster: Qrapliite;Molybdenite.

Unmetallic LtrSTBH ; Apoplijllite; Topaz: Talc; the Micu and Cfalorites; Chalcophjl-llte, etc. Pyroxene ofteu shovrs narked basal pariiog.

Plnacoid«L— Metallic Lt'BTER : Slibolte.

UsHBTALLic LuBTEit: Gypsum; Orplmeut; Euclase; Dlaspore, etc.

II. HARDNESS.

1. Soft Mlnorala.—Tbfl followiDg minerals or less; Ihey hence have » grtiity 'eel. (See furtlier ihe Tal

Metaxuc Luster: Qiapblte; Molybdenite; Tetradyi Kat^agite; some of the Naliva Metals (Lead. etc.).

Ummetallic Luster: Talc; Pyrophyllili CtuDsbarj Sulphur; Gypsum.

Also Calomel, ArseaoUte, and many hydn

2. Hard Mlnarala.—Mlaenils whose hardui Tbe followlog minerals are here included:

LnBTRa Unmstallio.

Sternbergiie ; Argentite; Brucite: Tyrollie; Orplment; Cerargyrite; Biilpbates, phosphates, etc. ia equal to or greater th«n 7 (Quartz s Ty.

Quartz (p. 8M) 7

Triilymlto(p. S38) 7

BnryliteCp. 408) 7

DumorUerita (p. 44S) 7

Daiiburito (p. 480) 7-7-25

Boracite (p. 619) 7

Ziiiiyili: (p. 416) 7

Ctanite (p: 494) 5-7 as

TouRMAUNB (p. 447) 7-75

Garnet (p. 415) 6-6-7-6

loLiTE (p. 407) 7-7 6

Staurolitb (p. 450) 7-7'5

8c)iorlomlte(p. 419) 7-7'5

Sappbirine (p. 451) ,^7-6

Euclase (p. 466) 7'5

Hambergile (p, 518) 7-8

ZiRCOK (p. 428) 7-6

Ahdalusiib (p. 433) 7*5

Bertl(p 405) 7.5-8

LawsoDiiefp. 447) 75-8

Pheiiaciie (p. 428). 7-6-8

Gahnite (p. 880) 7-5-8

HercyDlie (p. 889) 7-6-8

Spinei, (p. 888) 8

Topaz (p. 431) 8

Hhmliziie (p. 518) 8

Chbvsobbbtl (p. 842) 8'6

CoRUHDUu (p. 838) B

DiAHOKD (p. 271} 10

The followiag minerals have hardness equal lo 6 to 7. or fl-6—7.

Luster Metallic : Irldosmloe (p. 280); Iridium (p. 280): Bperryllte (p. 802).

LtlBTBR UNKBTALLtc: Ardennlle (p. 446); Axlulte (p. 441); Betrandlte (p. 446):

III. SPECIFIC GRAVITY.

AttflDttonlscalted to tbe remarks In Art. 280 (p. 158), on tbe relallon of specific graTityto chemical composilion. Also to the Btntemenis ic Art. S81 as to th« awrage speclBc gravity among minenis of metallic and unmetalllc lusier respectively. The species In each of tbe separate Hits of Table I. of minerals clnsslficd with reference lo cryttalllxatioD are arranged according to ascending $p«eifie gravitia. Hence the lists give at a glance mlBsraU dlt-tlngutsh«d by both low and high density.

IV. LUaTER. (See Art. US, p. 168.)

MatalUo.—NaUte meUlH; most 8ulphid«a; some Oxides, thow conUinlng Iron, mas* ^DMe, lead, etc

SDbmetalllo.'-EeTe belons chleflj cerlain iron compounds, as Ilmenlte; Ilvalto; Culutnbitt; TsDlalitB (and allied apecieaj; Wolfnmlte, etc. Also Unmlnlte, etc.

Adamant!ne. —(a) Some ftard inlDenls: Diamond; Corundum; Casdterite; Zircon; Riulle. (&) Hunj compounda of lead, also ol siWeT, copper, raercuiy. Thna, Ceruaaite. Auelesiie, Pboseenlte, etc.; Cerargyrile: Cuprite; some Cinnabar, etc (c) Also certain Tariellea of Bpholerlle, Tllanlte anii OcUhedrite.

MetalUo-Adatnaiitina —Pjrargyrile; aome varielies of the following: Ouprita, Cenurile, Oclabedrite, Butile.

R«iiM>na or WaxT.—Bphnleiite; Elreolite; many Phoapbatea.

Tib'sona.—Quartz and maDf BUicates, as Garnet, Beijl.

PMflf.—Tbe foliiited species: Talc, Brucite, Pyiopbylllte. Also (on cleaTSgemrfocea) conspicuously tlie following: Apopbjtlits, gtllblle, Heulandit«. Also, lesaprominentiBarlta; Celeailie; some Feldspar, and others.

BIU7.—Borne fibrous minerals, aa Qypaum, Caldte; also AabeatUB.

V. COLOR

The following lists may be of aome uaa Id the way of suggestion. It la to be noted, bonever. tlitic especially In tbe cuse of metallic mlner^ a alight aurface change may alter the effect of color. Further, among mineralH of unmetalllc luster parttcularly, no sharp line can t>e drawn between colors slightly different, and many TarlaLlons of shade occur In tbe case of a slugle ipecies. For theae reasons no liEta, unleaa luconTenlently axICDded, could maiie any claim lo completeness.

(a) Metallic Ltthtbr.

8ilver-wblt«, Tin-wblta.—Native silver; Native Antimony, Arsenic and Tellurium; Amnlpim: Arsenopyiiie an 1 LOUingite: several sulphides, arsenides, etc., of cobalt or niikel, as Cobnltile (reddish); some Tellurldea. No Hbarp line can be drawn between these and tbe following group.

Stael-gray.—Platinum: Manganite; Clialcoclte; Sylvanlte; Bonrnonite.

Blna-gray.—Molybdenite.

Iiead-gray.—Many sulphides, aa Qalena (bluiab); Slibnite; many Sulpharaenlles, etc., as Jameaonlte, DufrenoysiCe, eic.

IrOD-black.—GraplJlte: Tetrahedrite; Polyboslte; Stephanite; Enarglte; PTrolualle: Magnetite; Ilcinallte; Frankliuile,

Black (with snbmetallic luster).—Ilmenile; LimoniU; Columblte; IVntalile, etc.; Wolfmmiie; Ilvaite; Uraninlte, etc. Tbe following are usually brownish black: Brannlte; Hausmauniie.

Oopper-red.—Native copper.

Bronze-red.—Bomlte (quickly tarnished); Niccollte.

Bronae-yeUow.—Pyrrhollte ; Pentlandlte; Brelthauptlte.

Braaa-yellow.—Chalcopyrtle; Hlllerite (bronze.) Pale bTaaeTelloW: ^rrltai Ha>-casite (wliiler than Pyrlie).

Qold-jellow.—Native gold.

Streak.—The following minerals of metallic latter ate notftble for the color 1^ their Mreak: '

Coehitieal-rtd: Pyrargyrite. Ctiwry-red: Mlargyriie. Dvll Red : Hematite (also Cuprite). Baarlet: Cinnabar (usually unnielnllic).

Dark Brown: Mangaoite; FraokllDlLe ; Clironilte.

Yellov): LImonite.

Tamiih.—Tlie following are conBplcuous for their bright or varlegaUd tarnish-BorDil« ; Ohalcopjrlte ; Tctrahedrite ; some Limonlte.

{b) UmiBTALuc LnBTEB.

Oolorleu.—In CltTSTAI.S: QimrlE; Calcitei Anigonlte; OypauiD ; Ceniulle ; Aasles* tte ; Alblle : Barlle : Adularia ; Topaz : Apoplivllite ; NatroUte and other Zcoirtet t Celestile ; Diupore ; Nephellte ; Meioulte ; Calamine ; CiyoUte ; Phenacite, etc.

Mabsite : Quartz; CalHle ; Gjpsum ; Hyalite (botry old al).

Whlta,—CuvHTAia: Amplilbole (tremolltc) : Pyroieue (diopslde, usually greentah).

Habbitx : Calclte ; Milky Quartz ; Feldapars, espcclallv Albite ; Barite ; Ce>-uS8ite; Scapolite ; Talc ; Meervchaum ; Maguesllе ; Kaoliuite ; Amblygoulte, etc.

Blue.—BT.ACKIBH Bluk: Azurlte ; Crocidollte.

Indiqu-blite : ladlculite (Tourmaline): Vlrlanlte.

AzTHiB-BLDB: Lazulite ; Azurlte ; Lapis Lazuli; Turqiiob.

PRT1SBU.N-BL1IB; Sapphire; Cyauite ; lollte ; Asurite ; Cbaloothlte and tnaii; copper compounds.

Skt-blub. HouMTAiM-fiLoE : Bervl; Celeatlte.

YlOLET-BLDB : Amethyst; Fluorite,

Grebnibh Blue : AmazoD-stooe ; CbryBocolla ; Calamine ; 8mi[hgonlt« ; some Tui> quois ; Beryl.

Oreen.— Blackibb Oreen : Epidote ; SerpeDtiue ; Pyroxeoe : Ampblbole.

Ekbuald-uherh : Beryl (Ememld) ; Malachite; Dloptase ; Atacamite j and maay Other copper compounds ; BpodumeDe (liiddenite); Pyroxene (rare) ; Oahulle ; Jadeit« and Jitde.

BLriBH Orbbb : Beryl ; Apatile ; Fluorite ; Amnxon-BlODe ; Frebnfte ; Calamine; Smilbaoulle ; Clirygocolla ; Chlorile : tome Turqnois.

Mountain oreen ; Beryl (aquamarlue) ; Euclase.

ApPLE-SBRBn 1 Talc ; Garnet ; CbryBoprnae ; Wlllemlte ; Garnierlte; Pyrophylllle j ■ome MuscoTJI« ; Jadeite and Jade ; Pyropliyllite.

PlBTACBio-QBBEN: Epidote.

OaABS-OKEEH : Pyromorphite ; Wnveilile ; Varlactte ; Chrysoberrl.

Gratibh Greer : Ampbibole and Pyroxene, many commou kinda ; Jaaper; Jade.

Yellow-oreen lo Olite-Orebn : Beryl : Apatite ; Cbrysoberyl; Chrysolite (oliT»> green); Chlorite ; Serpentine ; Titiinite ; Datolite; OHvenite ; VesuTianile.

Tollow.—StTLPHUR-TELLOW r fiiilpbur : some VesuTianLte.

ORANaB-YELLOW : Orpimeiit; Wulfenile : Mlmelite.

Straw tbi.low, also WiNB-TELr.ow, Waitellow : Topaz; Bulphur; Fluorite; Can-crlnite ; Wulfenits ; Vanadinite ; Willemlte ; Calclle ; Bsnie; Chrysolite ; Choadrodlte; Titaiiite; Datolite. etc.

Bruwhish Yrliaw : Much Sphalerite : giderlte ; GOIhfte.

OCHBR-TEi,ix>w: G&tbite ; Yellow ocber (limonlte).

Red.— Rubt-red: Ruby (coruudum); Ruby spinel; much Garnet; Proustlte; Vanadinite ; Sphalerite : Chondrodite.

CocniNEAL-RBD: Ciiprilc ; Cinuabar.

Hyacinth-red. —Zircon.

Ohangbred: Zincite.

Okahgb-rbd to aurora-hed : Realgar ; Wulfenlte.

CitiMMiN-RRD : Tourmaline (rubellite) ; Spinel, Fluorite.

Scarlbt-red : Cinnabar.

BiiiCK-RBD: Some Hematite (red ocber).

Rose red to Pink ; Itnse quurtz ; Rliodonite ; Rhodochroalte i Erytbrlle; some Scapolite Apophylllle and Zoiaite ; Eudialytc ; Pelalllp : Margarlte.

PEACH-BLoasoM Rbd to LiLAC I Lepidollte ; Rubellite.

Flbbh-rbd: Some Onhoclase ; Willemite (the variety troostlte); some Chabaztle ; Stit bite and Heulandlte ; Apatite ; rarely Cakice ; Polylialiie.

Bbownisb Red : Jasper ; Limonile ; Garnet ; Sphalerite ; Slderite ; Rutlle.

Brown.— Reddibh BROvn : Some Oarnet; Mme SphaleiiU ; Stanrollte ; CaBsiterite ; ButllB.

Clote-bbowr : Aiioite : Zlrcxm : Pyromorphite.

Tellowibu Brown : Slderite and routed carbonates ; Sphalerite ; Ja«per; Llmonlte; GCtliite ; Toiirmaliue; VemiTiaDite; Chondnxlite ; Staurolite.

Blackish Brown : TiUnite ; tome Sldtrite ; Bpbalerlte.

Bhokv Bbowh : Qiiariz.

Black; TouTmaliue ; black Garnet (raelauite); wme Hlca feapeclally biotite); alio lome Amphlbule, Pyroxene and Epidote (tbese are moatly greenisli or bruwiilsb black); fiiTtber. some Bphalerile auiJ some klndg of Quart/ (varylne from smoky browu lo black) ; also Allinite; Bamarsklte. Some black mluemls with aubmetalllc luBl«r are meutiooed on p. 483.

Streak.— T\ie»treakiBtohK noted in Ibe case of nome mjnerala with un metal lie luster. By far llie mujoiity bavc, even when deeply colored In the mass (e.g. Tourmallue}, a streak differing but little from wblle. The following may be mentioned:

ORANOB-rKLLOW: Zincite, Crocoite.

CoCBiNEAL-RBD : Pyrargyrlte nnd pTOUBtlte.

ScARLBT RED : Cionabiir.

Bhownish kbd : Cuprite ; Hematilo.

Browk : Limoiille.

Tbe streak of the varlouB copper, green and blue minerals, as Halacblte, Azarlte, etc. k about the tame as the color of the minenl Itself, though often a little paler.

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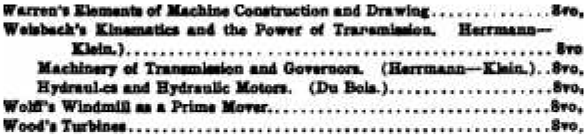

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