2. SILICATES

The Silicates are in part strictly anhydrous, in part hydrous, as the zeolites and the amorphous clays, etc. Furthermore, a large number of the silicates yield more or less water upon ignition, and in many cases it is known that they are, therefore, to be regarded as basic (or acid) silicates. The line, however, between the strictly anhydrous and hydrous silicates cannot be sharply drawn, since with many species which yield water upon ignition the part played by the elements forming the water is 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 exhibited by introducing the related hydrous species immediately after the others.

This chapter closes with a section including the Titanates, Silico-titanates, Titano-niobates, etc., which connect the Silicates with the Niobates and Tantalates. Some Titanates have already been included among the Oxides.

Section A. Chiefly Anhydrous Silicates

I. Disilicates, Polysilicates
II. Metasilicates
III. Orthosilicates
IV. Subsilicates

The DISILICATES, RSi_2O_5, are salts of disilicic acid, $H_2Si_2O_5$, and have an oxygen ratio of silicon to bases of 4 : 1, as seen when the formula is written after the dualistic method, $RO.2SiO_2$.

The POLYSILICATES, $R_2Si_3O_8$, are salts of polysilicic acid, $H_4Si_3O_8$, and have an oxygen ratio of 3 : 1, as seen in $2RO.3SiO_2$.

The METASILICATES, $RSiO_3$, are salts of metasilicic acid, H_2SiO_3, and have an oxygen ratio of 2 : 1. They have hence been called *bisilicates*.

The ORTHOSILICATES, R_2SiO_4, are salts of orthosilicic acid, H_4SiO_4, and have an oxygen ratio of 1 : 1. They have hence been called *unisilicates*. The majority of the silicates fall into one of the last 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 SUBSILICATES. Their true position is often in doubt; in 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 polysilicates, range from the true polysilicate, $NaAlSi_3O_8$, to the orthosilicate, $CaAl_2Si_2O_8$, with many intermediate compounds, regarded as isomorphous mixtures of these extremes. Similarly of the scapolite group, which, however, is included among the orthosilicates, since the majority of the compounds observed approximate to that type. The micas form another example.

I. Disilicates, RSi_2O_5. Polysilicates, $R_2Si_3O_8$

PETALITE.

Monoclinic. Crystals rare (*castorite*). Usually massive, foliated cleavable (*petalite*).

Cleavage: *c* (001) perfect; *o* (201) easy; *z* $(\bar{9}05)$ difficult and imperfect. Fracture imperfectly conchoidal. Brittle. H. = 6–6·5. G. = 2·39–2·46. Luster vitreous, on *c* (001) pearly. Colorless, white, gray, occasionally reddish or greenish white. Streak uncolored. Transparent to translucent. α = 1·504. β = 1·510. γ = 1·516.

Comp. — $LiAl(Si_2O_5)_2$ or $Li_2O.Al_2O_3.8SiO_2$ = Silica 78·4, alumina 16·7, lithia, 4·9 = 100.

Pyr., etc. — Gently heated emits a blue phosphorescent light. B.B. fuses quietly at 4 and gives the reaction for lithia. With borax it forms a clear, colorless glass. Not acted on by acids.

Obs. — Petalite occurs at the iron mine of Utö, Sweden, with lepidolite, tourmaline, spodumene, and quartz; on Elba (*castorite*). In the United States, at Bolton, Mass., with scapolite; at Peru, Me., with spodumene in albite. The name *petalite* is from *πέταλον, a leaf,* alluding to the cleavage.

Milarite. $HKCa_2Al_2(Si_2O_5)_6$. In hexagonal prisms. H. = 5·5–6. G. = 2·55–2·59. Colorless to pale green, glassy. From Val Giuf, Grisons, Switzerland.

Eudidymite. $HNaBeSi_3O_8$. Monoclinic. In white, glassy, twinned crystals, tabular in habit. H. = 6. G. = 2·553. Optically +. Indices, 1·545–1·551. Occurs very sparingly in elæolite-syenite on the island Ovre-Arö, in the Langesundfiord, Norway; from Narsarsuk, Greenland.

Epididymite. Same composition as eudidymite. Orthorhombic. Tabular || *c* (001). Cleavage, *b*(010) and *c*(001), perfect. H. = 5·5. G. = 3·55. Optically –. Indices, 1·565–1·569. Narsarsuk, Greenland.

RIVAITE. $(Ca,Na_2)Si_2O_5$. Monoclinic? In fibrous aggregates. H. = 5. G. = 2·55. Color, pale lavender to dark blue. Fibers show parallel extinction with positive elongation. Easily fusible. Insoluble in hydrochloric acid. Found in loose nodules on Vesuvius.

Feldspar Group

α. Monoclinic Section

		$a : b : c$	β'
Orthoclase	$KAlSi_3O_8$	0·6585 : 1 : 0·5554	116° 3′
Soda-Orthoclase	$(K,Na)AlSi_3O_8$ $(Na,K)AlSi_3O_8$		
Hyalophane	$(K_2,Ba)Al_2Si_4O_{12}$	0·6584 : 1 : 0·5512	115° 35′
Celsian	$BaAl_2Si_2O_8$	0·657 : 1 : 0·554	115° 2′

β. Triclinic Section

Microcline	$KAlSi_3O_8$
Soda-microcline	$(K,Na)AlSi_3O_8$
Anorthoclase	$(Na,K)AlSi_3O_8$

Albite-anorthite Series. *Plagioclase Feldspars*

		$a : b : c$	α	β	γ
Albite	$NaAlSi_3O_8$	0·6335 : 1 : 0·5577	94° 3′	116° 29′	88° 9′
Oligoclase	$\begin{pmatrix} nNaAlSi_3O_8 \\ mCaAl_2Si_2O_8 \end{pmatrix}$	0·6321 : 1 : 0·5524	93° 4′	116° 23′	90° 5′
Andesine		0·6357 : 1 : 0·5521	93° 23′	116° 29′	89° 59′
Labradorite		0·6377 : 1 : 0·5547	93° 31′	116° 3′	89° 54½′
Anorthite	$CaAl_2Si_2O_8$	0·6347 : 1 : 0·5501	93° 13′	115° 55′	91° 12′

The general characters of the species belonging in the Feldspar Group are as follows:

1, *Crystallization* in the monoclinic or triclinic systems, the crystals of the different species resembling each other closely 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 two similar directions parallel to the base c (001) and clinopinacoid (or brachypinacoid) b (010), inclined at an angle of 90° or nearly 90°. 3, *Hardness* between 6 and 6·5. 4, *Specific Gravity* varying between 2·5 and 2·9, 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): Orthoclase, potassium feldspar, and Soda-orthoclase, potassium-sodium feldspar; also Hyalophane and Celsian, barium feldspars.

The *triclinic* species include: Microcline and Anorthoclase, potassium-sodium feldspars; Albite, sodium feldspar; Anorthite, calcium feldspar.

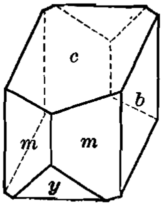
Also intermediate between albite and anorthite the isomorphous sub-species, sodium-calcium or calcium-sodium feldspars: Oligoclase, Andesine, Labradorite.

α. Monoclinic Section

ORTHOCLASE.

Monoclinic. Axes $a : b : c = 0{\cdot}6585 : 1 : 0{\cdot}5554$; $\beta = 63° 57'$.

767



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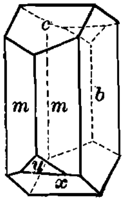

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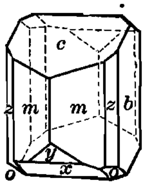

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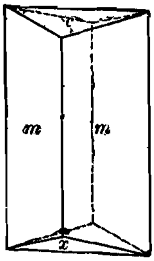
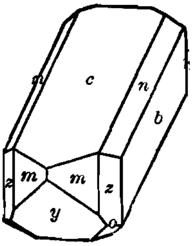


mm''', $110 \wedge 1\bar{1}0 = 61° 13'$.
zz', $130 \wedge \bar{1}30 = 58° 48'$.
cx, $001 \wedge \bar{1}01 = 50° 16\tfrac{1}{2}'$.
cy, $001 \wedge \bar{2}01 = 80° 18'$.

cn, $001 \wedge 021 = 44° 56\tfrac{1}{2}'$.
nn', $021 \wedge 0\bar{2}1 = 89° 53'$.
cm, $001 \wedge 110 = 67° 47'$.
co, $001 \wedge \bar{1}11 = 55° 14\tfrac{1}{2}'$.

Twins: tw. pl. (1) *a* (100), or tw. axis *c*, the common *Carlsbad* twins, either of irregular penetration (Fig. 772) or contact type; the latter usually with *b* (010) as composition-face, often then (Fig. 773) with *c* (001) and *x* ($\bar{1}01$) nearly in a plane, but to be distinguished by luster, cleavage, etc. (2) *n* (021), the *Baveno* twins forming nearly square prisms (Fig. 774), since $cn = 44° 56\tfrac{1}{2}'$, and hence $c\underline{c} = 89° 53'$; often repeated as fourlings (Fig. 447, p. 171), also in square prisms, elongated || *a* axis. (3) *c* (001), the *Manebach* twins (Fig. 775), usually contact-twins with *c* as comp.-face. Also other rarer laws.

771



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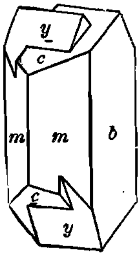

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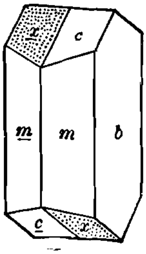

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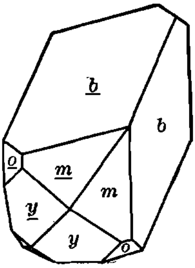

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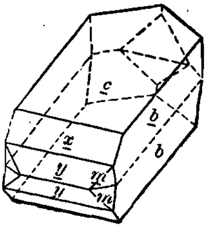


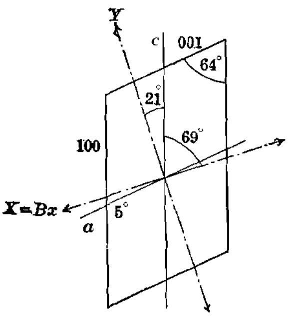
Crystals often prismatic || *c* axis; sometimes orthorhombic in aspect (Fig. 770) since *c* (001) and *x* ($\bar{1}01$) are inclined at nearly equal angles to the vertical axis; also elongated || *a* axis (Fig. 771) with *b* (010) and *c* (001) nearly equally developed; also thin tabular || *b* (010): rarely tabular || *a* (100), a face not often observed. Often massive, coarsely cleavable to granular; sometimes lamellar. Also compact crypto-crystalline, and flint-like or jasper-like.

Cleavage: *c* (001) perfect; *b* (010) somewhat less so; prismatic *m* (110) 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 satin-like luster or schiller (p. 251), the latter also often present when the parting is not distinct. Fracture conchoidal to uneven. Brittle. H. = 6. G. = 2·57. Luster vitreous; on *c* (001) often pearly. Colorless, white, pale yellow and flesh-red common, gray; rarely green. Streak uncolored.

Optically negative in all cases (Fig. 776). Ax. pl. usually ⊥ *b* (010), sometimes || *b*, also changing from the former to the latter on increase of temperature (see p. 297). For *adularia* $Bx_{a.r} \wedge c$ axis $= -69° 11'$, $Bx_{a.bl} \wedge c$ axis $= -69° 37'$. Hence Bx_a and the extinction-direction (Fig. 776) inclined a few degrees only to *a* axis, or the edge *b*/*c*; thus +3° to +7° usually, or up to +10° or +12° in varieties rich in Na_2O. Dispersion $\rho > v$; also horizontal, strongly marked, or inclined, according to position of ax. pl. Axial angles variable. Birefringence low, $\gamma - \alpha = 0·007 - 0·005$. For adularia

$$\alpha_y = 1·5190, \quad \beta_y = 1·5237, \quad \gamma_y = 1·5260.$$
$$\therefore\ 2V_y = 69° 43', \quad 2E_y = 121° 6'.$$

776



Comp. — A silicate of aluminium and potassium, $KAlSi_3O_8$ or $K_2O.Al_2O_3.6SiO_2$ = 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 amount; these varieties are embraced under the name soda-orthoclase (the name *barbierite* has been proposed for this material whose existence, as a distinct though rare mineral, seems to have been proven).

Var. — The prominent varieties depend upon crystalline habit and method of occurrence more than upon difference of composition.

1. *Adularia.* The pure or nearly pure potassium silicate. Usually in crystals, like Fig. 770 in habit; often with vicinal planes; Baveno twins common. G. = 2·565. Transparent or nearly so. Often with a pearly opalescent reflection or schiller or a delicate play of colors; some *moonstone* is here included, but the remainder belongs to albite or other of the triclinic feldspars. The original adularia (Adular) is from the St. Gothard region in Switzerland. *Valencianite,* from the silver mine of Valencia, Mexico, is adularia.

2. *Sanidine* or *glassy feldspar.* Occurs in crystals, often transparent and glassy, embedded in rhyolite, trachyte (as of the Siebengebirge, Germany), phonolite, etc. Habit often tabular || *b* (010) (hence named from σανίς, a *tablet,* or *board*); also in square prisms (*b*, *c*); Carlsbad twins common. Most varieties contain sodium as a prominent constituent, and hence belong to the soda-orthoclase. Natronsanidine is a sanidine-like soda-orthoclase from a soda liparite from Mitrowitza, Servia.

Rhyacolite. Occurs in glassy crystals at Monte Somma, Vesuvius; named from ῥύαξ, *stream* (lava stream).

3. *Isothose* is said to be a variety having a different optical orientation than normal orthoclase.

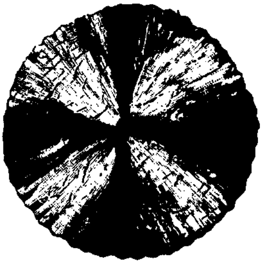
4. *Ordinary.* In crystals, Carlsbad and other twins common; also massive or cleavable, varying in color from white to pale yellow, red or green, translucent; sometimes aventurine. Here belongs the common feldspar of granitoid rocks or granite veins. Usually contains a greater or less percentage of soda (soda-orthoclase). Compact cryptocrystalline orthoclase makes up the mass of much felsite, but to a greater or less degree admixed with quartz; of various colors, from white and brown to deep red. Much of what has been called orthoclase, or common potash feldspar, has proved to belong to the related triclinic species, microcline. Cf. p. 461 on the relations of the two species. Chesterlite and Amazon stone are microcline; also most aventurine orthoclase. *Loxoclase* contains sodium in considerable amount (7·6 Na_2O); from Hammond, St. Lawrence Co., N. Y. *Murchisonite* is a flesh-red feldspar similar to perthite (p. 460), with gold-yellow reflections in a direction ⊥ *b* (010) and nearly parallel to $\bar{7}01$ or $\bar{8}01$ (p. 457); from Dawlish and Exeter, England.

The spherulities noted in some volcanic rocks, as in the rhyolite of Obsidian Cliff in the Yellowstone Park, are believed to consist essentially of orthoclase needles with quartz.

These are shown in Figs. 777 and 778 (from Iddings; much magnified) as they appear in polarized light (crossed nicols).

777

778



Pyr., etc. — B.B. fuses at 5; varieties containing much soda are more fusible. Loxoclase fuses at 4. Not acted upon by acids. Mixed with powdered gypsum and heated B. B. gives violet potassium flame visible through blue glass.

Diff. — Characterized by its crystalline form and the two cleavages at right angles to each other; harder than barite and calcite; not attacked by acids; difficultly fusible. Massive corundum is much harder and has a higher specific gravity.

Micro. — Distinguished in rock sections by its low refraction (low relief) and low interference-colors, which last scarcely rise to white of the first order — hence lower than those of quartz; also by its biaxial character in convergent light and by the distinct cleavages. It is colorless in ordinary light and may be limpid, but is frequently turbid and brownish from the presence of very minute scales of kaolin due to alteration from weathering; this change is especially common in the older granular rocks, as granite and gneiss.

Artif. — Orthoclase has not been produced artificially by the methods of dry fusion. It can, however, be crystallized from a dry melt when certain other substances, like tungstic acid, alkaline phosphates, etc., are added. The function of these additions in the reactions is not clear. Orthoclase is more easily formed by hydrochemical methods. It has been produced by heating gelatinous silica, alumina, caustic potash and water in a sealed tube. Orthoclase has also been formed by heating potassium silicate and water together with muscovite.

Obs. — Orthoclase in its several varieties belongs especially to the crystalline rocks, occurring as an essential constituent of granite, gneiss, syenite, also porphyry, further (var., *sanidine*) trachyte, phonolite, etc. In the massive granitoid rocks it is seldom in distinct, well-formed, separable crystals, except in veins and cavities; such crystals are more common, however, in volcanic rocks like trachyte.

Adularia occurs in the crystalline rocks of the central and eastern Alps, associated with smoky quartz and albite, also titanite, apatite, etc.; the crystals are often coated with chlorite; also on Elba. Fine crystals of orthoclase, often twins, are obtained from Baveno, Lago Maggiore, Italy; the Fleimstal, Tyrol, Austria, a red variety; Bodenmais, Carlsbad, and Elbogen in Bohemia; Striegau, etc., in Silesia. Also Arendal in Norway, and near Shaitansk in the Ural Mts.; Land's End and St. Agnes in Cornwall; the Mourne Mts., Ireland, with beryl and topaz. From Tamagama Yama, Japan, with topaz and smoky quartz. *Moonstone* is brought from Ceylon. Crystals of gem quality from Itrongahy, Madagascar. *Valencianite* from Guanajuato, Mexico. Crystals from Eganville, Ontario.

In the United States, orthoclase is common in the crystalline rocks of New England, also of States south, further Colorado, California, etc. Thus at the Paris tourmaline locality, Me. In N. H., at Acworth. In Mass., at South Royalston and Barre. In Conn., at Haddam and Middletown, in large coarse crystals. In N. Y., in St. Lawrence Co., at Rossie; at Hammond (*loxoclase*); in Lewis Co., in white limestone near Natural Bridge; at Amity and Edenville. In Pa., in crystals at Leiperville, Mineral Hill, Delaware Co.; sunstone in Kennett Township. In N. C., at Washington Mine, Davidson Co. In Col., at the summit of Mt. Antero, Chaffee Co., in fine crystals, often twins; at Gunnison; Black

Hawk; Kokomo, Summit Co., Robinson, also at other points. Also similarly in Nev. and Cal. Large twin crystals from Barringer Hill, Llano Co., Texas.

Alter. — Orthoclase is frequently altered, especially through the action of carbonated or alkaline waters; the final result is often the removal of the potash and the formation of kaolin. Steatite, talc, chlorite, leucite, mica, laumontite, occur as pseudomorphs after orthoclase; and cassiterite and calcite often replace these feldspars by some process of solution and substitution.

Use. — In the manufacture of porcelain, both in the body of the ware and in the glaze on its surface.

PERTHITE. As first described, a flesh-red aventurine feldspar from Perth, Ontario, Canada, called a soda-orthoclase, but shown by Gerhard to consist of interlaminated orthoclase and albite. Many similar occurrences have since been noted, as also those in which microcline and albite are similarly interlaminated, the latter called *microcline-perthite*, or microcline-albite-perthite; this is true in part of the original perthite. When the structure is discernible only with the help of the microscope it is called *microperthite*. Brögger has investigated not only the microperthites of Norway, but also other feldspars characterized by a marked schiller; he assumes the existence of an extremely fine interlamination of albite and orthoclase || $\bar{8}01$, not discernible by the microscope (cryptoperthite), and connected with secondary planes of parting || 100 or || $\bar{8}01$, which is probably to be explained as due to incipient alteration.

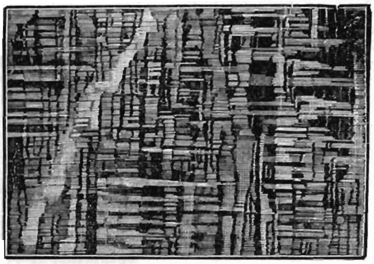
Hyalophane. $(K_2,Ba)Al_2(SiO_3)_4$ or $K_2O.BaO.2Al_2O_3.8SiO_2$. Silica 51·6, alumina 21·9, baryta 16·4, potash 10·1 = 100. In crystals, like adularia in habit (Fig. 770, p. 457); also massive. Cleavage: *c* (001) perfect; *b* (010) somewhat less so. H. = 6–6·5. G. = 2·805. Optically –. α = 1·542. β = 1·545. γ = 1·547. Occurs in a granular dolomite in the Binnental, Switzerland; also at the manganese mine of Jakobsberg, Sweden. Some other feldspars containing 7 to 15 p. c. BaO have been described.

Celsian. $BaAl_2Si_2O_8$, similar in composition to anorthite, but containing barium instead of calcium. Monoclinic. In crystals showing a number of forms; twinned according to Carlsbad, Manebach and Baveno laws. Usually cleavable massive. H. = 6–6·5. G. = 3·37. Extinction on *b* (010) = 28° 3′. Colorless. Optically +. α = 1·584. β = 1·589. γ = 1·594. From Jakobsberg, Sweden. Name *baryta-orthoclase* given to mixtures of celsian and orthoclase. *Paracelsian* from Candoglia, Piedmont, Italy, is the same species.

β. Triclinic Section

MICROCLINE.

779



Triclinic. Near orthoclase in angles and habit, but the angle *bc* (010 ∧ 001) = about 89° 30′. Twins: like orthoclase, also polysynthetic twinning according to the albite and pericline laws (p. 464), common, producing two series of fine lamellæ nearly at right angles to each other, hence the characteristic grating-structure of a basal section in polarized light (Fig. 779). Also massive cleavable to granular compact.

Cleavage: *c* (001) perfect; *b* (010) somewhat less so; *M* $(1\bar{1}0)$ sometimes distinct; *m* (110) also sometimes distinct, but less easy. Fracture uneven. Brittle. H. = 6–6·5. G. = 2·54–2·57. Luster vitreous, on *c* (001) sometimes pearly. Color white to pale cream-yellow, also red, green. Transparent to translucent. Optically –. Ax. pl. nearly perpendicular (82°–83°) to *b* (010). Bx_0 inclined 15° 26′ to a normal to *b* (010). Dispersion $\rho < v$ about Bx_0. Extinction-angle on *c* (001), +15° 30′; on *b* (010), +5° to 6° (Fig. 784, p. 462). Optically –. α = 1·522. β = 1·526. γ = 1·530: 2 V = 83°.

The essential identity of orthoclase and microcline has been urged by Mallard and Michel-Lévy on the ground that the properties of the former would belong to an aggregate of submicroscopic twinning lamellæ of the latter, according to the albite and pericline laws.

Comp. — Like orthoclase, $KAlSi_3O_8$ or $K_2O.Al_2O_3.6SiO_2$ = Silica 64·7, alumina 18·4, potash 16·9 = 100. Sodium is usually present in small amount: sometimes prominent, as in soda-microcline.

Pyr. — As for orthoclase.

Diff. — Resembles orthoclase but distinguished by optical characters (*e.g.*, the grating structure in polarized light, Fig. 779); also often shows fine twinning-striations on a basal surface (albite law).

Micro. — In thin sections like orthoclase but usually to be distinguished by the grating-like structure in polarized light due to triclinic twinning.

Obs. — Occurs under the same conditions as much common orthoclase. The beautiful *amazonstone* from the Ural Mts., also that occurring in fine groups of large crystals of deep color in the granite of Pike's Peak, Col., is microcline. Crystals from Ivigtut, Greenland. From Antsongombato and Antoboko (amazonstone), Madagascar. *Chesterlite* from Poorhouse quarry, Chester Co., Pa., and the aventurine feldspar of Mineral Hill, Pa., belong here. A pure variety occurs at Magnet Cove, Ark. Ordinary microcline is common at many points.

Use. — Same as for orthoclase; sometimes as an ornamental material (amazonstone).

Anorthoclase. Soda-microcline. A triclinic feldspar with a cleavage-angle, *bc*, 010 ∧ 001, varying but little from 90°. Form like that of the ordinary feldspars. Twinning as with orthoclase; also polysynthetic according to the albite and pericline laws; but in many cases the twinning laminæ very narrow and hence not distinct. Rhombic section (see p. 462) inclined on *b* (010) 4° to 6° to edge *b*/*c*. G. = 2·57–2·60. Cleavage, hardness, luster, and color as with other members of the group. Optically −. Extinction-angle on *c* (001) +5° 45′ to + 2°; on *b* (010) 6° to 9.8°. Bx_a nearly ⊥ *y* ($\bar{2}01$). Dispersion $\rho > v$; horizontal distinct. $\alpha = 1{\cdot}523$. $\beta = 1{\cdot}529$. $\gamma = 1{\cdot}531$. Axial angle variable with temperature, becoming in part monoclinic in optical symmetry between 86° and 264° C., but again triclinic on cooling; this is true of those containing little calcium.

Chiefly a soda-potash, feldspar $NaAlSi_3O_8$ and $KAlSi_3O_8$, the sodium silicate usually in larger proportion (2 : 1, 3 : 1, etc.), as if consisting of albite and orthoclase molecules. Calcium ($CaAl_2Si_2O_8$) is also present in relatively very small amount.

These triclinic soda-potash feldspars are chiefly known from the andesitic lavas of Pantelleria. Most of these feldspars come from a rock, called pantellerite. Also prominent from the augite-syenite of southern Norway and from the "Rhomben-porphyr" near Christiania. Here is referred also a feldspar in crystals, tabular ∥ *c* (001), and twinned according to the Manebach and less often Baveno laws occurring in the lithophyses of the rhyolite of Obsidian Cliff, Yellowstone Park. It shows the blue opalescence in a direction parallel with a steep orthodome (cf. p. 457).

Albite-Anorthite Series. *Plagioclase Feldspars* *

Between the isomorphous species

ALBITE	$NaAlSi_3O_8$	Ab
ANORTHITE	$CaAl_2Si_2O_8$	An

there are a number of intermediate subspecies, regarded, as urged by Tschermak, as isomorphous mixtures of these molecules, and defined according to the ratio in which they enter; their composition is expressed in general by the formula Ab_nAn_m. They are:

OLIGOCLASE	Ab_6An_1	to	Ab_3An_1
ANDESINE	Ab_3An_1	to	Ab_1An_1
LABRADORITE	Ab_1An_1	to	Ab_1An_3
and Bytownite	Ab_1An_3	to	Ab_1An_6

From albite through the successive intermediate compounds to anorthite with the progressive change in composition (also specific gravity, melting

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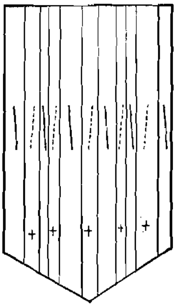
* The triclinic feldspars of this series, in which the two cleavages *b* (010) and *c* (001) are oblique to each other, are often called in general *plagioclase* (from *πλάγιος, oblique*).

points, etc.), there is also a corresponding change in crystallographic form, and in certain fundamental optical properties.

Crystalline Form. The axial ratios and angles given on p. 456 show that these triclinic feldspars approach orthoclase closely in form, the most obvious difference being in the cleavage-angle bc 010 ∧ 001, which is 90° in orthoclase, 86° 24′ in albite, and 85° 50′ in anorthite. There is also a change in the axial angle γ, 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.

780



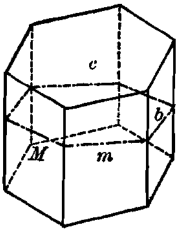
781

Plagioclase with twinning lamellæ. Fig. 780 section ∥ c (001) showing vibration-directions (cf. Fig. 784), ordinary light; Fig. 781 section in polarized light.

Twinning. The plagioclase feldspars are often twinned in accordance with the Carlsbad, Baveno, and Manebach laws common with orthoclase (p. 457). Twinning is also almost universal according to the *albite law* — twinning plane the brachypinacoid; this is usually polysynthetic, *i.e.*, repeated in the form of thin lamellæ, giving rise to fine striations on the basal cleavage surface (Figs. 780, 781). Twinning is also common according to the *pericline law* — twinning axis the macrodiagonal axis b; when polysynthetic this gives another series of fine striations seen on the brachypinacoid.

The composition-plane in this pericline twinning is a plane passing through the crystal in such a direction that its intersections with the prismatic faces and the brachypinacoid make equal plane angles with each other. The position of this rhombic section and the consequent direction of the striations on the brachypinacoid change rapidly with a small variation in the angle γ. In general it may be said to be approximately parallel to the base, but in albite it is inclined backward (+, Figs. 782 and 784) and in anorthite to the front (−, Fig. 783); for the intermediate species its position varies progressively with the composition.

782



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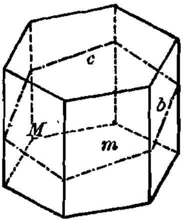

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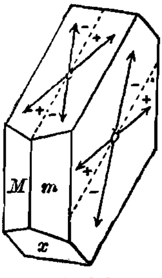
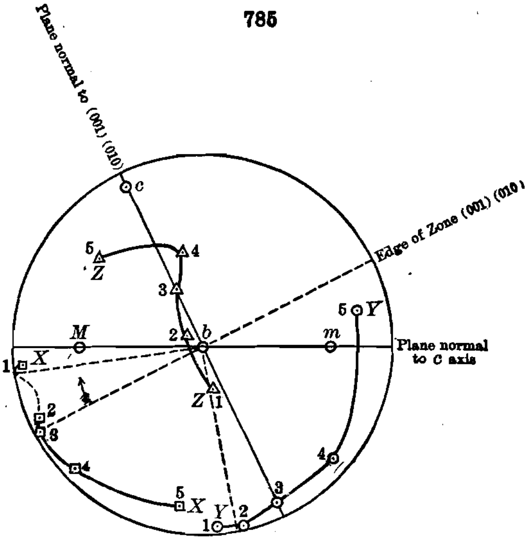


Fig. 782, Rhombic section in albite. 783, Same in anorthite. 784, Typical form showing + and − extinction-directions on c (001) and b (010).

Thus for the angle between the trace of this plane on the brachypinacoid and the edge b/c, we have for Albite +22° to +20°; for Oligoclase +9° to +3½°; for Andesine +1° to −2°; for Labradorite −9° to −10°; for Anorthite −15° to −17°.

If the composition-plane is at right angles or nearly so to the basal plane, as happens in the case of microcline, the polysynthetic lamellæ then show prominently in a basal section, together with those due to the albite twinning. Hence the grating structure characteristic of microline.

785

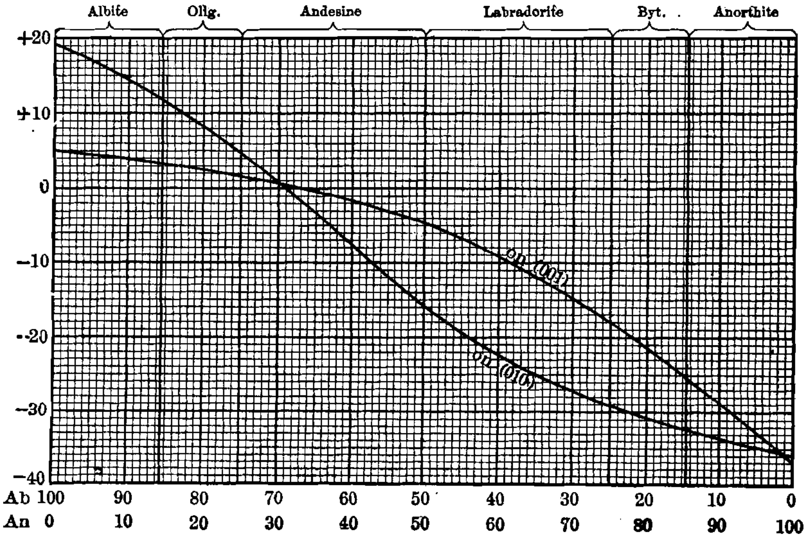


Projection of the optical directions X, Y and Z upon *b* (010). 1, Albite; 2, Oligoclase; 3, Andesine; 4, Labradorite; 5, Anorthite. (After Iddings.)

Optical Characters. There is also a progressive change in the position of the ether-axes and the optic axial plane in passing from albite to anorthite. This is most simply exhibited by the position of the planes of light-vibration, as observed in sections parallel to the two cleavages, basal *c* and brachy-pinacoidal *b*, in other words the extinction-angle formed on each face with the edge *b*/*c* (cf. Fig. 784).

The approximate position of the ether-axes for the different feldspars is shown in Fig. 785 (after Iddings). The axis *Z* does not vary very much from the zone *bc*, 010 ∧ 001, but the axis *X* varies widely, and hence the axial plane has an entirely different position in albite from what it has in anorthite. Furthermore albite is optically pos-

786



Extinction Angles on (001) and (010) in the Lime-soda feldspars. (After Iddings.)

itive, that is Z = Bx, while anorthite is negative or X = Bx; for certain andesines the axial angle is sensibly 90°.

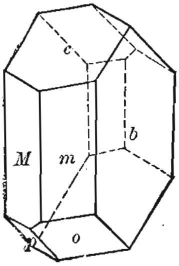
Fig. 786 (after Iddings) shows the variation in the extinction angles on the cleavage faces, *c* (001) and *b* (010), for the different mixtures of the albite and anorthite molecule.

Micro. — In rock sections the plagioclase feldspars are distinguished by their lack of color, low refractive relief, and low interference-colors, which in good sections are mainly dark gray and scarcely rise into white of the first order; also by their biaxial character in converging light. In the majority of cases they are easily told by the parallel bands or fine lamellæ which pass through them due to the multiple twinning according to the albite law; one set of bands or twin lamellæ exhibits in general a different interference-color from the other (cf. Figs. 780, 781). They are thus distinguished not only from quartz and orthoclase, with which they are often associated, but from all the common rock-making minerals. To distinguish the different species and sub-species from one another, as albite from laboradorite or andesine, is more difficult. In sections having a definite orientation (‖ *c* (001) and ‖ *b* (010)) this can generally be done by determining the extinction angles (cf. p. 462 and Fig. 784). In general in rock sections special methods are required; these are discussed in the various texts devoted to this subject.

ALBITE.

Triclinic. Axes $a : b : c = 0{\cdot}6335 : 1 : 0{\cdot}5577$; $\alpha = 94° 3'$, $\beta = 116° 29'$, $\gamma = 88° 9'$.

787



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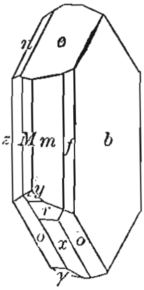

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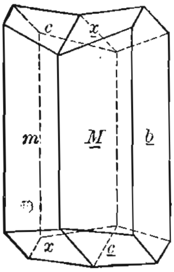


bc, $010 \wedge 001 = 86° 24'$.
mM, $110 \wedge 1\bar{1}0 = 59° 14'$.
bm, $010 \wedge 110 = 60° 26'$.
cm, $001 \wedge 110 = 65° 17'$.
cM, $001 \wedge 1\bar{1}0 = 69° 10'$.
cx, $001 \wedge \bar{1}01 = 52° 16'$.

Twins as with orthoclase; also very common, the tw. pl. *b* (010), *albite law* (p. 462), usually contact-twins, and polysynthetic, consisting of thin lamellæ and with consequent fine striations on *c*(001) (Fig. 790); tw. axis *b* axis, *pericline law*, contact-twins whose composition-face is the *rhombic section* (Figs. 782 and 792); often polysynthetic and showing fine striations which on *b* (010) are inclined backward +22° to the edge *b*/*c*.

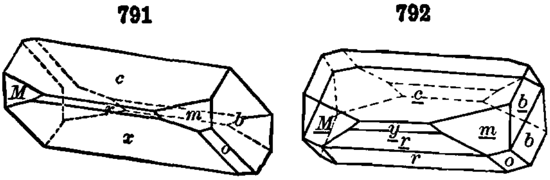
790

Crystals often tabular ‖ *b* (010); also elongated ‖ *b* axis as in the variety pericline. Also massive, either lamellar or granular; the laminæ often curved, sometimes divergent; granular varieties occasionally quite fine to impalpable.

Cleavage: *c*(001) perfect; *b*(010) somewhat less so; *m* (110) imperfect. Fracture uneven to conchoidal. Brittle. H. = 6–6·5. G. = 2·62–2·65. Luster vitreous; 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* (001). Streak uncolored. Transparent to subtranslucent.

Optically +. Extinction-angle with edge $b/c = +4° 30'$ to 2° on *c*, and = +20° to 15° on *b* (Fig. 782). Dispersion for Bx_a, $\rho < v$; also inclined, horizontal; for Bx_o, $\rho > v$; inclined, crossed. $\alpha = 1{\cdot}531$. $\beta = 1{\cdot}534$. $\gamma = 1{\cdot}540$. 2 Y = 77°. Birefringence weak, $\gamma - \alpha = 0{\cdot}009$.

791 792



Pericline

Comp. — A silicate of aluminium and sodium, $NaAlSi_3O_8$ or $Na_2O.Al_2O_3.6SiO_2$ = Silica 68·7, alumina 19·5, soda 11·8 = 100. Calcium is usually present in small amount, as anorthite ($CaAl_2Si_2O_8$), and as this increases it graduates through oligoclase-albite to oligoclase (cf. p. 466). Potassium may also be present, and it is then connected with anorthoclase and microcline.

Var. — *Ordinary.* In crystals and massive. The crystals often tabular ‖ *b* (010). The massive forms are usually nearly pure white, and often show wavy or curved laminæ. *Peristerite* is a whitish adularia-like albite, slightly iridescent, named from *περιστερά, pigeon. Aventurine* and *moonstone* varieties also occur. *Pericline* from the chloritic schists of the Alps is in rather large opaque white crystals, with characteristic elongation in the direction of the *b* axis, as shown in Figs. 791 and 792, and commonly twinned with this as the twinning axis (pericline law).

Pyr., etc. — B.B. fuses at 4 to a colorless or white glass, imparting an intense yellow to the flame. Not acted upon by acids.

Diff. — Resembles barite in some forms, but is harder and of lower specific gravity; does not effervesce with acid (like calcite). Distinguished optically and by the common twinning striations on *c* (001) from orthoclase; from the other triclinic feldspars partially by specific gravity and better by optical means (see p. 463).

Artif. — Albite acts, in regard to its artificial formation, like orthoclase, which see.

Obs. — Albite is a constituent of many igneous rocks, especially those of alkaline type, as granite, elæolite-syenite, diorite, etc.; also in the corresponding feldspathic lavas. In *perthite* (p. 460) it is interlaminated with orthoclase or microcline, and similar aggregations, often on a microscopic scale, are common in many rocks. Albite is common also in gneiss, and sometimes in the crystalline schists. Veins of albitic granite are often repositories of the rarer minerals and of fine crystallizations of gems, including beryl, tourmaline, allanite, columbite, etc. It is found in disseminated crystals in granular limestone.

Some of the most prominent European localities are in cavities and veins in the granite or granitoid rocks of the Swiss and Austrian Alps, associated with adularia, smoky quartz, chlorite, titanite, apatite, and many rarer species: it is often implanted in parallel position upon the orthoclase. Thus in the Alps the St. Gothard region; Roc Tourné near Modane, Savoie; on Mt. Skopi (*pericline*); Tavetschtal; in Austria at Schmirn and Greiner, Tyrol; also Pfitsch, Rauris, the Zillertal, Krimml, Schneeberg in Passeir, Tyrol, in simple crystals. Also in Dauphiné, France, in similar association; Elba. Also Hirschberg in Silesia; Penig in Saxony; with topaz at Mursinka in the Ural Mts. and near Miask in the Ilmen Mts.; Cornwall, England; Mourne Mts. in Ireland. Fine crystals from Greenland.

In the United States, in Me., at Paris, with red and blue tourmalines, also at Topsham. In Mass., at Chesterfield, in lamellar masses (*cleavelandite*), slightly bluish, also fine granular. In N. H., at Acworth and Alstead. In Conn., at Haddam; at the Middletown feldspar quarries, at Branchville, in fine crystals and massive. In N. Y., at Moriah, Essex Co., of a greenish color; at Diana, Lewis Co., and Macomb, St. Laurence Co. In Pa., at Unionville, Chester Co. In Va., at the mica mines near Amelia Court-House in splendid crystallizations. In Col., in the Pike's Peak region with smoky quartz and amazonstone.

The name *albite* is derived from *albus*, white, in allusion to its common color.

Use. — Same as orthoclase but not so commonly employed; some varieties which show an opalescent play of colors when polished form the ornamental material known as *moonstone.*

Oligoclase.

Triclinic. Axes, see p. 456. *bc*, 010 ∧ 001 = 86° 32′. Twins observed according to the Carlsbad, albite, and pericline laws. Crystals not common. Usually massive, cleavable to compact.

Cleavage: *c* (001) perfect; *b* (010) somewhat less so. Fracture conchoidal to uneven. Brittle. H. = 6–6·5. G. = 2·65–2·67. Luster vitreous to somewhat pearly or waxy. Color usually whitish, with a faint tinge of grayish green, grayish white, reddish white, greenish, reddish; sometimes aventurine. Transparent, subtranslucent. Optical characters, see p. 463.

Comp. — Intermediate between albite and anorthite and corresponding to Ab_6An_1 to Ab_2An_1, but chiefly to Ab_3An_1, p. 461.

Var. — 1. *Ordinary.* In crystals or more commonly massive, cleavable. The varieties containing soda up to 10 p. c. are called *oligoclase-albite.* 2. *Aventurine oligoclase,* or *sunstone,* is of a grayish white to reddish gray color, usually the latter, with internal yellowish or reddish fire-like reflections proceeding from disseminated crystals of probably either hematite or göthite.

Pyr., etc. — B.B. fuses at 3·5 to a clear or enamel-like glass. Not materially acted upon by acids.

Diff. — See orthoclase (p. 459) and albite (p. 465); also pp. 456, 463.

Obs. — Occurs in porphyry, granite, syenite, and also in different effusive rocks, as andesite. It is sometimes associated with orthoclase in granite or other granite-like rock. Among its localities are Danviks-Zoll near Stockholm, Sweden; Pargas in Finland; Shaitansk, Ural Mts.; in syenite of the Vosges Mts., France; at Albula in Grisons, Switzerland; Marienbad, Bohemia; in France at Chalanches in Allemont, and Bourg d'Oisans, Dauphiné; as *sunstone* at Tvedestrand, Norway; at Hitterö, Norway; Lake Baikal, Siberia.

In the United States, at Fine and Macomb, St. Lawrence Co., N. Y., in good crystals; at Danbury, Conn., with orthoclase and danburite; Haddam, Conn.; at the emery mine, Chester, Mass., granular; at Unionville, Pa., with euphyllite and corundum; Mineral Hill, Delaware Co., Pa.; at Bakersville, N. C., in clear glassy masses, showing cleavage but no twinning. Named in 1826 by Breithaupt from ὀλίγος, *little,* and κλάσις, *fracture.*

Andesine.

Triclinic. Axes, see p. 456. *bc*, 010 ∧ 001 = 86° 14′. Twins as with albite. Crystals rare. Usually massive, cleavable or granular.

Cleavage: *c* (001) perfect; *b* (010) less so; also *M* $(1\bar{1}0)$ sometimes observed. H. = 5–6. G. = 2·68–2·69. Color white, gray, greenish, yellowish, flesh-red. Luster subvitreous to pearly. Optical characters, see p. 463.

Comp. — Intermediate between albite and anorthite, corresponding to Ab : An in the ratio of 3 : 2, 4 : 3 to 1 : 1, see p. 461.

Pyr., etc. — Fuses in thin splinters before the blowpipe. Imperfectly soluble in acids.

Obs. — Observed in many granular and volcanic rocks; thus occurs in the Andes, at Marmato, Colombia, as an ingredient of the rock called *andesite;* in the porphyry of l'Esterel, Dept. du Var, France; in the syenite of Alsace in the Vosges Mts.; at Vapnefiord, Iceland; Bodenmais, Bavaria; Frankenstein, Silesia. Sanford, Me., with vesuvianite. Common in the igneous rocks of the Rocky Mts. Crystals from Sardinia and Greenland.

Labradorite. Labrador Feldspar.

Triclinic. Axes, see p. 456. Cleavage angle *bc* 010 ∧ 001 = 86° 4′. Forms and twinning similar to the other plagioclase species. Crystals often very thin tabular || *b* (010); and rhombic in outline bounded by *cy* or *cx* (Fig. 455, p. 172). Also massive, cleavable or granular; sometimes cryptocrystalline or hornstone-like.

Cleavage: *c* (001) perfect; *b* (010) less so; *M* $(1\bar{1}0)$ sometimes distinct. H. = 5–6. G. = 2·70–2·72. Luster on *c* pearly, passing into vitreous; elsewhere vitreous or subresinous. Color gray, brown, or greenish; sometimes colorless and glassy; rarely porcelain-white; usually a beautiful change of colors in cleavable varieties, especially || *b* (010). Streak uncolored. Translucent to subtranslucent. Optical characters, see p. 463.

Play of colors a common character, but sometimes wanting as in some colorless crystals. Blue and green are the predominant colors; but yellow, fire-red, and pearl-gray also occur. Vogelsang regards the common blue color of labradorite as an interference-phenomenon due to its lamellar structure, while the golden or reddish schiller, with the other colors, is due to the presence of black acicular microlites and yellowish red microscopic lamellæ, or to the combined effect of these with the blue reflections. Schrauf has examined the inclusions, their position, etc., and given the names *microplakite* and *microphyllite* to two groups of them. (See references on p. 181.)

Comp. — Intermediate between albite and anorthite and corresponding chiefly to Ab : An in a ratio of from 1 : 1 to 1 : 3, p. 461.

The feldspars which lie between labradorite proper and anorthite have been embraced by Tschermak under the name *bytownite*. The original bytownite of Thomson was a greenish white feldspathic mineral found in a boulder near Bytown (now Ottawa) in Ontario, Canada.

Pyr., etc. — B.B. fuses at 3 to a colorless glass. Decomposed with difficulty by hydrochloric acid, generally leaving a portion of undecomposed mineral.

Diff. — The beautiful play of colors is a common but not universal character. Otherwise distinguished as are the other feldspars (pp. 459, 465).

Obs. — Labradorite is an essential constituent of various igneous rocks, especially of the basic kinds, and usually associated with some member of the pyroxene or amphibole groups. Thus with hypersthene in norite, with diallage in gabbro, with some form of pyroxene in diabase, basalt, dolerite, also andesite, tephrite, etc. Labradorite also occurs in other kinds of lava, and is sometimes found in them in glassy crystals, as in those of Etna, Vesuvius, at Kilauea, Hawaiian Islands.

The labradoritic massive rocks are most common among the formations of the Archæan era. Such are part of those of British America, northern New York, Pennsylvania, Arkansas; those of Greenland, Norway, Finland, Sweden, and probably of the Vosges Mts.

On the coast of Labrador, labradorite is associated with hornblende, hypersthene, and magnetite. It is met with in many places in Quebec. Occurs abundantly through the central Adirondack region in northern N. Y.; in the Wichita Mts., Ark.

Labradorite was first brought from the Isle of Paul, on the coast of Labrador, by Mr. Wolfe, a Moravian missionary, about the year 1770.

Use. — The varieties showing a play of colors are used as ornamental material.

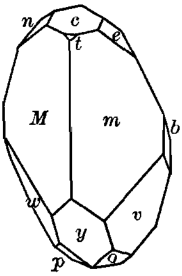
MASKELYNITE. In colorless isotropic grains in meteorites; composition near labradorite.

ANORTHITE. Indianite.

Triclinic. Axes $a : b : c = 0{\cdot}6347 : 1 : 0{\cdot}5501$; $\alpha = 93^\circ\ 13'$, $\beta = 115^\circ\ 55\tfrac{1}{2}'$, $\gamma = 91^\circ\ 12'$.

bc, $010 \wedge 001 = 85^\circ\ 50'$.
mM, $110 \wedge \bar{1}10 = 59^\circ\ 29'$.
bm, $010 \wedge 110 = 58^\circ\ 4'$.
cm, $001 \wedge 110 = 65^\circ\ 53'$.
cM, $001 \wedge 1\bar{1}0 = 69^\circ\ 20'$.
cy, $001 \wedge \bar{2}01 = 81^\circ\ 14'$.

793



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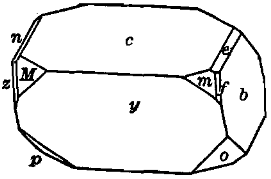


Twins as with albite (p. 462 and p. 464). Crystals usually prismatic || *c* axis (Fig. 793, also Fig. 364, p. 146), less often elongated || *b* axis, like pericline (Fig. 794). Also massive, cleavable, with granular or coarse lamellar structure.

Cleavage: *c* (001) perfect; *b* (010) somewhat less so. Fracture conchoidal to uneven. Brittle. H. = 6–6·5. G. = 2·74–2·76. Color white, grayish, reddish. Streak uncolored. Transparent to translucent.

Optically −. Ax. pl. nearly $\perp$ *e* (021), and its trace inclined 60° to the edge *c*/*e* from left above behind to right in front below. Extinction-angles on *c* (001), −34° to −42° with edge *b*/*c*; on *b* (010), −35° to −43° (Fig. 784, p. 462). Dispersion $\rho < v$, also inclined. 2 V = 78°. α = 1·576. β = 1·584. γ = 1·588. Birefringence stronger than with albite.

Comp. — A silicate of aluminium and calcium, $CaAl_2Si_2O_8$ or $CaO.Al_2O_3.2SiO_2$ = Silica 43·2, alumina 36·7, lime 20·1 = 100. Soda (as $NaAlSi_3O_8$) is usually present in small amount, and as it increases there is a gradual transition through bytownite to labradorite.

Var. — *Anorthite* was described from the glassy crystals of Mte. Somma, Vesuvius; and *christianite* and *biotine* are the same mineral. *Thiorsauite* is the same from Iceland. *Indianite* is a white, grayish, or reddish granular anorthite from India, where it occurs as the gangue of corundum, first described in 1802 by Count Bournon. *Cyclopite* occurs in small, transparent, and glassy crystals, tabular ‖ *b* (010), coating cavities in the dolerite of the Cyclopean Islands and near Trezza on Etna. *Amphodelite, lepolite, latrobite* also belong to anorthite.

Pyr., etc. — B.B. fuses at 5 to a colorless glass. Anorthite from Mte. Somma, and indianite from the Carnatic, India, are decomposed by hydrochloric acid, with separation of gelatinous silica.

Artif. — Anorthite is the easiest of the feldspars to be formed artificially. Unlike the alkalic feldspars it can be easily formed in a dry fusion of its constituents. This method becomes progressively more difficult as the albite molecule is added to the composition. Anorthite is frequently observed in slags and is easily produced in artificial magmas. It further is often produced when more complex silicates are broken down by fusion.

Obs. — Occurs in some diorites; occasionally in connection with gabbro and serpentine rocks; in some cases along with corundum; in many volcanic rocks, andesites, basalts, etc.; as a constituent of some meteorites (Juvenas, Stannern).

Anorthite (*christianite* and *biotine*) occurs at Mount Vesuvius in isolated blocks among the old lavas in the ravines of Monte Somma; in the Albani Mts.; on the Pesmeda Alp, Monzoni, Tyrol, as a contact mineral; Aranyer Berg, Transylvania, in andesite; in Iceland; near Bogoslovsk in the Ural Mts. In the Cyclopean Islands (*cyclopite*). In the lava of the island of Miyake, Japan.

In crystals from Franklin, N. J.; from Phippsburg, Me.

Anorthite was named in 1823 by Rose from ανορθός, *oblique*, the crystallization being triclinic.

Anemousite. A feldspar having the composition, $Na_2O.2CaO.3Al_2O_3.9SiO_2$. This does not agree with any possible member of the albite-anorthite series. This is explained by assuming the presence in small amount of a sodium-anorthite molecule, $Na_2O.Al_2O_3.2SiO_2$, to which the name *carnegieite* has been given. Cleavage angle = 85° 59′. G. = 2·68. α = 1·555. β = 1·559. γ = 1·563. 2 V = 82° 48′. Found as loose crystals on Mte. Rosso, Island of Linosa. Name derived from the ancient Greek name of the island. *Carnegieite* is named in honor of Andrew Carnegie.

II. Metasilicates. $RSiO_3$

Salts of Metasilicic Acid, H_2SiO_3; characterized by an oxygen ratio of 2 : 1 for silicon to bases. The Division closes with a number of species, in part of somewhat doubtful composition, forming a transition to the Orthosilicates.

The metasilicates include two prominent and well-characterized groups, viz., the Pyroxene Group and the Amphibole Group. There are also others less important.

Leucite Group. Isometric

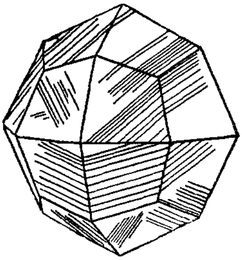
In several respects leucite is allied to the species of the FELDSPAR GROUP, which immediately precede.

Leucite	$KAl(SiO_3)_2$	Isometric at 500°
	Pseudo-isometric at ordinary temperatures.	
Pollucite	$H_2Cs_4Al_4(SiO_3)_9$	Isometric

LEUCITE. Amphigène.

Isometric at 500° C.; pseudo-isometric under ordinary conditions (see p. 302). Commonly in crystals varying in angle but little from the tetragonal trisoctahedron *n* (211), sometimes with *a* (100), and *d* (110) as subordinate forms. Faces often showing fine striations due to twinning (Fig. 795). Also in disseminated grains; rarely massive granular.

795



Cleavage: *d* (110) very imperfect. Fracture conchoidal. Brittle. H. = 5·5–6. G. = 2·45–2·50. Luster vitreous. Color white, ash-gray or smoke-gray. Streak uncolored. Translucent to opaque. Usually shows very feeble double refraction: ω = 1·508, ϵ = 1·509 (p. 302).

Comp. — $KAl(SiO_3)_2$ or $K_2O.Al_2O_3.4SiO_2$ = Silica 55·0, alumina 23·5. potash 21·5 = 100.

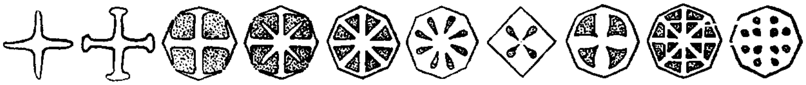
Soda is present only in small quantities, unless as introduced by alteration; traces of lithium, also of rubidium and cæsium, have been detected. Leucite and analcite are closely related chemically as is shown by the fact that the two species can be converted into each other when heated with sodium or potassium chlorides or carbonates.

Pyr., etc. — B.B. infusible; with cobalt solution gives a blue color (aluminium). Decomposed by hydrochloric acid without gelatinization.

Diff. — Characterized by its trapezohedral form, absence of color, and infusibility. It is softer than garnet and harder than analcite; the latter yields water and fuses.

Micro. — Recognized in thin sections by its extremely low refraction, isotropic character, and the symmetrical arrangement of inclusions (Fig. 796; also Fig. 485, p. 180). Larger crystals are commonly not wholly isotropic and, further, show complicated systems of twinning-lines (Fig. 795); the birefringence is, however, very low, and the colors scarcely rise above dark gray; they are best seen by introduction of the quartz or gypsum plate yielding red of the first order. The smaller leucites, which lack this twinning or the inclusions, are only to be distinguished from sodalite or analcite by chemical tests.

796



Leucite crystals from the leucitite of the Bearpaw Mts., Montana (Pirsson). These show the progressive growth from skeleton forms to complete crystals with glass inclusions.

Artif. — Leucite is easily prepared artificially by simply fusing together its constituents in proper proportion and allowing the melt to crystallize slowly. The addition of potassium vanadate produces larger crystals. Leucite has been formed when microcline and biotite were fused together and also when muscovite was fused alone.

Obs. — Leucite occurs only in igneous rocks, and especially in recent lavas, as one of the products of crystallization of magmas rich in potash and low in silica (for which reason this species rather than orthoclase is formed). The larger embedded crystals are commonly anisotropic and show twinning lamellæ; the smaller ones, forming the groundmass, are isotropic and without twinning. Found in leucitites and leucite-basalts, leucitophyres, leucite-phonolites and leucite-tephrites; also in certain rocks occurring in dikes. Very rare in intruded igneous rocks, only one or two instances being known; but its former presence under such conditions is indicated by pseudomorphs, often of large size (*pseudoleucite*) consisting of nephelite and orthoclase, also of analcite.

The prominent localities are, first of all, Vesuvius and Mte. Somma, where it is thickly disseminated through the lava in grains, and in large perfect crystals; also in ejected masses; also near Rome, at Capo di Bove, Rocca Monfina, etc. Further in leucite-tephrite at Proceno near Lake Bolsena in central Italy; in Germany about the Laacher See and at several points in the Eifel; at Rieden near Andernach; at Meiches in the Vogelsgebirge; in the Kaiserstuhlgebirge; Wiesental, Bohemia. Occurs in Brazil, at Pinhalzinho. From the Cerro de las Virgines, Lower California. In the United States it is present in a rock in the Green River Basin at the Leucite Hills, Wy.; also in the Absaroka range, in northwestern Wy.; in the Highwood and Bearpaw Mts., Mon. (in part pseudoleucite). On the shores of Vancouver Island, where magnificent groups of crystals have been found as drift boulders.

Pseudoleucite (see above) occurs in the phonolite (tinguaite) of the Serra de Tingua, Brazil; at Magnet Cove, Ark.; near Hamburg, N.J.; Mon.; also in the Cariboo District, British Columbia.

Named from λευκός, *white*, in allusion to its color.

Pollucite. Essentially $H_2O.2Cs_2O.2Al_2O_3.9SiO_2$. Isometric; often in cubes; also massive. H. = 6·5. G. = 2·901. Colorless. n = 1·525. Occurs very sparingly in the island of Elba, with petalite (castorite); also at Hebron and Rumford, Me.

Ussingite. $HNa_2Al(SiO_3)_3$. Triclinic. Three cleavages. G. = 2·5. H. = 6–7. Color reddish violet. Indices, 1·50–1·55. Easily fusible. Soluble in hydrochloric acid. Found in rolled masses from pegmatite at Kangerdluarsuk, Greenland.

Pyroxene Group

Orthorhombic, Monoclinic, Triclinic

Composition for the most part that of a metasilicate, $RSiO_3$, with R = Ca,Mg,Fe chiefly, also Mn,Zn. Further $RSiO_3$ with $\overset{II}{R}(Fe,Al)_2SiO_6$, less often containing alkalies (Na,K), and then $RSiO_3$ with $\overset{I}{R}Al(SiO_3)_2$. Rarely including zirconium and titanium, also fluorine.

α. Orthorhombic Section

		$a : b : c$	or	$b : a : c$
Enstatite	$MgSiO_3$	0·9702 : 1 : 0·5710		1·0307 : 1 : 0·5885
Bronzite	$(Mg,Fe)SiO_3$			
Hypersthene	$(Fe,Mg)SiO_3$	0·9713 : 1 : 0·5704		1·0319 : 1 : 0·5872

The second set of axial ratios, with a = 1, brings out the similarity of the form to the monoclinic species.

β. Monoclinic Section

	$a : b : c$	β
Pyroxene	1·0921 : 1 : 0·5893	74° 10′

I. *NON-ALUMINOUS VARIETIES:*

1. Diopside	$CaMg(SiO_3)_2$ $Ca(Mg,Fe)(SiO_3)_2$
Malacolite, Salite, Diallage, etc.	
2. Hedenbergite	$CaFe(SiO_3)_2$
Manganhedenbergite	$Ca(Fe,Mn)(SiO_3)_2$
3. Schefferite	$(Ca,Mg)(Fe,Mn)(SiO_3)_2$
Jeffersonite	$(Ca,Mg)(Fe,Mn,Zn)(SiO_3)_2$

II. *ALUMINOUS VARIETIES:*

4. AUGITE $\begin{cases} Ca(Mg,Fe)(SiO_3)_2 \\ \text{with } (Mg,Fe)(Al,Fe)_2SiO_6 \end{cases}$

Leucaugite, Fassaite, Ægirite-augite.

		$a : b : c$	β
Acmite (Ægirite)	$Na\overset{\text{III}}{Fe}(SiO_3)_2$	1·0996 : 1 : 0·6012	73° 11′
Spodumene	$LiAl(SiO_3)_2$	1·1238 : 1 : 0·6355	69° 40′
Jadeite	$NaAl(SiO_3)_2$	1·103 : 1 : 0·613	72° 44½′
		$a : b : c$	β
Wollastonite	$CaSiO_3$	1·0531 : 1 : 0·9676	84° 30′
Pectolite	$HNaCa_2(SiO_3)_3$	1·1140 : 1 : 0·9864	84° 40′

γ. **Triclinic Section**

		$a : b : c$	α	β	γ
Rhodonite	$MnSiO_3$	1·0729 : 1 : 0·6213	103° 18′	108° 44′	81° 39′
	also $(Mn,Ca)SiO_3$				
	$(Mn,Fe)SiO_3$				
	$(Mn,Zn,Fe,Ca)SiO_3$				
Babingtonite	$(Ca,Fe,Mn)SiO_3.Fe_2(SiO_3)_3$	1·0691 : 1 : 0·6308	104° 21½′	108° 31′	83° 34′

The rare species Rosenbuschite, Låvenite, Wöhlerite also belong under the monoclinic section and Hiortdahlite under the triclinic section of this group.

The PYROXENE GROUP embraces a number of species which, while falling in different systems — orthorhombic, monoclinic, and triclinic — are yet closely related in form. Thus all have a fundamental prism with an angle of 93° and 87°, parallel to which there is more or less distinct cleavage. Further, the angles in other prominent zones show a considerable degree of similarity. In composition the metasilicates of calcium, magnesium, and ferrous iron are most prominent, while compounds of the form $\overset{\text{II}}{R}(Al,\overset{\text{III}}{Fe})_2SiO_6$, $\overset{\text{I}}{R}Al(SiO_3)_2$ are also important.

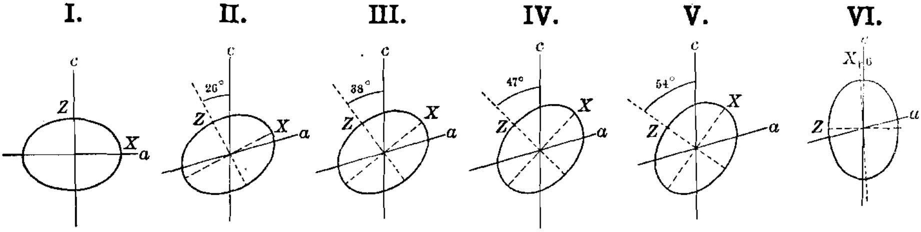
The species of the pyroxene group are closely related in composition to the corresponding species of the amphibole group, which also embraces members in the orthorhombic, monoclinic, and triclinic systems. In a number of cases the same chemical compound appears in each group; furthermore, a change by paramorphism of pyroxene to amphibole is often observed. In form also the two groups are related, as shown in the axial ratio; also in the parallel growth of crystals of monoclinic amphibole upon or about those of pyroxene (Fig. 461, p. 173). The axial ratios for the typical monoclinic species are:

Pyroxene	$a : b : c = 1·0921 : 1 : 0·5893 \quad \beta = 74° 10'$
Amphibole	$a : \frac{1}{2}b : c = 1·1022 : 1 : 0·5875 \quad \beta = 73° 58'$

See further on p. 486.

The optical relations of the prominent members of the Pyroxene Group, especially as regards the connection between the position of the ether-axes and the crystallographic axes are exemplified in the following figures (Cross). A corresponding exhibition of the prominent amphiboles is given under that group, Fig. 826, p. 486.

797



I, Enstatite, etc. II, Spodumene. III, Diopside, etc. IV, Hedenbergite, Augite. V, Augite. VI, Acmite.

α. Orthorhombic Section

ENSTATITE.

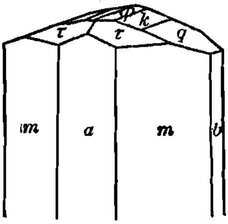
Orthorhombic. Axes $a : b : c = 0{\cdot}9702 : 1 : 0{\cdot}5710$.

mm''', $110 \wedge 1\bar{1}0 = 88° 16'$. $\tau\tau'$, $223 \wedge \bar{2}23 = 40° 16\frac{1}{2}'$.
qq', $023 \wedge 0\bar{2}3 = \bar{2}41° 41'$. $\tau\tau'''$, $223 \wedge 2\bar{2}3 = 39° 1\frac{1}{2}'$.

Twins rare: tw. pl. *h* (014) as twinning lamellæ; also tw. pl. (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* (110) rather easy. Parting || *b* (010); also *a* (100). Fracture uneven. Brittle. H. = 5·5. G. = 3·1–3·3. Luster, a little pearly on cleavage-surfaces to vitreous; often metalloidal in the bronzite variety. Color grayish, yellowish or greenish white, to olive-green and brown. Streak uncolored, grayish. Translucent to nearly opaque. Pleochroism weak, more marked in varieties relatively rich in iron. Optically +. Ax. pl. || *b* (010). $Bx_a \perp c$ (001). Dispersion $\rho < v$ weak. Axial angle large and variable, increasing with the amount of iron, usually about 90° for FeO = 10 p. c. $\beta = 1{\cdot}669$; $\gamma - \alpha = 0{\cdot}009$.

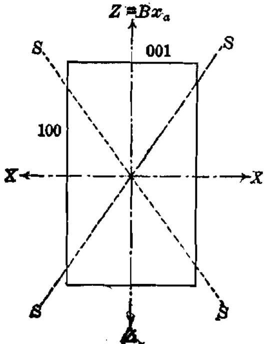
798



Bamle

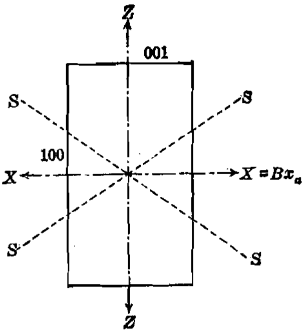
Comp. — $MgSiO_3$ or $MgO.SiO_2$ = Silica 60. magnesia 40 = 100. Also $(Mg,Fe)SiO_3$ with Mg : Fe = 8 : 1, 6 : 1, 3 : 1, etc.

799



Enstatite (Bronzite)

800



Hypersthene

Var. — 1. *With little or no iron; Enstatite.* Color white, yellowish, grayish, or greenish white; luster vitreous to pearly; G. = 3·10–3·13. *Chladnite* (Shepardite of Rose), which makes up 90 p. c. of the Bishopville meteorite, belongs here and is the purest kind. *Victorite,* occurring in the Deesa meteoric iron in rosettes of acicular crystals, is similar.

2. *Ferriferous; Bronzite.* Color grayish green to olive-green and brown. Luster on cleavage-surface often adamantine-pearly to submetallic or bronze-like; this, however, is usually of secondary origin and is

not essential. With the increase of iron (above 12 to 14 p. c.) bronzite passes to hypersthene, the optic axial angle changing so that in the latter $X = Bx_a \perp a$ (100). This is illustrated by Figs. 799, 800.

Pyr., etc. — B.B. almost infusible, being only slightly rounded on the thin edges; F. = 6. Insoluble in hydrochloric acid.

Artif. — Enstatite is formed from a melt having the proper composition at temperatures slightly under 1100°. At higher temperatures the monoclinic pyroxenes appear. Enstatite has also been formed by fusing olivine with silica. When serpentine is melted it breaks down into enstatite and olivine.

Micro. — In thin sections is colorless or light yellow or green; marked relief; prominent cleavage with parallel extinction; little pleochroism but becoming stronger with increase of iron; inclusions common lying parallel to brachypinacoid, producing characteristic schiller of mineral.

Obs. — Enstatite (including bronzite) is a common constituent of peridotites and the serpentines derived from them; it also occurs in crystalline schists. It is often associated in parallel growth with a monoclinic pyroxene, *e.g.*, diallage. A common mineral in meteoric stones often occurring in chondrules with eccentric radiated structure.

Occurs near Aloystal in Moravia, in serpentine; at Kupferberg in Bavaria; at Baste in the Harz Mts., Germany (*protobastite*); in the so-called olivine bombs of the Dreiser Weiher in the Eifel, Germany; in immense crystals, in part altered, at the apatite deposits of Kjörrestad near Bamle, Norway; in the peridotite associated with the diamond deposits of South Africa.

In the United States, in N. Y. at the Tilly Foster magnetite mine, Brewster, Putnam Co., with chondrodite and at Edwards; Texas, Pa.; bronzite from Webster, N. C.; Bare Hills, Baltimore, Md.

Named from ἐνστάτης, an *opponent*, because so refractory. The name *bronzite* has priority, but a bronze luster is not essential, and is far from universal.

HYPERSTHENE.

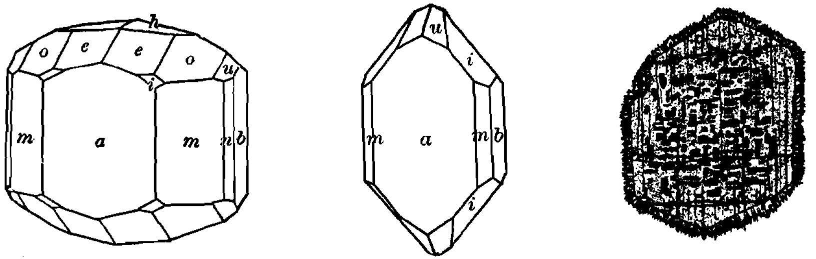
Orthorhombic. Axes $a : b : c = 0{\cdot}9713 : 1 : 0{\cdot}5704$.

mm''', $110 \wedge 1\bar{1}0 = 88° 20'$.
oo''', $111 \wedge 1\bar{1}1 = 52° 23'$.
hh', $014 \wedge 0\bar{1}4 = 16° 14'$.
uu''', $232 \wedge 2\bar{3}2 = 72° 50'$.

Crystals rare, habit prismatic, often tabular || *a* (100), less often || *b* (010). Usually foliated massive; sometimes in embedded spherical forms.

Cleavage: *b* (010) perfect; *m* (110) and *a* (100) distinct but interrupted. Fracture uneven. Brittle. H. = 5–6. G. = 3·40–3·50. Luster somewhat pearly on a cleavage-surface, and sometimes metalloidal. Color dark brownish green, grayish black, greenish black, pinchbeck-brown. Streak grayish, brownish gray. Translucent to nearly opaque. Pleochroism often strong, especially in the kinds with high iron percentage; thus || *X* or *a* axis brownish red, *Y* or *b* axis reddish yellow, *Z* or *c* axis green. Optically –. Ax. pl. || *b* (010). $Bx_a \perp a$ (100). Dispersion $\rho > v$. Axial angle rather large and

801 802 803



Figs. 801, *Amblystegite*, Laacher See. 802, Málnás. 803, Section || *b* (010) showing inclusions; the exterior transformed to actinolite; from Lacroix.

variable, diminishing with increase of iron, cf. enstatite, p. 472, and Figs. 799, 800, p. 472. $\beta = 1{\cdot}702$; $\gamma - \alpha = 0{\cdot}013$.

Hypersthene often encloses minute tabular scales, usually of a brown color, arranged mostly parallel to the basal plane (Fig. 803), also less frequently vertical or inclined 30° to c axis; they may be brookite (göthite, hematite), but their true nature is doubtful. They are the cause of the peculiar metalloidal luster or schiller, and are often of secondary origin, being developed along the so-called "solution-planes" (p. 189).

Comp. — $(Fe,Mg)SiO_3$ with Fe : Mg = 1 : 3(FeO = 16·7 p. c.), 1 : 2 (FeO = 21·7 p. c.) to nearly 1 : 1(FeO = 31·0 p. c.). Alumina is sometimes present (up to 10 p. c.) and the composition then approximates to the aluminous pyroxenes.

Of the orthorhombic magnesium-iron metasilicates, those with FeO > 12 to 15 p. c. are usually to be classed with hypersthene, which is further characterized by being optically negative and having dispersion $\rho > v$.

Pyr., etc. — B.B. fuses to a black enamel, and on charcoal yields a magnetic mass; fuses more easily with increasing amount of iron. Partially decomposed by hydrochloric acid.

Micro. — In thin sections similar to enstatite except shows distinct reddish or greenish color with stronger pleochroism and is optically −.

Artif. — Similar to enstatite, which see.

Obs. — Hypersthene, associated with a triclinic feldspar (labradorite), is common in certain granular eruptive rocks, as norite, hyperite, gabbro, also in some andesites (*hypersthene-andesite*), a rock shown to occur rather extensively in widely separated regions.

It occurs at Isle St. Paul, Labrador; in Greenland; at Farsund and elsewhere in Norway; Elfdalen in Sweden; Penig in Saxony; Ronsberg in Bohemia; the Tyrol; Neurode in Silesia; Bodenmais, Bavaria. *Amblystegite* is from the Laacher See, Germany. *Szaboite* occurs with pseudobrookite and tridymite, in cavities in the andesite of the Aranyer Berg, Transylvania, and elsewhere.

Occurs in the norites of the Cortlandt region on the Hudson river, N. Y.; also common with labradorite in the Adirondack Archæan region of northern N. Y. and northward in Canada. In the hypersthene-andesites of Mt Shasta, Cal.; Buffalo Peaks, Col., and other points.

Hypersthene is named from ὑπέρ and σθένος, *very strong*, or *tough*.

BASTITE, or SCHILLER SPAR. An altered enstatite (or bronzite) having approximately the composition of serpentine. It occurs in foliated form in certain granular eruptive rocks and is characterized by a bronze-like metalloidal luster or schiller on the chief cleavage-face b (010), which "schillerization" (p. 251) is of secondary origin. H. = 3·5–4. G. = 2·5–2·7. Color leek-green to olive- and pistachio-green, and pinchbeck-brown. Pleochroism not marked. Optically −. Double refraction weak. Ax. pl. ∥ a (010) (hence normal to that of enstatite). $Bx_a \perp b$ (010). Dispersion $\rho > v$. The original bastite was from Baste near Harzburg in the Harz Mts., Germany; also from Todtmoos in the Schwarzwald, Germany.

PECKHAMITE, $2(Mg,Fe)SiO_3.(Mg,Fe)SiO_4$. Occurs in rounded nodules in the meteorite of Estherville, Emmet Co., Iowa, May 10, 1879. G. = 3·23. Color light greenish yellow.

β. Monoclinic Section

PYROXENE.

Monoclinic. Axes $a : b : c = 1{\cdot}0921 : 1 : 0{\cdot}5893$; $\beta = 74° 10'$.

mm''', $110 \wedge 1\bar{1}0 = 92° 50'$.
ca, $001 \wedge 100 = 74° 10'$.
cp, $001 \wedge \bar{1}01 = 31° 20'$.
ee', $011 \wedge 0\bar{1}1 = 59° 6'$.
zz', $021 \wedge 0\bar{2}1 = 97° 11'$.
cu, $001 \wedge 111 = 33° 49\tfrac{1}{2}'$.
cv, $001 \wedge 221 = 49° 54'$.
cn, $001 \wedge 110 = 79° 9\tfrac{1}{2}'$.
cs, $001 \wedge \bar{1}11 = 42° 2'$.
uu', $111 \wedge 1\bar{1}1 = 48° 29'$.
ss', $\bar{1}11 \wedge \bar{1}\bar{1}1 = 59° 11'$.
oo', $\bar{2}21 \wedge \bar{2}\bar{2}1 = 84° 11'$.

Twins: tw. pl. (1) a (100), contact-twins, common (Fig. 810), sometimes polysynthetic. (2) c (001), as twinning lamellæ producing striations on the vertical faces and pseudocleavage or parting ∥ c (Fig. 811); very common, often secondary. (3) *y* (101) cruciform-twins, not common (Fig. 451, p. 171). (4) *W* ($\bar{1}22$) the vertical axes crossing at angles of nearly 60°; sometimes repeated as a six-rayed star (Fig. 450, p. 171). Crystals usually prismatic in habit, often short and thick, and either a square prism (*a* (100), *b* (010) prominent), or nearly square (93°, 87°) with *m* (110) predominating; sometimes a nearly symmetrical 8-sided prism with *a*, *b*, *m* (Fig. 811). Often coarsely lamellar, || *c* (001) or *a* (100). Also granular, coarse or fine; rarely fibrous or columnar.

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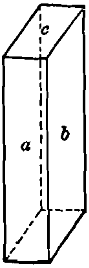

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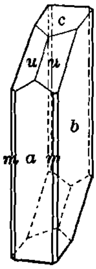

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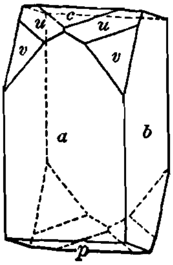

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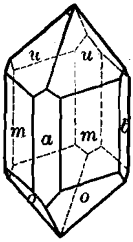

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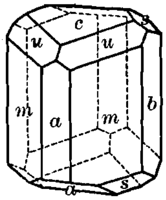

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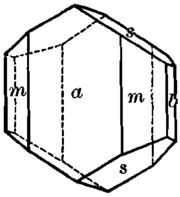

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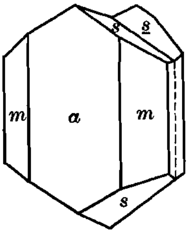

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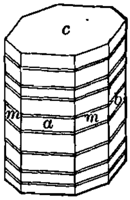

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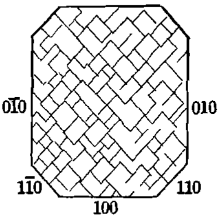
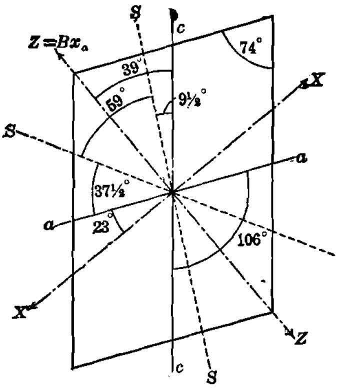


Cleavage: *m* (110) sometimes rather perfect, but interrupted, often only observed in thin sections ⊥ *c* axis (Fig. 812). Parting || *c* (001), due to twinning, often prominent, especially in large crystals and lamellar masses (Fig. 811); also || *a* (100) less distinct and not so common. Fracture uneven to conchoidal. Brittle. H. = 5–6. G. = 3·2–3·6, varying with the composition. Luster vitreous inclining to resinous; often dull; sometimes pearly || *c*(001) in kinds showing parting. Color usually green of various dull shades, varying from nearly colorless, white, or grayish white to brown and black; rarely bright green, as in kinds containing chromium; also blue. Streak white to gray and grayish green. Transparent to opaque. Pleochroism usually weak, even in dark-colored varieties; sometimes marked, especially in violet-brown kinds containing titanium. (*Violaite* is name given to a highly pleochroic variety from the Caucasus Mts.)

813



Optically +. Birefringence strong, $(\gamma - \alpha) = 0{\cdot}02 - 0{\cdot}03$. Ax. pl. $\|$ *b* (010). Bx_a or $Z \wedge c$ axis = $+36°$ in diopside, to $+52°$ in augite (which see), or $Z \wedge c$ (001) = 20° to 36°, the angle in general increasing with amount of iron. For diopside 2 V = 59°. $\alpha = 1{\cdot}673$. $\beta = 1{\cdot}680$. $\gamma = 1{\cdot}702$.

Comp. — For the most part a normal metasilicate, $RSiO_3$, chiefly of calcium and magnesium, also iron, less 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 most simply considered as molecular compounds of $Ca(Mg,Fe)Si_2O_6$ and $(Mg,Fe)(Al,Fe)_2SiO_6$, as suggested by Tschermak. Chromium is sometimes present in small amount; also titanium replacing silicon.

The name *Pyroxene* is from πυρ, *fire* and ξενος, *stranger*, and records Haüy's idea that the mineral was, as he expresses it, "a stranger in the domain of fire," whereas, in fact, it is, next to the feldspars, the most universal constituent of igneous rocks.

The varieties are numerous and depend upon variations in composition chiefly; the more prominent of the varieties properly rank as sub-species.

Artif. — The monoclinic pyroxene, $MgSiO_3$, can be crystallized from a melt having the theoretical composition at temperatures about 1500° or at a lower temperature from solution in molten calcium or magnesium vanadate. It is the most stable form of $MgSiO_3$. It has no true melting point but at about 1550° breaks down into forsterite and silica.

I. *Containing little or no Aluminium*

1. **Diopside.** Malacolite, Alalite. *Calcium-magnesium pyroxene.* Formula $CaMg(SiO_3)_2$ = Silica 55·6, lime 25·9, magnesia 18·5 = 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 prismatic crystals, often slender; also granular and columnar to lamellar massive. G. = 3·2–3·38. $Bx_a \wedge c$ axis = + 36° and upwards. $\gamma - \alpha = 0{\cdot}03$. Iron is present usually in small amount as noted below, and the amount increases as it graduates toward true hedenbergite.

The following belong here: *Chrome-diopside*, contains chromium (1 to 2·8 p. c. Cr_2O_3), often a bright green.

Malacolite, as originally described, was a pale-colored translucent variety from Sala, Sweden.

Alalite occurs in broad right-angled prisms, colorless to faint greenish or clear green, from the Mussa Alp in the Ala valley, Piedmont, Italy.

Traversellite, from Traversella, Piedmont, Italy, is similar.

Violan is a fine blue diopside from St. Marcel, Piedmont, Italy; occurring in prismatic crystals and massive.

Canaanite is a grayish-white or bluish-white pyroxene rock occurring with dolomite at Canaan, Conn.

Lavrovite is a pyroxene, colored green by vanadium, from the neighborhood of Lake Baikal, in eastern Siberia.

Diopside is named from δις, *twice* or *double*, and ὄψις, *appearance*. Malacolite is from μαλακός, *soft*, because softer than feldspar, with which it was associated.

2. **Hedenbergite.** *Calcium-iron pyroxene.* Formula $CaFe(SiO_3)_2$ = Silica 48·4, iron protoxide 29·4, lime 22·2 = 100. Color black. In crystals, and also lamellar massive. G. = 3·5–3·58. $Bx_a \wedge c$ axis = + 48°. Manganese is present in *manganhedenbergite* to 6·5 p. c. Color grayish green. G. = 3·55.

Between the two extremes, diopside and hedenbergite, there are numerous transitions conforming to the formula $Ca(Mg,Fe)Si_2O_6$. As the amount of iron increases the color changes from light to dark green to nearly black, the specific gravity increases from 3·2 to 3·6, and the angle $Bx_a \wedge c$ axis also from 36° to 48°.

The following are varieties, coming under these two sub-species, based in part upon structure, in part on peculiarities of composition.

Salite (Sahlite), color grayish green to deep green and black; sometimes grayish and yellowish white; in crystals; also lamellar (parting ‖ *c* (001)), and granular massive; from Sala in Sweden. *Baikalite*, a dark dingy green variety, in crystals, with parting ‖ *c* (001), from Lake Baikal, in Siberia.

Coccolite is a granular variety, embedded in calcite, also forming loosely coherent to compact aggregates; color varying from white to pale green to dark green, and then containing considerable iron; the latter the original coccolite. Named from κόκκος, a *grain*.

DIALLAGE. A lamellar or thin-foliated pyroxene, characterized by a fine lamellar structure and parting ‖ *a* (100), with also parting ‖ *b* (010), and less often ‖ *c* (001). Also a fibrous structure ‖ *c* axis. Twinning ‖ *a* (100), often polysynthetic; interlamination with an orthorhombic pyroxene common. Color grayish green to bright grass-green, and deep green; also brown. Luster of surface *a* (100) often pearly, sometimes metalloidal or exhibiting schiller and resembling bronzite, from the presence of microscopic inclusions of secondary origin. $Bx_a \wedge c$ axis = + 39 to 40°; $\beta = 1{\cdot}681$; $\gamma - \alpha = 0{\cdot}024$. H. = 4; G. = 3·2–3·35. In composition near diopside, but often containing alumina and sometimes in considerable amount, then properly to be classed with the augites. Often changed to amphibole, see smaragdite, and uralite, p. 490. Named from διαλλαγή, *difference*, in allusion to the dissimilar planes of fracture. This is the characteristic pyroxene of gabbro, and other related rocks.

Omphacite. The granular to foliated pyroxenic constituent of the garnet-rock called eclogite, often interlaminated with amphibole (smaragdite); color grass-green. Contains some Al_2O_3.

3. SCHEFFERITE. A manganese pyroxene, sometimes also containing much iron. Color brown to black.

In crystals, sometimes tabular ‖ *c* (001), also with *p* ($\bar{1}$01) prominent, more often elongated in the direction of the zone *b* (010) : *p* ($\bar{1}$01), rarely prismatic, ‖ *c* axis. Twins, with *a* (100) as tw. pl. very common. Also crystalline, massive. Cleavage prismatic, very distinct. Color yellowish brown to reddish brown; also black (*iron-schefferite*). Optically +. Bx_a or $Z \wedge c$ axis = 44° 25½′. The iron-schefferite from Pajsberg, Sweden, is black in color and has $Z \wedge c$ axis = + 49° to 59° for different zones in the same crystal. The brown iron-schefferite (*urbanite*) from Långban, Sweden, has $Z \wedge c$ axis = 69° 3′. It resembles garnet in appearance.

Jeffersonite is a manganese-zinc pyroxene from Franklin Furnace, N. J. (but the zinc may be due to impurity). In large, coarse crystals with edges rounded and faces uneven. Color greenish black, on the exposed surface chocolate-brown.

Blanfordite. A pyroxene containing some sodium, manganese and iron. Strongly pleochroic (rose-pink to sky-blue). Found with manganese ores in the Central Provinces, India.

Clinoenstatite has been suggested as the name for the monoclinic magnesium pyroxene.

II. *Aluminous*

4. AUGITE. *Aluminous pyroxene*. Composition chiefly $CaMgSi_2O_6$ with $(Mg,Fe)(Al,Fe)_2SiO_6$, and occasionally also containing alkalies and then graduating toward acmite. Titanium is also sometimes present. Here belong:

a. LEUCAUGITE. Color white or grayish. Contains alumina, with lime and magnesia, and little or no iron. Looks like diopside. H. = 6·5; G. = 3·19. Named from λευκός, *white*.

b. FASSAITE. Includes the pale to dark, sometimes deep-green crystals, or pistachio-green and then resembling epidote. The aluminous kinds of diallage also belong here. Named from the locality in the Fassatal, Tyrol. *Pyrgom* is from πύργωμα, *a tower*.

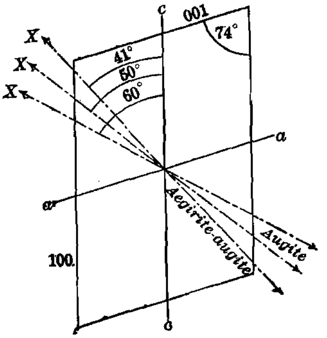
c. AUGITE. Includes the greenish or brownish black and black kinds, occurring mostly in eruptive rocks. It is usually in short prismatic crystals, thick and stout, or tabular ‖ *a* (100); often twins (Figs. 809, 810). Ferric iron is here present, in a relatively large amount, and the angle $Bx_a \wedge c$ axis becomes + 50° to 52°. $\beta = 1{\cdot}717$; $\gamma - \alpha = 0{\cdot}022$. TiO_2 is present in some kinds, which are then pleochroic. Named from αὐγή, *luster*.

d. ALKALI-AUGITE. Here belong varieties of augite characterized by the presence of alkalies, especially soda; they approximate in composition and optically to acmite and ægirite ($Bx_a \wedge c$ axis = 60°, Fig. 814), and are sometimes called ægirite-augite (cf. Fig. 818,

p. 480). Known chiefly from rocks rich in alkalies, as elæolite-syenite, phonolite, leucitite, etc.

Pyr., etc. — Varying widely, owing to the wide variations in composition in the different varieties, and often by insensible gradations. Fusibility, 3·75 in diopside; 3·5 in salite, baikalite, and omphacite; 3 in jeffersonite and augite; 2·5 in hedenbergite. *Varieties rich in iron afford* a magnetic globule when fused on charcoal, and in general the fusibility varies with the amount of iron. Many varieties give with the fluxes reactions for manganese. Most varieties are unacted upon by acids.

814



Diff. — Characterized by monoclinic crystallization and the prismatic angle of 87° and 93°, hence yielding nearly square prisms; these may be mistaken for scapolite if terminal faces are wanting or indistinct (but scapolite fuses easily B. B. with intumescence). The oblique parting (∥ *c* (001), Fig. 811) often distinctive, also the common dull green to gray and brown colors. Amphibole differs in prismatic angle (55½° and 124½°) and cleavage, and in having common columnar to fibrous varieties, which are rare with pyroxene. (See also p. 486.)

Micro. — The common rock-forming pyroxenes are distinguished in thin sections by their high relief; usually greenish to olive tones of color; distinct system of interrupted cleavage-cracks crossing one another at nearly right angles in sections ⊥ *c* axis (Fig. 812); high interference-colors; general lack of pleochroism; large extinction-angle, 35° to 50° and higher, for sections ∥ *b* (010). The last-named sections are easily recognized by showing the highest interference colors; yielding no optical figures in convergent light and having parallel cleavage-cracks, the latter in the direction of the vertical axis. See also ægirite, p. 480.

A zonal banding is common, the successive laminæ sometimes differing in extinction-angle and pleochroism; also the hour-glass structure occasionally distinct (Fig. 815, from Lacroix).

815

Obs. — Pyroxene is a very common mineral in igneous rocks, being the most important of the ferromagnesian minerals. Some rocks consist almost entirely of pyroxene. It most commonly occurs in volcanic rocks but is found also, but less abundantly, in connection with granitic rocks. It is a common mineral in crystalline limestone and dolomite, in serpentine and metamorphic schists; sometimes forms large beds or veins, especially in Archæan rocks. It occurs also in meteorites. The pyroxene of limestone is mostly white and light green or gray in color, falling under *diopside* (malacolite, salite, coccolite); that of most other metamorphic rocks is sometimes white or colorless, but usually green of different shades, from pale green to greenish black, and occasionally black; that of serpentine is sometimes in fine crystals, but often of the foliated green kind called *diallage;* that of eruptive rocks is usually the black to greenish black *augite.*

In limestone the associations are often amphibole, scapolite, vesuvianite, garnet, orthoclase, titanite, apatite, phlogopite, and sometimes brown tourmaline, chlorite, talc, zircon, spinel, rutile, etc.; and in other metamorphic rocks mostly the same. In eruptive rocks it may be in distinct embedded crystals, or in grains without external crystalline form; it often occurs with similarly disseminated chrysolite (olivine), crystals of orthoclase (sanidine), labradorite, leucite, etc.; also with a rhombic pyroxene, amphibole, etc.

Pyroxene, as an essential rock-making mineral, is especially common in basic eruptive rocks. Thus, as augite, with a triclinic feldspar (usually labradorite), magnetite, often chrysolite, in basalt, basaltic lavas and diabase; in andesite; also in trachyte; in peridotite and pikrite; with nephelite in phonolite. Further with elæolite, orthoclase, etc., in elæolite-syenite and augite-syenite; also as diallage in gabbro; in many peridotites and the *serpentines formed from them;* as diopside (malacolite) in crystalline schists. In limburgite, augitite and pyroxenite, pyroxene is present as the prominent constituent, while feldspar is absent; it may also form rock masses alone nearly free from associated minerals.

Diopside (alalite, mussite) occurs in fine crystals on the Mussa Alp in the Ala valley in Piedmont, Italy, associated with garnets (hessonite) and talc in veins traversing serpentine; in fine crystals at Traversella, Piedmont; at Zermatt in Switzerland; Schwarzenstein in the Zillertal, Ober-Sulzbachtal, and elsewhere in Tyrol and in the Salzburg Alps; Reichenstein, Silesia, Germany; Ober-Sulzbachtal and elsewhere in Tyrol and in the Salzburg Alps; Reichenstein Lake; Rezbánya, Hungary; Achmatovsk in the Ural Mts., with almandite, clinochlore; Lake Baikal (*baikalite*) in eastern Siberia; Pargas in Finland; at Nordmark, Sweden.

Hedenbergite is from Tunaberg and Nordmark, Sweden; Arendal, Norway. Manganhedenbergite from Vester Silfberg, Sweden; *schefferite* from Långban, Sweden.

Augite (including fassaite) occurs on the Pesmeda Alp, Mt. Monzoni, and elsewhere in the Fassatal, Tyrol, as a contact formation; at Carlsbad and Teplitz, Bohemia; Traversella, Piedmont, Italy; the Laacher See, Eifel and Sasbach in the Kaiserstuhl, Germany; in Italy at Vesuvius, white rare, green, brown, yellow to black, Frascati, Etna; the Azores and Cape Verde Islands; the Hawaiian Islands, and many other regions of volcanic rocks.

In North America, occurs in Me., at Raymond and Rumford, diopside, salite, etc. In Vt., at Thetford, black augite, with chrysolite, in bowlders of basalt. In Conn., at Canaan, white crystals, often externally changed to tremolite, in dolomite; also the pyroxenic rock called *canaanite*. In N. Y., at Warwick, fine crystals; in Westchester Co., white, at the Sing Sing quarries; in Orange Co., in Monroe, at Two Ponds, crystals, often large, in limestone; near Greenwood furnace, and also near Edenville; in Lewis Co., at Diana, white and black crystals; in St. Lawrence Co., at Fine, in large crystals; at De Kalb, fine diopside; also at Gouverneur, Rossie, Russell, Pitcairn; at Moriah, coccolite, in limestone. In N. J., Franklin Furnace, Sussex Co., good crystals, also *jeffersonite*. In Pa., near Attleboro, crystals, and granular; in Pennsbury, at Burnett's quarry, diopside; at the French Creek mines, Chester Co., chiefly altered to fibrous amphibole. In Tenn., at the Ducktown mines.

In Canada, at Calumet Island, grayish green crystals in limestone; in Bathurst, colorless or white crystals; at Grenville, dark green crystals, and granular; Burgess, Lanark Co.; Renfrew Co., with apatite, titanite, etc.; crystals from Adams Lake, Ontario; Orford, Sherbrooke Co., white crystals, also of a chrome-green color with chrome garnet; at Hull and Wakefield, white crystals with nearly colorless garnets, honey-yellow vesuvianite, etc. At many other points in the Archæan of Quebec and Ontario, especially in connection with the apatite deposits.

Pyroxene undergoes alteration in different ways. A change of molecular constitution without essential change of composition, i.e., by *paramorphism* (using the word rather broadly), may result in the formation of some variety of amphibole. Thus, the white pyroxene crystals of Canaan, Conn., are often changed on the exterior to tremolite; similarly with other varieties at many localities. See *uralite*, p. 490. Also changed to steatite, serpentine, etc.

PIGEONITE, is the name given to a pyroxene with small and variable axial angle from Pigeon Point, Minn.

ACMITE. ÆGIRITE.

Monoclinic. Axes: $a : b : c = 1{\cdot}0996 : 1 : 0{\cdot}6012$; $\beta = 73° 11'$.

Twins: tw. pl. a (100) very common; crystals often polysynthetic, with enclosed twinning lamellæ. Crystals long prismatic, vertically striated or channeled; acute terminations very characteristic.

The above applies to ordinary *acmite*. For *ægirite*, crystals prismatic, bluntly terminated; twins not common; also in groups or tufts of slender acicular to capillary crystals, and in fibrous forms.

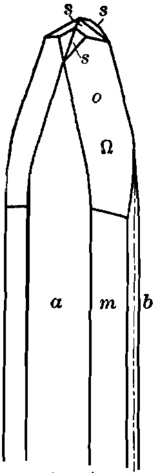
Cleavage: m (110) distinct; b (010) less so. Fracture uneven. Brittle. H. = 6–6·5. G. = 3·50–3·55. Luster vitreous, inclining to resinous. Streak pale yellowish gray. Color brownish or reddish brown, green; in the fracture blackish green. Subtransparent to opaque. Optically –. Ax. pl. $\parallel b$ (010). Bx_a or $X \wedge c$ axis $= +2\frac{1}{2}°$ acmite, to 6° ægirite. $\alpha = 1{\cdot}763$. $\beta = 1{\cdot}799$. $\gamma = 1{\cdot}813$.

Var. — Includes *acmite* in sharp-pointed crystals (Fig. 816) often twins. $Bx_a \wedge c$ axis $= 5\frac{1}{2}°–6°$. Also *ægirite* (Fig. 817) in crystals bluntly terminated, twins rare, $Bx_a \wedge c$ axis $= 2\frac{1}{2}°–3\frac{1}{2}°$.

Crystals of acmite often show a marked zonal structure, green within and brown on the exterior, particularly $\parallel a$ (100), b (010), p ($\bar{1}01$), s (111). The brown portion (acmite) is feebly pleochroic, the green (ægirite) strongly pleochroic. Both have absorption $X > Y > Z$, but the former has X light brown with tinge of green, Y greenish yellow with tinge of brown, Z brownish yellow; the latter has X deep grass-green, Y lighter grass-green, Z yellowish brown to yellowish.

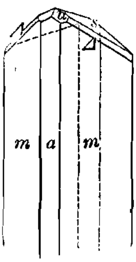
With some authors (vom Rath, etc.) s = (011) and $X \wedge c$ axis = − 2° to − 6°, as in Fig. 819. Fig. 818 shows the optical orientation according to Brögger.

816



Acmite

817



Ægirite

III

Comp. — Essentially $NaFe(SiO_3)_2$ or $Na_2O.Fe_2O_3.4SiO_2$ = Silica 52·0, iron sesquioxide 34·6, soda 13·4 = 100. Ferrous iron is also present.

Pyr., etc. — B.B. fuses at 2 to a lustrous black magnetic globule, coloring the flame deep yellow; with the fluxes reacts for iron and sometimes manganese. Slightly acted upon by acids.

Micro. — Ægirite is characterized in thin sections by its grass-green color; strong pleochroism in tones of green and yellow; the small extinction-angle in sections ∥ b(010). Distinguished from common green hornblende, with which it might be confounded, by the fact that in such sections the direction of extinction lying near the cleavage is negative (X), while the same direction in hornblende is positive (Z).

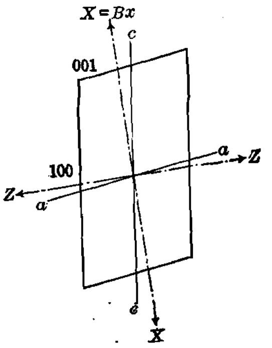
Artif. — Acmite can be produced artificially by fusing together its constituent oxides but usually under such conditions only a glass containing crystals of magnetite is formed.

Obs. — The original *acmite* occurs in a pegmatite vein; at Rundemyr, east of the little lake called Rokebergskjern, in the parish of Eker, near Kongsberg, Norway. It is in slender crystals, sometimes a foot long, embedded in feldspar and quartz.

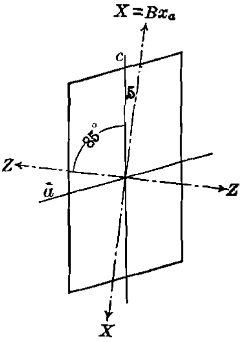
Ægirite occurs especially in igneous rocks rich in soda and containing iron, commonly in rocks containing leucite or nephelite; thus in ægirite-granite, nephelite-syenite, and some varieties of phonolite; often in such cases iron-ore grains are wanting in the rock, their place being taken by ægirite crystals. In the sub-variety of phonolite called tinguaite, the rock has often a deep greenish color due to the abundance of minute crystals of ægirite. Large crystals are found in the pegmatite facies of nephelite-syenites as in West Greenland, Southern Norway, the peninsula Kola in Russian Lapland, Ditro in Transylvania.

Prominent American occurrences are the following: Magnet Cove, Ark. (large crystals); Salem and Quincy, Mass.; Libertyville, N. J. (dike); Trans Pecos district in Texas; Black Hills, S. D.; Cripple Creek, Col.; Bearpaw Mts., Judith Mts. and the Crazy Mts. in Mon.; also vanadium-bearing ægirites from Libby, Mon., also at Montreal, Canada.

818



819



Acmite is named from ἀκμή, *point*, in allusion to the pointed extremities of the crystals; *Ægirite* is from Ægir, the Icelandic god of the sea.

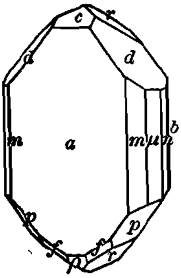
SPODUMENE. Triphane.

Monoclinic. Axes $a : b : c$ = 1·1238 : 1 : 0·6355; β = 69° 40′.

Twins: tw. pl. a (100). Crystals prismatic (mm''' 110 ∧ 1$\bar{1}$0 = 93° 0′), often flattened ∥ a (100); the vertical planes striated and furrowed; crystals sometimes very large. Also massive, cleavable.

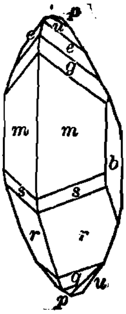
Cleavage m (110) perfect. A lamellar structure ∥ a (100) sometimes very prominent, a crystal then separating into thin plates. Fracture uneven to subconchoidal. Brittle. H. = 6·5–7. G. = 3·13–3·20. Luster vitreous, on cleavage surfaces somewhat pearly. Color greenish white, grayish white, yellowish green, emerald-green, yellow, amethystine purple. Streak white. Transparent to translucent. Pleochroism strong in deep green varieties. Optically +. Ax. pl. || *b* (010). $Bx_a \wedge c$ axis = + 26°. Dispersion $\rho > v$, horizontal. 2 V = 58°. $\alpha = 1·651$. $\beta = 1·669$. $\gamma = 1·677$.

820



Norwich, Mass

821



Hiddenite

Hiddenite has a yellow-green to emerald-green color; the latter variety is used as a gem. In small (½ to 2 inches long) slender prismatic crystals, faces often etched.

Kunzite is a clear lilac-colored variety found near Pala, San Diego Co., California, and also at Vanakarata, Madagascar. The unaltered material from Branchville, Conn., shows the same color. Used as a gem stone.

Comp. — $LiAl(SiO_3)_2$ or $Li_2O.Al_2O_3.4SiO_2$ = Silica 64·5, alumina 27·4, lithia 8·4 = 100. Generally contains a little sodium; the variety hiddenite also chromium, to which the color may be due.

Pyr., etc. — B.B. becomes white and opaque, swells up, imparts a purple-red color (lithia) to the flame (sometimes obscured by sodium), and fuses at 3·5 to a clear or white glass. Not acted upon by acids. Kunzite shows strong phosphorescence with an orange-pink color when excited by an oscillating electric discharge, by ultra violet rays, X-rays, or radium emanations.

Diff. — Characterized by its perfect parting || *a* (100) (in some varieties) as well as by prismatic cleavage; has a higher specific gravity and more pearly luster than feldspar or scapolite. Gives a red flame B.B. Less fusible than amblygonite.

Alter. — Spodumene undergoes very commonly alteration. First by the action of solutions containing soda it is changed to a mixture of eucryptite, $LiAlSiO_4$, and albite, $NaAlSi_3O_8$. Later through the influence of potash salts the eucryptite is changed to muscovite. This resulting mixture of albite and muscovite is known as *cymatolite*, having a wavy fibrous structure and silky luster. These alteration products are well shown in the specimens from Branchville, Conn.

Artif. — An artificial spodumene has been obtained together with other silicates by fusing together lithium carbonate, alumina and silica. This spodumene differs, however, from the natural mineral in its optical properties and has been called *β-spodumene*. The natural mineral, or spodumene, is transformed into the β modification on heating to 1000°.

Obs. — Spodumene occurs in pegmatite veins, sometimes in crystals of very great size. Crystals from the Etta tin mine, S. D., with faces up to 40 feet in length have been reported. Occurs on the island of Utö, Sweden; at Killiney Bay, Ireland; in small transparent crystals of a pale yellow in Brazil, province of Minas Geraes. Variously colored spodumene from Madagascar.

In the United States, in granite at Goshen, Mass.; also at Chesterfield, Chester, Huntington (formerly Norwich), and Sterling, Mass.; at Windham, Me., with garnet and staurolite and at Peru, with beryl, triphylite, petalite. In Conn., at Branchville, the crystals often of immense size; near Stony Point, Alexander Co., N. C. (*hiddenite*); in S. D. at the Etta tin mine in Pennington Co. Kunzite from Pala, Cal.

The name spodumene is from *σποδιός*, *ash-colored*. *Hiddenite* is named for W. E. Hidden and *Kunzite* for Dr. G. F. Kunz.

Use. — The colored transparent varieties are used as gem stones; see above.

JADEITE.

Monoclinic. Axes, see p. 471. Cleavage and optical characters like pyroxene. Usually massive, with crystalline structure, sometimes granular, also obscurely columnar, fibrous foliated to closely compact.

Cleavage: prismatic, at angles of about 93° and 87°; also || *a* (100) difficult. Fracture splintery. Extremely tough. H. = 6·5–7. G. = 3·33–3·35. Luster subvitreous, pearly on surfaces of cleavage. Color apple-green to nearly emerald-green, bluish green, leek-green, greenish white, and nearly white; sometimes white with spots of bright green. Optically +. $Bx_a \wedge c$ axis = 30° to 40°. 2 V = 72°. $\beta = 1·654$. Streak uncolored. Translucent to subtranslucent.

Comp. — Essentially a metasilicate of sodium and aluminium corresponding to spodumene, $NaAl(SiO_3)_2$ or $Na_2O.Al_2O_3.4SiO_2$ = Silica 59·4, alumina 25·2, soda 15·4 = 100.

Chloromelanite is a dark green to nearly black kind of jadeite (hence the name), containing iron sesquioxide and not conforming exactly to the above formula.

Pyr., etc. — B.B. fuses readily to a transparent blebby glass. Not attacked by acids after fusion, and thus differing from saussurite.

Obs. — Occurs chiefly in eastern Asia, thus in the Mogoung district in Upper Burma, in a valley 25 miles southwest of Meinkhoom, in rolled masses in a reddish clay; in Yung-chang, province of Yunnan, southern China; in Thibet. Much uncertainty prevails, however, as to the exact localities, since jadeite and nephrite have usually been confused with each other. May occur also on the American continent, in Mexico and South America; perhaps also in Europe.

Jadeite has long been highly prized in the East, especially in China, where it is worked into ornaments and utensils of great variety and beauty. It is also found with the relics of early man, thus in the remains of the lake-dwellers of Switzerland, at various points in France, in Mexico, Greece, Egypt, and Asia Minor.

A pyroxene, resembling jadeite in structure and consisting of the molecules of jadeite, diopside, and acmite in nearly equal proportions, occurs at the manganese mines of St. Marcel, Italy.

Use. — As the material jade, is used as an ornamental stone. See below.

JADE is a general term used to include various mineral substances of tough, compact texture and nearly white to dark green color used by early man for utensils and ornaments, and still highly valued in the East, especially in China. It includes properly two species only; *nephrite*, a variety of amphibole (p. 489), either tremolite or actinolite, with G. = 2·95–3·0. and *jadeite*, of the pyroxene group and in composition a soda-spodumene, with G. = 3·3–3·35; easily fusible.

The jade of China belongs to both species, so also that of the Swiss lake-habitations and of Mexico. Of the two, however, the former, nephrite, is the more common and makes the jade (ax stone or Punamu stone) of the Maoris of New Zealand; also found in Alaska.

The name jade is also sometimes loosely used to embrace other minerals of more or less similar characters, and which have been or might be similarly used — thus sillimanite, pectolite, serpentine; also vesuvianite, garnet. Bowenite is a jade-like variety of serpentine. The "jade tenace" of de Saussure is now called saussurite.

WOLLASTONITE. Tabular Spar

Monoclinic. Axes $a : b : c = 1·0531 : 1 : 0·9676$; $\beta = 84° 30'$.

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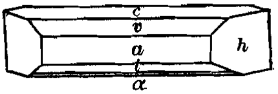

Diana, N. Y.

mm''', $110 \wedge 1\bar{1}0 = 92° 42'$.
hh''', $540 \wedge 5\bar{4}0 = 79° 58'$.
gg', $011 \wedge 0\bar{1}1 = 87° 51'$.
cv, $001 \wedge 101 = 40° 3'$.
cr, $001 \wedge \bar{3}01 = 74° 59'$.
ct, $001 \wedge \bar{1}01 = 45° 5'$.

Twins: tw. pl. *a* (100). Crystals commonly tabular || *a* (100) or *c* (001); also short prismatic. Usually cleavable massive to fibrous, fibers parallel or reticulated; also compact.

Cleavage: *a* (100) perfect; also *c* (001); *t* ($\bar{1}01$) less so. Fracture uneven. Brittle. H. = 4·5–5. G. = 2·8–2·9. Luster vitreous, on cleavage surfaces pearly. Color white, inclining to gray, yellow, red, or brown. Streak white. Subtransparent to translucent. Optically −. $Bx_a \wedge c$ axis = + 32°. Dispersion $\rho > v$, inclined distinct. Ax. pl. $\|$ b (010). 2 E = 70°; α = 1·621. β = 1·633. γ = 1·635.

Comp. — Calcium metasilicate, $CaSiO_3$ or $CaO.SiO_2$ = Silica 51·7, lime 48·3, = 100.

When wollastonite is heated above 1190° C. it develops a basal cleavage, becomes pseudohexagonal, optically positive, nearly uniaxial but probably monoclinic. This material has been called *pseudowollastonite.*

Pyr., etc. — B.B. fuses quietly to a white, almost glassy globule. With hydrochloric acid decomposed with separation of silica; most varieties effervesce slightly from the presence of calcite. Often phosphoresces.

Micro. — In thin sections wollastonite is colorless with a moderate relief and medium birefringence. The plane of the optic axes is usually normal to the elongation of the crystals.

Artif. — Wollastonite may be obtained artificially by heating a glass of the composition $CaSiO_3$ to between 800° and 1000°. At higher temperatures the pseudowollastonite modification is obtained.

Obs. — Wollastonite is found especially in granular limestone, and in regions of granite, as a contact formation; it is very rare in eruptive rocks. It is often associated with a lime garnet, diopside, etc.

Occurs in Hungary in the copper mines of Cziklowa in the Banat; at Pargas in Finland; at Harzburg in the Harz Mts., Germany; at Auerbach, Hesse, Germany, in granular limestone; at Vesuvius, rarely in fine crystals; on the islands of Elba and Santorin.

In the United States, in N. Y., at Willsborough; Diana, Lewis Co.; Bonaparte Lake, Lewis Co. In Pa., Bucks Co., 3 m. west of Attleboro; in Cal., at Crestmore. In Canada, at Grenville; at St. Jérôme and Morin, Quebec, with apatite.

Named after the English chemist, W. H. Wollaston (1766–1828).

Alamosite. Lead metasilicate, $PbSiO_3$. Closely related to wollastonite in crystal forms. Monoclinic. In radiating fibrous aggregates. Cleavage $\|$ b (010). G. = 6·5. H. = 4·5. Colorless or white. Refractive index about 1·96. Found near Alamos, Sonora, Mexico.

PECTOLITE.

Monoclinic. Axes $a : b : c$ = 1·1140 : 1 : 0·9864; β = 84° 40′.

Commonly in close aggregations of acicular crystals; elongated $\|$ b axis, but rarely terminated. Fibrous massive, radiated to stellate.

Cleavage: a (100) and c (001) perfect. Fracture uneven. Brittle. H. = 5. G. = 2·68–2·78. Luster of the surface of fracture silky or subvitreous. Color whitish or grayish. Subtranslucent to opaque. Optically +. Ax. pl. and $Bx_a \perp b$ (010); Bx_o nearly $\perp a$ (100). 2 V = 60°. β = 1·61.

Comp. — $HNaCa_2(SiO_3)_3$ or $H_2O.Na_2O.4CaO.6SiO_2$ = Silica 54·2, lime 33·8, soda 9·3, water 2·7 = 100.

Pectolite is sometimes classed with the hydrous species allied to the zeolites.

Pyr., etc. — In the closed tube yields water. B.B. fuses at 2 to a white enamel. Decomposed in part by hydrochloric acid with separation of silica as a jelly. Often gives out light when broken in the dark.

Obs. — A secondary mineral, occurring like the zeolites mostly in basic eruptive rocks, in cavities or seams; occasionally in metamorphic rocks. Found in Scotland near Edinburgh; at Kilsyth, Corstorphine Hill (*walkerite*); Island Skye. Also at Mt. Baldo and Mt. Monzoni in the Tyrol; at Niederkirchen, Bavaria (*osmelite*).

Occurs also at Bergen Hill, Paterson and Great Notch, N. J.; Lehigh Co., Pa.; compact at Isle Royale, Lake Superior; at Magnet Cove, Ark., in elæolite-syenite (*manganpectolite* with 4 p. c. MnO); compact, massive in Alaska, where used, like jade, for implements.

Schizolite. Like manganpectolite, $HNa(Ca,Mn)_2(SiO_3)_3$, but triclinic. In prismatic crystals. Two cleavages. H. = 5–5·5. G. = 3·0–3·1. Color light red to brown. From the nepheline syenite of Julianehaab, southern Greenland.

Rosenbuschite. Near pectolite, but contains zirconium. Index, 1·65. From Norway. In nephelite-syenite-porphyry, Red Hill, Moultonboro, N. H.

Wöhlerite. A zirconium-silicate and niobate of Ca, Na, etc. In prismatic, tabular crystals, yellow to brown. Indices, 1·700–1·726. Occurs in elæolite-syenite, on several islands of the Langesund fiord, near Brevik, in Norway. In syenite from Red Hill, N. H.

Låvenite. A complex zirconuim-silicate of Mn, Ca, etc., containing also F, Ti, Ta, etc. In yellow to brown prismatic crystals. Index, 1·750. Found on the island Låven in the Langesund fiord, southern Norway; also elsewhere in elæolite-syenite.

γ. Triclinic Section

RHODONITE.

Triclinic. Axes $a : b : c = 1·07285 : 1 : 0·6213$; $\alpha = 103° 18'$; $\beta = 108° 44'$; $\gamma = 81° 39'$.

Crystals usually large and rough with rounded edges. Commonly tabular || c (001); sometimes resembling pyroxene in habit. Commonly massive, cleavable to compact; also in embedded grains.

Cleavage: m (110), M $(1\bar{1}0)$ perfect; c (001) less perfect. Fracture conchoidal to uneven; very tough when compact. H. = 5·5–6·5. G. = 3·4–3·68. Luster vitreous; on cleavage surfaces somewhat pearly. Color light brownish red, flesh-red, rose-pink; sometimes greenish or yellowish, when impure; often black outside from exposure. Streak white. Transparent to translucent. Optically –. $\beta = 1·73$.

Comp. — Manganese metasilicate, $MnSiO_3$ or $MnO.SiO_2$ = Silica 45·9, manganese protoxide 54·1 = 100. Iron, calcium (in *bustamite*), and occasionally zinc (in *fowlerite*) replace part of the manganese.

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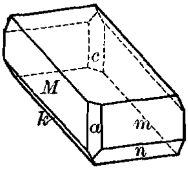

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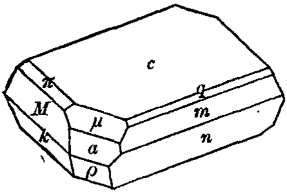

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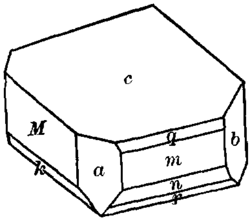


Franklin Furnace, N. J.

ab, $100 \wedge 010 = 94° 26'$.
ac, $100 \wedge 001 = 72° 36\frac{1}{2}'$.
bc, $010 \wedge 001 = 78° 42\frac{1}{2}'$.
am, $100 \wedge 110 = 48° 33'$.
mM, $110 \wedge 1\bar{1}0 = 92° 28\frac{1}{2}'$.
cn, $001 \wedge \bar{2}\bar{2}1 = 73° 52'$.
ck, $001 \wedge \bar{2}21 = 62° 23'$.
kn, $\bar{2}21 \wedge \bar{2}\bar{2}1 = 86° 5'$.

Pyr., etc. — B.B. blackens and fuses with slight intumescence at 2·5; with the fluxes gives reactions for manganese; fowlerite gives with soda on charcoal a reaction for zinc. Slightly acted upon by acids. The calciferous varieties often effervesce from mechanical admixture of calcium carbonate. In powder, partly dissolves in hydrochloric acid, and the insoluble part becomes of a white color. Darkens on exposure to the air, and sometimes becomes nearly black.

Diff. — Characterized by its pink color; distinct cleavages; hardness; fusibility and manganese reactions B.B.

Obs. — Occurs in Sweden at Långban, Wermland, in iron-ore beds, in broad cleavage-plates, and also granular massive, and at the Pajsberg iron mines near Filipstad (*paisbergite*) sometimes in small brilliant crystals; in the district of Ekaterinburg in the Ural Mts., massive like marble, whence it is obtained for ornamental purposes; with tetrahedrite at Kapnik and Rezbánya, Hungary; St. Marcel, Piedmont, Italy; Mexico (*bustamite*, containing CaO). In crystals from Broken Hill, New South Wales.

Occurs in Cummington, Mass.; on Osgood's farm, Blue Hill Bay, Me.; *fowlerite* (containing ZnO) at Mine Hill, Franklin Furnace, and Sterling Hill, near Ogdensburgh, N. J., usually embedded in calcite and sometimes in fine crystals.

Named from *ῥοδον, a rose,* in allusion to the color.

Rhodonite is often altered chiefly by oxidation of the MnO (as in *marceline, dyssnite*); also by hydration (*stratopeite, neotocite,* etc.); further by introduction of CO_2 (*allagite, photicite,* etc.).

Use. — Rhodonite at times is used as an ornamental stone.

Pyroxmangite. A triclinic, manganese-iron pyroxene. In cleavage masses. Indices, 1·75–1·76. H. = 5·5–6. G. = 3·8. Color, amber to dark brown. Easily fusible to black magnetic globule. Alters to *skemmatite.* Found near Iva, Anderson Co., South Carolina.

Babingtonite. $(Ca,Fe,Mn)SiO_3$ with $Fe_2(SiO_3)_3$. In small black triclinic crystals, near rhodonite in angle (axes on p. 471). H. = 5·5–6. G. = 3·35–3·37. Index, 1·72. From Arendal, Norway; at Herbornseelbach, Nassau, Germany; at Baveno, Italy. From Somerville and Athol, Mass.; in the zeolite deposits of Passaic Co., N. J.

Hiortdahlite. Essentially $(Na_2,Ca)(Si,Zr)O_3$, with also fluorine. In pale yellow tabular crystals (triclinic). Index, 1·695. Occurs sparingly on an island in the Langesund fiord, southern Norway.

Sobralite. A triclinic pyroxene. Optically +. Colorless. From eulysite rock at Södermanland, Sweden.

3. *Amphibole Group*

Orthorhombic, Monoclinic, Triclinic

Composition for the most part that of a metasilicate, $RSiO_3$, with R = Ca,Mg,Fe chiefly, also Mn,Na_2,K_2,H_2. Further often containing aluminium and ferric iron, in part with alkalies as $NaAl(SiO_3)_2$ or $NaFe(SiO_3)_2$; perhaps also containing $\overset{II}{R}\overset{III}{R}_2SiO_6$.

α. Orthorhombic Section

		$a : b$
Anthophyllite	$(Mg,Fe)SiO_3$	0·5138 : 1
GEDRITE	$(Mg,Fe)SiO_3$ with $(Mg,Fe)Al_2SiO_6$	

β. Monoclinic Section

	$a : b : c$	β
Amphibole	0·5511 : 1 : 0·2938	73° 58′

I. *NONALUMINOUS VARIETIES.*

1. TREMOLITE	$CaMg_3(SiO_3)_4$
2. ACTINOLITE	$Ca(Mg,Fe)_3(SiO_3)_4$
Nephrite, Asbestus,	Smaragdite, etc.
Cummingtonite	$(Fe,Mg)SiO_3$
Dannemorite	$(Fe,Mn,Mg)SiO_3$
Grünerite	$FeSiO_3$
3. RICHTERITE	$(K_2,Na_2Mg,Ca,Mn)_4(SiO_3)_4$

II. *ALUMINOUS VARIETIES.*

4. HORNBLENDE	
Edenite Pargasite and Common Hornblende	Chiefly $Ca(Mg,Fe)_3(SiO_3)_4$ with $Na_2Al_2(SiO_3)_4$ and $(Mg,Fe)_2(Al,Fe)_4Si_2O_{12}$

		$a : b : c$	β
Glaucophane	$NaAl(SiO_3)_2.(Fe,Mg)SiO_3$		
Riebeckite	$2NaFe(SiO_3)_2.FeSiO_3$	0·5475 : 1 : 0·2925	= 76° 10′
Crocidolite	$NaFe(SiO_3)_2.FeSiO_3$		
Arfvedsonite	$Na_8(Ca,Mg)_3(Fe,Mn)_{14}(Al,Fe)_2Si_{21}O_{45}$	0·5509 : 1 : 0·2378	= 73° 2′

γ. Triclinic Section

Ænigmatite.

The only species included under the triclinic section is the rare and imperfectly known ænigmatite (cossyrite).

The Amphibole Group embraces a number of species which, while falling in different systems, are yet closely related in form — as shown in the common prismatic cleavage of 54° to 56° — also in optical characters and chemical composition. As already noted (see p. 471), the species of this group form chemically a series parallel to that of the closely allied Pyroxene Group, and between them there is a close relationship in crystalline form and other characters. The Amphibole Group, however, is less fully developed, including fewer species, and those known show less variety in form.

The chief *distinctions* between pyroxene and amphibole proper are the following:

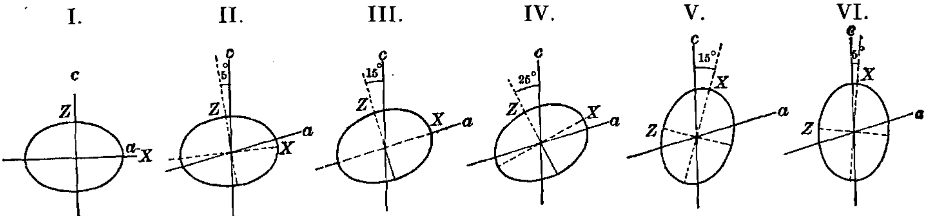
Prismatic angle with pyroxene 87° and 93°; with amphibole 56° and 124°; the prismatic cleavage being much more distinct in the latter.

With pyroxene, crystals usually short prismatic and often complex, structure of massive kinds mostly lamellar or granular; with amphibole, crystals chiefly long prismatic and simple, columnar and fibrous massive kinds the rule.

The specific gravity of most of the pyroxene varieties is higher than of the like varieties of amphibole. In composition of corresponding kinds, magnesium is present in larger amount in amphibole (Ca : Mg = 1 : 1 in diopside, = 1 : 3 in tremolite); alkalies more frequently play a prominent part in amphibole.

The optical relations of the prominent members of the group, as regards the position of the ether-axes, is exhibited by the following figures (Cross); compare Fig. 797, p. 472, for a similar representation for the corresponding members of the pyroxene group.

826



I. Anthophyllite. II. Glaucophane. III. Tremolite, etc. IV. Hornblende. V. Arfvedsonite. VI. Riebeckite.

α. Orthorhombic Section

ANTHOPHYLLITE.

Orthorhombic. Axial ratio $a : b = 0·5137 : 1$. Crystals rare, habit prismatic (mm''' 110 ∧ 1$\bar{1}$0 = 54° 23). Commonly lamellar, or fibrous massive; fibres often very slender; in aggregations of prisms.

Cleavage: prismatic, perfect; *b* (010) less so; *a* (100) sometimes distinct. H. = 5·5–6. G. = 3·1–3·2. Luster vitreous, somewhat pearly on the cleavage face. Color brownish gray, yellowish brown, clove-brown, brownish green, emerald-green, sometimes metalloidal. Streak uncolored or grayish. Transparent to subtranslucent. Sometimes pleochroic Usually optically +; also + for red, − for yellow, green. Ax. pl. always ∥ *b* (010). Bx_a usually ⊥ *c* (001); also ⊥ *c* (001) for red, ⊥ *a* (100) for yellow, green. 2 V = 84°. $\alpha = 1·633$. $\beta = 1·642$. $\gamma = 1·657$.

Comp. — $(Mg,Fe)SiO_3$, corresponding to enstatite-bronzite-hypersthene in the pyroxene group. Aluminium is sometimes present in considerable amount. There is the same relation in optical character between anthophyllite (+) and gedrite (−) as between enstatite and hypersthene (cf. Figs. 799 800, p. 472).

Var. — ANTHOPHYLLITE, Mg : Fe = 4 : 1, 3 : 1, etc. For 3 : 1, the percentage composition is: Silica 55·6, iron protoxide 16·6, magnesia 27·8 = 100. Anthophyllite sometimes occurs in forms resembling asbestus.

Aluminous, GEDRITE. Iron is present in larger amount, and also aluminium; it hence corresponds nearly to a hypersthene, some varieties of which are highly aluminous.

Ferroanthophyllite is a name given to an iron anthophyllite from Idaho and elsewhere.

Hydrous anthophyllites have been repeatedly described, but in most cases they have been shown to be hydrated monoclinic amphiboles.

Pyr., etc. — B.B. fuses with difficulty to a black magnetic enamel; with the fluxes gives reactions for iron; unacted upon by acids.

Micro. — In sections colorless, non-pleochroic. Parallel extinction. Commonly fibrous.

Artif. — Anthophyllite is formed artificially when magnesium metasilicate is heated considerably above its melting point and then quickly cooled.

Obs. — Anthophyllite occurs in mica schist near Kongsberg in Norway: at Hermannschlag, Moravia. In the United States, at the Jenks corundum mine, Franklin, Macon Co., N. C.; from Rockport, Mass. A colorless or pale red variety from Edwards, N. Y., has been called *valléite*. The original *gedrite* is from the valley of Héas, near Gedres, France. Named from *anthophyllum*, *clove*, in allusion to the clove-brown color.

β. Monoclinic Section

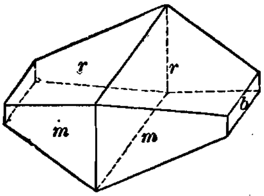
AMPHIBOLE. Hornblende.

Monoclinic. Axes $a : b : c = 0·5511 : 1 : 0·2938$; $\beta = 73° 58'$.

mm''', $110 \wedge 1\bar{1}0 = 55° 49'$. *rr'*, $011 \wedge 0\bar{1}1 = 31° 32'$.
ca, $001 \wedge 100 = 73° 58'$. *ii*, $031 \wedge 0\bar{3}1 = 80° 32'$.
cp, $001 \wedge \bar{1}01 = 31° 0'$. *pr*, $\bar{1}01 \wedge 011 = 34° 25'$.

Twins: (1) tw. pl. *a* (100), common as contact-twins; rarely polysynthetic. (2) *c* (001), as tw. lamellæ, occasionally producing a parting analogous to that more common with pyroxene (Fig. 461, p. 173). Crystals commonly

827



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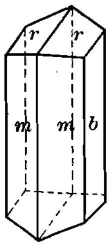

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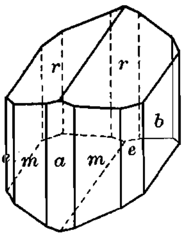

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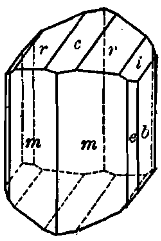


prismatic; usually terminated by the low clinodome, *r* (011), sometimes by *r* and *p* ($\bar{1}01$) equally developed and then suggesting rhombohedral forms (as of tourmaline). Also columnar or fibrous, coarse or fine, fibres often like flax; rarely lamellar; also granular massive, coarse or fine, and usually strongly coherent, but sometimes friable.

Cleavage: *m* (110) highly perfect; *a* (100), *b* (010) sometimes distinct. Fracture subconchoidal, uneven. Brittle. H. = 5–6. G. = 2·9–3·4, varying with the composition. Luster vitreous to pearly 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 uncolored, or paler than color. Sometimes nearly transparent; usually subtranslucent to opaque.

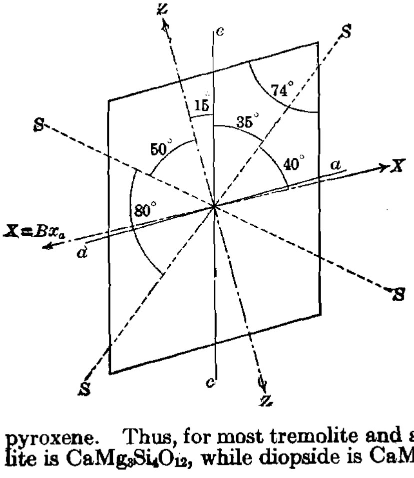
Pleochroism strongly marked in all the deeply colored varieties, as described beyond. Absorption usually $Z > Y > X$. Optically –, rarely +. Ax. pl. $\parallel$ *b* (010). Extinction-angle on *b* (010), or $Z \wedge c$ axis = + 15° to 18° in most cases, but varying from about 1° up to 37°; hence also $\mathrm{Bx_a} \wedge c$ axis = – 75° to – 72°, etc. See Fig. 832. Dispersion $\rho < v$. Axial angles variable; see beyond.

Optical characters, particularly indices of refraction, birefringence and extinction angles vary with change in composition, particularly with the total amount of iron present. In general the indices and extinction angles increase with increase of iron content while the birefringence decreases.

Comp. — In part a normal metasilicate of calcium and magnesium, $\mathrm{RSiO_3}$, usually with iron, also manganese, and thus in general analogous to the pyroxenes. The alkali metals, sodium and potassium, also present, and more commonly so than with pyroxene. In part also aluminous, corresponding to the aluminous pyroxenes. Titanium sometimes is present and also rarely fluorine in small amount.

The aluminium is in part present as $\mathrm{NaAl(SiO_3)_2}$, but many amphiboles containing aluminium or ferric iron are more basic than a normal metasilicate; they may sometimes be explained as containing $\overset{\text{II}}{\mathrm{R}}(\mathrm{Al},\overset{\text{III}}{\mathrm{Fe}})_2\mathrm{SiO_6}$, but the exact nature of the compound is often doubtful. The amphibole formulas are in many cases double the corresponding ones for pyroxene. Thus, for most tremolite and actinolite, Ca : Mg(Fe) = 1 : 3, and hence tremolite is $\mathrm{CaMg_3Si_4O_{12}}$, while diopside is $\mathrm{CaMgSi_2O_6}$, etc.

832



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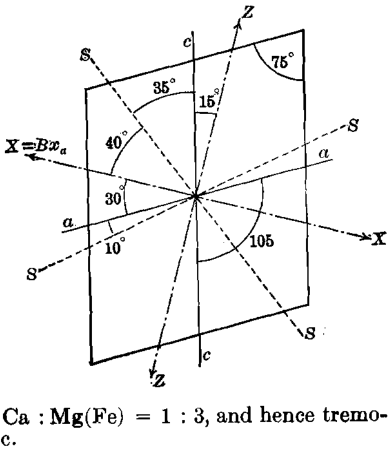


Rammelsberg has shown that the composition of most aluminous amphiboles may be expressed in the general form $m\mathrm{RSiO_3}.n\mathrm{Al_2O_3}$; while Scharizer, modifying this view, proposes to regard the amphiboles as molecular compounds of $\mathrm{Ca(Mg,Fe)_3Si_4O_{12}}$ (actinolite), and the orthosilicate $(\overset{\mathrm{I}}{\mathrm{R}}_2,\overset{\mathrm{II}}{\mathrm{R}})_3\overset{\mathrm{III}}{\mathrm{R}}_2\mathrm{Si_3O_{12}}$, for which he uses Breithaupt's name *syntagmatite*, originally given to the Vesuvian hornblende.

Penfield concludes that (1) amphibole is a metasilicate, (2) that fluorine and hydroxyl are isomorphous with the protoxides and (3) that the presence of sesquioxides is explained by their introduction into the molecule in the form of various bivalent radicals.

The crystallographic position here adopted is that suggested by Tschermak, which best exhibits the relation between amphibole and pyroxeme. Some authors retain the former position, according to which $p = (001)$, $r = (\bar{1}11)$, etc. Fig. 833 shows the corresponding optical orientation.

I. *Containing little or no Aluminium*

1. TREMOLITE. Grammatite, nephrite in part. *Calcium-magnesium amphibole.* Formula $\mathrm{CaMg_3(SiO_4)_3}$ = Silica 57·7, magnesia 28·9, lime 13·4 = 100. Ferrous iron, replacing the magnesium, present only sparingly, up to 3 p. c. Colors white to dark gray. In distinct crystals, either long-bladed or short and stout. In aggregates long and thin columnar, or fibrous; also compact granular massive (nephrite, below). G. = 2·9–3·1. Sometimes transparent and colorless. Optically −. Extinction-angle on b (010), or $Z \wedge c$ axis = +16° to 18°, hence $\mathrm{Bx_a} \wedge c$ axis = − 74° to − 72°. 2V = 80° to 88°. $\alpha = 1{\cdot}609$. $\beta = 1{\cdot}623$. $\gamma = 1{\cdot}635$.

Tremolite was named by Pini from the Tremola valley on the south side of the St. Gothard.

Winchite is the name given to a blue amphibole near tremolite from the manganese mines of Central India.

2. ACTINOLITE. *Calcium-magnesium-iron amphibole.* Formula $\mathrm{Ca(Mg,Fe)_3(SiO_3)_4}$. Color bright green and grayish green. In crystals, either short- or long-bladed, as in tremolite; columnar or fibrous; granular massive. G. = 3–3·2. Sometimes transparent. The variety in long bright-green crystals is called *glassy actinolite;* the crystals break easily across the prism. The fibrous and radiated kinds are often called *asbestiform actinolite and radiated actinolite.* Actinolite owes its green color to the ferrous iron present.

Pleochroism distinct, increasing as the amount of iron increases, and hence the color becomes darker; Z emerald-green, Y yellow-green, X greenish yellow. Absorption $Z > Y > X$, Zillertal. Optically −. Extinction-angle on b (010), $Z \wedge c$ axis = + 15° and $\mathrm{Bx_a} \wedge c$ axis = − 75°. 2V = 78°; $\rho < v$; $\alpha = 1{\cdot}611$. $\beta = 1{\cdot}627$. $\gamma = 1{\cdot}636$.

Named actinolite from ἀκτὶς, *a ray,* and λἴθος, *stone,* a translation of the German *Strahlstein* or *radiated stone.* Name changed to *actinote* by Haüy, without reason.

NEPHRITE. Jade in part. A tough, compact, fine-grained tremolite (or actinolite). breaking with a splintery fracture and glistening luster. H. = 6–6·5. G. = 2·96–3·1. Named from a supposed efficacy in diseases of the kidney, from νεφρός, *kidney.* It varies in color from white (tremolite) to dark green (actinolite), in the latter, iron protoxide being present up to 6 or 7 p. c. The latter kind sometimes encloses distinct prismatic crystals of actinolite. A derivation from an original pyroxenic mineral has been suggested in some cases. Nephrite or jade was brought in the form of carved ornaments from Mexico or Peru soon after the discovery of America. A similar stone comes from Eastern Asia, New Zealand and Alaska. See jadeite, p. 481; jade, p. 482.

Széchenyiite is an amphibole occurring with jadeite from Central Asia.

ASBESTUS. Asbestos. Tremolite, actinolite, and other varieties of amphibole, excepting those containing much alumina, pass into fibrous varieties, the fibers of which are sometimes very long, fine, flexible, and easily separable by the fingers, and look like flax. These kinds are called *asbestus* (from the Greek for *incombustible*). The colors vary from white to green and wood-brown. The name *amianthus* is applied usually to the finer and more silky kinds. Much that is popularly called asbestus is *chrysotile*, or fibrous serpentine, containing 12 to 14 p. c. of water. *Byssolite* is a stiff fibrous variety.

Mountain leather is in thin flexible sheets, made of interlaced fibers; and *mountain cork* the same in thicker pieces; both are so light as to float on water, and they are often hydrous, color white to gray or yellowish. *Mountain wood* is compact fibrous, and gray to brown in color, looking a little like dry wood.

SMARAGDITE. A thin-foliated variety of amphibole, near actinolite in composition but carrying some alumina. It has a light grass-green color, resembling much common green diallage. In many cases derived from pyroxene (diallage) by uralitization, see below. It retains much of the structure of the diallage and also often encloses remnants of the original mineral. It forms, along with whitish or greenish saussurite, a rock called saussurite-gabbro, the euphotide of the Alps. The original mineral is from Corsica, and the rock is the *verde di Corsica duro* of the arts.

URALITE. Pyroxene altered to amphibole. The crystals, when distinct, retain the form of the original mineral, but have the cleavage of amphibole. The change usually commences on the surface, transforming the outer layer into an aggregation of slender amphibole prisms, parallel in position to each other and to the parent pyroxene (cf. Fig. 803, p. 473). When the change is complete the entire crystal is made up of a bundle of amphibole needles or fibers. The color varies from white (tremolite) to pale or deep green, the latter the more common. In composition uralite appears to conform nearly to actinolite, as also in optical characters. The most prominent change in composition in passing from the original pyroxene is that corresponding to the difference existing between the two species in general, that is, an increase in the magnesium and decrease in calcium. The change, therefore, is not strictly a case of paramorphism, although usually so designated. Uralite was originally described by Rose in a rock from the Ural Mts. It has since been observed from many localities. The microscopic study of rocks has shown the process of "uralitization" to be very common, and some authors regard many hornblendic rocks and schists to represent altered pyroxenic rocks on a large scale.

CUMMINGTONITE. Amphibole-Anthophyllite. *Iron-Magnesium Amphibole.* Here belong certain varieties of amphibole resembling anthophyllite and essentially identical with it in composition, but optically monoclinic. From Kongsberg, Norway; Greenland. The original *cummingtonite* is gray to brown in color; usually fibrous or fibro-lamellar, often radiated. G. = 3·1–3·32; from Cummington, Mass.

DANNEMORITE. *Iron-Manganese Amphibole.* Color yellowish brown to greenish gray. Columnar or fibrous, like tremolite and asbestus. Contains iron and manganese. From Sweden. *Juddite* is a manganese amphibole found at Kácharwáhi, India.

GRÜNERITE. *Iron-Amphibole.* Asbestiform or lamellar-fibrous. Luster silky; color brown; G. = 3·713. Formula $FeSiO_3$.

3. RICHTERITE. *Sodium-Magnesium-Manganese Amphibole.* $(K_2,Na_2,Mg,Ca,Mn)_4(SiO_3)_4$.

In elongated crystals, seldom terminated. G. = 3·09. Color brown, yellow, rose-red. Transparent to translucent. $Z \wedge c$ axis $= +17°–20°$; $\beta = 1·63$; $\gamma - \alpha = 0·024$. From Pajsberg and Långban, Sweden. Characterized by the presence of manganese and alkalies in relatively large amount.

Imerinite is a soda-amphibole, related to soda-richterite from the province Imerina, Madagascar.

Breislakite occurs in wool-like forms at Vesuvius and Capo di Bove, Italy. Color dark brown to black, pleochroism strongly marked. Inferred to belong near richterite.

II. *Aluminous.*

4. ALUMINOUS AMPHIBOLE. Hornblende. Contains alumina or ferric iron, and usually both, with ferrous iron (sometimes manganese), magnesium, calcium, 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 increase in amount of iron. Extinction-angle variable, from 0° to 37°, see below. Pleochroism strong. Absorption usually $Z < Y < X$.

EDENITE. *Aluminous Magnesium-Calcium Amphibole.* Color white to gray and pale green, and also colorless; G. = 3·0–3·059. Resembles anthophyllite and tremolite. Named from the locality at Edenville, N. Y. To this variety belong various pale-colored amphiboles, having less than 5 p. c. of iron oxides.

Koksharovite is a variety from the neighborhood of Lake Baikal, Siberia, named after the Russian mineralogist, von Koksharov.

Soretite is an aluminous amphibole from the anorthite-diorite rocks of Koswinsky in the northern Ural Mts.

Common Hornblende, Pargasite. Colors bright or dark green, and bluish green to grayish black and black. G. = 3·05–3·47. *Pargasite* is usually made to include green and bluish green kinds, occurring in stout lustrous crystals, or granular; and *Common hornblende* the greenish black and black kinds, whether in stout crystals or long-bladed, columnar, fibrous, or massive granular. But no line can be drawn between them. The extinction-angle on b (010), or $Z \wedge c$ axis = + 15° to 25° chiefly. Absorption $Z > Y > X$.

Pargasite occurs at Pargas, Finland, in bluish green and grayish black crystals. $Z \wedge c$ axis = + 18°; $\beta = 1·64$; $\gamma - \alpha = 0·019$; 2V = 59°. Pleochroism: Z greenish blue; Y emerald-green; X greenish yellow.

The dark brown to black *hornblendes* from basaltic and other igneous rocks vary somewhat widely in optical characters. The angle $Z \wedge c$ axis = 0° to + 10° chiefly; $\beta = 1·725$; $\gamma - \alpha = 0·072$ (maximum). Pleochroism: Z brown, Y yellow, X yellow-green, but variable.

Speziaite, from Traversella, Italy, is an iron amphibole with strong pleochroism; X = green, Y = yellow-brown, Z = azure-blue, $Z \wedge c$ axis = 23°.

The *Kataforite* of Norway (Brögger) has $Z \wedge c$ axis = 30° to 60°; absorption $Y > Z > X$; pleochroism: Z yellow, Z violet, X yellow-brown; it approximates toward arfvedsonite (p. 494).

Kupfferite, from a graphite mine in the Tunkinsk Mts., near Lake Baikal, Siberia, is a deep green amphibole (aluminous) formerly referred to anthophyllite.

Syntagmatite is the black hornblende of Vesuvius.

Bergamaskite is an iron-amphibole containing almost no magnesia. From Monte Altino, Province of Bergamo, Italy.

Kaersutite is a titaniferous amphibole from Kaersut, Umanaks fiord, North Greenland.

Hastingsite is an amphibole low in silica and high in iron and soda, from the nephelite-syenite of Dungannon, Hastings Co., Ontario.

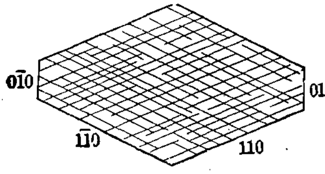
Philipstadite from Philipstad, Sweden, is an iron-magnesium amphibole showing unusual pleochroism.

Pyr. — Essentially the same as for the corresponding varieties of pyroxene, see p. 478.

Diff. — Distinguished from pyroxene (and tourmaline) by its distinct prismatic cleavage, yielding angles of 56° and 124°. Fibrous and columnar forms are much more common than with pyroxene, lamellar and foliated forms rare (see also pp. 478, 486). Crystals often long, slender, or bladed. Differs from the fibrous zeolites in not gelatinizing with acids. Epidote has a peculiar green color, is more fusible, and shows a different cleavage.

Micro. — In rock sections amphibole generally shows distinct colors, green, sometimes olive or brown, and is strongly pleochroic. Also recognized by its high relief; generally rather high interference-colors; by the very perfect system of cleavage-cracks crossing at angles of 56° and 124° in sections ⊥ c axis (Fig. 834). In sections ∥ b (010) (recognized by yielding no axial figure in convergent light, by showing the highest interference-colors, and by having parallel cleavage-cracks, ∥ c axis), the extinction-direction for common hornblendes makes a small angle (12°–15°) with the cleavage-cracks (*i.e.*, with c axis); further, this direction is positive Z (different from common pyroxene and ægirite, cf. Figs. 813 and 818).

834



Artif. — Experiments on the artificial production of the amphiboles have shown that in general they are unstable at high temperatures and that their formation in igneous rocks is due either to the rapid cooling of the magma, to the presence of water or to some unusual conditions of pressure, etc. In general when the amphiboles are fused they are transformed into the corresponding pyroxenes.

Obs. — Amphibole occurs only sparingly in volcanic rocks but is found in many crystalline limestones, and granitic and schistose rocks. *Tremolite*, the magnesia-lime variety, is especially common in limestones, particularly magnesian or dolomitic; *actinolite* (also nephrite), the magnesia-lime-iron variety, in the crystal line schists, in steatitic rocks and with serpentine; and dark green and black *hornblende*, occurs in both igneous and metamorphic rocks. It is found in granites, syenites, diorites and some varieties of peridotite, in gneisses and the hornblende schists.

Hornblende-rock, or *amphibolite*, consists of massive hornblende of a dark greenish black or black color, and has a granular texture. Occasionally the *green* hornblende, or actinolite, occurs in rock-masses, as at St. Francis, in Canada. *Hornblende-schist* has the same composition as amphibolite, but is schistose or slaty in structure. It often contains a little feldspar. In some varieties of it the hornblende is in part in minute needles. Granite and syenite often contain hornblende, and with diorite it is a common constituent. This is also true of the corresponding forms of gneiss. In these cases it is usually present in small, irregular masses, often fibrous in structure; also as rough bladed crystals.

Prominent foreign localities of amphibole are the following: *Tremolite* (grammatite) in dolomite at Campolongo, Switzerland; also at Orawitza, Rezbánya, Hungary; Gulsjö, Wermland, Sweden. *Actinolite* in the crystalline schists of the Central and Eastern Alps, especially at Greiner in the Zillertal, Tyrol; at Zöblitz in Saxony; Arendal, Norway. *Asbestus* at Sterzing, Zillertal, and elsewhere in Tyrol; in Savoie, France; also in the island of Corsica. *Pargasite* at Pargas, Finland; Saualpe in Carinthia. *Hornblende* at Arendal, Kongsberg and Kargerö, Norway; in Sweden and Finland; at Vesuvius; Aussig and Teplitz, Bohemia; etc. *Nephrite*, which in the form of "jade" ornaments and utensils is widely distributed among the relics of early man (see jade, p. 482), is obtained at various points in Central Asia. The most important source is that in the Karakash valley in the Kuen Lun Mts., on the southern borders of Turkestan; also other localities in Central Asia. In New Zealand. Nephrite has been found in Europe as a rolled mass at Schwemmsal near Leipzig; in Swiss Lake habitations and similarly elsewhere.

In the United States, in Me., black crystals occur at Thomaston; pargasite at Phippsburg. In Ver., actinolite in the steatite quarries of Windham and New Fane. In Mass., tremolite at Lee; black crystals at Chester; asbestus at Pelham; *cummingtonite* at Cummington. In Conn., in large flattened white crystals and in bladed and fibrous forms (tremolite) in dolomite, at Canaan. In N. Y., Warwick, Orange Co.; near Edenville; near Amity; at the Stirling mines, Orange Co.; in short green crystals at Gouverneur, St. Lawrence Co.; with pyroxene at Russell; a black variety at Pierrepont; at Macomb; Pitcairn; tremolite at Fine; in Rossie, 2 miles north of Oxbow; in large white crystals at Diana, Lewis Co.; asbestus near Greenwood Furnace. *Hudsonite* from Cornwall, N. Y., formerly classed as a pyroxene has been shown to be an amphibole. In N. J., tremolite or gray amphibole in good crystals at Bryam, and other varieties of the species at Franklin and Newton, radiated actinolite. In Pa., actinolite at Mineral Hill, in Delaware Co.; at Unionville; at Kennett, Chester Co. In Md., actinolite and asbestus at the Bare Hills in serpentine; asbestus is mined at Pylesville, Harford Co. In Va., actinolite at Willis's Mt., in Buckingham Co.; asbestus at Barnet's Mills, Fauquier Co. Nephrite occurs in Alaska.

In Canada, tremolite is abundant in the Laurentian limestones, at Calumet Falls, Litchfield, Pontiac Co., Quebec; also at Blythfield, Renfrew Co., and Dalhousie, Lanark Co. Black hornblende at various localities in Quebec and Ontario with pyroxene, apatite, titanite, etc., as in Renfrew Co. Asbestus and mountain cork at Buckingham, Ottawa Co., Quebec; a bed of actinolite at St. Francis, Beauce Co., Quebec; nephrite has been found in British Columbia and Northwest Territory.

GLAUCOPHANE.

Monoclinic; near amphibole in form. Crystals prismatic in habit, usually indistinct; commonly massive, fibrous, or columnar to granular.

Cleavage: *m* (110) perfect. Fracture conchoidal to uneven. Brittle. H. = 6–6·5. G. = 3·103–3·113. Luster vitreous to pearly. Color azure-blue, lavender-blue, bluish black, grayish. Streak grayish blue. Translucent. Pleochroism strongly marked: Z sky-blue to ultramarine-blue, Y reddish or bluish violet, X yellowish green to colorless. Absorption $Z > Y > X$. Optically +. Ax. pl. $\parallel b$ (010). $Z \wedge c$ axis = 4° to 6°, rarely higher values. 2V = 45°. $\alpha = 1·621$. $\beta = 1·638$. $\gamma = 1·638$.

Comp. — Essentially $NaAl(SiO_3)_2.(Fe,Mg)SiO_3$. If Mg : Fe = 2 : 1, the formula requires: Silica 57·6, alumina 16·3, iron protoxide 7·7, magnesia 8·5, soda 9·9 = 100.

Obs. — Occurs as the hornblendic constituent of certain crystalline schists, called *glaucophane-schists*, or glaucophanite; also more or less prominent in mica schists, amphibolites, gneiss, eclogites, etc. It is often associated with mica, garnet, diallage and omphacite, epidote and zoisite, etc. First described from the island of Syra, one of the Cyclades; since shown to be rather widely distributed, as on the southern slope of the Alps (*gastaldite*), Corsica, Japan, etc. *Rhodusite* is a fibrous variety from the Island Rhodus and Asskys river, Minassinsk, Siberia. *Holmquistite* is a lithium-bearing variety from the Island of Utö.

In the United States, glaucophane schists have been described from the Coast Ranges of California, as at Sulphur Bank, Lake Co.

Glaucophane is named from γλαυκός, *bluish green*, and φαίνεσθαι, *to appear*.

Crossite. An amphibole intermediate in composition between glaucophane and riebeckite, being optically more nearly related to the latter. Occurs in lath shaped crystals. Color blue. Strongly pleochroic. Found in the crystalline schists of the Coast Ranges of California.

RIEBECKITE.

Monoclinic. Axes $a : b : c = 0{\cdot}5475 : 1 : 0{\cdot}2925$; $\beta = 76° 10'$. In embedded prismatic crystals, longitudinally striated. Cleavage: prismatic (56°) perfect. Luster vitreous. Color black. Pleochroism very strongly marked: Z green, Y (= b axis) deep blue, X (nearly $\|$ c axis) dark blue. Optically −. Extinction-angle small, $X \wedge c$ axis = 4°–5° (±?). Axial angle large. $\beta = 1{\cdot}687$.

Comp. — Essentially $2NaFe(SiO_3)_2.FeSiO_3$ = Silica 50·5, iron sesquioxide 26·9, iron protoxide 12·1, soda 10·5 = 100. It corresponds closely to acmite (ægirite) among the pyroxenes.

Obs. — Originally described from the granite and syenite of the island of Socotra in the Indian Ocean, 120 m. N. E. of Cape Guardafui, the eastern extremity of Africa; occurs in groups of prismatic crystals, often radiating and closely resembling tourmaline; also in granophyre blocks found at Ailsa Crag and at other points in Scotland and Ireland. A similar amphihole occurs at Mynydd Mawr, Carnarvonshire, Wales. Also another in granulite in Corsica. Found at Narsarsuk, Greenland. From pegmatite at Quincy, Mass. A so-called arfvedsonite from St. Peter's Dome, Pike's Peak region, Col., occurring with astrophyllite and zircon, is shown by Lacroix to be near riebeckite. Extinction-angle on b, $X \wedge c$ axis = 3° to 4°. A soda amphibole, related to riebeckite, from Bababudan Hills, Mysore, India, has been named *bababudanite.*

CROCIDOLITE. Blue Asbestus.

Fibrous, asbestus-like; fibers long but delicate, and easily separable. Also massive or earthy. Cleavage: prismatic, 56°. H. = 4. G. = 3·20–3·30. Luster silky; dull. Color and streak lavender-blue or leek-green. Opaque. Fibers somewhat elastic. Pleochroism: Z green, Y violet, X blue. Optically +. Extinction-angle on b (010) inclined 18° to 20° with c axis. 2E = 95° approx. $\gamma - \alpha = 0{\cdot}025$.

Comp. — $NaFe(SiO_3)_2.FeSiO_3$ (nearly) = Silica 49·6, iron sesquioxide 22·0, iron protoxide 19·8, soda 8·6 = 100.

Magnesium and calcium replace part of the ferrous iron, and hydrogen part of the sodium.

Pyr., etc. — B.B. fuses easily with intumescence to a black magnetic glass, coloring the flame yellow (soda). With the fluxes gives reactions for iron. Unacted upon by acids.

Obs. — Occurs in South Africa, in Griqualand-West, north of the Orange river, in a range of quartzose schists called the Asbestos Mountains. In a micaceous porphyry near Framont, in the Vosges Mts. At Golling in Salzburg, Austria. In the United States, at Beacon Pole Hill, near Cumberland, R. I. Emerald Mine, Buckingham, and Perkin's Mill, Templeton, Ottawa Co., Ontario, Canada.

Abriachanite is an earthy amorphous form occurring in the Abriachan district, near Loch Ness, Scotland. Crocidolite is named from κροκίς, *woof*, in allusion to its fibrous structure.

The South African mineral is largely altered by both oxidation of the iron and infiltration of silica, resulting in a compact siliceous stone of delicate fibrous structure, chatoyant luster, and bright yellow to brown color, popularly called *tiger-eye* (also cat's-eye). Many varieties occur forming transitions from the original blue mineral to the final product; also varieties depending upon the extent to which the original mineral has penetrated the quartz.

ARFVEDSONITE.

Monoclinic. Axes $a : b : c = 0{\cdot}5569 : 1 : 0{\cdot}2978$; $\beta = 73° 2'$.

Crystals long prisms, often tabular || b (010), but seldom distinctly terminated; angles near those of amphibole; also in prismatic aggregates. Twins: tw. pl. a (100).

Cleavage: prismatic, perfect; b (010) less perfect. Fracture uneven. Brittle. H. = 6. G. = 3·44–3·45 Luster vitreous. Color pure black; in thin scales deep green. Streak deep bluish gray. Opaque except in thin splinters. Pleochroism strongly marked: Z deep greenish blue, Y lavender, X pale greenish yellow. Absorption $Z > Y > X$; sections || a (100) are deep greenish blue, || b (010) olive-green. Optically –. Axial angle, large. $\alpha = 1{\cdot}687$. $\beta = 1{\cdot}707$. $\gamma = 1{\cdot}708$. Extinction-angle on b (010), with c axis = 14°.

Comp. — A slightly basic metasilicate of sodium, calcium, and ferrous iron chiefly.

The supposed arfvedsonite from Greenland has been shown to be ægirite; that from Pike's Peak, Col., has been referred to riebeckite.

Pyr., etc. — B.B. fuses at 2 with intumescence to a black magnetic globule; colors the flame yellow (soda); with the fluxes gives reactions for iron and manganese. Not acted upon by acids.

Micro. — In thin sections shows brown- or gray-green or gray-violet colors; strongly pleochroic in blue and green tints; negative elongation.

Obs. — Arfvedsonite and amphiboles of similar character, containing much iron and soda, are constituents of certain igneous rocks which are rich in alkalies, as nephelite-syenite, certain porphyries, etc. Large and distinct crystals are found only in the pegmatite veins in such rocks, as at Kangerdluarsuk, Narsarsuk, Greenland, where the associated minerals are sodalite, eudialyte, feldspar, etc. Arfvedsonite occurs also in the nephelite-syenites and related rocks of the Christiania region in southern Norway; on the Kola peninsula in Russian Lapland; Dungannon township, Ontario; Trans Pecos district, Texas. The related brownish pleochroic amphiboles (cf. barkevikite) occur in similar rocks at Montreal, Canada; Red Hill, N. H.; Salem, Mass.; Magnet Cove, Ark.; Black Hills, S. D.; Square Butte, Mon. St. Peter's Dome, Col., etc.

Osannite from an amphibole-gneiss at Cevadaes, Portugal, and *Tschernichéwite* from a magnetite bearing quartzite in the northern Ural Mts., are near arfvedsonite.

BARKEVIKITE. An amphibole near arfvedsonite but more basic. In prismatic crystals. Cleavage: prismatic (55° 44½'). G. = 3·428. Color deep velvet-black. Pleochroism marked, colors brownish. Extinction-angle with c axis on b (010) = 12½°. Occurs at the wöhlerite locality near Barkevik, on the Langesund fiord, and elsewhere in southern Norway. In large crystals at Lugar, Ayrshire, Scotland.

Ænigmatite. Cossyrite. Essentially a titano-silicate of ferrous iron and sodium, but containing also aluminium and ferric iron. In prismatic triclinic crystals. Cleavage: prismatic, distinct (66°). G. = 3·74–3·80. Color black. Ænigmatite is from the sodalite-syenite of Tunugdliarfik and Kangerdluarsuk, Greenland. *Cossyrite* occurs in minute crystals embedded in the liparite lavas of the island Pantellaria (ancient name Cossyra); also widespread in the rocks of East Africa. *Rhönite* is like ænigmatite but contains much less ferrous oxide and alkalies with increase in alumina, ferric oxide, etc. From basaltic rocks in the Rhön district and elsewhere in Germany and Bohemia.

WEINBERGERITE. Perhaps $NaAlSiO_4.3FeSiO_3$. Orthorhombic. In spherical aggregates of radiating fibers. Black color. From a meteoric iron at Codai Canal, Palni Hills, Madras, India.

BERYL.

Hexagonal. Axis $c = 0{\cdot}4989$.

Crystals usually long prismatic, often striated vertically, rarely transversely; distinct terminations exceptional. Occasionally in large masses, coarse columnar or granular to compact.

Cleavage: *c* (0001), imperfect and indistinct. Fracture conchoidal to uneven. Brittle. H. = 7·5–8. G. = 2·63–2·80; usually 2·69–2·70. Luster vitreous, sometimes resinous. Colors emerald-green, pale green, passing into light blue, yellow and white; also pale rose-red. Streak white. Transparent to subtranslucent. Dichroism more or less distinct. Optically −. Birefringence low. Often abnormally biaxial. $\omega = 1{\cdot}5820$, $\epsilon = 1{\cdot}5765$, aquamarine.

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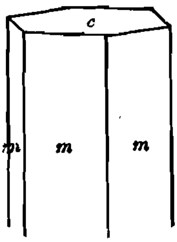

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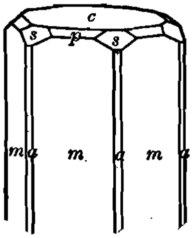

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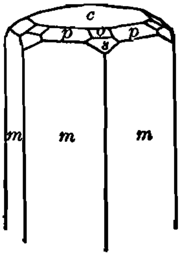

cp, $0001 \wedge 10\bar{1}1 = 29^\circ\ 56\tfrac{1}{2}'$. *cs*, $0001 \wedge 11\bar{2}1 = 44^\circ\ 56'$.
co, $0001 \wedge 11\bar{2}2 = 26^\circ\ 31'$. *pp'*, $10\bar{1}1 \wedge 01\bar{1}1 = 28^\circ\ 54\tfrac{1}{2}'$.

Var. — 1. *Emerald.* Color bright emerald-green, due to the presence of a little chromium; highly prized as a gem when clear and free from flaws.

2. *Ordinary; Beryl.* Generally in hexagonal prisms, often coarse and large; green the common color. The principal kinds are : (*a*) colorless; (*b*) bluish green, called *aquamarine;* (*c*) apple-green; (*d*) greenish yellow to iron-yellow and honey-yellow; sometimes a clear bright yellow as in the *golden beryl* (a yellow gem variety from Southwest Africa has been called *heliodor*); (*e*) pale yellowish green; (*f*) clear sapphire blue; (*g*) pale sky-blue; (*h*) pale violet or reddish; (*i*) rose colored called *morganite* or *vorobyevite;* (*j*) opaque brownish yellow, of waxy or greasy luster. The *oriental emerald* of jewelry is emerald-colored sapphire.

Comp. — $Be_3Al_2(SiO_3)_6$ or $3BeO.Al_2O_3.6SiO_2$ = Silica 67·0, alumina 19·0, glucina 14·0 = 100.

Alkalies (Na_2O, Li_2O, Cs_2O) are sometimes present replacing the beryllium, from 0·25 to 5 p. c.; also chemically combined water, including which the formula becomes $H_2Be_6Al_4Si_{12}O_{37}$.

Pyr., etc. — B.B. alone, unchanged or, if clear, becomes milky white and clouded; at a high temperature the edges are rounded, and ultimately a vesicular scoria is formed. Fusibility = 5·5, but somewhat lower for beryls rich in alkalies. Glass with borax, clear and colorless for beryl, a fine green for emerald. Unacted upon by acids.

Diff. — Characterized by its green or greenish blue color, glassy luster and hexagonal form; rarely massive, then easily mistaken for quartz. Distinguished from apatite by its hardness, not being scratched by a knife, also harder than green tourmaline; from chrysoberyl by its form; from euclase and topaz by its imperfect cleavage.

Artif. — Crystals of beryl have been produced artificially by fusing a mixture of silica, alumina and glucina with boric oxide as a flux.

Obs. — Beryl is a common accessory mineral in granite veins, especially in those of a pegmatitic character. Emeralds occur in clay slate, in isolated crystals or in nests, near Muso, etc., 75 m. N.N.E. of Bogotà, Colombia. Emeralds of less beauty, but larger, occur in Siberia, on the river Tokovoya, N. of Ekaterinburg, embedded in mica schist. Emeralds of large size, though not 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 Shaitanka, near Ekaterinburg; near Miask with topaz; in the mountains of Adun-Chalon with topaz, in E. Siberia. A clear aquamarine crystal weighing 110·5 kg. was found at Marambaya, Minas Geraes, Brazil. Beautiful crystals also occur at Elba; the tin mines of Ehrenfriedersdorf in Saxony, and Schlackenwald in Bohemia. Other localities are the Mourne Mts., Ireland; yellowish green at Rubislaw, near Aberdeen, Scotland (*davidsonite*); Limoges in France; Finbo and Broddbo in Sweden; Tamela in Finland; Pfitsch-Joch, Tyrol; Bodenmais and Rabenstein in Bavaria; in New South Wales. Pink, alkali-rich beryls are found in Madagascar.

In the United States, beryls of gigantic dimensions have been found in N. H., at Acworth and Grafton, and in Mass., at Royalston. In Me., at Albany; Norway; Bethel; at Hebron, a cæsium beryl (Cs_2O, 3·60 p. c.), associated with pollucite; in Paris, with black tourmaline; at Topsham, pale green or yellowish; at Stowe and Stoneham. In Mass., at Barre; at Goshen (*goshenite*), and at Chesterfield. In Conn., at Haddam, and at the Middletown and Portland feldspar quarries; at New Milford, of a clear golden yellow to dark amber color; Branchville. In Pa., at Leiperville and Chester; at Mineral Hill. In Va., at Amelia Court House, sometimes white. In N. C., in Alexander Co., near Stony Point, fine emeralds; in Mitchell Co.; Morganton, Burke Co., and elsewhere. In Ala., Coosa Co., of a light yellow color. In Col., near the summit of Mt. Antero, beautiful aquamarines. In S. D., in the Black Hills in large crystals. Rose-pink crystals, often showing prominent pyramid faces, from San Diego Co., Cal., also colorless and aquamarine.

Use. — The transparent mineral is used as a gem stone; see above under *Varieties*.

Eudialyte. Essentially a metasilicate of Zr,Fe(Mn),Ca,Na, etc. In red to brown tabular or rhombohedral crystals; also massive. H. = 5–5·5. G. = 2·9–3·0. Optically +. ω = 1·606. ϵ = 1·611. From Kangerdluarsuk, West Greenland, etc., with arfvedsonite and sodalite; at Lujaor on the Kola peninsula, Russian Lapland, in elæolite-syenite, there forming a main constituent of the rock-mass. *Eucolite*, from islands of the Langesund fiord in Norway, is similar (but optically −). Eudialyte and eucolite also occur at Magnet Cove, in Ark., of a rich crimson to peach-blossom red color, in feldspar, with elæolite and ægirite.

Elpidite. $Na_2O.ZrO_2.6SiO_2.3H_2O$. — Massive, fibrous. H. = 7. G. = 2·54. Color white to brick-red. Biaxial, +. Indices = 1·560–1·574. Southern Greenland.

ASTROLITE. $(Na,K)_2Fe(Al,Fe)_2(SiO_3)_5.H_2O$?. In globular forms with radiating structure. H. = 3·5. G. = 2·8. Color green. Fusible, 3·5. Found in a diabase tuff near Neumark, Germany.

The following are rare species of complex composition, all from the Langesund fiord region of southern Norway.

Catapleiite. $H_4(Na_2,Ca)ZrSi_3O_{11}$. In thin tabular hexagonal prisms. H. = 6. G. = 2·8. Color light yellow to yellowish brown. Biaxial, +. Indices, 1·591–1·627. *Natron-catapleiite*, or soda-catapleiite, contains only sodium; color blue to gray and white; on heating the blue color disappears.

Cappelenite. A boro-silicate of yttrium and barium. In greenish brown hexagonal crystals.

Melanocerite. A fluo-silicate of the cerium and yttrium metals and calcium chiefly (also B, Ta, etc.). In brown to black tabular rhombohedral crystals.

Caryocerite. Near melanocerite, containing ThO_2.

Steenstrupine (from Greenland) is allied to the two last-named species. Rhombohedral. H. = 4. G. = 3·4. Color dark brown to nearly black. Optically −.

Tritomite. A fluo-silicate of thorium, the cerium and yttrium metals and calcium, with boron. In dark brown crystals of acute triangular pyramidal form.

The following are also from the same region:

Leucophanite. $Na(BeF)Ca(SiO_3)_2$. In glassy greenish tabular crystals (orthorhombic-sphenoidal). H. = 4. G. = 2·96. Optically −. Indices, 1·571–1·598.

Meliphanite. A fluo-silicate of beryllium, calcium, and sodium near leucophanite. In low square pyramids (tetragonal). Color yellow. H. = 5–5·5. G. = 3·01. Optically −. Indices, 1·593–1·612.

Custerite. $Ca_2(OH,F)SiO_3$. Monoclinic. In fine granular masses. Cleavages parallel to base and prism, all making nearly 90° with each other. Twinning plane *c* (001), showing in twin lamellæ. H. = 5. G. = 2·91. Color greenish gray. Transparent. Optically +. Bx_a nearly perpendicular to *c* (001). Indices, 1·58–1·60. Difficultly fusible. Decomposed by hydrochloric acid. Found in limestone contact zone at the Empire mine, Custer Co., Idaho.

Didymolite. $2CaO.3Al_2O_3.9SiO_2$. Monoclinic. In small twinned crystals. H. = 4–5. G. = 2·71. Color dark gray. Opaque. Index 1·5. Difficultly fusible. Insoluble. Found as contact mineral in limestone from Tatarka River, Yenisei District, Siberia.

IOLITE. Cordierite. Dichroite.

Orthorhombic. Axes $a : b : c = 0·5871 : 1 : 0·5585$.

Twins: tw. pl. *m* (110), also *d* (130), both yielding pseudo-hexagonal forms. Habit short prismatic ($mm''' = 60° 50'$) (Fig. 838). As embedded grains; also massive, compact.

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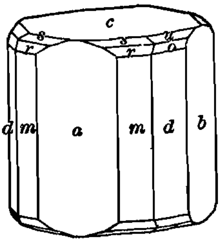

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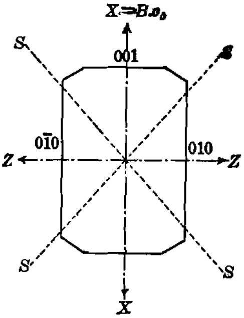

Cleavage: *b* (010) distinct; *a*(100) and *c*(001) indistinct. Crystals often show a lamellar structure || *c* (001), especially when slightly altered. Fracture subconchoidal. Brittle. H. = 7–7·5. G. = 2·60–2·66. Luster vitreous. Color various shades of blue, light or dark, smoky blue. Transparent to translucent. Pleochroism strongly marked except in thin sections. Axial colors variable. Thus:

Bodenmais *Z* (= *b* axis) dark Berlin-blue. *Y* (= *a* axis) light Berlin-blue. *X* (= *c* axis) yellowish white.

Absorption $Z > Y > X$. Pleochroic halos common, often bright yellow; best seen in sections || *c* axis. Exhibits idiophanous figures. Optically −. Ax. pl. || *a* (100). Bx. ⊥ *c* (001). Dispersion feeble, $\rho < v$. $2V = 70° 23'$ (also 40° to 84°). Indices variable, from 1·534 to 1·599.

Comp. — $H_2(Mg,Fe)_4Al_8Si_{10}O_{37}$ or $H_2O.4(Mg,Fe)O.4Al_2O_3.10SiO_2$.

If Mg : Fe = 7 : 2, the percentage composition is: Silica 49·4, alumina 33·6, iron protoxide 5·3, magnesia 10·2, water 1·5 = 100. Ferrous iron replaces part of the magnesium. Calcium is also present in small amount.

Pyr., etc. — B.B. loses transparency and fuses at 5–5·5. Only partially decomposed by acids. Decomposed on fusion with alkaline carbonates.

Diff. — Characterized by its vitreous luster, color and pleochroism; fusible on the edges unlike quartz; less hard than sapphire.

Micro. — Recognized in thin sections by lack of color; low refraction and low interference-colors; it is very similar to quartz, but distinguished by its biaxial character; in volcanic rocks commonly shows distinct crystal outlines and a twinning of three individuals like aragonite. In the gneisses, etc., it is in formless grains, but the common occurrence of inclusions, especially of sillimanite needles, the pleochroic halos of a yellow color around small inclusions, particularly zircons, and the constant tendency to alteration to micaceous pinite seen along cleavages, help to distinguish it.

Obs. — Occurs in granite, gneiss (*cordierite-gneiss*), hornblendic, chloritic and talcose schist, and allied rocks, with quartz, orthoclase or albite, tourmaline, hornblende, andalusite, sillimanite, garnet, and sometimes beryl. Less commonly in or connected with igneous rocks, thus formed directly from the magma, as in andesite, etc.; also in ejected masses (in fragments of older rocks); further formed as a contact-mineral in connection with eruptive dikes, as in slates adjoining granite.

Occurs at Bodenmais, Bavaria, in granite, with pyrrhotite, etc.; Orijärvi, in Finland (*steinheilite*); Tunaberg, in Sweden; from Switzerland; in colorless crystals from Brazil; Ceylon affords a transparent variety, the *saphir d'eau* of jewelers; from Ibity, Madagascar; from Greenland.

In the United States, at Haddam, Conn., associated with tourmaline in a granitic vein in gneiss. In large altered crystals from Litchfield, Conn. At Brimfield, Mass.; at Richmond, N. H.

Named *Iolite* from *'ἴον, violet,* and *λίθος, stone; Dichroite* (from *δίχροος, two-colored*), from its dichroism; *Cordierite*, after Cordier, the French geologist (1777–1861).

Alteration. The alteration of iolite takes place so readily by ordinary exposure, that the mineral is most commonly found in an altered state, or enclosed in the altered iolite. This change may be a simple hydration; or a removal of part of the protoxide bases by carbon dioxide; or the introduction of oxide of iron; or of alkalies, forming pinite and mica. The first step in the change consists in a division of the prisms of iolite into plates parallel to the base, and a pearly foliation of the surfaces of these plates; with a change of color to grayish green and greenish gray, and sometimes brownish gray. As the alteration proceeds, the foliation becomes more complete; afterward it may be lost. The mineral in this altered condition has many names: as *hydrous iolite* (including *bonsdorffite* and *auralite*) from Åbo, Finland; *fahlunite* from Falun, Sweden, also *pyrargillite* from Helsingfors; *esmarkite* and *praseolite* from near Brevik, Norway, also *raumite* from Raumo, Finland, and *peplolite* from Ramsberg, Sweden; *chlorophyllite* from Unity, Me.; *aspasiolite* and *polychroilite* from Kragerö. There are further alkaline kinds, as *pinite, cataspilite, gigantolite, iberite,* belonging to the Mica Group.

Use. — Iolite is sometimes used as a gem.

Jurupaite. $H_2(Ca,Mg)_2Si_2O_7$. Monoclinic? Radiating fibrous. White. H. = 4. G. = 2·75. n = 1·57. Crestmore, Cal.

The following are rare lead, zinc, and barium silicates:

Barysilite. $Pb_3Si_2O_7$. Rhombohedral. In embedded masses with curved lamellar structure. Cleavage: basal. H. = 3. G. = 6·11–6·55. Color white; tarnishing on exposure. From the Harstig mine, Pajsberg, and Långban, Sweden.

Molybdophyllite. $(Pb,Mg)SiO_4.H_2O$. Hexagonal. In irregular foliated masses with perfect basal cleavage. H. = 3–4. G. = 4·7. Colorless to pale green. ω = 1·81. Difficultly fusible. From Långban, Sweden.

Ganomalite. $Pb_4(PbOH)_2Ca_4(Si_2O_7)_3$. In prismatic crystals (tetragonal); also massive, granular. H. = 3. G. = 5·74. Colorless to gray. Indices, 1·83–1·93. From Långban, Sweden; also Jakobsberg.

Nasonite. Closely related to *ganomalite*. $Pb_4(PbCl)_2Ca_4(Si_2O_7)_3$. Probably tetragonal. Massive, granular cleavable. H. = 4. G. = 5·4. White. Fusible. From Franklin, N. J.

Margarosanite. $Pb(Ca,Mn)_2(SiO_3)_3$. Triclinic. Slender prismatic crystals and cleavable granular. Three cleavages, one perfect. Colorless and transparent with pearly luster. H. = 2·5–3. G. = 3·99. Easily fusible. From Franklin, N. J., and Långban, Sweden.

Hardystonite. $Ca_2ZnSi_2O_7$. Tetragonal. In granular masses. Three cleavages. H. = 3–4. G. = 3·4. Color white. From Franklin, N. J.

Hyalotekite. Approximately $(Pb,Ba,Ca)B_2(SiO_3)_{12}$. Massive; coarsely crystalline. H. = 5–5·5. G. = 3·81. Color white to pearly gray. From Långban, Sweden.

Barylite. $Ba_4Al_4Si_7O_{24}$. In groups of colorless prismatic orthorhombic crystals. H. = 7. G. = 4·03. Luster greasy. Optically +. β = 1·685. Occurs with hedyphane in crystalline limestone at Långban, Sweden.

Taramellite. $Ba_4\overset{II}{Fe}\overset{III}{Fe}_4Si_{10}O_{31}$. Orthorhombic? Fibrous. Color reddish brown. H. = 5·5. G. = 3·9. Strong pleochroism, almost black to flesh-red. Found in limestone at Candoglia, Italy.

Roeblingite. $5(H_2CaSiO_4).2(CaPbSO_4)$. In dense, white, compact, crystalline masses. H. = 3. G. = 3·433. From Franklin Furnace, N. J.

III. Orthosilicates. R_2SiO_4

Salts of Orthosilicic Acid, H_4SiO_4; characterized by an oxygen ratio of 1 : 1 for silicon to bases.

The following list includes the more prominent groups among the Orthosilicates.

A number of basic orthosilicates are here included, which yield water upon ignition; also others which are more or less basic than a normal orthosilicate, but which are of necessity introduced here in the classification, because of their relationship to other normal salts. The Mica Group is so closely related to many Hydrous Silicates that (with also Talc, Kaolinite, and some others) it is described later with them.

Nephelite Group. Hexagonal.
Sodalite Group. Isometric.
Helvite Group. Isometric-tetrahedral.
Garnet Group. Isometric.
Chrysolite Group. Orthorhombic.
Phenacite Group. Tri-rhombohedral.
Scapolite Group. Tetragonal-pyramidal.
Zircon Group. Tetragonal.
Danburite Group. Orthorhombic.
Datolite Group. Monoclinic.
Epidote Group. Monoclinic.

Nephelite Group. Hexagonal

Typical formula $\overset{\text{I}}{R}AlSiO_4$

Nephelite	$K_2Na_6Al_8Si_9O_{34}$		$c = 0{\cdot}8389$
Soda-nephelite (artif.)	$NaAlSiO_4$		
Eucryptite	$LiAlSiO_4$	**Kaliophilite**	$KAlSiO_4$
Cancrinite	$H_6Na_6Ca(NaCO_3)_2Al_8(SiO_4)_9$		$2c = 0{\cdot}8448$
Microsommite	$(Na,K)_{10}Ca_4Al_{12}Si_{12}O_{52}SCl_4$		$2c = 0{\cdot}8367$

The species of the Nephelite Group are hexagonal in crystallization and have in part the typical orthosilicate formula $\overset{\text{I}}{R}AlSiO_4$. From this formula nephelite itself deviates somewhat, though an artificial soda-nephelite, $NaAlSiO_4$, conforms to it. The species Cancrinite and Microsommite are related in form and also in composition, though in the latter respect somewhat complex. They serve to connect this group with the sodalite group following.

NEPHELITE. Nepheline. Elæolite.

Hexagonal-hemimorphic (p. 101). Axis $c = 0{\cdot}83893$.

In thick six- or twelve-sided prisms with plane or modified summits. Also massive compact, and in embedded grains; structure sometimes thin columnar.

Cleavage: *m* (110) distinct; *c* (001) imperfect. Fracture subconchoidal. Brittle. H. = 5·5–6. G. = 2·55–2·65. Luster vitreous to greasy; a little opalescent in some varieties. Colorless, white, or yellowish; also, when massive, dark green, greenish or bluish gray, brownish red and brick-red. Transparent to opaque. Optically −. Indices: $\omega = 1{\cdot}542$, $\epsilon = 1{\cdot}538$.

Var. — 1. *Nephelite. Glassy.* — Usually in small glassy crystals or grains, transparent with vitreous luster, first found on Mte. Somma, Vesuvius. Characteristic particularly of younger eruptive rocks and lavas. 2. *Elæolite.* — In large coarse crystals, or more commonly massive, with a greasy luster, and reddish, greenish, brownish or gray in color. Usually clouded by minute inclusions. Characteristic of granular crystalline rocks, syenite, etc.

Comp. — $NaAlSiO_4$. This is the composition of the artificial mineral. Natural nephelite always contains silica in varying excess and also small amounts of potash. The composition usually approximates to $Na_6K_2Al_8Si_9O_{34}$.

Synthetic experiments, yielding crystals like nephelite with the composition $NaAlSiO_4$, lead to the conclusion that a natural soda-nephelite would be an orthosilicate with this formula, while the higher silica in the potash varieties may be explained by the presence, in molecular combination, of $KAlSiO_4$ and $NaAlSi_3O_8$ (albite in hexagonal modification). The variation in composition may be more simply explained by considering normal nephelite, $NaAlSiO_4$, to take up in solid solution silica or other silicate molecules. The other species of the group are normal orthosilicates, viz., eucryptite $LiAlSiO_4$. and kaliophilite, $KAlSiO_4$.

Pyr., etc. — B.B. fuses quietly at 3·5 to a colorless glass, coloring the flame yellow. Gelatinizes with acids.

Diff. — Distinguished by its gelatinizing with acids from scapolite and feldspar, as also from apatite, from which it differs too in its greater hardness. Massive varieties have a characteristic greasy luster.

Micro. — Recognized in thin sections by its low refraction; very low interference-colors, which scarcely rise to gray; parallel extinction when in crystals; faint negative uniaxial cross yielded by basal sections in converging light. The negative character is best told by aid of the gypsum plate (see p. 266). Micro-chemical tests serve to distinguish non-characteristic particles from similar ones of alkali feldspar; the section is treated with dilute acid, and the resultant gelatinous silica, which coats the nephelite particles, stained with eosine or other dye.

Artif. — Nephelite is easily prepared artificially by fusing its constituents together in the proper proportions.

Obs. — Nephelite is rather widely distributed (as shown by the microscopic study of rocks) in igneous rocks as the product of crystallization of a magma rich in soda and at the same time low in silica (which last prevents the soda from being used up in the formation of albite). It is thus an essential component of the nephelite-syenites and phonolites where it is associated with alkali feldspars chiefly. It is also a constituent of more basic augitic rocks such as nephelinite, nephelite-basalts, nephelite-tephrites, theralite, etc., most of which are volcanic in origin. The variety *elæolite* is associated with the granular plutonic rocks, while the name *nephelite* was originally used for the fresh glassy crystals of the modern lavas; the terms have in this sense the same relative significance as orthoclase and sanidine. Modern usage, however, tends to drop the name *elæolite.*

The original *nephelite* occurs in crystals in the older lavas of Mte. Somma, Vesuvius, with mica, vesuvianite, etc.; at Capo di Bove, near Rome; in the basalt of Katzenbuckel, near Heidelberg, Germany; Aussig in Bohemia; Löbau in Saxony. Occurs also in massive forms and large coarse crystals (*elæolite*) in the nephelite-syenites of Southern Norway, especially along the Langesund fiord; similarly in west Greenland; the peninsula of Kola, Russia; Miask in the Ilmen Mts. (in the rock *miascite*); Sierra Monchique, Portugal (in the rock *foyaite*); Ditró, Hungary (in the rock *ditroite*); Pousac, France; Brazil; South Africa.

Elæolite occurs massive and crystallized at Litchfield, Me., with cancrinite; Salem, Mass.; Red Hill, N. H.; in the Ozark Mts., near Magnet Cove, Ark.; elæolite-syenite is also found near Beemersville, northern N. J.; near Montreal, Canada; at Dungannon township, Ontario, in enormous crystals. Nephelite rocks also occur at various points, as the Transpecos district, Texas; Pilot Butte, Texas; also in western North America, as in Col. at Cripple Creek; in Mon., in the Crazy Mts., the Highwood, Bearpaw and Judith Mts.; Black Hills in S. D.; Ice River, British Columbia.

Named *nephelite* from νεφελη, *a cloud*, in allusion to its becoming cloudy when immersed in strong acid; *elæolite* is from ελαίον, *oil*, in allusion to its greasy luster.

Gieseckite is a pseudomorph after nephelite. It occurs in Greenland in six-sided greenish gray prisms of greasy luster; also at Diana in Lewis Co., N. Y. *Dysyntribite* from Diana is similar to gieseckite, as is also *liebenerite*, from the valley of Fleims, in Tyrol, Austria. See further PINITE under the MICA GROUP.

Eucryptite. $LiAlSiO_4$. In symmetrically arranged crystals (hexagonal), embedded, in albite and derived from the alteration of spodumene at Branchville, Conn. (see Fig. 488, p. 181). G. = 2·667. Colorless or white.

Kaliophilite. $KAlSiO_4$. Phacellite. Phacelite. Facellite. In bundles of slender acicular crystals (hexagonal), also in fine threads, cobweb-like. H. = 6. G. = 2·493–2·602. Colorless. Occurs in ejected masses at Mte. Somma, Vesuvius.

CANCRINITE.

Hexagonal. Axis $c = 0·4224$; and *mp* $10\bar{1}0 \wedge 10\bar{1}1 = 64°$, *pp′* $1011 \wedge 01\bar{1}1 = 25° 58′$. Rarely in prismatic crystals with a low terminal pyramid. Usually massive.

Cleavage: prismatic, *m* $(10\bar{1}0)$ perfect; *a* $(11\bar{2}0)$ less so. H. = 5–6. G. = 2·42–2·5. Color white, gray, yellow, green, blue, reddish. Streak uncolored. Luster subvitreous, or a little pearly or greasy. Transparent to translucent. Optically –. $\omega = 1·524$. $\epsilon = 1·496$.

Comp. — $H_6Na_6Ca(NaCO_3)_2Al_8(SiO_4)_9$ or $3H_2O.4Na_2O.CaO.4Al_2O_3.9SiO_2.2CO_2$ = Silica 38·7, carbon dioxide 6·3, alumina 29·3, lime 4·0, soda 17·8, water 3·9 = 100.

Pyr., etc. — In the closed tube gives water. B.B. loses color, and fuses (F. = 2) with intumescence to a white blebby glass, the very easy fusibility distinguishing it readily from nephelite. Effervesces with hydrochloric acid, and forms a jelly on heating, but not before.

Micro. — Recognized in thin sections by its low refraction; quite high interference-colors and negative uniaxial character. Its common association with nephelite, sodalite, etc., are valuable characteristics. Evolution of CO_2 with acid distinguishes it from all other minerals except the carbonates, which show much higher interference-colors.

Artif. — Cancrinite has been prepared artificially by heating under pressure a mixture of sodium silicate, alumina and sodium carbonate; also by the treatment of nephelite and labradorite by sodium carbonate at high temperatures.

Obs. — Cancrinite occurs only in igneous rocks of the nephelite-syenite and related rock groups. It is in part believed to be original, i.e., formed directly from the molten magma; in part held to be secondary and formed at the expense of nephelite by infiltrating waters holding calcium carbonate in solution. Prominent localities are Miask in the Ilmen Mts., Russia, in coarse-grained nephelite-syenite; similarly at Barkevik and other localities on the Langesund fiord in southern Norway; in the parish of Knolajärvi in northern Finland (where, associated with orthoclase, ægirite and nephelite, it composes a mass of cancrinite-syenite); at Ditró, Transylvania, etc.; in nephelite-syenite of Sarna and Alnö in Sweden, and in Brazil; also in small amount as an occasional accessory component of many phonolitic rocks at various localities.

In the United States at Litchfield and West Gardiner, Me., with elæolite and blue sodalite. Named after Count Cancrin, Russian Minister of Finance.

Sulphatic cancrinite with nearly one-half the CO_2 replaced by SO_3 is found in an altered rock on Beaver Creek, Gunnison Co., Col. Has lower refractive indices and birefringence than *cancrinite.*

Microsommite. Near cancrinite; perhaps $(Na,K)_{10}Ca_4Al_{12}Si_{12}O_{52}SCl_4)$. In minute colorless prismatic crystals (hexagonal. See Fig. 30, p. 19). From Vesuvius (Monte Somma). H. = 6. G. = 2·42–2·53. $\omega = 1·521$. $\epsilon = 1·529$.

Davyne. Near microsommite. From Mte. Somma; Laacher See, Germany. $\omega = 1·518$. $\epsilon = 1·521$.

Sodalite Group. Isometric

Sodalite	$Na_4(AlCl)Al_2(SiO_4)_3$
Haüynite	$(Na_2,Ca)_2(NaSO_4.Al)Al_2(SiO_4)_3$
Noselite	$Na_4(NaSO_4.Al)Al_2(SiO_4)_3$
Lazurite	$Na_4(NaS_3.Al)Al_2(SiO_4)_3$

The species of the Sodalite Group are isometric in crystallization and perhaps tetrahedral like the following group. In composition they are peculiar (like cancrinite of the preceding group) in containing radicals with Cl, SO_4 and S, which are elements usually absent in the silicates. These are shown in the formulas written above in the form suggested by Brögger, 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 GARNET GROUP proper, p. 505.

The formulas are also often written as if the compound consisted of a silicate and chloride (sulphate, sulphide) — thus for sodalite, $3NaAlSiO_4 + NaCl$, etc.

SODALITE.

Isometric, perhaps tetrahedral. Common form the dodecahedron. Twins: tw. pl. *o* (111), forming hexagonal prisms by elongation in the direction of an octahedral axis (Fig. 406, p. 165). Also massive, in embedded grains; in concentric nodules resembling chalcedony, formed from elæolite.

Cleavage: dodecahedral, more or less distinct. Fracture conchoidal to uneven. Brittle. H. = 5·5–6. G. = 2·14–2·30. Luster vitreous, sometimes inclining to greasy. Color gray, greenish, yellowish, white; sometimes blue, lavender-blue, light red. Transparent to translucent. Streak uncolored. $n = 1·4827$.

Comp. — $Na_4(AlCl)Al_2(SiO_4)_3$ = Silica 37·2, alumina 31·6, soda 25·6, chlorine 7·3 = 101·7, deduct (O = 2Cl) 1·7 = 100. Potassium replaces a small part of the sodium. The formula may also be written $3NaAlSiO_4 + NaCl$.

Pyr., etc. — In the closed tube the blue varieties become white and opaque. B.B. fuses with intumescence, at 3·5–4, to a colorless glass. Soluble in hydrochloric acid and yields gelatinous silica upon evaporation.

Diff. — Distinguished from much analcite, leucite and haüynite by chemical tests alone; dissolving the mineral in dilute nitric acid and testing for chlorine is the simplest and best.

Micro. — Recognized in thin sections by its very low refraction, isotropic character and lack of good cleavage; also, in most cases, by its lack of color. In uncovered rock sections the minerals of this group may be distinguished from each other by covering them with a little nitric acid which is allowed to evaporate slowly. With sodalite crystals of sodium chloride will form; with haüynite crystals of gypsum; with noselite crystals of both compounds after the addition of calcium chloride; lazurite will evolve hydrogen sulphide which will blacken silver.

Artif. — Sodalite can be obtained by fusing nephelite with sodium chloride; also by the action of sodium carbonate and caustic soda upon muscovite at 500°. It has been produced also in various artificial magmas at temperatures below 700°.

Obs. — Sodalite occurs only in igneous rocks of the nephelite-syenite and related rock groups, as a product of the crystallization of a magma rich in soda; also as a product associated with enclosed masses and bombs ejected with such magmas in the form of lava, as at Vesuvius. Often associated with nephelite (or elæolite), cancrinite and eudialyte. With sanidine it forms a *sodalite-trachyte* at Scarrupata in Ischia, Italy, in crystals. In Sicily, Val di Noto, with nephelite and analcite. At Vesuvius, in bombs on Monte Somma in white, translucent, dodecahedral crystals; massive and of a gray color at the Kaiserstuhl and near Lake Laach, Germany. A variety from Monte Somma containing 2 per cent of molybdenum trioxide has been called *molybdosodalite*. At Ditró, Transylvania, in an elæolite-syenite. In the foyaite of southern Portugal. At Miask, in the Ilmen Mts., Russia; in the augite-syenite of the Langesund-fiord region in Norway. Further in West Greenland in sodalite-syenite; the peninsula of Kola, Russia.

A blue massive variety occurs at Litchfield and West Gardiner, Me. Occurs in the theralite of the Crazy Mts., Mon., also at Square Butte, Highwood Mts., and in the Bearpaw Mts., in tinguaite. Occurs also in the elæolite-syenite of Brome, Brome Co., and of Montreal and Belœil, province of Quebec; at Dungannon, Ontario, in large blue masses and in small pale pink crystals. At Kicking Horse Pass, Bristish Columbia.

Hackmanite. A sodalite containing about 6 per cent of the molecule $Na_4[Al(NaS)]Al_2(SiO_4)_3$ from a rock called *tawite* from the Tawa valley on the Kola peninsula, Lapland.

HAÜYNITE. Haüyne.

Isometric. Sometimes in dodecahedrons, octahedrons, etc.

Twins: tw. pl. *o* (111); contact-twins, also polysynthetic; penetration-twins (Fig. 405, p. 165). Commonly in rounded grains, often looking like crystals with fused surfaces.

Cleavage: dodecahedral, rather distinct. Fracture flat conchoidal to uneven. Brittle. H. = 5·5–6. G. = 2·4–2·5. Luster vitreous, to somewhat greasy. Color bright blue, sky blue, greenish blue; asparagus-green, red, yellow. Streak slightly bluish to colorless. Subtransparent to translucent; often enclosing symmetrically arranged inclusions (Fig. 840). n = 1·4961.

Comp. — $Na_2Ca(NaSO_4.Al)Al_2(SiO_4)_3$. This is analogous to the garnet formula (Brögger) where the place of the R_3 is taken by Na_2, Ca and the group $Na–O–SO_2–O–Al$. The percentage composition is: Silica 32·0, sulphur trioxide 14·2, alumina 27·2, lime 10·0, soda 16·6 = 100. The ratio of Na_2 : Ca also varies from 3 : 2; potassium may be present in small amount. The formula may also be written $2(Na_2,Ca)Al_2(SiO_4)_2 + (Na\ ,Ca)SO_4$.

Pyr., etc. — In the closed tube retains its color. B.B. in the forceps fuses at 4·5 to a white glass. Soluble in hydrochloric acid and yields gelatinous silica upon evaporation. The solution gives a test for the sulphate radical with barium chloride.

Micro. — Similar to sodalite, which see.

Artif. — Has been produced artificially in the same ways as with sodalite with the use of a sulphate instead of a chloride.

Obs. — Common in certain igneous rocks, thus in haüynophyre, in phonolite, tephrite; very commonly associated with nephelite and leucite. Occurs in the Vesuvian lavas, on Mte. Somma; at Melfi, on Mt. Vultur, Naples; in the lavas of the Campagna, Rome, also in a basalt tuff near Albano, Italy; at Niedermendig, in the Eifel, Germany; the phonolites of Hohentwiel, Baden, Germany.

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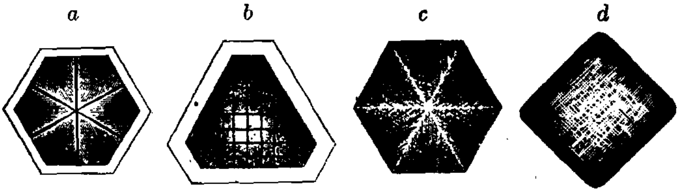

Section of crystals of haüynite (after Möhl)

Noselite or Nosean. Near haüynite, but contains little or no lime. Color grayish, bluish, brownish; sometimes nearly opaque from the presence of inclusions (cf. Fig. 840). n = 1·495. Not uncommon in phonolite. In Germany at Andernach, the Laacher See, and elsewhere.

LAZURITE. Lapis-Lazuli. Lasurite.

Isometric. In cubes and dodecahedrons. Commonly massive, compact.

Cleavage: dodecahedral, imperfect. Fracture uneven. H. = 5–5·5. G. = 2·38–2·45. Luster vitreous. Color rich Berlin-blue or azure-blue, violet-blue, greenish blue. Translucent. n = 1·500.

Comp. — Essentially $Na_4(NaS\ .Al)Al_2(SiO_4)_3$, but containing also in molecular combination haüynite and sodalite. The percentage composition of this ultramarine compound is as follows: Silica 31·7, alumina 26·9, soda 27·3, sulphur 16·9 = 102·9, or deduct (O = S) 2·9 = 100.

The heterogeneous character of what had long passed as a simple mineral under the name Lapis-lazuli was shown by Fischer (1869), Zirkel (1873), and more fully by Vogelsang (1873).

The ordinary natural *lapis lazuli* is shown by Brögger and Bäckström to contain lazurite or haüynite (sometimes changed to a zeolite), a diopside free from iron, amphibole (koksharovite), mica (muscovite), calcite, pyrite; also in some varieties in relatively small amount scapolite, plagioclase, orthoclase (microperthite?), apatite, titanite, zircon, and an undetermined mineral optically + and probably uniaxial. Regarded by Brögger as a result of contact metamorphism in limestone.

Micro. — Similar to sodalite, which see.

Pyr., etc. — Heated in the closed tube gives off some moisture; the variety from Chile glows with a beetle-green light, but the color of the mineral remains blue on cooling. Fuses easily (3) with intumescence to a white glass. Soluble in hydrochloric acid and yields gelatinous silica upon evaporation and evolves hydrogen sulphide.

Obs. — Occurs in Badakshan, India, in the valley of the Kokcha, a branch of the Oxus, a few miles above Firgamu. Also at the south end of Lake Baikal, Siberia. Further, in Chile in the Andes of Ovalle. In ejected masses at Monte Somma, Vesuvius, rare. From Siberia and Persia.

Use. — The richly colored varieties of lapis lazuli are highly esteemed for costly vases and ornamental furniture; also employed in the manufacture of mosaics; and when powdered constitutes the rich and durable paint called *ultramarine*. This has been replaced, however, by artificial ultramarine, now an important commercial product.

Helvite Group. Isometric-tetrahedral

Helvite	$(Mn,Fe)_2(Mn_2S)Be_3(SiO_4)_3$
Danalite	$(Fe,Zn,Mn)_2((Zn,Fe)_2S)Be_3(SiO_4)_3$
Eulytite	$Bi_4(SiO_4)_3$
Zunyite	$(Al(OH,F,Cl)_2)_6Al_2(SiO_4)_3$

The HELVITE GROUP includes several rare species, isometric-tetrahedral in crystallization and in composition related to the species of the SODALITE GROUP and also to those of the GARNET GROUP which follows:

HELVITE.

Isometric-tetrahedral. Commonly in tetrahedral crystals; also in spherical masses.

Cleavage: octahedral in traces. Fracture uneven to conchoidal. Brittle. H. = 6–6·5. G. = 3·16–3·36. Luster vitreous, inclining to resinous. Color honey-yellow, inclining to yellowish brown, and siskin-green, reddish brown. Streak uncolored. Subtransparent. $n = 1·739$. Pyroelectric.

Comp. — $(Be,Mn,Fe)_7Si_3O_{12}S$. This may be written $(Mn,Fe)_2(Mn_2S)Be_3(SiO_4)_3$ analogous to the Garnet Group, the bivalent group $-Mn-S-Mn$ taking the place of a bivalent element, R, and 3Be corresponding to 2Al, cf. p. 505. Composition also written $3(Be,Mn,Fe)_2SiO_4.(Mn,Fe)S$.

Pyr., etc. — Fuses at 3 in R.F. with intumescence to a yellowish brown opaque bead, becoming darker in R.F. With the fluxes gives the manganese reaction. Soluble in hydrochloric acid, giving hydrogen sulphide and yielding gelatinous silica upon evaporation.

Obs. — Occurs at Schwarzenberg and Breitenbrunn, in Saxony; at Kapnik, Hungary; also in the pegmatite veins of the augite-syenite of the Langesund fiord, Norway; in the Ilmen Mts., Russia, near Miask, in pegmatite. In the United States, with spessartite, at the mica mines near Amelia Court-House, Amelia Co., Va.; etc. Named by Werner, in allusion to its yellow color, from ἥλιος, *the sun*.

Danalite. $(Be,Fe,Zn,Mn)_7Si_3O_{12}S$. In octahedrons; usually massive. H. = 5·5–6. G. = 3·427. Color flesh-red to gray. Occurs in small grains in the Rockport granite, Cape Ann, Mass.; at the iron mine at Bartlett, N. H.; El Paso Co., Col. In England at Redruth, Cornwall.

Eulytite. $Bi_4Si_3O_{12}$. Usually in minute tetrahedral crystals; also in spherical forms. H. = 4·5. G. = 6·106. Color dark hair-brown to grayish, straw-yellow, or colorless. $n = 2·05$. Found with native bismuth near Schneeberg, Saxony; also at Johanngeorgenstadt, Germany, in crystals on quartz.

Zunyite. — A highly basic orthosilicate of aluminium, $(\mathrm{Al(OH,F,Cl)_2})_6\mathrm{Al_2Si_3O_{12}}$. In minute transparent tetrahedrons. H. = 7. G. = 2·875. From the Zuñi mine, near Silverton, San Juan Co., and on Red Mountain, Ouray Co., Col.

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4. *Garnet Group.* Isometric

$$\overset{\mathrm{II}}{\mathrm{R}}_3\overset{\mathrm{III}}{\mathrm{R}}_2(\mathrm{SiO_4})_3 \quad \text{or} \quad 3\mathrm{RO.R_2O_3.3SiO_2}.$$

$$\overset{\mathrm{II}}{\mathrm{R}} = \mathrm{Ca,Mg,}\overset{\mathrm{II}}{\mathrm{Fe}},\overset{\mathrm{II}}{\mathrm{Mn}}. \qquad \overset{\mathrm{III}}{\mathrm{R}} = \mathrm{Al,}\overset{\mathrm{III}}{\mathrm{Fe}},\mathrm{Cr,}\overset{\mathrm{III}}{\mathrm{Ti}}.$$

Garnet

A. Grossularite	$\mathrm{Ca_3Al_2(SiO_4)_3}$	E. Andradite	$\mathrm{Ca_3Fe_2(SiO_4)_3}$
B. Pyrope	$\mathrm{Mg_3Al_2(SiO_4)_3}$	Also	$\mathrm{(Ca,Mg)_3Fe_2(SiO_4)_3}$,
C. Almandite	$\mathrm{Fe_3Al_2(SiO_4)_3}$		$\mathrm{Ca_3Fe_2((Si,Ti)O_4)_3}$
D. Spessartite	$\mathrm{Mn_3Al_2(SiO_4)_3}$	F. Uvarovite	$\mathrm{Ca_3Cr_2(SiO_4)_3}$,
Schorlomite	$\mathrm{Ca_3(Fe,Ti)_2(\ (Si,Ti)O_4)_3}$		

The Garnet Group includes a series of important sub-species included under the same specific name. They all crystallize in the normal class of the isometric system and are alike in habit, the dodecahedron and trapezohedron being the common forms. They have also the same general formula, and while the elements present differ widely, there are many intermediate varieties. Some of the garnets include titanium, replacing silicon, and thus they are connected with the rare species schorlomite, which probably also has the same general formula.

Closely related to the Garnet Group proper are the species of the Sodalite and Helvite Groups (pp. 501, 504). All are characterized by isometric crystallization, and all are orthosilicates, with similar chemical structure. Thus the formula of the Garnet Group is $\overset{\mathrm{II}}{\mathrm{R}}_3\overset{\mathrm{III}}{\mathrm{R}}_2(\mathrm{SiO_4})_3$; to this Sodalite conforms if written $\mathrm{Na_4(AlCl)Al_2(SiO_4)_3}$, where $\mathrm{Na_4}$ and the bivalent radical AlCl are equivalent to $\mathrm{R_3}$; similarly for Noselite (Haüynite) if the presence of the bivalent group $\mathrm{NaSO_4{-}Al}$ is assumed.

In the Helvite Group, which is characterized by the tetrahedral character of the species (perhaps true also of the Sodalites), the chemical relation is less close but probably exists, as exhibited by writing the formula of Helvite $\mathrm{(Mn,Fe)(Mn_2S)Be_3(SiO_4)_3}$, where the bivalent group –S–Mn–S– enters, and 3Be may be regarded as taking the place of 2Al.

GARNET.

Isometric. The dodecahedron and trapezohedron, *n* (211), the common simple forms; also these in combination, or with the hexoctahedron *s* (321). Cubic and octahedral faces rare. Often in irregular embedded grains. Also

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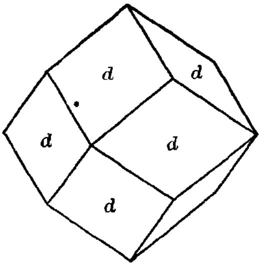

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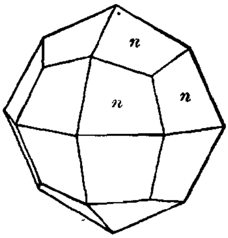

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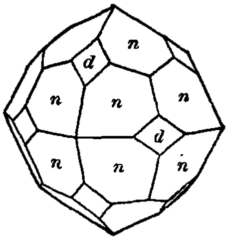

massive; granular, coarse or fine, and sometimes friable; lamellar, lamellæ thick and bent. Sometimes compact, cryptocrystalline like nephrite.

Parting: *d* (110) sometimes rather distinct. Fracture subconchoidal to uneven. Brittle, sometimes friable when granular massive; very tough when compact cryptocrystalline. H. = 6·5–7·5. G. = 3·15–4·3, varying with the composition. Luster vitreous to resinous. Color red, brown, yellow, white, apple-green, black; some red and green, colors often bright. Streak white. Transparent to subtranslucent. Often exhibits anomalous double refraction, especially grossularite (also topazolite, etc.), see Art. 429. Refractive index rather high, and varying directly with the composition. The different pure molecules have approximately the following indices.

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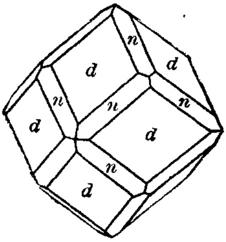

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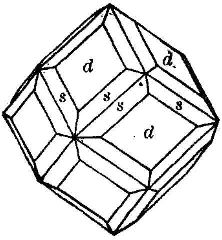

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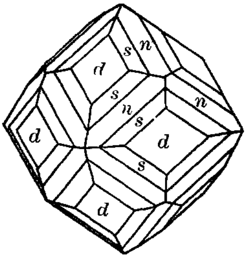


Pyrope 1·705, Grossularite 1·735, Spessartite 1·800, Almandite 1·830, Uvarovite 1·870, Andradite 1·895.

Comp. — An orthosilicate having the general formula $\overset{II}{R}_3\overset{III}{R}_2(SiO_4)_3$, or $3RO.R_2O_3.3SiO_2$. The bivalent element may be calcium, magnesium, ferrous iron or manganese; the trivalent element, aluminium, ferric iron or chromium, rarely titanium; further, silicon is also sometimes replaced by titanium. The different garnet molecules are isomorphous with each other although there are apparently definite limits to their miscibility. The greater majority will be found to have two or three component molecules; in the case, however, where three are present one is commonly in subordinate amount. The index of refraction and specific gravity vary directly with the variation in composition.

Var. — There are three prominent groups, and various subdivisions under each, many of these blending into each other.

I. *Aluminium Garnet,* including			
A.	GROSSULARITE	Calcium-Aluminium Garnet	$Ca_3Al_2(SiO_4)_3$
B.	PYROPE	Magnesium-Aluminium Garnet	$Mg_3Al_2(SiO_4)_3$
C.	ALMANDITE	Iron-Aluminium Garnet	$Fe_3Al_2(SiO_4)_3$
D.	SPESSARTITE	Manganese-Aluminium Garnet	$Mn_3Al_2(SiO_4)_3$
II. *Iron Garnet,* including			
E.	ANDRADITE	Calcium-Iron Garnet	$Ca_3Fe_2(SiO_4)_3$
	(1) Ordinary.	(2) Magnesian. (3) Titaniferous.	(4) Yttriferous.
III. *Chromium Garnet.*			
F.	UVAROVITE	Calcium-Chromium Garnet	$Ca_3Cr_2(SiO_4)_3$

The name Garnet is from the Latin *granatus,* meaning *like a grain,* and directly from *pomegranate,* the seeds of which are small, numerous, and red, in allusion to the aspect of the crystals.

A. Grossularite. Essonite or Hessonite. Cinnamon-stone. *Calcium-aluminium Garnet.* Formula $3CaO.Al_2O_3.3SiO_2$ = Silica 40·0, alumina 22·7, lime 37·3 = 100. Often containing ferrous iron replacing the calcium, and ferric iron replacing aluminium, and hence graduating toward groups C and E. G. = 3·53. Color (*a*) colorless to white; (*b*) pale green; (*c*) amber- and honey-yellow; (*d*) wine-yellow, brownish yellow, cinnamon-brown; (*e*) rose-red; rarely (*f*) emerald-green from the presence of chromium. Often shows optical anomalies (Art. 429).

The original *grossularite* (*wiluite* in part) included the pale green from Siberia, and was so named from the botanical name for the gooseberry; G. = 3·42–3·72. *Cinnamon-stone*, or *essonite* (more properly *hessonite*), included a cinnamon-colored variety from Ceylon, there called *hyacinth;* but under this name the yellow and yellowish red kinds are usually included; named from *ἥσσων*, *inferior*, because of less hardness than the true hyacinth which it resembles. *Succinite* is an amber-colored kind from the Ala valley, Piedmont, Italy. *Romanzovite* is brown.

Pale green, yellowish, and yellow-brown garnets are not invariably grossularite; some (including topazolite, demantoid, etc.) belong to the group of Calcium-Iron Garnet, or Andradite.

B. Pyrope. Precious garnet in part. *Magnesium-aluminium Garnet.* Formula $3MgO.Al_2O_3.3SiO_2$ = Silica 44·8, alumina 25·4, magnesia 29·8 = 100. Magnesia predominates, but calcium and iron are also present; the original pyrope also contained chromium. G. = 3·51. Color deep red to nearly black. Often perfectly transparent and then prized as a gem. The name *pyrope* is from *πυρωπός*, *fire-like.*

Rhodolite, of delicate shades of pale rose-red and purple, brilliant by reflected light, corresponds in composition to two parts of pyrope and one of almandite; from Macon Co., N. C.

C. Almandite. Almandine. Precious garnet in part. Common garnet in part. *Iron-aluminium Garnet.* Formula $3FeO.Al_2O_3.3SiO_2$ = Silica 36·2, 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, cf. rhodolite above. G. = 4·25. Color fine deep red, transparent, in *precious garnet;* brownish red, translucent or subtranslucent, in *common garnet;* black. Part of common garnet belongs to *Andradite.*

The Alabandic carbuncles of Pliny were so called because cut and polished at Alabanda. Hence the name almandine or almandite, now in use.

D. Spessartite. Spessartine. *Manganese-aluminium Garnet.* Formula $3MnO.Al_2O_3.3SiO_2$ = Silica 36·4, alumina 20·6, manganese protoxide 43·0 = 100. Ferrous iron replaces the manganese to a greater or less extent, and ferric iron also the aluminium. G. = 4·18. Color dark hyacinth-red, sometimes with a tinge of violet, to brownish red.

E. Andradite. Common Garnet, Black Garnet, etc. *Calcium-iron Garnet.* Formula $3CaO.Fe_2O_3.3SiO_2$ = Silica 35·5, iron sesquioxide 31·5, lime 33·0 = 100. Aluminium replaces the ferric iron; ferrous iron, manganese and sometimes magnesium replace the calcium. G. = 3·75. Colors various: wine-, topaz- and greenish yellow, apple-green to emerald-green; brownish red, brownish yellow; grayish green, dark green; brown; grayish black, black.

Named *Andradite* after the Portuguese mineralogist, d'Andrada, who in 1800 described and named one of the included subvarieties, Allochroite. Chemically there are the following varieties:

1. Simple *Calcium-iron Garnet*, in which the protoxides are wholly or almost wholly lime. Includes: (*a*) *Topazolite*, having the color and transparency of topaz, and also sometimes green; crystals often showing a vicinal hexoctahedron. *Demantoid*, a grass-green to emerald-green variety with brilliant diamond-like luster, used as a gem. (*b*) *Colophonite*, a coarse granular kind, brownish yellow to dark reddish brown in color, resinous in luster, and usually with iridescent hues; named after the resin *colophony*. (*c*) *Melanite* (from *μέλας, black*), black, either dull or lustrous; but all black garnet is not here included. *Pyreneite* is grayish black melanite. (*d*) Dark green garnet, not distinguishable from some allochroite, except by chemical trials.

2. *Manganesian Calcium-iron Garnet*. (*a*) *Rothoffite*. The original *allochroite* was a manganesian iron-garnet of brown or reddish brown color, and of fine-grained massive structure. *Rothoffite*, from Långban, Sweden, is similar, yellowish brown to liver-brown. Other common kinds of manganesian iron-garnet are light and dark, dusky green and black, and often in crystals. *Polyadelphite* is a massive brownish yellow kind, from Franklin Furnace, N. J. *Bredbergite*, from Sala, Sweden, contains a large amount of magnesia. (*b*) *Aplome* (properly haplome) has its dodecahedral faces striated parallel to the shorter diagonal, whence Haüy inferred that the fundamental form was the cube; and as this form is simpler than the dodecahedron, he gave it a name derived from ἁπλόος, simple. Color of the original aplome (of unknown locality) dark brown; also found yellowish green and brownish green at Schwarzenberg in Saxony, and on the Lena in Siberia.

3. *Titaniferous*. Contains titanium and probably both TiO_2 and Ti_2O_3; formula hence $3CaO.(Fe,Ti,Al)_2O_3.3(Si,Ti)O_2$. It thus graduates toward schorlomite. Color black.

4. *Yttriferous Calcium-iron Garnet*. Contains yttria in small amount; rare.

F. UVAROVITE. Ouvarovite. Uwarowit. *Calcium-chromium Garnet.* Formula $3CaO.Cr_2O_3.3SiO_2$ = Silica 35·9, chromium sesquioxide 30·6, lime 33·5 = 100. Aluminium takes the place of the chromium in part. H. = 7·5. G. = 3·41–3·52. Color emerald-green.

Pyr. etc. — Most varieties of garnet fuse easily to a light brown or black glass; F. = 3 in almandite, spessartite, and grossularite; 3·5 in andradite and pyrope; but uvarovite, the chrome-garnet, is almost infusible, F. = 6. Andradite and almandite fuse to a magnetic globule. Reactions with the fluxes vary with the bases. Almost all kinds react for iron; strong manganese reaction in spessartite, and less marked in other varieties; a chromium reaction in uvarovite, and in most pyrope. Some varieties are partially decomposed by acids; all except uvarovite after ignition become soluble in hydrochloric acid, and generally yield gelatinous silica on evaporation. Decomposed on fusion with alkaline carbonates.

The density of garnets is largely diminished by fusion. Thus a Greenland garnet fell from 3·90 to 3·05 on fusion, and a Vilui grossularite from 3·63 to 2·95.

Diff. — Characterized by isometric crystallization, usually in isolated crystals, dodecahedrons or trapezohedrons; massive forms rare, then usually granular. Also distinguished by hardness, vitreous luster, and in the common kinds the fusibility. Vesuvianite fuses more easily, zircon and quartz are infusible; the specific gravity is higher than for tourmaline, from which it differs in form; it is much harder than sphalerite.

Micro. — Distinguished in thin sections by its very high relief; lack of cleavage; isotropic character; usually shows a pale pink color; sometimes not readily told from some of the spinels.

Artif. — While members of the garnet group have been formed artificially their synthesis is difficult. Apparently they can be produced only under exact conditions of temperature and pressure that are difficult to reproduce. Natural garnets when fused break down into various other minerals.

Obs. — *Grossularite* is especially characteristic of metamorphosed impure calcareous rocks, whether altered by local igneous or general metamorphic processes; it is thus commonly found in the contact zone of intruded igneous rocks and in the crystalline schists. *Almandite* is characteristic of the mica schists and metamorphic rocks containing alumina and iron; it occurs also in some igneous rocks as the result of later dynamic and metamorphic processes; it forms with the variety of amphibole called smaragdite the rock eclogite. *Pyrope* is especially characteristic of such basic igneous rocks as are formed from magmas containing much magnesia and iron with little or no alkalies, as the peridotites, dunites, etc.; also found in the serpentines formed from these rocks; then often associated with spinel, chromite, etc. *Spessartite* occurs in granitic rocks, in quartzite, in whetstone schists (Belgium); it has been noted with topaz in lithophyses in rhyolite (Colorado). The black variety of andradite, *melanite*, is common in eruptive rocks, especially with nephelite, leucite, thus in phonolites, leucitophyres, nephelinites: in such cases often titaniferous or associated with a titaniferous garnet, sometimes in zonal intergrowth; it also occurs as a product of contact metamorphism. *Demantoid* occurs in serpentine. *Uvarovite* belongs particularly with chromite in serpentine; it occurs also in granular limestone.

Garnet crystals often contain inclusions of foreign matter, but only in part due to alteration; as, vesuvianite, calcite, epidote, quartz (Fig. 486, p. 180); at times the garnet is a mere shell, or perimorph, surrounding a nucleus of another species. A black garnet from Arendal, Norway, contains both calcite and epidote; crystals from Tvedestrand, Norway, are wholly calcite within, there being but a thin crust of garnet. Crystals from East Woodstock, Me., are dodecahedrons with a thin shell of cinnamon-stone enclosing calcite; others from Raymond, Me., show successive layers of garnet and calcite. Many such cases have been noted.

847

Garnets are often altered, thus to chlorite, serpentine; even to limonite. Crystals of pyrope are sometimes surrounded by a chloritic zone (kelyphite of Schrauf) not homogeneous, as shown in Fig. 847.

Among prominent foreign localities of garnets, besides those already mentioned, are the following — GROSSULARITE: Fine *cinnamon-stone* comes from Ceylon; on the Mussa-Alp in the Ala valley in Piedmont, Italy, with clinochlore and diopside; at Zermatt, Switzerland; pale yellow at Auerbach, Germany; brownish (*romanzovite*) at Kimito in Finland; honey-yellow *octahedrons* in Elba; pale greenish from the banks of the Vilui in Siberia, in serpentine with vesuvianite; also from Cziklowa and Orawitza in the Banat, Hungary; with vesuvianite and wollastonite in ejected masses at Vesuvius; in white or colorless crystals in Tellemark, in Norway; also dark brown at Mudgee, New South Wales; dark honey-yellow at Guadalcazar, and clear pink or rose-red dodecahedrons at Xalostoc, Morelos, Mexico, called variously, *landerite, xalostocite* and *rosolite.*

PYROPE: In serpentine (from peridotite) near Meronitz and the valley of Krems, in Bohemia (used as a gem); at Zöblitz in Saxony; in the Vosges Mts.; in the diamond diggings of South Africa ("Cape rubies"). ALMANDITE: Common in granite, gneiss, eclogite, 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 the Zillertal, Tyrol, Austria. Precious garnet comes in fine crystals from Ceylon, Pegu, British India, Brazil, and Greenland. SPESSARTITE: From Aschaffenburg in the Spessart, Bavaria; at St. Marcel, Piedmont, Italy; near Chanteloube, Haute Vienne, France, etc.

ANDRADITE: The beautiful green *demantoid* or "Uralian emerald" occurs in transparent greenish rolled pebbles, also in crystals, in the gold washings of Nizhni-Tagilsk in the Ural Mts.; green crystals occur at Schwarzenberg, Saxony; brown to green at Morawitza and Dognacska, Hungary; emerald-green at Dobschau, Hungary; in the Ala valley, Piedmont, Italy, the yellow to greenish *topazolite. Allochroite,* apple-green and yellowish, occurs at Zermatt, Switzerland; black crystals (*melanite*), also brown, at Vesuvius on Mte. Somma; near Barèges in the Hautes-Pyrénées, France, (*pyreneite*). *Aplome* occurs at Schwarzenberg in Saxony, in brown to black crystals. Other localities are Pfitschtal, Tyrol, Austria; Långban, Sweden; Pitkäranta, Finland; Arendal, Norway. UVAROVITE: Found at Saranovskaya near Bisersk, also in the vicinity of Kyshtymsk, Ural Mts., in chromic iron; at Jordansmühl, Silesia; Pic Posets near Vénasque in the Pyrenees on chromite.

In North America, in Me., beautiful crystals of cinnamon-stone (with vesuvianite) occur at Parsonsfield, Phippsburg, and Rumford, at Raymond. In N. H., at Hanover, small clear crystals in gneiss; at Warren, cinnamon garnets; at Grafton. In Ver., at New Fane, in chlorite slate. In Mass., in gneiss at Brookfield; in fine dark red or nearly black trapezohedral crystals at Russell, sometimes very large. In Conn., trapezohedrons, in mica slate, at Reading and Monroe; dodecahedrons at Southbury and Roxbury; at Haddam, crystals of spessartite. In N. Y., brown crystals at Crown Point, Essex Co.; colophonite as a large vein at Willsboro, Essex Co.; in Middletown, Delaware Co., large brown crystals; a cinnamon variety at Amity. In N. J., at Franklin, black, brown, yellow, red, and green dodecahedral garnets; also near the Franklin Furnace (*polyadelphite*). In Pa., in Chester Co., at Pennsbury, fine dark brown crystals; near Knauertown; at Chester, brown; in Concord, on Green's Creek, resembling pyrope; in Leiperville, red; at Mineral Hill, fine brown; at Avondale quarry, fine hessonite; uvarovite at Woods' chrome mine, Lancaster Co. In Va., beautiful transparent spessartite, used as a gem, at the mica mines at Amelia Court-House. In N. C., fine cinnamon-stone at Bakersville; red garnets in the gold washings of Burke, McDowell, and Alexander counties; *rhodolite* in Macon Co.; also mined near

Morgantown and Warlich, Burke Co., to be used as "emery," and as "garnet-paper." In Ky., fine pyrope in the peridotite of Ellis Co. In Ark., at Magnet Cove, a titaniferous melanite with schorlomite. Large dodecahedral crystals altered to chlorite occur at the Spurr Mt. iron mine, Lake Superior, Mich. In Col., at Nathrop, fine spessartite crystals in lithophyses in rhyolite; in large dodecahedral crystals at Ruby Mt., Salida, Chaffee Co., the exterior altered to chlorite. In Ariz., yellow-green crystals in the Gila cañon; pyrope on the Colorado river in the western part of the territory. N. M., fine pyrope on the Navajo reservation with chrysolite and a chrome-pyroxene. In Cal., green with copper ore, Hope Valley, El Dorado Co.; uvarovite, in crystals on chromite, at New Idria. Fine crystals of a rich red color and an inch or more in diameter occur in the mica schists at Fort Wrangell, mouth of the Stickeen river, in Alaska.

In Canada, at Marmora, dark red; at Grenville, a cinnamon-stone; an emerald-green chrome-garnet, at Orford, Quebec, with millerite and calcite; fine colorless to pale olive-green, or brownish crystals, at Wakefield, Ottawa Co., Quebec, with white pyroxene, honey-yellow vesuvianite, etc., also others bright green carrying chromium; dark red garnet in the townships of Villeneuve (spessartite) and Templeton; at Hull, Quebec.

Use. — The various colored and transparent garnets are used as semiprecious gem stones. At times the mineral is also used as an abrasive.

Schorlomite. Probably analogous to garnet, $3CaO.(Fe,Ti)_2O_3.3(Si,Ti)O_2$. Usually massive, black, with conchoidal fracture and vitreous luster. H. = 7–7·5. G. = 3·81–3·88. From Magnet Cove, Ark.; in nepheline-syenite on Ice River, British Columbia.

Partschinite. $(Mn,Fe)_3Al_2Si_3O_{12}$ like spessartite. In small dull crystals (monoclinic). H. = 6·5–7. G. = 4·006. Color yellowish, reddish. From the auriferous sands of Oláhpian, Transylvania.

Agricolite. Same as for eulytite, $Bi_4Si_3O_{12}$, but monoclinic. In globular or semi-globular forms. From Johanngeorgenstadt, Germany.

Chrysolite Group. R_2SiO_4. Orthorhombic

		mm'''	hh'	
		$110 \wedge 1\bar{1}0$	$011 \wedge 0\bar{1}1$	$a : b : c$
Monticellite	$CaMgSiO_4$	46° 54′	59° 52′	0·4337 : 1 : 0·5758
Forsterite	Mg_2SiO_4	49° 51′	60° 43′	0·4648 : 1 : 0·5857
Chrysolite	$(Mg,Fe)_2SiO_4$	49° 57′	60° 47′	0·4656 : 1 : 0·5865
Hortonolite	$(Fe,Mg,Mn)_2SiO_4$			
Fayalite	Fe_2SiO_4	49° 15′	60° 10′	0·4584 : 1 : 0·5793
Knebelite	$(Fe,Mn)_2SiO_4$			
Tephroite	Mn_2SiO_4	49° 24′	61° 25′	0·4600 : 1 : 0·5939

The CHRYSOLITE GROUP includes a series of orthosilicates of magnesium, calcium, iron and manganese. They all crystallize in the orthorhombic system with but little variation in axial ratio. The prismatic angle is about 50°, and that of the unit brachydome about 60°; corresponding to the latter threefold twins are observed. The type species is chrysolite (or olivine), which contains both magnesium and iron in varying proportions and is hence intermediate between the comparatively rare magnesium and iron silicates.

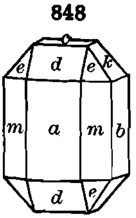
In form, the species of the Chrysolite Group, R_2SiO_4, are closely related in angle to Chrysoberyl, $BeAl_2O_4$; also somewhat less closely to the species of the Diaspore Group, $H_2Al_2O_4$, etc. There is also an interesting relation between the chrysolites and the humites (see p. 535).

CHRYSOLITE. Olivine. Peridot.

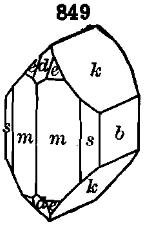
Orthorhombic. Axes $a : b : c = 0{\cdot}46575 : 1 : 0{\cdot}5865$.

mm''', $110 \wedge 1\bar{1}0 = 49° 57'$.
ss', $120 \wedge \bar{1}20 = 94° 4'$.
dd', $101 \wedge \bar{1}01 = 103° 6'$.
kk, $021 \wedge 0\bar{2}1 = 99° 6'$.
ee''', $111 \wedge 1\bar{1}1 = 40° 5'$.
ff''', $121 \wedge 1\bar{2}1 = 72° 13'$.

848



849



Twins rare: tw. pl. h (011) with angle between basal planes of the two individuals = 60° 47′, penetration-twins, sometimes repeated; tw. pl. w (012), the vertical axes crossing at an angle of about 30°. Crystals often flattened || a (100) or b (010), less commonly elongated || c axis. Massive, compact, or granular; in embedded grains.

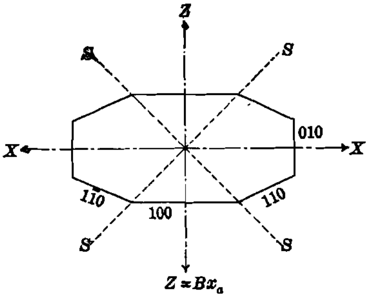
Cleavage: b (010) rather distinct; a (100) less so. Fracture conchoidal. Brittle. H. = 6·5–7. G. = 3·27–3·37, increasing with the amount of iron; 3·57 for hyalosiderite (30 p. c. FeO). Luster vitreous. Color green — commonly olive-green, sometimes brownish, grayish red, grayish green, becoming yellowish brown or red by oxidation of the iron. Streak usually uncolored, rarely yellowish. Transparent to translucent. Optically +. Ax. pl. || c (001), Bx ⊥ a (100). Dispersion $\rho < v$, weak. Axial angle large. $\alpha = 1{\cdot}662$. $\beta = 1{\cdot}680$. $\gamma = 1{\cdot}699$.

Var. — *Precious.* — Of a pale yellowish green color, and transparent. G. = 3·441, 3·351. Occasionally seen in masses as large as "a turkey's egg," but usually much smaller. It has long been brought from the Levant for jewelry, but the exact locality is not known.

Common; Olivine. — Dark yellowish green to olive- or bottle-green. G. = 3·26–3·40. Disseminated in crystals or grains in basic igneous rocks, basalt and basaltic lavas, etc. *Hyalosiderite* is a highly ferruginous variety.

Comp. — $(Mg,Fe)_2SiO_4$ or $2(Mg,Fe)O.SiO_2$. The ratio of Mg : Fe varies widely, from 16 : 1, 12 : 1, etc., to 2 : 1 in hyalosiderite, and hence passing from forsterite on the one side to fayalite on the other. No sharp line can be drawn on either side. Titanium dioxide is sometimes present replacing silica; also tin and nickel in minute quantities.

850



Pyr., etc. — B. B. whitens, but is infusible in most cases; hyalosiderite and other varieties rich in iron fuse to a black magnetic globule; some kinds turn red upon heating. With the fluxes gives reactions for iron. Some varieties give reactions for titanium and manganese. Soluble in hydrochloric acid and yields gelatinous silica upon evaporation.

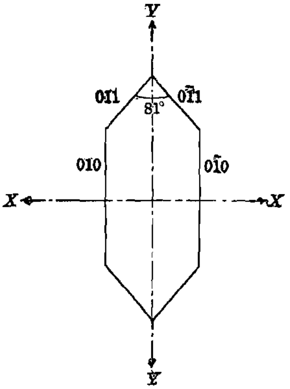
Diff. — Characterized by its infusibility, the yellow-green color, granular form and cleavage (quartz has none).

Micro. — Recognized in thin sections by its high relief; lack of color; its few but marked rough cleavage-cracks; high interference-colors, which are usually the brilliant and pronounced tones of the second order; parallel extinction; biaxial character; characteristic outlines (usually with acute terminations) when in distinct crystals (Figs. 850–852), its frequent association with iron ore and augite, and its very common alteration, in a greater or less degree, to serpentine, the first stages being marked by the separation of iron-ore grains along the lines of fracture (Fig. 853).

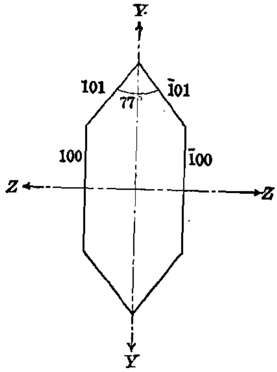
Artif. — The different members of the Chrysolite Group have been easily synthesized in various ways. They are often observed in slags.

Obs. — Chrysolite (olivine) has two distinct methods of occurrence: (*a*) in igneous rocks, as peridotite, norite, basalt, diabase and gabbro, formed by the crystallization of magmas low in silica and rich in magnesia; from an accessory component in such rocks the olivine may increase in amount until it is the main rock constituent as in the dunites; also (*b*) as the product of metamorphism of certain sedimentary rocks containing magnesia and silica, as in impure dolomites. In the dunites and peridotites of igneous origin the chrysolite is commonly associated with chromite, spinel, pyrope, etc., which are valuable indications also of the origin of serpentines derived from olivine. In the metamorphic rocks the above are wanting, and carbonates, as dolomite, breunnerite, magnesite, etc., are the common associations; chrysolitic rocks of this latter kind may also occur altered to serpentine.

851



852



853

Chrysolite also occurs in grains, rarely crystals, embedded in some meteoric irons. Also present in meteoric stones, frequently in spherical forms, or chondrules, sometimes made up of a multitude of grains with like (or unlike) optical orientation enclosing glass between.

Among the more prominent localities are: Vesuvius in lava and on Monte Somma in ejected masses, with augite, mica, etc. In Germany observed in the so called sanidine bombs at the Laacher See; at Forstberg near Mayen in the Eifel and forming the mass of "olivine bombs" in the Dreiser Weiher near Daun in the same region; at Sasbach in the Kaiserstuhl, Baden (*hyalosiderite*). In crystals of gem-quality from Egypt. In Sweden, with ore-deposits, as at Långban, Pajsberg, Persberg, etc. In serpentine at Snarum, Norway, in large crystals, themselves altered to the same mineral. Common in the volcanic rocks of Sicily, the Hawaiian Islands, the Azores, etc.

In the United States, in Thetford and Norwich, Ver., in boulders of coarsely crystallized basalt, the crystals or masses several inches through. In olivine-gabbro of Waterville, in the White Mts., N. H.; at Webster, in Jackson Co., N. C., with serpentine and chromite; with chromite in Loudon Co., Va.; in Lancaster Co., Pa. In small clear olive-green grains with garnet at some points in Ariz. and N. M. In basalt in Canada, near Montreal, at Rougemont and Mounts Royal and Montarville, and in eruptive rocks at other points.

Alteration of chrysolite often takes place through the oxidation of the iron; the mineral becomes brownish or reddish brown and iridescent. The process may end in leaving the cavity of the crystal filled with limonite or red oxide of iron. A very common kind of alteration is to the hydrous magnesium silicate, serpentine, with the partial removal of the iron or its separation in the form of grains of magnetite, also as iron sesquioxide; this change has often taken place on a large scale. See further under serpentine, p. 573.

Chrysolite is named from χρυσός, *gold*, and λίθος. The hyalosiderite, from ὕαλος, *glass*, and σίδηρος, *iron*. The *chrysolithus* of Pliny was probably our topaz; and his *topaz* our *chrysolite*.

Use. — The clear, fine green varieties are used as a gem stone; usually called *peridot*.

IDDINGSITE. From the rock carmeloite of Carmelo Bay, Cal.; a silicate resembling an altered chrysolite, exact composition undetermined. Has been noted as a pseudomorph after chrysolite in a basalt from the Mittelgebirge, Bohemia. Orthorhombic, foliated and cleavable. G. = 2·839. Color brown.

The axial ratios of the other members of the Chrysolite Group are given in the table on p. 510. The species are briefly characterized as follows:

Monticellite. $CaMgSiO_4$. Occurs in colorless to gray crystals on Mte. Somma, Vesuvius; in masses (*batrachite*) on Mt. Monzoni, Tyrol, Italy; in crystals or grains in limestone at Magnet Cove, Ark. G. = 3·03–3·25. Optically −. Indices, 1·651–1·668.

Glaucochroite. $CaMnSiO_4$. In embedded prismatic crystals. Crystal constants and optical properties near those of Chrysolite Group. Color, delicate bluish green. Found at Franklin Furnace, N. J. H. = 6. G. = 3·4.

Forsterite. Mg_2SiO_4. Occurs in white crystals at Vesuvius; in greenish or yellowish embedded grains at Bolton, Mass. (*boltonite*). G. = 3·21–3·33. Optically +. β = 1·659.

Hortonolite. $(Fe,Mg,Mn)_2SiO_4$. In rough dark-colored crystals or masses. Occurs at the iron mine of Monroe, Orange Co., N. Y.; Iron Mine Hill, Cumberland, R. I. G. = 3·91. Optically −. Indices, 1·768–1·803.

Fayalite. Fe_2SiO_4. From the Mourne Mts., Ireland; the Azores; the Yellowstone Park; Rockport, Mass., etc. From Cuddia Mida, Island of Pantelleria, Italy. Crystals and massive, brown to black on exposure. G. = 4·1 Optically −. Indices, 1·824–1·874. *Manganfayalite* is a manganese variety found at Södermanland, Sweden.

Knebelite. $(Fe,Mn)_2SiO_4$. From Dannemora, and elsewhere in Sweden. G. = 4·1.

Tephroite. Mn_2SiO_4; also with zinc, in the variety *roepperite*. From Sterling Hill and Franklin Furnace, N. J.; also from Sweden; from Benderneer, New South Wales. Color flesh-red to ash-gray. G. = 4·1. Optically −. Index about 1·80.

Phenacite Group. R_2SiO_4. Tri-rhombohedral.

		rr'	c
Willemite	Zn_2SiO_4	64° 30′	0·6775
Troostite	$(Zn,Mn)_2SiO_4$		
Phenacite	Be_2SiO_4	63° 24′	0·6611

The Phenacite Group includes the above orthosilicates of zinc (manganese) and beryllium. Both belong to the tri-rhombohedral class of the trigonal division of the hexagonal system, and have nearly the same rhombohedral angle. The rare species trimerite, $MnSiO_4.BeSiO_4$, which is pseudohexagonal (triclinic) is probably to be regarded as connecting this group with the preceding Chrysolite Group.

The following rare species are related:

			rr'	c
Dioptase	H_2CuSiO_4	Tri-rhombohedral	54° 5′	0·5342
Friedelite	$H_7(MnCl)Mn_4(SiO_4)_4$		56° 17′	0·5624
Pyrosmalite	$H_7((Fe,Mn)Cl)(Fe,Mn)_4(SiO_4)_4$		53° 49′	0·5308

These species are very near to each other in form, as shown in the above axial ratios; they further approximate to the species of the Phenacite Group proper. They are also closely related among themselves in composition, since they are all acid orthosilicates, and have the general formula H_2RSiC_4 = $H_8R_4(SiO_4)_4$, where (*e.g.* for Friedelite) in the latter form the place of one hydrogen atom is taken by the univalent radical (MnCl).

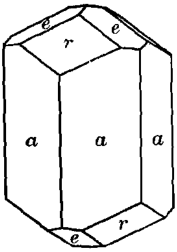
WILLEMITE.

Tri-rhombohedral. Axis c = 0·6775; rr' (1011) $\wedge$ ($\bar{1}$101) = 64° 30′; ee' (01$\bar{1}$2) $\wedge$ ($\bar{1}$012) = 36° 47′.

In hexagonal prisms, sometimes long and slender, again short and stout; rarely showing subordinate faces distributed according to the phenacite type. Also massive and in disseminated grains; fibrous.

Cleavage: c (0001) easy, Moresnet; difficult, N. J.; a (11$\bar{2}$0) easy, N. J. Fracture conchoidal to uneven. Brittle. H. = 5·5. G. = 3·89–4·18. Luster vitreo-resinous, rather weak. Color white or greenish yellow, when purest; apple-green, flesh-red, grayish white, yellowish brown· often dark brown when impure. Streak uncolored. Transparent to opaque. Optically +. $\omega = 1{\cdot}693$. $\epsilon = 1{\cdot}712$.

854



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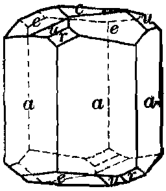

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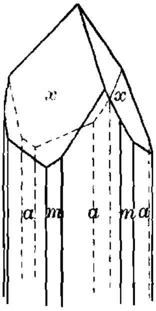

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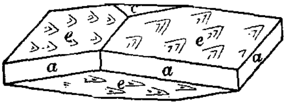


Colorado

Figs. 854–857, New Jersey. e $(01\bar{1}2)$, s $(11\bar{2}3)$, u $(2\bar{1}\bar{1}3)$, x $(3\bar{1}\bar{2}1)$.

Comp. — Zinc orthosilicate, Zn_2SiO_4 or $2ZnO.SiO_2$ = Silica 27·0, zinc oxide 73·0 = 100. Manganese often replaces a considerable part of the zinc (in *troostite*), and iron is also present in small amount.

Pyr., etc. — B.B. in the forceps glows and fuses with difficulty to a white enamel; the varieties from New Jersey fuse from 3·5 to 4. The powdered mineral on charcoal in R.F. gives a coating, yellow while hot and white on cooling, which, moistened with solution of cobalt, and treated in O.F., is colored bright green. With soda the coating is more readily obtained. Soluble in hydrochloric acid and yields gelatinous silica upon evaporation.

Obs. — From Altenberg near Moresnet, Belgium; at Stolberg, near Aix-la-Chapelle. From Musartut, Greenland; Mindouli, French Congo; Kristiania, Norway. In N. J. at Mine Hill, Franklin Furnace, and at Sterling Hill, two miles distant. Occurs with zincite and franklinite, varying in color from white to pale honey-yellow and light green to dark ash-gray and flesh-red; sometimes in large reddish crystals (*troostite*). Rare at the Merritt mine, Socorro Co., N. M.; also at the Sedalia mine, Salida, Col. Named by Lévy after William I., King of the Netherlands.

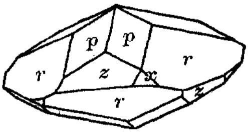
Use. — An ore of zinc.

PHENACITE.

Tri-rhombohedral. Axis $c = 0{\cdot}6611$; rr' $(10\bar{1}1) \wedge (\bar{1}101) = 63° 24'$.

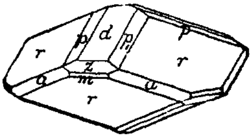
Crystals commonly rhombohedral in habit, often lenticular in form, the prisms wanting; also prismatic, sometimes terminated by the rhombohedron of the third series, x (see further, pp. 110–112).

858



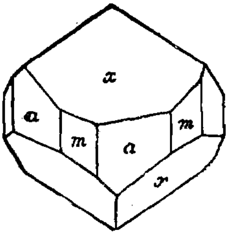
Miask.

859



Florissant, Col.

860



Mt. Antero, Col., Pfd.

Cleavage: *a* (11$\bar{2}$0) distinct; *r* (10$\bar{1}$1) imperfect. Fracture conchoidal. Brittle. H. = 7·5–8. G. = 2·97–3·00. Luster vitreous. Colorless; also bright wine-yellow, pale rose-red; brown. Transparent to subtranslucent. Optically +. ω = 1·6540; ϵ = 1·6697.

Comp. — Beryllium orthosilicate, Be_2SiO_4 or $2BeO.SiO_2$ = Silica 54·45, glucina 45·55 = 100.

Pyr., etc. — Alone remains unaltered; with borax fuses with extreme slowness, unless pulverized, to a transparent glass. With soda affords a white enamel; with more, intumesces and becomes infusible. Dull blue with cobalt solution.

Obs. — Occurs at the emerald and chrysoberyl mine of Takovaya, 85 versts east of Ekaterinburg, Ural Mts.; also in the Ilmen Mts., near Miask, Russia; near Framont in the Vosges Mts.; Kragerö, Norway; at the Cerro del Mercado, Durango, Mexico; crystals from San Miguel di Piracicaba, Minas Geraes, Brazil.

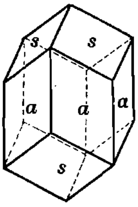
In Col., on amazon-stone, at Topaz Butte, near Florissant, 16 miles from Pike's Peak; also on quartz and beryl at Mt. Antero, Chaffee county. Occurs at Chatham, N. H. Named from φέναξ, *a deceiver*, in allusion to its having been mistaken for quartz.

Trimerite. $(Mn,Ca)_2SiO_4.Be_2SiO_4$. In thick tabular prismatic crystals, pseudohexagonal (triclinic) in form and angle. H. = 6–7. G. = 3·474. Color salmon-pink to nearly colorless in small crystals. Optically −. Indices, 1·715–1·725. From the Harstig mine, Wermland, Sweden.

Dioptase. H_2CuSiO_4 or $H_2O.CuO.SiO_2$. Commonly in prismatic crystals (*ss'* 0$\bar{2}$21 ∧ $\bar{2}$021 = 84° 33½'). Also in crystalline aggregates; massive. Cleavage: *r* (10$\bar{1}$1) perfect. Fracture conchoidal to uneven. H. = 5. G. = 3·28–3·35. Luster vitreous. Color emerald-green. Optically +. ω = 1·654. ϵ = 1·707.

Occurs in druses of well-defined crystals on quartz, occupying seams in a compact limestone west of the hill of Altyn-Tübe in the Kirghiz Steppe, Russia; in the gold washings at several points in Siberia; at Rezbánya, Hungary. From Copiapo, Chile, on quartz with other copper ores. In fine crystals at the Mine Mindouli, two leagues east of Comba, in the French Congo State. Also at the copper mines of Clifton, Graham Co., and from Metcalfe and near Florence, Ariz.

861



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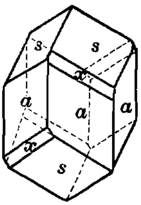


Planchéite. $H_2Cu_7(Cu.OH)_8(SiO_3)_{12}$. Fibrous, often mammillary. Blue color. G. = 3·4. Found associated with dioptase, etc., at Mindouli, French Congo.

Friedelite. $H_7(MnCl)Mn_4Si_4O_{16}$. Crystals commonly tabular ‖ *c* (0001); also massive, cleavable to closely compact. H. = 4–5. G. = 3·07. Color rose-red. From the manganese mine of Adervielle, vallée du Louron, Hautes Pyrénées, France; from Sjö mine, Wermland, Sweden; from Franklin Furnace, N. J.

Pyrosmalite. $H_7((Fe,Mn)Cl)(Fe,Mn)_4Si_4O_{16}$. Crystals thick hexagonal prisms or tabular; also massive, foliated. H. = 4–4·5. G. = 3·06–3·19. Color blackish green to pale liver-brown or gray. Index about 1·66. From the iron mines of Nordmark in Wermland and at Dannemora, Sweden.

Scapolite Group. Tetragonal-pyramidal

Meionite	*c* = 0·4393	**Mizzonite,** Dipyre	*c* = 0·4424
Wernerite	*c* = 0·4384	**Marialite**	*c* = 0·4417

The species of the SCAPOLITE GROUP crystallize in the pyramidal class of the tetragonal system with nearly the same axial ratio. They are white or grayish white in color, except when impure, and then rarely of dark color.

Hardness = 5–6·5; G. = 2·5–2·8. In composition they are silicates of aluminium with calcium and sodium in varying amounts; chlorine is also often present, sometimes only in traces. Iron, magnesia, potash are not present unless by reason of inclusions or of alteration. Carbon dioxide and sulphur trioxide have been noted in certain analyses. It has been suggested that these radicals enter into the composition in the same manner as the chlorine.

The Scapolites are 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. Tschermak has shown that the variation in composition may be explained by the assumption of two fundamental end compounds, viz.:

Meionite	$Ca_4Al_6Si_6O_{25}$	Me
Marialite	$Na_4Al_3Si_9O_{24}Cl$	Ma

By the isomorphous combination of these compounds the composition of the species mentioned above may be explained; no sharp line can, however, be drawn between them.

Optically the series is characterized by the decrease in the strength of the double refraction in passing from meionite to marialite. Thus (Lacroix) for meionite $\omega - \epsilon = 0·036$; for typical wernerite 0·03–0·02; for dipyre 0·015.

The tetragonal species melilite and gehlenite are near the Scapolites in angle. The more common vesuvianite is also related.

MEIONITE.

Tetragonal. Axis $c = 0·43925$. In prismatic crystals (Fig. 201, p. 86), either clear and glassy or milky white; also in crystalline grains and massive. Cleavage: *a* (100) rather perfect, *m* (110) somewhat less so. Fracture conchoidal. Brittle. H. = 5·5–6 G. = 2·70–2·74. Luster vitreous. Colorless to white. Transparent to translucent; often cracked within. Optically –. $\omega = 1·597$; $\epsilon = 1·560$.

Comp. — $Ca_4Al_6Si_6O_{25}$ or $4CaO.3Al_2O_3.6SiO_2$ = Silica 40·5, alumina 34·4, lime 25·1 = 100.

The varieties included here range from nearly pure meionite to those consisting of meionite and marialite in the ratio of 3 : 1, *i.e.*, Me : Ma = 3 : 1. No sharp line can be drawn between meionite and the following species.

Obs. — Occurs in small crystals in cavities, usually in limestone blocks, on Monte Somma, Vesuvius. Also in ejected masses at the Laacher See, Germany. A mineral in an amphibole-gneiss from the Black Forest, Germany, which is like meionite except for a basal cleavage has been called *pseudomeionite*.

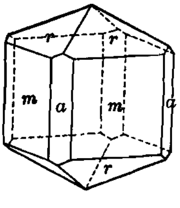
WERNERITE. COMMON SCAPOLITE.

Tetragonal-pyramidal. Axis $c = 0·4384$.

Crystals prismatic, usually coarse, with uneven faces and often large. The symmetry of the pyramidal class sometimes shown in the development of the faces *z* (311) and z_1 (131). Also massive, granular, or with a faint fibrous appearance; sometimes columnar.

ee′, 101 ∧ 011 = 32° 59′.
rr′, 111 ∧ $\bar{1}11$ = 43° 45′.
mr, 110 ∧ 111 = 58° 12′.
zz‴, 311 ∧ 311 = 29° 43′.

863



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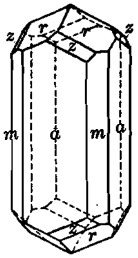


Cleavage: *a* (100) and *m* (110) rather distinct, but interrupted. Fracture subconchoidal. Brittle. H. = 5–6. G. = 2·66–2·73. Luster vitreous to pearly externally, inclining to resinous; cleavage and cross-fracture surface vitreous. Color white, gray, bluish, greenish, and reddish, usually light; streak uncolored. Transparent to faintly subtranslucent. Optically –. $\omega = 1{\cdot}570$. $\epsilon = 1{\cdot}549$.

Comp. — 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 also increase. Scapolites with silica from 54 p. c. to 60 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:

Me : Ma 3 : 1 SiO_2 46·10 Al_2O_3 30·48 CaO 19·10 Na_2O 3·54 Cl 1·01 = 100·23

Pyr., etc. — B.B. fuses easily with intumescence to a white blebby glass giving a strong sodium flame color. Imperfectly decomposed by hydrochloric acid.

Diff. — Characterized by its square form and prismatic cleavage (90°); resembles feldspar when massive, but has a characteristic fibrous appearance on the cleavage surface; it is also more fusible, and has a higher specific gravity; also distinguished by fusibility with intumescence from pyroxene (which see, p. 478).

Micro. — Recognized in thin sections by its low refraction; lack of color; rather high interference-colors reaching the yellows and reds of the first order, sections showing which extinguish parallel to the cleavage; by the distinct negative axial cross of basal sections which show the cleavage-cracks crossing at right angles.

Obs. — Occurs in metamorphic rocks, crystalline schists, gneisses, amphibolites and most abundantly in granular limestone near its junction with the associated granitic or allied rocks; sometimes in beds of magnetite accompanying limestone. It is often associated with a light-colored pyroxene, amphibole, garnet, and also with apatite, titanite, zircon; amphibole is a less common associate than pyroxene, but in some cases has resulted from the alteration of pyroxene. Scapolite has been shown also to be frequently a component of basic igneous rocks, especially those rich in plagioclases containing much lime; it is regarded as a secondary product through a certain kind of alteration. The scapolites are easily altered; pseudormorphs of mica, more rarely other minerals, are common.

Prominent localities are at Pargas, Finland, where it occurs in limestone; Arendal in Norway, and Malsjö in Wermland, Sweden, where it occurs with magnetite in limestone. *Passauite* is from Obernzell, near Passau, in Bavaria. The pale blue or gray scapolite from Lake Baikal, Siberia, is called *glaucolite*. In the United States, occurs in Ver., at Marlborough, massive. In Mass., at Bolton; at Chelmsford. In N. Y. in Orange Co., Essex Co., Lewis Co.; Grasse Lake, Jefferson Co.; at Gouverneur, in limestone. In N. J., at Franklin and Newton. In Pa., at the Elizabeth mine, French Creek, Chester Co.

In Canada, at Calumet Island, massive; at Grenville; Templeton; Wakefield, Ottawa Co.; at Bedford and Bathurst, Ont : Scapolite rocks occur at several points.

Mizzonite. Dipyre. Here are included scapolites with 54 to 57 p. c. SiO_2, corresponding to a molecular combination from Me : Ma = 1 : 2 to Me : Ma = 1 : 3. *Mizzonite* occurs in clear crystals in ejected masses on Mte. Somma, Vesuvius.

Dipyre occurs in elongated square prisms, often slender, sometimes large and coarse, in limestone and crystalline schists, chiefly from the Pyrenees; also in diorite at Bamle, Norway; Saint-Nazaire, France; Algeria. *Couseranite* from the Pyrenees is a more or less altered form of dipyre.

Marialite. Theoretically $Na_4Al_3Si_9O_{24}Cl$, see p. 516. Indices, 1·541–1·554. The actual mineral corresponds to Me : Ma = 1 : 4. It occurs in a basalt tuff, at Pianura, near Naples.

Sarcolite. $(Ca,Na_2)_3Al_2(SiO_4)_3$. In small tetragonal crystals. H. = 6. G. = 2·545–2·932. Color flesh-red. Indices, 1·640–1·656. From Monte Somma, Vesuvius.

MELILITE.

Tetragonal. Axis $c = 0·4548$. Usually in short square prisms (a (100)) or octagonal prisms (a, m (110)), also in tetragonal tables.

Cleavage: c (001) distinct; a (100) indistinct. Fracture conchoidal to uneven. Brittle. H. = 5. G. = 2·9–3·10. Luster vitreous, inclining to resinous. Color white, pale yellow, greenish, reddish, brown. Pleochroism distinct in yellow varieties. Sometimes exhibits optical anomalies. Optically −. $\omega = 1·634$. $\epsilon = 1·629$.

Comp. — Perhaps $\overset{II}{R}_{12}\overset{III}{R}_4Si_9O_{36}$ or $Na_2(Ca,Mg)_{11}(Al,Fe)_4(SiO_4)_9$ for melilite. If Ca : Mg = 8 : 3, and Al : Fe = 1 : 1, the percentage composition is: Silica 37·7, alumina 7·1, iron sesquioxide 11·2, lime 31·3, magnesia 8·4, soda 4·3 = 100. Potassium is also present.

The composition of the melilite-gehlenite group can be explained as isomorphous mixtures of the three compounds, *sarcolite*, $3CaO.Al_2O_3.3SiO_2$ or *soda-sarcolite* $3Na_2O.Al_2O_3.3SiO_2$; *åkermanite*, $8CaO.4MgO.9SiO_2$; velardeñite, $2CaO.Al_2O_3.SiO_2$. The last is noted in large amount in gehlenite from the Velardeña mining district, Mexico.

Artif. — Melilite has been formed artificially by fusing together its constituent oxides. It is found in slags and has been produced in various artificial magmas.

Pyr., etc. — B.B. fuses at 3 to a yellowish or greenish glass. With the fluxes reacts for iron. Soluble in hydrochloric acid and yields gelatinous silica upon evaporation.

Micro. — Distinguished in thin sections by its moderate refraction; very low interference-colors, showing often the "*ultra blue*" (Capo di Bove); parallel extinction; negative character; usual development in tables parallel to the base and very common "peg structure" due to parallel rod-like inclusions penetrating the crystal from the basal planes inward: this, however, is not always easily seen.

Obs. — Melilite is a component of certain igneous rocks formed from magmas very low in silica, rather deficient in alkalies, and containing considerable lime and alumina. In such cases melilite appears to crystallize in the place of the more acid plagioclase.

Melilite of yellow and brownish colors is found at Capo di Bove, near Rome, in leucitophyre with nephelite, augite, hornblende; at Vesuvius in dull yellow crystals (*somervillite*); not uncommon in certain basic eruptive rocks, as the *melilite-basalts* of Hochbohl near Owen in Württemberg, of the Swabian Alp, of Görlitz, the Erzgebirge, Germany; also in the nephelite basalts of the Hegau, of Oahu, Hawaiian Islands, etc.; perovskite is a common associate. Occurs as chief constituent of rock on Beaver Creek, Gunnison Co., Col. Common in furnace slags. Melilite is named from μέλι, *honey*, in allusion to the color.

Humboldtilite occurs in cavernous blocks on Monte Somma, Vesuvius, with greenish mica, also apatite, augite; the crystals are often rather large, and covered with a calcareous coating; less common in transparent lustrous crystals with nephelite, sarcolite, etc., in an augitic rock. *Zurlite* is impure humboldtilite. *Deeckeite* is a pseudomorph after *melilite* with the composition $(H,K,Na)_2(Mg,Ca)(Al,Fe)_2(Si_2O_5)_5.9H_2O$, found in a melilite basalt from the Kaiserstuhl, Baden, Germany.

Cebollite. $H_2Ca_5Al_2Si_3O_{16}$. Orthorhombic (?). Fibrous. H. = 5. G. = 2·96. Color white to greenish gray. Indices, 1·59–1·63. Fusible at 5. Soluble in acids. Found as an alteration product of *melilite* near Cebolla Creek, Gunnison Co., Col.

Gehlenite. $Ca_3Al_2Si_2O_{10}$. Crystals usually short square prisms. Axis $c = 0·4001$. G. = 2·9–3·07. Different shades of grayish green to liver-brown. From Mount Monzoni, in the Fassatal, in Tyrol, Austria. From Velardeña mining district, Mexico.

FUGGERITE Corresponds to a member of the gehlenite-åkermanite series, 3 åk : 10 geh. From Monzonite of Monzonital, Tyrol, Austria.

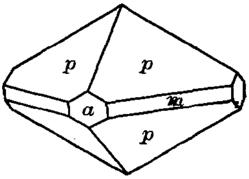
Åkermanite. Tetragonal, isomorphous with melilite and gehlenite. Found in certain slags. See further under Melilite.

VESUVIANITE. Idocrase.

Tetragonal. Axis $c = 0{\cdot}5372$.

ce, 001 ∧ 101 = 28° 15′.
cp, 001 ∧ 111 = 37° 13½′.
ct, 001 ∧ 331 = 66° 18′.
pp′, 111 ∧ $\bar{1}$11 = 50° 39′.
ss^{vii}, 311 ∧ 3$\bar{1}$1 = 31° 38′.

865



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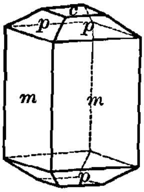

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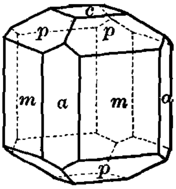

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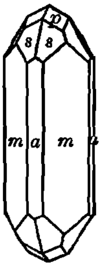

Ala

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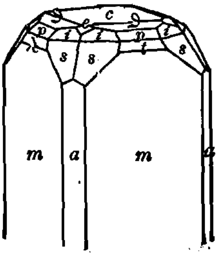
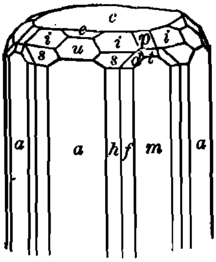


Zermatt

870



Sandford, Me.

Often in crystals, prismatic or pyramidal. Also massive; columnar, straight and divergent, or irregular; granular massive; cryptocrystalline.

Cleavage: *m* (110) not very distinct; *a* (100) and *c* (001) still less so. Fracture subconchoidal to uneven. Brittle. H. = 6·5. G. = 3·35–3·45. Luster vitreous; often inclining to resinous. Color brown to green, and the latter frequently bright and clear; occasionally sulphur-yellow, and also pale blue. Streak white. Subtransparent to faintly subtranslucent. Dichroism not usually strong. Optically −; also + rarely. Birefringence very low. Sometimes abnormally biaxial. Indices variable, from 1·715 to 1·720.

Comp. — A basic calcium-aluminium silicate, but of uncertain formula; perhaps $Ca_6[Al(OH,F)]Al_2(SiO_4)_5$. Ferric iron replaces part of the aluminium and magnesium the calcium. Fluorine and titanium may be present. Another general formula has been proposed, $\overset{I}{R}_4Ca_7Al_2Si_6O_{24}$, in which $\overset{I}{R}_4$ may be $Ca_2,(AlOH)_2,(AlO_2H)_4$, or H_4.

Pyr., etc. — B.B. fuses at 3 with intumescence to a greenish or brownish glass. With the fluxes gives reactions for iron, and some varieties a strong manganese reaction. *Cyprine*, a blue variety, gives a reaction for copper with salt of phosphorus. Partially decomposed by hydrochloric acid, and completely when the mineral has been previously ignited.

Diff. — Characterized by its tetragonal form and easy fusibility. Resembles some brown varieties of garnet, tourmaline, and epidote.

Micro. — Recognized in thin sections by its high refraction producing a very strong relief and its extremely low birefringence; * also in general by its color, pleochroism, and uniaxial negative character; the latter, on account of the low birefringence, being difficult to determine. The low birefringence, however, aids in distinguishing it from epidote, with which at times it may be confounded.

Obs. — Vesuvianite was first found among the ancient ejections of Vesuvius and the dolomitic blocks of Monte Somma, whence its name. It commonly occurs as a contact mineral from the alteration of impure limestones, then usually associated with lime garnet (grossularite), phlogopite, diopside, wollastonite; also epidote; also in serpentine, chlorite schist, gneiss and related rocks.

Prominent localities are Vesuvius; the Albani Mts.; in Switzerland at Zermatt, etc.; the Mussa Alp in the Ala valley, in Piedmont, Italy; Mt. Monzoni in the Fassatal, Austria; at Orawitza and Dognaczka, Hungary; Haslau near Eger in Bohemia (*egeran*); near Jordansmühl, Silesia; on the Vilui river, near Lake Baikal, Siberia (sometimes called *wiluite* or viluite, like the grossular garnet from the same region); Achmatovsk, Ural Mts.; in Norway; at Arendal, "*colophonite*"; at Egg, near Christiansand; at Morelos, Mexico.

In North America, in Me. at Phippsburg and Rumford; at Sandford. In N. H., at Warren with cinnamon-stone. In N. Y., near Amity. In N. J., at Newton. In Lewis and Clark Co., Mon. In Cal. near San Carlos in Inyo Co.; at Crestmore, Riverside Co. In Canada, at Calumet Falls, Litchfield, Pontiac Co.; at Grenville in calcite; at Templeton, Ottawa Co., Quebec. A lavender-colored variety, known as *mangan-vesuvianite* comes from near Black Lake, Quebec.

Californite is a closely compact variety of an olive-green to a grass-green color from Siskiyou, Fresno and Tulare Cos., Cal.

Zircon Group. $\overset{\text{IV}}{R}SiO_4$. Tetragonal

Zircon	$ZrSiO_4$	$c = 0{\cdot}6404$
Thorite	$ThSiO_4$	$c = 0{\cdot}6402$

This group includes the orthosilicates of zirconium and thorium, both alike in tetragonal crystallization, axial ratio and crystalline habit.

These species are sometimes regarded as oxides and then included in the RUTILE GROUP (p. 425), to which they approximate closely in form. A similar form belongs also to the tantalate, Tapiolite, and to the phosphate, Xenotime; further, compound groups consisting of crystals of Xenotime and Zircon in parallel position are not uncommon (Fig. 462, p. 173).

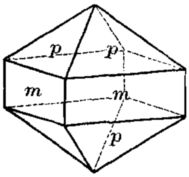
ZIRCON.

Tetragonal. Axis $c = 0{\cdot}64037$.

ee', $101 \wedge \underline{0}11 = 44^\circ\ 50'$
ee'', $101 \wedge \bar{1}01 = 65^\circ\ 16'$.
pp', $111 \wedge \bar{1}11 = 56^\circ\ 40\tfrac{1}{2}'$.
uu', $331 \wedge \bar{3}31 = 83^\circ\ 9'$.

mp $110 \wedge 111 = 47^\circ\ 50'$.
mu, $110 \wedge 3\underline{3}1 = 20^\circ\ 12\tfrac{1}{2}'$.
xx^{vii}, $311 \wedge 3\bar{1}1 = 32^\circ\ 57'$.
ax, $100 \wedge 311 = 31^\circ\ 43'$.

871



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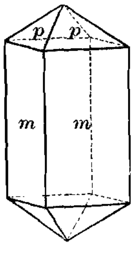

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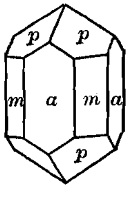

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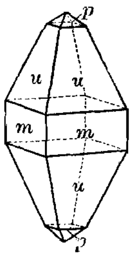

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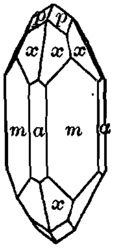
* Frequently minerals, which, like vesuvianite, melilite and zoisite, are doubly refracting but of extremely low birefringence and possibly (where they are positive for one color

Twins: tw. pl. *e* (101), geniculated twins like rutile (Fig. 412, p. 166). Commonly in square prisms, sometimes pyramidal. Also in irregular forms and grains.

875



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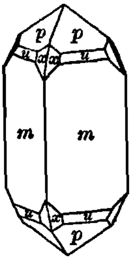

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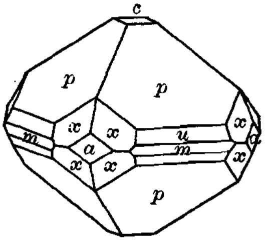

Colorado

Cleavage: *m* (110) imperfect; *p* (111) less distinct. Fracture conchoidal. Brittle. H. = 7·5. G. = 4·68–4·70 most common, but varying widely to 4·2 and 4·86. Luster adamantine. Colorless, pale yellowish, grayish, yellowish green, brownish yellow, reddish brown. Streak uncolored. Transparent to subtranslucent and opaque. Optically +. Birefringence high. $\omega = 1{\cdot}9239$, $\epsilon = 1{\cdot}9682$, Ceylon. Sometimes abnormally biaxial.

Hyacinth is the orange, reddish and brownish transparent kind used for gems. *Jargon* is a name given to the colorless or smoky zircons of Ceylon, in allusion to the fact that while resembling the diamond in luster, they are comparatively worthless; thence came the name *zircon.*

Comp. — $ZrSiO_4$ or $ZrO_2.SiO_2$ = Silica 32·8, zirconia 67·2 = 100. A little iron (Fe_2O_3) is usually present.

Pyr., etc. — Infusible: the colorless varieties are unaltered, the red become colorless, while dark-colored varieties are made white; some varieties glow and increase in density by ignition. Not perceptibly acted upon by salt of phosphorus. In powder decomposed when fused with soda on the platinum wire, and if the product is dissolved in dilute hydrochloric acid it gives the orange color characteristic of zirconia when tested with turmeric paper. Not acted upon by acids except in fine powder with concentrated sulphuric acid. Decomposed by fusion with alkaline carbonates and bisulphates.

Diff. — Characterized by the prevailing square pyramid or square prism; also by its adamantine luster, hardness, high specific gravity, and infusibility; the diamond is optically isotropic.

Micro. — Recognized in thin sections by its very high relief; very high interference-colors, which approach white of the higher order except in very thin sections; positive uniaxial character. It is distinguished from cassiterite and rutile only by its lack of color, and from the latter also in many cases by method of occurrence.

Artif. — Zircon has been prepared artificially by heating zirconium oxide with quartz in gaseous silicon fluoride.

Obs. — A common accessory constituent of igneous rocks, especially those of the more acid feldspathic groups and particularly the kinds derived from magmas containing much soda, as granite, syenite, diorite, etc. It is one of the earliest minerals to crystallize from a cooling magma. Is generally present in minute crystals, but in pegmatitic facies often in large and well-formed crystals. Occurs more rarely elsewhere, as in granular limestone, chloritic and other schists; gneiss; sometimes in iron-ore beds. Crystals are common in most auriferous sands. Sometimes found in volcanic rocks, probably in part as inclusions derived from older rocks.

Zircon in distinct crystals is so common in the pegmatitic forms of the nephelite-syenite

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but negative for another), do not show a gray color between crossed nicols but a curious blue, at times an intense Berlin blue, which is quite distinct from the other blues of the color scale and is known as the "*ultra blue.*"

and augite-syenite of southern Norway (with ægirite, etc.) that this rock there and elsewhere has sometimes been called a "zircon-syenite."

Found in alluvial sands in Ceylon; in the gold regions of the Ural Mts.; in Norway, at Laurvik, at Arendal, in the iron mines, at Fredriksvärn, and in veins in the augite-syenite of the Langesund fiord; Pfitschtal, Tyrol, Austria; in Germany in lava at Niedermendig in the Eifel, red crystals; from Madagascar; from Minas Geraes, Brazil.

In North America, in Me., at Litchfield; in N. Y., in Moriah, Essex Co., cinnamon-red; near the outlet of Two Ponds, Orange Co., with scapolite, pyroxene and titantite; at Warwick, chocolate-brown, near Amity; in St. Lawrence Co., in the town of Hammond; at Rossie, Fine, Pitcairn. In Pa., near Reading. In N. C., abundant in the gold sands of Burke, McDowell, Polk, Rutherford, Henderson, and other counties. In Col., with astrophyllite, etc., in the Pike's Peak region in El Paso Co.; at Cheyenne Mt. In Cal., in auriferous gravels.

In Canada, at Grenville, Argenteuil Co.; in Templeton and adjoining townships in Ottawa Co., Quebec; in Renfrew Co., sometimes very large; in North Burgess, Lanark Co.

Use. — Zircon in its transparent varieties serves frequently as a gem stone; also as a source of zirconium oxide used in the manufacture of the incandescent gas mantles.

Malacon is an altered zircon. *Cyrtolite* is related but contains uranium, yttrium and other rare elements.

Naëgite is apparently zircon with yttrium, niobium-tantalum, thorium, and uranium oxides. Occurs in spheroidal aggregates near Takoyama, Mino, Japan. Color green, gray, brown. H. = 7·5. G. = 4·1.

Thorite. Thorium silicate, $ThSiO_4$, like zircon in form; usually hydrated, black in color, and then with G. = 4·5–5; also orange-yellow and with G. = 5·19–5·40 (*orangite*). From the Brevik region and Arendal, Norway.

Auerlite. Like zircon in form; supposed to be a silico-phosphate of thorium. Henderson Co., N. C.

Danburite-Topaz Group. Orthorhombic. $\overset{\text{II}}{R}\overset{\text{III}}{R}_2(SiO_4)_2$ or $(\overset{\text{III}}{R}O)\overset{\text{III}}{R}SiO_4$

Danburite	$CaB_2(SiO_4)_2$	$a : b : c = 0{\cdot}5444 : 1 : 0{\cdot}4807$
Topaz	$[Al(F,OH)_2]AlSiO_4$	$a : b : c = 0{\cdot}5285 : 1 : 0{\cdot}4770$
Andalusite	$(AlO)AlSiO_4$	$\frac{1}{2}b : a : \frac{2}{3}c = 0{\cdot}5070 : 1 : 0{\cdot}4749$
		or $a : b : c = 0{\cdot}9861 : 1 : 0{\cdot}7025$

Sillimanite	Al_2SiO_5	Orthorhombic	$a : b = 0{\cdot}970 : 1$
Cyanite	Al_2SiO_5	Triclinic	

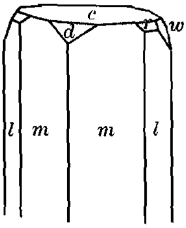
$a : b : c = 0{\cdot}8994 : 1 : 0{\cdot}7090;\ \alpha = 90^\circ\ 5\tfrac{1}{2}',\ \beta = 101^\circ\ 2',\ \gamma = 105^\circ\ 44\tfrac{1}{2}'.$

DANBURITE.

Orthorhombic. Axes $a : b : c = 0{\cdot}5444 : 1 : 0{\cdot}4807$.

mm''', $110 \wedge 1\bar{1}0 = 57^\circ\ 8'$. dd', $101 \wedge \bar{1}01 = 82^\circ\ 53'$.
ll', $120 \wedge \bar{1}20 = 85^\circ\ 8'$. ww', $041 \wedge 0\bar{4}1 = 125^\circ\ 3'$.

878



Habit prismatic, resembling topaz. Also in indistinct embedded crystals, and disseminated masses.

Cleavage: *c* (001) very indistinct. Fracture uneven to subconchoidal. Brittle. H. = 7–7·25. G. = 2·97–3·02. Color pale wine-yellow to colorless, yellowish white, dark wine-yellow, yellowish brown. Luster vitreous to greasy, on crystal surfaces brilliant. Transparent to translucent. Streak white. Optically –. 2V = 88°. $\alpha = 1{\cdot}632$. $\beta = 1{\cdot}634$. $\gamma = 1{\cdot}636$.

Comp. — $CaB_2(SiO_4)_2$ or $CaO.B_2O_3.2SiO_2$ = Silica 48·8, boron trioxide 28·4, lime 22·8 = 100.

Pyr., etc. — B.B. fuses at 3·5 to a colorless glass, and imparts a green color to the O. F. (boron). Not decomposed by hydrochloric acid, but sufficiently attacked for the solution to give the reaction of boric acid with turmeric paper. When previously ignited gelatinizes with hydrochloric acid. Phosphoresces on heating, giving a reddish light.

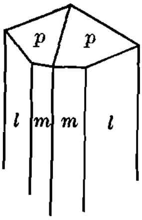
Obs. — Occurs at Danbury, Conn., with microcline and oligoclase in dolomite. At Russell, N. Y., in fine crystals. On the Piz Valatscha, the northern spur of Mt. Skopi south of Dissentis in eastern Switzerland, in slender prismatic crystals and elsewhere in Switzerland. In crystals from Takachio, Hinga, and from Obira, Bungo, Japan. From Mt. Bity and Maharitra, Madagascar.

Barsowite. This doubtful species, occurring with blue corundum in the Ural Mts., is by some authors classed with danburite; composition $CaAl_2Si_2O_8$ like anorthite.

TOPAZ.

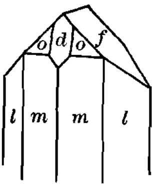
Orthorhombic. Axes $a : b : c = 0·52854 : 1 : 0·47698$.

879



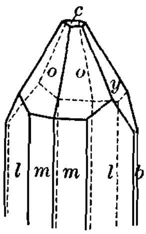
Brazil

880



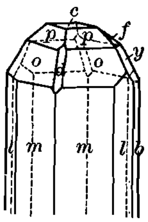
Japan

881



Durango

882



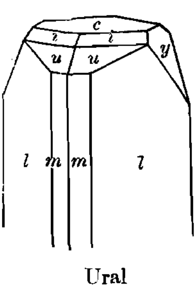
Ural

mm''',	$110 \wedge 1\bar{1}0$	= 55° 43'.	*yy'*,	$041 \wedge 0\bar{4}1$	= 124° 41'.	*uu'*,	$111 \wedge \bar{1}11$	= 78° 20'.
ll,	$120 \wedge \bar{1}20$	= 89° 49'.	*ci*,	$001 \wedge 223$	= 34° 14'.	*uu'''*,	$111 \wedge 1\bar{1}1$	= 39° 0'.
dd',	$201 \wedge \bar{2}01$	= 122° 1'.	*cu*,	$001 \wedge 111$	= 45° 35'.	*oo'*,	$221 \wedge \bar{2}21$	= 105° 7'.
XX',	$043 \wedge 0\bar{4}3$	= 64° 55'.	*co*,	$001 \wedge 221$	= 63° 54'.	*oo'''*	$221 \wedge 2\bar{2}1$	= 49° 37½'.
ff',	$021 \wedge 0\bar{2}1$	= 87° 18'.						

Crystals commonly prismatic, *m* (110) predominating; or *l* (120) and the form then a nearly square prism resembling andalusite. Faces in the prismatic zone often vertically striated, and often showing vicinal planes. Also firm columnar; granular, coarse or fine.

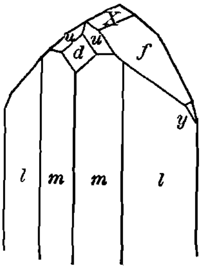
Cleavage: *c* (001) highly perfect. Fracture subconchoidal to uneven. Brittle. H. = 8. G. = 3·4–3·6. Luster vitreous. Color straw-yellow, wine-yellow, white, grayish, greenish, bluish, reddish. Streak uncolored. Transparent to subtranslucent. Optically +. Ax. pl. || *b* (010). Bx ⊥ *c* (001). Axial angles variable. 2V = 49° to 66°. Refractive indices, Brazil:

883



Ural

884



Japan

For D $\alpha = 1·62936$ $\beta = 1·63077$ $\gamma = 1·63747$ ∴ 2V = 49° 31'

Var. — *Ordinary.* In prismatic crystals usually colorless or pale yellow, less often pale blue, pink, etc. The yellow of the Brazilian crystals is changed by heating to a pale rose-pink. Often contains inclusions of liquid CO_2.

Physalite, or *pyrophysalite*, is a coarse nearly opaque variety, from Finbo, Sweden; intumesces when heated, hence its name from φυσαλίς, *bubble*, and πῦρ, *fire*. *Pycnite* has a columnar, very compact structure. Rose made out that the cleavage was the same, and the form probably the same; and Des Cloizeaux showed that the optical characters were those of topaz.

Comp. — $(AlF)_2SiO_4$; usually containing hydroxyl and then $[Al(F,OH)]_2SiO_4$ or as given on p. 522. The former requires Silica 32·6, alumina 55·4, fluorine 20·7 = 108·7, deduct (O = 2F) 8·7 = 100.

Pyr., etc. — B.B. infusible. Fused in the closed tube, with potassium bisulphate gives the characteristic fluorine reactions. With cobalt solution the pulverized mineral gives a fine blue on heating. Only partially attacked by sulphuric acid. A variety of topaz from Brazil, when heated, assumes a pink or red hue, resembling the Balas ruby.

Diff. — Characterized by its prismatic crystals with angles of 56° (124°) or 87° (93°); also by the perfect basal cleavage; hardness; infusibility; yields fluorine B.B.

Artif. — Topaz has been made artificially by heating a mixture of silica and aluminium fluoride and then igniting this mixture in silicon fluoride gas.

Obs. — Topaz occurs especially in the highly acid igneous rocks of the granite family, as granite and rhyolite, in veins and cavities, where it appears to be the result of fumarole action after the crystallization of the magma; sometimes also in the surrounding schists, gneisses, etc., as a result of such action. In these occurrences often accompanied by fluortie, cassiterite, tourmaline. Frequently occurs in tin-bearing pegmatites. Topaz alters aesily into a compact mass of muscovite.

Fine topaz comes from Russia from the Ural Mts., from Alabashka, in the region of Ekaterinburg; from Miask in the Ilmen Mts.; also the gold-washings on the River Sanarka in Govt. Orenburg; in Nerchinsk, beyond Lake Baikal, in the Adun-Chalon Mts., etc.; in the province of Minas Geraes, Brazil, at Ouro Preto and Villa Rica, of deep yellow color; in Germany at the tin mines of Zinnwald and Ehrenfriedersdorf, and smaller crystals at Schneckenstein and Altenberg; sky-blue crystals in Cairngorm, Aberdeenshire, Scotland; the Mourne mountains, Ireland; on the island of Elba. *Physalite* occurs in crystals of great size, at Fossum, Norway; Finbo, Sweden. *Pycnite* is from the tin mine of Altenberg in Saxony; also of Schlackenwald, Zinnwald, etc. Fine crystals occur at Durango, Mexico, with tin ore; at San Luis Potosi in rhyolite. Mt. Bischoff, Tasmania, with tin ores; similarly in New South Wales. In Japan in pegmatite from Otani-yama, Province of Omi, near Kioto.

In the United States, in Me., at Stoneham, in albitic granite. In Conn., at Trumbull, with fluorite; at Willimantic. In N. C., at Crowder's Mountain. In Col., in fine crystals colorless or pale blue from the Pike's Peak region; at Nathrop, Chaffee Co., in wine-colored crystals with spessartite in lithophyses in rhyolite; similarly in the rhyolite of Chalk Mt. In Texas in fine crystals at Streeter. In Utah, in fine transparent colorless crystals with quartz and sanidine in the rhyolite of the Thomas Range, 40 miles north of Sevier Lake. In Col. in Ramona Co.

The name topaz is from *τοπάξιος*, an island in the Red Sea, as stated by Pliny. But the topaz of Pliny was not the true topaz, as it "yielded to the file." Topaz was included by Pliny and earlier writers, as well as by many later, under the name *chrysolite*.

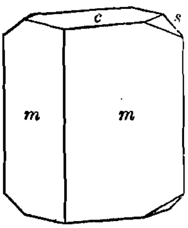
Use. — As a gem stone.

ANDALUSITE.

Orthorhombic. Axes $a : b : c = 0{\cdot}9861 : 1 : 0{\cdot}70245$.

mm''', $110 \wedge 1\bar{1}0 = 89° 12'$.
ss', $011 \wedge 0\bar{1}1 = 70° 10'$.

885



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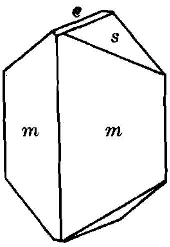
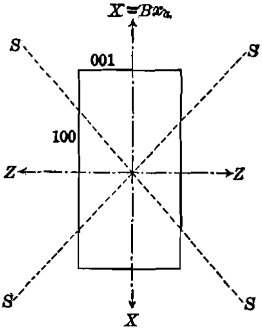


Usually in coarse prismatic forms, the prisms nearly square in form. Massive, imperfectly columnar; sometimes radiated and granular.

Cleavage: *m* (110) distinct, sometimes perfect (Brazil); *a* (100) less perfect; *b* (010) in traces. Fracture uneven, subconchoidal. Brittle. H. = 7·5. G = 3·16–3·20. Luster vitreous; often weak. Color whitish, rose-red, flesh-red, violet, pearl-gray, reddish brown, olive-green.

Streak uncolored. Transparent to opaque, usually subtranslucent. Pleochroism strong in some colored varieties. Absorption strong, $X > Y > Z$. Sections normal to an optic axis are idiophanous or show the polarization-brushes distinctly (p. 288). Optically −. Ax. pl. $\parallel b$ (010). Bx $\perp c$ (001). $2V = 85°$. $\alpha = 1{\cdot}632$. $\beta = 1{\cdot}638$. $\gamma = 1{\cdot}643$.

887



Var. — *Chiastolite*, or *Macle* is a variety in stout crystals having the axis and angles of a different color from the rest, owing to a regular arrangement of carbonaceous impurities through the interior, and hence exhibiting a colored cross, or a tesselated appearance in a transverse section. Fig. 888 shows sections of a crystal. *Viridine* is a green variety containing some iron and manganese from near Darmstadt, Germany.

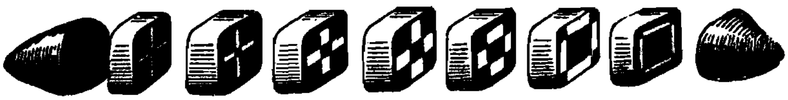
Comp. — $Al_2SiO_5 = (AlO)AlSiO_4$ or $Al_2O_3.SiO_2$ = Silica 36·8, alumina 63·2 = 100. Manganese is sometimes present, as in *manganandalusite.*

Pyr., etc. — B.B. infusible. With cobalt solution gives a blue color after ignition. Not decomposed by acids. Decomposed on fusion with caustic alkalies and alkaline carbonates.

Diff. — Characterized by the nearly square prism, pleochroism, hardness, infusibility; reaction for alumina B.B.

Micro. — Distinguished in thin sections by its high relief; low interference-colors, which are only slightly above those of quartz; negative biaxial character; negative extension of the crystals (diff. from sillimanite); rather distinct prismatic cleavage and the constant parallel extinction (diff. from pyroxenes, which have also greater birefringence); also by its characteristic arrangement of impurities when these are present (Fig. 888). The pleochroism, which is often lacking, is, when present, strong and characteristic.

888



Obs. — Most common in argillaceous schist, or other schists imperfectly crystalline; also in gneiss, mica schist and related rocks; rarely in connection with serpentine. The variety chiastolite is commonly a contact mineral in clay-slates, *e.g.*, adjoining granitic dikes. Sometimes associated with sillimanite with parallel axes.

Found in Spain, in Andalusia; in Austria in the Tyrol, Lisens Alp; in Saxony, at Bräunsdorf; Bavaria, at Wunsiedel, etc. In Brazil, province of Minas Geraes, in fine crystals and as rolled pebbles. Remarkable crystals of chiastolite from Mt. Howden, near Bimbowrie, South Australia.

In North America, in Me., at Standish. N. H., White Mtn. Notch; Mass., at Westford; Lancaster, both varieties; Sterling, chiastolite. Conn., at Litchfield and Washington. Pa., in Delaware Co., near Leiperville, large crystals; Upper Providence.

Named from Andalusia, the first locality noted. The name *macle* is from the Latin *macula*, a spot. Chiastolite is from χιάστος, *arranged diagonally*, and hence from *chi*, the Greek name for the letter X.

Use. — When clear and transparent may serve as a gem stone.

Guarinite. $2(K,Na)_2O.8CaO.5(Al,Fe,Ce)_2O_3.10SiO_2$. Orthorhombic. In minute thin tables, flattened $\parallel b$ (010), nearly tetragonal in form. H. = 6·5. G. = 2·9–3·3. Color sulphur-yellow, honey-yellow. Pleochroic, canary-yellow to colorless. Found in a grayish trachyte on Mte. Somma, Vesuvius. Axial ratio and optical properties agree closely with those of danburite.

SILLIMANITE. Fibrolite.

Orthorhombic. Axes $a : b = 0{\cdot}970 : 1$. mm''' 110 ∧ 110 = 88° 15′, hh' 230 ∧ $\bar{2}30$ = 69°. Prismatic faces striated and rounded. Commonly in long slender crystals not distinctly terminated; often in close parallel groups, passing into fibrous and columnar massive forms; sometimes radiating.

Cleavage: b (010) 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 +. Double refraction strong. Ax. pl. || b (010). Bx ⊥ c (001). Dispersion $\rho > \upsilon$. Axial angle and indices variable. 2V = 20° (approx.). $\alpha = 1{\cdot}638$. $\beta = 1{\cdot}642$. $\gamma = 1{\cdot}653$.

Comp. — $Al_2SiO_5 = (AlO)AlSiO_4$, like andalusite. Silica 36·8, alumina 63·2 = 100.

Sillimanite is the most stable of the three aluminium silicates. Both andalusite and cyanite are converted into sillimanite when strongly heated.

Pyr. — Same as andalusite.

Diff. — Characterized by its fibrous or columnar form; perfect cleavage; infusibility; reaction for alumina.

Micro. — In thin sections recognized by its form, usually with transverse fractures; parallel extinction; high interference-colors.

Artif. — Sillimanite has been made artificially by fusing its oxides together. Both andalusite and cyanite are converted into sillimanite when strongly heated.

Obs. — Often present in the quartz of gneisses and sometimes granites in very slender, minute prisms commonly aggregated together and sometimes intergrown with andalusite; iolite is also a common associate; rarely as a contact mineral; often occurs with corundum.

Observed in many localities, thus near Moldau in Bohemia; at Fassa in Tyrol, Austria (*bucholzite*); in the Carnatic, India, with corundum (*fibrolite*); at Bodenmais, Bavaria; Freiberg, Saxony; in France, near Pontgibaud and other points in Auvergne; forms rolled masses in the diamantiferous sands of Minas Geraes, Brazil.

In the United States, in Mass., at Worcester. In Conn.; near Norwich, with zircon, monazite and corundum; at Willimantic. In N. Y., at Yorktown, Westchester Co.; in Monroe, Orange Co., (*monrolite*). In Pa., at Chester on the Delaware, near Queensbury forge; in Delaware Co.; Del., at Brandywine Springs. With corundum in N. C.

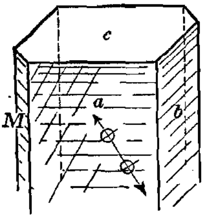
Named *fibrolite* from the fibrous massive variety; *sillimanite*, after Prof. Benjamin Silliman of New Haven (1779–1864).

Bamlite, xenolite, wörthite probably belong to sillimanite; the last is altered.

CYANITE. Kyanite. Disthene.

Triclinic. Axes $a : b : c = 0{\cdot}8994 : 1 : 0{\cdot}7090$; $\alpha = 90°\ 5\frac{1}{2}'$, $\beta = 101°\ 2'$, $\gamma = 105°\ 44\frac{1}{2}'$. ac, 100 ∧ 001 = 78° 30′; bc, 010 ∧ 001 = 86° 45′.

889



Usually in long bladed crystals, rarely terminated. Also coarsely bladed columnar to subfibrous.

Cleavage: a (100) very perfect; b (010) less perfect; also parting || c (001). H. = 5–7·25; the least, 4–5, on a (100) || c axis; 6–7 on a (100) || edge a (100)/ c (001); 7 on b (010). G. = 3·56–3·67. Luster vitreous 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. Pleochroism distinct in colored varieties. Optically −. Ax. pl. nearly ⊥ a (100) and inclined to edge a/b on a about 30°, and about $7\frac{1}{2}°$ on b (010), cf. **Fig.** 889. 2V = 82°. $\alpha = 1{\cdot}717$. $\beta = 1{\cdot}722$. $\gamma = 1{\cdot}729$.

Comp. — Empirical formula Al_2SiO_5 or $Al_2O_3.SiO_2$, like andalusite and sillimanite. Perhaps a basic metasilicate, $(AlO)_2SiO_3$.

Pyr., etc. Same as for andalusite. At a high temperature cyanite assumes the physical characters of sillimanite.

Diff. — Characterized by the bladed form; common blue color; varying hardness; infusibility; reaction for alumina.

Obs. — Occurs principally in gneiss and mica schist (both the ordinary variety with muscovite and also that with paragonite) often accompanied by garnet and sometimes by staurolite; also in eclogite schist. It is often associated with corundum.

Found in transparent crystals at Monte Campione in the St. Gothard region in Switzerland in paragonite schist; on Mt. Greiner, Zillertal, and in the Pfitschtal (*rhætizite*, white) in Tyrol, Austria; in eclogite of the Saualpe, Carinthia; Horrsjöberg in Wermland, Sweden; Villa Rica, Brazil, etc.

In Mass., at Chesterfield, with garnet in mica schist. In Conn., at Litchfield, Washington, Canton, Barkhamstead, etc. In Ver., at Thetford. In Pa., in Chester Co. and in Delaware Co. In Va., Buckingham Co. In N. C., with rutile, lazulite, etc., at Crowder's Mt., Gaston Co.; in Gaston and Rutherford counties associated with corundum, damourite; beautiful clear green in Yancey Co. Named from *κυανός, blue*.

Datolite Group. Monoclinic

Basic Orthosilicates. $H\overset{\text{II}}{R}\overset{\text{III}}{R}SiO_5$ or $\overset{\text{II}}{R}_3\overset{\text{III}}{R}_2(SiO_5)_2$. Oxygen ratio for R : Si = 3 : 2.

$\overset{\text{II}}{R}$ = Ca,Be,Fe, chiefly; $\overset{\text{III}}{R}$ = Boron, the yttrium (and cerium) metals, etc.

	a : *b* : *c*	*β*
Datolite	0·6345 : 1 : 1·2657	89° 51′
$HCaBSiO_5$ or $Ca(BOH)SiO_4$		
Homilite	0·6249 : 1 : 1·2824	89° 21′
$Ca_2FeB_2Si_2O_{10}$ or $Ca_2Fe(BO)_2(SiO_4)_2$		
	2 *a* : *b* : 4*c*	*β*
Euclase	0·6474 : 1 : 1·3330	79° 44′
$HBeAlSiO_5$ or $Be(AlOH)SiO_4$	*a*	
Gadolinite	0·6273 : 1 : 1·3215	89° 26½′
$Be_2FeY_2Si_2O_{10}$ or $Be_2Fe(YO)_2(SiO_4)_2$		

The species of the DATOLITE GROUP are usually regarded as basic orthosilicates, the formulas being taken in the second form given above. They all crystallize in the monoclinic system, and all but Euclase conform closely in axial ratio; with the latter there is also a distinct morphological relationship.

DATOLITE.

Monoclinic. Axes *a* : *b* : *c* = 0·6345 : 1 : 1·2657; *β* = 89° 51⅓′.

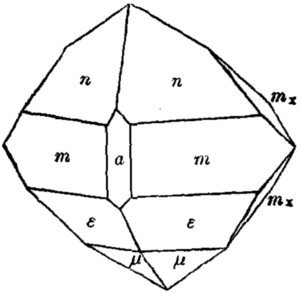
mm‴,	$110 \wedge 1\bar{1}0$ = 64° 47′.	*cn*,	$001 \wedge 111$ = 66° 57′.
ac,	$100 \wedge 001$ = 89° 51′.	*cm*,	$001 \wedge 110$ = 89° 53′.
ax,	$100 \wedge 101$ = 45° 0′.	*cε*,	$001 \wedge \bar{1}12$ = 49° 49′.
gg′,	$012 \wedge 0\bar{1}2$ = 64° 39½′.	*nn′*,	$111 \wedge 1\bar{1}1$ = 59° 4½′.
$m_x m_x'$,	$011 \wedge 0\bar{1}1$ = 103° 23′.	*εε′*,	$\bar{1}12 \wedge \bar{1}\bar{1}2$ = 48° 19½′.

Crystals varied in habit; usually short prismatic with either *m* (110) or m_x (011) predominating; sometimes tabular ‖ *x* (201); also of other types, and often highly modified (Figs. 890–893). Also botryoidal and globular, having a columnar structure; divergent and radiating; sometimes massive, granular to compact and crypto-crystalline.

Cleavage not observed. Fracture conchoidal to uneven. Brittle.

H. = 5–5·5. G. = 2·9–3·0. Luster vitreous, rarely subresinous on a surface of fracture. Color white; sometimes grayish, pale green, yellow, red, or amethystine, rarely dirty olive-green or honey-yellow. Streak white. Transparent to translucent; rarely opaque white. Optically –. 2V = 74°. α = 1·625. β = 1·653. γ = 1·669.

890



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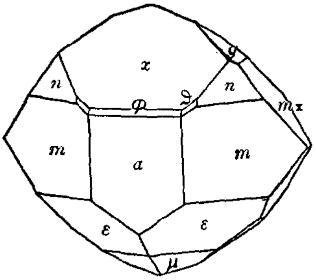
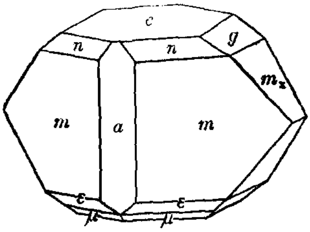


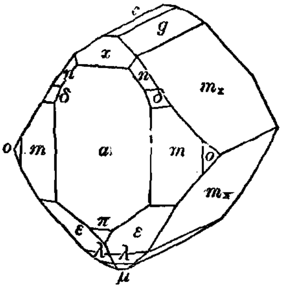
Bergen Hill

892



Bergen Hill

893



Andreasberg

Var. — 1. *Ordinary.* In glassy crystals of varied habit, usually with a greenish tinge. The angles in the prismatic and clinodome zones vary but little, *e. g.*, $110 \wedge \bar{1}10 = 64° 47$, while $0\bar{1}1 \wedge 01\bar{1} = 66° 37'$, etc. 2. *Compact massive.* White opaque cream-colored, pink; breaking with the surface of porcelain or Wedgewood ware. From the Lake Superior region. 3. *Botryoidal; Botryolite.* Radiated columnar, having a botryoidal surface, and containing more water than the crystals, but optically identical.

Comp. — A basic orthosilicate of boron and calcium; empirically $HCaBSiO_5$ or $H_2O.2CaO.B_2O_3.2SiO_2$; this may be written $Ca(BOH)SiO_4$ = Silica 37·6, boron trioxide 21·8, lime 35·0, water 5·6 = 100.

Pyr., etc. — In the closed tube gives off much water. B.B. fuses at 2 with intumescence to a clear glass, coloring the flame bright green. Gelatinizes with hydrochloric acid.

Diff. — Characterized by its glassy, greenish, complex crystals; easy fusibility and green flame B. B.

Obs. — Datolite is found chiefly as a secondary mineral in veins and cavities in basic eruptive rocks, often associated with calcite, prehnite and various zeolites; sometimes associated with danburite; also in gneiss, diorite, and serpentine; in metallic veins; sometimes in beds of iron ore. Found in Scotland, in trap, at the Kilpatrick Hills, etc.; in a bed of magnetite at Arendal in Norway (*botryolite*); at Utö in Sweden; at Andreasberg, Germany, in diabase and in veins of silver ores; in Rhenish Bavaria (the *humboldtite*); at the Seisser Alp, Tyrol, Austria, and at Theiss, near Claussen, Hungary; in geodes in amygdaloid; in Italy, in granite at Baveno near Lago Maggiore, at Toggiana in Modena, in serpentine, at Monte Catini in Tuscany.

In the United States not uncommon with the diabase of Conn. and Mass. Thus at the Rocky Hill quarry, Hartford, Conn.; at Middlefield Falls and Roaring Brook, Conn.; Westfield, Mass. In N. J., at Bergen Hill and Great Notch in splendid crystals; at Paterson, Passaic Co. Both crystals and the opaque compact variety, in the Lake Superior region.

Named from δατεῖσθαι, *to divide*, alluding to the granular structure of a massive variety.

Homilite. $(Ca,Fe)_3B_2Si_2O_{10}$ or $(Ca,Fe)_3(BO)_2(SiO_4)_2$. Crystals often tabular ǁ *c* (001); angles near those of datolite. H. = 5. G. = 3·38. Color black, blackish brown. Index about 1·68. Found on Stokö and other islands, in the Langesund fiord, Norway.

Euclase. $HBeAlSiO_5$ or $Be(AlOH)SiO_4$. In prismatic crystals. Cleavage ǁ *b* (010) perfect. H. = 7·5. G. = 3·05–3·10. Luster vitreous. Colorless to pale green or blue. Optically +. $\beta = 1{\cdot}655$. From Brazil, in the province of Minas Geraes; in the auriferous sands of the Orenburg district, southern Ural Mts., near the river Sanárka; in the Glossglockner region of the Austrian Alps; from Epprechtstein, Fichtelgebirge, Bavaria.

Gadolinite. $Be_2FeY_2Si_2O_{10}$ or $Be_2Fe(YO)_2(SiO_4)_2$. Crystals, often prismatic, rough and coarse; commonly in masses. Cleavage none. Fracture conchoidal or splintery. Brittle. H. = 6·5–7. G. = 4·0–4·5; normally 4·36–4·47 (anisotropic), 4·24–4·29 (isotropic and amorphous from alteration). Luster vitreous to greasy. Color black, greenish black, also brown. From near Falun and Ytterby, Sweden; Hitterö, Norway; also in Llano Co., Texas, in nodular masses and rough crystals, sometimes up to 40 or 60 pounds in weight. Crystals from Kumak, East Greenland.

The yttrium earths or "gadolinite-earths" (partly replaced by the oxides of cerium, lanthanum and didymium) form a complex group which contains considerable erbium, also several new elements (ytterbium, scandium, etc.) of more or less definite character.

Yttrialite. A silicate of thorium and the yttrium metals chiefly. Massive; amorphous. G. = 4·575. Color on the fresh fracture olive-green, changing to orange-yellow on surface. Associated with the gadolinite of Llano Co., Texas.

Rowlandite. An yttrium silicate, occurring massive with gadolinite of Llano Co., Texas; color drab-green.

Thalénite. An yttrium silicate. In tabular or prismatic monoclinic crystals. H. = 6·5. G. = 4·2. Color flesh-red. $\beta = 1{\cdot}74$. Found in Sweden at Österby in Dalecarlia and at Åskagen in Wermland.

Thortveitite. A silicate of the yttrium metals, $(Sc,Y)_2Si_2O_7$. Orthorhombic. In radiating groups of large tapering crystals. Prismatic cleavage. H. = 6–7. G. = 3·57. Color grayish green to white when altered. Usually translucent. Difficultly fusible. Found in pegmatite in Iveland parish, Sätersdalen, Norway.

Mackintoshite. Silicate of uranium, thorium, cerium, etc. Massive. Color black. Llano Co., Texas.

Epidote Group Orthorhombic and Monoclinic

Basic Orthosilicates, $H\overset{II}{R}_2\overset{III}{R}_3Si_3O_{13}$ or $\overset{II}{R}_2(\overset{III}{R}OH)\overset{III}{R}_2(SiO_4)_3$

$\overset{II}{R} = Ca,\overset{II}{Fe};\ \overset{III}{R} = Al,\overset{III}{Fe},\overset{III}{Mn},Ce$, etc.

α. Orthorhombic Section

		a : *b* : *c*
Zoisite	$Ca_2(AlOH)Al_2(SiO_4)_3$	0·6196 : 1 : 0·3429

β. Monoclinic Section

		a : *b* : *c*	
Epidote	$m Ca_2(AlOH)Al_2(SiO_4)_3$ $n Ca_2(FeOH)Fe_2(SiO_4)_3$	1·5787 : 1 : 1·8036	64° 37′
Piedmontite	$Ca_2(AlOH)(Al,Mn)_2(SiO_4)_3$	1·6100 : 1 : 1·8326	64° 39′
Allanite	$(Ca,Fe)_2(AlOH)(Al,Ce,Fe)_2(SiO_4)_3$	1·5509 : 1 : 1·7691	64° 59′

The EPIDOTE GROUP includes the above complex orthosilicates. The monoclinic species agree closely in form. To them the orthorhombic species zoisite is also related in angle, its prismatic zone corresponding to the monoclinic orthodomes, etc. Thus we have:

Zoisite *mm'''*, $110 \wedge 1\bar{1}0 = 63° 34'$. Epidote *cr*, $001 \wedge \bar{1}01 = 63° 42'$.
uu', $021 \wedge 0\bar{2}1 = 68° 54'$. *mm'*, $110 \wedge \bar{1}10 = 70° 4'$, etc.

There seems to be, however, a monoclinic calcium compound, having the composition of zoisite, but monoclinic and strictly isomorphous with ordinary epidote; it is called *clinozoisite*.

ZOISITE.

Orthorhombic. Axes $a : b : c = 0·6196 : 1 : 0·34295$.

mm''', $110 \wedge 1\bar{1}0 = 63° 34'$. *ff'*, $011 \wedge 0\bar{1}1 = 37° 52'$.
dd', $101 \wedge \bar{1}01 = 57° 56'$. *oo'''*, $111 \wedge 1\bar{1}1 = 33° 24'$.

Crystals prismatic, deeply striated or furrowed vertically, and seldom distinctly terminated. Also massive; columnar to compact.

Cleavage: *b* (010) very perfect. Fracture uneven to subconchoidal. Brittle. H. = 6–6·5. G. = 3·25–3·37. Luster vitreous; on the cleavage-face, *b* (010), pearly. Color grayish white, gray, yellowish brown, greenish gray, apple-green; also peach-blossom-red to rose-red. Streak uncolored. Transparent to subtranslucent.

Pleochroism strong in pink varieties. Optically +. Ax. pl. usually $\parallel$ *b* (010); also $\parallel$ *c* (001). Bx $\perp$ *a* (100). Dispersion strong, $\rho < v$; also $\rho > v$. Axial angle variable even in the same crystal. 2V = 0°–60°. $\alpha = 1·700$. $\beta = 1·703$. $\gamma = 1·706$.

Var. — 1. *Ordinary.* Colors gray to white and brown; also green. Usually in indistinct prismatic or columnar forms; also in fibrous aggregates. G. = 3·226–3·381. *Unionite* is a very pure zoisite. 2. *Rose-red* or *Thulite.* Fragile; pleochroism strong. 3. *Compact, massive.* Includes the essential part of most of the mineral material known as *saussurite* (*e.g.*, in saussurite-gabbro), which has arisen from the alteration of feldspar.

Comp. — $HCa_2Al_3Si_3O_{13}$ or $4CaO.3Al_2O_3.6SiO_2.H_2O$ = Silica 39·7, alumina 33·7, lime 24·6, water 2·0 = 100. The alumina is sometimes replaced by iron, thus graduating toward epidote, which has the same general formula.

Pyr., etc. — B.B. swells up and fuses at 3–3·5 to a white blebby mass. Not decomposed by acids; when previously ignited gelatinizes with hydrochloric acid. Gives off water when strongly ignited.

Diff. — Characterized by the columnar structure; fusibility with intumescence; resembles some amphibole.

Micro. — Distinguished in thin sections by its high relief and very low interference-colors; lack of color and biaxial character. From epidote it is distinguished by its lack of color and low birefringence; from vesuvianite by its color and biaxial character. Thin sections frequently show the "*ultra blue*" (p. 520) between crossed nicols.

Obs. — Occurs especially in those crystalline schists which have been formed by the dynamic metamorphism of basic igneous rocks containing plagioclase rich in lime. Commonly accompanies some one of the amphiboles (actinolite, smaragdite, glaucophane, etc.); thus in amphibolite, glaucophane schist, eclogite; often associated with corundum.

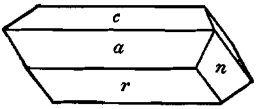
The original zoisite is that of the eclogite of the Saualpe in Carinthia (*saualpite*). Other localities are: Rauris in Salzburg; Sterzing, etc., in Tyrol, Austria; the Fichtelgebirge in Bavaria; Marschendorf in Moravia; Saastal in Switzerland; the island of Syra, one of the Cyclades, in glaucophane schist. In crystals from Chester, Mass.. *Thulite* occurs at Kleppan in Tellemarken, Norway, and at Traversella in Piedmont, Italy.

EPIDOTE. Pistacite.

Monoclinic. Axes $a : b : c = 1·5787 : 1 : 1·8036$; $\beta = 64° 37'$.

mm''',	110 ∧ $1\bar{1}0$ = 109° 56'.	*cl*,	001 ∧ $\bar{2}01$ = 89° 26'.
ca,	001 ∧ 100 = 64° 37'.	*co*,	001 ∧ 011 = 58° 28'.
ce,	001 ∧ 101 = 34° 43'.	*cn*,	001 ∧ $\bar{1}11$ = 75° 11'.
cr,	001 ∧ $\bar{1}01$ = 63° 42'.	*an'''*,	100 ∧ $11\bar{1}$ = 69° 2'.
ar',	100 ∧ $10\bar{1}$ = 51° 41'.	*nn'''*,	$\bar{1}11$ ∧ $11\bar{1}$ = 70° 29'.

894



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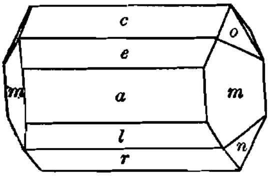

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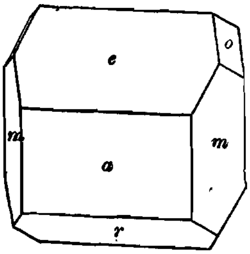

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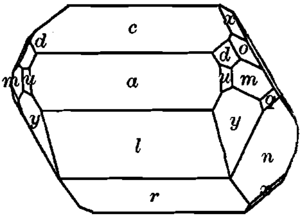
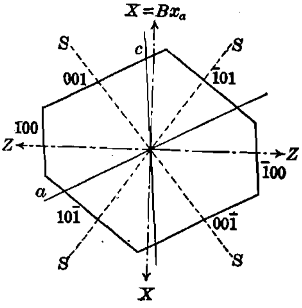


Twins: tw. pl. *a* (100) common, often as embedded tw. lamellæ. Crystals usually prismatic || the ortho-axis *b* and terminated at one extremity only; passing into acicular forms; the faces in the zone *a* (100)/*c* (001) deeply striated. Also fibrous, divergent or parallel; granular, particles of various sizes, sometimes fine granular, and forming rock-masses.

Cleavage: *c* (001) perfect; *a* (100) imperfect. Fracture uneven. Brittle. H. = 6–7. G. = 3·25–3·5. Luster vitreous; on *c* (001) inclining to pearly or resinous. Color pistachio-green or yellowish green to brownish green, greenish black, and black; sometimes clear red and yellow; also gray and grayish white, rarely colorless. Streak uncolored, grayish. Transparent to opaque: generally subtranslucent.

Pleochroism strong: vibrations || *Z* green, *Y* brown and strongly absorbed, *X* yellow. Absorption usually $Y > Z > X$; but sometimes $Z > Y > X$ 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 || *r* ($\bar{1}01$). (See p. 288.) Optically –. Ax. pl. || *b* (010). $\text{Bx}_{a,r} \wedge c$ axis = – 2° 56'. Hence $Z \perp a$ (100) nearly. Dispersion inclined, strongly marked; of the axes feeble, $\rho > v$. Axial angle large. $\alpha = 1·729$. $\beta = 1·754$. $\gamma = 1·768$.

898



Var. — Epidote has ordinarily a peculiar yellowish green (pistachio) color, seldom found in other minerals. But this color passes into dark and light shades — black on one side and brown on the other; red, yellow and colorless varieties also occur.

Var. 1. *Ordinary.* Color green of some shade, as described, the pistachio tint rarely absent. (*a*) In crystals. (*b*) Fibrous. (*c*) Granular massive. (*d*) *Scorza* is epidote sand from the gold washings in Transylvania. The Arendal, Norway, epidote (*Arendalite*) is mostly in dark green crystals; that of Bourg d'Oisans, Dauphiné, France, (*Thallite, Del-*

phinite, Oisanite) in yellowish green crystals, sometimes transparent. *Puschkinite* includes crystals from the auriferous sands of Ekaterinburg, Ural Mts. *Achmatite* is ordinary epidote from Achmatovsk, Ural Mts. A variety from Garda, Hoste Island, Terra del Fuego, is colorless and resembles zoisite.

2. The *Bucklandite* from Achmatovsk, Ural Mts., described by Hermann, is black with a tinge of green, and differs from ordinary epidote in having the crystals nearly symmetrical and not, like other epidote, lengthened in the direction of the ortho-axis. G. = 3·51.

3. *Withamite*. Carmine-red to straw-yellow, strongly pleochroic; deep crimson and straw-yellow. H. = 6–6·5; G. = 3·137; in small radiated groups. From Glencoe, in Argyleshire, Scotland. Sometimes referred to piedmontite, but contains little MnO.

4. *Tawmanite* is a chromium-bearing epidote from Tawman, Kachin Hills, Upper Burma. Deep green color and strong pleochroism, emerald-green to bright yellow.

Comp. — $HCa_2(Al,Fe)_3Si_3O_{13}$ or $H_2O.4CaO.3(Al,Fe_3)_2O_3.6SiO_2$, the ratio of aluminium to iron varies commonly from 6 : 1 to 3 : 2. Percentage composition:

For Al : Fe = 3 : 1 SiO_2 37·87, Al_2O_3 24·13, Fe_2O_3 12·60, CaO 23·51, H_2O 1·89 = 100

Clinozoisite is an epidote without iron, having the composition of zoisite; *fouqueite* is probably the same from an anorthite-gneiss in Ceylon. *Picroepidote* is supposed to contain Mg in place of Ca.

Pyr., etc. — In the closed tube gives water on strong ignition. B.B. fuses with intumescence at 3–3·5 to a dark brown or black mass which is generally magnetic. Reacts for iron and sometimes for manganese with the fluxes. Partially decomposed by hydrochloric acid, but when previously ignited, gelatinizes with acid. Decomposed on fusion with alkaline carbonates.

Diff. — Characterized often by its peculiar yellowish green (pistachio) color; readily fusible and yields a magnetic globule B.B. Prismatic forms often longitudinally striated, but they have not the angle, cleavage or brittleness of tremolite; tourmaline has no distinct cleavage, is less fusible (in common forms) and usually shows its hexagonal form.

Micro. — Recognized in thin sections by its high refraction; strong interference-colors rising into those of the third order in ordinary sections; decided color and striking pleochroism; also by the fact that the plane of the optic axes lies transversely to the elongation of the crystals.

Obs. — Epidote is commonly formed by the metamorphism (both local igneous and of general dynamic character) of impure calcareous sedimentary rocks or igneous rocks containing much lime. It thus often occurs in gneissic rocks, mica schist, amphibole schist, serpentine; so also in quartzites, sandstones and limestones altered by neighboring igneous rocks. Often accompanies beds of magnetite or hematite in such rocks. Has also been found in granite (Maryland), and regarded as an original mineral.

It is often associated with quartz, feldspar, actinolite, axinite, chlorite, etc. It sometimes forms with quartz an epidote rock, called *epidosite*. A similar rock exists at Melbourne in Canada. A gneissoid rock consisting of flesh-colored orthoclase, quartz and epidote from the Unaka Mts. (N. C. and Tenn.) has been called unakyte.

Beautiful crystallizations come from Bourg d'Oisans, Dauphiné, France; the Ala valley and Traversella, in Piedmont, Italy; Elba; Zermatt, Switzerland; Zillertal in Tyrol, Austria; also in fine crystals from the Knappenwand in the Untersulzbachtal, Pinzgau, Austria, associated with asbestus, adularia, apatite, titanite, scheelite; further at Striegau, Silesia; Zöptau, Moravia; Arendal, Norway; the Achmatovsk mine near Zlatoust, Ural Mts.

In North America, occurs in N. H., at Franconia and Warren. In Mass., at Hadlyme and Chester in crystals in gneiss; at Athol, in syenitic gneiss, in fine crystals; Newbury, in limestone. In Conn., at Haddam, in large splendid crystals. In N. Y., near Amity; Monroe, Orange Co.; Warwick, pale yellowish green, with titanite and pyroxene. In N. C., at Hampton's, Yancey Co.; White's mill, Gaston Co.; Franklin, Macon Co.; in crystals and crystalline masses in quartz at White Plains, Alexander Co. In Mich., in the Lake Superior region, at many of the mines. Crystals from Seven Devils mining district, Idaho; from Riverside, Cal.; from Sulzer, Prince of Wales Island, Alaska.

Epidote was named by Haüy, from the Greek ἐπίδοσις, *increase*, translated by him, "qui à recu un accroissement," the base of the prism (rhomboidal prism) having one side longer than the other. *Pistacite*, from πιστακια, *the pistachio-nut*, refers to the color.

Piedmontite. Similar in angle to ordinary epidote, but contains 5 to 15 p. c. Mn_2O_3. H. = 6·5. G. = 3·404. Color reddish brown and reddish black. Pleochroism strong.

Absorption $X > Y > Z$. Optically +. Ax. pl. || *b* (010). $Bx_{a.r} \wedge c$ axis = + 82° 34′, $X \wedge c$ axis = − 6° to − 3°. $\beta = 1{\cdot}73$. Occurs with manganese ores at St. Marcel, Piedmont, Italy. In crystalline schists on Ile de Groix, France; in glaucophane-schist in Japan. Occasionally in quartz porphyry, as in the antique red porphyry of Egypt, also that of South Mountain, Pa.

Hancockite. Belongs in Epidote Group containing, PbO, MnO, CaO, SrO, MgO, Al_2O_3, Fe_2O_3, Mn_2O_3. Crystals which are very small and lath shaped show characteristic epidote habit and closely related angles. Brownish red. H. = 6–7. G. = 4·0. Found at Franklin, N. J.

ALLANITE. Orthite.

Monoclinic. Axes, p. 529. In angle near epidote. Crystals often tabular || *a* (100); also long and slender to acicular prismatic by elongation || axis *b*. Also massive and in embedded grains.

Cleavage: *a* (100) and *c* (001) in traces; also *m* (110) sometimes observed. Fracture uneven or subconchoidal. Brittle. H. = 5·5–6. G. = 3·0–4·2. Luster submetallic, pitchy or resinous. Color brown to black. Subtranslucent to opaque. Pleochroism strong: *Z* brownish yellow, *Y* reddish brown, *X* greenish brown. Optically −. Ax. pl. || *b* (010). $Bx_a \wedge c$ axis = 32½° approx. $\beta = 1{\cdot}682$. Birefringence variable. Also isotropic and amorphous by alteration analogous to gadolinite.

Var. — *Allanite.* The original mineral was from East Greenland, in tabular crystals or plates. Color black or brownish black. G. = 3·50–3·95. *Bucklandite* is anhydrous allanite in small black crystals from a magnetite mine near Arendal, Norway. *Bagrationite* occurs in black crystals which are like the bucklandite of Achmatovsk (epidote).

Orthite included, in its original use, the slender or acicular prismatic crystals, containing some water, from Finbo, near Falun, Sweden. But these graduate into massive forms, and some orthites are anhydrous, or as nearly so as most allanite. The name is from ὀρθός *straight.*

Comp. — Like epidote $H\overset{II}{R}\overset{III}{R}_3Si_3O_{13}$ or $H_2O.4RO.3R_2O_3.6SiO_2$ with $\overset{II}{R}$ = Ca and Fe, and $\overset{III}{R}$ = Al,Fe, the cerium metals Ce, Di, La, and in smaller amounts those of the yttrium group. Some varieties contain considerable water, but probably by alteration.

Pyr., etc. — Some varieties give much water in the closed tube, and all kinds yield a small amount on strong ignition. B.B. fuses easily and swells up (F. = 2·5) to a dark, blebby, magnetic glass. With the fluxes reacts for iron. Most varieties gelatinize with hydrochloric acid, but if previously ignited are not decomposed by acid.

Obs. — Occurs in albitic and common feldspathic granite, gneiss, syenite, zircon syenite, porphyry. Thus in Greenland; Norway; Sweden; Striegau, Silesia. Also in white limestone as at Auerbach on the Bergstrasse, Germany; often in mines of magnetic iron. Rather common as an accessory constituent in many rocks, as in andesite, diorite, dacite, rhyolite, the tonalite of Mt. Adamello, Austria, the scapolite rocks of Odegaarden, Norway, etc. Sometimes inclosed as a nucleus in crystals of the isomorphous species, epidote. From Madagascar.

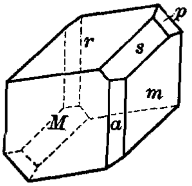
At Vesuvius in ejected masses with sanidine, sodalite, nephelite, hornblende, etc. Similarly in trachytic ejected masses at the Laacher See, Germany (*bucklandite*).

In Mass., at the Bolton quarry. In N. Y., Moriah, Essex Co., with magnetite and apatite; at Monroe, Orange Co. In N. J., at Franklin Furnace with feldspar and magnetite. In Pa., at South Mountain, near Bethlehem, in large crystals; at East Bradford; near Eckhardt's furnace, Berks Co., abundant. In Va., in large masses in Amherst Co.; also in Bedford, Nelson, and Amelia counties. In N. C., at many points. At the Devil's Head Mt., Douglas Co., Col. In Texas in Llano Co.

AXINITE.

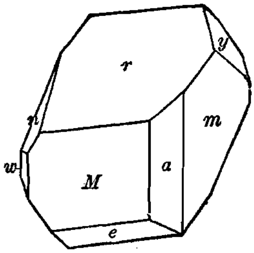
Triclinic. Axes $a : b : c = 0{\cdot}4921 : 1 : 0{\cdot}4797$; $\alpha = 82° 54'$, $\beta = 91° 52'$, $\gamma = 131° 32'$.

899



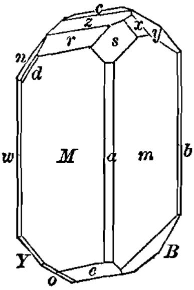
Dauphiné

900



Poloma

901



Bethlehem, Pa.

am, 100 ∧ 110 = 15° 34′.
aM, 100 ∧ $1\bar{1}0$ = 28° 55′.
as, 100 ∧ 201 = 21° 37′.
Mr, $1\bar{1}0$ ∧ $1\bar{1}1$ = 45° 15′.
mr, 110 ∧ $1\bar{1}1$ = 64° 22′.
ms, 110 ∧ 201 = 27° 57′.

Crystals usually broad and acute-edged, but varied in habit. Also massive, lamellar, lamellæ often curved; sometimes granular.

Cleavage: *b* (010) distinct. Fracture conchoidal. Brittle. H. = 6·5–7. G. = 3·271–3·294. Luster highly glassy. Color clove-brown, plum-blue, and pearl-gray; also honey-yellow, greenish yellow. Streak uncolored. Transparent to subtranslucent. Pleochroism strong. Optically −. Ax. pl. and Bx_a approximately ⊥ *x* (111). Axial angles variable. 2V = 65°–70°. $\beta = 1{\cdot}68$ (approx.). Pyroelectric (p. 307).

Comp. — A boro-silicate of aluminium and calcium with varying amounts of iron and manganese. Formula, $\overset{II}{R}_7\overset{III}{R}_4B_2(SiO_4)_8$. R = Calcium chiefly, sometimes in large excess, again in smaller amount and manganese prominent; iron is present in small quantity, also magnesium and basic hydrogen.

Pyr., etc. — B.B. fuses readily with intumescence, imparts a pale green color to the O.F., and fuses at 2 to a dark green to black glass; with borax in O.F. gives an amethystine bead (manganese), which in R.F. becomes yellow (iron). Fused with a mixture of bisulphate of potash and fluorite on the platinum loop colors the flame green (boric acid). Not decomposed by acids, but when previously ignited, gelatinizes with hydrochloric acid.

Obs. — Axinite occurs in clove-brown crystals, near Bourg d'Oisans in Dauphiné, France; at Andreasberg, Harz Mts., Germany; Striegau, Silesia; on Mt. Skopi, in eastern Switzerland; Elba; at the silver mines of Kongsberg, Norway; Nordmark, Sweden; near Miask in the Ural Mts.; in Cornwall, England, of a dark color, at the Botallack mine near St. Just, etc. From Obira, Japan.

In the United States, at Phippsburg, Me.; Franklin Furnace, N. J., honey-yellow; at Bethlehem, Pa.; in Cal. at Bonsall, San Diego Co., at Riverside, Riverside Co., and at Consumers Mine, Amador Co.

Named from ἀξίνη, *an axe*, in allusion to the form of the crystals.

PREHNITE.

Orthorhombic-hemimorphic. Axes $a : b : c = 0{\cdot}8401 : 1 : 0{\cdot}5549$.

Distinct individual crystals rare; usually tabular ∥ *c* (001); sometimes prismatic, *mm‴* (110) ∧ ($1\bar{1}0$) = 80° 4′; again acute pyramidal. Commonly in groups of tabular crystals, united by *c* (001) making broken forms, often barrel-shaped. Reniform, globular, and stalactitic with a crystalline surface. Structure imperfectly columnar or lamellar, strongly coherent; also compact granular or impalpable.

Cleavage: *c* (001) distinct. Fracture uneven. Brittle. H. = 6–6·5. G. = 2·80–2·95. Luster vitreous; on base weak pearly. Color light green, oil-green, passing into white and gray; often fading on exposure. Subtransparent to translucent. Streak uncolored.

Comp. — An acid orthosilicate, $H_2Ca_2Al_2(SiO_4)_3$ = Silica 43·7, alumina 24·8, lime 27·1, water 4·4 = 100.

Prehnite is sometimes classed with the zeolites, with which it is often associated; the water here, however, has been shown to go off only at a red heat, and hence plays a different part.

Pyr., etc. — In the closed tube yields water. B.B. fuses at 2 with intumescence to a blebby enamel-like glass. Decomposed slowly by hydrochloric acid without gelatinizing; after fusion dissolves readily with gelatinization.

Diff. — B.B. fuses readily, unlike beryl, green quartz, and chalcedony. Its hardness is greater than that of the zeolites.

Obs. — Occurs chiefly in basic eruptive rocks, basalt, diabase, etc., as a secondary mineral in veins and cavities, often associated with some of the zeolites, also datolite, pectolite, calcite, but commonly one of the first formed of the series; also less often in granite, gneiss, syenite, and then frequently associated with epidote; sometimes associated with native copper, as in the Lake Superior region.

At St. Christophe, near Bourg d'Oisans in Dauphiné, France; Fassatal, Tyrol, Austria; the Ala valley in Piedmont, Italy; in the Harz Mts. near Andreasberg, Germany; in granite at Striegau, Silesia; Arendal, Norway; Ædelfors in Sweden (*edelite*); at Corstorphine Hill, near Edinburgh, Scotland; Mourne Mts., Ireland.

In the United States, finely crystallized at Farmington, Conn.; Paterson and Bergen Hill, N. J.; in syenite, at Somerville, Mass.; on north shore of Lake Superior, and the copper region.

Named (1790) after Col. Prehn, who brought the mineral from the Cape of Good Hope.

Harstigite. An acid orthosilicate of manganese and calcium. In small colorless prismatic crystals. H. = 5·5. G. = 3·049. Indices, 1·678–1·683. From the Harstig mine, near Pajsberg, Wermland, Sweden.

Cuspidine. Contains silica, lime, fluorine, and from alteration carbon dioxide; formula perhaps $Ca_2Si(O,F_2)_4$. In minute spear-shaped crystals. H. = 5–6. G. = 2·853–2·860. Color pale rose-red. Indices, 1·590–1·602. From Vesuvius, in ejected masses in the tufa of Monte Somma. From Franklin, N. J.

IV. Subsilicates

The species here included are basic salts, for the most part to be referred either to the metasilicates or orthosilicates, like many basic compounds already included in the preceding pages. Until their constitution is definitely settled, however, they are more conveniently grouped by themselves as SUBSILICATES. It may be noted that those species having an oxygen ratio of silicon to bases of 2 : 3, like topaz, andalusite, sillimanite, datolite, etc., also calamine, carpholite, and perhaps tourmaline, are sometimes regarded as salts of the hypothetical parasilicic acid, H_6SiO_5.

The only prominent group in this subdivision is the HUMITE GROUP.

Humite Group

			$a : b : c$	β
Prolectite	$[Mg(F,OH)]_2Mg[SiO_4]_1$?	Monoclinic	$1{\cdot}0803 : 1 : 1{\cdot}8861$	90°
Chondrodite	$[Mg(F,OH)]_2Mg_3[SiO_4]_2$	Monoclinic	$1{\cdot}0863 : 1 : 3{\cdot}1447$	90°
Humite	$[Mg(F,OH)]_2Mg_5[SiO_4]_3$	Orthorhombic	$b : a : c$ $1{\cdot}0802 : 1 : 4{\cdot}4033$	—
Clinohumite	$[Mg(F,OH)]_2Mg_7[SiO_4]_4$	Monoclinic	$1{\cdot}0803 : 1 : 5{\cdot}6588$	90°

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 (see also below). Furthermore, though one species is orthorhombic, the others monoclinic, they here also correspond closely, since the axial angle β in the latter cases does not sensibly differ from 90°.

In composition, as shown by Penfield and Howe (also Sjögren), 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 are very similar, and several of them may occur together at the same locality and even intercrystallized in parallel lamellæ.

The species of the group approximate closely in angle to chrysolite and chrysoberyl. The axial ratios may be compared as follows:

Prolectite	$a : b : \frac{1}{3}c$	$= 1{\cdot}0803 : 1 : 0{\cdot}6287$
Chondrodite	$a : b : \frac{1}{5}c$	$= 1{\cdot}0863 : 1 : 0{\cdot}6289$
Humite	$b : a : \frac{1}{7}c$	$= 1{\cdot}0802 : 1 : 0{\cdot}6291$
Clinohumite	$a : b : \frac{1}{9}c$	$= 1{\cdot}0803 : 1 : 0{\cdot}6288$
Chrysolite	$b : 2a : c$	$= 1{\cdot}0735 : 1 : 0{\cdot}6296$
Chrysoberyl	$b : 2a : c$	$= 1{\cdot}0637 : 1 : 0{\cdot}6170$

CHONDRODITE — HUMITE — CLINOHUMITE.

Axial ratios as given above. Habit varied, Figs. 902 to 910. Twins common, the twinning planes inclined 60°, also 30°, to *c* (001) in the brachydome or clinodome zone, hence the axes crossing at angles near 60°; often repeated as trillings and as polysynthetic lamellæ (cf. Fig. 609, p. 299). Also twins, with *c* (001) as tw. plane. Two of the three species are often twinned together.

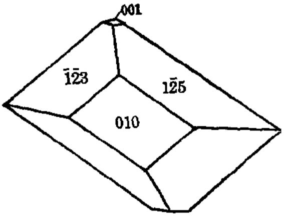
Cleavage: *c* (001) sometimes distinct. Fracture subconchoidal to uneven. Brittle. H. = 6–6·5. G. = 3·1–3·2. Luster vitreous to resinous. Color white, light yellow, honey-yellow to chestnut-brown and garnet- or hyacinth-red. Pleochroism sometimes distinct. Optically +.

Chondrodite. Absorption $X > Z > Y$. Optically +. Ax. pl. and $Bx_a \perp b$ (010). $Bx_o \wedge c$ axis $= X \wedge c$ axis $= +25° 52'$ Brewster; 28° 56′ Kafveltorp; 30° approx., Mte. Somma. $\beta = 1{\cdot}619$; $\gamma - \alpha = 0{\cdot}031$. 2V = 80°.

Humite. Ax. pl. $\parallel c$ (001). $Bx \perp a$ (100). $\beta = 1{\cdot}643$. $\gamma - \alpha = 0{\cdot}035$.

Clinohumite. Ax. pl. and $Bx_a \perp b$ (010). $Bx_o \wedge c$ axis $= +11°–12°$; $7\frac{1}{2}°$ approx., Brewster. 2V = 76°. $\beta = 1{\cdot}670$. $\gamma - \alpha = 0{\cdot}038$.

902



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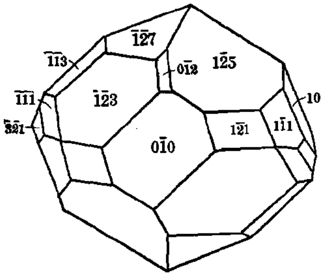

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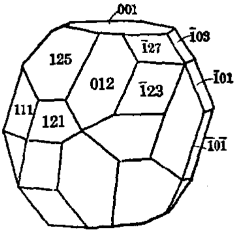
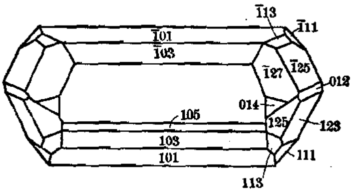


Figs. 902, 903, *Chondrodite*, Brewster, N. Y.

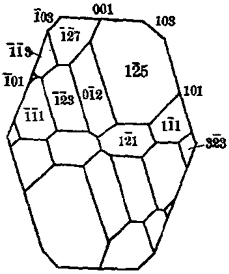
Chondrodite, Sweden

905



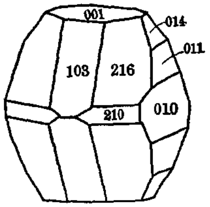
Projection on (001)

906



Projection on (01̄0)

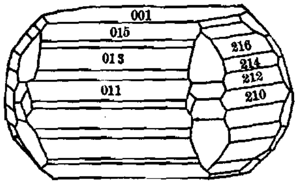
907



Figs. 905, 906, *Chondrodite*, Mte. Somma

Humite, Sweden

908



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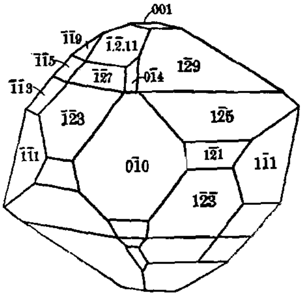

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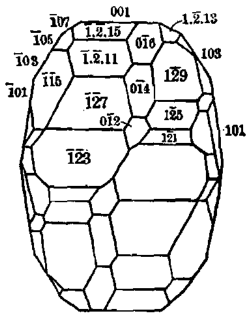


Projection on (01̄0)

Humite, Vesuvius

Clinohumite, Brewster

Clinohumite, Mte. Somma

Comp. — Basic fluosilicates of magnesium with related formulas as shown in the table above. Hydroxyl replaces part of the fluorine, and iron often takes the place of magnesium.

Pyr., etc. — B.B. infusible; some varieties blacken and then burn white. Fused with potassium bisulphate in the closed tube gives a reaction for fluorine. With the fluxes a reaction for iron. Gelatinizes with acids. Heated with sulphuric acid gives off silicon fluoride.

Obs. — Chondrodite, humite, and clinohumite all occur at Vesuvius in the ejected masses both of limestone or feldspathic type found on Monte Somma. They are associated with chrysolite, biotite, pyroxene, magnetite, spinel, vesuvianite, calcite, etc.; also less often with sanidine, meionite, nephelite. Of the three species, humite is the rarest and clinohumite of most frequent occurrence. They seldom all occur together in the same mass, and only rarely two of the species (as humite and clinohumite) appear together. Occasionally clinohumite interpenetrates crystals of humite, and parallel intergrowths with chrysolite have also been observed.

Chondrodite occurs at Mte. Somma, Vesuvius, as above noted; at Pargas, Finland, honey-yellow in limestone; at Kafveltorp, Nya-Kopparberg, Sweden, associated with chalcopyrite, galena, sphalerite. At Brewster, N. Y., at the Tilly Foster magnetic iron mine in deep garnet-red crystals. Also probably at numerous points where the occurrence of "chondrodite" has been reported.

Humite also occurs at the Ladu mine near Filipstadt, Sweden, with magnetite in crystalline limestone. In crystalline limestone with clinohumite in Andalusia, Spain. Also in large, coarse, partly altered crystals at the Tilly Foster iron-mine at Brewster, N. Y. Noted at Franklin Furnace, N. J.

Clinohumite occurs at Mte. Somma and in Andalusia; in crystalline limestone near Lake Baikal in East Siberia; at Brewster, N. Y., in rare but highly modified crystals.

Hydroclinohumite is a titaniferous variety (originally called *titanolivine*) from Ala Valley, Piedmont, Italy.

Prolectite is from the Ko mine, Nordmark, Sweden; very rare; imperfectly known.

Numerous other localities of "chondrodite" have been noted, chiefly in crystalline limestone; most of them are probably to be referred to the species chondrodite, but the identity in many cases is yet to be proved. At Brewster large quantities of massive "chondrodite" occur associated with magnetite, enstatite, ripidolite, and from its extensive alteration serpentine has been formed on a large scale. The granular mineral is common in limestone in Sussex Co., N. J., and Orange Co., N. Y., associated with spinel, and occasionally with pyroxene and corundum. Also in Mass., at Chelmsford, with scapolite; at South Lee, in limestone. In Canada, in limestone at St. Jerome, Grenville, etc., abundant.

The name chondrodite is from χόνδρος, *a grain*, alluding to the granular structure. Humite is from Sir Abraham Hume.

Leucophœnicite. $Mn_5(MnOH)_2(SiO_4)_3$, similar to the humite type of formula. Monoclinic. In striated crystals elongated parallel to ortho-axis. Massive. H. = 5·5–6. G. = 3·8. Color light purplish red. Fusible. From Franklin, N. J.

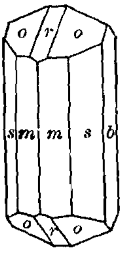
ILVAITE. Lievrite. Yenite.

Orthorhombic. Axes $a : b : c = 0{\cdot}6665 : 1 : 0{\cdot}4427$.

mm''', $110 \wedge 1\bar{1}0 = 67° 22'$. rr', $101 \wedge \bar{1}01 = 67° 11'$.

ss', $120 \wedge \bar{1}20 = 73° 45'$. oo', $111 \wedge \bar{1}11 = 62° 33'$.

911



Commonly in prisms, with prismatic faces vertically striated. Columnar or compact massive.

Cleavage: *b* (010), *c* (001) rather distinct. Fracture uneven. Brittle. H. = 5·5–6. G. = 3·99–4·05. Luster submetallic. Color iron-black or dark grayish black. Streak black, inclining to green or brown. Opaque.

Comp. — $CaFe_2(FeOH)(SiO_4)_2$ or $H_2O.CaO.4FeO.Fe_2O_3.4SiO_2$ = Silica 29·3, iron sesquioxide 19·6, iron protoxide 35·2, lime 13·7, water 2·2 = 100. Manganese may replace part of the ferrous iron.

Pyr., etc. — B.B. fuses quietly at 2·5 to a black magnetic bead. With the fluxes reacts for iron. Some varieties give also a reaction for manganese. Gelatinizes with hydrochloric acid.

Obs. — Found on Elba in dolomite; on Mt. Mulatto near Predazzo, Tyrol, Austria, in granite; Schneeberg, Saxony; Fossum, in Norway. In crystals from Siorarsiut, South Greenland. Reported as formerly found at Cumberland, R. I.; also at Milk Row quarry, Somerville, Mass. In fine crystals from South Mountain mine, Owyhee Co., Idaho. Named *Ilvaite* from the Latin name of the island (Elba).

Ardennite. Dewalquite. A vanadio-silicate of aluminium and manganese; also containing arsenic. In prismatic crystals resembling ilvaite. H. = 6–7. G. = 3·620. Yellow to yellowish brown. Index about 1·79. Found at Salm Château in the Ardennes, Belgium.

Långbanite. Manganese silicate with ferrous antimonate; formula doubtful. Rhombohedral-tetartohedral. In iron-black hexagonal prismatic crystals. H. = 6·5. G. = 4·918. Luster metallic. From Långban, Sweden.

The following are rare lead silicates. See also p. 498.

Kentrolite. Probably $3PbO.2Mn_2O_3.3SiO_2$. In minute prismatic crystals; often in sheaf-like forms; also massive. H. = 5. G. = 6·19. Color dark reddish brown; black on the surface. From southern Chile; Långban and Jakobsberg, Sweden; Bena Padru, near Ozieri, Sardinia.

Melanotekite. $3PbO.2Fe_2O_3.3SiO_2$ or $(Fe_4O_3)Pb_3(SiO_4)_3$. Orthorhombic; prismatic. Massive; cleavable. H. = 6·5. G. = 5·73. Luster metallic to greasy. Color black to blackish gray. Occurs with native lead at Långban, Sweden. Also in crystals resembling kentrolite at Hillsboro, N. M.

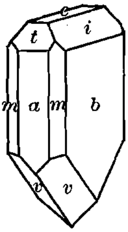
Bertrandite. $H_2Be_4Si_2O_9$ or $H_2O.4BeO.2SiO_2$. Orthorhombic-hemimorphic. In small tabular or prismatic crystals. H. = 6–7. G. = 2·59–2·60. Colorless to pale yellow. Optically −. β = 1·603. Usually occurs in feldspathic veins, often with other beryllium minerals as a result of the alteration of beryl. At the quarries of Barbin near Nantes, France; Pisek, Bohemia; Irkutka Mt., Altai Mts., Russia; Iveland, Southern Norway; Cornwall, England; Mt. Antero, Chaffee Co., Col., with phenacite; Amelia Court-House, Va.; Oxford Co., Me.

CALAMINE. Smithsonite. Hemimorphite.

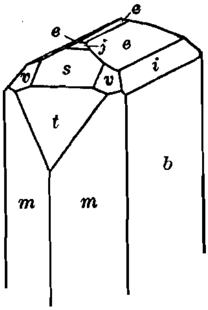
Orthorhombic-hemimorphic. Axes $a : b : c = 0{\cdot}7834 : 1 : 0{\cdot}4778$.

mm''', $110 \wedge 10\bar{1} = 76° \ 9'$.
ss', $101 \wedge \bar{1}01 = 62° \ 46'$.
tt', $301 \wedge \bar{3}01 = 122° \ 41'$.
ee', $011 \wedge 0\bar{1}1 = 51° \ 5'$.
ii', $031 \wedge 0\bar{3}1 = 110° \ 12'$.
vv''', $121 \wedge 1\bar{2}1 = 78° \ 26'$.

912



913



Crystals often tabular || *b* (010); also prismatic; faces *b* vertically striated. Usually implanted and showing one extremity only. Often grouped in sheaf-like forms and forming drusy surfaces in cavities. Also stalactitic, mammillary, botryoidal, and fibrous forms; massive and granular.

Cleavage: *m* (110) perfect; *s* (101) less so; *c* (001) in traces. Fracture uneven to subconchoidal. Brittle. H. = 4·5–5, the latter when crystallized. G. = 3·40–3·50. Luster vitreous; *c* (001) subpearly, sometimes adamantine. Color white; sometimes with a delicate bluish or greenish shade; also yellowish to brown. Streak white. Transparent to translucent. Optically +. 2V = 46°. α = 1·614. β = 1·617. γ = 1·636. Strongly pyroelectric.

Comp. — H_2ZnSiO_5 or $(ZnOH)_2SiO_3$ or $H_2O.2ZnO.SiO_2$ = 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., etc. — In the closed tube decrepitates, whitens, and gives off water. B.B. almost infusible (F. = 6). On charcoal with soda gives a coating which is yellow while hot, and white on cooling. Moistened with cobalt solution, and heated in O.F., this coating assumes a bright green color, but the ignited mineral itself becomes blue. Gelatinizes with acids even when previously ignited.

Diff. — Characterized by its infusibility; reaction for zinc; gelatinization with acids. Resembles some smithsonite (which effervesces with acid), also prehnite.

Obs. — Calamine and smithsonite are usually found associated in veins or beds in stratified calcareous rocks accompanying sulphides of zinc, iron and lead. Thus at Aix-la-Chapelle, Germany; Raibel and Bleiberg, in Carinthia; Moresnet in Belgium; Rezbánya, and Schemnitz, Hungary. At Roughten Gill, in Cumberland; at Alston Moor, white; near Matlock, in Derbyshire; Leadhill, Scotland; at Nerchinsk, in eastern Siberia. From Santa Eulalia, Chihuahua, Mexico.

In the United States occurs at Sterling Hill, near Ogdensburg, N. J., in fine clear crystalline masses. In Pa., at the Perkiomen and Phenixville lead mines; at Friedensville. Abundant in Va., at Austin's mines in Wythe Co. With the zinc deposits of southwestern Missouri, especially about Granby, both as crystallized and massive calamine. Crystals from Leadville, Col.; from Organ Mts., N. M.; Elkhorn Mts., Mon. At the Emma mine, Cottonwood Cañon, Utah.

The name *Calamine* (with *Galmei* of the Germans) is commonly supposed to be a corruption of *Cadmia*. Agricola says it is from *calamus*, a *reed*, in allusion to the slender forms (stalactitic) common in the *cadmia fornacum*.

Use. — An ore of zinc.

Clinohedrite. $H_2CaZnSiO_5$. Monoclinic-clinohedral (see Figs. 352, 353, p. 138). H. = 5·5. G. = 3·33. Colorless or white to amethystine. Index, 1·67. From Franklin, N. J.

Stokesite. — Perhaps $H_4CaSnSi_3O_{11}$. Orthorhombic. Prismatic cleavage. H. = 6. G. = 3·2. Colorless. β = 1·61. From Roscommon Cliff, St. Just, Cornwall.

Carpholite. $H_4MnAl_2Si_2O_{10}$. In radiated and stellated tufts. G. = 2·935. Color straw- to wax-yellow. Biaxial, −. β = 1·63. Occurs at the tin mines of Schlaggenwald, Bohemia; Wippra, in the Harz Mts., on quartz, etc.

Lawsonite. $H_4CaAl_2Si_2O_{10}$. In prismatic orthorhombic crystals; *mm'''*, $110 \wedge 1\bar{1}0 = 67° 16'$. G. = 3·09. Luster vitreous to greasy. Colorless, pale blue to grayish blue. Optically +. β = 1·669. Occurs in crystalline schists of the Tiburn peninsula, Marin Co., Cal.; also in the schists of Pontgibaud, France, and New Caledonia.

Hibschite. Same as for *lawsonite*, $H_4CaAl_2Si_2O_{10}$. In minute isometric crystals, usually octahedrons. H. = 6. G. = 3·0. Colorless or pale yellow. Refractive index, 1·67. Infusible. From the phonolite of Marienberg, Bohemia. Associated with melanite.

Cerite. A silicate of the cerium metals chiefly, with water. Crystals rare; commonly massive; granular. H. = 5·5. G. = 4·86. Color between clove-brown and cherry-red to gray. Indices, 1·83–1·93. Occurs at Bastnäs, near Riddarhyttan, Sweden.

Toernebohmite. A silicate of the cerium metals, chiefly, $R_3(OH)(SiO_4)_2$. Monoclinic? Color, green to olive. β = 1·81. Biaxial, +. Strong dispersion, $\rho < v$. Pleochroic, rose to blue-green. From Bastnäs, near Riddarhyttan, Sweden.

Beckelite. $Ca_3(Ce,La,Di)_4Si_3O_{15}$. Isometric Crystals small, often microscopic. Cubic cleavage. H. = 5. G. = 4·1. Color yellow. Infusible. Occurs with nepheline syenite rocks near Mariupol, Russia.

Hellandite. A basic silicate chiefly of the cerium metals, aluminium, manganese and calcium. Monoclinic. Prismatic habit. H. = 5·5. G. = 3·7. Color brown. Fusible. Found in pegmatite near Kragerö, Norway.

Bazzite. A silicate of scandium with other rare earth metals, iron and a little soda. Hexagonal. In minute prisms, often barrel shaped. H. = 6·5. G. = 2·8. Color azure-blue. Transparent in small individuals. Optically −. Refractive indices, ω = 1·626. ϵ = 1·605. Strongly dichroic, ω = pale greenish yellow, ϵ = azure-blue. Infusible. Insoluble in ordinary acids. Found at Baveno, Italy.

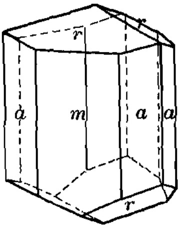
ANGARALITE. $2(Ca,Mg)O.5(Al,Fe)_2O_3.6SiO_2$. In thin tabular hexagonal(?) crystals. G. = 2·62. Color black from carbonaceous impurities. Uniaxial, +. In contact zone of limestone, southern part of Yenisei District, Siberia.

TOURMALINE.

Rhombohedral-hemimorphic. Axis c = 0·4477.

cr, $0001 \wedge 10\bar{1}1 = 27° 20'$. *rr'*, $10\bar{1}1 \wedge \bar{1}101 = 46° 52'$. *uu'*, $32\bar{5}1 \wedge \bar{3}5\bar{2}1 = 66° 1'$.
co, $0001 \wedge 02\bar{2}1 = 45° 57'$. *oo'*, $02\bar{2}1 \wedge \bar{2}021 = 77° 0'$. *uu*^{v}, $32\bar{5}1 \wedge 5\bar{3}\bar{2}1 = 42° 36'$.

914



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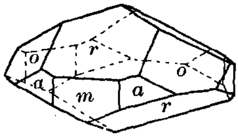

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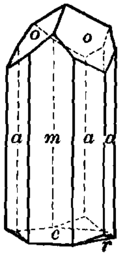

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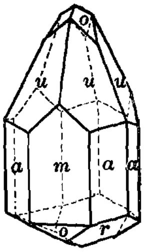

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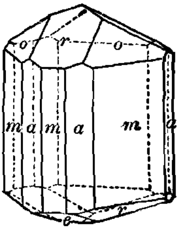

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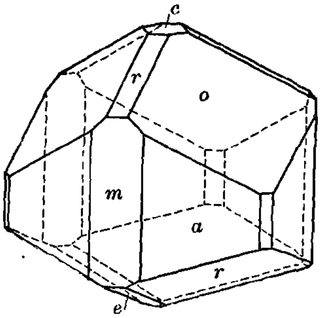

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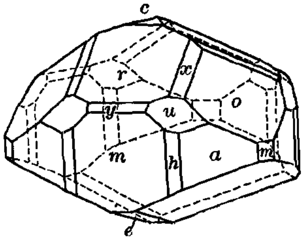
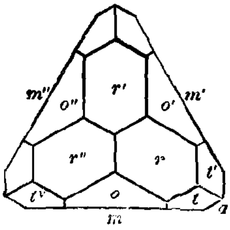


Crystals usually prismatic in habit, often slender to acicular; rarely flattened, the prism nearly wanting. Prismatic faces strongly striated vertically, and the crystals hence often much rounded to barrel-shaped. The cross-section of the prism three-sided (*m*, Fig. 921), six-sided (*a*), or nine-sided (*m* and *a*). Crystals commonly hemimorphic. Sometimes isolated, but more commonly in parallel or radiating groups. Sometimes massive compact; also columnar, coarse or fine, parallel or divergent.

921



Cleavage: *a* $(11\bar{2}0)$, *r* $(10\bar{1}1)$ difficult. Fracture subconchoidal to uneven. Brittle and often rather friable. H. = 7–7·5. G. = 2·98–3·20. Luster vitreous to resinous. Color black, brownish black, bluish black, most common; blue, green, red, and sometimes of rich shades; rarely white or colorless; some specimens red internally and green externally; and others red at one extremity, and green, blue or black at the other; the zonal arrangement of different colors widely various both as to the colors and to crystallographic directions. Streak uncolored. Transparent to opaque.

Strongly dichroic, especially in deep-colored varieties; axial colors varying widely. Absorption for ω much stronger than for ϵ, thus sections $\|$ c axis transmit sensibly the extraordinary ray only, and hence their use (*e.g.*, in the tourmaline tongs (p. 243)) for giving polarized light. Exhibits idiophanous figures (p. 288). Optically −. Birefringence rather high, $\omega - \epsilon = 0{\cdot}02$. Indices: $\omega_y = 1{\cdot}6366$, $\epsilon_y = 1{\cdot}6193$ colorless variety; $\omega_r = 1{\cdot}6435$, $\epsilon_r = 1{\cdot}6222$ blue-green. Sometimes abnormally biaxial. Becomes electric by friction; also strongly pyroelectric.

Var. — *Ordinary*. In crystals as above described; black much the most common. (*a*) *Rubellite;* the red, sometimes transparent; the Siberian is mostly violet-red (*siberite*), the Brazilian rose-red; that of Chesterfield and Goshen, Mass., pale rose-red and opaque; that of Paris, Me., fine ruby-red and transparent. (*b*) *Indicolite*, or *indigolite;* the blue, either pale or bluish black; named from the indigo-blue color. (*c*) *Brazilian Sapphire* (in jewelry); Berlin-blue and transparent. (*d*) *Brazilian Emerald, Chrysolite* (or *Peridot*) *of Brazil;* green and transparent. (*e*) *Peridot of Ceylon;* honey-yellow. (*f*) *Achroite;* colorless tourmaline, from Elba. (*g*) *Aphrizite;* black tourmaline, from Kragerö, Norway. (*h*) *Columnar* and *black;* coarse columnar. Resembles somewhat common hornblende, but has a more resinous fracture, and is without distinct cleavage or anything like a fibrous appearance in the texture; it often has the appearance on a broken surface of some kinds of soft coal.

Comp. — A complex silicate of boron and aluminium, with also either magnesium, iron or the alkali metals prominent. A general formula may be written as $H_9Al_3(B.OH)_2Si_4O_{19}$ (Penfield and Foote) in which the hyrogen may be replaced by the alkalies and also the bivalent elements, Mg,Fe,Ca. Fluorine is commonly present in small amounts.

The varieties based upon composition fall into three prominent groups, between which there are many gradations:

1. ALKALI TOURMALINE. Contains sodium or lithium, or both; also potassium. G. = 3·0–3·1. Color red to green; also colorless. From pegmatites.

2. IRON TOURMALINE. G. = 3·1–3·2. Color usually deep black. Accessory mineral in siliceous igneous rocks and in mica schists, etc.

3. MAGNESIUM TOURMALINE. G. = 3·0–3·09. Usually yellow-brown to brownish black; also colorless. From limestone or dolomite.

A *chromium tourmaline* also occurs. G. = 3·120. Color dark green.

Pyr., etc. — The magnesia varieties fuse rather easily to a white blebby glass or slag; the iron-magnesia varieties fuse with a strong heat to a blebby slag or enamel; the iron varieties fuse with difficulty, or, in some, only on the edges; the iron-magnesia-lithia varieties fuse on the edges, and often with great difficulty, and some are infusible; the lithia varieties are infusible. With the fluxes many varieties give reactions for iron and manganese. Fused with a mixture of potassium bisulphate and fluor-spar gives a distinct reaction for boric acid. Not decomposed by acids. Crystals, especially of the lighter colored varieties, show strong pyroelectricity.

Diff. — Characterized by its crystallization, prismatic forms usual, which are three-, six-, or nine-sided, and often with rhombohedral terminations; massive forms with columnar structure; also by absence of cleavage (unlike amphibole and epidote); in the common black kinds by the coal-like fracture; by hardness; by difficult fusibility (common kinds), compared with garnet and vesuvianite. The boron test is conclusive.

Micro. — Readily distinguished in thin sections by its somewhat high relief; rather strong interference-colors; negative uniaxial character; decided colors in ordinary light in which basal sections often exhibit a zonal structure. Also, especially, by its remarkable absorption when the direction of crystal elongation is ⊥ to the vibration-plane of the lower nicol; this with its lack of cleavage distinguishes it from biotite and amphibole, which alone among rock-making minerals show similar strong absorption.

Obs. — Commonly found in granite and gneisses as a result of fumarole action or of mineralizing gases in the fluid magma, especially in the pegmatite veins associated with such rocks; at the periphery of such masses or in the schists, or altered limestones, gneisses, etc., immediately adjoining them. It marks especially the boundaries of granitic masses, and its associate minerals are those characteristic of such occurrences; quartz, albite, microcline, muscovite, etc. The variety in granular limestone or dolomite is commonly brown; the bluish-black variety sometimes associated with tin ores; the brown with titanium; the lithium variety is often associated with lepidolite. Red or green varieties, or both, occur near Ekaterinburg in the Ural Mts.; Elba; Campolongo in Tessin, Switzerland; Penig, Saxony; also the province Minas Geraes, Brazil; yellow and brown from Ceylon; dark brown varieties from Eibenstock, Saxony; the Zillertal, Tyrol, Austria; black from Arendal, Norway; Snarum and Kragerö, Norway; pale yellowish brown at Windisch Kappel in Carinthia; fine black crystals occur in Cornwall at different localities. Variously colored from Madagascar.

In the United States, in Me. at Paris and Hebron, magnificent red and green tourmalines with lepidolite, etc.; also blue and pink varieties; and at Norway; pink at Rumford, embedded in lepidolite; at Auburn in clear crystals of a delicate pink or lilac with lepidolite, etc.; at Albany, green and black. In Mass., at Chesterfield, red, green, and blue; at Goshen, blue and green; at Norwich, New Braintree and Carlisle, good black crystals. In N. H., Grafton, Acworth; at Orford, brownish black in steatite. In Conn., at Monroe, dark brown in mica-slate; at Haddam, black in mica slate; also fine pink and green; at New Milford, black. In N. Y., near Gouverneur, brown crystals, with tremolite, etc., in granular limestone; black near Port Henry, Essex Co.; near Edenville; splendid black crystals at Pierrepont, St. Lawrence Co.; colorless and glassy at De Kalb; dark brown at McComb. In N. J., at Hamburg and Newton, black and brown crystals in limestone, with spinel; also grass-green crystals in crystalline limestone near Franklin Furnace. In Pa., at Newlin, Chester Co.; near Unionville, yellow; at Chester, fine black; Middletown, black; Marple, green in talc; near New Hope on the Delaware, large black crystals. A chrome variety from the chromite beds in Montgomery Co., Md. In N. C., Alexander Co., in fine black crystals with emerald and hiddenite. In Cal., fine groups of rubellite in lepidolite from Mesa Grande, Pala, etc. in San Diego Co.

In Canada, in the province of Quebec, yellow crystals in limestone at Calumet Falls, Litchfield, Pontiac Co.; at Hunterstown; fine brown crystals at Clarendon, Pontiac Co.; black at Grenville and Argenteuil, Argenteuil Co. In Ontario, in fine crystals at North Burgess, Lanark Co.; Galway and Stoney Lake in Dummer, Peterborough Co.

The name *turmalin* from *Turamali* in Cingalese (applied to zircon by jewelers of Ceylon) was introduced into Holland in 1703, with a lot of gems from Ceylon.

Use. — The variously colored and transparent varieties are used as gem stones; see under "Var." above.

Dumortierite. A basic aluminium borosilicate, perhaps $8Al_2O_3.B_2O_3.6SiO_2.H_2O$ (Schaller). The water and boric oxide have been considered as variable in amount and basic in character with the general formula, $(AlO)_{16}Al_4(SiO_4)_7$ (Ford).

Orthorhombic. Prismatic angle approximately 60°. Usually in fibrous to columnar aggregates. Cleavage: *a* (100), distinct; also prismatic, imperfect. H. = 7. G. = 3·26–3·36. Luster vitreous. Color bright smalt-blue to greenish blue. Transparent to translucent. Pleochroism very strong: *X* deep-blue or nearly colorless, *Y* yellow to red-violet or nearly colorless, *Z* colorless or pistachio-green. Exhibits idiophanous figures, analogous to andalusite. Optically −. Ax. pl. ‖ *b* (010). Bx ⊥ *c* (001). $\alpha = 1·678$. $\beta = 1·686$. $\gamma = 1·689$.

Recognized in thin section by its rather high relief; low interference-colors (like those of quartz); occurrence in slender prisms, needles or fibers, with negative optical extension; parallel extinction; biaxial character and especially by its remarkable pleochroism.

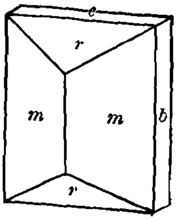
Found embedded in feldspar in blocks of gneiss at Chaponost, near Lyons, France; from Wolfshau, near Schmiedeberg, Silesia; in the iolite of the gneiss of Tvedestrand, Norway; Rio de Janeiro, Brazil. In the United States, it occurs near Harlem, New York Island, in the pegmatoid portion of a biotite-gneiss; in a quartzose rock at Clip, Yuma Co., Arizona; from San Diego Co., Cal.; Woodstock, Wash.

STAUROLITE. Staurotide.

Orthorhombic. Axes $a : b : c = 0·4734 : 1 : 0·6828$.

mm''', $110 \wedge 1\bar{1}0 = 50° 40'$. *cr*, $001 \wedge 101 = 55° 16'$.
rr', $101 \wedge \bar{1}01 = 110° 32'$. *mr*, $110 \wedge 101 = 42° 2'$.

922



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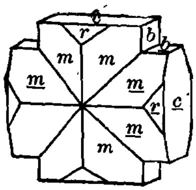

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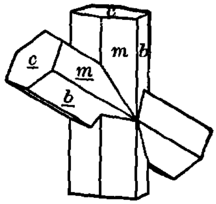
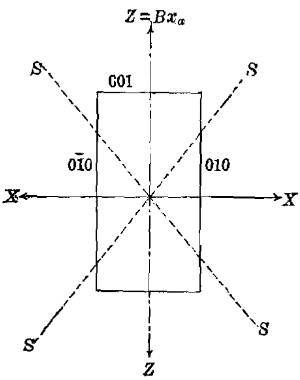


Twins cruciform: tw. pl. *x* (032), the crystals crossing nearly at right angles; tw. pl. *z* (232), crossing at an angle of 60° approximately; tw. pl.

y (230) rare, also in repeated twins (cf. Figs. 397, p. 164; 439, 440, 441, p. 170). Crystals commonly prismatic and flattened || *b* axis; often with rough surfaces.

Cleavage: *b* (010) distinct, but interrupted; *m* (110) in 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 uncolored to grayish. Translucent to nearly or quite opaque. Pleochroism distinct: *Z* (= *c* axis) hyacinth-red to blood-red, *X*, *Y* yellowish red; or *Z* gold-yellow, *X*, *Y* light yellow to colorless. Optically +. Ax. pl. || *a* (100). Bx ⊥ *c* (001). 2V = 88° (approx.). $\alpha = 1{\cdot}736$. $\beta = 1{\cdot}741$. $\gamma = 1{\cdot}746$.

925



Comp. — $HFeAl_5Si_2O_{13}$, which may be written $(AlO)_4(AlOH)Fe(SiO_4)_2$ or $H_2O.2FeO.5Al_2O_3.4SiO_2$ = Silica 26·3, alumina 55·9, iron protoxide 15·8, water 2·0 = 100. Magnesium (also manganese) replaces a little of the ferrous iron; ferric iron part of the aluminium.

Nordmarkite from Nordmark, Sweden, contains manganese in large amounts.

Pyr., etc. — B.B. infusible, excepting the manganesian variety, which fuses easily to a black magnetic glass. With the fluxes gives reactions for iron, and sometimes for manganese. Imperfectly decomposed by sulphuric acid.

Diff. — Characterized by the obtuse prism (unlike andalusite, which is nearly square); by the frequency of twinning forms; by hardness and infusibility.

Micro. — Under the microscope, sections show a decided color (yellow to red or brown) and strong pleochroism (yellow and red); also characterized by strong refraction (high relief), rather bright interference-colors, parallel extinction and biaxial character (generally positive in the direction of elongation). Easily distinguished from rutile (p. 427) by its biaxial character and lower interference-colors.

Obs. — Usually found in crystalline schists, as mica schist, argillaceous schist, and gneiss, as a result of regional or contact metamorphism; often associated with garnet, sillimanite, cyanite, and tourmaline. Sometimes encloses symmetrically arranged carbonaceous impurities like andalusite (p. 524). Other impurities are also often present, especially silica, sometimes up to 30 to 40 p. c.; also garnet, mica, and perhaps magnetite, brookite.

Occurs with cyanite in paragonite schist, at Mt. Campione, Switzerland; in the Zillertal, Tyrol, Austria; Goldenstein in Moravia; Aschaffenburg, Bavaria; in large twin crystals in the mica schists of Brittany and Scotland. In the province of Minas Geraes, Brazil.

Abundant throughout the mica schists of New England. In Me., at Windham. In N. H., brown at Franconia; at Lisbon; on the shores of Mink Pond, loose in the soil. In Mass., at Chesterfield, in fine crystals. In Conn., at Bolton, Vernon, etc.; Southbury with garnets; at Litchfield, black crystals. In N. C., near Franklin, Macon Co.; also in Madison and Clay counties. In Ga., in Fannin Co., loose in the soil in fine crystals. In large crystals from Ducktown, Tenn.

Named from σταυρός, *a cross.*

Use. — Occasionally a transparent stone is cut for a gem.

Kornerupine. Near $MgAl_2SiO_6$. In fibrous to columnar aggregates, resembling sillimanite. H. = 6·5. G. = 3·273 kornerupine; 3·341 prismatine. Colorless to white, or brown. Biaxial, −. Indices, 1·669–1·682.

Kornerupine occurs at Fiskernäs on the west coast of Greenland. *Prismatine* is from Waldheim, Saxony. Found in large clear crystals of a sea-green color and gem quality from near Betroka, Madagascar.

Sapphirine. $Mg_5Al_{12}Si_2O_{27}$. In indistinct tabular crystals. Usually in disseminated grains, or aggregations of grains. H. = 7·5. G. = 3·42–3·48. Color pale to dark blue or green. Biaxial, −. Indices, 1·705–1·711. From Fiskernäs, southwestern Greenland. Occurs near Betroka, Madagascar. From St. Urbain, Quebec.

Grandidierite. A basic silicate of aluminium, ferric iron, magnesium, ferrous iron, etc. Orthorhombic. In elongated crystals. Two cleavages. G. = 3·0. Color bluish green.

β = 1·64. Strongly pleochroic. Found in pegmatite at Andrahomana in southern Madagascar.

Serendibite. $10(Ca,Mg)O.5Al_2O_3.B_2O_3.6SiO_2$. In irregular grains showing polysynthetic twinning; probably monoclinic or triclinic. H. = 6·7. G. = 3·4. Color blue. Pleochroism marked. Refractive index, 1·7. Infusible. From Gangapitiya near Ambakotte, Ceylon.

Silicomagnesiofluorite. A fluosilicate of calcium and magnesium, perhaps, $H_2Ca_4Mg_3Si_2O_7F_{10}$. Radiating fibrous in spherical forms. H. = 2·5. G. = 2·9. Color ash-gray, light greenish or bluish. Fusible. From Lupikko, near Pitkäranta, Finland.

Grothine. A silicate of calcium with aluminium and a little iron of uncertain composition. Orthorhombic. In small tabular crystals. Colorless. Transparent. G. = 3·09. Optically +. Infusible. Decomposed by sulphuric acid. Found with *microsommite* on limestone near Nocera and Sarno, Campagna, Italy.

ALOISIITE. Luigite. A basic silicate containing ferrous oxide, lime, magnesia, and soda. Amorphous. Color, brown to violet. Acts as a cement in a tuff found at Fort Portal, Uganda.

PÖCHITE. $H_{16}Fe_8Mn_2Si_3O_{29}$. Amorphous. H. = 3·5–4. G. = 3·70. Color reddish brown. Opaque. Found in iron ore near Vareš, Bosnia.

SILICATES

Section B. Chiefly Hydrous Species

The SILICATES of this second section include the true hydrous compounds, 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, Talc, Kaolinite — which, while they yield water upon ignition, are without doubt to be taken as acid or basic metasilicates, orthosilicates, etc. Their relation, however, is so close 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 whose 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. Zeolites

II. Mica Division

1. Mica Group. 2. Clintonite Group. 3. Chlorite Group

III. Serpentine and Talc Division

Chiefly Silicates of Magnesium.

IV. Kaolin Division

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 heavy metals, iron, manganese, etc.

I. Zeolite Division

1. *Introductory Subdivision*

Of the species here included, several, as Apophyllite, Okenite, etc., while not strictly ZEOLITES, are closely related to them in composition and method of occurrence. Pectolite (p. 483) and Prehnite (p. 534) are also sometimes classed here.

Inesite. $H_2(Mn,Ca)_6Si_6O_{19}.3H_2O$. Crystals small, prismatic; also fibrous, radiated and spherulitic. H. = 6. G. = 3·029. Color rose- to flesh-red. Occurs at the manganese mines near Dillenburg, Germany. *Rhodotilite* is the same species from the Harstig mine, Pajsberg, Sweden. From Jakobsberg and Långban, Sweden; Villa Corona, Durango, Mexico.

Hillebrandite. $Ca_2SiO_4.H_2O$. Orthorhombic; radiating fibrous. H. = 5·5. G. = 2·7. Refractive index = 1·61. Color white. Fusible with difficulty. Found in contact zone between limestone and diorite in the Velardeña mining district, Mexico.

Crestmoreite. Probably $4H_2CaSiO_4.3H_2O$. Compact. Color, snow-white. H. = 3. G. = 2·2. β = 1·59. An alteration product of *Wilkeite*. From Crestmore, Riverside Co., Cal.

Riversideite. $2CaSiO_5.H_2O$. In compact fibrous veinlets. Silky luster. H. = 3. G. = 2·64. Indices, 1·59–1·60. Easily fusible. From Crestmore, Riverside Co., Cal.

Ganophyllite. $7MnO.Al_2O_3.8SiO_2.6H_2O$. In short prismatic crystals; also foliated, micaceous. Color brown. H. = 4–4·5. G. = 2·84. Biaxial, –. Indices, 1·705–1·730. From the Harstig mine, near Pajsberg, Sweden.

Lotrite. $3(Ca,Mg)O.2(Al,Fe)_2O_3.4SiO_2.2H_2O$. Massive, in an aggregate of small grains and leaves. One cleavage. H. = 7·5. G. = 3·2. Color green. Refractive index, 1·67. Found in small veins in a chlorite schist in the valley of the Lotru, Transylvania.

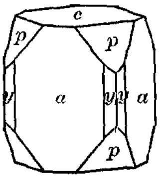
Okenite. $H_2CaSi_2O_6.H_2O$. Commonly fibrous; also compact. H. = 4·5–5. G. = 2·28–2·36. Color white, with a shade of yellow or blue. Biaxial, –. Index, 1·556. Occurs in basalt or related eruptive rocks; as in the Faroe Islands; Iceland; Disko, Niorkornat, etc., Greenland; Poona, India. From Crestmore, Riverside Co., Cal.

Gyrolite. $H_2Ca_2Si_3O_9.H_2O$. Rhombohedral-tetartohedral. In white concretions, lamellar-radiate in structure. Optically –. ω = 1·56. From the Isle of Skye, with stilbite, laumontite, etc.; in India, etc. With apophyllite of New Almaden, California; also Nova Scotia. Found also at various places in Bohemia; from Scotland and the Faroe Islands; São Paulo, Brazil. *Reyerite* from Greenland is similar to gyrolite. *Zeophyllite* is a similar species which may be identical with gyrolite. Rhombohedral. In spherical forms with radiating foliated structure. Perfect basal cleavage. H. = 3. G. = 2·8. Color white. ω = 1·56. From various localities in Bohemia and elsewhere.

APOPHYLLITE.

Tetragonal. Axis c = 1·2515.

926



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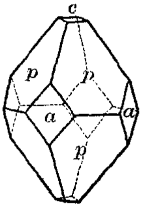

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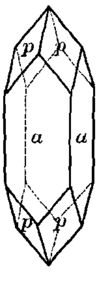

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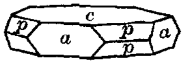


ay, 100 ∧ 310 = 18° 26′.
cp, 001 ∧ 111 = 60° 32′.

ap, 100 ∧ 111 = 52° 0′.
pp′, 111 ∧ $\bar{1}$11 = 76° 0′.

Habit varied; in square prisms (*a* (100)) usually short and terminated by *c* (001) or by *c* and *p* (111), and then resembling a cube or cubo-octahedron;

also acute pyramidal (p (111)) with or without c and a; less often thin tabular || c. Faces c often rough; a bright but vertically striated; p more or less uneven. Also massive and lamellar; rarely concentric radiated.

Cleavage: c (001) highly perfect; m (110) less so. Fracture uneven. Brittle. H. = 4·5–5. G. = 2·3–2·4. Luster of c pearly; of other faces vitreous. Color white, or grayish; occasionally with a greenish, yellowish, or rose-red tint, flesh-red. Transparent; rarely nearly opaque. Birefringence low; usually +, also −. Often shows anomalous optical characters (Art. **429**, Fig. 617). Indices, 1·535–1·537.

Comp. — $H_7KCa_4(SiO_3)_8.4\frac{1}{2}H_2O$ or $K_2O.8CaO.16SiO_2.16H_2O$ = Silica 53·7, lime 25·0, potash 5·2, water 16·1 = 100. A small amount of fluorine replaces part of the oxygen.

The above formula differs but little from $H_2CaSi_2O_6.H_2O$, in which potassium replaces part of the basic hydrogen. The form often accepted, $H_2(Ca,K)Si_2O_6.H_2O$, corresponds less well with the analyses.

Pyr., etc. — In the closed tube exfoliates, whitens, and yields water, which reacts acid. B.B. exfoliates, colors the flame violet (potash), and fuses to a white vesicular enamel. F. = 1·5. Decomposed by hydrochloric acid, with separation of slimy silica.

Diff. — Characterized by its tetragonal form, the square prism and pyramid the common habits; by the perfect basal cleavage and pearly luster on this surface.

Obs. — Occurs commonly as a secondary mineral in basalt and related rocks, with various zeolites, also datolite, pectolite, calcite; also occasionally in cavities in granite, gneiss, etc. Greenland, Iceland, the Faroe Islands, and British India, especially at Poonah, afford fine specimens of apophyllite in amygdaloidal basalt or diabase. Occurs also at Andreasberg, Harz Mts., Germany, of a delicate pink; Radautal in the Harz Mts.; at Orawitza, Hungary, with wollastonite; Utö, Sweden; on the Seisser Alp in Tyrol, Austria; Guanajuato, Mexico, often of a beautiful pink upon amethyst.

In the United States, large crystals occur at Bergen Hill, Paterson, West Paterson, and Great Notch, N. J.; in Pa., at the French Creek mines, Chester Co.; at the Cliff, Phœnix and other mines, Lake Superior region; Table Mt. near Golden, Col.; in Cal., at the mercury mines of New Almaden often stained brown by bitumen; also from Nova Scotia at Cape Blomidon, and other points.

Named by Haüy in allusion to its tendency to exfoliate under the blowpipe, from ἀπὸ and φύλλον, *a leaf*. Its whitish pearly aspect, resembling the eye of a fish after boiling, gave rise to the earlier name *Ichthyophthalmite*, from ἰχθύς, *fish*, ὀφθαλμός, *eye*.

2. Zeolites

The ZEOLITES form a family of well-defined hydrous silicates, closely related to each other in composition, in conditions of formation, and hence in mode of occurrence. They are often with right spoken of as analogous to the Feldspars, like which they are all silicates of aluminium with sodium and calcium chiefly, also rarely barium and strontium; magnesium, 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 ($CaAl_2Si_2O_8$) or a calcium-albite ($CaAl_2Si_6O_{16}$) as shown by Doelter. The Zeolites do not, however, form a single group of species related in crystallization, like the Feldspars, but include a number of independent groups widely diverse in form and distinct in composition; chief among these are the monoclinic PHILLIPSITE GROUP; the rhombohedral CHABAZITE GROUP, and the orthorhombic (and monoclinic) NATROLITE GROUP. A transition in composition between certain end compounds has been more or less well-established in certain cases, but, unlike the Feldspars, with these species calcium and sodium seem to replace one another and an increase in alkali does not necessarily go with an increase in silica.

Like other hydrous silicates they are characterized by inferior hardness, chiefly from 3·5 to 5·5, and the specific gravity 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 gelatinization. The intumescence B.B., which gives the name to the family (from ζεῖν, *to boil*, and λίθος, *stone*) is characteristic of a large part of the 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 elæolite, sodalite, etc.; potash by leucite, etc. The different species of the family are often associated together; also with pectolite and apophyllite (sometimes included with the zeolites), datolite, prehnite and, further, calcite. Many of the zeolites have been produced synthetically by various hydrochemical reactions. In general they appear to have been formed in nature by reactions upon the feldspar or feldspathoid minerals.

Ptilolite. $RAl_2Si_{10}O_{44}.5H_2O$. Here R = Ca : K_2 : Na_2 = 6 : 2 : 1 approx. In short capillary needles, aggregated in delicate tufts. Colorless, white. Biaxial, +. Indices, 1·480–1·485. Occurs upon a bluish chalcedony in cavities in a vesicular augite-andesite found in fragments in the conglomerate beds of Green and Table mountains, Jefferson Co., and from Silver Cliff, Custer Co., Col., also from Elba and Iceland.

Mordenite. $3RAl_2Si_{10}O_{24}.20H_2O$, where R = K_2 : Na_2 : Ca = 1 : 1 : 1. In minute crystals resembling heulandite in habit and angles; also in small hemispherical or reniform concretions with fibrous structure. H. = 3–4. G. = 2·15. Color white, yellowish or pinkish. Occurs near Morden, King's Co., Nova Scotia, in trap; also in western Wyoming near Hoodoo Mt., on the ridge forming the divide between Clark's Fork and the East Fork of the Yellowstone river. Also from Seiseralpe, Tyrol, Austria and the Faroe Islands.

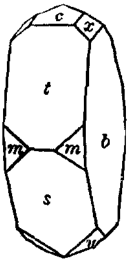
HEULANDITE. Stilbite *some authors.*

Monoclinic. Axes $a : b : c = 0{\cdot}4035 : 1 : 0{\cdot}4293$; $\beta = 88° 34\frac{1}{2}'$.

mm''', $110 \wedge 1\bar{1}0 = 43° 56'$. *cs*, $001 \wedge \bar{2}01 = 66° 0'$.

ct, $001 \wedge 201 = 63° 40'$. *cx*, $001 \wedge 021 = 40° 38\frac{1}{2}'$.

930



Crystals sometimes flattened || *b* (010), the surface of pearly luster (Fig. 930; also Fig. 21, p. 12); form often suggestive of the orthorhombic system. since the angles *cs* and *ct* differ but little. Also in globular forms; granular.

Cleavage: *b* (010) perfect. Fracture subconchoidal to uneven. Brittle. H. = 3·5–4. G. = 2·18–2·22. Luster of *b* strong pearly; of other faces vitreous. Color various shades of white, passing into red, gray and brown. Streak white. Transparent to subtranslucent. Optically +. Ax. pl. and $Bx_a \perp b$ (010). Ax. pl. and Bx_o for some localities nearly || *c* (001); also for others nearly ⊥ *c* in white light. $Bx_o \wedge c$ axis = $+ 57\frac{1}{2}°$. Axial angle variable, from 0° to 92°; usually $2E_r = 52°$. $\alpha = 1{\cdot}498$. $\beta = 1{\cdot}499$. $\gamma = 1{\cdot}505$.

Comp. — $H_4CaAl_2(SiO_3)_6.3H_2O$ or $5H_2O.CaO.Al_2O_3.6SiO_2$ = Silica 59·2, alumina 16·8, lime 9·2, water 14·8 = 100.

Strontia is usually present, sometimes up to 3·6 p. c.

Pyr. — As with stilbite, p. 551.

Obs. — Heulandite occurs principally in basaltic rocks, associated with chabazite, stilbite and other zeolites; also in gneiss, and occasionally in metalliferous veins.

The finest specimens of this species come from Berufiord, and elsewhere in Iceland; the Faroe Islands; in British India, near Bombay; also in railroad cuttings in the Bhor and Thul Ghâts. Also occurs in the Kilpatrick Hills, near Glasgow; on the Island of Skye; Fassatal, Tyrol, Austria; Andreasberg, Harz Mts., Germany; Viesch and elsewhere, Switzerland.

In the United States, in diabase at Bergen Hill, West Paterson and Great Notch, N. J.; on north shore of Lake Superior; with haydenite at Jones's Falls near Baltimore (*beaumontite*), Md. At Peter's Point, Nova Scotia; also at Cape Blomidon, and other points.

Named after the English mineralogical collector, H. Heuland, whose cabinet was the basis of the classical work (1837) of Lévy.

Brewsterite. $H_4(Sr,Ba,Ca)Al_2(SiO_3)_6.3H_2O$. In prismatic crystals. H. = 5. G. = 2·45. Color white, inclining to yellow and gray. Biaxial, +. Index, 1·45. From Strontian in Argyleshire, Scotland; near Freiburg in Breisgau, Germany.

Epistilbite. Probably like heulandite, $H_4CaAl_2(SiO_3)_6.3H_2O$. Crystals monoclinic, uniformly twins; habit prismatic. In radiated spherical aggregations; also granular. G. = 2·25. Color white. Biaxial, −. Indices, 1·502–1·512. Occurs with scolecite at the Berufiord, Iceland; the Faroe Islands; Poona, India; in small reddish crystals, at Margaretville, Nova Scotia, etc. *Reissite* is from Santorin Island.

Phillipsite Group. Monoclinic

		$a : b : c$	β
Wellsite	$(Ba,Ca,K_2)Al_2Si_3O_{10}.3H_2O$	0·768 : 1 : 1·245	53° 27′
Phillipsite	$(K_2,Ca)Al_2Si_4O_{12}.4\frac{1}{2}H_2O$	0·7095 : 1 : 1·2563	55° 37′
Harmotome	$(K_2,Ba)Al_2Si_5O_{14}.5H_2O$	0·7032 : 1 : 1·2310	55° 10′
Stilbite	$(Na_2,Ca)Al_2Si_6O_{16}.6H_2O$	0·7623 : 1 : 1·1940	50° 50′

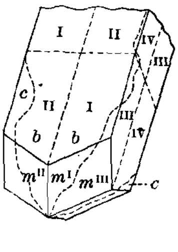
The above species, while crystallizing in the monoclinic system, are remarkable for the pseudo-symmetry exhibited by their twinned forms. Certain of these twins are pseudo-orthorhombic, others pseudo-tetragonal and more complex twins even pseudo-isometric.

Fresenius has shown that the species of this group may be regarded as forming a series, in which the ratio of RO : Al_2O_3 is constant (= 1 : 1), and that of SiO_2 : H_2O also chiefly 1 : 1. The end compounds assumed by him are:

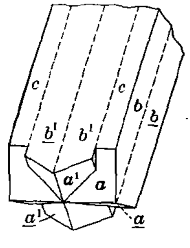
$$RAl_2Si_6O_{16}.6H_2O; \qquad R_2Al_4Si_4O_{16}.6H_2O.$$

Here R = Ca chiefly, in phillipsite and stilbite, Ba in harmotome, while in wellsite Ba, Ca, and K_2 are present; also in smaller amounts Na_2, Sr_2. The first of the above compounds may be regarded as a hydrated calcium albite, the second as a hydrated anorthite. Pratt and Foote, however, show that the anorthite end compound more probably has the formula $RAl_2Si_2O_8.2H_2O$ (or this doubled). The formulas given beyond are those corresponding to reliable analyses of certain typical occurrences.

931



932



Wellsite. $RAl_2Si_3O_{10}.3H_2O$ with R = Ca : Ba : K_2 = 3 : 1 : 3; Sr and Na also present in small amount. Percentage composition: SiO_2 42·9, Al_2O_3 24·3, BaO 6·6, CaO 7·3, K_2O 6·1, H_2O 12·8 = 100. Monoclinic (axes above); in complex twins, analogous to those of phillipsite and harmotome (Figs. 931, 932). Brittle. No cleavage. H. = 4–4·5. G. = 2·278–2·366. Luster vitreous. Colorless to white. Optically +. Bx ⊥ b (010). Birefringence weak.

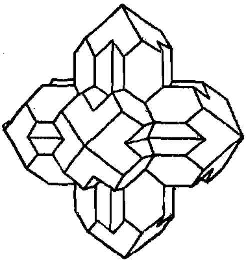
Occurs at the Buck Creek (Cullakanee) corundum mine in Clay Co., N. C.; in isolated crystals attached to feldspar, also to hornblende and corundum; intimately associated with chabazite. Also found at Kurzy near Simferopol, Crimea, Russia.

PHILLIPSITE.

Monoclinic. Axes $a : b : c = 0{\cdot}7095 : 1 : 1{\cdot}2563$; $\beta = 55° 37'$.

mm''', $110 \wedge 1\bar{1}0 = 60° 42'$. *cm*, $001 \wedge 110 = 60° 50'$.
af, $100 \wedge \bar{1}01 = 34° 23'$. *ee'*, $011 \wedge 0\bar{1}1 = 92° 4'$.

933



Crystals uniformly penetration-twins, but often simulating orthorhombic or tetragonal forms. Twins sometimes, but rarely, simple (1) with tw. pl. *c* (001), and then cruciform so that diagonal parts on *b* (010) belong together, hence a fourfold striation, || edge *b/m*, may be often observed on *b*. (2) Double twins, the simple twins just noted united with *e* (011) as tw. pl., and, since *ee'* varies but little from 90°, the result is a nearly square prism, terminated by what appear to be pyramidal faces each with a double series of striations away from the medial line. See Figs. 452–454, p. 172; also Fig. 400, p. 164. Faces *b* (010) often finely striated as just noted, but striations sometimes absent and in general not so distinct as with harmotome; also *m* (110) striated || edge *b/m*. Crystals either isolated, or grouped in tufts or spheres, radiated within and bristled with angles at surface.

Cleavage: *c* (001), *b* (010), rather distinct. Fracture uneven. Brittle. H. = 4–4·5. G. = 2·2. Luster vitreous. Color white, sometimes reddish. Streak uncolored. Translucent to opaque. Optically +. Ax. pl. and Bx_o ⊥ *b* (010). The ax. pl. lies in the obtuse angle of the *a–c* axes, and is usually inclined to *a* axis about 15° to 20°, or 75° to 70° to the normal to *c* (001). The position, however, is variable. $2H_{a.r} = 71°–84°$. Indices, 1·48–1·57.

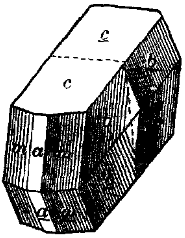
Comp. — In some cases the formula is $(K_2,Ca)Al_2Si_4O_{12}.4H_2O$ = Silica 48·8, alumina 20·7, lime 7·6, potash 6·4, water 16·5 = 100. Here Ca : K_2 = 2 : 1.

Pyr., etc. — B.B. crumbles and fuses at 3 to a white enamel. Gelatinizes with hydrochloric acid.

Obs. — In translucent crystals in basalt, at the Giant's Causeway, Ireland; at Capo di Bove, near Rome; Aci Castello and elsewhere in Sicily; among the lavas of Mte. Somma, Vesuvius; in Germany at Stempel, near Marburg; Annerod, near Giessen; in the Kaiserstuhl, with faujasite, at Salesl, Bohemia; in the ancient lavas of the Puy-de-Dôme, France; from Richmond, Victoria. *Pseudophillipsite*, found near Rome, Italy, differs from phillipsite only in the manner in which it loses water on heating.

HARMOTOME.

934



Monoclinic. Axes $a : b : c = 0{\cdot}7031 : 1 : 1{\cdot}2310$; $\beta = 55° 10'$.

Crystals uniformly cruciform penetration-twins with *c* (001) as tw. pl.; either (1) simple twins (Fig. 934) or (2) united as fourlings with tw. pl. *e* (011). These double twins often have the aspect of a square prism with diagonal pyramid, the latter with characteristic feather-like striations from the medial line. Also in more complex groups analogous to those of phillipsite.

Cleavage: *b* (010) easy, *c* (001) less so. Fracture uneven to subconchoidal. Brittle. H. = 4·5. G. = 2·44–2·50. Luster vitreous. Color white; passing into gray, yellow, red or brown. Streak white. Subtransparent to translucent.

Ax. pl. and $Bx_a \perp b$ (010). Ax. pl. in obtuse angle a–c axes and inclined about 65° to a axis and 60° to c axis. Optically +. $2V = 43°$. $\alpha = 1{\cdot}503$. $\beta = 1{\cdot}505$. $\gamma = 1{\cdot}508$.

Comp. — In part $H_2(K_2,Ba)Al_2Si_5O_{15}.4H_2O$ or $(K_2,Ba)O.Al_2O_3.5SiO_2.5H_2O$ = Silica 47·1, alumina 16·0, baryta 20·6, potash 2·1, water 14·1 = 100.

Pyr., etc. — B.B. whitens, then crumbles and fuses without intumescence at 3·5 to a white translucent glass. Some varieties phosphoresce when heated. Decomposed by hydrochloric acid without gelatinizing.

Obs. — Occurs in basalt and similar eruptive rocks, also phonolite, trachyte; not infrequently on gneiss, and in some metalliferous veins. At Strontian, in Scotland; in a metalliferous vein at Andreasberg in the Harz Mts., Germany; at Rudelstadt, Silesia; Oberstein, Germany, on agate in siliceous geodes; at Kongsberg, Norway.

In the United States, in small brown crystals with stilbite on the gneiss of New York Island; near Port Arthur, Lake Superior.

Named from ἁρμός, *joint*, and τέμνειν, *to cut*, alluding to the fact that the pyramid (made by the prismatic faces in twinning position) divides parallel to the plane that passes through the terminal edges.

STILBITE. Desmine.

Monoclinic. Axes $a : b : c = 0{\cdot}7623 : 1 : 1{\cdot}1940$; $\beta = 50° 50'$.

Crystals uniformly cruciform penetration-twins with tw. pl. c (001), analogous to phillipsite and harmotome. The apparent form a rhombic pyramid whose faces are in fact formed by the prism faces of the two individuals; the vertical faces being then the pinacoids b (010) and c (001) (cf. Figs. 613–615, p. 299). Usually thin tabular || b (010). These compound crystals are often grouped in nearly parallel position, forming sheaf-like aggregates with the side face (b), showing its characteristic pearly luster, often deeply depressed. Also divergent or radiated; sometimes globular and thin lamellar-columnar.

935

Cleavage: b (010) perfect. Fracture uneven. Brittle. H. = 3·5–4. G. = 2·094–2·205. Luster vitreous; of b (010) pearly. Color white; occasionally yellow, brown or red, to brick-red. Streak uncolored. Transparent to translucent. Optically −. Ax. pl. || b (010). Bx_a inclined 5° to axis a in obtuse angle a–c axes; hence $Bx_a \wedge c$ axis $= -55° 50'$. $2V = 33°$ (approx.). $\alpha = 1{\cdot}494$. $\beta = 1{\cdot}498$. $\gamma = 1{\cdot}500$.

Comp. — For most varieties $H_4(Na_2,Ca)Al_2Si_6O_{18}.4H_2O$ or $(Na_2,Ca)O.Al_2O_3.6SiO_2.6H_2O$ = Silica 57·4, alumina 16·3, lime 7·7, soda 1·4, water 17·2 = 100. Here $Ca : Na_2 = 6 : 1$.

Some kinds show a lower percentage of silica, and these have been called *hypostilbite.*

Pyr., etc. — B.B. exfoliates, swells up, curves into fan-like or vermicular forms, and fuses to a white enamel. F. = 2–2·5. Decomposed by hydrochloric acid, without gelatinizing.

Diff. — Characterized by the frequency of radiating or sheaf-like forms; by the pearly luster on the clinopinacoid. Does not gelatinize with acids.

Obs. — Stilbite occurs mostly in cavities in amygdaloidal basalt, and similar rocks. It is also found in some metalliferous veins, and in granite and gneiss.

Abundant on the Faroe Islands; in Iceland; on the Isle of Skye, in amygdaloid; also in Dumbartonshire, Scotland, in red crystals; the Giant's Causeway, Ireland; at Andreasberg in the Harz Mts., Germany, and Kongsberg and Arendal in Norway, with iron ore; on the Seisser Alp in Tyrol, Austria, and at the Puflerloch (*puflerite*); on the granite of Striegau, Silesia. A common mineral in the Deccan trap area of British India.

In North America, sparingly in small crystals at Chester and at the Somerville syenite quarries, Mass.; at Phillipstown, N. Y.; and at Bergen Hill, West Paterson and Great Notch, N. J.; also at the Michipicoten Islands, Lake Superior. In Nova Scotia at Partridge Island, also at Isle Haute, Two Islands, Digby Neck, Cape Blomidon, etc.

The name *stilbite* is from στίλβη, *luster*, and *desmine* from δέσμη, *a bundle.*

Flokite. $H_8(Ca,Na_2)Al_2Si_9O_{26}.2H_2O$. Monoclinic. In slender prismatic crystals. Perfect cleavages parallel to (100) and (010). H. = 5. G. = 2·10. Colorless and transparent. Indices, 1·472–1·474. Fuses with intumescence. From Iceland.

Gismondite. Perhaps $CaAl_2Si_2O_8.4H_2O$. In pyramidal crystals, pseudo-tetragonal. H. = 4·5. G. = 2·265. Colorless or white, bluish white, grayish, reddish. Biaxial, –. Index, 1·539. Occurs in the leucitophyre of Mt. Albano, near Rome, at Capo di Bove, and elsewhere, etc.; on the Gorner glacier, near Zermatt, Switzerland; Schlauroth near Görlitz in Silesia; Salesl, Bohemia, etc.

LAUMONTITE. Leonhardite. Caporcianite.

Monoclinic. Axes $a : b : c = 1·1451 : 1 : 0·5906$; $\beta = 68° 46'$.

Twins: tw. pl. *a* (100). Common form the prism *m* (mm''' $110 \wedge 1\bar{1}0 = 93° 44'$) with oblique termination *e*, $\bar{2}01$ (ce $001 \wedge \bar{2}01 = 56° 55'$). Also columnar, radiating and divergent.

Cleavage: *b* (010) and *m* (110) very perfect; *a* (100) imperfect. Fracture uneven. Not very brittle. H. = 3·5–4. G. = 2·25–2·36. Luster vitreous, inclining to pearly upon the faces of cleavage. Color white, passing into yellow or gray, sometimes red. Streak uncolored. Transparent to translucent; becoming opaque and usually pulverulent on exposure. Optically –. Ax. pl. ∥ *b* (010). $Bx_a \wedge c$ axis = + 65° to 70°. Dispersion large, $\rho < v$; inclined, slight. $2E_r = 52° 24'$. $\alpha = 1·513$. $\beta = 1·524$. $\gamma = 1·525$.

Comp. — $H_4CaAl_2Si_4O_{14}.2H_2O = 4H_2O.CaO.Al_2O_3.4SiO_2$ = Silica 51·1, alumina 21·7, lime 11·9, water 15·3 = 100.

Var. — *Leonhardite* is a laumontite which has lost part of its water (to one molecule), and the same is probably true of *caporcianite*. *Schneiderite* is laumontite from the serpentine of Monte Catini, Italy, which has undergone alteration through the action of magnesian solutions.

Pyr., etc. — B.B. swells up and fuses at 2·5–3 to a white enamel. Gelatinizes 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 Faroe Islands; Disko in Greenland; in Bohemia, at Eule in clay slate; St. Gothard in Switzerland; Baveno, Italy; Nagyag, Transylvania; the Fassatal, Tyrol, Austria; the Kilpatrick hills, near Glasgow, Scotland; the Hebrides, and the north of Ireland. In India, in the Deccan trap area, at Poona, etc.

Peter's Point, Nova Scotia, affords fine specimens of this species. Found at Phippsburg, Me. Abundant in many places in the copper veins of Lake Superior in trap, and on Isle Royale; on north shore of Lake Superior, between Pigeon Bay and Fond du Lac. Found also at Bergen Hill, N. J.; at the Tilly Foster iron mine, Brewster, N. Y.

Laubanite. $Ca_2Al_2Si_5O_{16}.6H_2O$. Resembles stilbite. H. = 4·5–5. G. = 2·23. Color snow-white. Occurs upon phillipsite in basalt at Lauban, Silesia.

Chabazite Group. Rhombohedral

		rr'	c	
Chabazite	$(Ca,Na_2)Al_2Si_4O_{12}.6H_2O$	85° 14'	1·0860	
Gmelinite	$(Na_2Ca)Al_2Si_4O_{12}.6H_2O$	68° 8'	0·7345	or $\frac{3}{2}c = 1·1017$
Levynite	$CaAl_2Si_3O_{10}.5H_2O$	73° 56'	0·8357	$\frac{4}{3}c = 1·1143$

The Chabazite Group includes these three rhombohedral species. The fundamental rhombohedrons have different angles, but, as shown in the axial ratios above, they are closely related, since, taking the rhombohedron of Chabazite as the basis, that of Gmelinite has the symbol $(20\bar{2}3)$ and of Levynite $(30\bar{3}4)$.

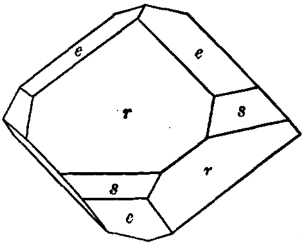
The variation in composition often observed in the first two species has led to the rather plausible hypothesis that they are to be viewed as isomorphous mixtures of the feldspar-like compounds

$(Ca,Na_2)Al_2Si_2O_8.4H_2O$, $(Ca,Na_2)Al_2Si_6O_{16}.8H_2O$.

CHABAZITE.

Rhombohedral. Axis $c = 1{\cdot}0860$; $0001 \wedge 10\bar{1}1 = 51° 25\frac{3}{4}'$.

936



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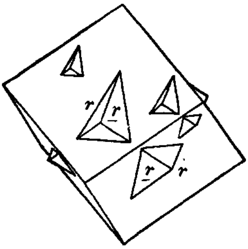

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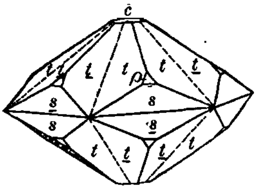


Phacolite

Twins: (1) tw. axis c axis, penetration-twins common. (2) Tw. pl. r ($10\bar{1}1$); contact-twins, rare. Form commonly the simple rhombohedron varying little in angle from a cube (rr' $1\bar{1}01 \wedge \bar{1}101 = 85° 14'$); also r and e ($01\bar{1}2$), ($ee' = 54° 47'$). Also in complex twins. Also amorphous.

Cleavage: r ($10\bar{1}1$) 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 + (Andreasberg, also *haydenite*). 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 1·5.

Var. — 1. *Ordinary.* The most common form is the fundamental rhombohedron, in which the angle is so near 90° that the crystals were at first mistaken for cubes. *Acadialite,* from Nova Scotia (*Acadia* of the French of 18th century), is a reddish chabazite; sometimes nearly colorless. *Haydenite* is a yellowish variety in small crystals from Jones's Falls, near Baltimore, Md. 2. *Phacolite* is a colorless variety occurring in twins of hexagonal form (Fig. 938), and lenticular in shape (whence the name, from φακός, *a bean*); the original was from Leipa in Bohemia. Here belongs also *herschelite* (seebachite) from Richmond, Victoria; the composite twins of great variety and beauty. Probably also the original herschelite from Sicily. It occurs in flat, almost tabular, hexagonal prisms with rounded terminations divided into six sectors.

Comp. — Somewhat uncertain, since a rather wide variation is often noted even among specimens from the same locality. The ratio of $(Ca,Na_2,K_2) : Al$ is nearly constant (= 1 : 1), but of $Al_2 : Si$ varies from 1 : 3 to 1 : 5; the water also increases with the increase in silica. The composition usually corresponds to $(Ca,Na_2)Al_2Si_4O_{12}.6H_2O$, which, if calcium alone is present, requires: Silica 47·4, alumina 20·2, lime 11·1, water 21·3 = 100. If $Ca : Na_2 = 1 : 1$, the percentage composition is: Silica 47·2, alumina 20·0, lime 5·5, soda 6·1, water 21·2 = 100.

Potassium is present in small amount, also sometimes, barium and strontium. Streng explains the supposed facts most satisfactorily by the hypothesis that the members of the group are isomorphous mixtures analogous to the feldspars, as noted above.

Pyr., etc. — B.B. intumesces and fuses to a blebby glass, nearly opaque. Decomposed by hydrochloric acid, with separation of slimy silica.

Diff. — Characterized by rhombohedral form (resembling a cube). It is harder than calcite and does not effervesce with acid; unlike calcite and fluorite in cleavage; fuses B.B. with intumescence unlike analcite.

Obs. — Occurs mostly in basaltic rocks, and occasionally in gneiss, syenite, mica schist, hornblendic schist. Occurs at the Faroe Islands, Greenland, and Iceland, associated with chlorite and stilbite; at Aussig in Bohemia; in Germany at Oberstein, with harmotome, and at Annerod, near Giessen; at the Giant's Causeway, Antrim, Ireland, and Renfrewshire, Scotland; Isle of Skye, etc. In Australia (*phacolite*) at Richmond, near Melbourne, etc.

In the United States, in syenite at Somerville, Mass.; at Bergen Hill and West Paterson, N. J., in crystals; at Jones's Falls near Baltimore, Md. (*haydenite*). In Nova Scotia, wine yellow or flesh-red (the last the *acadialite*), associated with heulandite, analcite and calcite, at Five Islands, Swan's Creek, Digby Neck, Two Islands, Wasson's Bluff, etc.

The name *chabazite* is from χαβάζιος, an ancient name of a stone.

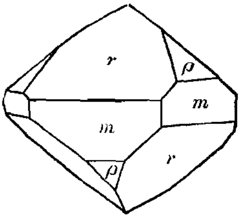
GMELINITE.

Rhombohedral. Axis $c = 0·7345$.

Crystals usually hexagonal in aspect; sometimes ρ $(01\bar{1}1)$ smaller than $r(10\bar{1}1)$, and habit rhombohedral; rr' $10\bar{1}1 \wedge \bar{1}101 = 68° 8'$, $r\rho$ $10\bar{1}1 \wedge 01\bar{1}1 = 37° 44'$.

Cleavage: m $(10\bar{1}0)$ easy; $c\,(0001)$ sometimes distinct. Fracture uneven. Brittle. H. = 4·5. G. = 2·04–2·17. Luster vitreous. Colorless, yellowish white, greenish white, reddish white, flesh-red. Transparent to translucent. Optically positive, also negative. Birefringence very low. Interference-figure often disturbed, and basal sections divided optically into sections analogous to chabazite. Mean refractive index, 1·47.

939



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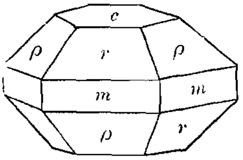


Comp. — In part $(Na_2,Ca)Al_2Si_4O_{12}.6H_2O$. If sodium alone is present this requires: Silica 46·9, alumina 19·9, soda 12·1, water 21·1 = 100. See also p. 552.

Pyr., etc. — B.B. fuses easily (F. = 2·5–3) to a white enamel. Decomposed by hydrochloric acid with separation of silica.

Obs. — Occurs in flesh-red crystals in amygdaloidal rocks at Montecchio Maggiore, Italy; at Andreasberg, Germany; in Transylvania; Antrim, Ireland; Talisker in Isle of Skye, in large colorless crystals. In Australia at Flinders, Victoria.

In the United States in fine white crystals at Bergen Hill, Great Notch and Paterson, N. J. At Cape Blomidon, Nova Scotia (*ledererite*); also at Two Islands and Five Islands.

Named *Gmelinite* after Prof. Gmelin of Tübingen (1792–1860).

Levynite. $CaAl_2Si_3O_{10}.5H_2O$. In rhombohedral crystals. H. = 4–4·5. G. = 2·09–2·16. Colorless, white, grayish, reddish, yellowish. Optically −. $\omega = 1·50$. Found at Glenarm and at Island Magee, Antrim, Ireland; at Dalsnypen, Faroe Islands, in Iceland; in East Greenland; in the basalt of Table Mountain near Golden, Col.

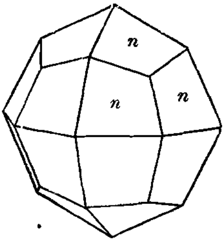
Offretite. A potash zeolite, related to the species of the chabazite group. In basalt of Mont Simiouse, France.

ANALCITE. Analcime.

Isometric. Usually in trapezohedrons; also cubes with faces n (211); again the cubic faces replaced by a vicinal trisoctahedron. Sometimes in composite groups about a single crystal as nucleus (Fig. 389, p. 161). Also massive granular; compact with concentric structure.

Cleavage: cubic, in traces. Fracture subconchoidal. Brittle. H. = 5–5·5. G. = 2·22–2·29. 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. **429**). $n = 1·4874$.

941



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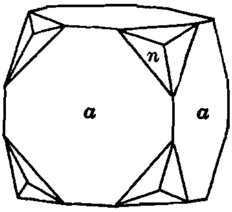


Comp. — $NaAlSi_2O_6H_2O$ = $Na_2O.Al_2O_3.4SiO_2.2H_2O$ = Silica 54.5, alumina 23·2, soda 14·1, water 8·2 = 100.

Analyses show always a varying excess of silica and water above amounts required by formula. It has been assumed that a molecule containing the acid $H_2Si_2O_5$ is present in soild solution in small amounts.

Pyr., etc. — Yields water in the closed tube. B.B. fuses at 2·5 to a colorless glass. Gelatinizes with hydrochloric acid.

Diff. — Characterized by trapezohedral form, but is softer than garnet, and yields water B.B., unlike leucite (which is also infusible); fuses without intumescence to a clear glass unlike chabazite. From leucite and sodalite surely distinguished only by chemical tests, i.e., absence of chlorine in the nitric-acid test (see sodalite, p. 502), absence of much potash and abundance of soda in the solution, and evolution of much water from the powder in a closed glass tube below a red heat.

Micro. — Recognized in thin sections by its very low relief and isotropic character; often shows optical anomalies.

Obs. — Occurs frequently with other zeolites, also prehnite, calcite, etc., in cavities and seams in basic igneous rocks, as basalt, diabase, etc.; also in granite, gneiss, etc. Recently shown to be also a rather widespread component of the groundmass of various basic igneous rocks, at times being the only alkali-alumina silicate present, as in the so-called analcite-basalts. Has been held in such cases to be a primary mineral produced by the crystallization of a magma containing considerable soda and water vapor held under pressure.

The Cyclopean Islands, near Catania, Sicily, afford pellucid crystals; also the Fassatal in Tyrol, Austria; other localities are, in Scotland, in the Kilpatrick Hills; Co. Antrim, etc., in Ireland; the Faroe Islands; Iceland; near Aussig, Bohemia; at Arendal, Norway, in beds of iron ore; at Andreasberg, in the Harz Mts., Germany, in silver mines.

In the United States, occurs at Bergen Hill and West Paterson, N. J.; in gneiss near Yonkers, Westchester Co., N. Y.; abundant in fine crystals with prehnite, datolite, and calcite, in the Lake Superior region; at Table Mt. near Golden, Col., with other zeolites. Nova Scotia affords fine specimens.

The name *analcime* is from ἀναλκις, *weak*, and alludes to its weak electric power when heated or rubbed. The correct derivative is *analcite*, as here adopted for the species.

Faujasite. Perhaps $H_4Na_2CaAl_4Si_{10}O_{38}.18H_2O$.
In isometric octahedrons. H. = 5. G. = 1·923. Colorless, white. $n = 1·48$. Occurs with augite in the limburgite of Sasbach in the Kaiserstuhl, Baden, Germany, etc.

Edingtonite. Perhaps $BaAl_2Si_3O_{10}.3H_2O$. Crystals pyramidal in habit (orthorhombic, pseudo-tetragonal); also massive. H. = 4–4·5. G. = 2·694. White, grayish white, pink. Optically −. Indices, 1·538–1·554. Occurs in the Kilpatrick Hills, near Glasgow, Scotland, with harmotome. From Böhlet, Sweden.

Natrolite Group. Orthorhombic and Monoclinic

		$a : b : c$	
Natrolite	$Na_2Al_2Si_3O_{10}.2H_2O$	0·9785 : 1 : 0·3536	
		$a : b : c$	β
Scolecite	$Ca(AlOH)_2(SiO_3)_3.2H_2O$	0·9764 : 1 : 0·3434	89° 18′
Mesolite	$\begin{cases} Na_2Al_2Si_3O_{10}.2H_2O \\ 2[CaAl_2Si_3O_{10}.3H_2O] \end{cases}$		

The three species of the NATROLITE GROUP agree closely in angle, though varying in crystalline system; Natrolite is orthorhombic usually, also rarely monoclinic; Scolecite is monoclinic, perhaps also in part triclinic; Mesolite seems to be both monoclinic and triclinic. Fibrous, radiating or divergent groups are common to all these species.

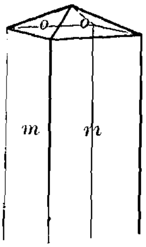
The Natrolite Group includes the sodium silicate, Natrolite, with the empirical formula $Na_2Al_2Si_3O_{10}.2H_2O$; the calcium silicate, Scolecite, $CaAl_2Si_3O_{10}.3H_2O$; also Mesolite intermediate between these and corresponding to $\left\{\begin{array}{l} mNa_2Al_2Si_3O_{10}.2H_2O \\ nCaAl_2Si_3O_{10}.3H_2O. \end{array}\right.$

NATROLITE.

Orthorhombic.* Axes $a : b : c = 0·9785 : 1 : 0·3536$.

mm''', $110 \wedge 1\bar{1}0 = 88° 45\frac{1}{2}'$.
mo, $110 \wedge 111 = 63° 11'$.
oo', $111 \wedge \bar{1}11 = 37° 38'$.
oo''', $111 \wedge 1\bar{1}1 = 36° 47\frac{1}{2}'$.

943



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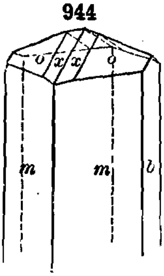

Crystals prismatic, usually very slender to acicular; frequently divergent, or in stellate groups. Also fibrous, radiating, massive, granular, or compact.

Cleavage: m (110) perfect; b (010) imperfect, perhaps only a plane of parting. Fracture uneven. H. = 5–5·5. G. = 2·20–2·25. Luster vitreous, sometimes inclining to pearly, especially in fibrous varieties. Color white, or colorless; to grayish, yellowish, reddish to red. Transparent to translucent. Optically +. Ax. pl. $\parallel$ b (010). Bx $\perp$ c (001). 2V = 63°. $\alpha = 1·480$. $\beta = 1·482$. $\gamma = 1·493$.

Var. — *Ordinary.* Commonly either (*a*) in groups of slender colorless prismatic crystals, varying but little in angle from square prisms, often acicular, or (*b*) in fibrous divergent or radiated masses, vitreous in luster, or but slightly pearly (these radiated forms often resemble those of thomsonite and pectolite); often also (*c*) solid amygdules, usually radiated fibrous, and somewhat silky in luster within; (*d*) rarely compact massive. *Galactite* is ordinarily natrolite, in colorless needles from southern Scotland.

Bergmannite, spreustein, brevicite, are names which have been given to the natrolite from the augite-syenite of southern Norway, on the Langesund fiord, in the "Brevik" region, where it occurs fibrous, massive, and in long prismatic crystallizations, and from white to red in color. Derived in part from elæolite, in part from sodalite. *Iron-natrolite* is a dark green opaque variety, either crystalline or amorphous, from the Brevik region; the iron is due to inclusions.

Comp. — $Na_2Al_2Si_3O_{10}.2H_2O$ or $Na_2O.Al_2O_3.3SiO_2.2H_2O$ = Silica 47·4, alumina 26·8, Na_2O 16·3, water 9·5 = 100.

Pyr., etc. — In the closed tube whitens and becomes opaque. B.B. fuses quietly at 2 to a colorless glass. Fusible in the flame of an ordinary wax candle. Gelatinizes with acids.

Diff. — Distinguished from aragonite and pectolite by its easy fusibility and gelatinization with acid.

Obs. — Occurs in cavities in amygdaloidal basalt, and other related igneous rocks; sometimes in seams in granite, gneiss, and syenite. Found at Aussig and Teplitz in Bohemia; in fine crystals in Auvergne, France; Fassatal, Tyrol, Austria; Kapnik, Hungary. In red amygdules (*crocalite*) in amygdaloid of Ireland, Scotland and Tyrol; the amygdaloid of Bishopton, Scotland (*galactite*) and at Glen Farg (*fargite*) in Fifeshire. Common in the augite-syenite of the Langesund fiord, near Brevik, southern Norway. From various localities in Greenland.

In North America, in the trap of Nova Scotia; at Bergen Hill and West Paterson, N. J.; at Copper Falls, Lake Superior; from benitoite locality, San Benito Co., Cal.

Named *Mesotype* by Haüy, from *μέσος, middle,* and *τύπος, type,* because the form of the crystal — in his view a square prism — was intermediate between the forms of stilbite

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* In rare cases the crystals seem to be monoclinic.

and analcite. *Natrolite*, of Klaproth, is from *natron, soda;* it alludes to the presence of soda, whence also the name *soda-mesotype,* in contrast with scolecite, or *lime-mesotype.*

SCOLECITE.

Monoclinic. Axes $a : b : c$ = 0·9764 : 1 : 0·3434; β = 89° 18′.

Crystals slender prismatic (mm''' 110 $\wedge$ $1\bar{1}0$ = 88° 37½′), twins showing a feather-like striation on b (010), diverging upward; also as penetration-twins. Crystals in divergent groups. Also massive, fibrous and radiated, and in nodules.

Cleavage: m (110) nearly perfect. H. = 5–5·5. G. = 2·16–2·4. Luster vitreous, or silky when fibrous. Transparent to subtranslucent. Optically −. Ax. pl. and $Bx_o \perp b$ (010). $Bx_a \wedge c$ axis = 15°–16°. 2V = 36° (approx.). α = 1·512. β = 1·519. γ = 1·519.

Comp. — $CaAl_2Si_3O_{10}.3H_2O$ or $CaO.Al_2O_3.3SiO_2.3H_2O$ = Silica 45·9, alumina 26·0, lime 14·3, water 13·8 = 100.

Pyr., etc. — B.B. sometimes curls up like a worm (whence the name from σκώληξ, *a worm*, which gives *scolecite*, and not *scolesite* or *scolezite*); other varieties intumesce but slightly, and all fuse at 2–2·2 to a white blebby enamel. Gelatinizes with acids like natrolite.

Obs. — Occurs in the Berufiord, Iceland; in Scotland in amygdaloid at Staffa Island and in Isle of Skye, at Talisker; near Eisenach, Saxony; in Auvergne, France; common in fine crystallizations in the Deccan trap area, in British India. In crystals from Karsananguit-Kakait, Greenland. In the United States, in Col. at Table Mountain near Golden in cavities in basalt. In Canada, at Black Lake, Megantic Co., Quebec.

Mesolite. Intermediate between natrolite and scolecite (see p. 556). In acicular and capillary crystals; delicate divergent tufts, etc. G. = 2·29. White or colorless. Indices, 1·505–1·506. In amygdaloidal basalt at numerous points. Crystals from Faroe Islands appear to be triclinic, pseudomonoclinic through twinning. *Pseudomesolite* is name given to a zeolite from Carlton Peak, Minn., like mesolite except for its optical characters.

Gonnardite. $(Ca,Na_2)_2Al_2Si_5O_{15}.5\frac{1}{2}H_2O$. In spherules with radiating structure. G. = 2·25–2·35. From basalt of Gignat, Puy-de-Dôme, France.

THOMSONITE.

Orthorhombic. Axes $a : b : c$ = 0·9932 : 1 : 1·0066.

Distinct crystals rare; in prisms, mm''' 110 $\wedge$ $1\bar{1}0$ = 89° 37′. Commonly columnar, structure radiated; in radiated spherical concretions; also closely compact.

Cleavage: b (010) perfect; a (100) less so; c (001) in traces. Fracture uneven to subconchoidal. Brittle. H. = 5–5·5. G. = 2·3–2·4. Luster vitreous, more or less pearly. Snow-white; reddish, green; impure varieties brown. Streak uncolored. Transparent to translucent. Pyroelectric. Optically +. Ax. pl. $\parallel c$ (001). $Bx \perp b$ (010). Dispersion $\rho > v$ strong. 2V = 54° (approx.). α = 1·497. β = 1·503. γ = 1·525.

Var. — 1. *Ordinary.* (*a*) In regular crystals, usually more or less rectangular in outline, prismatic in habit. (*b*) Prisms slender, often vesicular to radiated. (*c*) Radiated fibrous. (*d*) Spherical concretions, consisting of radiated fibers or slender crystals. Also massive, granular to impalpable, and white to reddish brown, less often green as in *lintonite.* The spherical massive forms also radiated with several centers and of varying colors, hence of much beauty when polished. *Ozarkite* is a white massive thomsonite from Arkansas.

Comp. — $(Na_2,Ca)Al_2Si_2O_8.2\frac{1}{2}H_2O$ or $(Na_2,Ca)O.Al_2O_3.2SiO_2.2\frac{1}{2}H_2O$. The ratio of Na_2 : Ca varies from 3 : 1 to 1 : 1. If Ca : Na_2 = 3 : 1 the percentage composition requires: SiO_2 37·0, Al_2O_3 31·4, CaO 12·9, Na_2O 4·8, H_2O 13·9 = 100.

Pyr., etc. — B.B. fuses with intumescence at 2 to a white enamel. Gelatinizes with hydrochloric acid.

Diff. — Resembles some natrolite, but fuses to an opaque, not to a clear glass.

Obs. — Found in cavities in lava in amygdaloidal igneous rocks, sometimes with elæolite as a result of its alteration. Occurs near Kilpatrick, Scotland; in the lavas of Mte Somma (*comptonite*), Vesuvius; in basalt at the Pflasterkaute in Saxe Weimar, Germany; in Bohemia, in phonolite; the Cyclopean islands, Sicily; near Brevik, Norway; the Faroe Islands; Iceland (carphostilbite, straw-yellow); at Mt. Monzoni, Fassatal, Tyrol, Austria.

Occurs at Peter's Point, Nova Scotia. In the United States, at West Paterson, N. J.; at Magnet Cove (*ozarkite*) in the Ozark Mts., Ark.; in the amygdaloid of Grand Marais, Lake Superior, which yields the water-worn pebbles resembling agate, in part green (*lintonite*); in the basalt of Table Mt. near Golden, Col.

HYDROTHOMSONITE. $(H_2,Na_2,Ca)Al_2Si_2O_8.5H_2O$. An alteration product of thomsonite or scolecite from Tschakwa near Batum on the Black Sea.

Arduinite. A zeolite containing lime and soda. In radiating fibrous aggregates. G. = 2·26. Color red. From Val dei Zuccanti, Venetia, Italy.

Echellite. $(Ca,Na_2)O.2Al_2O_3.3SiO_2.4H_2O$. In radiating, fibrous, spheroidal masses. White. H. = 5. β = 1·533. Elongated $\parallel$ Y. From Sextant Portage, Abitibi River, Northern Ontario.

Epidesmine. Comp. same as for stilbite. Orthorhombic. In minute crystals, only the three pinacoids showing. Cleavages parallel to both vertical pinacoids. Colorless to yellow. Index = 1·50. Bxa perpendicular to *c* (001). Optically −. G. = 2·16. Easily fusible with intumescence. Occurs as a crust on calcite from Schwarzenberg, Saxony.

Stellerite. $CaAl_2Si_7O_{18}.7H_2O$. Orthorhombic. Crystals tabular parallel to *b* (010). Cleavage perfect parallel to *b* (010), imperfect parallel to *a* (100) and *c* (001). H. = 3·5–4. G. = 2·12. Indices, 1·48–1·50. Found in cavity in a diabase tuff, Copper Island, Commander Islands.

Erionite. $H_2CaK_2Na_2Al_2Si_6O_{17}.5H_2O$. Orthorhombic. In aggregates of very slender fibers, resembling wool. G. = 1·997. White. Occurs in cavities in rhyolite from Durkee, Oregon.

Bavenite. $Ca_3Al_2(SiO_3)_6.H_2O$. Monoclinic. Fibrous-radiated groups of prismatic crystals. One cleavage. H. = 5·5. G. = 2·7. Color white. β = 1·58. Occurs in pegmatitic druses in the granite of Baveno, Italy.

Bityite. A hydrous silicate of calcium and aluminium, with small amounts of the alkalies. Pseudo-hexagonal. In minute hexagonal plates which in polarized light show division into six biaxial sectors. Cleavage parallel to base. H. = 5·5. G. = 3·0. Indices 1·62–1·64. Found as crystal crusts in pegmatite veins at Maharitra, Madagascar.

Hydronephelite. $HNa_2Al_3Si_3O_{12}.3H_2O$. Massive, radiated. H. = 4·5–6. G. = 2·263. Color white; also dark gray. Index, 1·50. From Litchfield, Me.; said however to be a mixture of natrolite, hydrargillite and diaspore. *Ranite* from the Langesund fiord, Norway, is similar.

II. Mica Division

The species embraced under this Division fall into three groups: 1, the MICA GROUP, including the Micas proper; 2, the CLINTONITE GROUP, or the Brittle Micas; 3, the CHLORITE GROUP. Supplementary to these are the Vermiculites, hydrated compounds, chiefly results 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 yield easily thin laminæ. 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 60° or 120°, marking the relative position of the chief zones of forms present, and giving them the appearance of hexagonal or rhombohedral 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.

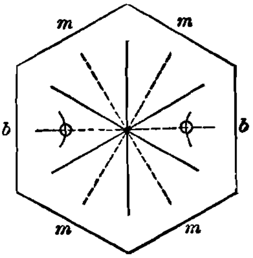
More or less closely related to these species are those of the Serpentine and Talc Division and the Kaolin Division following, many of which show distinctly a mica-like structure and cleavage and also pseudo-hexagonal symmetry.

1. *Mica Group.* Monoclinic

Muscovite	Potassium Mica	$H_2KAl_3(SiO_4)_3$
		$a : b : c = 0·57735 : 1 : 3·3128 \quad \beta = 89° 54'$
Paragonite	Sodium Mica	$H_2NaAl_3(SiO_4)_3$
Lepidolite	Lithium Mica.	$KLi[Al(OH,F)_2]Al(SiO_3)_3$ in part.
Zinnwaldite	Lithium-iron Mica	
Biotite	Magnesium-iron Mica	$(H,K)_2(Mg,\overset{II}{Fe})_2(Al,\overset{III}{Fe})_2(SiO_4)_3$ in part.
		$a : b : c = 0·57735 : 1 : 3·2743 \quad \beta = 90° 0'$
Phlogopite		$(H,K,(MgF))_3Mg_3Al(SiO_4)_3$
	Magnesium Mica; usually containing fluorine, nearly free from iron.	
Lepidomelane	Annite.	
	Iron Micas. Contain ferric iron in large amount.	

The species of the Mica Group crystallize in the monoclinic system, but with a close approximation to either rhombohedral or orthorhombic symmetry; the plane angles of the base are in all cases 60° or 120°. They are all characterized by highly perfect basal cleavage, yielding very thin, tough, and more or less elastic laminæ. The negative bisectrix, X, 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 very 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°.

945



The Micas may be referred to the 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 intercrystallization in parallel position, as biotite with muscovite, lepidolite with muscovite, etc.

A blow with a somewhat dull-pointed instrument on a cleavage plate of mica develops in all the species a six-rayed *percussion-figure* (Fig. 945, also Fig. 491, p. 189), two lines of which are nearly parallel to the prismatic edges; the third, which is the most strongly characterized, is parallel to the clinopinacoid or plane of symmetry. The micas are often divided into two classes, according to the position of the plane of the optic axes. In the *first class* belong those kinds for which the optic axial plane is normal to *b* (010), the plane of symmetry (Fig. 945); in the *second class* the axial plane is parallel to the plane of symmetry. The percussion figure serves to fix the crystallographic 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-figure;* this is sometimes six-rayed, more often shows three branches only, and sometimes only two are developed. In Fig. 945 the position of the pressure-figure is indicated by the broken lines. These lines are connected with gliding-planes inclined some 67° to the plane of cleavage (see beyond).

The micas of the *first class* include: Muscovite, paragonite, lepidolite, also some rare varieties of biotite called anomite.

The *second class* embraces: Zinnwaldite and most biotite, including lepidomelane and phlogopite.

Chemically considered, the micas are silicates, and in most cases orthosilicates, of aluminium with potassium and hydrogen, also often magnesium, ferrous iron, and in certain cases ferric iron, sodium, lithium (rarely rubidium and cæsium); further, rarely, barium, manganese, chromium. Fluorine is prominent in some species, and titanium is also sometimes present. Other elements (boron, etc.) may be present in traces. All micas yield water upon ignition in consequence of the hydrogen (or hydroxyl) which they contain.

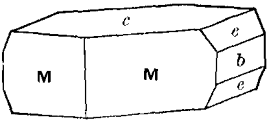
MUSCOVITE. Common Mica. Potash Mica.

Monoclinic. Axes $a : b : c = 0·57735 : 1 : 3·3128$; $\beta = 89° 54'$.

Twins common according to the *mica-law:* tw. pl. a plane in the zone *cM* 001 ∧ 221 normal to *c* (001) 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; vicinal forms common. Folia often very small and aggregated in stellate, plumose, or globular forms; or in scales, and scaly massive; also cryptocrystalline and compact massive.

Cleavage: basal, eminent. Also planes of secondary cleavage as shown in the percussion-figure (see pp. 559 and 189); natural plates hence often yield narrow strips or thin fibers || axis *b*, and less distinct in directions inclined 60° to this.

946



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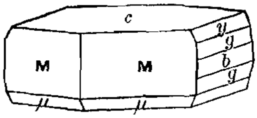


cM, 001 ∧ $\underline{2}21$ = 85° 36'.
cμ, 001 ∧ $\bar{1}11$ = 81° 30'.
MM', $\underline{2}21$ ∧ $\underline{2}\bar{2}1$ = 59° 48'.
μμ', $\bar{1}11$ ∧ $\bar{1}\bar{1}1$ = 59° 16½'.

Thin laminæ flexible and elastic when bent, very tough, harsh to the touch, passing into kinds which are less elastic and have a more or less unctuous or talc-like feel. Etching-figures on *c* (001), monoclinic in symmetry (Fig. 495, p. 190).

H. = 2–2·5. G. = 2·76–3. Luster vitreous to more or less pearly or silky. Colorless, gray, brown, hair-brown, pale green, and violet, yellow, dark olive-green, rarely rose-red. Streak uncolored. Transparent to translucent.

Pleochroism usually feeble; distinct in some deep-colored varieties (see beyond). Absorption in the direction normal to the cleavage plane (vibrations || *Y*, *Z*) strong, much more so than transversely (vibrations || *X*); hence a crystal unless thin is nearly or quite opaque in the first direction though translucent through the prism. Optically −. Ax. pl. ⊥ *b* (010) and nearly ⊥ *c* (001). Bx_a (= *X*) inclined about − 1° (behind) to a normal to *c* (001). Dispersion $\rho > v$. 2V variable, usually about 40°, but diminishing in kinds (phengite) relatively high in silica. $\alpha = 1{\cdot}561$. $\beta = 1{\cdot}590$. $\gamma = 1{\cdot}594$.

Var. — 1. *Ordinary Muscovite.* In crystals as above described, often tabular ∥ *c* (001), also tapering with vertical faces rough and striated; the basal plane often rough unless as developed by cleavage. More commonly in plates without distinct outline, except as developed by pressure (see above); the plates sometimes very large, but passing into fine scales arranged in plumose or other forms. In normal muscovite the thin laminæ spring back with force when bent, the scales are more or less harsh to the touch, unless very small, and a pearly luster is seldom prominent.

2. DAMOURITE. Including *margarodite, gilbertite, hydro-muscovite,* and most HYDRO-MICA in general. Folia less elastic; luster somewhat pearly or silky and feel unctuous like talc. The scales are usually small and it passes into forms which are fine scaly or fibrous, as *sericite,* and finally into the compact crypto-crystalline kinds called *oncosine,* including much *pinite.* Often derived by alteration of cyanite, topaz, corundum, etc. Although often spoken of as *hydrous* micas, it does not appear that damourite and the allied varieties necessarily contain more water than ordinary muscovite; they may, however, give it off more readily.

Margarodite, as originally named, was the talc-like mica of Mt. Greiner in the Zillertal, Tyrol, Austria; granular to scaly in structure, luster pearly, color grayish white. *Gilbertite* occurs in whitish, silky forms from the tin mine of St. Austell, Cornwall. *Sericite* is a fine scaly muscovite united in fibrous aggregates and characterized by its silky luster (hence the name from *σηρικός, silky*).

Comp. — For the most part an orthosilicate of aluminium and potassium $(H,K)AlSiO_4$. If, as in the common kinds, H : K = 2 : 1, this becomes $H_2KAl_3(SiO_4)_3 = 2H_2O.K_2O.3Al_2O_3.6SiO_2$ = Silica 45·2, alumina 38·5, potash 11·8, water 4·5 = 100.

Some kinds give a larger amount of silica (47 to 49 p. c.) than corresponds to a normal orthosilicate, and they have been called *phengite.* As shown by Clarke, these acid muscovites can be most simply regarded as molecular mixtures of $H_2KAl_3(SiO_4)_3$ and $H_2KAl_3(Si_3O_8)_3$.

Iron is usually present in small amount only. Barium is rarely present, as in *oellacherite.* G. = 2·88–2·99. Chromium is also present in *fuchsite* from Schwarzenstein, Zillertal, Tyrol, and elsewhere.

Pyr., etc. — In the closed tube gives water. B.B. whitens and fuses on the thin edges (F. = 5·7) to a gray or yellow glass. With fluxes gives reactions for iron and sometimes manganese, rarely chromium. Not decomposed by acids. Decomposed on fusion with alkaline carbonates.

Diff. — Distinguished in normal kinds from all but the species of this division by the perfect basal cleavage and micaceous structure, the pale color separates it from most biotite; the laminæ are more flexible and elastic than those of phlogopite and still more than those of the brittle micas and the chlorites.

Micro. — In thin sections recognized by want of color and by the perfect cleavage shown by fine lines (as in Fig. 951, p. 564) in sections ⊥ *c* (001), in a direction parallel to *c*. By reflected light under the microscope the same sections show a peculiar mottled surface with satin-like luster; birefringence rather high, hence interference-colors bright.

Obs. — Muscovite is the most common of the micas. It is an essential constituent of mica schist and related rocks, and is a prominent component of certain common varieties of granite and gneiss; also found at times in fragmental rocks and limestones; in volcanic rocks it is rare and appears only as a secondary product. The largest and best developed crystals occur in the pegmatite dikes associated with granitic intrusions, either directly cutting the granite or in its vicinity. Often in such occurrences in enormous plates from which the mica or "isinglass" of commerce is obtained. It is then often associated with crystallized orthoclase, quartz, albite; also apatite, tourmaline, garnet, beryl, columbite, etc., and other mineral species characteristic of granitic veins. Further, muscovite often encloses flattened crystals of garnet, tourmaline, also quartz in thin plates between the sheets; further not infrequently magnetite in dendrite-like forms following in part the directions of the percussion-figure.

Some of the best known localities, are: Abühl in the Sulzbachtal, Austrian Tyrol; with adularia; Rothenkopf in the Zillertal, Tyrol; Soboth, Styria; St. Gothard, Binnental, and elsewhere in Switzerland; Mourne Mts., Ireland; Cornwall; Utö, Falun, Sweden; Skutterud, and Bamble, Norway. Obtained in large plates from Greenland and the East Indies.

In Me., at Mount Mica in the town of Paris; at Buckfield, in fine crystals. In N. H., at Acworth, Grafton. In Mass., at Chesterfield; South Royalston; at Goshen, rose-red. In Conn., at Monroe; at Litchfield, with cyanite; at the Middletown feldspar quarry; at Haddam; at Branchville, with albite, etc.; New Milford. In N. Y., near Warwick; Edenville; Edwards. In Pa., at Pennsbury, Chester Co.; at Unionville, Delaware Co., and at Middletown. In Md., at Jones's Falls, Baltimore. In Va., at Amelia Court-House. In N. C., extensively mined at many places in the western part of the state; the chief mines are in Mitchell, Yancey, Jackson and Macon Cos.; crystals from Lincoln Co. The mica mines have also afforded many rare species, as columbite, samarskite, hatchettolite, uraninite, etc.; in good crystals in Alexander Co. In S. C., there are also muscovite deposits; also in Ga. and Ala.

Mica mines have also been worked to some extent in the Black Hills, S. D.; in Wash., at Rockford, Spokane Co.; in Col. The important states for the production of mica are North Carolina, New Hampshire, Idaho, South Dakota, Virginia, Alabama, New York, Connecticut.

Muscovite is named from *Vitrum Muscoviticum* or *Muscovy-glass*, formerly a popular name of the mineral.

Use. — As an insulating material in electrical apparatus; as a non-inflammable transparent material for furnace doors, etc.; in a finely divided form as a non-conductor of heat and fireproofing material; mixed with oil as a lubricant, etc.

Pinite. A general term used to include a large number of alteration-products especially of iolite, also spodumene, nephelite, scapolite, feldspar and other minerals. In composition essentially a hydrous silicate of aluminium and potassium corresponding more or less closely to muscovite, of which it is probably to be regarded as a massive, compact variety, usually very impure from the admixture of clay and other substances. Characters as follows: Amorphous; granular to cryptocrystalline. Rarely a submicaceous cleavage. H. = 2·5–3·5. G. = 2·6–2·85. Luster feeble, waxy. Color grayish white, grayish green, pea-green, dull green, brownish, reddish. Translucent to opaque. The following are some of the minerals also classed as pinite: *gigantolite*, *gieseckite* (see p. 500), *liebenerite*, *dysyntribite*, *parophite*, *rosite*, *polyargite*, *wilsonite*, *killinite*.

Agalmatolite (pagodite) is like ordinary massive pinite in its amorphous compact texture, luster, and other physical characters, but contains more silica, which may be from free quartz or feldspar as impurity. The Chinese has H. = 2–2·5; G. = 2·785–2·815. Colors usually grayish, grayish green, brownish, yellowish. Named from ἄγαλμα, *an image; pagodite* is from *pagoda*, the Chinese carving the soft stone into miniature pagodas, images, etc. Part of the so-called agalmatolite of China is true pinite in composition, another part is compact pyrophyllite, and still another steatite (see these species).

Paragonite. A sodium mica, corresponding to muscovite in composition; formula, $H_2NaAl_3(SiO_4)_3$. In fine pearly scales; also compact. G. = 2·78–2·90. Index, 1·60. Color yellowish, grayish, greenish; constitutes the mass of the rock at Monte Campione near Faido in Canton Tessin, Switzerland, containing cyanite and staurolite; called paragonite-schist. Occurs associated with tourmaline and corundum at Unionville, Delaware Co., Pa. *Hallerite*, a mica with an iridescent silver color and pearly luster. Perhaps a lithium-bearing *paragonite*. Found at Mesores, near Autun, France.

BADDECKITE, an iron mica related to muscovite. In small scales with a copper-red color. From near Baddeck, Nova Scotia.

LEPIDOLITE. Lithia Mica.

In aggregates of short prisms, often with rounded terminal faces. Crystals sometimes twins or trillings according to the mica law. Also in cleavable plates, but commonly massive scaly-granular, coarse or fine.

Cleavage: basal, highly eminent. H. = 2·5–4. G. = 2·8–2·9. Luster pearly. Color rose-red, violet-gray or lilac, yellowish, grayish white, white. Translucent. Optically −. Ax. pl. usually ⊥ *b* (010); rarely || *b*. Bx_a (*X*) inclined 1° 47′ red, and 1° 33½′ yellow to normal to *c* (001). Axial angle large, from 50°–72°, β = 1·5975.

Comp. — In part a metasilicate, $\overset{\mathrm{I}}{R}_3Al(SiO_3)_3$ or $KLi[Al(OH,F)_2]Al(SiO_3)_3$. The ratio of fluorine and hydroxyl is variable.

It has been suggested that the pure lepidolite molecule is represented by $3Li_2O.2K_2O.3Al_2O_3.8F.12SiO_2$ and that most lepidolites are mixtures of this and the muscovite molecule.

Pyr., etc. — In the closed tube gives water and reaction for fluorine. B.B. fuses with intumescence at 2–2·5 to a white or grayish glass sometimes magnetic, coloring the flame purplish red at the moment of fusion (lithia). With the fluxes some varieties give reactions for iron and manganese. Attacked but not completely decomposed by acids. After fusion, gelatinizes with hydrochloric acid.

Obs. — Occurs in granite and gneiss, especially in granitic veins; often associated with lithia-tourmaline; also with amblygonite, spodumene, cassiterite, etc.; sometimes associated with muscovite in parallel position.

Found near Utö in Sweden; Penig, Saxony; Rozena (or Rožna), Moravia; Madagascar, etc. In the United States, common in the western part of Me., in Hebron, Auburn, Paris, etc.; at Chesterfield, Mass.; Middletown and Haddam Neck, Conn.; with rubellite near San Diego, Cal.

Named lepidolite from λεπίς, *scale*, after the earlier German name *Schuppenstein*, alluding to the scaly structure of the massive variety of Rozena.

Use. — As a source of lithium compounds.

Cookeite is a micaceous mineral occurring in rounded aggregations on rubellite, also with lepidolite, tourmaline, etc., at Hebron, Me. An alteration of lepidolite or tourmaline. Composition $Li[Al(OH)_2]_3(SiO_3)_2$.

Zinnwaldite. An iron-lithia mica in form near biotite. Color pale violet, yellow to brown and dark gray. Occurs at Zinnwald and Altenberg, Germany; similarly in Cornwall, England. From Narsarsuk, Greenland, and the York region, Alaska.

Cryophyllite is a related lithium mica from Rockport, Mass. *Polylithionite* is a lithium mica from Kangerdluarsuk, Greenland. *Irvingite* is an alkalie mica containing lithium from near Wausau, Wis.

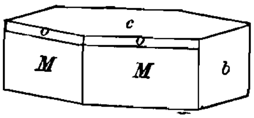
Manandonite. A basic boro-silicate of lithium and aluminium, $H_{24}Li_4Al_{14}B_4Si_6O_{63}$. Micaceous. In lamellar aggregates or mammillary crusts of hexagonal plates. Perfect basal cleavage. Color white. Luster pearly. Optically +. Axial angle small and variable. Easily fusible giving red flame. Unattacked by acids. Found in pegmatite at Antandrokomby, near the Manandona River, Madagascar.

BIOTITE.

Monoclinic; pseudo-rhombohedral. Axes $a : b : c = 0·57735 : 1 : 3·2743$; $\beta = 90°$.

Habit tabular or short prismatic; the pyramidal faces often repeated in oscillatory combination. Crystals often apparently rhombohedral in symmetry since r (101) and z (132), z' ($1\bar{3}2$), which are inclined to c (001) at sensibly the same angle, often occur together; further, the zones to which these faces belong are inclined 120° to each other, hence the hexagonal outline of basal sections. Twins, according to the mica law, tw. pl. a plane in the prismatic zone ⊥ c (001). Often in disseminated scales, sometimes in massive aggregations of cleavable scales.

948



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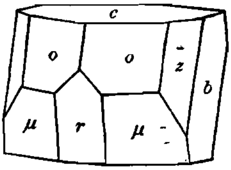

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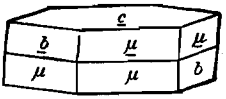


co, 001 ∧ 112 = 73° 1′.
cM, 001 ∧ 221 = 85° 38′.
$c\mu$, 001 ∧ $\bar{1}11$ = 81° 19′.
cr, 001 ∧ $\bar{1}01$ = 80° 0′.
cz, 001 ∧ 132 = 80° 0′.
MM', 221 ∧ $\bar{2}21$ = 59° 48½′.

Cleavage: basal, highly perfect; planes of separation shown in the percussion-figure; also gliding-planes ρ $(\bar{2}05)$, ζ (135) shown in the pressure-figure inclined about 66° to c (001) and yielding pseudo-crystalline forms (Fig. 489, p. 188). H. = 2·5–3. G. = 2·7–3·1. Luster splendent, and more or less pearly on a cleavage surface, and sometimes submetallic when black; lateral surfaces vitreous when smooth and shining. Colors usually green to black, often deep black in thick crystals, and sometimes even in thin laminæ, unless the laminæ are very thin; such thin laminæ green, blood-red, or brown by transmitted light; also pale yellow to dark brown; rarely white. Streak uncolored. Transparent to opaque.

Pleochroism strong; absorption $Y = Z$ nearly, for X much stronger. Hence sections $\parallel$ c (001) dark green or brown to opaque; those $\perp$ c lighter and deep brown or green for vibrations $\parallel$ c, pale yellow, green or red for vibrations $\perp$ c. Pleochroic halos often noted, particularly about microscopic inclusions. Optically $-$. Ax. pl. usually $\parallel$ b (010), rarely $\perp$ b. $\mathrm{Bx_a}$ $(=X)$ nearly coincident with the normal to c (001), but inclined about half a degree, sometimes to the front, sometimes the reverse. Axial angle usually very small, and often sensibly uniaxial; also up to 50°. Birefringence high, $\gamma - \alpha = 0{\cdot}04$ to $0{\cdot}06$.

Comp. — In most cases an orthosilicate, chiefly ranging between $(\mathrm{H,K})_2(\mathrm{Mg,Fe})_4(\mathrm{Al,Fe})_2(\mathrm{SiO_4})_4$ and $(\mathrm{H,K})_2(\mathrm{Mg,Fe})_2\mathrm{Al_2}(\mathrm{SiO_4})_3$. Of these the second formula may be said to represent typical biotite. The amount of iron varies widely.

Var. — Biotite is divided into two classes by Tschermak:

I. MEROXENE. Axial plane $\parallel$ b (010). II. ANOMITE. Ax. pl. $\perp$ b (010). Of these two kinds, meroxene includes nearly all ordinary biotite, while anomite is, so far as yet observed, of restricted occurrence, the typical localities being Greenwood Furnace, Orange Co., N. Y., and Lake Baikal in East Siberia. *Meroxene* is a name early given to the Vesuvian biotite. Anomite is from *ανομος*, contrary to law.

Haughtonite and *Siderophyllite* are kinds of biotite containing much iron.

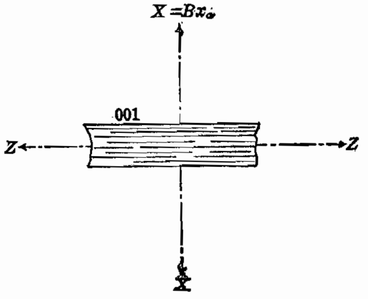
Manganophyllite is a manganesian biotite. Occurs in aggregations of thin scales. Color bronze- to copper-red. Streak pale red. From Pajsberg and Långban, Sweden; Piedmont, Italy.

Pyr., etc. — In the closed tube gives a little water. Some varieties give the reaction for fluorine in the open tube; some kinds give little or no reaction for iron with the fluxes, while others give strong reactions for iron. B.B. whitens and fuses on the thin edges. Completely decomposed by sulphuric acid, leaving the silica in thin scales.

Diff. — Distinguished by its dark green to brown and black color and micaceous structure, usually nearly uniaxial.

Micro. — Recognized in thin sections by its brown (or green) color; strong pleochroism and strong absorption parallel to the elongation (unlike tourmaline). Sections $\parallel$ c (001) are non-pleochroic, commonly exhibit more or less distinct hexagonal outlines and yield a negative sensibly uniaxial figure. Sections $\perp$ c are strongly pleochroic and are marked by fine parallel cleavage lines (Fig. 951); 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.

951



Obs. — Biotite is an important constituent of many different kinds of igneous rocks, especially those formed from magmas containing considerable potash and magnesia. Common in certain varieties of granites, syenite, diorite, etc., of the massive granular type; also in rhyolite, trachyte, and andesite among the lavas; in minettes, kersantites, etc. It occurs also as the product of metamorphic action in a variety of rocks. It is not infrequently associated in parallel position with muscovite, the latter, for example, forming the outer portions of plates having a nucleus of biotite.

Some of the prominent localities of crystallized biotite are as follows: Vesuvius, common particularly in ejected limestone masses on Monte Somma, with augite, chrysolite, nephelite, humite, etc. The crystals are sometimes nearly colorless or yellow and then usually complex in form; also dark green to black; Mt. Monzoni in the Fassatal and Schwarzenstein, Zillertal, Tyrol, Austria; Rezbánya and Morawitza in Hungary; in Germany at Schelingen and other points in the Kaiserstuhl and the Laacher See; on the west side of Lake Ilmen near Miask, Russia.

In the United States ordinary biotite is common in granite, gneiss, etc.; but notable localities of distinct crystals are not numerous. It occurs with muscovite (which see) as a more or less prominent constituent of the pegmatite veins in the New England States; also Pennsylvania, Virginia, North Carolina. From Greenwood, Orange Co., N. Y. *Siderophyllite* is from the Pike's Peak region, Col.

CASWELLITE. An altered biotite from Franklin Furnace, N. J.

PHLOGOPITE.

Monoclinic. In form and angles near biotite. Crystals prismatic, tapering; often large and coarse; in scales and plates.

Cleavage: basal, highly eminent. Thin laminæ tough and elastic. H. = 2·5–3. G. = 2·78–2·85. Luster pearly, often submetallic on cleavage surface. Color yellowish brown to brownish red, with often something of a copper-like reflection; also pale brownish yellow, green, white, colorless. Often exhibits asterism in transmitted light, due to regularly arranged inclusions. Pleochroism distinct in colored varieties: Z brownish red, Y brownish green, X yellow. Absorption $Z > Y > X$. Optically $-$. Ax. pl. $\parallel$ b (010). Bx_a nearly $\perp$ c (001). Axial angle small but variable even in the same specimen, from 0° to 50°. Dispersion $\rho < v$. The axial angle appears to increase with the amount of iron. Indices variable, from 1·541–1·638.

Comp. — A magnesium mica, near biotite, but containing little iron; potassium is prominent as in all the micas, and in most cases fluorine. Typical phlogopite is $\overset{\text{I}}{R}_3Mg_3Al(SiO_4)_3$, where $\overset{\text{I}}{R} = H,K,MgF$.

Obs. — Phlogopite is especially characteristic of crystalline limestone or dolomite. It is often associated with pyroxene, amphibole, serpentine, etc. Thus as at Pargas, Finland; in St. Lawrence Co. and Jefferson Co., N. Y.; Franklin, N. J.; also Burgess, Ontario, and elsewhere in Canada.

Named from φλογωπός, *fire-like*, in allusion to the color.

The asterism of phlogopite, seen when a candle-flame is viewed through a thin sheet, is a common character, particularly prominent in the kinds from northern New York and Canada. It has been shown to be due to minute acicular inclusions, rutile or tourmaline, arranged chiefly in the direction of the rays of the pressure-figure, producing a distinct six-rayed star; also parallel to the lines of the percussion-figure, giving a secondary star, usually less prominent than the other.

Tæniolite. Essentially a potassium-magnesium silicate. Monoclinic, belonging to the mica group. Perfect basal cleavage. Folia somewhat elastic. H. = 2·5–3. G. = 2·9. Colorless. Fusible. From Narsarsuk, southern Greenland.

Lepidomelane. Near biotite, but characterized by the large amount of ferric iron present. From Langesund fiord, Norway; Haddam, Conn. *Annite* from Cape Ann, Mass., belongs here. In small six-sided tables, or an aggregate of minute scales. H. = 3. G. = 3·0–3·2. Color black, with occasionally a leek-green reflection.

Alurgite. A manganese mica from St. Marcel, Piedmont, Italy. Color copper-red. Index, 1·59. *Mariposite* may belong here.

Roscoelite. A vanadium mica; essentially a muscovite in which vanadium has partly replaced the aluminium. In minute scales; structure micaceous. G. = 2·92–2·94. Color clove-brown to greenish brown. Indices, 1·610–1·704. Occurs in Cal. at the gold mine at Granite Creek, Placerville, and elsewhere, El Dorado Co.

2. *Clintonite Group.* Monoclinic

The minerals here included are sometimes called the Brittle Micas. They are near the micas in cleavage, crystalline form and optical properties, but are marked physically by the brittleness of the laminæ, and chemically by their basic character.

In several respects they form a transition from the micas proper to the chlorites. Margarite, or calcium mica, is a basic silicate of aluminium and calcium, while Chloritoid is a basic silicate of aluminium and ferrous iron (with magnesium), like the chlorites.

MARGARITE.

Monoclinic. Rarely in distinct crystals. Usually in intersecting or aggregated laminæ; sometimes massive, with a scaly structure.

Cleavage: basal, perfect. Laminæ rather brittle. H. = 3·5–4·5. G. = 2·99–3·08. Luster of base pearly, of lateral faces vitreous. Color grayish, reddish white, pink, yellowish. Translucent, subtranslucent.

Optically –. Ax. pl. ⊥ *b* (010). Bx_a approximately ⊥ *c* (001), but varying more widely than the ordinary micas. $X \wedge c$ axis = $+ 6\frac{1}{2}°$. Dispersion $\rho < v$. Axial angle large, from 76° to 128° in air. Refractive index β = 1·64–1·65.

Comp. — $H_2CaAl_4Si_2O_{12}$ = Silica 30·2, alumina 51·3, lime 14·0, water 4·5 = 100.

Pyr., etc. — Yields water in the closed tube. B.B. whitens and fuses on the edges. Slowly and imperfectly decomposed by boiling hydrochloric acid.

Obs. — Associated commonly with corundum, and in many cases obviously formed directly from it; thus at the emery deposits of Gumuch-dagh in Asia Minor, the islands Naxos, Nicaria, etc. Occurs in chlorite of Mt. Greiner, Sterzing, Tyrol. In the United States at the emery mine at Chester, Mass.; at Unionville, Chester Co., Pa.; with corundum in Madison Co. and elsewhere in N. C.; at Gainesville, Hall Co., Ga.; at Dudleyville, Ala.

Named *Margarite* from *μαργαρίτης, pearl.*

SEYBERTITE. Clintonite. Brandisite.

Monoclinic, near biotite in form. Also foliated massive; sometimes lamellar radiate.

Cleavage: basal, perfect. Structure foliated, micaceous. Laminæ brittle. Percussion- and pressure-figures, as with mica. H. = 4–5. G. = 3–3·1. Luster pearly submetallic. Color reddish brown, yellowish, copper-red. Streak uncolored, or slightly yellowish or grayish. Pleochroism rather feeble. Optically –. Ax. pl. ⊥ *b* (010) *seybertite;* ‖ *b* ***brandisite.*** Bx_a nearly ⊥ *c* (001). Axial angles variable, but not large. α = 1·646. β = 1·657. γ = 1·658.

Var. — 1. The Amity *seybertite* (*clintonite*) is in reddish brown to copper-red brittle foliated masses; the surfaces of the folia often marked with equilateral triangles like some mica and chlorite. Axial angle 3°–13°.

2. ***Brandisite*** (***disterrite***), from the Fassatal, Tyrol, is in hexagonal prisms of a yellowish green or leek-green color to reddish gray; H. = 5 of base; of sides, 6–6·5. Ax. pl. ‖ *b* (010). Axial angle 15°–30°. Some of it pseudomorphous, after fassaite.

Comp. — In part $H_3(Mg,Ca)_5Al_5Si_2O_{18} = 3H_2O.10(Mg,Ca)O.5Al_2O_3.4SiO_2$.

Pyr., etc. — Yields water. B.B. infusible but whitens. In powder acted on by concentrated acids.

Obs. — *Seybertite* occurs at Amity, N. Y., in limestone with serpentine, associated with amphibole, spinel, pyroxene, graphite, etc.; also a chlorite near leuchtenbergite. *Brandisite* occurs on Mt. Monzoni in the Fassatal, Tyrol, Austria, in white limestone, with fassaite and black spinel.

Xanthophyllite. Perhaps $H_8(Mg,Ca)_{14}Al_{16}Si_5O_{52}$. The original *xanthophyllite* is in crusts or in implanted globular forms. Optically negative. Axial angle usually very small, or sensibly uniaxial; sometimes 20°. Indices, 1·649–1·661. From near Zlatoust in the Ural Mts. Found at Crestmore, Riverside Co., Cal.

Waluewite is the same species occurring in distinct pseudo-rhombohedral crystals. Folia brittle. H. = 4·6. G. = 3·093. Luster vitreous; on cleavage plane pearly. Color leek- to bottle-green. Transparent to translucent. Pleochroism rather feeble: $\parallel$ *c* axis fine green; $\perp$ *c* axis reddish brown. Optically —. Ax. pl. $\parallel$ *b* (010). Bx sensibly $\perp$ *c* (001). Axial angle 17° to 32°. Found with perovskite and other species in chloritic schists near Achmatovsk, in the southern Ural Mts.

CHLORITOID. Ottrelite. Phyllite.

Probably triclinic. Rarely in distinct tabular crystals, usually hexagonal in outline, often twinned with the individuals turned in azimuth 120° to each other. Crystals grouped in rosettes. Usually coarsely foliated massive; folia often curved or bent and brittle; also in 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* (010) difficult. Laminæ brittle. H. = 6·5. G. = 3·52–3·57. Color dark gray, greenish gray, greenish black, grayish black, often grass-green in very thin plates. Streak uncolored, or grayish, or very slightly greenish. Luster of surface of cleavage somewhat pearly.

Pleochroism strong: *Z* yellow green, *Y* indigo-blue, *X* olive-green. Optically +. Ax. pl. nearly $\parallel$ *b* (010). Bx_a inclined about 12° or more to the normal to *c* (001). Dispersion $\rho > v$, large, also horizontal. Axial angles, in air 65° to 120°. $\beta = 1·75$. Birefringence low, $\gamma - \alpha = 0·007–0·016$.

Comp. — For chloritoid $H_2(Fe,Mg)Al_2SiO_7$. If iron alone is present, this requires: Silica 23·8, alumina 40·5, iron protoxide 28·5, water 7·2 = 100.

Micro. — Recognized in thin sections by the crystal outlines and general micaceous appearance; high relief; green colors; distinct cleavage; frequent twinning; strong phleochroism and low interference-colors. By the last character readily distinguished from the micas; also by the high relief and extinction oblique to the cleavage from the chlorites.

Obs. — Chloritoid (ottrelite, etc.) are characteristic of sedimentary rocks which have suffered dynamic metamorphism, especially in the earlier stages; thus found in argillites, conglomerates, etc., which have assumed the schistose condition. With more advanced degree of metamorphism it disappears. Often grouped in fan-shaped, sheaf-like forms, also in irregular or rounded grains.

The original *chloritoid* from Kosoibrod, near Ekaterinburg in the Ural Mts., is in large curving laminæ or plates, grayish to blackish green in color, often spotted with yellow from mixture with limonite. Other localities are Ile le Groix (Morbihan), France; embedded in large crystals at Vanlup, Shetland; Ardennes, France, and Belgium, in schists with ottrelite; also from Upper Michigan; Leeds, Canada, etc.

Sismondine ($H_{14}Fe_7Al_{16}Si_8O_{64}$) is from St. Marcel, Piedmont, Italy; it occurs also with glaucophane at Zermatt in the Valais, Switzerland, and elsewhere.

Salmite is a manganesian variety occurring in irregular masses, having a coarse saccharoidal structure and grayish color. G. = 3·38. From Vielsalm, Belgium.

Masonite, from Natic, R. I., is in very broad plates of a dark grayish green color, but bluish green in very thin laminæ parallel to *c* (001) and grayish green at right angles to this; occurs in argillaceous schist.

Ottrelite is generally classed with chloritoid, though it is not certain that they are identical; it seems to have the composition $H_2(Fe,Mn)Al_2Si_2O_9$. It occurs in small, oblong, shining scales or plates, more or less hexagonal in form and gray to black in color; in argillaceous schist near Ottrez, on the borders of Luxemburg, and from the Ardennes, France, and Belgium; also near Serravezza, Tuscany, Italy; Tintagel in Cornwall. *Venasquite* is from Venasque in the Pyrenees, and from Teulé, Finistére, France. *Phyllite* is from the schists of New England.

3. *Chlorite Group.* Monoclinic

The Chlorite Group takes its name 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 respects closely related to the micas. They crystallize in the monoclinic system, but in part with distinct monoclinic symmetry, in part with rhombohedral symmetry, with corresponding uniaxial optical character. The plane angles of the base are also 60° or 120°, marking the mutual inclinations of the chief zones of forms. The mica-like basal cleavage is prominent in distinctly crystallized forms, but the laminæ are tough and comparatively inelastic. Percussion 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 asymmetric, suggesting a reference to the triclinic system.

Chemically considered the chlorites are silicates of aluminium with ferrous iron and magnesium and chemically combined water. Ferric iron may be present replacing the aluminium in small amount; chromium enters similarly in some forms, which 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 the same composition, but while the former is monoclinic in form and habit, the latter is pseudo-rhombohedral and usually uniaxial. Prochlorite (including some ripidolite) and Corundophilite also occur in distinct cleavage masses.

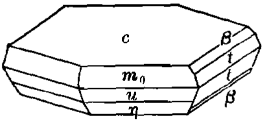
Besides the species named there are other kinds less distinct in form, occurring in scales, also fibrous to massive or earthy; they are often of more or less undetermined composition, but in many cases, because of their extensive occurrence, of considerable geological importance. These latter forms occur as secondary minerals resulting from the alteration especially of ferro-magnesian silicates, such as biotite, pyroxene, amphibole; also garnet, vesuvianite, etc. They are often accompanied by other secondary minerals, as serpentine, limonite, calcite, etc., especially in the altered forms of basic rocks.

The rock-making chlorites are recognized in thin sections by their characteristic appearance in thin leaves, scales or fibers, sometimes aggregated into spherulites; by their greenish 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.

CLINOCHLORE. Ripidolite in part.

Monoclinic. Axes $a : b : c = 0·57735 : 1 : 2·2772$; $\beta = 89° 40'$.

952



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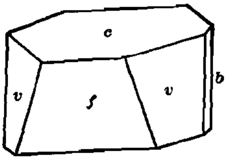
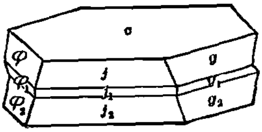


Schwarzenstein

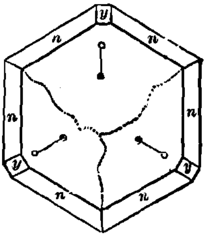
954



Zillertal

Crystals usually hexagonal in form, often tabular || c (001). Plane angles of the basal section = 60° or 120°, and since closely similar angles are found in the zones which are separated by 60°, the symmetry approximates to that of the rhombohedral system.

955



Achmatovsk

Twins: (1) *Mica law*, tw. pl. ⊥ c (001) in the zone cm_0 001 ∧ 112; sometimes contact-twins with c as composition face, the one part revolved 60° or a multiple of 60° in azimuth with reference to the other; also in threefold twins. (2) *Penninite law*, tw. pl. c, contact-twins also united by c (Fig. 954); here corresponding faces differ 180° in position. Massive, coarse scaly granular to fine granular and earthy.

Cleavage: c (001) highly perfect. Laminæ flexible tough, and but slightly elastic. Percussion-figure and pressure-figures orientated as with the micas (p. 559). H. = 2–2·5. G. = 2·65–2·78. Luster of cleavage-face somewhat 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 usually X green, Z yellow. Optically usually +. Ax. pl. in most cases || b (010). Bx_a inclined somewhat to the normal to c (001), forward; for Achmatovsk 2° 30′. Dispersion $\rho < v$. Axial angles variable, even in the same crystal, 0°–90°; sometimes sensibly uniaxial. Birefringence low. Indices approximately; $\alpha = 1·585$. $\beta = 1·586$. $\gamma = 1·596$.

Var. — 1. *Ordinary*; green clinochlore, passing into bluish green; (*a*) in crystals, as described, usually with distinct monoclinic symmetry; (*b*) foliated; (*c*) massive.

Leuchtenbergite. Contains usually little or no iron. Color white, pale green, yellowish; often resembles talc. From near Zlatoust in the Ural Mts.

Kotschubeite. Contains several per cent of chromium oxide. Crystals rhombohedral in habit. Color rose-red. From the southern Ural Mts.

Manganiferous. Manganchlorite. A chlorite from the Harstig mine near Pajsberg, Sweden, is peculiar in containing 2·3 p. c. MnO.

Comp. — Normally $H_8Mg_5Al_2Si_3O_{18} = 4H_2O.5MgO.Al_2O_3.3SiO_2$ = Silica 32·5, alumina 18·4, magnesia 36·1, water 13·0 = 100. Ferrous iron usually replaces a small part of the magnesia, and the same is true of manganese rarely; sometimes chromium replaces the aluminium.

Pyr., etc. — Yields water. B.B. in the platinum forceps whitens and fuses with difficulty on the edges to a grayish black glass. With borax, a clear glass colored by iron, and sometimes chromium. In sulphuric acid wholly decomposed.

Micro. — In thin sections characterized by pale green color and pleochroism; distinctly biaxial and usually +.

Obs. — Occurs in connection with chloritic and talcose rocks or schists and serpentine; sometimes in parallel position with biotite or phlogopite. Prominent localities are: Achmatovsk in the Ural Mts.; Ala in Piedmont, Italy; the Zillertal, Tyrol, Austria; Zermatt, Switzerland; Marienberg, Saxony; Zöptau, Moravia. A manganesian variety occurs at Pajsberg, Sweden.

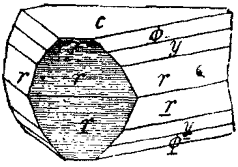
In the United States, at Westchester, Pa., in large crystals and plates; also Unionville and Texas, Pa.; at the magnetic iron mine at Brewster, N. Y., in part changed to serpentine; near Lowell, Ver., in crystals.

PENNINITE. Pennine.

Apparently rhombohedral in form but strictly pseudo-rhombohedral and monoclinic.

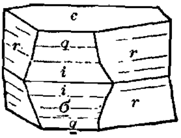
Habit rhombohedral: sometimes thick tabular with *c* (001) prominent, again steep rhombohedral; also in tapering six-sided pyramids. Rhombohedral faces often horizontally striated. Crystals often in crested groups. Also massive, consisting of an aggregation of scales; also compact cryptocrystalline.

956



Texas

957



Zermatt

Cleavage: *c* (001) highly perfect. Laminæ flexible. Percussion-figure and pressure-figure as with clinochlore but less easy to obtain; not elastic. H. = 2–2·5. G. = 2·6–2·85. 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 subtranslucent. Pleochroism distinct: usually || *c* (001) green; ⊥ *c* yellow. Optically +, also −, and sometimes both in adjacent laminæ 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 1·579.

Var. — 1. *Penninite*, as first named, included a green crystallized chlorite from the Penninine Alps.

Kämmererite. In hexagonal forms bounded by steep six-sided pyramids. Color kermes-red; peach-blossom-red. Pleochroism distinct. Optically − from Lake Itkul, Bisersk, Perm, Russia; + Texas, Pa. Uniaxial or biaxial with axial angle up to 20°. Rhodophyllite from Texas, Pa., and rhodochrome from Lake Itkul belong here.

Pseudophite is compact massive, without cleavage, and resembles serpentine.

Comp. — Essentially the same as clinochlore, $H_8(Mg,Fe)_5Al_2Si_3O_{18}$.

Pyr., etc. — In the closed tube yields water. B.B. exfoliates somewhat and is difficultly fusible. With the fluxes all varieties give reactions for iron, and many varieties react for chromium. Partially decomposed by hydrochloric and completely by sulphuric acid.

Micro. — In thin sections shows pale green color and pleochroism; usually nearly uniaxial, −.

Obs. — Occurs with serpentine in the region of Zermatt, Valais, Switzerland, near Mt. Rosa, especially in the moraines of the Findelen glacier; crystals from Zermatt are sometimes 2 in. long and 1½ in. thick; also at the foot of the Simplon Pass, Switzerland; at Ala, Piedmont, Italy, with clinochlore; at Schwarzenstein in Tyrol, Austria; at Taberg in Wermland, Sweden; at Snarum, Norway, greenish and foliated.

Kämmererite is found at the localities already mentioned; also near Miask in the Ural Mts.; at Haroldswick in Unst, Shetland Isles. In large crystals enclosed in the talc in crevices of the chromite from Kraubat, Styria. Abundant at Texas, Lancaster Co., Pa., along with clinochlore, some crystals being embedded in clinochlore, or the reverse. Also in N. C., with chromite at Culsagee, Macon Co.; Webster, Jackson Co.; and other points. From Washington, Cal.

PROCHLORITE. Ripidolite in part.

Monoclinic. In six-sided tables or prisms, the side planes strongly furrowed and dull. Crystals often implanted by their sides, and in divergent groups, fan-shaped, vermicular, or spheroidal. Also in large folia. Massive, foliated, or granular.

H. = 1–2. G. = 2·78–2·96. Translucent to opaque; transparent only in very thin folia. Luster of cleavage surface feebly pearly. Color green, grass-green, olive-green, blackish green; across the axis by transmitted light sometimes red. Streak uncolored or greenish. Laminæ flexible, not elastic. Pleochroism distinct. Optically + in most cases. Bx inclined to the normal to *c* (001) some 2°. Axial angle small, often nearly uniaxial; again 2E = 23°–30°. Dispersion $\rho < v$.

Comp. — Lower in silicon than clinochlore, and with ferrous iron usually, but not always, in large amount.

Obs. — Like other chlorites in modes of occurrence. Occasionally formed from amphibole. Sometimes in implanted crystals, as at St. Gothard, Switzerland, enveloping often adularia, etc.; Mt. Greiner in the Zillertal, Tyrol, Austria; Rauris in Salzburg, Austria; Traversella in Piedmont, Italy; at Mts. Sept Lacs and St. Cristophe in Dauphiné, France; in Styria, Bohemia. Also massive in Cornwall, England, in tin veins; at Arendal in Norway; Salberg and Dannemora, Sweden; Dognacska, Hungary. In Scotland at various points. In the United States, near Washington, D. C.; on Castle Mt., Batesville, Va., a massive form resembling soapstone, color grayish green, feel greasy; Steele's mine, Montgomery Co., N. C.; also with corundum at the Culsagee mine, in broad plates of a dark green color and fine scaly; it differs from ordinary prochlorite in the small amount of ferrous iron.

Corundophilite. A chlorite occurring in deep green laminæ resembling clinochlore but more brittle; contains but 24 p. c. SiO_2. $\beta = 1·583$. Occurs with corundum at Chester, Mass.

AMESITE. $H_4(Mg,Fe)_2Al_2SiO_9$. Silica 21·4 p. c. In hexagonal plates, foliated, resembling the green talc from the Tyrol. H. = 2·5–3. G. = 2·71. Color apple-green. Luster pearly on cleavage face. Optically +, sensibly uniaxial. Occurs with diaspore at Chester, Mass.

SHERIDANITE. A chlorite from Sheridan Co., Wy., containing only little iron.

OTHER CHLORITES. Besides the chlorites already described which occur usually in distinct crystals or plates, there are, as noted on p. 568, forms varying from fine scaly to fibrous and earthy, which are prominent in rocks. In some cases they may belong to the species before described, but frequently the want of sufficient pure material has left their composition in doubt. These chlorites are commonly characterized by their green color, distinct pleochroism and low birefringence (p. 568).

The following are names which have been given particularly to the chlorites filling cavities or seams in basic igneous rocks: *aphrosiderite, diabantite, delessite, epichlorite, euralite, chlorophæite, hullite, pycnochlorite.*

The following are other related minerals.

Moravite. $2FeO.2(Al,Fe)_2O_3.7SiO_2.2H_2O$. In lamellar, scaly and granular forms with perfect basal cleavage. H. = 3·5. G. = 2·4. Color iron-black. Fuses difficultly. Found at iron mines of Gobitschau near Sternberg, Moravia.

Cronstedite. $4FeO.2Fe_2O_3.3SiO_2.4H_2O$. Occurs tapering in hexagonal pyramids; also in diverging groups; amorphous. Cleavage: basal, highly perfect. Thin laminæ elastic. G. = 3·34–3·35. Color coal-black to brownish black; by transmitted light in thin scales emerald-green. Streak dark olive-green. $\beta = 1·80$. From Přibram in Bohemia; also in Cornwall, England.

Thuringite. $8FeO.4(Al,Fe)_2O_3.6SiO_2.9H_2O$. Massive; an aggregation of minute pearly scales. Color olive-green to pistachio-green. $\beta = 1·63$. From near Saalfeld, in Thuringia; Hot Springs, Ark., etc.; from the metamorphic rocks on the Potomac, near Harper's

Ferry (*owenite*). *Stilpnochloran* is name given to an alteration product of thuringite from Gobitschau, near Sternberg, Moravia. In yellow to bronze-red scales.

Brunsvigite. $9(Fe,Mg)O.2Al_2O_3.6SiO_2.8H_2O$. In cryptocrystalline and foliated masses sometimes forming spherical radiated aggregates. Under microscope folia show hexagonal outline. Color olive-green to yellow-green. H. = 1–2. G. = 3·0. Occurs in cavities in the gabbro of the Radautal in the Harz Mts., Germany.

Griffithite. $4(Mg,Fe,Ca)O.(Al,Fe)_2O_3.5SiO_2.7H_2O$. A member of the Chlorite Group. Color dark green. H. = 1. G. = 2·31. Fusible to magnetic slag. Pleochroic, pale yellow, olive-green, brown-green. Indices 1·48–1·57. Occurs in amygdaloidal cavities in a basalt from Cahuenga Pass, Griffith Park, Los Angeles, Cal.

CHAMOSITE. Contains iron (FeO) with but little MgO. Occurs compact or oölitic with H. about 3; G. = 3–3·4; color greenish gray to black. From Chamoson, near St. Maurice, in the Valais, Switzerland.

Stilpnomelane. An iron silicate. In foliated plates; also fibrous, or as a velvety coating. G. = 2·77–2·96. Color black, greenish black. Occurs at Obergrund and elsewhere in Silesia; also in Moravia; near Weilburg, Nassau, Germany. *Chalcodite*, from the Sterling Iron mine, in Antwerp, Jefferson Co., N. Y., coating hematite and calcite, is the same mineral in velvety coating of mica-like scales with a bronze color.

Minguétite. A member of Chlorite Group. A silicate of ferric and ferrous iron, intermediate between *stilpnomelane* and *lepidomelane*. G. = 2·86. Color blackish green. Strongly pleochroic, light yellow to opaque black. Optically –. Fuses to a black magnetic enamel. Decomposed by hydrochloric acid. From Minguet mine, near Segré, Maine-et-Loire, France.

Strigovite. $H_4Fe_2(Al,Fe)_2Si_2O_{11}$. In aggregations of minute crystals. Color dark green. Occurs as a fine coating over the minerals in cavities in the granite of Striegau in Silesia.

Rumpfite. Probably a variety of clinochlore. Massive; granular, consisting of very fine scales. Color greenish white. Occurs with talc near St. Michael and elsewhere in Styria.

Spodiophyllite. $(Na_2,K_2)_2(Mg,Fe)_3(Fe,Al)_2(SiO_3)_8$. In rough hexagonal prisms. Micaceous cleavage. Laminæ brittle. H. = 3–3·2. G. = 2·6. Color ash-gray. Fusible. From Narsarsuk, southern Greenland.

APPENDIX TO THE MICA DIVISION. — VERMICULITES.

The VERMICULITE GROUP includes a number of micaceous minerals, all hydrated silicates, in part closely related to the chlorites, but varying somewhat widely in composition. They are alteration-products chiefly of the micas, biotite, phlogopite, etc., and retain more or less perfectly the micaceous cleavage, and often show the negative optical character and small axial angle of the original species. Many of them are of a more or less indefinite chemical nature, and the composition varies with that of the original mineral and with the degree of alteration.

The laminæ in general are soft, pliable, and inelastic; the luster pearly or bronze-like, and the color varies from white to yellow and brown. Heated to 100°–110° or dried over sulphuric acid most of the vermiculites lose considerable water, up to 10 p. c., which is probably hygroscopic; at 300° another portion is often given off; and at a red heat a somewhat larger amount is expelled. Connected with the loss of water upon ignition is the common physical character of exfoliation; some of the kinds especially show this to a marked degree, slowly opening out, when heated gradually, into long worm-like threads. This character has given the name to the group, from the Latin *vermiculari, to breed worms.* The minerals included can hardly rank as distinct species and only their names can be given here: *Jefferisite, vermiculite, culsageeite, kerrite, lennilite, hallite, philadelphite, vaalite, maconite, dudleyite, pyrosclerite.*

III. Serpentine and Talc 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 silicates, in part amorphous, are included with them.

SERPENTINE.

Monoclinic. In distinct crystals, but only as pseudomorphs. Sometimes 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 cryptocrystalline; slaty. Crystalline in structure but often by compensation nearly isotropic; amorphous.

Cleavage *b* (010), sometimes distinct; also prismatic (50°) in chrysotile. Fracture usually conchoidal or splintery. Feel smooth, sometimes greasy. H. = 2·5–4, rarely 5·5. G. = 2·50–2·65; some fibrous varieties 2·2–2·3; retinalite, 2·36–2·55. Luster subresinous 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 + in chrysotile. Double refraction weak. Ax. pl. || *a* (100). Bx (*X*) ⊥ *b* (010) the cleavage surface; *Z* || elongation of fibers. Biaxial, angle variable, often large; 2V = 20° to 90°. Indices variable, from 1·490–1·571.

Var. — Many unsustained species have been made out of serpentine, differing in structure (massive, slaty, foliated, fibrous), or, as supposed, in chemical composition; and these now, in part, stand as varieties, along with some others based on variations in texture, etc.

A. In Crystals — Pseudomorphs. The most common have the form of chrysolite. Other kinds are pseudomorphs after pyroxene, amphibole, spinel, chondrodite, garnet, phlogopite, etc. *Bastite* or *Schiller Spar* is enstatite (hypersthene) altered more or less completely to serpentine. See p. 474.

B. Massive. 1. *Ordinary massive.* (*a*) *Precious* or *Noble Serpentine* is of a rich oil-green color, of pale or dark shades, and translucent even when in thick pieces. (*b*) *Common Serpentine* is of dark shades of color, and subtranslucent. The former has a hardness of 2·5–3; the latter often of 4 or beyond, owing to impurities.

Resinous. Retinalite. Massive, honey-yellow to light oil-green, waxy or resin-like luster.

Bowenite (Nephrite *Bowen*). Massive, of very fine granular texture, and much resembles nephrite, and was long so called. It is apple-green or greenish white in color; G. = 2·594–2·787; and it has the unusual hardness 5·5–6. From Smithfield, R. I.; also a similar kind from New Zealand.

Ricolite is a banded variety with a fine green color from Mexico.

C. Lamellar. *Antigorite*, thin lamellar in structure, separating into translucent folia. H. = 2·5; G. = 2·622; color brownish green by reflected light; feel smooth, but not greasy. From Antigorio valley, Piedmont, Italy.

D. Thin Foliated. *Marmolite*, thin foliated; the laminæ brittle but separable. G. = 2·41; colors greenish white, bluish white to pale asparagus-green. From Hoboken, N. J.

E. Fibrous. *Chrysotile.* Delicately fibrous, the fibers usually flexible and easily separating; luster silky, or silky metallic; color greenish white, green, olive-green, yellow and brownish; G. = 2·219. Often constitutes seams in serpentine. It includes most of the silky *amianthus* of serpentine rocks and much of what is popularly called *asbestus* (asbestos). Cf. p. 489.

Picrolite, columnar, but fibers or columns not easily flexible, and often not easily separable, or affording only a splintery fracture; color dark green to mountain-green, gray, brown. The original was from Taberg, Sweden. *Baltimorite* is picrolite from Bare Hills, Md.

Radiotine is like serpentine except in regard to its solubility and specific gravity. In spherical aggregates of radiating fibers from near Dillenburg, Nassau.

F. Serpentine Rocks. Serpentine often constitutes rock-masses. It frequently occurs mixed with more or less of dolomite, magnesite, or calcite, making a rock of clouded green, sometimes veined with white or pale green, called *verd antique*, *ophiolite*, or *ophicalcite*. Serpentine rock is sometimes mottled with red, or has something of the aspect of a red porphyry; the reddish portions containing an unusual amount of oxide of iron. Any serpentine rock cut into slabs and polished is called *serpentine marble.*

Microscopic examination has established the fact that serpentine in rock-masses has been largely produced by the alteration of chrysolite, and many apparently homogeneous serpentines show more or less of this original mineral. In other cases it has resulted from the alteration of pyroxene or amphibole. Sections of the serpentine derived from chrysolite often show a peculiar structure, like the meshes of a net (Fig. 958); the lines marked by grains of magnetite also follow the original cracks and cleavage directions of the chrysolite (Fig. 959, *a*). The serpentine from amphibole and pyroxene commonly shows an analogous structure; the iron particles following the former cleavage lines. Hence the nature of the original mineral can often be inferred. Cf. Fig. 959, *a*, *b*, *c* (Pirsson).

958

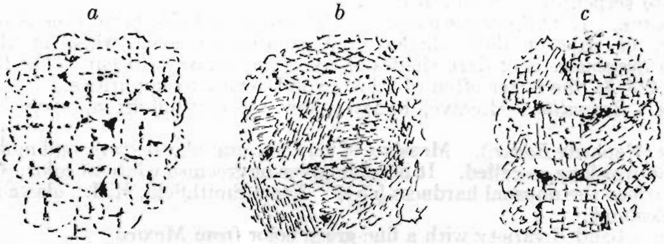
Comp. — A magnesium silicate, $H_4Mg_3Si_2O_9$ or $3MgO.2SiO_2.2H_2O$ = Silica 44.1, magnesia 43·0, water 12·9 = 100. Iron protoxide often replaces a small part of the magnesium; nickel in small amount is sometimes present. The water is chiefly expelled at a red heat.

Pyr., etc. — In the closed tube yields water. B.B. fuses on the edges with difficulty. F. = 6. Gives usually an iron reaction. Decomposed by hydrochloric and sulphuric acids. From chrysotile the silica is left in fine fibers.

Diff. — Characterized by softness, absence of cleavage and feeble waxy or oily luster; low specific gravity; by yielding much water B.B.

Micro. — Readily recognized in thin sections by its greenish or yellowish green color; low relief and aggregate polarization due to its fibrous structure. When the fibers are parallel, the interference-colors are not very low, but the confused aggregates may show the "ultra blue" or even be isotropic. The constant association with other magnesia bearing minerals like chrysolite, pyroxene, hornblende, etc., is also characteristic. The presence of lines of iron oxide particles as noted above (Fig. 959) is characteristic.

959



a, Serpentine derived from chrysolite; *b*, from amphibole; *c*, from pyroxene

Obs. — Serpentine is always a secondary mineral resulting, as noted above, from the alteration of silicates containing magnesia, particularly chrysolite, amphibole or pyroxene. It frequently forms large rock-masses, then being derived from the alteration of peridotites, dunites and other basic rocks of igneous origin; also of amphibolites, or pyroxene and chrysolite rocks of metamorphic origin. In the first case it is usually accompanied by spinel, garnet, chromite and sometimes nickel ores; in the second case by various carbonates such as dolomite, magnesite, breunnerite, etc.

Crystals of serpentine, pseudomorphous after monticellite, occur in the Fassatal, Tyrol, Austria. A variety containing soda from the Zillertal, Tyrol, is called *nemaphyllite.* Near Miask at Lake Aushkul, Barsovka, Ekaterinburg, and elsewhere in Russia; in Norway, at Snarum; etc. Fine precious serpentines come from Falun and Gulsjö in Sweden, the Isle of Man, the neighborhood of Portsoy in Aberdeenshire, Scotland; the Lizard in Cornwall, England; Corsica, Siberia, Saxony, etc.

In North America, in Me., at Deer Isle, precious serpentine. In Ver., at New Fane, Roxbury, etc. In Mass., fine at Newburyport. In R. I., at Newport; *bowenite* at Smithfield. In Conn., near New Haven and Milford, at the verd-antique quarries. In N. Y., at Port Henry, Essex Co.; at Antwerp, Jefferson Co., in crystals; in Gouverneur, St. Lawrence Co., in crystals; in Cornwall, Monroe, and Warwick, Orange Co., sometimes in large crystals at Warwick; and from Richmond to New Brighton, Richmond Co.; Brewsters. In N. J., at Hoboken, with brucite, magnesite, etc.; at Montville, Morris Co., chrysotile and retinalite, with common serpentine, produced by the alteration of pyroxene. In Pa., massive, fibrous, and foliated, at Texas, Lancaster Co.; at West Chester, Chester Co., *williamsite;* at Mineral Hill, Newtown, Marple, and Middletown, Delaware Co. In Md., at Bare Hills; at Cooptown, Harford Co., with diallage. In Cal., at various points in the Coast Range. Asbestus in notable deposits is found in the Grand Canyon, Ash Creek and Sierra Ancha Mts., Ariz.

In Canada, abundant among the metamorphic rocks of the Eastern Townships and Gaspé peninsula, Quebec; at Thetford, Coleraine, Broughton, Orford, South Ham, Bolton, Shipton, Melbourne, etc. The fibrous variety chrysotile (asbestus, bostonite) often forms seams several inches in thickness in the massive mineral, and is now extensively mined for technical purposes. Massive Laurentian serpentine also occurs in Grenville, Argenteuil Co., Quebec, and North Burgess, Lanark Co., Ontario. In New Brunswick, at Crow's Nest in Portland.

The names *Serpentine*, *Ophite*, *Lapis colubrinus*, allude to the green serpent-like cloudings of the serpentine marble. *Retinalite* is from ῥετινὴ, *resin; Picrolite*, from πικρός, *bitter*, in allusion to the magnesia (or Bittererde) present; *Thermophyllite*, from θέρμη, *heat*, and φύλλον, *leaf*, on account of the exfoliation when heated; *Chrysotile*, from χρυσος, *golden*, and τίλος, *fibrous; Metaxite*, from μέταξα, *silk; Marmolite*, from μαρμαίρω, *to shine*, in allusion to its peculiar luster.

Use. — As an ornamental stone; the fibrous variety furnishes the greater part of the heat insulating material known as asbestus.

Deweylite. A magnesian silicate near serpentine but with more water. Formula perhaps $4MgO.3SiO_2.6H_2O$. Amorphous, resembling gum arabic, or a resin. H. = 2–3·5. G. = 2·0–2·2. Color whitish, yellowish, reddish, brownish. Index, 1·55. Occurs with serpentine in the Fleimstal, Tyrol, Austria; also at Texas, Pa., and the Bare Hills, Md. *Gymnite* of Thomson, named from γυμνός, *naked*, in allusion to the locality at Bare Hills, Md., is the same species.

Genthite. Nickel Gymnite. A gymnite with part of the magnesium replaced by nickel, $2NiO.2MgO.3SiO_2.6H_2O$. Amorphous, with a delicate stalactitic surface, incrusting. H. = 3–4; sometimes very soft. G. = 2·409. Luster resinous. Color pale apple-green, or yellowish. From Texas, Lancaster Co., Pa., in thin crusts on chromite.

Nepouite. $3(Ni,Mg)O.2SiO_2.2H_2O$. In microscopic crystal plates with hexagonal outline. Good cleavages. H. = 2–2·5. G. = 2·5–3·2. Color pale to deep green. β = 1·62–1·63. Occurs in the nickel deposits of New Caledonia.

Garnierite. Noumeite. An important ore of nickel, consisting essentially of a hydrated silicate of magnesium and nickel, perhaps $H_2(Ni,Mg)SiO_4$ + water, but very variable in composition, particularly as regards the nickel and magnesium; not always homogeneous. Amorphous. Soft and friable. G. = 2·3–2·8. Luster dull. Color bright apple-green, pale green to nearly white. Index, 1·59. In part unctuous; sometimes adheres to the tongue. Occurs in serpentine rock near Noumea, capital of New Caledonia, associated with chromic iron and steatite, where it is extensively mined. A similar ore occurs at Riddle in Douglas County, southern Oregon; also at Webster, Jackson Co., N. C.

TALC.

Orthorhombic or monoclinic. Rarely in tabular crystals, hexagonal or rhombic with prismatic angle of 60°. Usually foliated massive; sometimes in globular and stellated groups; also granular massive, coarse or fine; fibrous (pseudomorphous); also compact or cryptocrystalline.

Cleavage: basal, perfect. Sectile. Flexible in thin laminæ, but not elastic. Percussion-figure a six-rayed star, oriented as with the micas. Feel greasy. H. = 1–1·5. G. = 2·7–2·8. Luster pearly on cleavage surface. Color apple-green to white, or silvery white; also greenish gray and dark green; sometimes bright green perpendicular to cleavage surface, and brown and less translucent at right angles to this direction; brownish to blackish green and reddish when impure. Streak usually white; of dark green varieties lighter than the color. Subtransparent to translucent. Optically negative. Ax. pl. $\|$ a (100). Bx $\perp$ c (001). Axial angle small, variable. Indices approx.; $\alpha = 1{\cdot}539$. $\beta = 1{\cdot}589$. $\gamma = 1{\cdot}589$.

Var. — *Foliated, Talc.* Consists of folia, usually easily separated, having a greasy feel, and presenting ordinarily light green, greenish white, and white colors. G. = 2·55–2·78.

Massive, Steatite or *Soapstone.* *a.* Coarse granular, grayish green, and brownish gray in color; H. = 1–2·5. *Pot-stone* is ordinary soapstone, more or less impure. *b.* Fine granular or cryptocrystalline, and soft enough to be used as chalk; as the *French chalk,* which is milk-white with a pearly luster. *c. Indurated talc.* An impure slaty talc, harder than ordinary talc.

Pseudomorphous. *a.* Fibrous, fine to coarse, altered from enstatite and tremolite. *b. Rensselaerite,* having the form of pyroxene from northern New York and Canada.

Comp. — An acid metasilicate of magnesium, $H_2Mg_3(SiO_3)_4$ or $H_2O.3MgO.4SiO_2$ = Silica 63·5, magnesia 31·7, water 4·8 = 100. The water goes off only at a red heat. Nickel is sometimes present in small amount.

Pyr., etc. — In the closed tube B.B., when intensely ignited, most varieties yield water. In the platinum forceps whitens, exfoliates, and fuses with difficulty on the thin edges to a white enamel. Moistened with cobalt solution, assumes on ignition a pale red color. Not decomposed by acids. Rensselaerite is decomposed by concentrated sulphuric acid.

Diff. — Characterized by extreme softness, soapy feel; common foliated structure; pearly luster; it is flexible but inelastic. Yields water only on intense ignition.

Obs. — Talc or steatite is a very common mineral, and in the latter form constitutes extensive beds in some regions. It is often associated with serpentine, talcose or chloritic schist, and dolomite, and frequently contains crystals of dolomite, breunnerite, also asbestus, actinolite, tourmaline, magnetite.

Steatite is the material of many pseudomorphs, among which the most common are those after pyroxene, hornblende, mica, scapolite, and spinel. The magnesian minerals are those which commonly afford steatite by alteration; while those like scapolite and nephelite, which contain soda and no magnesia, most frequently yield pinite-like pseudomorphs. There are also steatitic pseudomorphs after quartz, dolomite, topaz, chiastolite, staurolite, cyanite, garnet, vesuvianite, chrysolite, gehlenite. Talc in the fibrous form is pseudomorph after enstatite and tremolite.

Apple-green talc occurs at Mt. Greiner in the Zillertal, Tyrol, Austria; in the Valais and St. Gothard in Switzerland; in Cornwall, England, near Lizard Point, with serpentine; the Shetland islands.

In North America, foliated talc occurs in Me., at Dexter. In Ver., at Bridgewater, handsome green talc, with dolomite; Newfane. In Mass., at Middlefield, Windsor, Blanford, Andover, and Chester. In R. I., at Smithfield, delicate green and white in a crystalline limestone. In N. Y., at Edwards, St. Lawrence Co., a fine fibrous talc (*agalite*) associated with pink tremolite; on Staten Island. In N. J., Sparta. In Pa., at Texas, Nottingham, Unionville; in South Mountain, ten miles south of Carlisle; at Chestnut Hill, on the Schuylkill, talc and also soapstone, the latter quarried extensively. In Md., at Cooptown, of green, blue, and rose colors. In N. C., at Webster, Jackson Co. The important states for the production of talc and soapstone are New York, Vermont and Virginia. In Canada, in the townships Bolton, Sutton, and Potton, Quebec, with steatite in beds of Cambrian age; in the township of Elzevir, Hastings Co., Ontario, an impure grayish variety in Archæan rocks.

Use. — In the form of soapstone used for wash tubs, sinks, table tops, switchboards, hearth stones, furnace linings, etc.; the tips of gas burners, tailors' chalk, slate pencils, carved ornaments, etc.; in powdered form as filler in papers, as a lubricant, in toilet powders, etc.

Gavite is apparently a variety of talc, differing in the amount of water present and in its solubility in acids. From Gava valley, Italy.

SEPIOLITE. Meerschaum.

Compact, with a smooth feel, and fine earthy texture, or clay-like; also rarely fibrous. H. = 2–2·5. G. = 2. Impressible by the nail. In dry masses floats on water. Color grayish white, white, or with a faint yellowish or reddish tinge, bluish green. Opaque. Biaxial, −. $\beta = 1{\cdot}55$.

Comp. — $H_4Mg_2Si_3O_{10}$ or $2H_2O.2MgO.3SiO_2$ = Silica 60·8, magnesia 27·1, water 12·1 = 100. Some analyses show more water, which is probably to be regarded as hygroscopic. Copper and nickel may replace part of the magnesium.

Pyr., etc. — In the closed tube yields first hygroscopic moisture, and at a higher temperature gives much water and a burnt smell. B.B. some varieties blacken, then burn white, and fuse with difficulty on the thin edges. With cobalt solution a pink color on ignition. Decomposed by hydrochloric acid with separation of silica.

Obs. — Occurs in Asia Minor, in masses in stratified earthy or alluvial deposits at the plains of Eskihi sher; at Hrubschitz in Moravia; in Morocco, called in French *Pierre de Savon de Maroc;* at Vallecas in Spain, in extensive beds.

A fibrous mineral, having the composition of sepiolite, occurs in Utah.

The word *meerschaum* is German for *sea-froth,* and alludes to its lightness and color. *Sepiolite* is from *σήπια, cuttle-fish,* the bone of which is light and porous.

Connarite. A hydrous nickel silicate, perhaps $H_4Ni_2Si_3O_{10}$. In small fragile grains. G. = 2·459–2·619. Color yellowish green. From Röttis, in Saxon Voigtland.

Spadaite. Perhaps $5MgO.6SiO_2.4H_2O$. Massive, amorphous. Color reddish. From Capo di Bove, near Rome.

SAPONITE. Piotine.

Massive. In nodules, or filling cavities. Soft, like butter or cheese, but brittle on drying. G. = 2·24–2·30. Luster greasy. Color white, yellowish, grayish green, bluish, reddish. Does not adhere to the tongue.

Comp. — A hydrous silicate of magnesium and aluminium; but the material is amorphous and probably always impure, and hence analyses give no uniform results. Contains SiO_2 40–45 p. c., Al_2O_3 5–10 p. c., MgO 19–26 p. c., H_2O 19–21 p. c.; also Fe_2O_3, FeO, etc.

Pyr., etc. — B.B. gives out water very readily and blackens; thin splinters fuse with difficulty on the edge. Decomposed by sulphuric acid.

Obs. — Occurs in cavities in basalt, diabase, etc.; also with serpentine. Thus at Lizard Point, Cornwall, in veins in serpentine; at various localities in Scotland, etc.

Saponite is from *sapo, soap;* and piotine from *πιότης, fat.*

LASSALLITE. Composition perhaps $3MgO.2Al_2O_3.12SiO_2.8H_2O$. In snow-white fibrous masses. G. = 1.5. From the antimony mine at Miramont and at Can Pey near Arles-sur-Tech, France.

Celadonite. A silicate of iron, magnesium and potassium. Earthy or in minute scales. Very soft. Color green. Index, 1·63. From cavities in amygdaloid at Mte. Baldo near Verona, Italy.

Glauconite. Essentially a hydrous silicate of iron and potassium. Amorphous, and resembling earthy chlorite; either in cavities in rocks, or loosely granular massive. Color dull green. Index, 1·61. Occurs in rocks of nearly all geological ages; abundant in the "green sand," of the Chalk formation, sometimes constituting 75 to 90 p. c. of the whole. Found abundantly in ocean sediments near the continental shores. A manganese glauconite from the Marsjat forest, Ural Mts., has been called *marsjatskite.* ***Greenalite* is a** green hydrated ferrous silicate found as granules in the cherty rock associated with iron ores of the Mesabi district, Minn. Resembles glauconite but contains no potash.

Pholidolite. Corresponds approximately to $K_2O.12(Fe,Mg)O.Al_2O_3.13SiO_2.5H_2O$. In minute crystalline scales. G. = 2·408. Color grayish yellow. From Taberg in Wermland, Sweden, with garnet, diopside, etc.

IV. KAOLIN DIVISION

KAOLINITE. Kaolin.

Monoclinic; in thin rhombic, rhomboidal or hexagonal scales or plates with angles of 60° and 120°. Usually constituting a clay-like mass, either compact, friable or mealy.

Cleavage: basal, perfect. Flexible, inelastic. H. = 2–2·5. G. = 2·6–2·63. Luster of plates, pearly; of mass, pearly to dull earthy. Color white, grayish white, yellowish, sometimes brownish, bluish or reddish. Scales transparent to translucent; usually unctuous and plastic.

Optically biaxial, negative. $Bx_o \perp b$ (010). Bx_a and ax. pl. inclined behind some 20° to normal to c (001). Axial angle large, approx. 90°. $\beta = 1{\cdot}482$.

Var. — 1. *Kaolinite.* In crystalline scales, pure white and with a satin luster in the mass. 2. *Ordinary.* Common kaolin, in part in crystalline scales but more or less impure including the compact *lithomarge.*

Comp. — $H_4Al_2Si_2O_9$, or $2H_2O.Al_2O_3.2SiO_2$ = Silica 46.5, alumina 39.5, water 14·0 = 100. The water goes off at a high temperature, above 330°.

Pyr., etc. — Yields water. B.B. infusible. Gives a blue color on ignition with cobalt solution. Insoluble in acids.

Diff. — Characterized by unctuous, soapy feel and the alumina reaction B.B. Resembles infusorial earth, but readily distinguished under the microscope.

Obs. — Ordinary kaolin is a result of the decomposition of aluminous minerals, especially the feldspar of granitic and gneissoid rocks and porphyries. In some regions where these rocks have decomposed on a large scale, the resulting clay remains in vast beds of *kaolin,* usually more or less mixed with free quartz, and sometimes with oxide of iron from some of the other minerals present. Pure kaolinite in scales often occurs in connection with iron ores of the Coal formation. It sometimes forms extensive beds in the Tertiary formation, as near Richmond, Va. Also met with accompanying diaspore and emery or corundum.

Occurs in the coal formation in Belgium; Schlan in Bohemia; in argillaceous schist at Lodève, Dept. of Hérault, France; as kaolin at Diendorf (Bodenmais) in Bavaria; at Schemnitz, Hungary; with fluorite at Zinnwald, Germany. Yrieix, near Limoges, France, is the best locality of kaolin in Europe (a discovery of 1765); it affords material for the famous Sèvres porcelain manufactory. Large quantities of clay (kaolin) are found in Cornwall and West Devon, England.

In the United States, kaolin occurs at Newcastle and Wilmington, Del.; at various localities in the limonite region of Ver. (at Brandon, etc.), Mass., Delaware Co., Pa.; Jacksonville, Ala.; near Webster, N. C.; Edgefield, S. C.; near Augusta, Ga. In crystal plates from National Belle mine, Silverton, Col. From Lawrence Co., Ind.

The name *Kaolin* is a corruption of the Chinese *Kauling,* meaning *high-ridge,* the name of a hill near Jauchau Fu, where the material is obtained.

Use. — The finer, purer grades used in the manufacture of porcelain, china, etc.; in the form of clay in pottery, stoneware, bricks, etc.

Pholerite. Near kaolinite, but some analyses give 15 p. c. water. The original was from the coal mines of Fins, Dept. of Allier, France.

Faratsihite. $(Al,Fe)_2O_3.2SiO_2.2H_2O$. Intermediate between *kaolinite* and *chloropal.* Monoclinic. In microscopic hexagonal plates. Soft. G. = 2. Color pale yellow. Index a little higher than that of kaolinite. Difficultly fusible. Decomposed by hydrochloric acid. From Faratsiho, Madagascar.

HALLOYSITE.

Massive. Clay-like or earthy.

Fracture conchoidal. Hardly plastic. H. = 1–2. G. = 2·0–2·20. Luster somewhat pearly, or waxy, to dull. Color white, grayish, greenish, yellowish, bluish, reddish. Translucent to opaque, sometimes becoming translucent or even transparent in water, with an increase of one-fifth in weight.

Var. — *Ordinary.* Earthy or waxy in luster and opaque massive. *Galapectite* is halloysite of Angleur, Belgium. *Pseudosteatite* is an impure variety, dark green in color, with H. = 2·25. G. = 2·469. *Indianaite* is a white porcelain clay from Lawrence Co., Indiana, where it occurs with allophane in beds four to ten feet thick.

Smectite is greenish, and in certain states of humidity appears transparent and almost gelatinous; it is from Condé, near Houdan, France.

Bole, in part, may belong here; that is those colored, unctuous clays containing more or less iron oxide, which also have about 24 p. c. of water; the iron gives them a brownish, yellowish or reddish color; but they may be mixtures. Here belongs *Bergseife* (mountain-soap).

Comp. — A silicate of aluminium ($Al_2O_3.2SiO_2$) like kaolinite, but amorphous and containing more water; the amount is somewhat uncertain, but the formula is probably to be taken as $H_4Al_2Si_2O_9.H_2O$ or $2H_2O.Al_2O_3.2SiO_2.H_2O$ = Silica 43·5, alumina 36·9, water 19·6 = 100.

Pyr., etc. — Yields water. B.B. infusible. A fine blue on ignition with cobalt solution. Decomposed by acids.

Obs. — Occurs often in veins or beds of ore, as a secondary product; also in granite and other rocks, being derived from the decomposition of some aluminous minerals.

TERMIERITE. A clay-like substance resembling halloysite of uncertain composition from the antimony mines of Miramont, France.

Newtonite. $H_8Al_2Si_2O_{11}.H_2O$. In soft white compact masses resembling kaolin. Found on Sneed's Creek in the northern part of Newton Co., Ark.

BATCHELORITE. $Al_2O_3.2SiO_2.H_2O$. A green foliated mineral from Mt. Lyell mine, Tasmania.

Cimolite. A hydrous silicate of aluminium, $2Al_2O_3.9SiO_2.6H_2O$. Amorphous clay-like, or chalky. Very soft. G. = 2·18–2·30. Color white, grayish white, reddish. From the island of Argentiera (Kimolos of the Greeks).

Montmorillonite. Probably $H_2Al_2Si_4O_{12}.nH_2O$. Massive, clay-like. Very soft and tender. Luster feeble. Color white or grayish to rose-red, and bluish; also pistachio-green. Unctuous. *Montmorillonite*, from Montmorillon, France, is rose-red. *Confolensite* is paler rose-red; from Confolens, Dept. of Charente at St. Jean-de-Cole, near Thiviers.

Stolpenite is a clay from the basalt of Stolpen, Germany. *Saponite* of Nicklès is a white, plastic, soap-like clay from the granite from which issues one of the hot springs of Plombières, France, called *Soap Spring;* it was named *smegmatite* by Naumann.

PYROPHYLLITE.

Monoclinic? Foliated, radiated lamellar or somewhat fibrous; also granular to compact or cryptocrystalline; the latter sometimes slaty.

Cleavage: basal, eminent. Laminæ 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. Subtransparent to opaque. Optically −. Bx ⊥ cleavage. Ax. angle large, to 108°. Mean index, 1·58.

Var. — (1) *Foliated*, and often radiated, closely resembling talc in color, feel, luster and structure. (2) *Compact massive*, white, grayish and greenish, somewhat resembling compact steatite, or French chalk. This compact variety includes part of what has gone under the name of agalmatolite, from China; it is used for slate-pencils, and is sometimes called *pencil-stone.*

Comp. — $H_2Al_2(SiO_3)_4$ or $H_2O.Al_2O_3.4SiO_2$ = Silica 66·7, alumina 28·3, water 5·0 = 100.

Pyr., etc. — Yields water, but only at a high temperature. B.B. whitens, and fuses with difficulty on the edges. The radiated varieties exfoliate in fan-like forms, swelling up to many times the original volume of the assay. Moistened with cobalt solution and heated gives a deep blue color (alumina). Partially decomposed by sulphuric acid, and completely on fusion with alkaline carbonates.

Diff. — Resembles some talc, but distinguished by the reaction for alumina with cobalt solution.

Obs. — Compact pyrophyllite is the material or base of some schistose rocks. The foliated variety is often the gangue of cyanite. Occurs in the Ural Mts.; at Westanå, Sweden; near Ottrez, Luxemburg; Ouro Preto, Brazil.

Also in white stellate aggregations in Cottonstone Mt., Mecklenburg Co., N. C.; in Chesterfield Dist., S. C., with lazulite and cyanite; in Lincoln Co., Ga., on Graves Mt. The compact kind, at Deep River, N. C., is extensively used for making slate-pencils and resembles the so-called agalmatolite or pagodite of China, often used for ornamental carvings.

Use. — For the same purposes as talc, which see.

ALLOPHANE.

Amorphous. In incrustations, usually thin, with a mammillary surface, and hyalite-like; sometimes stalactitic. Occasionally almost pulverulent.

Fracture imperfectly conchoidal and shining, to earthy. Very brittle. H. = 3. G. = 1·85–1·89. Luster vitreous to subresinous; bright and waxy internally. Color pale sky-blue, sometimes greenish to deep green, brown, yellow or colorless. Streak uncolored. Translucent. n = 1·49.

Comp. — Hydrous aluminium silicate, $Al_2SiO_5.5H_2O$ = Silica 23·8, alumina 40·5, water 35·7 = 100. Some analyses give 6 equivalents of water = Silica 22·2, alumina 37·8, water 40·0 = 100.

Impurities are often present. The coloring matter of the blue variety is due to traces of chrysocolla, and substances intermediate between allophane and chrysocolla (mixtures) are not uncommon. The green variety is colored by malachite, and the yellowish and brown by iron.

Pyr., etc. — Yields much water in the closed tube. B.B. crumbles but is infusible. Gives a blue color on ignition with cobalt solution. Gelatinizes with hydrochloric acid.

Obs. — Allophane is regarded as a result of the decomposition of some aluminous silicate (feldspar, etc.); and it often occurs incrusting fissures or cavities in mines, especially those of copper and limonite, and even in beds of coal.

Named from *αλλος*, *other*, and *φαίνεσθαι*, *to appear*, in allusion to its change of appearance under the blowpipe.

Melite. $2(Al,Fe)_2O_3.SiO_2.8H_2O$. In imperfect prisms. Stalactitic, massive. H. = 3. G. = 2·2. Color bluish brown. Infusible. From Saalfield, Thuringia.

Collyrite. $2Al_2O_3.SiO_2.9H_2O$. A clay-like mineral, white, with a glimmering luster, greasy feel, and adhering to the tongue. G. = 2–2·15. From Ezquerra in the Pyrenees.

Schrötterite. $8Al_2O_3.3SiO_2.30H_2O$. Resembles allophane; sometimes like gum in appearance. H. = 3–3·5. G. = 1·95–2·05. Color pale green or yellowish. From Dollinger mountain, near Freienstein, in Styria; at the Falls of Little River, on the Sand Mt., Cherokee Co., Ala.

The following are clay-like minerals or mineral substances: *Sinopite, smectite, catlinite.*

Cenosite. $H_4Ca_2(Y,Er)_2CSi_4O_{17}$. Orthorhombic. G. = 3·38. Color yellowish brown. From Hitterö, Norway; Nordmark, Sweden.

Britholite. A complex silicate and phosphate of the cerium metals and calcium. Hexagonal. In minute crystals. H. = 5·5. G. = 4·4. Color brown. From nepheline syenite region of Julianehaab, South Greenland.

Erikite. Composition uncertain; essentially a silicate and phosphate of the cerium metals. Orthorhombic. In prismatic crystals. H. = 5·5. G. = 3·5. Color light yellow-brown to dark gray-brown. From nepheline-syenite in South Greenland.

Plazolite. $3CaO.Al_2O_3.2(SiO_2,CO_2).2H_2O$. Isometric. In minute dodecahedrons. H. = 6·5. G. = 3·13. Colorless to light yellow. n = 1·71. From Crestmore, Cal.

Thaumasite. $CaSiO_3.CaCO_3.CaSO_4.15H_2O$. Massive, compact, crystalline. Cleavage in traces. H. = 3·5. G. = 1·877. Color white. Uniaxial, −. ω = 1·507. ε = 1·468. Occurs filling cavities and crevices at the Bjelke mine, near Åreskuta, Jemtland, Sweden; at first soft but hardens on exposure to the air. Also in fibrous crystalline masses at Paterson, N. J.; from Beaver Co., Utah.

Spurrite. $2Ca_2SiO_4.CaCO_3$. Probably monoclinic. In granular cleavable masses. H. = 5. Color pale gray. β = 1·67. Infusible. From contact zone between limestone and diorite in Velardeña mining district, Mexico.

Uranophane. Uranotil. $CaO.2UO_3.2SiO_2.6H_2O$. In radiated aggregations; massive, fibrous. G. = 3·81–3·90. Color yellow. Biaxial, −. Indices, 1·650–1·670. From the granite of Kupferberg, Silesia. *Uranotil* occurs at Wölsendorf, Bavaria; Mitchell Co., N. C.

Dixenite. $MnSiO_3.2Mn_2(OH)AsO_3$. Hexagonal. In aggregates of thin folia. H. = 3–4. Basal cleavage. Color nearly black, red by transmitted light. Optically +. n = 1·96. From Långban, Sweden.

Bakerite. A hydrated calcium borosilicate, $8CaO.5B_2O_3.6SiO_2.6H_2O$. In compact masses resembling unglazed porcelain. H. = 4·5. G. = 2·7–2·9. Color white. Fusible. From borax deposits in Mohave desert, 16 miles N. E. of Daggett, San Bernardino Co., Cal.

CHRYSOCOLLA.

Cryptocrystalline; often opal-like or enamel-like in texture; earthy. Incrusting or filling seams. Sometimes botryoidal. In microscopic acicular crystals from Mackay, Idaho.

Fracture conchoidal. Rather sectile; translucent varieties brittle. H. = 2–4. G. = 2–2·238. Luster vitreous, shining, earthy. Color mountain-green, bluish green, passing into sky-blue and turquois-blue; brown to black when impure. Streak, when pure, white. Translucent to opaque. Crystals from Idaho gave: Uniaxial, +; ω = 1·46; ε = 1·57; weakly pleochroic, ω = colorless, ε = pale blue-green.

Comp. — True chrysocolla appears to correspond to $CuSiO_3.2H_2O$ = Silica 34·3, copper oxide 45·2, water 20·5 = 100, the water being double that of dioptase.

Composition varies much through impurities; free silica, also alumina, black oxide of copper, oxide of iron (or limonite) and oxide of manganese may be present; the color consequently varies from bluish green to brown and black. It has been suggested that the composition of most chrysocolla is not definite but that it is usually in the form of a mineral gel with copper oxide, silica and water occurring in varying proportions according to the conditions of formation.

Pyr., etc. — In the closed tube blackens and yields water. B.B. decrepitates, colors the flame emerald-green, but is infusible. With the fluxes gives the reactions for copper. With soda and charcoal a globule of metallic copper. Decomposed by acids without gelatinization.

Obs. — Accompanies other copper ores, occurring especially in the upper part of veins. Found in copper mines in Cornwall, England; Hungary; Siberia; Saxony; South Australia; Chile, etc.

In the United States, similarly at the Schuyler's mines, N. J.; at Morgantown, Pa.; at the Clifton mines, Graham Co., in Gila Co., Ariz.; Emma mine, Utah. In crystals from Mackay, Idaho.

Chrysocolla is from χρυσος, *gold*, and κόλλα, *glue*, and was the name of a material used in soldering gold. The name is often applied now to borax, which is so employed.

Use. — Chrysocolla may serve as a minor ore of copper.

Shattuckite. $2CuSiO_3.H_2O$. Compact, granular, fibrous. G. = 3·8. Color blue. Indices, 1·73–1·80. Pleochroic, dark to light blue. Found at Shattuck mine, Bisbee, Ariz., forming pseudomorphs after *malachite*.

Bisbeeite. $CuSiO_3.H_2O$. Orthorhombic, fibrous. Color pale blue to nearly white; Elongation of fibers positive. Indices 1·59 to 1·65. Pleochroic, very pale green to pale olive-brown. Found at Shattuck mine at Bisbee, Ariz., resulting from the hydration of *shattuckite*.

CHLOROPAL.

Compact massive, with an opal-like appearance; earthy.

H. = 2·5–4·5. G. = 1·727–1·870, earthy varieties, the second a conchoidal specimen; 2·105, Ceylon. Color greenish yellow and pistachio-green. Opaque to subtranslucent. Fragile. Fracture conchoidal and splintery to earthy. Adheres feebly to the tongue.

Var. — *Chloropal* has the above-mentioned characters, and was named from the Hungarian mineral occurring at Unghwar.

Nontronite is pale straw-yellow or canary-yellow, and greenish, with an unctuous feel; flattens and grows lumpy under the pestle, and is polished by friction; from Nontron, Dept. of Dordogne, France. *Pinguite* is siskin- and oil-green, extremely soft, like new-made soap, with a slightly resinous luster, not adhering to the tongue; from Wolkenstein in Saxony. *Graminite* has a grass-green color (whence the name), and occurs at Menzenberg, in the Siebengebirge, Germany; in thin fibrous seams, or as delicate lamellæ.

Comp. — A hydrated silicate of ferric iron, perhaps with the general formula $H_6Fe_2(SiO_4)_3.2H_2O$ or $Fe_2O_3.3SiO_2.5H_2O$ = Silica 41·9, iron sesquioxide 37·2, water 20·9 = 100. Alumina is present in some varieties.

The water and silica both vary much. The Hungarian chloropal occurs mixed with opal, and graduates into it, and this accounts for the high silica of some of its analyses.

Obs. — Localities mentioned above. *Chloropal* occurs also at Meenser Steinberg near Göttingen, Germany; *pinguite* at Sternberg, Moravia. On Lehigh Mt., Pa., south of Allentown, occurs in connection with iron deposits. From Palmetto Mts., Esmeralda Co., Nev.

HŒFERITE. An iron silicate near chloropal. Color green. From Křitz, Bohemia.

Müllerite. *Zamboninite.* $Fe_2Si_3O_9.2H_2O$. Massive. Resembles nontronite. Soft. G. = 2·0. Color yellowish green. Infusible. From Nontron, Dordogne, France.

Hisingerite. A hydrated ferric silicate, of uncertain composition. Amorphous, compact. Fracture conchoidal. H. = 3. G. = 2·5–3·0. Luster greasy. Color black to brownish black. Streak yellowish brown. From Riddarhyttan, Tunaberg, Sweden; Långban, etc., Norway; from Greenland.

Morencite. A hydrated ferric silicate of uncertain composition. Fibrous. Color brownish yellow. From Morenci, Ariz.

The following are hydrous manganese silicates.

Bementite. $H_6Mn_5(SiO_4)_4$. Orthorhombic. Cleavages || to three pinacoids. In soft radiated masses resembling pyrophyllite. G. = 2·981. Color pale grayish yellow. From the zinc mines of Franklin Furnace, N. J.

Ectropite. $Mn_2Si_8O_{28}.7H_2O$. Monoclinic(?). In thin tabular crystals. Good cleavage. H. = 4. G. = 2·46. Color brown. Opaque. Indices, 1·62–1·63. From Långban, Sweden.

Agnolite. $H_2Mn_3(SiO_3)_4.H_2O$. Name given to the manganese silicate occurring as part of the material from Schemnitz, Hungary, known as *manganocalcite*. Triclinic. In radiating fibrous masses. Color flesh-red to rose. H. = 5. G. = 3·0.

Orientite. $Ca_4\overset{III}{Mn}_4(SiO_4)_5.4H_2O$. Orthorhombic. Radiating prismatic. Brown to black. Transparent to opaque. H. = 4·5–5. G. = 3. Optically +. $\alpha = 1·758$. $\beta = 1·776$. $\gamma = 1·795$. From Oriente Province, Cuba.

Hodgkinsonite. $3(Zn,Mn)O.SiO_2.H_2O$. Monoclinic. In acute pyramidal crystals. Perfect basal cleavage. H. = 4·5–5. G. = 3·91. Color, bright pink to reddish brown. $n = 1·73$. Decrepitates and then fuses readily. Soluble in acids. From Franklin, N. J.

Gageite. — A hydrous silicate of manganese, magnesium and zinc, $8RO.3SiO_2.2H_2O$. In radiating groups of needle-like crystals. Colorless and transparent. From Franklin, N. J.

Caryopilite. Approximately $4MnO.3SiO_2.3H_2O$. In stalactitic and reniform shapes. G. = 2·83–2·91. Color brown. From the Harstig mine near Pajsberg, Sweden.

Neotocite. A hydrated silicate of manganese and iron, of doubtful composition, usually derived from the alteration of rhodonite. Amorphous. Color black to dark brown and liver-brown.

Searlesite. $NaB(SiO_3)_2.H_2O$. Monoclinic (?). In minute spherulites composed of radiating fibers. Color white. Indices, 1·52–1·53. Fusible. Decomposed by hydrochloric acid. Found at Searles Lake, San Bernardino Co., Cal.

Colerainite. $4MgO.Al_2O_3.2SiO_2.5H_2O$. Hexagonal. In minute, thin, hexagonal plates. H. = 2·5–3. G. = 2·51. Colorless or white. Optically +. Index, 1·56. Found in Black Lake area, Coleraine township, Quebec.

TARTARKAITE. A complex hydrous silicate of aluminium, magnesium, etc. Tabular crystals. G. = 2·7. Color dark gray to black. Uniaxial, +. In limestone on the Tartarka river, Yenisei District, Siberia.

ITANO-SILICATES, TITANATES

This section includes the common calcium titano-silicate, Titanite; also a number of silicates which contain titanium, but whose relations are not altogether clear; further the titanate, Perovskite, and niobo-titanate, Dysanalyte, which is intermediate between Perovskite and the species Pyrochlore, Microlite, Koppite of the following section.

In general the part played by titanium in the many silicates in which it enters is more or less uncertain. It is probably in most cases, as shown in the preceding pages, to be taken as replacing the silicon; in others, however, it seems to play the part of a basic element; in schorlomite (p. 510) it may enter in both relations.

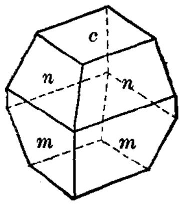
TITANITE. Sphene.

Monoclinic. Axes $a : b : c = 0{\cdot}7547 : 1 : 0{\cdot}8543$; $\beta = 60° 17'$.

mm''', $110 \wedge 1\bar{1}0 = 66° 29'$.
cx, $001 \wedge 102 = 21° 0'$.
ss', $021 \wedge 0\bar{2}1 = 112° 3'$.
nn', $111 \wedge 1\bar{1}1 = 43° 49'$.

ll', $\bar{1}12 \wedge \bar{1}\bar{1}2 = 46° 7\tfrac{1}{2}'$.
cn, $001 \wedge 111 = 38° 16'$.
cm, $001 \wedge 110 = 65° 30'$.
cl, $001 \wedge \bar{1}12 = 40° 34'$.

960



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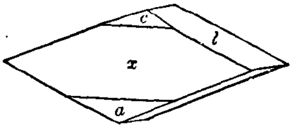

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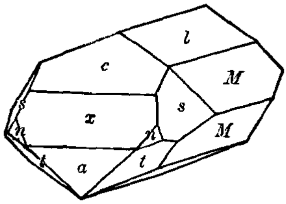

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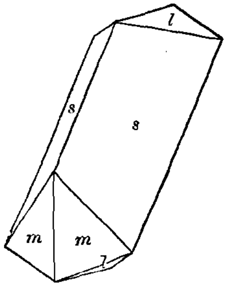

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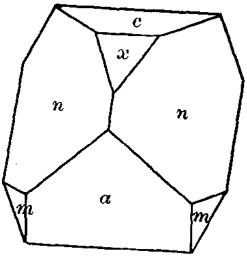

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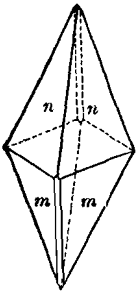

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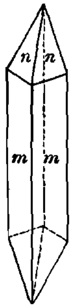

Twins: tw. pl. *a* (100) rather common, both contact-twins and cruciform penetration-twins. Crystals very varied in habit; often wedge-shaped and