

Comp.— $H_2(Mg,Fe)_4Al_2Si_6O_{20}$, or $H_2O.4(Mg,FeO).4Al_2O_3.10SiO_2$.
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.

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*), hornblende, 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; in colorless crystals from Brazil; Ceylon affords a transparent variety, the *saphir d'eau* of jewelers.

In the U. S., at Haddam, Conn., associated with tourmaline in a granitic vein in gneiss. At Brimfield, Mass.; at Richmond, N. H.

Named *Iolite* from *iov, violet*, and *lithos, stone*; *Dichroite* (from *δύχρως, two-colored*), from its dichroism; *Cordierite*, after Cordier, the French geologist (1777-1861).

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 alkalis, 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* (incl. *bonsdorffite* and *auralite*) from Åbo, Finland; *fahlunite* from Falun, Sweden, also *pyrrargillite* 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.

The following are rare lead and barium silicates:

Barysilite. $Pb_3Si_2O_7$. 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, Sweden.

Ganomalite. $Pb_3Si_2O_7.(Ca,Mn)_2SiO_4$. In prismatic crystals (tetragonal); also massive, granular. H. = 3. G. = 5.74. Colorless to gray. From Långban, Sweden; also Jakobsberg.

Hyalotekite. Approximately $(Pb,Ba,Ca)_3(SiO_3)_{12}$. Massive; coarsely crystalline. H. = 5-5.5. G. = 3.81. Color white to pearly gray. From Långban, Sweden.

Barylite. $Ba_4Al_4Si_4O_{24}$. In groups of colorless prismatic crystals. H. = 7. G. = 4.03. Luster greasy. Occurs with hedyphane in crystalline limestone at Långban, Sweden.

Roebblingite. $5(H_2CaSiO_4).2(CaPbSO_4)$. 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_2SiO_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.	Scapolite Group. Tetragonal-pyramidal.
Sodalite Group. Isometric.	Zircon Group. Tetragonal.
Helvite Group. Isometric-tetrahedral.	Danburite Group. Orthorhombic.
Garnet Group. Isometric.	Datolite Group. Monoclinic.
Chrysolite Group. Orthorhombic.	Epidote Group. Monoclinic.
Phenacite Group. Tri-rhombohedral.	

Nephelite Group. Hexagonal.

Typical formula $\bar{R}AlSiO_4$.

Nephelite	$K_2Na_4Al_2Si_6O_{24}$	$d = 0.8389$
Soda-nephelite (artif.)	$NaAlSiO_4$	
Eucryptite	$LiAlSiO_4$	Kaliophilite $KAlSiO_4$
Cancrinite	$H_2Na_4Ca(NaCO_3)_2Al_2(SiO_4)_6$	$2d = 0.8448$
Microsommitte	$(Na,K)_6Ca_4Al_2Si_{12}O_{48}S_2Cl_4$	$2d = 0.8367$

The species of the NEPHELITE GROUP are hexagonal in crystallization and have in part the typical orthosilicate formula $\bar{R}AlSiO_4$. From this formula nephelite itself deviates somewhat, though an artificial soda-nephelite, $NaAlSiO_4$, conforms to it. The species Cancrinite and Microsommitte 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.

Hexagonal-hemimorphic (p. 73). Axis $d = 0.83893$.

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* distinct; *c* 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: $\omega_y = 1.542$, $\epsilon_y = 1.538$.

Var.—1. Nephelite. Glassy.—Usually in small glassy crystals or grains, transparent with vitreous luster, first found on Mte. Somma. 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.— $\bar{R}_2\text{Al}_2\text{Si}_2\text{O}_8$; if $\bar{R} = \text{Na} : \text{K} = 3 : 1$, this is equivalent to $3\text{Na}_2\text{O} \cdot \text{K}_2\text{O} \cdot 4\text{Al}_2\text{O}_3 \cdot 9\text{SiO}_2$ = Silica 44.0, alumina 33.2, soda 15.1, potash 7.7 = 100. In most analyses $\text{Na} : \text{K} = 4 : 1$ or $5 : 1$.

Synthetic experiments, yielding crystals like nephelite with the composition $\text{NaAlSi}_3\text{O}_8$, 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 KAlSi_2O_6 or $\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$ (= leucite). The other species of the group are normal orthosilicates, viz., eucryptite $\text{LiAlSi}_3\text{O}_8$, and kaliophilite, KAlSi_3O_8 .

Pyr., etc.—B.B. fuses quietly at 3.5 to a colorless glass. 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.

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 selenite plate (see p. 201). 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.

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, with mica, vesuvianite, etc.; at Capo di Bove, near Rome; in the basalt of Katzenbuckel, near Heidelberg; 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; Miask in the Ilmen Mts. (in the rock *niascite*); Sierra Monchique, Portugal (in the rock *foyaite*); Ditró, Hungary (in the rock *ditróite*); 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, Arkansas; *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 distr., Texas; Pilot Butte, Texas; also in western N. America, as in Colorado at Cripple Creek; in Montana, in the Crazy Mts., the Highwood, Bearpaw and Judith Mts.; Black Hills in So. Dakota; Ice River, British Columbia.

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

Giesekite 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. *Dysyntrite* from Diana is similar to giesekite, as is also *liebenerite*, from the valley of Fleims, in Tyrol. See further **PINITE** under the **MICA GROUP**.

Eucryptite. $\text{LiAlSi}_3\text{O}_8$. In symmetrically arranged crystals (hexagonal), embedded in albite and derived from the alteration of spodumene at Branchville, Conn. (see Fig. 474, p. 141). $G. = 2.667$. Colorless or white.

Kaliophilite. KAlSi_3O_8 . 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.

CANCRINITE.

Hexagonal. Axis $c = 0.4224$; and $mp = 64^\circ$, $pp' = 25^\circ 58'$. Rarely in prismatic crystals with a low terminal pyramid. Usually massive.

Cleavage: prismatic (m) perfect; a 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 uniaxial, negative.

Comp.— $\text{H}_6\text{Na}_4\text{Ca}(\text{NaCO}_3)_2\text{Al}_2(\text{SiO}_4)_2$ or $3\text{H}_2\text{O} \cdot 4\text{Na}_2\text{O} \cdot \text{CaO} \cdot 4\text{Al}_2\text{O}_3 \cdot 9\text{SiO}_2 \cdot 2\text{CO}_2$ = 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.

Diff.—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.

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., 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 Särna 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.

Microsommitte. Near cancrinite; perhaps $(\text{Na}, \text{K})_{10}\text{Ca}_4\text{Al}_{12}\text{Si}_{12}\text{O}_{52}\text{SCL}_4$. In minute colorless prismatic crystals (hexagonal). From Vesuvius (Monte Somma). $H. = 6$. $G. = 2.42-2.53$.

DAVYNE is in part at least microsommitte. From Mte. Somma.

Sodalite Group. Isometric.

Sodalite	$\text{Na}_4(\text{AlCl})\text{Al}_3(\text{SiO}_4)_3$
Häüynite	$(\text{Na}_2, \text{Ca})_2(\text{NaSO}_4, \text{Al})\text{Al}_2(\text{SiO}_4)_2$
Noselite	$\text{Na}_4(\text{NaSO}_4, \text{Al})\text{Al}_2(\text{SiO}_4)_2$
Lazurite	$\text{Na}_4(\text{NaS}_2, \text{Al})\text{Al}_2(\text{SiO}_4)_2$

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 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. 414.

The formulas are also often written as if the compound consisted of a silicate and chloride (sulphate, sulphide)—thus for sodalite, $3\text{NaAlSiO}_4 + \text{NaCl}$, etc.

SODALITE.

Isometric, perhaps tetrahedral. Common form the dodecahedron. Twins: tw. pl. *o*, forming hexagonal prisms by elongation in the direction of an octahedral axis (Fig. 368, p. 123). 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. $n_v = 1.4827$ Na.

Comp.— $\text{Na}_4(\text{AlCl})\text{Al}_2(\text{SiO}_4)_3 = \text{Silica } 37.2, \text{ alumina } 31.6, \text{ soda } 25.6, \text{ chlorine } 7.3 = 101.7, \text{ deduct } (\text{O} = 2\text{Cl}) 1.7 = 100.$ Potassium replaces a small part of the sodium. The formula may also be written $3\text{NaAlSiO}_4 + \text{NaCl}$.

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. Decomposed by hydrochloric acid, with separation of gelatinous silica.

Diff.—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. 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.

Obs.—Sodalite occurs only in igneous rocks of the nephelite-syenite and related rock groups, either directly, as is commonly the case, 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 Scarpupa in Ischia, 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; also near Lake Laach. At Ditró, Transylvania, in an *elæolite-syenite*. In the foyaite of southern Portugal. At Miask, in the Ilmen Mts.; in the augite-syenite of the Langesund-fiord region in Norway. Further in West Greenland in sodalite-syenite; the peninsula of Kola.

A blue massive variety occurs at Litchfield and West Gardiner, Me. Occurs in the *theralite* of the Crazy Mts., Montana; also at Square Butte, Highwood Mts., and in the Bearpaw Mts., in tinguaita. 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.

HAÜYNNITE. *Haüyne*.

Isometric. Sometimes in dodecahedrons, octahedrons, etc.

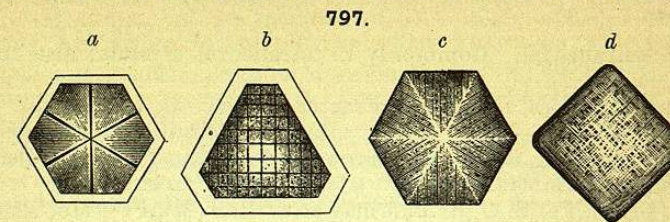
Twins: tw. pl. *e*; contact-twins, also polysynthetic; penetration-twins (Fig. 367, p. 123). Commonly in rounded grains, often looking like crystals with fused surfaces.

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. 797). $n_v = 1.4961$.

Comp.— $\text{Na}_2\text{Ca}(\text{NaSO}_4.\text{Al})\text{Al}_2(\text{SiO}_4)_3$. This is analogous to the garnet formula (Brögger) where the place of the R_2 is taken by Na_2, Ca and the group $\text{Na}-\text{O}-\text{SO}_2-\text{O}-\text{Al}$. The percentage composition is: Silica 32.0, sulphur trioxide 14.2, alumina 27.2, lime 10.0, soda 16.6 = 100. The ratio of $\text{Na}_2 : \text{Ca}$ also varies from 3 : 2; potassium may be present in small amount. The formula may also be written $2(\text{Na}_2, \text{Ca})\text{Al}_2(\text{SiO}_4)_3 + (\text{Na}_2, \text{Ca})\text{SO}_4$.

Pyr., etc.—In the closed tube retains its color. B.B. in the forceps fuses at 4.5 to a white glass. Fused with soda on charcoal affords a sulphide, which blackens silver. Decomposed by hydrochloric acid with separation of gelatinous silica.

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

Section of crystals of *haüynite* (after Möhl).

in the peperino near Albano; at Niedermendig, in the Eifel; the phonolites of Hohentwiel.

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. 797). Not uncommon in phonolite. 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.

Comp.—Essentially $\text{Na}_4(\text{NaS}_2.\text{Al})\text{Al}_2(\text{SiO}_4)_3$ (Brögger), 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 $(\text{O} = \text{S}) 2.9 = 100$.

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* (Lasurstein) 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.

Pyr., etc.—Heated in the closed tube gives off some moisture; the variety from Chili 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. Decomposed by hydrochloric acid, with separation of gelatinous silica and evolution of hydrogen sulphide.

Obs.—Occurs in Badakshan in the valley of the Kokcha, a branch of the Oxus, a few miles above Firgamu. Also at the south end of L. Baikal. Further, in Chili in the Andes of Ovalle. In ejected masses at Monte Somma, rare.

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	$(\text{Mn}, \text{Fe})_2(\text{Mn}_2\text{S})\text{Be}_3(\text{SiO}_4)_3$
Danalite	$(\text{Fe}, \text{Zn}, \text{Mn})_2(\text{Zn}, \text{Fe})_2\text{S}(\text{SiO}_4)_3$
Eulytite	$\text{Bi}_4(\text{SiO}_4)_3$
Zunyite	$(\text{Al}(\text{OH}, \text{F}, \text{Cl})_2)_6\text{Al}_2(\text{SiO}_4)_3$

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.— $(Be, Mn, Fe)_2 Si_3 O_{12} S$. This may be written $(Mn, Fe)_2 (Mn, S) Be_3 (SiO_4)_3$ (Brögger), 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. 415. Composition also written $3(Be, Mn, Fe)_2 SiO_4 (Mn, Fe)S$.

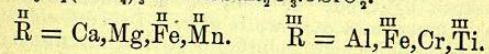
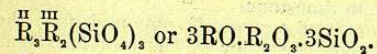
Pyr., etc.—Fuses at 3 in R.F. with intumescence to a yellowish-brown opaque bead, becoming darker in R.F. With the fluxes gives the manganese reaction. Decomposed by hydrochloric acid, with evolution of hydrogen sulphide and separation of gelatinous silica.

Obs.—Occurs at Schwarzenberg and Breitenbrunn, in Saxony; at Kapnik, Hungary; also in the pegmatite veins of the augite-syenite of the Langesund fiord; in the Ilmen Mts. near Miask in pegmatite. In the U. S., 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. $(Be, Fe, Zn, Mn)_2 Si_3 O_{12} S$. 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., Colorado.

Eulytite. $Bi_2 Si_3 O_{12}$. Wismuthblende, Kieselwismuth *Grm.* 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. Found with native bismuth near Schneeberg, Saxony; also at Johanngeorgenstadt in crystals on quartz.

Zunyite. A highly basic orthosilicate of aluminium, $(Al(OH, F, Cl)_2)_2 Al_2 Si_3 O_{12}$. In minute transparent tetrahedrons. $H. = 7$. $G. = 2.875$. From the Zúñi mine, near Silverton, San Juan Co., and on Red Mountain, Ouray Co., Colorado.

4. Garnet Group. Isometric.**Garnet**

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|-----------------|-----------------------|---------------|-----------------------------|
| A. GROSSULARITE | $Ca_3 Al_2 (SiO_4)_3$ | D. SPESARTITE | $Mn_3 Al_2 (SiO_4)_3$ |
| B. PYROPE | $Mg_3 Al_2 (SiO_4)_3$ | E. ANDRADITE | $Ca_3 Fe_2 (SiO_4)_3$ |
| C. ALMANDITE | $Fe_3 Al_2 (SiO_4)_3$ | Also | $(Ca, Mg)_3 Fe_2 (SiO_4)_3$ |
| | | | $Ca_3 Fe_2 ((Si, Ti)O_4)_3$ |
| | | F. UVAROVITE | $Ca_3 Cr_2 (SiO_4)_3$ |

Schorlomite $Ca_3 (Fe, Ti)_2 ((Si, Ti)O_4)_3$

The GARNET GROUP includes a series of important sub-species included under the same specific name. They all crystallize in the normal group 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

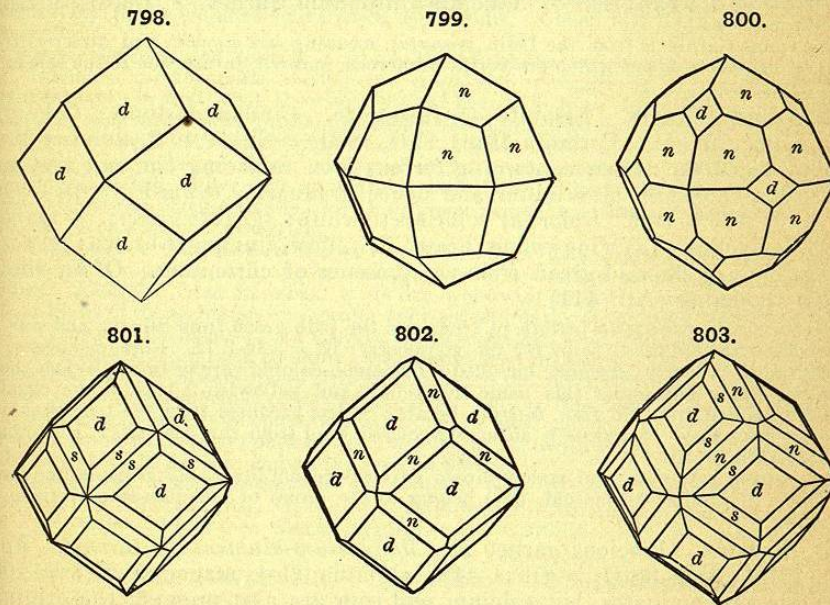
they are connected with the rare species schorlomite, which probably also has the same general formula.

Closely related to the GARNET GROUP proper are the species of the Sodalite and Helvite Groups (p. 411, p. 413). All are characterized by isometric crystallization, and all are orthosilicates, with similar chemical structure. Thus the formula of the Garnet Group is $\overset{II}{R}_3 \overset{III}{R}_2 (SiO_4)_3$; to this Sodalite conforms if written $Na_4 (AlCl) Al_2 (SiO_4)_3$, where Na_4 and the bivalent radical $AlCl$ are equivalent to R_3 ; similarly for Noselite (Haüyite) if the presence of the bivalent group $NaSO_4-Al$ 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 $(Mn, Fe)(Mn, S) Be_3 (SiO_4)_3$, 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 massive; granular, coarse or fine, and sometimes friable; lamellar, lamellar thick and bent. Sometimes compact, cryptocrystalline like nephrite.



Parting: d 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. 411. Refractive index rather high, thus n_r for:

Grossularite 1.7645, Pyrope 1.7776, Almandite 1.7716.

Comp., Var.—An orthosilicate having the general formula $R_2^{II}R_2^{III}(SiO_4)_3$ 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.

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	$Ca_3Cr_2(SiO_4)_3$
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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. = 3.55 to 3.66. 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. 411).

The original *grossularite* (*wiluite* pt.) 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 *ἡσσων*, *inferior*, because of less hardness than the true hyacinth which it resembles. *Succinite* is an amber-colored kind from the Ala valley, Piedmont. *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 pt. *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. = 3.70-3.75. Color deep red to nearly black. Often perfectly transparent and then prized as a gem. The name *pyrope* is from *πυρῶπιος*, *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 pt. Common garnet pt. *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. = 3.9-4.2. Color fine deep red, transparent, in *precious garnet*; brownish red, translucent or sub-translucent, 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. = 4.0-4.3. 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. = 3.8-3.9. 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, 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, 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 *ἄπλοος*, 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*; *Yttergranat*. Contains yttria in small amount; rare.

F. UVAROVITE. Uvarovite. 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, grossularite, and allochroite; 3.5 in pyrope; but uvarovite, the chrome-garnet, is almost infusible, F. = 6. Allochroite 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 are after ignition decomposed by hydrochloric acid, and generally with separation of gelatinous silica on evaporation. Decomposed on fusion with alkaline carbonates.