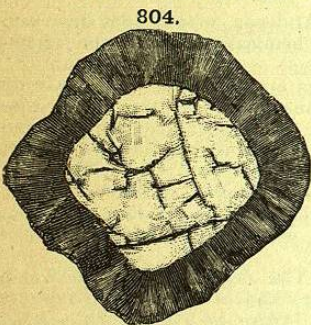


The density of garnets is largely diminished by fusion. Thus a Greenland garnet fell from 3.90 to 3.05 on fusion, and a Vilui grossularite from 3.63 to 2.95.

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.

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.

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 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 alkalis, 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.



show successive layers of garnet and calcite. Many such cases have been noted.

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. 804.

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, with clinocllore and diopside; at Zermatt; pale yellow at Auerbach; 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; 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 Morelos, Mexico.

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; 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 Zillerthal, Tyrol. Precious garnet comes in fine crystals from Ceylon, British India, Brazil, and Greenland. **SPESPARTITE:** From Aschaffenburg in the Spessart, Bavaria; at St. Marcel, Piedmont; near Chanteloube, Haute-Vienne, 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; green crystals occur at Schwarzenberg, Saxony; brown to green at Morawitza and Dognacska; emerald-green at Dobschau; in the Ala valley, Piedmont, the yellow to greenish *topazolite*. *Allochroite*, apple-green and yellowish, occurs at Zermatt; black crystals (*melanite*), also

brown, at Vesuvius on Mte. Somma; near Barèges in the Hautes-Pyrénées (*pyreneite*). *Aplome* occurs at Schwarzenberg in Saxony, in brown to black crystals. Other localities are Pötschthal, Tyrol; Långban, Sweden; Pitkäranta, Finland; Arendal, Norway. **UVAROVITE:** Found at Saranovskaya near Bisersk, also in the vicinity of Kyshtym, Ural, in chromic iron; at Jordansmühl, Silesia; Pic Posets near Vénasque in the Pyrenees on chromite.

In N. America, in *Maine*, beautiful crystals of cinnamon-stone (with vesuvianite) occur at Parsonsfield, Phippsburg, and Rumford. In *N. Hamp.*, at Hanover, small clear crystals in gneiss; at Warren, cinnamon garnets; at Grafton. In *Vermont*, 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; at Haddam, crystals of spessartite. In *N. York.*, brown crystals at Crown Point, Essex Co.; colophonite as a large vein at Willsboro, Essex Co.; in Middletown, Delaware Co., large brown cryst.; a cinnamon variety at Amity. In *N. Jersey*, at Franklin, black, brown, yellow, red, and green dodecahedral garnets; also near the Franklin Furnace (*polyadelphite*). In *Penn.*, in Chester Co., at Pennsbury, fine dark brown crystals; near Knauertown; at Chester, brown; in Concord, on Green's Creek, resembling pyrope; in Leiper'sville, red; at Mineral Hill, fine brown; at Avondale quarry, fine hessonite; uvarovite at Woods' chrome mine, Lancaster Co. In *Virginia*, beautiful transparent spessartite, used as a gem, at the mica mines at Amelia Court-House. In *N. Carolina*, 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 *Kentucky*, fine pyrope in the peridotite of Ellis Co. In *Arkansas*, at Magnet Cove, a titaniferous melanite with schorlomite. Large dodecahedral crystals altered to chlorite occur at the Spurr Mt. iron mine, Lake Superior. In *Colorado*, 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 *Arizona*, yellow-green crystals in the Gila cañon; pyrope on the Colorado river in the western part of the territory. *New Mexico*, fine pyrope on the Navajo reservation with chrysolite and a chrome-pyroxene. In *California*, 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 R., 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.

Schorlomite. Probably analogous to garnet, $3\text{CaO} \cdot (\text{Fe}, \text{Ti})_2\text{O}_3 \cdot 3(\text{Si}, \text{Ti})\text{O}_2$. Schorlamit. Usually massive, black, with conchoidal fracture and vitreous luster. H. = 7-7.5. G. = 3.81-3.88. From Magnet Cove, Arkansas.

Partschinite. $(\text{Mn}, \text{Fe})_2\text{Al}_2\text{Si}_3\text{O}_{12}$, like spessartite. In small dull crystals (monoclinic). H. = 6.5-7. G. = 4.006. Color yellowish, reddish. From the auriferous sands of Oláhpián, Transylvania.

Agricolite. Same as for eulytite, $\text{Bi}_4\text{Si}_3\text{O}_{12}$, but monoclinic. In globular or semi-globular forms. From Johanngeorgenstadt.

Chrysolite Group. R_2SiO_4 . Orthorhombic.

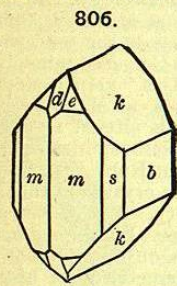
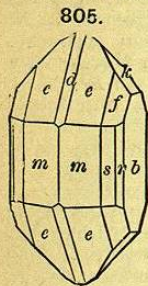
		mm'''	hh'	$a : b : c$
		$110 \wedge 110$	$011 \wedge 0\bar{1}0$	
Monticellite	CaMgSiO_4	$46^\circ 54'$	$59^\circ 52'$	0.4337 : 1 : 0.5758
Forsterite	Mg_2SiO_4	$49^\circ 51'$	$60^\circ 43'$	0.4648 : 1 : 0.5857
Chrysolite	$(\text{Mg}, \text{Fe})_2\text{SiO}_4$	$49^\circ 57'$	$60^\circ 47'$	0.4656 : 1 : 0.5865
Hortonolite	$(\text{Fe}, \text{Mg}, \text{Mn})_2\text{SiO}_4$			
Fayalite	Fe_2SiO_4	$49^\circ 15'$	$60^\circ 10'$	0.4584 : 1 : 0.5793
Knebelite	$(\text{Fe}, \text{Mn})_2\text{SiO}_4$			
Tephroite	Mn_2SiO_4	$49^\circ 24'$	$61^\circ 25'$	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. Cf. Brögger, Zs. Kryst., 13, 377, 1890. There is also an interesting relation between the chrysolites and the humites (see p. 443)

CHRYSOLITE. Olivine. Peridot.

Orthorhombic. Axes $a : b : c = 0.46575 : 1 : 0.5865$.



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

Twins rare: tw. pl. h (011) with $cc = 60^\circ 47'$, penetration-twins, sometimes repeated; tw. pl. w (012), the vertical axes crossing at an angle of about 30° , since $cc = 32^\circ 41'$. Crystals often flattened $\parallel a$ or b (cf. Fig. 62, p. 27), less

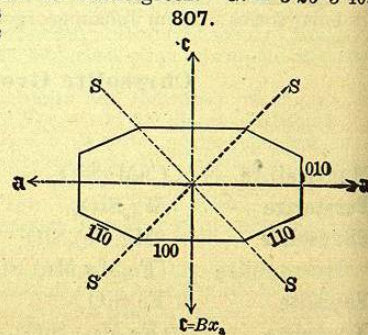
commonly elongated $\parallel c$. Massive, compact, or granular; in embedded grains. Cleavage; b rather distinct; a less so. Fracture conchoidal. Brittle. $H = 6.5-7$. $G = 3.27-3.37$, increasing with the amount of iron; 3.57 for hyalosiderite (30 p. c. FeO). Luster vitreous. Color green—commonly olive-green, 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. $\parallel c$. $Bx \perp a$. Dispersion $\rho < v$, weak. $2H_{a,r} = 105^\circ 58'$. $\beta_y = 1.678$. Birefringence high, $\gamma - \alpha = 0.036$.

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 fosterite 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.

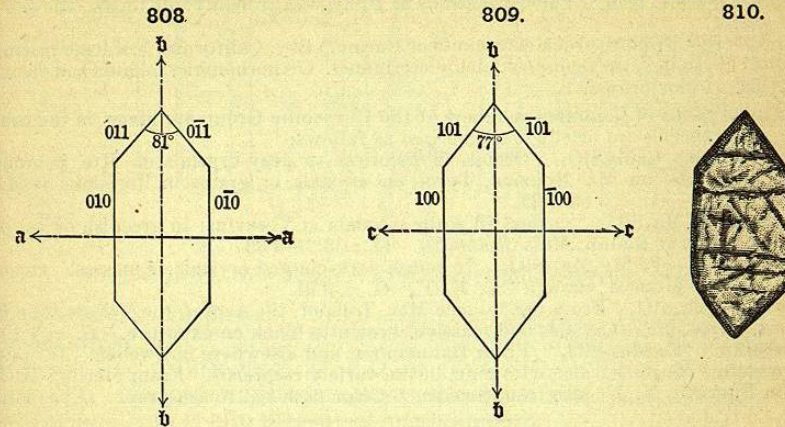
Pyr., etc.—B.B. whitens, but is infusible in most cases; hyalosiderite and other varieties rich in iron fuse to a black magnetic globule; some kinds turn red upon heating. With the fluxes gives reactions for iron. Some varieties give reactions



for titanium and manganese. Decomposed by hydrochloric and sulphuric acids with separation of gelatinous silica.

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

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



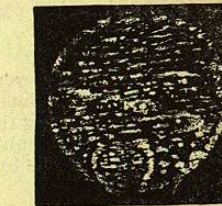
(usually with acute terminations) when in distinct crystals (Figs. 807-809), its frequent association with iron ore and augite, and its very common alteration, in a greater or lesser degree, to serpentine, the first stages being marked by the separation of iron-ore grains along the lines of fracture (Fig. 810).

Obs.—Chrysolite (olivine) has two distinct methods of occurrence: (a) in igneous rocks, as basalt, 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.

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 (Fig. 811).

Among the more prominent localities are: Vesuvius in lava and on Monte Somma in ejected masses, with augite, mica, etc. Observed in the so-called sandine 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 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 Sandwich Islands, the Azores, etc.

In the U. S., in Thetford and Norwich, Vermont, in boulders of coarsely cryst. 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 Arizona and New Mexico. In basalt in Canada, near Montreal, at Rougemont and Mounts Royal and Montarville, and in eruptive rocks at other points.



Chrysolite chondrule from the Knyahinya meteorite ($\times 10$ diam.).

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. 477.

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

IDDINGSITE. From the rock carmeloite of Carmelo Bay, California; a silicate resembling an altered chrysolite, exact composition undetermined. 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. 419. The species are briefly characterized as follows:

Monticellite. CaMgSiO_4 . Occurs in colorless to gray crystals on Mte. Somma; in masses (*batrachite*) on Mt. Monzoni, Tyrol; in crystals or grains in limestone at Magnet Cove, Arkansas. $G. = 3.03-3.25$.

Forsterite. Mg_2SiO_4 . Occurs in white crystals at Vesuvius; in greenish or yellowish embedded grains at Bolton, Mass. (*boltonite*). $G. = 3.21-3.33$.

Hortonolite. $(\text{Fe,Mg,Mn})_2\text{SiO}_4$. In rough dark-colored crystals or masses. Occurs at the iron mine of Monroe, Orange Co., N. Y. $G. = 3.91$.

Fayalite. Fe_2SiO_4 . From the Mourne Mts., Ireland; the Azores; the Yellowstone Park; Rockport, Mass., etc. Crystals and massive, brown to black on exposure. $G. = 4.1$.

Knebelite. $(\text{Fe,Mn})_2\text{SiO}_4$. From Dannemora, and elsewhere in Sweden. $G. = 4.1$.

Tephroite. Mn_2SiO_4 ; also with zinc, in the variety *roepferite*. From Sterling Hill and Franklin Furnace, N. J.; also from Sweden. Color flesh-red to ash-gray. $G. = 4.1$.

Phenacite Group. R_2SiO_4 . Tri-rhombohedral.

		rr'	ϵ
Willemite	Zn_2SiO_4	$64^\circ 30'$	0.6775
Troostite	$(\text{Zn,Mn})_2\text{SiO}_4$		
Phenacite	Be_2SiO_4	$63^\circ 24'$	0.6611

The PHENACITE GROUP includes the above orthosilicates of zinc (manganese) and beryllium. Both belong to the tri-rhombohedral group of the trigonal division of the hexagonal system, and have nearly the same rhombohedral angle. The rare species trimerite, $\text{MnSiO}_4 \cdot \text{BeSiO}_4$, which is pseudo-hexagonal (trigonal) is probably to be regarded as connecting this group with the preceding Chrysolite Group.

The following rare species are related:

			rr'	ϵ
Dioptase	H_2CuSiO_4	Tri-rhombohedral	$54^\circ 5'$	0.5342
Friedelite	$\text{H}_7(\text{MnCl})\text{Mn}_4(\text{SiO}_4)_4$		$56^\circ 17'$	0.5624
Pyrosmalite	$\text{H}_7(\text{Fe,MnCl})(\text{Fe,Mn})_4(\text{SiO}_4)_4$		$53^\circ 49'$	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 $\text{H}_2\text{RSiO}_4 = \text{H}_2\text{R}_4(\text{SiO}_4)_4$, where (*e.g.* for Friedelite) in the latter form the place of one hydrogen atom is taken by the univalent radical (MnCl).

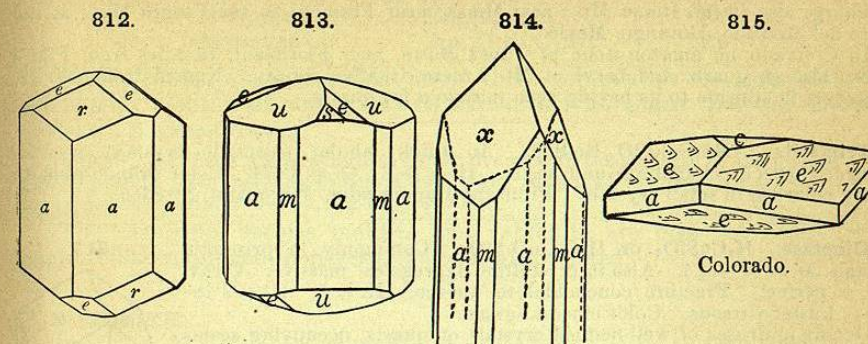
WILLEMITE.

Tri-rhombohedral. Axis $\epsilon = 0.6775$; $rr' = 64^\circ 30'$; $ee' = 36^\circ 47'$.

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* easy, Moresnet; difficult, N. J.; *a* 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



Figs. 812-814, New Jersey. $e(0\bar{1}12)$, $s(11\bar{2}3)$, $u(2\bar{1}\bar{1}3)$, $x(3\bar{1}\bar{2}1)$.

impure. Streak uncolored. Transparent to opaque. Optically +. Birefringence high.

Comp.—Zinc orthosilicate, Zn_2SiO_4 , or $2\text{ZnO} \cdot \text{SiO}_2 = \text{Silica } 27.0$, 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. Decomposed by hydrochloric acid with separation of gelatinous silica.

Obs.—From Altenberg near Moresnet; at Stolberg, near Aix-la-Chapelle. In New Jersey 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., New Mexico; also at the Sedalia mine, Salida, Colo. Named by Lévy after William I., King of the Netherlands.

PHENACITE.

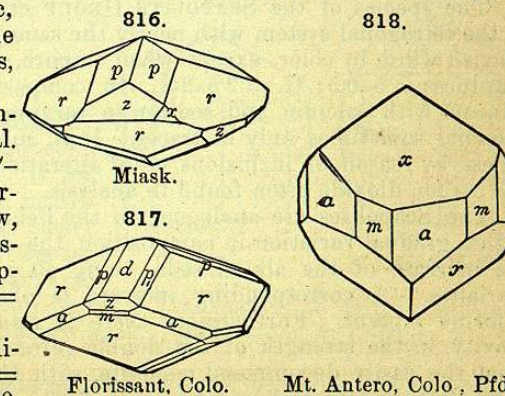
Tri-rhombohedral. Axis $\epsilon = 0.6611$; $rr' = 63^\circ 24'$.

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. 80-82).

Cleavage: *a* distinct; *r* 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 +. $\omega_y = 1.6540$; $\epsilon_y = 1.6697$, Framont.

Comp.—Beryllium orthosilicate, Be_2SiO_4 , or $2\text{BeO} \cdot \text{SiO}_2 = \text{Silica } 54.45$, 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 E. of Ekaterinburg; also in the Ilmen Mts., near Miask; near Framont in the Vosges Mts.; at the Cerro del Mercado, Durango, Mexico.

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

Trimerite. $(\text{Mn,Ca})_2\text{SiO}_4 \cdot \text{Be}_2\text{SiO}_4$. In thick tabular prismatic crystals, pseudo-hexagonal (triclinic) in form and angle. H. = 6–7. G. = 3.474. Color salmon-pink to nearly colorless in small crystals. From the Harstig mine, Wermland, Sweden.

Dioptase. H_2CuSiO_4 or $\text{H}_2\text{O} \cdot \text{CuO} \cdot \text{SiO}_2$. Commonly in prismatic crystals ($ss' = 84^\circ 33\frac{1}{2}'$). Also in crystalline aggregates; massive. Cleavage: *r* perfect. Fracture conchoidal to uneven. H. = 5. G. = 3.28–3.35. Luster vitreous. Color emerald-green.

Occurs in druses of well-defined crystals on quartz, occupying seams in a compact limestone west of the hill of Altyn-Tübe in the Kirghese Steppes; in the gold washings at several points in Siberia; at Rezbánya, Hungary. From Copiapo, Chili, 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., Arizona.

Friedelite. $\text{H}_7(\text{MnCl})\text{Mn}_4\text{Si}_4\text{O}_{16}$. Crystals commonly tabular || *c*; 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.

Pyrosmalite. $\text{H}_7(\text{Fe,MnCl})(\text{Fe,Mn})_4\text{Si}_4\text{O}_{16}$. 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. From the iron mines of Nordmark in Wermland; Dannemöra, Sweden.

Scapolite Group. Tetragonal-pyramidal.

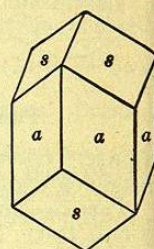
Meionite	$\delta = 0.4393$	Mizzonite, Dipyre	$\delta = 0.4424$
Wernerite	$\delta = 0.4384$	Marialite	$\delta = 0.4417$

Sarcolite $\frac{1}{2}\delta = 0.4437$

The species of the SCAPOLITE GROUP crystallize in the pyramidal group 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, which last cause also explains the carbon dioxide often found in analysis.

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

819.



variation in composition may be explained by the assumption of two fundamental end compounds, viz.:



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 $\delta = 0.43925$. In prismatic crystals (Fig. 179, p. 60), either clear and glassy or milky white; also in crystalline grains and massive. Cleavage: *a* rather perfect, *m* somewhat less so. Fracture conchoidal. Brittle. H. = 5.5–6. G. = 2.70–2.74. Luster vitreous. Colorless to white. Transparent to translucent; often cracked within. Optically —. Double refraction weak. Indices, Dx.: $\omega_y = 1.594$; $\epsilon_y = 1.558$.

Comp.— $\text{Ca}_4\text{Al}_6\text{Si}_6\text{O}_{25}$ or $4\text{CaO} \cdot 3\text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2$ = 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. Also in ejected masses at the Laacher See.

WERNERITE. COMMON SCAPOLITE.

Tetragonal-pyramidal. Axis $\delta = 0.4384$.

Crystals prismatic, usually coarse, with uneven faces and often large. The symmetry of the pyramidal group 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.

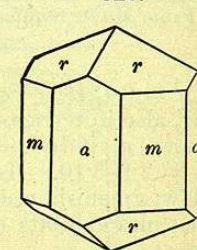
$$ee', 101 \wedge 011 = 32^\circ 59'.$$

$$rr', 111 \wedge \bar{1}11 = 43^\circ 45'.$$

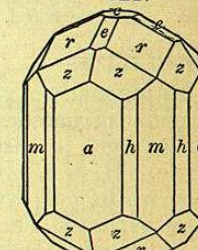
$$mr, 110 \wedge 111 = 58^\circ 12'.$$

$$zz'', 311 \wedge 3\bar{1}1 = 29^\circ 43'.$$

820.



821.



Cleavage: *a* and *m* 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 —. Birefringence weak. Indices: $\omega_r = 1.566$, $\epsilon_r = 1.545$ Arendal.

Comp., Var.—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 SiO₂ 46.10 Al₂O₃ 30.48 CaO 19.10 Na₂O 3.54 Cl 1.01 = 100.23

Pyr., etc.—B.B. fuses easily with intumescence to a white blebby glass. 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 (wh. see, p. 387).

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, 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.

Prominent localities are at Pargas, Finland, where it occurs in limestone; Arendal in Norway, and Malsjö in Wermland, where it occurs with magnetite in limestone. *Passauite* is from Oberzell, near Passau, in Bavaria. The pale blue or gray scapolite from L. Baikal, Siberia, is called *glaucolite*. In the U. S., occurs in Vermont, at Marlborough, massive. In Mass., at Bolton; at Chelmsford. In N. York, in Orange Co., Essex Co., Lewis Co.; Grasse Lake, Jefferson Co.; at Gouverneur, in limestone. In N. Jersey, at Franklin and Newton. In Penn., at the Elizabeth mine, French Creek, Chester Co.

In Canada, at G. Calumet Id., massive; at Grenville; Templeton; Wakefield, Ottawa Co. Scapolite rocks occur at several points.

Mizzonite. Dipyre. Here are included scapolites with 54 to 57 p. c. SiO₂, 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.

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 Na₄Al₃Si₃O₂₄Cl, see p. 425. The actual mineral corresponds to Me : Ma = 1 : 4. It occurs in a volcanic rock called piperno, at Pianura, near Naples.

Sarcollite. (Ca, Na₂)₃Al₂(SiO₄)₃. In small tetragonal crystals. H. = 6. G. = 2.545-2.932. Color flesh-red. From Monte Somma.

MELILITE.

Tetragonal. Axis $c = 0.4548$. Usually in short square prisms (a) or octagonal prisms (a, m), also in tetragonal tables.

Cleavage: c distinct; a indistinct. Fracture conchoidal to uneven. Brittle. H. = 5. G. = 2.9-3.10. Luster vitreous, inclining to resinous. Color white, pale yellow, greenish, reddish, brown. Pleochroism distinct in yellow varieties. Sometimes exhibits optical anomalies. Optically —. Birefringence low. Indices:

Humboldtite $\omega_x = 1.6312$ $\omega_y = 1.6339$ $\epsilon_r = 1.6262$ $\epsilon_y = 1.6291$ Henniger

Comp.—Perhaps $\overset{II}{R}_2\overset{III}{R}_2Si_3O_{36}$ or $Na_2(Ca, Mg)_{11}(Al, Fe)_4(SiO_4)_3$ 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.

Pyr., etc.—B.B. fuses at 3 to a yellowish or greenish glass. With the fluxes reacts for iron. Decomposed by hydrochloric acid with gelatinization.

Diff.—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 alkalis, 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 (*somervilleite*); not uncommon in certain basic eruptive rocks, as the *melilite-basalts* of Hochbohl near Owen in Württemberg, of the Schwabian Alb, of Görlitz, the Erzgebirge; also in the nephelite basalts of the Hegau, of Oahu, Sandwich Islands, etc.; perovskite is a common associate. Common in furnace slags. Melilite is named from $\mu\epsilon\lambda\lambda\iota$, *honey*, in allusion to the color.

Humboldtite occurs in cavernous blocks on Monte Somma 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, sarcollite, etc., in an augitic rock. *Zurite* is impure *humboldtite*.

Gehlenite. Ca₃Al₂Si₂O₁₀. 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 Fassathal, in Tyrol.

VESUVIANITE. Idocrase.

Tetragonal. Axis $c = 0.5372$.

$ce, 001 \wedge 101 = 28^\circ 15'$

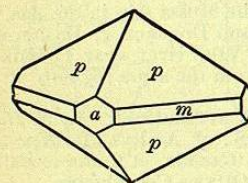
$cp, 001 \wedge 111 = 37^\circ 13\frac{1}{2}'$

$ct, 001 \wedge 331 = 66^\circ 18'$

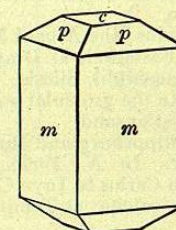
$pp', 111 \wedge 111 = 50^\circ 39'$

$ss^{VII}, 311 \wedge 3\bar{1}1 = 31^\circ 38'$

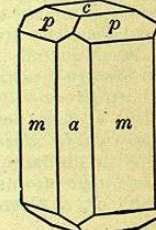
822.



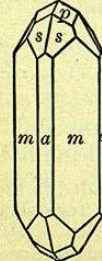
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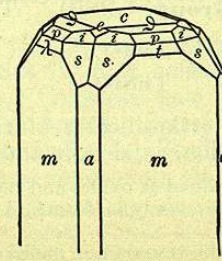


825.



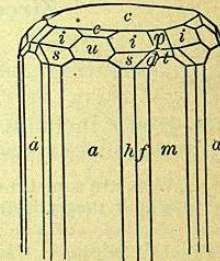
Ala.

826.



Zermatt.

827.



Sandford, Me.

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