

**Searlesite.**  $\text{NaB}(\text{SiO}_3)_2 \cdot \text{H}_2\text{O}$ . 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.**  $4\text{MgO} \cdot \text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 5\text{H}_2\text{O}$ . 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, Dysanallyte, which is intermediate between Perovskite and the species Pyrochlore, Microcline, 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  $a : b : c = 0.7547 : 1 : 0.8543$ ;  $\beta = 60^\circ 17'$ .

$$mm''', 110 \wedge \bar{1}\bar{1}0 = 66^\circ 29'.$$

$$cx, 001 \wedge 102 = 21^\circ 0'.$$

$$ss', 021 \wedge 0\bar{2}1 = 112^\circ 3'.$$

$$nn', 111 \wedge \bar{1}\bar{1}1 = 43^\circ 49'.$$

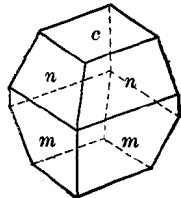
$$ll', \bar{1}12 \wedge \bar{1}\bar{1}2 = 46^\circ 7\frac{1}{2}'.$$

$$cn, 001 \wedge 111 = 38^\circ 16'.$$

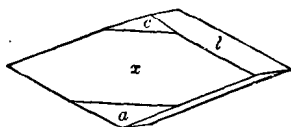
$$cm, 001 \wedge 110 = 65^\circ 30'.$$

$$cl, 001 \wedge \bar{1}12 = 40^\circ 34'.$$

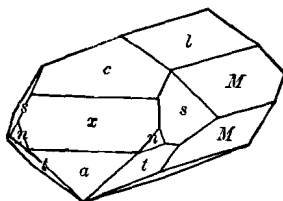
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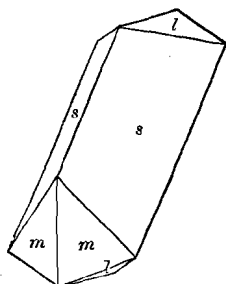
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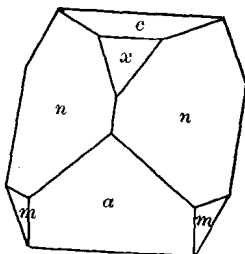
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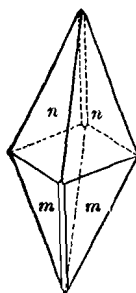
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Twins: tw. pl.  $a$  (100) rather common, both contact-twins and cruciform penetration-twins. Crystals very varied in habit; often wedge-shaped and

flattened  $\parallel c$  (001); also prismatic. Sometimes massive, compact; rarely lamellar.

Cleavage:  $m$  (110) rather distinct;  $a$  (100),  $l$  ( $\bar{1}12$ ) imperfect; in greenovite,  $n$  (111) easy,  $t$  ( $\bar{1}11$ ) less so. Parting often easy  $\parallel \eta$  (221) due to twinning lamellæ.  $H. = 5-5.5$ .  $G. = 3.4-3.56$ . Luster adamantine to resinous. Color brown, gray, yellow, green, rose-red and black. Streak white, slightly reddish in greenovite. Transparent to opaque.

Pleochroism in general rather feeble, but distinct in deep-colored kinds:  $Z$ , red with tinge of yellow;  $Y$ , yellow, often greenish;  $X$ , nearly colorless. Optically +. Ax. pl.  $\parallel b$  (010).  $Bx$  nearly  $\perp x$  (102), i.e.,  $Bx \wedge c$  axis =  $+51^\circ$ . Dispersion  $\rho > \nu$  very large, and hence the peculiarity of the axial interference-figure in white light. Axial angles variable.  $2V = 27^\circ$ .  $\alpha = 1.900$ .  $\beta = 1.907$ .  $\gamma = 2.034$ .

**Var.** — *Ordinary.* (a) *Titanite*; brown to black, the original being thus colored, also opaque or subtranslucent. (b) *Sphene* (named from  $\sigma\phi\eta\nu$ , a wedge); of light shades, as yellow, greenish, etc., and often translucent; the original was yellow. *Ligurite* is an apple-green sphene. *Spinthère* (or Semeline) a greenish kind. *Lederite* is brown, opaque, or subtranslucent, of the form in Fig. 960.

*Titanomorphite* is a white mostly granular alteration-product of rutile and ilmenite, not uncommon in certain crystalline rocks; here also belongs most leucoxene (see p. 418).

*Manganesian; Greenovite.* Red or rose-colored, owing to the presence of a little manganese; from St. Marcel, Piedmont, Italy; from Jothvād in Nárúkot, India.

Containing yttrium or cerium. Here belong *grothite*, *alschedite*, *eucolite-titanite*.

**Comp.** —  $\text{CaTiSiO}_5$  or  $\text{CaO} \cdot \text{TiO}_2 \cdot \text{SiO}_2 = \text{Silica } 30.6, \text{ titanium dioxide } 40.8, \text{ lime } 28.6 = 100$ . Iron is present in varying amounts, sometimes manganese and also yttrium in some kinds.

**Pyr., etc.** — B.B. some varieties change color, becoming yellow, and fuse at 3 with intumescence, to a yellow, brown or black glass. With borax they afford a clear yellowish green glass. Imperfectly soluble in heated hydrochloric acid; and if the solution be concentrated along with tin, it assumes a fine violet color. With salt of phosphorus in R. F. gives a violet bead; varieties containing much iron require to be treated with the flux on charcoal with metallic tin. Completely decomposed by sulphuric and hydrofluoric acids.

**Diff.** — Characterized by its oblique crystallization, a wedge-shaped form common; by resinous (or adamantine) luster; hardness less than that of staurolite and greater than that of sphalerite. The reaction for titanium is distinctive, but less so in varieties containing much iron.

**Micro.** — Distinguished in thin sections by its acute-angled form, often lozenge-shaped; its generally pale brown tone; very high relief and remarkable birefringence, causing the section to show white of the higher order; by its biaxial character (showing many lemniscate curves); and by its great dispersion, which produces colored hyperbolas.

**Artif.** — Titanite is apparently produced artificially only with difficulty. It has been obtained by fusing together silica and titanic oxide with calcium chloride.

**Obs.** — Titanite, as an accessory component, is widespread as a rock forming mineral, though confined mostly to the acidic feldspathic igneous rocks; it is much more common in the plutonic granular types than in the volcanic forms. Thus it is found in the more basic hornblende granites, syenites, and diorites, and is especially common and characteristic in the nephelite-syenites. It occurs also in the metamorphic rocks and especially in the schists, gneisses, etc., rich in magnesia and iron and in certain granular limestones. It is also found in beds of iron ore; commonly associated minerals are pyroxene, amphibole, chlorite, scapolite, zircon, apatite, etc. In cavities in gneiss and granite, it often accompanies adularia, smoky quartz, apatite, chlorite, etc.

Occurs at various points in the Grisons, Switzerland, associated with feldspar and chlorite; Tavetsch; Binnental; in the St. Gothard region; Zermatt in the Valais; Maderanertal in Uri; also elsewhere in the Alps; in Dauphiné (*spinthère*), France; in Italy at Ala (*ligurite*) and at St. Marcel, in Piedmont; at Schwarzenstein and Rothenkopf in the Zillertal, Pfätsch, Tyrol; Zöptau, Moravia; near Tavistock, England; near Tremadoc, in North Wales; from Kragerø and in titanic iron at Arendal, Norway; with magnetite at

Nordmark, Sweden; Achmatovsk, Ural Mts. Occasionally found among volcanic rocks, as at Lake Laach (*semeline*) and at Andernach on the Rhine.

In Me., in fine crystals at Sandford. In Mass., in gneiss, in the east part of Lee; at Bolton with pyroxene and scapolite in limestone. In N. Y., at Roger's Rock on Lake George, abundant in small brown crystals; at Gouverneur, in black crystals in granular limestone; in Diana near Natural Bridge, Lewis Co., in large dark brown crystals, among which is the variety *lederite*; at Rossie, Fine, Pitcairn, St. Lawrence Co.; in Orange Co., in limestone; near Edenville, in light brown crystals in limestone; at Brewster, at the Tilly Foster iron mine. In N. J., at Franklin Furnace, honey-yellow. In Pa., Bucks Co. three miles west of Attleboro', associated with wollastonite and graphite. In N. C., at Statesville, Iredell Co., yellowish white with sunstone; also Buncombe Co., Alexander Co., and other points.

Occurs in Canada in Quebec at Grenville, Argenteuil Co.; also Buckingham, Templeton, Wakefield, Hull, Ottawa Co.; in Ontario at North Burgess, honey-yellow; near Eganville, Renfrew Co., in very large dark brown crystals with apatite, amphibole, zircon.

**Molengraaffite.** A titano-silicate of lime and soda. Monoclinic(?). In imperfect prismatic crystals. Cleavage (100) perfect. Color yellow-brown. Indices, 1.73-1.77. From a rock, "lujaurite," in Pilandsberg, near Rustenberg, Transvaal.

**Keilhauite.** A titano-silicate of calcium, aluminium, ferric iron, and the yttrium metals. Crystals near titanite in habit and angles.  $H. = 6.5$ .  $G. = 3.52-3.77$ . Color brownish black. From near Arendal, Norway.

**Tscheffkinite.** A titano-silicate of the cerium metals, iron, etc., but an alteration product, more or less heterogeneous, and the composition of the original mineral is very uncertain. Massive, amorphous.  $H. = 5-5.5$ .  $G. = 4.508-4.549$ . Color velvet-black. From the Ilmen mountains in the Ural Mts. Also from South India, Kanjamalai Hill, Salem district. An isolated mass weighing 20 lbs. has been found on Hat Creek, near Massie's Mills, Nelson Co., Va.; also found, south of this point, in Bedford Co.

**Astrophyllite.** Probably  $\overset{1}{R}\overset{2}{R}\overset{3}{Ti}(\overset{1}{SiO_4})_4$  with  $\overset{1}{R} = H, Na, K$ , and  $\overset{2}{R} = Fe, Mn$  chiefly, including also  $Fe_2O_3$ . Orthorhombic. In elongated crystals; also in thin strips or blades; sometimes in stellate groups. Cleavage:  $b$  (010) perfect like mica, but laminae brittle.  $H. = 3$ .  $G. = 3.3-3.4$ . Luster submetallic, pearly. Color bronze-yellow to gold-yellow. Optically +. Indices, 1.678-1.733.

Occurs on the small islands in the Langesund fiord, near Brevik, Norway, in *elaolite-syenite*, embedded in feldspar, with *catapleiite*, *agirite*, black mica, etc. Similarly at Kangerdluarsuk and Narsarsuk, Greenland. Also with *arfvedsonite* and zircon at St. Peter's Dome, Pike's Peak, El Paso Co., Col.

**Johnstrupite.** A silicate of the cerium metals, calcium and sodium chiefly, with titanium and fluorine. In prismatic monoclinic crystals.  $G. = 3.29$ . Color brownish green. Index, 1.646. From near Barkevik, Norway.

**Mosandrite.** Near johnstrupite in form and composition and from the same region.

**Rinkite**, also near johnstrupite, is from Greenland.

**Narsarsukite.** A highly acidic titano-silicate of ferric iron and sodium. Tetragonal. In tabular crystals. Fine prismatic cleavage.  $H. = 7$ .  $G. = 2.7$ . Color honey-yellow, on weathering brownish gray or ochre-yellow.  $\omega = 1.55$ . Fusible. In pegmatite at Narsarsuk, southern Greenland.

**Neptunite.** A titano-silicate of iron (manganese) and the alkali metals. In prismatic monoclinic crystals.  $H. = 5-6$ .  $G. = 3.23$ . Color black. Streak, cinnamon-brown. Mean index, 1.70. Pleochroic, yellow to deep-red. Found at Narsarsuk and elsewhere, southern Greenland, and at the benitoite locality in San Benito Co., Cal. (originally called *carlosite*).

**Benitoite.**  $BaTiSi_3O_9$ . Hexagonal, trigonal (ditrigonal-bipyramidal). In crystals with  $\rho(10\bar{1}1)$  prominent.  $H. = 6.2-6.5$ .  $G. = 3.6$ . Color sapphire-blue to light blue and colorless. Transparent. Strongly dichroic, deep blue to colorless.  $\omega = 1.77$ . Fusible at 3. Found associated with *neptunite* and *natrolite* near the headwaters of the San Benito River in San Benito Co., Cal.

**Leucosphenite.**  $Na_4Ba(TiO)_2(Si_2O_5)_5$ . Monoclinic. In minute wedge-shaped crystals. Distinct cleavage.  $H. = 6.5$ .  $G. = 3.0$ . Color white.  $\beta = 1.66$ . Difficultly fusible. From Narsarsuk, southern Greenland.

**Lorenzenite.**  $\text{Na}_2(\text{TiO})_2\text{Si}_2\text{O}_7$ . Contains considerable zirconia. Orthorhombic. In minute acicular crystals. Distinct cleavage.  $H. = 6$ .  $G. = 3.4$ .  $\beta$  about 1.78. Fusible. From Narsarsuk, southern Greenland.

**Joaquinite.** A titano-silicate of calcium and iron. Orthorhombic. Color, honey-yellow. Associated with *benitoite* from San Benito Co., Cal.

#### PEROVSKITE. Perovskite.

Isometric or pseudo-isometric. Crystals in general (Ural Mts., Zermatt, Switzerland) cubic in habit and often highly modified, but the faces often irregularly distributed. Cubic faces striated parallel to the edges and apparently penetration-twins, as if of pyritohedral individuals. Also in reniform masses showing small cubes.

Cleavage: cubic, rather perfect. Fracture uneven to subconchoidal. Brittle.  $H. = 5.5$ .  $G. = 4.017-4.039$ . Luster adamantine to metallic-adamantine. Color pale yellow, honey-yellow, orange-yellow, reddish brown, grayish black. Streak colorless, grayish. Transparent to opaque. Usually exhibits anomalous double refraction. Mean index, about 2.38.

Geometrically considered, perovskite conforms to the isometric system; optically, however, it is uniformly biaxial and usually positive. The molecular structure (also as developed by etching) seems to correspond to orthorhombic symmetry. Cf. Art. 429.

**Comp.** — Calcium titanate,  $\text{CaTiO}_3 =$  Titanium dioxide 58.9, lime 41.1 = 100. Iron is present in small amount replacing the calcium.

**Pyr., etc.** — In the forceps and on charcoal infusible. With salt of phosphorus in O.F. dissolves easily, giving a greenish bead while hot, which becomes colorless on cooling; in R.F. the bead changes to grayish green, and on cooling assumes a violet-blue color. Entirely decomposed by boiling sulphuric acid.

**Obs.** — Occurs in small crystals, associated with chlorite, and magnetic iron in chlorite slate, at Achmatovsk, near Zlatoust, in the Ural Mts.; at Schelingen in the Kaiserstuhl, Germany, in granular limestone; in the valley of Zermatt, Switzerland, near the Findelen glacier; at Wildkreuzjoch, between Pfitsch and Pfunders in Tyrol, Austria; various localities, Piedmont, Italy. Sometimes noted in microscopic octahedral crystals as a rock constituent; thus in nephelite- and melilite-basalts; also in serpentine (altered peridotite) at Syracuse, N. Y.; in igneous rocks, Beaver Creek, Gunnison Co., Col.

**Knopite.** Near perovskite but contains cerium. In black isometric crystals. From Alnö, Sweden.

**Dysanalyte.** A titano-niobate of calcium and iron, like perovskite with lime replaced to some extent by iron, etc. Pseudo-isometric, probably orthorhombic. In cubic crystals. Color, iron-black. From the granular limestone of Vogtsburg, Kaiserstuhl, Baden, Germany. Has previously been called perovskite, but is in fact intermediate between the titanate, perovskite, and the niobates, pyrochlore and koppelite. From Mte. Somma, Vesuvius.

A related mineral, which has also long passed as perovskite, occurs with magnetite, brookite, rutile, etc., at Magnet Cove, Ark. It is in octahedrons or cubo-octahedrons, black or brownish black in color and submetallic in luster.

See also the allied titanate, *bixbyite*, mentioned on p. 425.

**Geikielite.** Magnesium iron titanate,  $(\text{Mg}, \text{Fe})\text{TiO}_3$ . Hexagonal, rhombohedral. Usually massive, as rolled pebbles.  $H. = 6$ .  $G. = 4$ . Color bluish or brownish black. Index, very high. From Ceylon.

**Delorenzite.** A titanate of iron, uranium and yttrium of uncertain composition. Orthorhombic. Prismatic habit. Color black. Resinous luster. Found in pegmatite at Gravaglia, Val Vigizzo, Piedmont, Italy.

**Yttracrasite.** A hydrous titanate of the yttrium earths and thorium. Orthorhombic.  $H. = 5.5-6$ .  $G. = 4.8$ . Black color with pitchy to resinous luster. Infusible. Found in Burnet Co., three miles east of Barringer Hill, Texas.

**Brannerite.** Essentially  $(\text{UO}, \text{TiO}, \text{UO}_2)\text{TiO}_3$ . Prismatic crystals or granular. Black. Streak, dark greenish brown.  $H. = 4.5$ .  $G. = 4.5-5.4$ . Found in gold placers, Stanley Basin, Idaho.