Oxygen Salts

3. NIOBATES, TANTALATES

The Niobates (Columbates) and Tantalates are chiefly salts of metaniobic and metatantalic acid, RNb_2O_6 and RTa_2O_6; also in part Pyroniobates, $R_2Nb_2O_7$, etc. Titanium is prominent in a number of the species, which are hence intermediate between the niobates and titanates. Niobium and tantalum also enter into the composition of a few rare silicates, as wöhlerite, låvenite, etc.

The following groups may be mentioned:

The isometric PYROCHLORE GROUP, including pyrochlore, microlite, etc. The tetragonal FERGUSONITE GROUP, including fergusonite and sipylite. The orthorhombic COLUMBITE GROUP, including columbite and tantalite. Also the orthorhombic SAMARSKITE GROUP, including yttrotantalite, samarskite, and ånnerodite.

The species belonging in this class are for the most part rare, and are hence but briefly described.

PYROCHLORE.

Isometric. Commonly in octanedrons; also in grains.

Cleavage: octahedral, sometimes distinct. Fracture conchoidal. Brittle. H. = 5–5·5. G. = 4·2–4·36. Luster vitreous or resinous, the latter on fracture surfaces. Color brown, dark reddish or blackish brown. Streak light brown, yellowish brown. Subtranslucent to opaque.

Comp. — Chiefly a niobate of the cerium metals, calcium and other bases, with also titanium, thorium, fluorine. Probably essentially a metaniobate with a titanate, $RNb_2O_6.R(Ti,Th)O_3$; fluorine is also present.

Obs. — Occurs in elæolite-syenite at Fredriksvärn and Laurvik, Norway; on the island Lövö, opposite Brevik, and at several points in the Langesund fiord; near Miask in the Ural Mts. Named from πῦρ, *fire*, and χλωρός, *green*, because B.B. it becomes yellowish green. A variety of pyrochlore from near Wausau, Wis., has been called *marignacite*.

Neotantalite. Composition near that of tantalite. Isometric, in octahedrons. H. = 5–6. G. = 5·2. Color clear yellow. Refractive index, 1·9. Found with kaolin at Colettes and Echassières, Dept. l'Allier, France.

Chalcolamprite. $\overset{II}{R}Nb_2O_6F_2.\overset{II}{R}SiO_3$. Isometric. In small octahedrons. H. = 5·5. G. = 3·8. Color dark gray-brown. Crystal faces show a copper-red metallic iridescence. Occurs sparingly at Narsarsuk, South Greenland. *Endeiolite* is a similar mineral from the same locality supposed to have the same composition with the substitution of the hydroxyl group for the fluorine.

Koppite. Essentially a pyroniobate of cerium, calcium, etc., near pyrochlore. In minute brown dodecahedrons. G. = 4·45–4·56. From Schelingen, Kaiserstuhl, Germany, embedded in limestone.

Hatchettolite. A tantalo-niobate of uranium, near pyrochlore. In octahedrons with *a* (100) and *m* (311). G. = 4·77–4·90. Color yellowish brown. Occurs with samarskite, at the mica mines of Mitchell Co., N. C.; from Mesa Grande, Cal.

Samirésite. A niobate of uranium, etc. Isometric. In octahedrons. G. = 5 24. Color golden-yellow. From Antsirabé, on Samiresy Hill, Madagascar.

Microlite. Essentially a calcium pyrotantalate, $Ca_2Ta_2O_7$, but containing also niobium, fluorine and a variety of bases in small amount. Isometric. Habit octahedral; crystals often very small and highly modified. H. = 5·5. G. = 5·485–5·562; 6·13 Virginia. Color pale yellow to brown, rarely hyacinth-red. n = 1·94. From Chesterfield, Mass., in albite; Branchville, Conn.; Rumford, Me.; Utö, Sweden; Green-

land. Also in fine crystals up to 1 in. in diameter at the mica mines at Amelia Court-House, Amelia Co., Va.

PYRRHITE. Probably a niobate related to pyrochlore, and perhaps identical with microlite. Occurs in minute orange-yellow octahedrons. From Alabashka, near Mursinka in the Ural Mts.; from Mte. Somma, Vesuvius.

RISÖRITE. A niobate of the yttrium metals. Isotropic. Color yellow-brown. H. = 5·5. G. = 4·18. In pegmatite at Risör, Norway.

FERGUSONITE. Tyrite. Bragite

Tetragonal-pyramidal. Axis $c = 1{\cdot}4643$. Crystals pyramidal or prismatic in habit.

Cleavage: s (111) in traces. Fracture subconchoidal. Brittle. H. = 5·5–6. G. = 5·8, diminishing to 4·3 when largely hydrated. Luster externally dull, on the fracture brilliantly vitreous and submetallic. Color brownish black; in thin scales pale liver-brown. Streak pale brown. Subtranslucent to opaque. Index, 2·19.

Comp. — Essentially a metaniobate (and tantalate) of yttrium with erbium, cerium, uranium, etc., in varying amounts; also iron, calcium, etc. General formula $\overset{III}{R}(Nb,Ta)O_4$ with $\overset{III}{R}$ = Y,Er,Ce.

Water is usually present and sometimes in considerable amount, but probably not an original constituent; the specific gravity falls as the amount increases.

Obs. — From Cape Farewell in Greenland, in quartz; also at Ytterby and Kårarfvet, Sweden. From near Beforona, Madagascar; South Africa; Australia; Ceylon; Takayama, Mino, Japan. *Tyrite* is associated with euxenite at Hampemyr on the island of Tromö, and Helle on the mainland, Norway; *bragite* is from Helle, Narestö, etc., Norway.

Found in the United States, at Rockport, Mass., in granite; in the Brindletown gold district, Burke Co., N. C., in gold washings; with zircon in Anderson Co., S. C.; at the gadolinite locality in Llano Co., Texas, in considerable quantity.

Sipylite. A niobate of erbium chiefly, also the cerium metals, etc., near fergusonite in form. Rarely in octahedral crystals. Usually in irregular masses. G. = 4·89. Color brownish black to brownish orange. Occurs sparingly with allanite in Amherst Co., Va.

COLUMBITE-TANTALITE.

Orthorhombic. Axes $a : b : c = 0{\cdot}8285 : 1 : 0{\cdot}8898$.

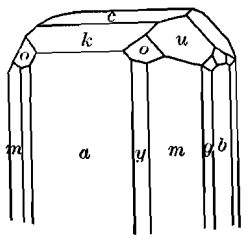
yy''',	$210 \wedge 2\bar{1}0 = 45°\ 0'$.	ce,	$001 \wedge 021 = 60°\ 40'$.
mm''',	$110 \wedge 1\bar{1}0 = 79°\ 17'$.	ao,	$100 \wedge 111 = 51°\ 16'$.
gg',	$130 \wedge \bar{1}30 = 43°\ 50'$.	cu,	$001 \wedge 133 = 43°\ 48'$.
ck,	$001 \wedge 103 = 19°\ 42'$.	uu',	$133 \wedge \bar{1}33 = 29°\ 57'$.
cq,	$001 \wedge 023 = 30°\ 41'$.	uu''',	$133 \wedge 1\bar{3}3 = 79°\ 54'$.

Twins: tw. pl. e (021) common, usually contact-twins, heart-shaped (Fig. 385, p. 160), also penetration-twins; further tw. pl. q ($0\bar{2}3$) rare (Fig. 434, p. 169). Crystals short prismatic, often rectangular prisms with the three pinacoids prominent; also thin tabular $\parallel a$ (100); the pyramids often but slightly developed, sometimes, however, acutely terminated by u (133) alone. Also in large groups of parallel crystals, and massive.

Cleavage: a (100) rather distinct; b (010) less so. Fracture subconchoidal to uneven. Brittle. H. = 6. G. = 5·3–7·3, varying with the composition (see below). Luster submetallic, often very brilliant, sub-resinous. Color iron-black, grayish and brownish black, opaque; rarely reddish brown and

translucent; frequently iridescent. Streak dark red to black. Optically +. $\alpha = 2{\cdot}26$. $\beta = 2{\cdot}29$. $\gamma = 2{\cdot}34$.

967



Middletown

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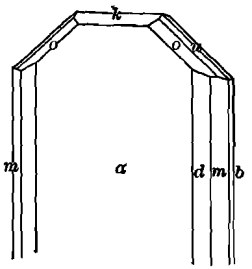

Black Hills

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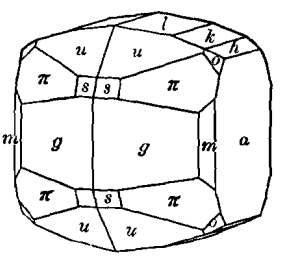


Greenland

Comp. — Niobate and tantalate of iron and manganese, (Fe,Mn)(Nb, Ta)$_2$O$_6$, passing by insensible gradations from normal COLUMBITE, the nearly pure niobate, to normal TANTALITE, the nearly pure tantalate. The iron and manganese also vary widely. Tin and tungsten are present in small amount. The percentage composition for $FeNb_2O_6$ = Niobium pentoxide 82·7, iron protoxide 17·3 = 100; for $FeTa_2O_6$ = Tantalum pentoxide 86·1, iron protoxide 13·9 = 100.

In some varieties, *manganocolumbite* or *manganotantalite*, the iron is largely replaced by manganese.

The connection between the specific gravity and the percentage of metallic acids is shown in the following table:

	G.	Ta_2O_5		G.	Ta_2O_5
Greenland	5·36	3·3	Bodenmais	5·92	27·1
Acworth, N. H.	5·65	15·8	Haddam	6·05	30·4
Limoges	5·70	13·8	Bodenmais	6·06	35·4
Bodenmais (*Dianite*)	5·74	13·4	Haddam	6·13	31·5
Haddam	5·85	10·0			
			Tantalite	7·03	65·6

Diff. — Distinguished (from black tourmaline, etc.) by orthorhombic crystallization, rectangular forms common; high specific gravity; submetallic luster, often with iridescent surface; cleavage much less distinct than for wolframite.

Pyr., etc. — For *tantalite*, B.B. alone unaltered. With salt of phosphorus dissolves slowly, giving an iron glass, which in R.F. is pale yellow on cooling; treated with tin on charcoal it becomes green. Decomposed on fusion with potassium bisulphate in the platinum spoon, and gives on treatment with dilute hydrochloric acid a yellow solution and a heavy white powder, which, on addition of metallic zinc, assumes a smalt-blue color; on dilution with water the blue color soon disappears. *Columbite*, when decomposed by fusion with caustic potash, and treated with hydrochloric and sulphuric acids, gives, on the addition of zinc, a blue color more lasting than with tantalite. Partially decomposed when the powdered mineral is evaporated to dryness with concentrated sulphuric acid, its color is changed to white, light gray, or yellow, and when boiled with hydrochloric acid and metallic zinc it gives a beautiful blue.

Obs. — Columbite occurs at Rabenstein and Bodenmais, Bavaria, in granite; Tammela, in Finland; Chanteloube, near Limoges, France, in pegmatite with tantalite; near Miask, in the Ilmen Mts., Russia, with samarskite; in the gold-washings of the Sanarka region in the Ural Mts.; in Greenland, in cryolite, at Ivigtut (or Evigtok), in brilliant crystals. In crystals from Ampangabé and Ambatofotsikely, Madagascar.

In the United States, in Me., at Standish, in splendent crystals in granite; also at Stoneham with cassiterite, etc., *manganotantalite* from Rumford. In N. H., at Acworth, at the mica mine. In Mass., at Chesterfield; Northfield. In Conn., at Haddam, in a granite vein; near Middletown; at Branchville, Fairfield Co., in a vein of albitic granite, in large

crystals and aggregates of crystals, also in minute translucent crystals (*manganocolumbite*), upon spodumene. In N. Y., at Greenfield, with chrysoberyl. In Pa., Mineral Hill, Delaware Co. In Va., Amelia Co., in fine splendent crystals with microlite, monazite, etc. In N. C., with samarskite at the mica mines of Mitchell Co. In Col., on microcline at the Pike's Peak region; Turkey Creek, Jefferson Co. In S. D. in the Black Hills region, common in the granite veins. In Cal., King's Creek district, Fresno Co., from Rincon and *manganotantalite* from Pala.

Mangantantalite (Nordenskiöld) from Utö, Sweden, occurs with petalite, lepidolite, microlite, etc. *Manganotantalite* (Arzruni) is from gold-washings in the Sanarka region in the Ural Mts.; from Pilbarra district, West Australia.

Massive tantalite occurs in Finland, in Tammela, at Härkäsaari near Torro; in Kimito, at Skogböle; in Somero at Kaidasuo, and in Kuortane at Katiala, with lepidolite, tourmaline, and beryl; in Sweden, near Falun, at Broddbo and Finbo; in France, at Chanteloube near Limoges, in pegmatite. In the United States, in Yancey Co., N. C.; Coosa Co., Ala.; also in the Black Hills, S. D.; in large masses near Cañon City, Col.

Use. — Source of tantalum used in making filaments for incandescent electric lights.

Tapiolite. $Fe(Ta,Nb)_2O_6$. Like tantalite, but occurring in square tetragonal octahedrons. Tapiolite shows close similarities with the minerals of the Rutile Group, in which some authors place it. G. = 7·496. Color pure black. From the Kulmala farm, Tammela, Finland. In twin crystals from Topsham, Me. *Mossite*, a niobium tapiolite. Found at Berg near Moss, Norway. *Skogbölite* and *ixiolite* are twinned varieties of tapiolite.

Stibiotantalite. $(SbO)_2(Ta,Nb)_2O_6$. Orthorhombic, hemimorphic in direction of a axis. Polysynthetic twinning parallel to a (100). Cleavage a (perfect). H. = 5·5. G. = 6·0–7·4 (varying with composition). β. = 2·40–2·42. Fusible. Color brown, reddish yellow, yellow. Luster adamantine to resinous. Originally found in tin-bearing sands of Greenbushes, Australia. In crystals from Mesa Grande, San Diego Co., Cal.

YTTROTANTALITE.

Orthorhombic. Axes $a : b : c = 0{\cdot}5412 : 1 : 1{\cdot}1330$. Crystals prismatic, mm''' 110 $\wedge$ $1\bar{1}0$ = 56° 50′.

Cleavage: b (010) very indistinct. Fracture small conchoidal. H. = 5–5·5. G. = 5·5–5·9. Luster submetallic to vitreous and greasy. Color black, brown, brownish yellow, straw-yellow. Streak gray to colorless. Opaque to subtranslucent.

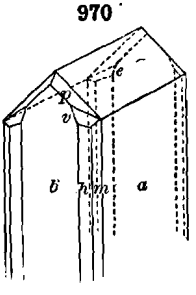
Comp. — Essentially $\overset{II}{R}\overset{III}{R}_2(Ta,Nb)_4O_{15}.4H_2O$, with $\overset{II}{R}$ = Fe, Ca, $\overset{III}{R}$ = Y, Er, Ce, etc. The water may be secondary.

The so-called yellow yttrotantalite of Ytterby and Kårarfvet belongs to fergusonite.

Obs. — Occurs in Sweden at Ytterby, near Vaxholm, in red feldspar; at Finbo and Broddbo, near Falun, in southern Norway.

SAMARSKITE.

Orthorhombic. Axes $a : b : c = 0{\cdot}5456 : 1 : 0{\cdot}5178$. Crystals rectangular prisms (a (100), b (010), with e (101) prominent). Angles, mm''' 110 $\wedge$ $1\bar{1}0$ = 57° 14′; ee' 101 $\wedge$ $\bar{1}01$ = 87°. Faces rough. Commonly massive, and in flattened embedded grains.



Cleavage: b (010) imperfect. Fracture conchoidal. Brittle. H. = 5–6. G. = 5·6–5·8. Luster vitreous to resinous, splendent. Color velvet-black. Streak dark reddish brown. Nearly opaque. Index, 2·21.

Comp. — $\overset{II}{R}_3\overset{III}{R}_2(Nb,Ta)_6O_{21}$ with $\overset{II}{R}$ = Fe, Ca, UO_2, etc.; $\overset{III}{R}$ = cerium and yttrium metals chiefly.

Pyr., etc. — In the closed tube decrepitates, glows, cracks open, and turns black. B.B. fuses on the edges to a black glass. With salt of phosphorus in both flames an emerald-

green bead. With soda yields a manganese reaction. Decomposed on fusion with potassium bisulphate, yielding a yellow mass which on treatment with dilute hydrochloric acid separates white tantalic acid, and on boiling with metallic zinc gives a fine blue color. In powder sufficiently decomposed on boiling with concentrated sulphuric acid to give the blue reduction test when the acid fluid is treated with metallic zinc or tin.

Obs. — Occurs in reddish brown feldspar, with æschynite and columbite in the Ilmen mountains, near Miask, Ural Mts.; from Antanamalaza, Madagascar. In the United States rather abundant and sometimes in large masses up to 20 lbs. at the mica mines in Mitchell Co., N. C., intimately associated with columbite; sparingly elsewhere.

Ampangabéite. A niobate of uranium, etc. In rectangular prisms, probably orthorhombic. Color brownish red. Luster greasy. H. = 4. G. = 3·97–4·29. Fuses to a black slag. Easily soluble in hydrochloric acid. Radioactive. Found in parallel growth with columbite at Ampangabé and Ambatofotsikely, Madagascar.

Ånnerödite. Essentially a pyro-niobate of uranium and yttrium. In prismatic crystals, often resembling columbite. H. = 6. G. = 5·7. Color black. From the pegmatite vein at Ånneröd, near Moss, Norway.

Hielmite. A stanno-tantalate (and niobate) of yttrium, iron, manganese, calcium. Crystals (orthorhombic) usually rough; massive. G. = 5·82. Color pure black. From the Kårarfvet mine, Falun, Sweden.

Æschynite. A niobate and titanate (thorate) of the cerium metals chiefly, also in small amount iron, calcium, etc. Crystals prismatic, orthorhombic. Fracture small conchoidal. Brittle. H. = 5–6. G. = 4·93 Hitterö; 5·168 Miask. Luster submetallic to resinous, nearly dull. Color nearly black, inclining to brownish yellow when translucent.

From Miask in the Ilmen Mts., Russia, in feldspar with mica and zircon; also with euclase in the gold sands of the Orenburg District, Southern Ural Mts. From Hitterö, Norway. Named from *αἰσχυνή, shame*, by Berzelius, in allusion to the inability of chemical science, at the time of its discovery, to separate some of its constituents.

Polymignite. A niobate and titanate (zirconate) of the cerium metals, iron, calcium. Crystals slender prisms, vertically striated. G. = 4·77–4·85. Color black. Occurs at Frederiksvärn, Norway.

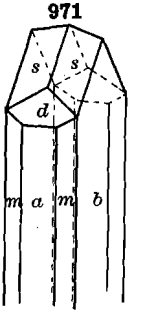
Euxenite. A niobate and titanate of yttrium, erbium, cerium and uranium. Crystals rare; commonly massive. H. = 6·5. G. = 4·7–5·0. Color brownish black.

Occurs in Norway, at Jölster near Tvedestrand; at Alve, etc., near Arendal; from Greenland; from various localities in Madagascar.

Loranskite and **Wiikite** are euxenite-like minerals from Impilaks, Finland. Usually in irregular masses but orthorhombic crystals are noted. H. = 6. G. = 3·8–4·8. Color black to brown and yellow.

Polycrase. A niobate and titanate of yttrium, erbium, cerium, uranium, like euxenite. Crystals thin prismatic, orthorhombic. Fracture conchoidal. H. = 5–6. G. = 4·97–5·04. Luster vitreous to resinous. Color black, brownish in splinters.

From Hitterö, Norway, in granite with gadolinite; at Slättåkra, Småland, Sweden. In the United States, in N. C., in the gold-washings on Davis land, Henderson Co., with zircon, monazite, xenotime, magnetite; also in S. C., four miles from Marietta in Greenville Co. Named from *πολυς, many*, and *κράσις, mixture*.



Blomstrandine-Priorite. Niobates and titanates of yttrium, erbium, cerium and uranium, similar to the *euxenite-polycrase* series. The two series may be dimorphous. The ratio of Nb_2O_5 : TiO_2 ranges from 1 : 2 in priorite to 1 : 6 in blomstrandine. Orthohombic. Crystals tabular parallel to *b* (010). Most prominent forms are *b* (010), *c* (001) and *n* (130). G. = 4·8–4·9. Color brownish black. Originally found in a pegmatite vein at Urstad, Island of Hitterö, Norway. Also noted from Arendal and elsewhere in southern Norway and from Miask, Ilmen Mts., Russia.

Betafite. A niobate and titanate of uranium, etc. Isometric with octahedron and dodecahedron. G. = 3·75–4·17. Color, a greenish black. Opaque. Greasy luster. Found in pegmatites from various localities in Madagascar, including Ambolotara, near Betafo.

Epistolite. A niobate of uncertain composition. Analysis shows chiefly SiO_2, TiO_2, Na_2O, H_2O. Monoclinic. In rectangular plates, also in aggregates of curved folia. Basal cleavage perfect. H. = 1–1·5. G. = 2·9. Color white, grayish, brownish. Refractive index 1·67. Found in pegmatite veins or in massive albite from Julianehaab, Greenland.

Plumboniobite. A niobate of yttrium, uranium, lead, iron, etc. Amorphous. H. = 5–5·5. G. = 4·81. Color dark brown to black. Found in mica mines at Morogoro, German East Africa.

Oxygen Salts

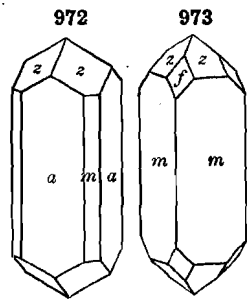
4. PHOSPHATES, ARSENATES, VANADATES, ANTIMONATES

A. Anhydrous Phosphates, Arsenates, Vanadates, Antimonates

Normal phosphoric acid is H_3PO_4, and consequently normal phosphates have the formulas $\overset{\text{I}}{R}_3PO_4$, $\overset{\text{II}}{R}_3(PO_4)_2$ and $\overset{\text{III}}{R}PO_4$, and similarly for the arsenates, etc. Only a comparatively small number of species conform to this simple formula. Most species contain more than one metallic element, and in the prominent Apatite Group the radical (CaF), (CaCl) or (PbCl) enters; in the Wagnerite Group we have similarly $(\overset{\text{II}}{R}F)$ or (ROH).

XENOTIME.

Tetragonal. Axis $c = 0{\cdot}6187$, zz' $(111 \wedge \bar{1}11) = 55° 30'$, zz'' $(111 \wedge \bar{1}\bar{1}1) = 82° 22'$. In crystals resembling zircon in habit; sometimes compounded with zircon in parallel position (Fig. 462, p. 173). In rolled grains.



Cleavage: m (110) perfect. Fracture uneven and splintery. Brittle. H. = 4–5. G. = 4·45–4·56. Luster resinous to vitreous. Color yellowish brown, reddish brown, hair-brown, flesh-red, grayish white, wine-yellow, pale yellow; streak pale brown, yellowish or reddish. Opaque. Optically +. $\omega = 1{\cdot}72$. $\epsilon = 1{\cdot}81$.

Comp. — Essentially yttrium phosphate, YPO_4 or $Y_2O_3.P_2O_5$ = Phosphorus pentoxide 38·6, yttria 61·4 = 100. The yttrium metals may include erbium in large amount; cerium is sometimes present; also silicon and thorium as in monazite.

Pyr., etc. — B.B. infusible. When moistened with sulphuric acid colors the flame bluish green. Difficultly soluble in salt of phosphorus. Insoluble in acids.

Diff. — Resembles zircon in its tetragonal form, but distinguished by inferior hardness and perfect prismatic cleavage.

Obs. — Occurs as an accessory mineral in granite veins; sometimes in minute embedded crystals generally distributed in granitic and gneissoid rocks. Found at Hitterö; at Moss, Kragerö, and from pegmatite veins at other points in Norway; at Ytterby, Sweden; the Fibia Berg, S.W. from St. Gothard and the Binnental, Switzerland. An accessory constituent in the muscovite-granites of Brazil. *Hussakite* was a xenotime from Brazil erroneously thought to contain large amounts of SO_3.

In the United States, in the gold washings of Clarksville, Ga.; in N. C., Burke Co., Henderson Co., Mitchell Co.; in brilliant crystals in Alexander Co. with rutile, etc.; with tysonite near Pike's Peak, Col.; rare on New York Island.