**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

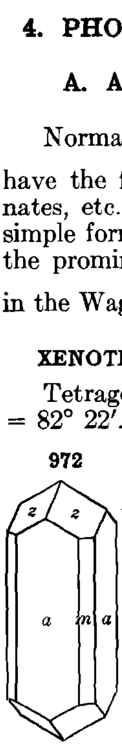
### A. Anhydrous Phosphates, Arsenates, Vanadates, Antimonates

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.

972



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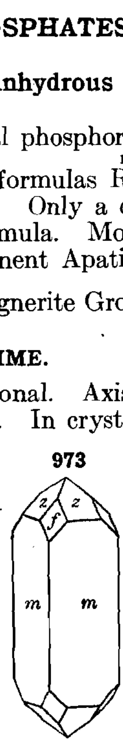


Cleavage: *m* (110) perfect. Fracture uneven and splintery. Brittle. H. = 4–5. G. = 4·45–4·56. Luster resinous to vitreous. Color yellowish brown, reddish brown, hair-brown, flesh-red, grayish white, wine-yellow, pale yellow; streak pale brown, yellowish or reddish. Opaque. Optically +. $\omega = 1{\cdot}72$.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

**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 $SO_3$.

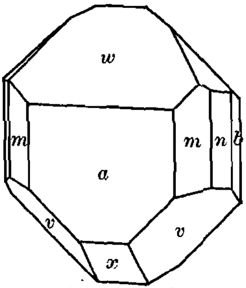
In the United States, in the gold washings of Clarksville, Ga.; in N. C., Burke Co., Henderson Co., Mitchell Co.; in brilliant crystals in Alexander Co. with rutile, etc.; with tysonite near Pike's Peak, Col.; rare on New York Island.

## MONAZITE

Monoclinic. Axes $a : b : c = 0{\cdot}9693 : 1 : 0{\cdot}9256$; $\beta = 76° 20'$.

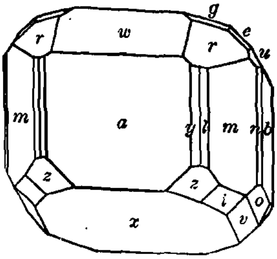
$mm'''$, $110 \wedge 1\bar{1}0 = 86° 34'$.
$aw$, $100 \wedge 101 = 39° 12\frac{1}{2}'$.
$a'x$, $\bar{1}00 \wedge \bar{1}01 = 53° 31'$.
$ee'$, $011 \wedge 0\bar{1}1 = 83° 56'$.
$rr'$, $111 \wedge 1\bar{1}1 = 60° 40'$.
$vv'$, $\bar{1}11 \wedge \bar{1}\bar{1}1 = 73° 19'$.

974



Norwich, Ct.

975



Switzerland

Crystals commonly small, often flattened || $a$ (100) or elongated || axis $b$; sometimes prismatic by extension of $v$ (111); also large and coarse. In masses yielding angular fragments; in rolled grains.

Cleavage: $c$ (001) sometimes perfect (parting?); also, $a$ (100) distinct; $b$ (010) difficult; sometimes showing parting || $c$ (001), $m$ (110). Fracture conchoidal to uneven. Brittle. H. = 5–5·5. G. = 4·9–5·3; mostly 5·0 to 5·2. Luster inclining to resinous. Color hyacinth-red, clove-brown, reddish or yellowish brown. Subtransparent to subtranslucent. Optically +. Ax. pl. $\perp$ $b$ (010) and nearly || $a$ (100). $Bx_a \wedge c$ axis = + 1° to 4°. Dispersion $\rho < v$ weak; horizontal weak. $2V = 14°$. $\alpha = 1{\cdot}786$. $\beta = 1{\cdot}788$. $\gamma = 1{\cdot}837$.

**Comp.** — Phosphate of the cerium metals, essentially $(Ce,La,Di)PO_4$.

Most analyses show the presence of $ThO_2$ and $SiO_2$, usually, but not always, in the proper amount to form thorium silicate; that this is mechanically present is not certain but possible.

**Pyr.**, etc. — B.B. infusible, turns gray, and when moistened with sulphuric acid colors the flame bluish green. With borax gives a bead yellow while hot and colorless on cooling; a saturated bead becomes enamel-white on flaming. Difficultly soluble in hydrochloric acid.

**Obs.** — Rather abundantly distributed as an accessory constituent of gneissoid rocks in certain regions, thus in North Carolina and Brazil. Occurs near Zlatoust in the Ilmen Mts., Russia, in granite. In Norway, near Arendal, and at Änneröd. In small yellow or brown crystals (*turnerite*) in Dauphiné, France, and Switzerland. Found also in the gold washings of Antioquia, Colombia; in the diamond gravels of Brazil. In crystals from Trundle near Condobolin and Emmaville, New South Wales; California Creek, Queensland; Olary, South Australia. In Madagascar at various localities.

In the United States, formerly found with the sillimanite of Norwich, and at Portland, Conn.; also at Yorktown, N. Y. In large coarse crystals and masses in albitic granite with microlite, etc., at Amelia Court-House, Va. In Alexander Co., N. C., in splendent crystals; in Mitchell, Madison, Burke, and McDowell counties, obtained in large quantities in rolled grains by washing the gravels. In the gold sands of southern Idaho.

Monazite is named from *μονάζειν, to be solitary*, in allusion to its rare occurrence.

*Cryptolite* occurs in wine-yellow prisms and grains in the green and red apatite of Arendal, Norway, and is discovered on putting the apatite in dilute nitric acid. It is probably monazite.

**Use.** — Monazite is the chief source of thorium oxide which is used in the manufacture of incandescent gaslight mantles.

**Berzeliite.** $R_3As_2O_8(R = Ca,Mg,Mn,Na_2)$. Isometric, usually massive. G. = 4·03. Color bright yellow. From Långban, Sweden. *Pyrrharsenite* from the Sjö mines, Sweden, contains also antimony; color yellowish red. *Caryinite*, associated with berzeliite, is related, but contains lead; massive (monoclinic).

**Monimolite.** An antimonate of lead, iron, and sometimes calcium; in part, $R_3Sb_2O_8$. Usually in octahedrons; massive, incrusting. G. = 6·58. Color yellowish or brownish green. From the Harstig mine, Pajsberg, Sweden.

**Carminite.** Perhaps $Pb_3As_2O_8.10FeAsO_4$. In clusters of fine needles; also in spheroidal forms. G. = 4·105. Color carmine to tile-red. From the Luise mine at Horhausen, Nassau, Germany.

**Georgiadésite.** $Pb_3(AsO_4)_2.3PbCl_2$. Orthorhombic. In small crystals with hexagonal outline. H. = 3·5. G. = 7·1. Resinous luster. Color white, brownish yellow. Found on lead slags at Laurium, Greece.

**Pucherite.** Bismuth vanadate, $BiVO_4$. In small orthorhombic crystals. H. = 4. G. = 6·249. Color reddish brown. Optically −. $\beta$ = 2·50. From the Pucher Mine, Schneeberg, Saxony; San Diego Co., Cal.

**Armangite.** $Mn_3(AsO_3)_2$. Hexagonal-rhombohedral. Prismatic habit. H. = 4. G. = 4·23. Poor basal cleavage. Color black, streak brown. Optically −. High refractive index. From Långban, Sweden.

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## *Triphylite Group.* Orthorhombic

| | | $a : b : c$ |
|---|---|---|
| **Triphylite** | $Li(Fe,Mn)PO_4$ | 0·4348 : 1 : 0·5265 |
| **Lithiophilite** | $Li(Mn,Fe)PO_4$ | |
| **Natrophilite** | $NaMnPO_4$ | |

Orthophosphates of an alkali metal, lithium or sodium, with iron and manganese.

### TRIPHYLITE-LITHIOPHILITE.

Orthorhombic. Axes $a : b : c$ = 0·4348 : 1 : 0·5265. Crystals rare, usually coarse and faces uneven. Commonly massive, cleavable to compact.

Cleavage: *c* (001) perfect; *b* (010) nearly perfect; *m* (110) interrupted. Fracture uneven to subconchoidal. H. = 4·5–5. G = 3·42–3·56. Luster vitreous to resinous. Color greenish gray to bluish in triphylite; also pale pink to yellow and clove-brown in lithiophilite. Streak uncolored to grayish white. Transparent to translucent. Axial angle variable, 0°–90°. Mean index, 1·68.

**Comp.** — A phosphate of iron, manganese and lithium, $Li(Fe,Mn)PO_4$, varying from the bluish gray TRIPHYLITE with little manganese to the salmon-pink or clove-brown LITHIOPHILITE with but little iron.

Typical *Triphylite* is $LiFePO_4$ = Phosphorus pentoxide 45·0, iron protoxide 45·5, lithia 9·5 = 100. Typical *Lithiophilite* is $LiMnPO_4$ = Phosphorus pentoxide 45·3, manganese protoxide 45·1, lithia 9·6 = 100. Both Fe and Mn are always present.

**Pyr., etc.** — In the closed tube sometimes decrepitates, turns to a dark color, and gives off traces of water. B.B. fuses at 1·5, coloring the flame beautiful lithia-red in streaks, with a pale bluish green on the exterior of the cone of flame. With the fluxes reacts for iron and manganese; the iron reaction is feeble in pure lithiophilite. Soluble in hydrochloric acid.

**Obs.** — *Triphylite* is often associated with spodumene; occurs at Rabenstein, near Zwiesel, in Bavaria; Keityö, Finland; Norwich, Mass.; Peru, Me.; Grafton, N. H. Named from τρίς, *threefold*, and φυλή, *family*, in allusion to its containing three phosphates.

*Lithiophilite* occurs at Branchville, Fairfield Co., Conn., in a vein of albitic granite, with spodumene, manganese phosphates, etc.; also at Norway, Me., in crystals from Pala, Cal. Named from *lithium* and φιλός, *friend*.

**Natrophilite.** $NaMnPO_4$. Near triphylite in form. Chiefly massive, cleavable. H. = 4·5–5. G. = 3·41. Color deep wine-yellow. Occurs sparingly at Branchville, Conn.

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**Graftonite.** $(Fe,Mn,Ca)_3P_2O_8$. Monoclinic. H. = 5. G. = 3·7. Color when fresh salmon-pink, usually dark from alteration. Fusible. Occurs in laminated intergrowths with triphyllite in a pegmatite from Grafton, N. H.

**Beryllonite.** A phosphate of sodium and beryllium, $NaBePO_4$. Crystals short prismatic to tabular, orthorhombic. H. = 5·5–6. G. = 2·845. Luster vitreous; on *c* (001) pearly. Colorless to white or pale yellowish. Optically −. $\beta = 1{\cdot}558$. From Stoneham, Me.

## *Apatite Group*

| | | | |
|---|---|---|---|
| General formula. | $R_5(F,Cl)[(P,As,V)O_4]_3 = (R(F,Cl))R_4[(P,As,V)O_4]_3$; | | |
| **Apatite** | $(CaF)Ca_4(PO_4)_3$ | Fluor-apatite | $c = 0{\cdot}7346$ |
| or | $(CaCl)Ca_4(PO_4)_3$ | Chlor-apatite | |
| **Pyromorphite** | $(PbCl)Pb_4(PO_4)_3$ | | 0·7362 |
| **Mimetite** | $(PbCl)Pb_4(AsO_4)_3$ | | 0·7224 |
| **Vanadinite** | $(PbCl)Pb_4(VO_4)_3$ | | 0·7122 |

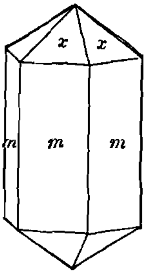
In addition to the above species, there are also certain intermediate compounds containing lead and calcium; others with phosphorus and arsenic, or arsenic and vanadium, as noted beyond. Further the rare calcium arsenate, Svabite, also seems to belong in this group. The radicals CaO, Ca.OH, may possibly replace the CaF radical in apatite. A probable member of the group, *wilkeite,* contains $CO_3$, $SiO_2$ and $SO_4$ in addition to usual radicals. *Fermorite* contains strontium.

The species of the APATITE GROUP crystallize in the hexagonal system, but all show, either by the subordinate faces, or in etching-figures, that they belong to the pyramidal class (p. 100). They are chemically phosphates, arsenates, vanadates of calcium or lead (also manganese), with chlorine or fluorine. The latter element is probably present as a univalent radical CaF (or CaCl), etc., in general RF (or RCl), replacing one hydrogen atom in the acid $\overset{\mathrm{I}}{R}_9(PO_4)_3$, so that the general formula is $(\overset{\mathrm{II}}{R}F)\overset{\mathrm{II}}{R}_4(PO_4)_3$, and similarly for the arsenates. This is a more correct way of viewing the composition than the other method sometimes adopted, viz., $3R_3(PO_4)_2.RF_2$, etc.

### APATITE.

Hexagonal-pyramidal. Axis $c = 0{\cdot}7346$.

976



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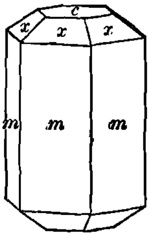

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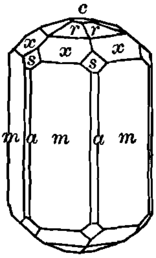

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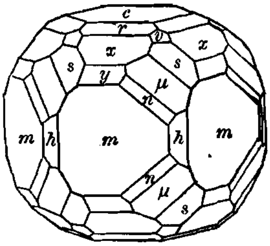
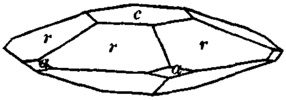


$cr$, $0001 \wedge 10\bar{1}2 = 22° 59'$.
$cx$, $0001 \wedge 10\bar{1}1 = 40° 18'$.
$cy$, $0001 \wedge 20\bar{2}1 = 59° 29'$.
$rr'$, $10\bar{1}2 \wedge 01\bar{1}2 = 22° 31'$.
$xx'$, $10\bar{1}1 \wedge \bar{1}011 = 37° 44\tfrac{1}{2}'$.
$ss'$, $11\bar{2}1 \wedge \bar{1}2\bar{1}1 = 48° 50'$.
$m\mu$, $10\bar{1}0 \wedge 21\bar{3}1 = 30° 20'$.
$ms$, $10\bar{1}0 \wedge 11\bar{2}1 = 44° 17'$.

980



Crystals varying from long prismatic to short prismatic and tabular. Also globular and reniform, with a fibrous or imperfectly columnar structure; massive, structure granular to compact.

Cleavage: *c* (0001) imperfect; *m* $(10\bar{1}0)$ more so. Fracture conchoidal and uneven. Brittle. H. = 5, sometimes 4·5 when massive. G. = 3·17–3·23 crystals. Luster vitreous, inclining to subresinous. Streak white. Color usually sea-green, bluish green; often violet-blue; sometimes white; occasionally yellow, gray, red, flesh-red and brown. Transparent to opaque. Optically −. Birefringence low. $\omega = 1{\cdot}6461$, $\epsilon = 1{\cdot}6417$.

**Var.** — 1. *Ordinary.* Crystallized, or cleavable and granular massive. Colorless to green, blue, yellow, flesh-red. (*a*) The *asparagus-stone*, originally from Murcia, Spain, is yellowish green. *Moroxite*, from Arendal, Norway, is in greenish blue and bluish crystals. (*b*) *Lasurapatite* is a sky-blue variety with lapis-lazuli in Siberia. (*c*) *Francolite*, from Wheal Franco, near Tavistock, Devonshire, England, occurs in small crystalline stalactitic masses and in minute curving crystals.

Ordinary apatite is *fluor-apatite*, containing fluorine often with only a trace of chlorine, up to 0·5 p. c.; rarely chlorine preponderates, and sometimes fluorine is entirely absent.

2. *Manganapatite* contains manganese replacing calcium to 10·5 p. c. MnO; color dark bluish green.

3. *Vœlckerite* is name given to the possible isomorphous molecule, $Ca_4(CaO)(PO_4)_3$ and *hydroxyapatite* to $Ca_4(Ca.OH)(PO_4)_3$.

4. *Fibrous, concretionary, stalactitic.* *Phosphorite* includes the fibrous concretionary and partly scaly mineral from Estremadura, Spain, and elsewhere. *Eupyrchroite*, from Crown Point, N. Y., belongs here; it is concentric in structure. *Staffelite* occurs incrusting the phosphorite of Staffel, Germany, in botryoidal, reniform, or stalactitic masses, fibrous and radiating. See p. 597.

5. *Earthy apatite; Osteolite.* Mostly altered apatite; *coprolites* are impure calcium phosphate.

**Comp.** — For *Fluor-apatite* $(CaF)Ca_4(PO_4)_3$; and for *Chlor-apatite* $(CaCl)Ca_4(PO_4)_3$; also written $3Ca_3P_2O_8.CaF_2$ and $3Ca_3P_2O_8.CaCl_2$. There are also intermediate compounds containing both fluorine and chlorine. The percentage composition for these normal varieties is as follows:

| | | | | | |
|---|---|---|---|---|---|
| *Fluor-apatite* | $P_2O_5$ 42·3 | CaO 55·5 | F 3·8 = 101·6 | or $Ca_3P_2O_8$ 92·25 | $CaF_2$ 7·75 = 100 |
| *Chlor-apatite* | $P_2O_5$ 41·0 | CaO 53·8 | Cl 6·8 = 101·6 | or $Ca_3P_2O_8$ 89·4 | $CaCl_2$ 10·6 = 100 |

Fluor-apatite is much more common than the other variety; here belongs the apatite of the Alps, Spain, St. Lawrence Co., N. Y., Canada. Apatites in which chlorine is prominent are rare; this is true of some Norwegian kinds.

**Pyr., etc.** — B.B. in the forceps fuses with difficulty on the edges (F. = 4·5–5), coloring the flame reddish yellow; moistened with sulphuric acid and heated colors the flame pale bluish green (phosphoric acid). Dissolves in hydrochloric and nitric acids, yielding with sulphuric acid a copious precipitate of calcium sulphate; the dilute nitric acid solution gives sometimes a precipitate of silver chloride on addition of silver nitrate. Most varieties will give a slight test for fluorine, when heated with potassium bisulphate in a closed tube.

**Diff.** — Characterized by the common hexagonal form, but softer than beryl, being scratched by a knife; does not effervesce in acid (like calcite); difficultly fusible; yields a green flame B.B. after being moistened with sulphuric acid.

**Micro.** — Recognized in thin sections by its moderately high relief; extremely low birefringence (hence not often showing a distinct axial figure in basal sections), the interference colors in ordinary sections scarcely rising above gray of the first order; parallel extinction and negative extension; columnar form; lack of color and cleavage; and by the rude cross parting seen as occasional cracks crossing the prism.

**Artif.** — Apatite may be prepared artificially by fusing sodium phosphate with calcium fluoride or calcium chloride.

**Obs.** — Apatite occurs in rocks of various kinds and ages, but is most common in metamorphic crystalline rocks, especially in granular limestone and in many metalliferous veins, particularly those of tin, in gneiss, syenite, hornblendic gneiss, mica schist, beds of iron ore; occasionally in serpentine. In the form of minute microscopic crystals it has an almost universal distribution as an accessory rock-forming mineral. It is found in all kinds of igneous rocks and is one of the earliest products of crystallization. In larger crystals it is especially characteristic of the pegmatite facies of igneous rocks, particularly the granites, and occurs there associated with quartz, feldspar, tourmaline, muscovite, beryl, etc. It is sometimes present in ordinary stratified limestone, beds of sandstone or shale of the Silurian, Carboniferous, Jurassic, Cretaceous, or Tertiary. It has been observed as the petrifying material of wood.

Among its localities are Ehrenfriedersdorf in Saxony; Schwarzenstein, the Knappenwand in Untersulzbachtal and Zillertal in the Tyrol, Austria; St. Gothard, Tavetsch, etc., in Switzerland; Mussa-Alp in Piedmont, Italy, white or colorless; Zinnwald and Schlackenwald in Bohemia; at Gellivare, Sweden; in England, in Cornwall, with tin ores; in Cumberland, at Carrock Fells; in Devonshire, cream-colored at Bovey Tracey, and at Wheal Franco (*francolite*). The *asparagus-stone* or *spargelstein* of Jumilla, in Murcia, Spain, is pale yellowish green in color. Large quantities of apatite are mined in Norway at Kragerö; also at Ödegaard, near Bamle, and elsewhere.

In Me., on Long Island, Blue-hill Bay; in fine purple crystals of gem-quality from Auburn. In N. H., Westmoreland. In Mass., at Norwich; at Bolton abundant. In Conn., at Branchville (*manganapatite*), also greenish white and colorless; at Haddam Neck. In N. Y., common in St. Lawrence Co., in granular limestone, also Jefferson Co.; Sandford mine, East Moriah, Essex Co., in magnetite; near Edenville, Orange Co.; at Tilly Foster iron mine. In Pa., at Leiperville, Delaware Co.; in Chester Co. In N. C., at Stony Point, Alexander Co., etc. In lavender-colored crystals from Mesa Grande, Cal.

In extensive beds in the Laurentian gneiss of Canada, usually associated with limestone, and accompanied by pyroxene, amphibole, titanite, zircon, garnet, vesuvianite and many other species. Prominent mines are in Ottawa County, Quebec, in the townships of Buckingham, Templeton, Portland, Hull, and Wakefield. Also in Renfrew county, Ontario, and in Lanark, Leeds, and Frontenac counties.

Apatite was named by Werner from *ἀπατάειν, to deceive*, older mineralogists having referred it to aquamarine, chrysolite, amethyst, fluorite, tourmaline, etc.

Besides the definite *mineral phosphates*, including normal apatite, phosphorite, etc., there are also extensive deposits of amorphous phosphates, consisting largely of "bone phosphate" ($Ca_3P_2O_8$), of great economic importance, though not having a definite chemical composition and hence not strictly belonging to pure mineralogy. Here belong the phosphatic nodules, coprolites, bone beds, guano, etc. Extensive phosphatic deposits also occur in North Carolina, Alabama, Florida, Tennessee, and in the western states, Idaho, Utah, and Wyoming. Guano is bone phosphate of lime, mixed with the hydrous phosphates, and generally with some calcium carbonate, and often a little magnesia, alumina, iron, silica, gypsum, and other impurities.

**Use.** — Apatite and phosphate rock are used chiefly as sources of mineral fertilizers. Some clear finely colored varieties of apatite may be used as gem stones. The mineral is too soft, however, to permit of extensive use for this purpose.

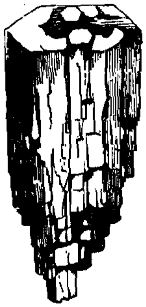
STAFFELITE. A carbonated calcium phosphate. Occurs incrusting the phosphorite of Staffel, Germany, in botryoidal or stalactitic masses, fibrous and radiating; it is the result of the action of carbonated waters. H. = 4. G. = 3·128. Color leek- to dark green, greenish yellow. *Dahllite*, from Bamle, Norway, is similar.

**Fermorite.** A member of the Apatite Group. $(Ca,Sr)_4[Ca(OH,F)][(P,As)O_4]_3$. H. = 5. G. = 3·52. Color pale pinkish white to white. Uniaxial, –. Index = 1·66. Found with manganese ores at Sitapar, Chhindwara District, Central provinces, India.

**Wilkeite.** $3Ca_3(PO_4)_2.CaCO_3.3Ca_3[(SiO_4)(SO_4)].CaO$. Probably a member of *Apatite Group*. Hexagonal. H. = 5. G. = 3·23. Color pale rose-red, yellow. Optically –. Index, 1·64. Fusible at 5·5. Dissolves in acids with separation of silica. In crystalline limestone at Crestmore, Riverside Co., Cal.

**PYROMORPHITE.** Green Lead Ore.

981



Hexagonal-pyramidal. Axis $c$ = 0·7362.

Crystals prismatic, often in rounded barrel-shaped forms; also in branching groups of prismatic crystals in nearly parallel position, tapering down to a slender point. Often globular, reniform, and botryoidal or in wart-like shapes, with usually a subcolumnar structure; also fibrous, and granular.

Cleavage: $m$ (10$\bar{1}$0), $x$ (10$\bar{1}$1) in traces. Fracture subconchoidal, uneven. Brittle. H. = 3·5–4. G. = 6·5–7·1 mostly, when pure; 5·9–6·5, when containing lime. Luster resinous. Color green, yellow, and brown, of different shades; sometimes wax-yellow and fine orange-yellow; also grayish white to milk-white. Streak white, sometimes yellowish. Subtransparent to subtranslucent. Optically –. $\omega$ = 2·050. $\epsilon$ = 2·042.

**Var.** — 1. *Ordinary.* (*a*) *In crystals* as described; sometimes yellow and in rounded forms resembling campylite (*pseudo-campylite*). (*b*) In *acicular* and *moss-like* aggregations. (*c*) *Concretionary* groups or masses of crystals, having the surface angular. (*d*) *Fibrous.* (*e*) *Granular massive.* (*f*) *Earthy;* incrusting.

2. *Polysphærite.* Containing lime; color brown of different shades, yellowish gray, pale yellow to nearly white; streak white; G. = 5·89–6·44. Rarely in separate crystals; usually in groups, globular, mammillary. *Miesite,* from Mies in Bohemia, is a brown variety. *Nussierite* is similar and impure, from Nussière, near Beaujeu, France; color yellow, greenish or grayish; G. = 5·042. 3. *Chromiferous;* color brilliant red and orange. 4. *Arseniferous;* color green to white; G. = 5·5–6·6. 5. *Pseudomorphous;* (*a*) after galena; (*b*) cerussite.

**Comp.** — $(PbCl)Pb_4(PO_4)_3$ or also written $3Pb_3P_2O_8.PbCl_2$ = Phosphorus pentoxide 15·7, lead protoxide 82·2, chlorine 2·6 = 100·5, or Lead phosphate 89·7, lead chloride 10·3 = 100.

The phosphorus is often replaced by arsenic, and as the amount increases the species passes into mimetite. Calcium also replaces the lead to a considerable extent.

**Pyr., etc.** — In the closed tube gives a white sublimate of lead chloride. B.B. in the forceps fuses easily (F. = 1·5), coloring the flame bluish green; on charcoal fuses without reduction to a globule, which on cooling assumes a crystalline polyhedral form, while the coal is coated white from lead chloride and, nearer the assay, yellow from lead oxide. With soda on charcoal yields metallic lead; some varieties contain arsenic, and give the odor of garlic in R.F. on charcoal. Soluble in nitric acid.

**Diff.** — Distinguished by its hexagonal form; high specific gravity; resinous luster; blowpipe characters.

**Obs.** — Pyromorphite occurs principally in veins, and accompanies other ores of lead. At Poullaouen and Huelgoet in Brittany, France; at Zschopau and other places in Saxony, Germany; at Přibram, Bleistadt, in Bohemia; in fine crystals at Ems, Braubach, in Nassau, Germany; also at Dernbach in Nassau; in Siberia at Beresov and in the Nerchinsk mining district; in England, in Cornwall, green and brown; Devon, gray; Derbyshire, green and yellow; Cumberland, golden yellow; in Scotland, Leadhill, red and orange. From Broken Hill and elsewhere, New South Wales.

In the United States, has been found very fine at Phenixville, Pa.; also in Me., at Lubec and Lenox; in N. Y., a mile south of Sing Sing; in Davidson Co., N. C., also in Cabarrus and Caldwell Cos.; from Mullan, Burke, Wardner and Mace, Idaho.

Named from *πῦρ*, *fire*, *μορφή*, *form*, alluding to the crystalline form the globule assumes on cooling. This species passes into mimetite.

**Use.** — A minor ore of lead.

## MIMETITE.

Hexagonal-pyramidal. Axis $c$ = 0·7224.

Habit of crystals like pyromorphite; sometimes rounded to globular forms. Also in mammillary crusts.

Cleavage: $x$ $(10\bar{1}1)$ imperfect. Fracture uneven. Brittle. H. = 3·5. G. = 7·0–7·25. Luster resinous. Color pale yellow, passing into brown; orange-yellow; white or colorless. Streak white or nearly so. Subtransparent to translucent. Optically –. $\omega$ = 2·135. $\epsilon$ = 2·118.

**Var.** — 1. *Ordinary.* (*a*) *In crystals,* usually in rounded aggregates. (*b*) *Capillary* or filamentous, especially marked in a variety from St. Prix-sous-Beuvray, France; somewhat like asbestus, and straw-yellow in color. (*c*) *Concretionary.*

*Campylite,* from Drygill in Cumberland, England, has G. = 7·218, and is in barrel-shaped crystals (whence the name, from *καμπυλος*, *curved*), yellowish to brown and brownish red; contains 3 p. c. $P_2O_5$.

**Comp.** — $(PbCl)Pb_4(AsO_4)_3$, also written $3Pb_3As_2O_8.PbCl_2$ = Arsenic pentoxide 23·2, lead protoxide 74·9, chlorine 2·4 = 100·5, or Lead arsenate 90·7, lead chloride 9·3 = 100.

Phosphorus replaces the arsenic in part, and calcium the lead. *Endlichite* (p. 599) is intermediate between mimetite and vanadinite.

**Pyr., etc.** — In the closed tube like pyromorphite. B.B. fuses at 1, and on charcoal gives in R.F. an arsenical odor, and is easily reduced to metallic lead, coating the coal at first with lead chloride, and later with arsenic trioxide and lead oxide. Soluble in nitric acid.

**Obs.** — Occurs in England near Redruth and elsewhere in Cornwall; Beer Alston, Devonshire; in Cumberland; in France near Pontgibaud, Puy-de-Dôme; in Germany at Johanngeorgenstadt, in fine yellow crystals, at Zinnwald; at Nerchinsk, Siberia; Långban, Sweden; from Santa Eulalia, Chihuahua, Mexico; at the Brookdale mine, Phenixville, Pa.; Eureka, Utah.

Named from μιμητής, *imitator*, it closely resembling pyromorphite.

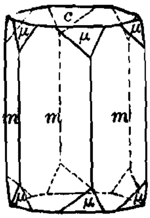
**Use.** — A minor ore of lead.

### VANADINITE.

Hexagonal-pyramidal. Axis $c = 0·7122$.

Crystals prismatic, with smooth faces and sharp edges; sometimes cavernous, the crystals hollow prisms; also in rounded forms and in parallel groupings like pyromorphite. In implanted globules or incrustations.

982



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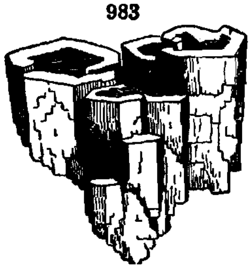


Fracture uneven, or flat conchoidal. Brittle. H. = 2·75–3. G. = 6·66–7·10. Luster of surface of fracture resinous. Color deep ruby-red, light brownish yellow, straw-yellow, reddish brown. Streak white or yellowish. Subtranslucent to opaque. Optically −. $\omega = 2·354$. $\epsilon = 2·299$.

**Comp.** — $(PbCl)Pb_4(VO_4)_3$, also written $3Pb_3V_2O_8.PbCl_2$ = Vanadium pentoxide 19·4, lead protoxide 78·7, chlorine 2·5 = 100·6, or Lead vanadate 90·2, lead chloride 9·8 = 100.

Phosphorus is sparingly present, also sometimes arsenic, both replacing vanadium. In *endlichite* the ratio of V : As = 1 : 1 nearly.

**Pyr., etc.** — In the closed tube decrepitates and yields a faint white sublimate. B.B. fuses easily, and on charcoal to a black lustrous mass, which in R.F. yields metallic lead and a coating of lead chloride; after completely oxidizing the lead in O.F. the black residue gives with salt of phosphorus an emerald-green bead in R.F., which becomes light yellow in O.F. Decomposed by hydrochloric acid.

**Obs.** — First discovered at Zimapan in Mexico. Later obtained at Wanlockhead in Dumfriesshire, Scotland; also at Berezov in the Ural Mts., with pyromorphite; and near Kappel in Carinthia, in crystals; at Undenäs, Bölet, Sweden. In the Sierra de Córdoba, Argentine Republic.

In the United States, sparingly near Sing Sing, N. Y. Abundant in the mining regions of Arizona and New Mexico, often associated with wulfenite and descloizite; in Ariz., at the mines in Yuma Co., in brilliant deep red crystals; Vulture, Phœnix, etc., in Maricopa Co.; the Mammoth gold mine, near Oracle, Pinal Co.; from Yavapai Co. In N. M. at Lake Valley, Sierra Co. (*endlichite*); and the Mimbres mines near Georgetown; Hillsboro; Magdalena.

**Use.** — A source of vanadium and a minor ore of lead.

**HEDYPHANE.** From Långban, Sweden; has ordinarily been included as a calcium variety of mimetite. Massive, cleavable. Color yellowish white. From Harstig mine, Pajsberg, Sweden.

**Svabite.** A calcium arsenate, related to the species of the Apatite Group. Crystals hexagonal prisms; colorless; $c = 0·7143$. H. = 5. G. = 3·52. From the Harstig mine, Pajsberg, and near Nordmark, Sweden.

### ***Wagnerite Group.*** Monoclinic

| | | $a : b : c$ | $\beta$ |
|---|---|---|---|
| **Wagnerite** | $(MgF)MgPO_4$ | 1·9145 : 1 : 1·5059; | 71° 53′ |
| **Triplite** | $(RF)RPO_4$, R = Fe : Mn = 2 : 1, 1 : 1, etc. | | |
| **Triploidite** | $(ROH)RPO_4$, R = Mn : Fe = 3 : 1 | 1·8572 : 1 : 1·4925; | 71° 46′ |
| **Adelite** | $(MgOH)CaAsO_4$ | 2·1978 : 1 : 1·5642; | 73° 15′ |
| **Tilasite** | $(MgF)CaAsO_4$ | | |
| **Sarkinite** | $(MnOH)MnAsO_4$ | 2·0017 : 1 : 1·5154; | 62° 13½′ |

Phosphates (and arsenates) of magnesium (calcium), iron and manganese containing fluorine (also hydroxyl). Formula $R_2FPO_4$ or $(RF)RPO_4$, etc.

**WAGNERITE.**

Monoclinic. Axes, see above. Crystals sometimes large and coarse. Also massive.

Cleavage: *a* (100), *m* (110) imperfect; *c* (001) in traces. Fracture uneven and splintery. Brittle. H. = 5–5·5. G. = 3·07–3·14. Luster vitreous. Streak white. Color yellow, of different shades; often grayish, also flesh-red, greenish. Translucent. Optically +. 2V = 26° (approx.). $\alpha$ = 1·569. $\beta$ = 1·570. $\gamma$ = 1·582.

**Comp.** — A fluo-phosphate of magnesium, $(MgF)MgPO_4$ or $Mg_3P_2O_8.MgF_2$ = Phosphorus pentoxide 43·8, magnesia 49·3, fluorine 11·8 = 104·9, deduct (O = 2F) 4·9 = 100. A little calcium replaces part of the magnesium.

**Pyr., etc.** — **B.B.** in the forceps fuses at 4 to a greenish gray glass; moistened with sulphuric acid colors the flame bluish green. With borax reacts for iron. On fusion with soda effervesces, but is not completely dissolved; gives a faint manganese reaction. Reacts for fluorine. Soluble in nitric and hydrochloric acids. With sulphuric acid evolves fumes of hydrofluoric acid.

**Obs.** — *Wagnerite* (in small highly modified crystals) occurs in the valley of Höllengraben, near Werfen, in Salzburg, Austria. *Kjerulfine* (massive, cleavable; also in coarse crystals) is from Kjörrestad, near Bamle, Norway.

**Spodiosite.** A calcium fluo-phosphate, perhaps $(CaF)CaPO_4$. In flattened prismatic orthorhombic crystals. G. = 2·94. Color ash-gray. From the Krangrufva, Wermland, and Nordmark, Sweden.

**TRIPLITE.**

Monoclinic. Massive, imperfectly crystalline. Cleavage: unequal in two directions perpendicular to each other, one much the more distinct. Fracture small conchoidal. H. = 4–5·5. G. = 3·44–3·8. Luster resinous, inclining to adamantine. Color brown or blackish brown. Streak yellowish gray or brown. Subtranslucent to opaque. Optically +. Mean index from 1·66–1·68.

**Comp.** — $(RF)RPO_4$ or $R_3P_2O_8.RF_2$ with R = Fe and Mn, also Ca and Mg. The ratio varies widely from Fe : Mn = 1 : 1 to 2 : 1 (zwieselite); 1 : 2; 1 : 7.

*Talktriplite* is a variety from Horrsjöberg, Sweden; contains magnesium and calcium in large amount.

**Pyr., etc.** — B.B. fuses easily at 1·5 to a black magnetic globule; moistened with sulphuric acid colors the flame bluish green. With borax in O.F. gives an amethystine-colored glass (manganese); in R.F. a strong reaction for iron. With soda reacts for manganese. With sulphuric acid evolves hydrofluoric acid. Soluble in hydrochloric acid.

**Obs.** — Found by Alluaud at Limoges in France; Helsingfors, Finland; Stoneham, Me.; Branchville, Conn.; from Reagan mining district, White Pine Co., Nev. *Zwieselite*, a clove-brown variety, is from Rabenstein, near Zwiesel in Bavaria.

GRIPHITE. A problematical phosphate related to triplite occurring in embedded reniform masses. From the Riverton lode near Harney City, Pennington Co., S. D.

Phosphoferrite. $H_6\overset{II}{R}_9(PO_4)_3$: R = Fe, Mn, Ca, Mg. Columnar. White to yellow or pale green. H. = 4–5. G. = 3·16. Habendorf, Bavaria.

**Triploidite.** Like triplite, but with the F replaced by (OH). Monoclinic. Commonly in crystalline aggregates. Fibrous to columnar. H. = 4·5–5. G. = 3·697. Color yellowish to reddish brown. Optically +. $\beta = 1{\cdot}726$. From Branchville, Fairfield Co., Conn.

**Adelite.** $(MgOH)CaAsO_4$. Monoclinic. Axes, see p. 600; also massive. H. = 5. G. = 3·74. Color gray or grayish yellow. Optically +. Mean index, 1·67. From Nordmark and Långban, Sweden.

**Tilasite.** Like adelite, but contains fluorine. Monoclinic. Optically –. $\beta = 1{\cdot}660$. From Långban, Sweden, and Kajlidongri, Jhabua, India.

**Sarkinite.** $(MnOH)MnAsO_4$. In monoclinic crystals; also in spherical forms. G. = 4·17. Color rose-red, flesh-red, reddish yellow. From the iron-manganese mines of Pajsberg, Sweden. *Polyarsenite* and *Xantharsenite* from the Sjö mine, Grythytte parish, Orebro, Sweden, and *Chondrasenite* from Pajsberg, Sweden, are essentially the same.

**Trigonite.** $Pb_3MnH(AsO_3)_3$. Monoclinic-clinohedral. In small wedge-shaped crystals. H. = 2–3. Perfect cleavage ∥ (010). Color sulphur-yellow. $\alpha = 2{\cdot}08$. $\gamma = 2{\cdot}16$. Ax. pl. ∥ (010). From Långban, Sweden.

**Herderite.** A fluo-phosphate of beryllium and calcium, $Ca[Be(F,OH)]PO_4$. In prismatic crystals, monoclinic with complex twinning. H. = 5. G. = 2·99–3·01. Luster vitreous. Color yellowish and greenish white. Optically –. $\beta = 1{\cdot}612$. From the tin mines of Ehrenfriedersdorf, Saxony; from Epprechtstein, Bavaria; also at Stoneham, Auburn, Hebron, and Paris, Me.

**Hamlinite.** A basic phosphate of aluminium, and strontium. In colorless rhombohedral crystals. H. = 4·5. G. = 3·16–3·28. Optically +. $\omega = 1{\cdot}620$. Occurs with herderite, bertrandite, etc., at Stoneham, Me. In the diamond sands of Diamantina, Brazil. Found also in Binnental, Switzerland (originally thought to be a new species and named *bowmannite*).

**Plumbogummite.** A basic phosphate of lead and aluminium. In chemical group with *hamlinite*. Resembles drops or coatings of gum; as incrustations. Color yellowish, brownish. From Roughten Gill, Cumberland, England. *Hitchcockite* from Canton mine, Ga., is closely identical. The material from Huelgoet, Brittany, France, is a mixture.

**Florencite.** A basic phosphate of aluminium and the cerium metals, closely analogous to hamlinite to which it is related in form. $3Al_2O_3.Ce_2O_3.2P_2O_5.6H_2O$. Hexagonal, rhombohedral. Habit rhombohedral. Basal cleavage. H. = 5. G. = 3·58. Color pale yellow. Infusible. Found in sands from near Ouro Preto and Diamantina, Minas Geraes, Brazil.

**Georceixite.** A basic phosphate of aluminium and barium (with smaller amounts of calcium and cerium). $BaO.2Al_2O_3.P_2O_5.5H_2O$. Microcrystalline, in rolled pebbles. H. = 6. G. = 3·1. Color brown and white. Refractive index, 1·63. From the diamond sands of Minas Geraes, Brazil. *Geraesite* is similar but more acidic in composition.

**Crandallite.** $2CaO.4Al_2O_3.2P_2O_5.10H_2O$. In compact to cleavable masses. Microscopically fibrous. Color white to light gray. Indices, 1·58–1·60. Found at Brooklyn mine near Silver City, Utah.

**Harttite.** A basic phosphate and sulphate of aluminium and strontium, $(Sr,Ca)O.2Al_2O_3.P_2O_5.SO_3.5H_2O$. Hexagonal. Usually microcrystalline as rolled pebbles. H. = 4·5–5. G. = 3·2. Color flesh-red. From the diamond sands of Minas Geraes, Brazil.

**Ježekite.** A fluo-phosphate of lime, soda, and alumina, $Na_4CaAl(AlO)(F,OH)_4(PO_4)_2$. Monoclinic. H. = 4·5. G. = 2·94. Cleavage perfect (100); imperfect (001). Indices, 1·55–1·59. Colorless or white. From Ehrenfriedersdorf, Saxony.

**Lacroixite.** A fluo-phosphate of soda, lime, manganese oxide, and alumina. $Na_4(Ca,Mn)_4Al_3(F,OH)_4P_3O_{16}.2H_2O$. Probably monoclinic. Pyramidal cleavage. H. = 4·1. G. = 3·13. Color pale yellow or green. Found at Ehrenfriedersdorf, Saxony.

**Durangite.** A fluo-arsenate of sodium and aluminium, $Na(AlF)AsO_4$. In monoclinic crystals. G. = 3·94–4·07. Color orange-red. Mean index, 1·673. From Durango, Mexico.

**AMBLYGONITE.** Hebronite.

Triclinic. Crystals large and coarse; forms rarely distinct. Usually cleavable to columnar and compact massive. Polysynthetic twinning lamellæ common.

Cleavage: *c* (001) perfect, with pearly luster; *a* (100) somewhat less so, vitreous; *e* $(0\bar{2}1)$ sometimes equally distinct; *M* $(1\bar{1}0)$ difficult; *ca* (001) ∧ (100) = 75° 30′, *ce* (001) ∧ $(0\bar{2}1)$ = 74° 40′, *cM* (001) ∧ $(1\bar{1}0)$ = 92° 20′. Fracture uneven to subconchoidal. Brittle. H. = 6. G. = 3·01–3·09. Luster vitreous to greasy, on *c* (001) pearly. Color white to pale greenish, bluish, yellowish, grayish or brownish white. Streak white. Subtransparent to translucent. Optically −. $\alpha = 1{\cdot}579$. $\beta = 1{\cdot}593$. $\gamma = 1{\cdot}597$.

**Comp.** — A fluo-phosphate of aluminium and lithium, $Li(AlF)PO_4$ or $AlPO_4.LiF$ = Phosphorus pentoxide 47·9, alumina 34·4, lithia 10·1, fluorine 12·9 = 105·3, deduct (O = 2F) 5·3 = 100. Sodium often replaces part of the lithium, and hydroxyl part of the fluorine.

**Pyr., etc.** — In the closed tube yields water, which at a high heat is acid and corrodes the glass. B.B. fuses easily (at 2) with intumescence, and becomes opaque white on cooling. Colors the flame yellowish red with traces of green; the Hebron variety gives an intense lithia-red; moistened with sulphuric acid gives a bluish green to the flame. With borax and salt of phosphorus forms a transparent colorless glass. In fine powder dissolves easily in sulphuric acid, more slowly in hydrochloric acid.

**Diff.** — Distinguished by its easy fusibility and by yielding a red flame B.B., from feldspar, barite, calcite, etc.; also by the acid water in the tube from spodumene.

**Obs.** — Occurs near Penig in Saxony; Arendal, Norway; Montebras, Creuze, France. In the United States, in Me., at Hebron; also at Paris, Peru, etc.; Branchville, Conn., Pala, San Diego Co., Cal.

The name *amblygonite* is from ἀμβλὶs, *blunt*, and γόνυ, *angle*.

**Fremontite.** Natramblygonite. Natromontebrasite. $(Na,Li)Al(OH,F)PO_4$. Monoclinic. Crystals coarse with rough faces. Three cleavages. Usually in cleavage masses. Polysynthetic twinning shown under microscope. H. = 5·5. G. = 3·04. Luster vitreous to greasy. Color, grayish white to white. Translucent to opaque. Optically −. Bisectrix nearly normal to basal cleavage. Easily fusible to a white enamel with strong sodium flame color. From a pegmatite near Canon City, Fremont County, Col.

## B. Basic Phosphates

This section includes a series of well-characterized basic phosphates, a number of which fall into the Olivinite Group. Acid phosphates are represented by one species only, the little known monetite, probably $HCaPO_4$, see p. 606.

### *Olivenite Group.* Orthorhombic

| | | *a* : *b* : *c* |
|---|---|---|
| **Olivenite** | $Cu_2(OH)AsO_4$ | 0·9396 : 1 : 0·6726 |
| **Libethenite** | $Cu_2(OH)PO_4$ | 0·9601 : 1 : 0·7019 |
| **Adamite** | $Zn_2(OH)AsO_4$ | 0·9733 : 1 : 0·7158 |
| **Descloizite** | $(Pb,Zn)_2(OH)VO_4$ | |
| *a* : *b* : *c* = | 0·6368 : 1 : 0·8045 or $\frac{3}{2}a$ : *b* : *c* = | 0·9552 : 1 : 0·8045 |
| Cuprodescloizite | $(Pb,Zn,Cu)_2(OH)VO_4$ | |

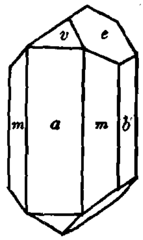
The Olivenite Group includes several basic phosphates, arsenates, etc., of copper, zinc, and lead, with the general formula $(ROH)RPO_4,(ROH)RAsO_4$, etc. They crystallize in the orthorhombic system with similar form. It is to be noted that this group corresponds in a measure to the monoclinic Wagnerite Group, p. 600, which also includes basic members.

**OLIVENITE.**

Orthorhombic. Axes $a : b : c = 0{\cdot}9396 : 1 : 0{\cdot}6726$.

*mm'''*, $110 \wedge 1\bar{1}0 = 86° 26'$. *ee'*, $011 \wedge 0\bar{1}1 = 67° 51'$.
*vv'*, $101 \wedge \bar{1}01 = 71° 11\frac{1}{2}'$. *ve*, $101 \wedge 011 = 47° 34'$.

984



Crystals prismatic, often acicular. Also globular and reniform, indistinctly fibrous, fibers straight and divergent, rarely irregular; also curved lamellar and granular.

Cleavage: *m* (110), *b* (010), *e* (011) in traces. Fracture conchoidal to uneven. Brittle. H. = 3. G. = 4·1–4·4. Luster adamantine to vitreous; of some fibrous varieties pearly. Color various shades of olive-green, passing into leek-, siskin-, pistachio-, and blackish green; also liver- and wood-brown; sometimes straw-yellow and grayish white. Streak olive-green to brown. Subtransparent to opaque. Mean index, 1·83.

**Var.** — (*a*) *Crystallized.* (*b*) *Fibrous;* finely and divergently fibrous, of green, yellow, brown and gray, to white colors, with the surface sometimes velvety or acicular; found investing the common variety or passing into it; called *wood-copper* or *wood-arsenate.* (*c*) *Earthy;* nodular or massive; sometimes soft enough to soil the fingers.

**Comp.** — $Cu_3As_2O_8Cu(OH)_2$ or $4CuO.As_2O_5.H_2O$ = Arsenic pentoxide 40·7, cupric oxide 56·1, water 3·2 = 100.

**Pyr., etc.** — In the closed tube gives water. B.B. fuses at 2, coloring the flame bluish green, and on cooling the fused mass appears crystalline. B.B. on charcoal fuses with deflagration, gives off arsenical fumes, and yields a metallic arsenide which with soda yields a globule of copper. With the fluxes reacts for copper. Soluble in nitric acid.

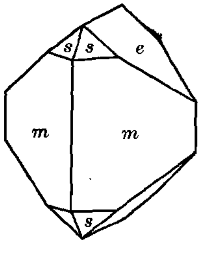
**Obs.** — The crystallized varieties occur in Cornwall, at various mines; Tavistock, in Devonshire; in Tyrol, Austria; the Banat, Hungary; Nizhni Tagilsk in the Ural Mts.; Chile. In the United States, in Utah, at the American Eagle and Mammoth mines, Tintic district, both in crystals and *wood-copper*. The name olivenite alludes to the olive-green color.

**LIBETHENITE.**

Orthorhombic. Axes $a : b : c = 0{\cdot}9601 : 1 : 0{\cdot}7019$.

*mm'''*, $110 \wedge 1\bar{1}0 = 87° 40'$. *ss'''*, $111 \wedge 1\bar{1}1 = 59° 4\frac{1}{2}'$.
*ee'*, $011 \wedge 0\bar{1}1 = 70° 8'$. *ss'*, $111 \wedge \bar{1}11 = 61° 47\frac{1}{2}'$.

985



In crystals usually small, short prismatic in habit; often united in druses. Also globular or reniform and compact.

Cleavage: *a* (100), *b* (010) very indistinct. Fracture subconchoidal to uneven. Brittle. H. = 4. G. = 3·6–3·8. Luster resinous. Color olive-green, generally dark. Streak olive-green. Translucent to subtranslucent. Mean index, 1·72.

**Comp.** — $Cu_3P_2O_8.Cu(OH)_2$ or $4CuO.P_2O_5.H_2O$ = Phosphorus pentoxide 29·8, cupric oxide 66·4, water 3·8 = 100.

**Pyr., etc.** — In the closed tube yields water and turns black. B.B. fuses at 2 and colors the flame emerald-green. On charcoal with soda gives metallic copper, sometimes also an arsenical odor. Fused with metallic lead on charcoal is reduced to metallic copper, with the formation of lead phosphate, which treated in R.F. gives a crystalline polyhedral bead on cooling. With the fluxes reacts for copper. Soluble in nitric acid.

**Obs.** — Occurs with chalcopyrite at Libethen, near Neusohl, Hungary; at Rheinbreitenbach and Ehl on the Rhine, Germany; at Nizhni Tagilsk in the Ural Mts.; from Viel-Salm, Belgium; in small quantities in Cornwall, England. In Clifton-Morenci district, Ariz.

**Tarbuttite.** $Zn_3P_2O_8.Zn(OH)_2$. Triclinic. Crystals striated and rounded, frequently in sheaf-like aggregates. Perfect basal cleavage. H. = 3·7. G. = 4·1. Colorless to pale yellow, brown, red, or green. Fusible. From Broken Hill, N. W. Rhodesia.

**Adamite.** $Zn_3As_2O_8.Zn(OH)_2$. In small orthorhombic crystals, often grouped in crusts and granular aggregations. H. = 3·5. G. = 4·34–4·35. Color honey-yellow, violet, rose-red, green, colorless. Mean index, 1·73. From Chañarcillo, Chile; Cap Garonne, France; from Mte. Valerio, Campiglia Marittima, Italy; at the ancient zinc mines of Laurion, Greece. From Island of Thasos, Turkey. Varieties from Cap Garonne, Var, France, containing cobalt and copper have been called *cobaltoadamite* and *cuproadamite*.

**Descloizite.** $R_2V_2O_8.R(OH)_2$ or $4RO.V_2O_5.H_2O$; $R$ = Pb, Zn chiefly, and usually in the ratio 1 : 1 approx. In small orthorhombic crystals, often drusy; also massive, fibrous radiated with mammillary surface. H. = 3·5. G. = 5·9–6·2. Color cherry-red and brownish red, to light or dark brown, black. Streak orange to brownish red or yellowish gray. Mean index, 1·83.

From the Sierra de Córdoba, Argentina; Kappel in Carinthia. Abundant at Lake Valley, Sierra Co., N. M., also near Georgetown and at Magdalena; in Ariz. near Tombstone; in Yavapai Co.; at the Mammoth Gold mine, near Oracle, Pinal Co.

A massive variety, containing copper (6·5 to 9 p. c.), in crusts, and reniform masses with radiated structure, occurs in San Luis Potosi, also in a vein of argentiferous galena in Zacatecas, Mexico; it has been variously named *cuprodescloizite*, *tritochorite*, *ramirite*. A similar variety (11 p. c. CuO) occurs as an incrustation on quartz at the Lucky Cuss mine, Tombstone, Cochise Co., and in stalactites at Shattuck Arizona mine, Bisbee, Ariz. From Camp Signal, San Bernardino Co., Cal.

EUSYNCHITE may be identical with descloizite. Massive: in nodular, stalactitic forms. G. = 5·596. Color yellowish red, reddish brown, greenish. From Hofsgrund near Freiburg in Baden, Germany. The same may be true of *aræoxene* from Dahn near Nieder-Schlettenbach, Rhenish Bavaria, Germany.

**Pyrobelonite.** $4PbO.7MnO.2V_2O_5.3H_2O$. Orthorhombic. In small acicular crystals. Fire-red color. H. = 3·5. G. = 5·377. High index. Probably related crystallographically to descloizite. From Långban, Sweden.

DECHENITE. Composition usually accepted as $PbV_2O_6$. Massive, botryoidal, nodular. G. = 5·6–5·81. Color deep red to yellowish red and brownish red. From Nieder-Schlettenbach in the Lautertal, Rhenish Bavaria, Germany.

**Calciovolborthite.** Probably $(Cu,Ca)_3V_2O_8.(Cu,Ca)(OH)_2$. In thin green tables; also gray, fine crystalline granular. Mean index, 2·05. From Friedrichsrode, Thuringia, Germany. Minerals from Richardson, southeastern Utah, and from near Baker City, Oregon, probably belong here.

**Higginsite.** $CuCa(OH)AsO_4$. Orthorhombic. Small prismatic crystals. H. = 4·5. G. = 4·33. $n$ = 1·745. Pleochroic, green, yellow-green, blue-green. From Higgins mine, Bisbee, Ariz.

**Brackebuschite.** Near descloizite (monoclinic?). From the State of Córdoba, Argentina.

TURANITE. A copper vanadate, $5CuO.V_2O_5.2H_2O$. Radiating fibrous. From Tyuya-Muyun, south of Andidjan, Alai Mts., Turkestan.

**Psittacinite.** A vanadate of lead and copper, from the Silver Star District, Mon. In thin coatings; also pulverulent. Color siskin- to olive-green.

MOTTRAMITE. A vanadate of lead and copper; possibly identical with psittacinite; in velvety black incrustations. From Mottram St. Andrew's, Cheshire, England.

**Furnacite.** A basic chrom-arsenate of lead and copper. In dark olive-green, small prismatic crystals. From Djocié, French Equatorial Africa.

**Tsumebite.** Preslite. A basic lead and copper phosphate. Orthorhombic? In small tabular crystals. H. = 3·5. G. = 6·1. Index, > 1·78. Color emerald-green. Pleochroic, blue-green to yellow-green. Easily fusible. From Tsumeb, Otavi, German S. W. Africa.

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**CLINOCLASITE.** Aphanèse.

Monoclinic. Axes $a : b : c$ = 1·9069 : 1 : 3·8507; $\beta$ = 80° 30′.

Crystals prismatic ($m$ (110)); also elongated || $b$ axis; often grouped in nearly spherical forms. Also massive, hemispherical or reniform; structure radiated fibrous.

Cleavage: *c* (001) highly perfect. Brittle. H. = 2·5–3. G. = 4·19–4·37. Luster: *c* pearly; elsewhere vitreous to resinous. Color internally dark verdigris-green; externally blackish blue-green. Streak bluish green. Subtransparent to translucent.

**Comp.** — $Cu_3As_2O_8.3Cu(OH)_2$ or $6CuO.As_2O_5.3H_2O$ = Arsenic pentoxide 30·3, cupric oxide 62·6, water 7·1 = 100.

**Pyr., etc.** — Same as for olivenite.

**Obs.** — Occurs in Cornwall, with other ores of copper. In Utah, Tintic district, at the Mammoth mine. From Collahurasi, Tarapaca, Chile. Named in allusion to the basal cleavage being oblique to the sides of the prism.

**Erinite.** $Cu_3As_2O_8.2Cu(OH)_2$. In mammillated crystalline groups. Color fine emerald-green. From Cornwall; also the Tintic district, Utah.

**Dihydrite.** $Cu_3P_2O_8.2Cu(OH)_2$. In dark emerald-green crystals (monoclinic). H. = 4·5–5. G. = 4–4·4. From Ehl near Linz on the Rhine, Germany; the Ural Mts., etc.

**Pseudomalachite.** In part $Cu_3P_2O_8.3Cu(OH)_2$. Massive, resembling malachite in color and structure. Indices, 1·83–1·93. From Rheinbreitenbach, Germany; Nizhni Tagilsk, Russia, etc. *Ehlite* is closely allied.

**DUFRENITE.** Kraurite.

Orthorhombic. Crystals rare, small, and indistinct. Usually massive, in nodules; radiated fibrous with drusy surface.

Cleavage: *a* (100), probably also *b* (010), but indistinct. H. = 3·5–4. G. = 3·2–3·4. Luster silky, weak. Color dull leek-green, olive-green, or blackish green; alters on exposure to yellow and brown. Streak siskin-green. Subtranslucent to nearly opaque. Strongly pleochroic. Indices, 1·83–1·93.

**Comp.** — Doubtful; in part $FePO_4.Fe(OH)_3 = 2Fe_2O_3.P_2O_5.3H_2O$ = Phosphorus pentoxide 27·5, iron sesquioxide 62·0, water 10·5 = 100.

**Pyr., etc.** — Same as for vivianite, but less water is given out in the closed tube. B.B. fuses easily to a slag.

**Obs.** — Occurs near Anglar, Dept. of Haute Vienne, France; in Germany at Hirschberg in Westphalia and from the Rothläufchen mine near Waldgirmes; St. Benigna, Bohemia; East Cornwall, England.

In the United States, at Allentown, N. J.; in Rockbridge Co., Va., in radiated coarsely fibrous masses; from Grafton, N. H. *Dufreniberaunite* is a variety intermediate in composition between *dufrenite* and *beraunite* from Hellertown, Pa.

**LAZULITE.**

Monoclinic: Axes $a : b : c = 0·9750 : 1 : 1·6483$; $\beta = 89° 14'$.

*at*, $100 \wedge 101 = 30° 24'$. *ee′*, $\bar{1}11 \wedge \bar{1}\bar{1}1 = 80° 20'$.
*pp′*, $111 \wedge 1\bar{1}1 = 79° 40'$. *pe*, $111 \wedge \bar{1}11 = 82° 30'$.

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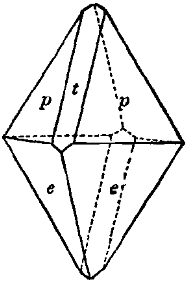

Crystals usually acute pyramidal in habit. Also massive, granular to compact.

Cleavage: prismatic, indistinct. Fracture uneven. Brittle. H. = 5–6. G. = 3·057–3·122. Luster vitreous. Color azure-blue; commonly a fine deep blue viewed along one axis, and a pale greenish blue along another. Streak white. Subtranslucent to opaque. Optically –. 2V = 69°. $\alpha = 1·603$. $\beta = 1·632$. $\gamma = 1·639$.

**Comp.** — $RAl_2(OH)_2P_2O_8$ or $2AlPO_4.(Fe,Mg)(OH)_2$ with Fe : Mg(Ca) = 1 : 12, 1 : 6, 1 : 2, 2 : 3. For 1 : 2 the formula requires: Phosphorus pentoxide 45·4, alumina 32·6, iron protoxide 7·7, magnesia 8·5, water 5·8 = 100.

**Pyr., etc.** — In the closed tube whitens and yields water. In the forceps whitens, cracks open, swells up, and without fusion falls to pieces, coloring the flame bluish green. B.B. with cobalt solution the blue color of the mineral is restored. The green color of the flame is made more intense by moistening the assay with sulphuric acid. With the fluxes gives an iron glass; with soda on charcoal an infusible mass. Unacted upon by acids, retaining perfectly its blue color.

**Obs.** — Occurs near Werfen in Salzburg, Austria; Krieglach, in Styria; also Horrsjöberg, Sweden; from Madagascar.

Abundant with corundum at Crowder's Mt., Gaston Co., N. C.; and on Graves Mt., Lincoln Co., Ga., with cyanite, rutile, etc.

The name lazulite is derived from an Arabic word, *azul*, meaning *heaven*, and alludes to the color of the mineral.

**Tavistockite.** $Ca_3P_2O_8.2Al(OH)_2$. In microscopic acicular crystals, sometimes stellate groups. Color white. From Tavistock, Devonshire.

**Cirrolite.** Perhaps $Ca_3Al(PO_4)_3.Al(OH)_3$. Compact. G. = 3·08. Color pale yellow. Occurs at the iron mine at Westanå, in Scania, Sweden.

**Arseniosiderite.** $Ca_3Fe(AsO_4)_3.3Fe(OH)_3$. In yellowish brown fibrous concretions. G. = 3·520. Index, 3·83. From Romanêche, near Mâcon, France; also at Schneeberg, Saxony.

**Allactite.** $Mn_3As_2O_8.4Mn(OH)_2$. Monoclinic. In small brownish red prismatic crysstals. Mean index, 1·786. From the Moss mine, Nordmark, and at Långban, Sweden.

**Synadelphite.** $2(Al,Mn)AsO_4.5Mn(OH)_2$. In prismatic crystals; also in grains. G. = 3·45–3·50. Color brownish black to black. From the Moss mine, Nordmark, Sweden.

**Flinkite.** $MnAsO_4.2Mn(OH)_2$. In minute orthorhombic crystals, tabular ‖ *c* (001); grouped in feather-like aggregates. G. = 3·87. Color greenish brown. From the Harstig mine, Pajsberg, Sweden.

**Hematolite.** Perhaps $(Al,Mn)AsO_4.4Mn(OH)_2$. In rhombohedral crystals. G. = 3·30–3·40. Color brownish red, black on the surface. Mean Index, 1·730. From the Moss mine, Nordmark, Sweden.

**Retzian.** A basic arsenate of the yttrium earths, manganese and calcium. In orthorhombic crystals. H. = 4. G. = 4·15. Color chocolate- to chestnut-brown. From the Moss mine, Nordmark, Sweden.

**Arseniopleite.** Perhaps $\overset{II}{R}_9\overset{III}{R}_2(OH)_6(AsO_4)_6$; $\overset{II}{R}$ = Mn, Ca, also Pb, Mg; $\overset{III}{R}$ = Mn, also Fe. Massive, cleavable. Color brownish red. Occurs at the Sjö mine, Grythytte parish, Sweden, with rhodonite in crystalline limestone.

**Manganostibiite.** Hematostibiite. Highly basic manganese antimonates. In embedded grains. Color black. *Manganostibiite* occurs at Nordmark, Sweden; *hematostibiite* is from the Sjö mine, Grythytte parish, Sweden.

**Atelestite.** Basic bismuth arsenate, $H_2Bi_3AsO_8$. In minute tabular crystals. G. = 6·4. Color sulphur-yellow. From Schneeberg, Saxony.

## C. Normal Hydrous Phosphates, etc.

The only important group among the normal hydrous phosphates is the monoclinic VIVIANITE GROUP.

**Struvite.** Hydrous ammonium-magnesium phosphate. In orthorhombic-hemimorphic crystals (Fig. 323, p. 127); white or yellowish; slightly soluble. Index, 1·502. From guano deposits.

**Collophanite.** $Ca_3P_2O_8.H_2O$. In layers resembling gymnite or opal. Colorless or snow-white. $n = 1.59$. From the island of Sombrero, West Indies. *Monite* is similar, from the islands Mona and Moneta in the West Indies, where it is associated with *monetite*, $HCaPO_4$ occurring in yellowish white triclinic crystals.

PYROPHOSPHORITE. $Mg_2P_2O_7.4(Ca_3P_2O_8.Ca_2P_2O_7)$. Massive, earthy. Color snow-white, dull. From the West Indies.

**Hopeite.** Hydrous zinc phosphate, $Zn_3P_2O_8.4H_2O$. Orthorhombic. In minute prismatic crystals. Also in reniform masses. Three cleavages: *a* (100), perfect; *b* (010), good; *c* (001), poor. Crystals from Broken Hill show interbanding of two modifications, $\alpha$- and $\beta$-hopeite which have the same composition but differ in their optical characters. H. = 3·2. G. = 3·0–3·1. Color grayish white. Optically –. $\beta$ = 1·59. Found in cavities in calamine at the zinc mines of Moresnet, Belgium; at the Broken Hill mines, Rhodesia.

**Parahopeite.** $Zn_3P_2O_8.4H_2O$. Same as for hopeite. Triclinic. In tabular crystals with deep striations. Good cleavage. H. = 3·7. G. = 3·3. Colorless. Found at Broken Hill, Rhodesia.

**Dickinsonite.** $3R_3P_2O_8.H_2O$ with R = Mn, Fe, $Na_2$ chiefly, also Ca, $K_2$, $Li_2$. In tabular, pseudo-rhombohedral crystals; commonly foliated to micaceous. G. = 3·338–3·343. Color olive- to oil-green, grass-green. $\beta$ = 1·662. From Branchville, Fairfield Co., Conn.

**Fillowite.** Formula as for dickinsonite and also from Branchville, Conn., but differing in angle. In granular crystalline masses. G. = 3·43. Color wax-yellow, yellowish to reddish brown, colorless. $\beta$ = 1·672.

The three following triclinic species are related in composition and may be in crystalline form.

**Roselite.** $(Ca,Co,Mg)_3As_2O_8.2H_2O$. In small crystals; often in druses and spherical aggregates. G. = 3·5–3·6. Color light to dark rose-red. From Schneeberg, Saxony.

**Brandtite.** $Ca_2MnAs_2O_8.2H_2O$. In prismatic crystals; crystals often united in radiated groups. G. = 3·671–3·672. Colorless to white. From the Harstig mine, near Pajsberg, Sweden.

**Fairfieldite.** A hydrous phosphate of calcium and manganese, $Ca_2MnP_2O_8.2H_2O$. Triclinic. In prismatic crystals; usually in foliated or fibrous crystalline aggregates. G. = 3·07–3·15. Color white or greenish white to pale straw-yellow. $\beta$ = 1·644. From Branchville, Fairfield Co., Conn.; Rabenstein, Bavaria (*leucomanganite*).

**Messelite.** $(Ca,Fe)_3P_2O_8.2\frac{1}{2}H_2O$. In minute tabular crystals. Colorless to brownish. $\beta$ = 1·653. From near Messel in Hesse, Germany. Perhaps an alteration of *Anapaite* through loss of water.

**Anapaite.** *Tamanite.* $(Ca,Fe)_3P_2O_8.4H_2O$. Triclinic. In tabular crystals. One perfect cleavage. H. = 3·5. G. = 2·8. Color greenish white. From the limonite mines near Anapa on the Taman peninsula, Russia.

**Reddingite.** $Mn_3P_2O_8.3H_2O$. In orthorhombic crystals near scorodite in angle; also granular. G. = 3·102. Color pinkish white to yellowish white. Optically +. $\beta$ = 1·656. From Branchville, Conn.

**Palaite.** Hydrous manganese phosphate, $5MnO.2P_2O_5.4H_2O$. Monoclinic? In crystalline masses. G. = 3·2. Color, flesh-pink. Indices 1·65–1·66. From Pala, San Diego Co., Cal. Derived by alteration from *lithiophilite* and alters into *hureaulite.*

**Stewartite.** Hydrous manganese phosphate, $3MnO.P_2O_5.4H_2O$. Triclinic? In fibers or minute crystals. G. = 2·94. Indices, 1·63–1·69. Pleochroic, colorless to yellow. Found as an alteration product of lithiophilite from Pala, Cal.

**Picropharmacolite.** $R_3As_2O_8.6H_2O$, with R = Ca : Mg = 5 : 1. In small spherical forms. Color white. From Riechelsdorf and Freiberg, Germany; Joplin, Mo.

**Trichalcite.** $Cu_3As_2O_8.5H_2O$. In radiated groups, columnar; dendritic. Color verdigris-green. From the Turginsk copper mine near Bogoslovsk, Ural Mts.

### *Vivianite Group.* Monoclinic

| | | | |
|---|---|---|---|
| **Vivianite** | $Fe_3P_2O_8.8H_2O$ | $a : b : c$ = 0·7498 : 1 : 0·7015 | $\beta$ = 75° 34′ |
| **Symplesite** | $Fe_3As_2O_8.8H_2O$ | 0·7806 : 1 : 0·6812 | 72° 43′ |
| **Bobierrite** | $Mg_3P_2O_8.8H_2O$ | | |
| **Hœrnesite** | $Mg_3As_2O_8.8H_2O$ | | |
| **Erythrite** | $Co_3As_2O_8.8H_2O$ | 0·75 : 1 : 0·70 | 75° |
| **Annabergite** | $Ni_3As_2O_8.8H_2O$ | | |
| **Cabrerite** | $(Ni,Mg)_3As_2O_8.8H_2O$ | | |
| **Köttigite** | $Zn_3As_2O_8.8H_2O$ | | |

The VIVIANITE GROUP includes hydrous phosphates of iron, magnesium, cobalt, nickel and zinc, all with eight molecules of water. The crystallization is monoclinic, and the angles, so far as known, correspond closely.

## VIVIANITE.

Monoclinic. Crystals prismatic (*mm‴* 110 ∧ $1\bar{1}0$ = 71° 58′); often in stellate groups. Also reniform and globular; structure divergent, fibrous, or earthy; also incrusting.

Cleavage: *b* (010) highly perfect; *a* (100) in traces; also fracture fibrous nearly ⊥ *c* axis. Flexible in thin laminæ; sectile. H. = 1·5 – 2. G = 2·58 – 2·68. Luster, *b* (010) pearly or metallic pearly; other faces vitreous. Colorless when unaltered, blue to green, deepening on exposure. Streak colorless to bluish white, changing to indigo-blue and to liver-brown. Transparent to translucent; opaque after exposure. Pleochroism strong; $X$ = cobalt-blue, $Y$ and $Z$ = pale greenish yellow. Optically +. $\alpha = 1·581$. $\beta = 1·604$. $\gamma = 1·636$.

**Comp.** — Hydrous ferrous phosphate, $Fe_3P_2O_8.8H_2O$ = Phosphorus pentoxide 28·3, iron protoxide 43·0, water 28·7 = 100.

Many analyses show the presence of iron sesquioxide due to alteration.

**Pyr., etc.** — In the closed tube yields neutral water, whitens, and exfoliates. B.B. fuses at 1·5, coloring the flame bluish green, to a grayish black magnetic globule. With the fluxes reacts for iron. Soluble in hydrochloric acid.

**Obs.** — Occurs associated with pyrrhotite and pyrite in copper and tin veins; sometimes in narrow veins with gold, traversing graywacke; both friable and crystallized in beds of clay, and sometimes associated with limonite, or bog iron ore; often in cavities of fossils or buried bones.

Occurs at St. Agnes and elsewhere in Cornwall, England; at Bodenmais, Germany; the gold mines of Verespatak in Transylvania. From Ashio, Shimotsuke, Japan. A variety from the Kertsch and Taman peninsulas, South Russia, that contains small quantities of manganese and magnesium has been called *paravivianite*. The earthy variety, sometimes called *blue iron-earth* or *native Prussian blue* (*Fer azuré*), occurs in Greenland, Carinthia, Guatemala, Bolivia, Victoria, Australia, etc.

In North America, in N. J., at Allentown, Monmouth Co., both crystallized, in nodules, and earthy; at Mullica Hill, Gloucester Co. (*mullicite*), in cylindrical masses. In Va., in Stafford Co. In Ky., near Eddyville. In Col. at Leadville; in Idaho, at Silver City. In Canada, with limonite at Vaudreuil.

**Symplesite.** Probably $Fe_3As_2O_8.8H_2O$. In small prismatic crystals and in radiated spherical aggregates. G. = 2·957. Color pale indigo, inclined to celandine-green. From Lobenstein, Germany; Hüttenberg, Carinthia.

**Bobierrite.** $Mg_3P_2O_8.8H_2O$. In aggregates of minute crystals; also massive. Colorless to white. From the guano of Mexillones, on the Chilian coast. *Hautefeuillite* is like bobierrite, but contains calcium. Monoclinic. Index 1·52. From Bamle, Norway.

**Hœrnesite.** $Mg_3As_2O_8.8H_2O$. In crystals resembling gypsum; also columnar; stellar-foliated. Color snow-white. From the Banat, Hungary.

## ERYTHRITE. Cobalt bloom.

Monoclinic. Crystals prismatic and vertically striated. Also in globular and reniform shapes, having a drusy surface and a columnar structure; sometimes stellate. Also pulverulent and earthy, incrusting.

Cleavage: *b* (010) highly perfect. Sectile. H. = 1·5–2·5; least on *b*. G. = 2·948. Luster of *b* pearly; other faces adamantine to vitreous; also dull, earthy. Color crimson- and peach-red, sometimes gray. Streak a little paler than the color. Transparent to subtranslucent. Strongly pleochroic. Optically –. $\alpha = 1·626$. $\beta = 1·661$. $\gamma = 1·699$.

**Comp.** — Hydrous cobalt arsenate, $Co_3As_2O_8.8H_2O$ = Arsenic pentoxide 38·4, cobalt protoxide 37·5, water 24·1 = 100. The cobalt is sometimes replaced by nickel, iron, and calcium.

**Pyr., etc.** — In the closed tube yields water at a gentle heat and turns bluish; at a higher heat gives off arsenic trioxide which condenses in crystals on the cool glass, and the residue has a dark gray or black color. B.B. in the forceps fuses at 2 to a gray bead, and colors the flame light blue (arsenic). B.B. on charcoal gives an arsenical odor, and fuses to a dark gray arsenide, which with borax gives the deep blue color characteristic of cobalt. Soluble in hydrochloric acid, giving a rose-red solution.

**Obs.** — Occurs at Schneeberg in Saxony, in micaceous scales; Wolfach in Baden; Modum in Norway. From the Veta Rica mine, Sierra Mojada, Coahuila, Mexico; Chile.

In the United States, in Pa., sparingly near Philadelphia; in Nev., at Lovelock's station. In Cal. In crystals from Cobalt, Canada. Named from ἐρυθρός, *red*.

**Annabergite.** $Ni_3As_2O_8.8H_2O$. Monoclinic. In capillary crystals; also massive and disseminated. Color fine apple-green. Optically −. Mean index, 1·68. From Allemont in Dauphiné, France; Annaberg, Schneeberg and Riechelsdorf, Germany; in Col.; Nev.; Cobalt, Ontario, Canada.

**Cabrerite.** $(Ni,Mg)_3As_2O_8.8H_2O$. Like erythrite in habit. Also fibrous, radiated; reniform, granular. Color apple-green. From the Sierra Cabrera, Spain; at Laurion, Greece.

**Köttigite.** Hydrous zinc arsenate, $Zn_3As_2O_8.8H_2O$. Massive, or in crusts. Color light carmine- and peach-blossom-red. Occurs with smaltite at the cobalt mine Daniel, near Schneeberg, Germany.

**Rhabdophanite.** Scovillite. A hydrous phosphate of the cerium and yttrium metals. Massive, small mamillary; as an incrustation. G. = 3·94–4·01. Color brown, pinkish or yellowish white. *Rhabdophanite* is from Cornwall; *Scovillite* is from the Scoville (limonite) ore bed in Salisbury, Conn.

**Churchite.** A hydrous phosphate of cerium and calcium. As a thin coating of minute crystals. G. = 3·14. Color pale smoke-gray tinged with flesh-red. From Cornwall, England.

**Uvanite.** $2UO_3.3V_2O_5.15H_2O$. Orthorhombic. Fine granular. Two pinacoidal cleavages. Color brownish yellow. Indices, 1·82–2·06. Found disseminated in rocks near Temple Rock, 45 miles southwest of Greenriver, Utah.

**Ferganite.** $U_3(VO_4)_2.6H_2O$. In scales. Color sulphur-yellow. From province of Fergana, Russian Turkestan.

**Fernandinite.** $CaO.V_2O_4.5V_2O_5.14H_2O$. Massive. Color dull green. Readily soluble in acids, partly soluble in water. Found at Minasragra, Peru.

**Pascoite.** Hydrous calcium vanadate, possibly $2CaO.3V_2O_5.11H_2O$. Monoclinic. In grains. H. = 2·5. G. = 2·46. Color orange. Streak yellow. Indices, 1·77–1·83. Easily fusible. Soluble in water. Found at Minasragra, Province of Pasco, Peru.

**Pintadoite.** Hydrous calcium vanadate, $2CaO.V_2O_5.9H_2O$. As an efflorescence. Color green. Found coating surfaces of sandstone in Canyon Pintado, Utah.

## SCORODITE.

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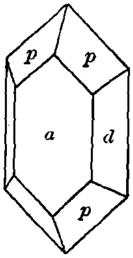


Orthorhombic. Axes *a* : *b* : *c* = 0·8658 : 1 : 0·9541.

*dd'*, $120 \wedge \bar{1}20 = 60° 1'$.     *pp''*, $111 \wedge \bar{1}11 = 111° 6'$.
*pp'*, $111 \wedge \bar{1}11 = 77° 8'$.     *pp'''*, $111 \wedge 1\bar{1}1 = 65° 20'$.

Habit octahedral, also prismatic. Also earthy, amorphous.

Cleavage: *d* (120) imperfect; *a* (100), *b* (010) in traces. Fracture uneven. Brittle. H. = 3·5–4. G. = 3·1–3·3. Luster vitreous to subadamantine and subresinous. Color pale leek-green or liver-brown. Streak white. Subtransparent to translucent. Mean index, 1·84.

**Comp.** — Hydrous ferric arsenate, $FeAsO_4.2H_2O$ = Arsenic pentoxide 49·8, iron sesquioxide 34·6, water 15·6 = 100.

**Pyr., etc.** — In the closed tube yields neutral water and turns yellow. B.B. fuses easily, coloring the flame blue. B.B. on charcoal gives arsenical fumes, and with soda a black magnetic scoria. With the fluxes reacts for iron. Soluble in hydrochloric acid.

**Obs.** — Often associated with arsenopyrite. From Schwarzenberg, Saxony; Dernbach, Nassau, Germany; Lölling, Carinthia; Schlaggenwald, Bohemia; Nerchinsk, Siberia, in fine crystals; leek-green, in the Cornish mines. From Congo Free State. From Obira, Japan.

Occurs near Edenville, N. Y., with arsenopyrite; in Utah, Tintic district, at the Mammoth mine on enargite. As an incrustation on siliceous sinter of the Yellowstone geysers. From Cobalt, Ontario, Canada.

Named from *σκόροδον*, *garlic*, alluding to the odor before the blowpipe.

**Vilateite.** Hydrous iron phosphate with a little manganese. Monoclinic. H. = 3–4. G. = 2·75. Color violet. Index, 1·74. Found in pegmatite at La Vilate near Chanteloube, Haute Vienne, France.

**Purpurite.** $2(Fe,Mn)PO_4.H_2O$. Orthorhombic(?). In small irregular masses. Two cleavages at right angles. H. = 4–4·5. G. = 3·4. Color deep red or reddish purple Refractive index, 1·60–1·65. Fusible. Found at Kings Mt., Gaston Co., N. C., sparingly from Pala, San Diego Co., Cal., Hill City, S. D., and Branchville, Conn.

**Strengite.** $FePO_4.2H_2O$. Crystals rare; in habit and angle near scorodite; generally in spherical and botryoidal forms. G. = 2·87. Color pale red. Optically +. $\beta$ = 1·72. From iron mines near Giessen, Germany; also in Rockbridge Co., Va., with dufrenite; from Pala, Cal.

**Phosphosiderite.** $2FePO_4.3\frac{1}{2}H_2O$. An iron phosphate near strengite, but with $3\frac{1}{2}H_2O$. Color red. Index 1·73. From the Siegen mining district, Germany; from Sardinia.

**Barrandite.** $(Al,Fe)PO_4.2H_2O$. In spheroidal concretions, color pale shades of gray. Index, 1·57. From Bohemia.

**Variscite.** $AlPO_4.2H_2O$. Orthorhombic. Commonly in crystalline aggregates and incrustations with reniform surface. Color green. Optically –. $\beta$ = 1·556. Strongly pleochroic. From Messbach in Saxon Voigtland; Montgomery Co., Ark., on quartz; in nodular masses from Tooele Co., Utah (*Utahlite*); crystalized from Lucin, Utah.

**Lucinite.** Comp. same as for *variscite*, $AlPO_4.2H_2O$. Orthorhombic. Octahedral habit. Also compact, massive. H. = 5. G. = 2·52. Color green. Indices, 1·56–1·59. Found with *variscite* at Utahlite Hill, near Lucin, Boxelder Co., Utah.

**Callainite.** $AlPO_4.2\frac{1}{2}H_2O$. Massive; wax-like. Color apple- to emerald-green. From a Celtic grave in Lockmariaquer, Brittany.

**Zepharovichite.** $AlPO_4.3H_2O$. Crystalline to compact. Color yellowish or grayish white. From Trenic in Bohemia.

**Palmerite.** $HK_2Al_2(PO_4)_3.7H_2O$. Amorphous, pulverulent. Color white. Occurs as a stratum in a guano deposit on Mte. Alburno, Salerno, Italy.

**Rosiérésite.** A hydrous phosphate of aluminium with lead and copper. In stalactites. G. = 2·2. Color yellow to brown. Index, 1·5. Isotropic. Infusible. Found in abandoned copper mine at Rosiéres, Tarn, France.

**Koninckite.** $FePO_4.3H_2O$. In small spherical aggregates of radiating needles. Color yellow. From Richelle, Belgium.

**Sicklerite.** A hydrous iron-manganese phosphate with lithia, $Fe_2O_3.6MnO.4P_2O_5.3(Li,H)_2O$. In cleavable masses. G. = 3·45. Color dark brown. Indices, 1·71–1·75. Pleochroic, yellow to orange-red. $Bx_a$ perpendicular to cleavage. Fusible, giving lithium flame. From Pala, Cal.

**Salmonsite.** A hydrous iron-manganese phosphate, $Fe_2O_3.9MnO.4P_2O_5.14H_2O$. Cleavable fibrous masses. G. = 2·88. Color buff. Indices, 1·65–1·67. Found at Pala, Cal., as alteration of *hureaulite*.

## Acid Hydrous Phosphates, etc.

### PHARMACOLITE.

Monoclinic. Crystals rare. Commonly in delicate silky fibers; also botryoidal, stalactitic.

Cleavage: *b* (010) perfect. Fracture uneven. Flexible in thin laminæ.

H. = 2–2·5. G. = 2·64–2·73. Luster vitreous; on *b* (010) inclining to pearly. Color white or grayish; frequently tinged red. Streak white. Translucent to opaque. Optically –. $\alpha = 1{\cdot}583$. $\beta = 1{\cdot}589$. $\gamma = 1{\cdot}594$.

**Comp.** — Probably $HCaAsO_4.2H_2O$ = Arsenic pentoxide 53·3, lime 25·9, water 20·8 = 100.

**Obs.** — Found with arsenical ores of cobalt and silver, also with arsenopyrite; at Andreasberg in the Harz Mts., Germany; Riechelsdorf in Hesse, Germany; Joachimstal in Bohemia, Markirch, Alsace, etc. Named from *φάρμακον*, *poison*.

**Haidingerite.** $HCaAsO_4.H_2O$. In minute crystal aggregates, botryoidal and drusy. G. = 2·848. Color white. Index, 1·67. From Joachimstal, Bohemia, with pharmacolite.

**Wapplerite.** $HCaAsO_4.3\frac{1}{2}H_2O$. In minute crystals; also in incrustations. Colorless to white. Found with pharmacolite at Joachimstal, Bohemia.

**Brushite.** $HCaPO_4.2H_2O$. In small slender monoclinic prisms; concretionary massive. Colorless to pale yellowish. $\beta = 1{\cdot}545$. Occurs in guano. **Metabrushite,** similarly associated, is $2HCaPO_4.3H_2O$. *Stoffertite* is a mineral similar to brushite but said to contain a little more water. From guano deposits on the island of Mona, West Indies.

**Martinite.** $H_2Ca_5(PO_4)_4.\frac{1}{2}H_2O$. From phosphorite deposits (from guano) in the island of Curacoa, West Indies.

**Hewettite.** $CaO.3V_2O_5.9H_2O$. In microscopic needles. G. = 2·5–2·6. Color deep red. Pleochroic, light orange-yellow to red. On heating loses water changing color through shades of brown to a bronze. Easily fusible. Found as an alteration of *patronite* at Minasragra, Peru. Also observed from Paradox Valley, Col.

**Metahewettite.** Comp. same as for *hewettite*. In minute tabular orthorhombic crystals. On heating loses water changing from dark red to yellow-brown. From Paradox Valley, Col., and at Thompson's, Utah.

**Newberyite.** $HMgPO_4.3H_2O$. In white orthorhombic crystals. Index, 1·52. From guano of Skipton Caves, Victoria. **Hannayite,** from same locality, is a hydrous phosphate of ammonium and magnesium. **Schertelite,** $Mg(NH_4)_2H_2(PO_4)_2.4H_2O$. Occurs in small tabular crystals in hot guano deposits near Skipton, southwest of Ballarat, Australia.

**Stercorite.** Microcosmic salt. $HNa(NH_4)PO_4.4H_2O$. In white crystalline masses and nodules in guano.

**Hureaulite.** $H_2Mn_5(PO_4)_4.4H_2O$. In short prismatic crystals (monoclinic). Also massive, compact, or imperfectly fibrous. Color yellowish, orange-red, rose, grayish. Optically –. $\beta = 1{\cdot}654$. From Limoges, commune of Huréaux, France. In the United States, at Branchville, Conn.; Pala, Cal.

**Forbesite.** $H_2(Ni,Co)_2As_2O_8.8H_2O$. Structure fibro-crystalline. Color grayish white. From Atacama, Chile.

FERRAZITE. $3(Ba,Pb)O.2P_2O_5.8H_2O$. A "fava" found in the diamond sands of Brazil. Color dark yellowish white. G. = 3·0–3·3.

### Basic Hydrous Phosphates, etc.

**Isoclasite.** $Ca_3P_2O_8.Ca(OH)_2.4H_2O$. In minute white crystals; also columnar. From Joachimstal, Bohemia.

**Hemafibrite.** $Mn_3As_2O_8.3Mn(OH)_2.2H_2O$. Commonly in spherical radiated groups. Color brownish red to garnet-red, becoming black. From the Moss mine, Nordmark, Sweden.

**EUCHROITE.**

Orthorhombic. Habit prismatic *mm'''* $110 \wedge 1\bar{1}0 = 62° 40'$. Cleavage: *m* (110), *n* (011) in traces. Fracture small conchoidal to uneven. Rather brittle. H. = 3·5–4. G. = 3·389. Luster vitreous. Color bright emerald- or leek-green. Transparent to translucent. Mean index, 1·70.

**Comp.** — $Cu_3As_2O_8.Cu(OH)_2.6H_2O$ = Arsenic pentoxide 34·2, cupric oxide 47·1, water 18·7 = 100.

**Obs.** — Occurs in quartzose mica slate at Libethen in Hungary, in crystals of considerable size, having much resemblance to dioptase. Named from *ευχροα*, *beautiful color*.

**Conichalcite.** Perhaps $(Cu,Ca)_3As_2O_8.(Cu,Ca)(OH)_2.\frac{1}{2}H_2O$. Orthorhombic. Usually reniform and massive, resembling malachite. Color pistachio-green to emerald-green From Andalusia, Spain; Maya-Tass, Akmolinsk, Siberia (crystals); Tintic district, Utah.

**Bayldonite.** $(Pb,Cu)_3As_2O_8.(Pb,Cu)(OH)_2.H_2O$. In mamillary concretions, drusy. Color green. From Cornwall, England.

**Tagilite.** $Cu_3P_2O_8.Cu(OH)_2.2H_2O$. In reniform or spheroidal concretions; earthy. Color verdigris- to emerald-green. From the Ural Mts.

**Leucochalcite.** Probably $Cu_3As_2O_8.Cu(OH)_2.2H_2O$. In white, silky acicular crystals. From the Wilhelmine mine in the Spessart, Germany.

**Barthite.** $3ZnO.CuO.3As_2O_5.2H_2O$. In small monoclinic (?) crystals. H. = 3. G. = 4·19. Color grass-green. Found in druses of a dolomite at Guchab, Otavi, German Southwest Africa.

**Volborthite.** A hydrous vanadate of copper, barium, and calcium. In small six-sided tables; in globular forms. Color olive-green, citron-yellow. Index, 1·90. From the Ural Mts.

**Hügelite.** A hydrous lead-zinc vanadate. Monoclinic. In microscopic hair-like crystals. Color orange-yellow to yellow-brown. From Reichenbach near Lahr, Baden, Germany.

**Cornwallite.** $Cu_3As_2O_8.2Cu(OH)_2.H_2O$. Massive, resembling malachite. Color emerald-green. From Cornwall, England.

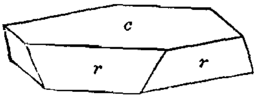
**Tyrolite.** Tirolit. Perhaps $Cu_3As_2O_8.2Cu(OH)_2.7H_2O$. Usually in fan-shaped crystalline groups; in foliated aggregates; also massive. Cleavage perfect, yielding soft thin flexible laminæ. Color pale green inclining to sky-blue. Index, 1·70. From Libethen, Hungary; Nerchinsk, Siberia; Falkenstein, Tyrol; etc. In the United States, in the Tintic district, Utah. Some analyses yield $CaCO_3$, usually regarded as an impurity, but it may be essential.

**Spencerite.** $Zn_3(PO_4)_2.Zn(OH)_2.3H_2O$. Monoclinic. In radiating and reticulated crystals. Cleavages parallel to three pinacoids. Color white. G. = 3·12. H. = 2·7. $\beta$ = 1·61. Optically −. From Hudson Bay Mine, Salmo, B. C.

**Hibbenite.** $2Zn_3(PO_4)_2.Zn(OH)_2.6\frac{1}{2}H_2O$. Orthorhombic. Tabular parallel to *a* (100). Cleavages parallel to three pinacoids. Color white. G. = 3·21. H. = 3·7. Optically −. From Hudson Bay Mine, Salmo, British Columbia.

## CHALCOPHYLLITE.

Rhombohedral. Axis $c$ = 2·761. $cr$ 0001 $\wedge$ 10$\bar{1}$1 = 72° 2′.



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In tabular crystals; also foliated massive; in druses.

Cleavage: $c$ (0001) highly perfect; $r$ (10$\bar{1}$1) in traces. H. = 2. G. = 2·4–2·66. Luster of $c$ pearly; of other faces vitreous or subadamantine. Color emerald- or grass-green to verdigris-green. Streak somewhat paler than the color. Transparent to translucent. Optically −. $\omega$ = 1·632. $\epsilon$ = 1·575.

**Comp.** — A highly basic arsenate of copper; formula uncertain, perhaps $7CuO.As_2O_5.14H_2O$.

**Pyr., etc.** — In the closed tube decrepitates, yields much water, and gives a residue of olive-green scales. In other respects like olivenite. Soluble in nitric acid, and in ammonia.

**Obs.** — From the copper mines near Redruth in Cornwall; at Sayda, Saxony; Moldawa in the Banat, Hungary; from Chile. In the United States, in the Tintic district, Utah; Bisbee, Ariz.

**Veszelyite.** A hydrous phospho-arsenate of copper and zinc, formula uncertain. Occurs as a greenish blue crystalline incrustation at Morawitza, in the Banat, Hungary.

## WAVELLITE.

Orthorhombic. Axes $a : b : c$ = 0·5049 : 1 : 0·3751. Crystals rare. Usually in aggregates, hemispherical or globular with crystalline surface, and radiated structure.

Cleavage: *p* (101) and *b* (010) rather perfect. Fracture uneven to subconchoidal. Brittle. H. = 3·25–4. G. = 2·316–2·337. Luster vitreous, inclining to pearly and resinous. Color white, passing into yellow, green, gray, brown, and black. Streak white. Translucent. Mean index, 1·526.

**Comp.** — $4AlPO_4.2Al(OH)_3.9H_2O$ = Phosphorus pentoxide 35·2, alumina 38·0, water 26·8 = 100. Fluorine is sometimes present, up to 2 p. c.

**Pyr., etc.** — In the closed tube gives off much water, the last portions of which may react acid (fluorine). B.B. in the forceps swells up and splits into fine infusible particles, coloring the flame pale green. Gives a blue on ignition with cobalt solution. Soluble in hydrochloric acid, and also in caustic potash.

**Obs.** — From Barnstaple in Devonshire, England; at Zbirow in Bohemia; at Frankenberg, Saxony; Arbrefontaine, Belgium; Montebras, France; Minas Geraes, Brazil, etc.

In the United States at the slate quarries of York Co., Pa.; White Horse Station, Chester Valley R. R., Pa.; Magnet Cove, Ark.

**Fischerite.** $AlPO_4.Al(OH)_3.2\frac{1}{2}H_2O$. In small prismatic crystals and in drusy crusts. Color green. Index, 1·55. From Nizhni Tagilsk in the Ural Mts.

**Peganite.** $Al(PO_4).Al(OH)_3.1\frac{1}{2}H_2O$. Occurs in green crusts, of small prismatic crystals, at Striegis, near Freiberg, Saxony.

## TURQUOIS. Turquoise.

Triclinic. Crystals minute and in angle near those of *chalcosiderite* with which it may be isomorphous. Usually massive; amorphous or cryptocrystalline. Reniform, stalactitic, or incrusting. In thin seams and disseminated grains. Also in rolled masses.

Cleavage in two directions in crystals; none in massive material. Fracture small conchoidal. Rather brittle. H. = 5–6. G. = 2·6–2·83. Luster somewhat waxy, feeble. Color sky-blue, bluish green to apple-green, and greenish gray. Streak white or greenish. Feebly subtranslucent to opaque. Optically +. $\alpha = 1{\cdot}61$. $\beta = 1{\cdot}62$. $\gamma = 1{\cdot}65$.

**Comp.** — A hydrous phosphate of aluminium and copper $CuO.3Al_2O_3.2P_2O_5.9H_2O$ or perhaps $H_5(CuOH)[Al(OH)_2]_6(PO_4)_4$ = Phosphorus pentoxide 34·12, alumina 36·84, cupric oxide 9·57, water 19·47 = 100.

Penfield considers that the H, (CuOH) and $Al(OH)_2$ mutually replace each other in the orthophosphoric molecule.

**Pyr., etc.** — In the closed tube decrepitates, yields water, and turns brown or black. B.B. in the forceps becomes brown and assumes a glassy appearance, but does not fuse; colors the flame green; moistened with hydrochloric acid the color is at first blue (copper chloride). With the fluxes reacts for copper. Soluble in hydrochloric acid.

**Obs.** — The highly prized oriental turquois occurs in narrow seams (2 to 4 or even 6 mm. in thickness) or in irregular patches in the brecciated portions of a porphyritic trachyte and the surrounding clay slate in Persia, not far from Nishâpûr, Khorassan; in the Megara Valley, Sinai; in the Kara-Tube Mts. in Turkestan, 50 versts from Samarkand.

In the United States, occurs in the Los Cerillos Mts., 20 m. S.E. of Santa Fé, New Mexico, in a trachytic rock, a locality long mined by the Mexicans and in recent years reopened and extensively worked; in the Burro Mts., Grant Co., N. M.; pale green variety near Columbus, and in Lincoln Co., Nevada. In crystals near Lynch Station, Campbell Co., Va.

Natural turquois of inferior color, is often artificially treated to give it the tint desired. Moreover, many stones which are of a fine blue when first found retain the color only so long as they are kept moist, and when dry they fade, become a dirty green, and are of little value. Much of the turquois (not artificial) used in jewelry in former centuries, as well as the present, and that described in the early works on minerals, was *bone-turquois* (called also *odontolite*, from *ὀδούς, tooth*), which is fossil bone, or tooth, colored by a phosphate of iron. Its organic origin becomes manifest under a microscope. Moreover, true turquois, when decomposed by hydrochloric acid, gives a fine blue color with ammonia, which is not true of the odontolite.

**Use.** — As an ornamental material.

**Wardite.** $2Al_2O_3.P_2O_5.4H_2O$. Forms light green or bluish green concretionary incrustations in cavities of nodular masses of variscite from Cedar Valley, Utah. H. = 5. G. = 2·77.

**Sphærite.** Perhaps $4AlPO_4.6Al(OH)_3$. In globular drusy concretions. Color light gray, bluish. From near St. Benigna, Bohemia.

**Liskeardite.** $(Al,Fe)AsO_4.2(Al,Fe)(OH)_3.5H_2O$. In thin incrusting layers, white or bluish. From Liskeard, Cornwall, England.

**Evansite.** $2AlPO_4.4Al(OH)_3.12H_2O$. Massive; reniform or botryoidal. Colorless, or milk-white. $n$ = 1·485. From Zsetcznik, Hungary; Gross-Tresny, Moravia; Tasmania; Coosa coalfield, Ala.; Goldburg, Idaho.

Cœruleolactite. Perhaps $3Al_2O_3.2P_2O_5.10H_2O$. Crypto-crystalline; milk-white to light copper-blue. From near Katzenellnbogen, Nassau, Germany; also East Whiteland Township, Chester Co., Pa.

**Augelite.** $2Al_2O_3.P_2O_5.3H_2O$. In tabular monoclinic crystals and massive. G. = 2·7. Colorless to white. Optically +. $\beta$ = 1·576. From Bolivia; from the iron mine of Westanå, Sweden. The same locality has also yielded the three following aluminium phosphates.

Berlinite. $2Al_2O_3.2P_2O_5.H_2O$. Compact, massive. G. = 2·64. Colorless to grayish or rose-red.

Trolleite. $4Al_2O_3.3P_2O_5.3H_2O$. Compact, indistinctly cleavable. G. = 3·10. Color pale green.

Attacolite. $P_2O_5,Al_2O_3,MnO,CaO,H_2O$, etc.; formula doubtful. Massive. G. = 3·09. Color salmon-red.

Minasite. An aluminium phosphate. In rolled pebbles from Brazil.

Vashegyite. $4Al_2O_3.3P_2O_5.30H_2O$. Massive. H. = 2–3. G. = 1·96. Color white or yellow to rust-brown when colored by iron oxide. From iron mine at Vashegy in Comitat Gömör, Hungary.

**Soumansite.** A fluo-phosphate of aluminium and sodium with water. Tetragonal. Pyramidal habit. H. = 4·5. G. = 2·87. Colorless. Indices, 1·55–1·56. Optically +. Fusible with intumescence. From Montebras in Soumans, Creuse, France.

### PHARMACOSIDERITE.

Isometric-tetrahedral. Commonly in cubes; also tetrahedral. Rarely granular.

Cleavage: $a$ (100) imperfect. Fracture uneven. Rather sectile. H. = 2·5. G. = 2·9–3. Luster adamantine to greasy, not very distinct. Color olive-, grass- or emerald-green, yellowish brown, honey-yellow. Streak green to brown, yellow, pale. Subtransparent to subtranslucent. $n$ = 1·676. Pyroelectric.

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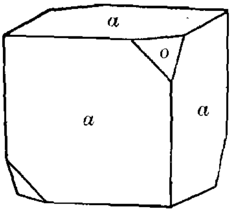


**Comp.** — Perhaps $6FeAsO_4.2Fe(OH)_3.12H_2O$ = Arsenic pentoxide 43·1, iron sesquioxide 40·0, water 16·9 = 100. Some varieties contain $K_2O$.

**Pyr., etc.** — Same as for scorodite.

**Obs.** — Obtained at the mines in Cornwall, England, with ores of copper; at Schneeberg and Schwarzenberg, Saxony; at Königsberg, near Schemnitz, Hungary. In Utah, at the Mammoth mine, Tintic district. Named from *φάρμακον*, *poison*, and *σίδηρος*, *iron*.

**Ludlamite.** $2Fe_3P_2O_8.Fe(OH)_2.8H_2O$. Occurs in small green tabular crystals (monoclinic), near Truro, Cornwall, England.

**Cacoxenite.** $FePO_4.Fe(OH)_3.4\frac{1}{2}H_2O$. In radiated tufts of a yellow or brownish color. Indices, 1·58–1·61. From near St. Benigna in Bohemia; Lancaster Co., Pa.

**Xanthoxenite.** Hydrous ferric phosphate with FeO, MnO, CaO, MgO, $Al_2O_3$. Monoclinic. In thin plates. Yellow. Pleochroic. G. = 2·84. From Hühnerkobel, Rabenstein, Bavaria.

**Beraunite.** Perhaps $2FePO_4.Fe(OH)_3.2\frac{1}{2}H_2O$. Commonly in druses and in radiated globules and crusts. Color reddish brown to dark hyacinth-red. From St. Benigna, near Beraun, in Bohemia. From Hellertown, Pa. *Eleonorite,* in tabular crystals, is the same mineral. From the Eleonore mine near Giessen, Germany.

GLOBOSITE, PICITE, DÉLVAUXITE, KERTSCHENITE, OXYKERTSCHENITE, are other hydrated ferric phosphates.

### CHILDRENITE.

Orthorhombic. Axes $a : b : c = 0{\cdot}7780 : 1 : 0{\cdot}52575$.

*mm'''*, $110 \wedge 1\bar{1}0 = 75° 46'$. *rr'''*, $131 \wedge 1\bar{3}1 = 105° 9'$.
*rr'*, $131 \wedge \bar{1}31 = 39° 47'$. *ss'*, $121 \wedge \bar{1}21 = 49° 56\frac{1}{2}'$.

Only known in crystals. Cleavage: *a* (100) imperfect. Fracture uneven. H. = 4·5–5. G. = 3·18–3·24. Luster vitreous to resinous. Color yellowish white, pale yellowish brown, brownish black. Streak white to yellowish. Translucent. 2E = 74°. Optically –. $\alpha = 1{\cdot}631$. $\beta = 1{\cdot}660$. $\gamma = 1{\cdot}664$.

**Comp.** — In general $2AlPO_4.2Fe(OH)_2.2H_2O$. Phosphorus pentoxide 30·9, alumina 22·2, iron protoxide 31·3, water 15·6 = 100. Manganese replaces part of the iron and it hence graduates into eosphorite.

**Pyr., etc.** — In the closed tube gives off neutral water. B.B. swells up into ramifications, and fuses on the edges to a black mass, coloring the flame pale green. Heated on charcoal turns black and becomes magnetic. With soda gives a reaction for manganese. With borax and salt of phosphorus reacts for iron and manganese. Soluble in hydrochloric acid.

**Obs.** — From Tavistock, Devonshire, England; from Greifenstein, Germany. In United States, at Hebron, Me.

KREUZBERGITE. Aluminium phosphate with Fe,Mn,$H_2O$. Orthorhombic. White to yellow. From the Kreuzberg, Pleystein, Bavaria.

**Eosphorite.** Form and composition as for childrenite, but containing chiefly manganese instead of iron. . In prismatic crystals; also massive. Color rose-pink, yellowish, etc. $\beta = 1{\cdot}65$. From Branchville, Conn.

**Mazapilite.** $Ca_3Fe_2(AsO_4)_4.2FeO(OH).5H_2O$. In slender prismatic crystals. G. = 3·567–3·582. Color black. From Mazapil, Mexico.

YUKONITE. $(Ca_3,Fe_2''')(AsO_4)_2.2Fe(OH)_3.5H_2O$. Amorphous. In irregular concretions. H. = 2–3. G. = 2·8. Color nearly black with brown tinge. Decrepitates at low heat, also when immersed in water. Easily fusible with intumescence. From Tagish Lake, Yukon Territory.

**Calcioferrite.** $Ca_3Fe_2(PO_4)_4.Fe(OH)_3.8H_2O$. Occurs in yellow to green nodules in clay at Battenberg, Rhenish Bavaria, Germany.

**Borickite.** Perhaps $Ca_3Fe_2(PO_4)_4.12Fe(OH)_3.6H_2O$. Reniform massive; compact. Color reddish brown. From Leoben in Styria; Bohemia. *Fouchérite,* possibly same as borichite from Fouchères, Aube, France.

**Egueïite.** A hydrous basic phosphate of ferric iron with calcium and aluminium. Amorphous. In small nodules with fibrous-lamellar structure. Index, 1·65. Fusibility 1. Easily soluble in hydrochloric acid. Found embedded in clay from Egueï, Sudan.

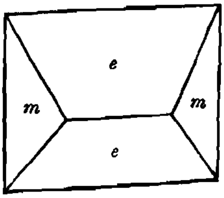
RICHELLITE. Perhaps $4FeP_2O_8.Fe_2OF_2(OH)_2.36H_2O$. Massive, compact or foliated. Color yellow. From Richelle, Belgium.

### LIROCONITE.

Monoclinic. Axes $a : b : c = 1{\cdot}3191 : 1 : 1{\cdot}6808$; $\beta = 88° 33'$.

*mm'''*, $110 \wedge 1\underline{1}0 = 105° 39'$. *me*, $\underline{1}10 \wedge 011 = 46° 10'$.
*ee'*, $011 \wedge 0\bar{1}1 = 118° 29'$. *m'e*, $\bar{1}10 \wedge 011 = 47° 24'$.

990



Crystals resembling rhombic octahedrons. Rarely granular. Cleavage: *m* (110), *e* (011) indistinct. Fracture subconchoidal to uneven. Imperfectly sectile. H. = 2–2·5. G. = 2·882–2·985. Luster vitreous, inclining to resinous. Color and streak sky-blue to verdigris-green.

**Comp.** — A hydrous arsenate of aluminium and copper, formula uncertain; analyses correspond nearly to $Cu_6Al(AsO_4)_5.3CuAl(OH)_5.20H_2O$ = Arsenic pentoxide 28·9, alumina 10·3, cupric oxide 35·9, water 24·9 = 100. Phosphorus replaces part of the arsenic.

**Pyr., etc.** — In the closed tube gives much water and turns olive-green. B.B. cracks open, but does not decrepitate; fuses less readily than olivenite to a dark gray slag; on charcoal cracks open, deflagrates, and gives reactions like olivenite. Soluble in nitric acid.

**Obs.** — From Cornwall; Herrengrund in Hungary.

**Chenevixite.** Perhaps $Cu_2(FeO)_2As_2O_8.3H_2O$. Massive to compact. Color dark green to greenish yellow. From Cornwall; Utah.

HENWOODITE. A hydrated phosphate of aluminium and copper. In botryoidal globular masses. Color turquois-blue. From Cornwall.

**Ceruleite.** $CuO.2Al_2O_3.As_2O_5.8H_2O$. Compact, made up of very minute crystals. G. = 2·8. Color, turquois-blue. Soluble in acids. From Huanaco, Taltal province, Chile.

**Chalcosiderite.** $CuO.3Fe_2O_3.2P_2O_5.8H_2O$. Probably isomorphous with turquois and should have $9H_2O$. In sheaf-like crystalline groups, as incrustations. Color light siskin-green. Indices, 1·83–1·93. From Cornwall.

ANDREWSITE, also from Cornwall, is near chalcosiderite.

**Kehoeite.** A hydrated phosphate of aluminium, zinc, etc. Massive. G. = 2·34. From Galena, S. D.

**Goyazite.** Perhaps $Ca_3Al_{10}P_2O_{23}.9H_2O$. Strontia has been found in the mineral and it is possible that it is identical with *hamlinite*. In small rounded grains. Color yellowish white. From Minas Geraes, Brazil.

**Roschérite.** $(Mn,Fe,Ca)_2Al(OH)(PO_4)_2.2H_2O$. Monoclinic. From Ehrensfriedersdorf, Saxony.

## *Uranite Group*

**TORBERNITE.** Copper Uranite.

Tetragonal. Axis $c$ = 2·9361. Crystals usually square tables, sometimes very thin, again thick; less often pyramidal. Also foliated, micaceous.

Cleavage: $c$ (001) perfect, micaceous. Laminæ brittle. H. = 2–2·5. G. = 3·4–3·6. Luster of $c$ pearly, other faces subadamantine. Color emerald- and grass-green, and sometimes leek-, apple-, and siskin-green. Streak paler than the color. Transparent to subtranslucent. Optically uniaxial; negative. $\omega$ = 1·61.

**Comp.** — A hydrous phosphate of uranium and copper, $Cu(UO_2)_2P_2O_8.12H_2O$ = Phosphorus pentoxide 14·1, uranium trioxide 56·6, copper 7·9, water 21·4 = 100. Arsenic may replace part of the phosphorus.

**Pyr., etc.** — In the closed tube yields water. Fuses at 2·5 to a blackish mass, and colors the flame green. With salt of phosphorus gives a green bead, which with tin on charcoal becomes on cooling opaque red (copper). With soda on charcoal gives a globule of copper. Soluble in nitric acid.

**Obs.** — From Germany at Schneeberg, etc., Saxony; Reichenbach, Baden; at Joachimstal, Bohemia; Ambert, Puy-de-Dôme, France. From Mt. Painter, South Australia. The material from Gunnis Lake, Cornwall corresponds to $Cu(UO_2)_2P_2O_8.8H_2O$ and is the same as the first dehydration product of torbernite, which has been called *meta-torbernite I*. G. = 3·68. $\omega$ = 1·623. $\epsilon$ = 1·625.

**Zeunerite.** $Cu(UO_2)_2As_2O_8.8H_2O$. In tabular crystals resembling torbernite in form and color. G. = 3·2. $\omega$ = 1·64. From Schneeberg, Saxony; near Joachimstal, Bohemia; Cornwall.

**AUTUNITE.** Lime Uranite.

Orthorhombic. In thin tabular crystals, nearly tetragonal in form and deviating but slightly from torbernite in angle; also foliated, micaceous.

Cleavage: basal, eminent. Laminæ brittle. H. = 2–2·5. G. = 3·05–3·19. Luster of *c* (001) pearly, elsewhere subadamantine. Color lemon- to sulphur-yellow. Streak yellowish. Transparent to translucent. Optically −. Ax. pl. $\parallel$ *b* (010). Bx $\perp$ *c* (001). $\alpha = 1·553$. $\beta = 1·575$. $\gamma = 1·577$.

**Comp.** — A hydrous phosphate of uranium and calcium, probably analogous to torbernite, $Ca(UO_2)_2P_2O_8.8H_2O$ or $CaO.2UO_3.P_2O_5.8H_2O$ = Phosphorus pentoxide 15·5, uranium trioxide 62·7, lime 6·1, water 15·7 = 100.

Some analyses give 10 and others 12 molecules of water, but it is not certain that the additional amount is essential.

**Pyr., etc.** — Same as for torbernite, but no reaction for copper.

**Obs.** — With uraninite, as in Germany at Johanngeorgenstadt and Falkenstein; in Italy at Lurisia, Cuneo; in Madagascar; at Tinh-Tuc, Tongking, China; from Mt. Painter, South Australia. In the United States, at Middletown and Branchville, Conn. In N. C., at mica mines in Mitchell Co.; in Alexander Co.; Black Hills, S. D.

**Bassetite.** Composition probably the same as *autunite*. Monoclinic. $\beta = 89° 17'$. Twinned; tw. pl. *b* (010). Cleavage parallel to three pinacoids. G. = 3·10. Color yellow. Transparent. Indices, 1·57–1·58. From the Basset mines, Cornwall. Previously considered to be *autunite*.

**Uranospinite.** Probably $Ca(UO_2)_2As_2O_8.8H_2O$. In thin tabular orthorhombic crystals rectangular in outline. Color siskin-green. $\beta = 1·63$. From near Schneeberg, Saxony.

**Uranocircite.** $Ba(UO_2)_2P_2O_8.8H_2O$. In crystals similar to autunite. Color yellow-green. $\beta = 1·62$. From Falkenstein, Saxon Voigtland, Germany.

**Carnotite.** Approximately, $K_2O.2U_2O_3.V_2O_5.3H_2O$. Orthorhombic. In the form of powder, sometimes in crystalline plates $\parallel$ *c* (001). Basal cleavage. Color yellow. $\beta = 1·86$. Occurs as a yellow crystalline powder, or in loosely cohering masses, intimately mixed with quartzose material. It is found in large quantities in western Colorado and eastern Utah. Is mined there not only for its uranium and vanadium content but also for the small amount of radium it contains. Noted also from Radium Hill, near Olary, South Australia, and from near Mauch Chunk, Pa.

TYUYAMUNITE. $CaO.2UO_3.V_2O_5.4H_2O$. Perhaps a calcium carnotite. Found at Tyuya-Muyun, Fergana, Russian Central Asia.

**Uranospathite.** A hydrated uranyl phosphate. Orthorhombic, pseudo-tetragonal. In elongated tabular crystals. Cleavages parallel to the three pinacoids. Color yellow to pale green. From Redruth, Cornwall. Previously considered to be *autunite*.

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**Phosphuranylite.** $(UO_2)_3P_2O_8.6H_2O$. As a pulverulent incrustation. Color deep lemon-yellow. From Mitchell Co., N. C.

**Trögerite.** $(UO_2)_3As_2O_8.12H_2O$. In thin druses of tabular crystals. Probably tetragonal. Color lemon-yellow. From near Schneeberg, Saxony.

**Walpurgite.** Probably $Bi_{10}(UO_2)_3(OH)_{24}(AsO_4)_4$. In thin yellow crystals resembling gypsum. G. = 5·76. Color yellow. Index, 2·00. From near Schneeberg, Saxony.

**Rhagite.** Perhaps $2BiAsO_4.3Bi(OH)_3$. In crystalline aggregates. Color yellowish green, wax-yellow. From near Schneeberg, Saxony.

ARSENO-BISMITE. A hydrous bismuth arsenate. In cryptocrystalline aggregates. Color yellowish green with tinge of brown. G. = 5·7. Index, 1·6. Found at Mammoth mine, Tintic district, Utah.

**Mixite.** A hydrated basic arsenate of copper and bismuth, formula doubtful. In acicular crystals; as an incrustation. Color green to whitish. From Joachimstal, Bohemia; Wittichen, Baden; Tintic district, Utah.

## Antimonates; also Antimonites, Arsenites.

A number of antimonates have been included in the preceding pages among the phosphates, arsenates, etc.

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**Bindheimite.** A hydrous antimonate of lead. Amorphous, reniform; also earthy or incrusting. Color gray, brownish, yellowish. Index, 2·0. A result of the decomposition of other antimonial ores; thus at Horhausen, Germany; in Cornwall, England; Sevier county, Ark.

**Romeite.** An antimonite of calcium, perhaps $CaSb_2O_4$. In groups of minute square octahedrons. H. above 5·5. G. = 4·713. Color hyacinth- or honey-yellow. $n$ = 1·83–1·87. From St. Marcel, Piedmont; Miguel Burnier, Minas Geraes. *Atopite* from Långban, Sweden, is probably the same species.

**Nadorite.** $PbClSbO_2$. In orthorhombic crystals. H. = 3·5–4. G. = 7·02. Color brownish yellow. $\beta$ = 2·35. From Djebel-Nador, Constantine, Algeria.

**Ecdemite.** Heliophyllite. Perhaps $Pb_4As_2O_7.2PbCl_2$. In crystals, massive, and as an incrustation. G. = 6·89–7·14. Color bright yellow to green. From Långban, Sweden; also Pajsberg (*heliophyllite*).

**Ochrolite.** Probably $Pb_4Sb_2O_7.2PbCl_2$. In small crystals, united in diverging groups. Color sulphur-yellow. From Pajsberg, Sweden.

**Trippkeite.** $n CuO.As_2O_3$. In small bluish green, tetragonal crystals. From Copiapo, Chile.

**Schafarzikite** is described as isomorphous with trippkeite with the formula, $n FeO.P_2O_3$. From Pernek, Comitat Pozsony, Hungary.

**Tripuhyite.** An iron antimonate. $2FeO.Sb_2O_5$. In microcrystalline aggregates of a dull greenish yellow color. From Tripuhy, Brazil.

**Flajolotite.** $4FeSbO_4.3H_2O$. Compact or earthy. Color lemon-yellow. In nodular masses. From Hammam N'Baïl, Constantine, Algiers.

**Catoptrite.** $14(Mn,Fe)O.2(Al,Fe)_2O_3.2SiO_2.Sb_2O_5$. Monoclinic. Crystals minute tabular parallel to $b$ (010). Perfect basal cleavage. H. = 5·5. G. = 4·5. Color black. In thin splinters, red. Pleochroic, red-brown to red-yellow. From Brattsfor mine, Nordmarken, Sweden.

**Derbylite.** An antimo-titanate of iron. In prismatic, orthorhombic crystals. H. = 5. G. = 4·53. Color black. Tripuhy, Brazil.

**Lewisite.** $5CaO.2TiO_2.3Sb_2O_5$. In minute yellow to brown isometric octahedrons. Tripuhy, Brazil.

**Mauzeliite.** A titano-antimonate of lead and calcium, related to lewisite. In dark brown isometric octahedrons. Jakobsberg, Sweden.

AMMIOLITE. A doubtful antimonite of mercury; forming a scarlet earthy mass. Chile.

## Phosphates or Arsenates with Carbonates, Sulphates, Borates

**Podolite.** $3Ca_3(PO_4)_2.CaCO_3$. Hexagonal. In microscopic prismatic crystals, also in spherulites. G. = 3·1. Color yellow. $\beta$ = 1·64. Occurs in cavities in the phosphorite nodules from near the Uschitza River, Podolien, southern Russia. See also *staffelite* and *dahllite*, p. 597.

**Diadochite.** A hydrated phosphate and sulphate of ferric iron. Index, 1·606. From Thuringia. *Destinezite* is similar; from Belgium.

**Pitticite.** A hydrated arsenate and sulphate of ferric iron. Reniform and massive. Yellowish and reddish brown. Index, 1·63. From Saxony, Cornwall, etc.

**Svanbergite.** A hydrated phosphate and sulphate of aluminium and calcium. In rhombohedral crystals. Color yellow to yellowish brown, rose-red. $\omega$ = 1·64. From Horrsjöberg, Sweden.

**Beudantite.** A phosphate or arsenate with sulphate of ferric iron and lead; formula perhaps, $3Fe_2O_3.2PbO.2SO_3.As_2O_5.6H_2O$. In rhombohedral crystals. Color green to brown and black. Indices, 1·75–1·94. From Dernbach and Horhausen, Nassau. *Corkite* is same mineral from Cork, Ireland; Beaver Co., Utah.

**Phosphophyllite.** $3Fe_3P_2O_8.2Al(OH)SO_4.9H_2O$, with Ca,Ba,Mg,Mn,$K_2$. Monoclinic. Colorless to pale blue-green. 3 pinacoidal cleavages. H. = 3–4. G. = 3·08. $n$ = 1·65. From Habendorf, Bavaria.

**Hinsdalite.** $2PbO.3Fe_2O_3.2SO_3.P_2O_5.6H_2O$. Pseudo-rhombohedral. In coarse, dull crystals. Cleavage, basal perfect. H. = 4·5. G. = 4·65. Colorless with greenish tone. Indices 1·67–1·69. Found at Golden Fleece mine, Hinsdale Co., Col.

**Lindackerite.** Perhaps $3NiO.6CuO.SO_3.2As_2O_5.7H_2O$. In rosettes, and in reniform masses. Color verdigris- to apple-green. From Joachimstal, Bohemia.

**Lüneburgite.** $3MgO.B_2O_3.P_2O_5.8H_2O$. Monoclinic? In flattened masses, fibrous to earthy structure. Biaxial, −. Index, 1·53. From Lüneburg, Hannover.

**Lossenite.** A hydrous iron arsenate and lead sulphate from Laurion, Greece.

## Nitrates

The Nitrates being largely soluble in water play but an unimportant rôle in Mineralogy.

### SODA NITER.

Rhombohedral. Axis $c$ = 0·8276; $rr''$ $10\bar{1}1 \wedge \bar{1}101$ = 73° 30′. Homœomorphous with calcite. Usually massive form, as an incrustation or in beds.

Cleavage: $r$ $(10\bar{1}1)$ perfect. Fracture conchoidal, seldom observable. Rather sectile. H. = 1·5–2. G. = 2·24–2·29. Luster vitreous. Color white; also reddish brown, gray and lemon-yellow. Transparent. Taste cooling. Optically −. $\omega$ = 1·5874, $\epsilon$ = 1·3361.

**Comp.** — Sodium nitrate, $NaNO_3$ = Nitrogen pentoxide 63·5, soda 36·5 = 100.

**Pyr., etc.** — Deflagrates on charcoal with less violence than niter, causing a yellow light, and also deliquesces. Colors the flame intensely yellow. Dissolves in three parts of water at 60° F.

**Obs.** — From Tarapaca, northern Chile, and also the neighboring parts of Bolivia; also in Humboldt Co., Nev.; near Calico, San Bernardino Co., Cal.

**Use.** — A source of nitrates. The deposits in Chile are of great importance.

**Niter.** Potassium nitrate, $KNO_3$. Orthorhombic. $\beta$ = 1·505. In thin white crusts and silky tufts.

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**Nitrocalcite.** Hydrous calcium nitrate, $Ca(NO_3)_2.nH_2O$. In efflorescent silky tufts and masses. In many limestone caverns, as those of Kentucky.

**Nitromagnesite.** $Mg(NO_3)_2.nH_2O$. In efflorescences in limestone caves.

**Nitrobarite.** Barium nitrate, $Ba(NO_3)_2$. Isometric-tetartohedral. $n$ = 1·57. From Chile.

**Gerhardtite.** Basic cupric nitrate, $Cu(NO_3)_2.3Cu(OH)_2$. In pyramidal orthorhombic crystals. G. = 3·426. Color emerald-green. $\beta$ = 1·713. From the copper mines at Jerome, Ariz.

**Darapskite.** $NaNO_3.Na_2SO_4.H_2O$. Monoclinic. In square tabular crystals. Colorless. From Atacama, Chile.

**Nitroglauberite.** $6NaNO_3.2Na_2SO_4.3H_2O$. From Atacama, Chile.

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**Lautarite.** Calcium iodate, $Ca(IO_3)_2$. In prismatic, monoclinic crystals, colorless to yellowish. From the sodium nitrate deposits of Atacama, Chile.

**Dietzeite.** A calcium iodo-chromate. Monoclinic; commonly fibrous or columnar. H. = 3–4. G. = 3·70. Color dark gold-yellow. From the same region as lautarite.

## Oxygen Salts

## 5. BORATES

The aluminates, ferrates, etc., allied chemically to the borates, have been already introduced among the oxides. They include the species of the Spinel Group, pp. 418–423, also Chrysoberyl, p. 423, etc.

### SUSSEXITE.

In fibrous seams or veins. H. = 3. G. = 3·42. Luster silky to pearly. Color white with a tinge of pink or yellow. Translucent. Index, 1·59.