

Oxygen Salts.

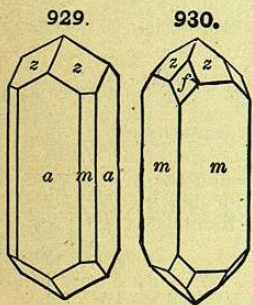
4. PHOSPHATES, ARSENATES, VANADATES, ANTIMONATES.

A. Anhydrous Phosphates, Arsenates, Vanadates, Antimonates.

Normal phosphoric acid is H_3PO_4 , and consequently normal phosphates have the formulas $\overset{I}{R}_3PO_4$, $\overset{II}{R}_2(PO_4)_2$, and $\overset{III}{R}PO_4$, 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 ($\overset{II}{R}F$) or (ROH).

XENOTIME.

Tetragonal. Axis $c = 0.6187$, zz' ($111 \wedge \bar{1}\bar{1}1$) = $55^\circ 30'$, zz'' ($111 \wedge \bar{1}\bar{1}\bar{1}$) = $82^\circ 22'$. In crystals resembling zircon in habit; sometimes compounded with zircon in parallel position (Fig. 314, p. 131). In rolled grains.



Cleavage: m 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 +.

Comp.—Essentially yttrium phosphate, YPO_4 , or $Y_2O_3 \cdot P_2O_5$ = 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 Binnenthal, Switzerland. An accessory constituent in the muscovite-granites of Brazil.

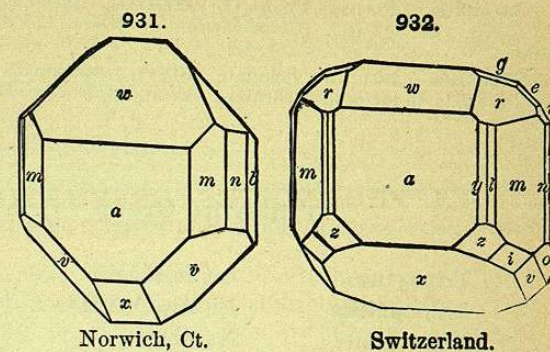
In the United States, in the gold washings of Clarksville, Georgia; in N. Carolina, Burke Co., Henderson Co., Mitchell Co.; in brilliant crystals in Alexander Co. with rutile, etc.; with tysonite near Pike's Peak, Colorado; rare on New York Island.

MONAZITE.

Monoclinic. Axes $a : b : c = 0.9693 : 1 : 0.9256$; $\beta = 76^\circ 20'$.

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

Crystals commonly small, often flattened $\parallel a$ or elongated \parallel axis b ; sometimes prismatic by extension of v (111) (Fig. 324, p. 102); also large and coarse. In masses yielding angular fragments; in rolled grains.



Norwich, Ct.

Switzerland.

Cleavage: c sometimes perfect (parting?); also, a distinct; b difficult; sometimes showing parting $\parallel c, m$. 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. $\perp b$ and nearly $\parallel a$. $Bx_a \wedge c = +1^\circ$ to 4° . Dispersion $\rho < v$ weak; horizontal weak. $2E_r = 29^\circ$ to 31° .

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. Typical analyses: 1, Blomstrand; 2, Penfield.

	G	P ₂ O ₅	Ce ₂ O ₃	La ₂ O ₃	Y ₂ (Er) ₂ O ₃	SiO ₂	ThO ₂	
1. Arendal	5.15	27.55	29.20	26.26	3.82	1.86	9.57	X 2.34 = 100.60
2. Burke Co., N. C.	5.10	29.28	31.38	30.88	—	1.40	6.49	ign 0.20 = 99.63

X = Fe₂O₃ 1.13, CaO 0.69, H₂O 0.52.

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., in granite. In Norway, near Arendal, and at Änneröd. In small yellow or brown crystals (*turnerite*) in Dauphiné and Switzerland. Found also in the gold washings of Antioquia; in the diamond gravels of Brazil.

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

Monazite is named from $\mu\omicron\nu\alpha\zeta\epsilon\iota\nu$, 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.

Berzeliite. $R_3As_2O_8$ ($R = Ca, Mg, Mn$). 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, $R_3Sb_2O_6$. Usually in octahedrons; massive, incrusting. $G. = 6.58$. Color yellowish or brownish green. From the Harstig mine, Pajsberg.

Carminite. Perhaps $Pb_3As_2O_8 \cdot 10FeAsO_4$. In clusters of fine needles; also in spheroidal forms. $G. = 4.105$. Color carmine to tile-red. From the Luise mine at Horhausen, Nassau.

Pucherite. Bismuth vanadate, $BiVO_4$. In small orthorhombic crystals. $H. = 4$. $G. = 6.249$. Color reddish brown. From the Pucher Mine, Schneeberg, Saxony.

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 perfect; b nearly perfect; m 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.

Comp., Var.—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. Named from *λίθιον* and *φίλος*, 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, Fairfield Co., Conn.

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 pearly. Colorless to white or pale yellowish. From Stoneham, Maine.

Apatite Group.

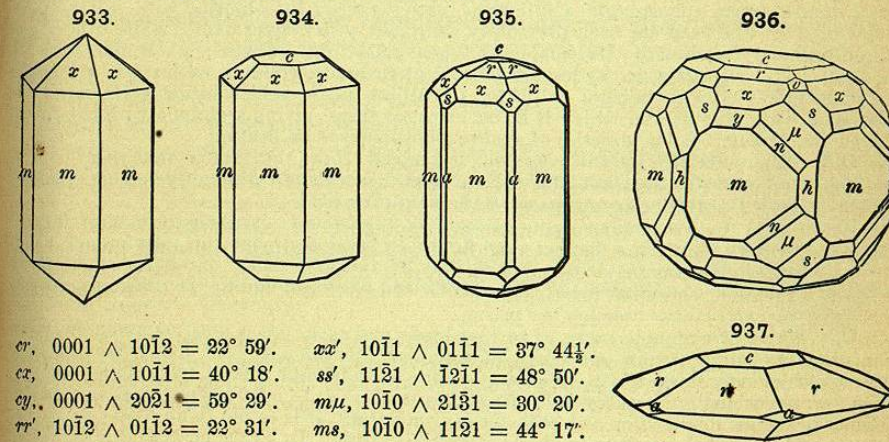
General formula	$R_3(F, Cl)[(P, As, V)O_4]_3 = (R(F, Cl))R_2[(P, As, V)O_4]_3;$		
Apatite	$(CaF)Ca_4(PO_4)_3$	Fluor-apatite	$c = 0.7346$
	or $(CaCl)Ca_4(PO_4)_3$	Chlor-apatite	
Pyromorphite	$(PbCl)Pb_4(PO_4)_3$		0.7362
Mimetite	$(PbCl)Pb_4(AsO_4)_3$		0.7224
Vanadinite	$(PbCl)Pb_4(VO_4)_3$		0.7122

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 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 group (p. 71). 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 $R_3(PO_4)_3$, so that the general formula is $(RF)R_2(PO_4)_3$, and similarly for the arsenates. This is a more correct way of viewing the composition than the other method sometimes adopted, viz., $3R_3(PO_4)_2 \cdot RF_2$, etc.

APATITE.

Hexagonal-pyramidal. Axis $c = 0.7346$.



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 imperfect; m more so. Fracture conchoidal and uneven. Brittle. $H. = 5$, sometimes 4.5 when massive. $G. = 3.17-3.23$ cryst. 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. $\omega_y = 1.6461$, $\epsilon_y = 1.6417$.

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. *Movoxite*, from Arendal, 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, 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. *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 in botryoidal, reniform, or stalactitic masses, fibrous and radiating. See p. 499.

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

Comp.—For *Fluor-apatite* $(\text{CaF})\text{Ca}_4(\text{PO}_4)_3$; and for *Chlor-apatite* $(\text{CaCl})\text{Ca}_4(\text{PO}_4)_3$; also written $3\text{Ca}_3\text{P}_2\text{O}_8 + \text{CaF}_2$ and $3\text{Ca}_3\text{P}_2\text{O}_8 + \text{CaCl}_2$. There are also intermediate compounds containing both fluorine and chlorine. The percentage composition for these normal varieties is as follows:

Fluor-apatite P₂O₅ 42.3 CaO 55.5 F 3.8 = 101.6 or Ca₃P₂O₈ 92.25 CaF₂ 7.75 = 100
Chlor-apatite P₂O₅ 41.0 CaO 53.8 Cl 6.8 = 101.6 or Ca₃P₂O₈ 89.4 CaCl₂ 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); some varieties react for chlorine with salt of phosphorus, when the bead has been previously saturated with copper oxide, while others give fluorine when fused with this salt in an open glass tube. Gives a phosphide with the sodium test. Dissolves in hydrochloric and nitric acids, yielding with sulphuric acid a copious precipitate of calcium sulphate; the dilute nitric acid solution gives with lead acetate a white precipitate, which B.B. on charcoal fuses, giving a globule with crystalline facets on cooling. Some varieties of apatite phosphoresce on heating.

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.

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.

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, svenite, hornblende gneiss, mica schist, beds of iron ore; occasionally in serpentine. In the form of minute microscopic crystals it has an almost universal distribution as a 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 Untersulzbachthal in the Tyrol; St. Gothard, Tavetsch, etc., in Switzerland; Mussa-Alp in Piedmont, white or colorless; Zinnwald and Schlackenwald in Bohemia; 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 quanti-

ties of apatite are mined in Norway at Kragerø; also at Ödegaard, near Bamle, and elsewhere.

In *Maine*, on Long Island, Blue-hill Bay. In *N. Hamp.*, Westmoreland. In *Mass.*, at Norwich; at Bolton abundant. In *Conn.*, at Branchville (*manganapatite*), also greenish white and colorless. In *New York*, common in St. Lawrence Co., in granular limestone; also Jefferson Co.; Sandford mine, East Moriah, Essex Co., in magnetite; near Edenville, Orange Co. In *Penn.*, at Leiperville, Delaware Co.; in Chester Co. In *N. Carolina*, at Stony Point, Alexander Co., etc.

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, fluor, schorl, etc.

Besides the definite *mineral phosphates*, including normal apatite, phosphorite, etc., there are also extensive deposits of amorphous phosphates, consisting largely of "bone phosphate" (Ca₃P₂O₈), 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 and Florida. 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.

STAFFELITE. A carbonated calcium phosphate. Occurs incrusting the phosphorite of Staffel, 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. *Dahlite*, from Bamle, Norway, is similar.

PYROMORPHITE. Green Lead Ore. Grünbleierz *Germ.*

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 verruciform, with usually a subcolumnar structure; also fibrous, and granular.

Cleavage: *m*, x (1011) 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 —.

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. *Polyspharite.* 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, verruciform. *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.— $(\text{PbCl})\text{Pb}_4(\text{PO}_4)_3$ or also written $3\text{Pb}_3\text{P}_2\text{O}_8 \cdot \text{PbCl}_2 =$ Phosphorus pentoxide 15.7, lead protoxide 82.2, chlorine 2.6 = 100.5, or Lead phosphate 89.7, lead chloride 10.3 = 100.

938.



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 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. With salt of phosphorus, previously saturated with copper oxide, gives an azure-blue color to the flame when treated in O.F. (chlorine). 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; at Zschopau and other places in Saxony; at Příbram, Bleistadt, in Bohemia; in fine crystals at Ems, Braubach, in Nassau; also at Dermbach in Nassau; Berezov in Siberia; in the Nerchinsk mining district; Cornwall, green and brown; Devon, gray; Derbyshire, green and yellow; Cumberland, golden yellow, in England; Leadhills, red and orange, in Scotland.

In the U. S., has been found very fine at Phenixville, Pa.; also in Maine, at Lubec and Lenox; in New York, a mile south of Sing Sing; in Davidson Co., N. C., also in Cabarrus and Caldwell Cos.

Named from $\pi\delta\rho$, *fire*, $\mu\omicron\rho\phi\acute{\eta}$, *form*, alluding to the crystalline form the globule assumes on cooling. This species passes into mimetite.

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.

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 asbestos, and straw-yellow in color. (c) *Concretionary.*

Campylite, from Drygill in Cumberland, has $G. = 7.218$, and is in barrel-shaped crystals (whence the name, from $\kappa\alpha\mu\pi\acute{\upsilon}\lambda\omicron\varsigma$, *curved*), yellowish to brown and brownish red; contains 3 p. c. P_2O_5 .

Comp.— $(PbCl)Pb_4(AsO_4)_3$, also written $3Pb_3As_2O_{11}.PbCl_2 =$ 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. 501) 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. Gives the chlorine reaction as under pyromorphite. Soluble in nitric acid.

Obs.—Occurs near Redruth and elsewhere in Cornwall; Beer Alston, Devonshire; in Cumberland; near Pontgibaud, Puy-de-Dôme; at Johanngeorgenstadt, in fine yellow crystals; at Nerchinsk, Siberia; at Zinnwald; Långban, Sweden; at the Brookdale mine, Phenixville, Pa.

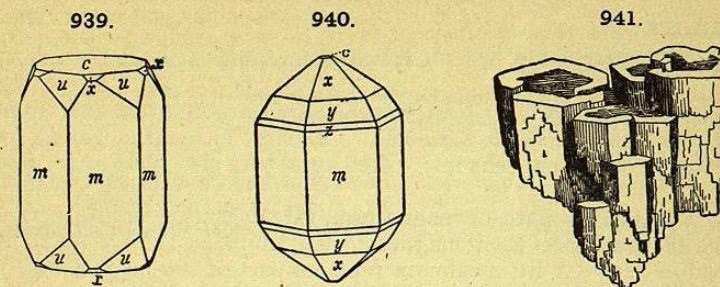
Named from $\mu\iota\mu\eta\tau\acute{\iota}\varsigma$, *imitator*, it closely resembling pyromorphite.

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.

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.

Comp.— $(PbCl)Pb_4(VO_4)_3$, also written $3Pb_3V_2O_{11}.PbCl_2 =$ 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. Gives the chlorine reaction with the copper test. Decomposed by hydrochloric acid.

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

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

HEDYPHANE. From Långban, Sweden; has ordinarily been included as a calcium variety of mimetite, but is now made monoclinic. Massive, cleavable. Color yellowish white.

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, Sweden.

Wagnerite Group. Monoclinic.

		$a : b : c$	β
Wagnerite	$(MgF)MgPO_4$	1.9145 : 1 : 1.5059;	$71^\circ 53'$
Triplite	$(RF)RPO_4$, $R = Fe : Mn = 2 : 1, 1 : 1$, etc.		
Tripliodite	$(ROH)RPO_4$, $R = Mn : Fe = 3 : 1$	1.8572 : 1 : 1.4925;	$71^\circ 46'$
Adelite	$(MgOH)CaAsO_4$	2.1978 : 1 : 1.5642;	$73^\circ 15'$
Tilasite	$(MgF)CaAsO_4$		
Sarkinite	$(MnOH)MnAsO_4$	2.0017 : 1 : 1.5154;	$62^\circ 13\frac{1}{2}'$

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 p. 501. Crystals sometimes large and coarse. Also massive.

Cleavage: *a*, *m* imperfect; *c* 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.

Comp.—A fluo-phosphate of magnesium, $(MgF)MgPO_4$ or $Mg_3P_2O_8 \cdot MgF_2$ = 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. Fused with salt of phosphorus in an open glass tube 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. *Kjærulfine* (massive, cleavable; also in coarse crystals) is from Kjörrestad, near Bamle, Norway.

Spodiosite. A calcium fluo-phosphate, perhaps $(CaF)CaPO_4$. In flattened prismatic crystals. *G.* = 2.94. Color ash-gray. From the Krangrufva, Wermland, 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.

Comp., Var.— $(RF)RPO_4$ or $R_3P_2O_8 \cdot RF_2$ 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; 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, Maine; Branchville, Conn. *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. Dakota.

Triplidite. Like triplite, but with the F replaced by (OH). Commonly in crystalline aggregates. Fibrous to columnar. *H.* = 4.5-5. *G.* = 3.697. Color yellowish to reddish brown. From Branchville, Fairfield Co., Conn.

Adelite. $(MgOH)CaAsO_4$. Monoclinic. Axes, see p. 501; also massive. *H.* = 5. *G.* = 3.74. Color gray or grayish yellow. From Nordmark and Långban, Sweden.

Tilasite. Like adelite, but contains fluorine. From Långban.

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* from the Sjö mine, Grythyttte parish, Örebro, Sweden, is essentially the same.

Herderite. A fluo-phosphate of beryllium and calcium, $(CaF)BePO_4$ with $(CaOH)BePO_4$. In prismatic crystals, monoclinic with complex twinning. *H.* = 5. *G.* = 2.99-3.01. Luster vitreous. Color yellowish and greenish white. From the tin mines of Ehrenfriedersdorf, Saxony; also at Stoneham, Auburn and Hebron, Maine.

Hamlinite. A basic phosphate of aluminium and strontium. In colorless rhombohedral crystals. *H.* = 4.5. *G.* = 3.16-3.28. Occurs with herderite, bertrandite, etc., at Stoneham, Maine.

Durangite. A fluo-arsenate of sodium and aluminium, $Na(AlF)AsO_4$. In monoclinic crystals. *G.* = 3.94-4.07. Color orange-red. From Durango, Mexico.

AMBLYGONITE. Hebronite.

Triclinic. Crystals large and coarse (Fig. 20, p. 10); forms rarely distinct. Usually cleavable to columnar and compact massive. Polysynthetic twinning lamellæ common.

Cleavage: *c* perfect, with pearly luster; *a* somewhat less so, vitreous; *e* (021) sometimes equally distinct; *M* (110) difficult; *ca* = 75° 30', *ce* = 74° 40', *cM* = 92° 20'. Fracture uneven to subconchoidal. Brittle. *H.* = 6. *G.* = 3.01-3.09. Luster vitreous to greasy, on *c* pearly. Color white to pale greenish, bluish, yellowish, grayish or brownish white. Streak white. Sub-transparent to translucent.

Comp.—A fluo-phosphate of aluminium and lithium, $Li(AlF)PO_4$ or $AlPO_4 \cdot LiF$ = 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; Montebraz, Creuze, France. In the U. States, in Maine, at Hebron; also at Paris, Peru, etc.; Branchville, Conn.

The name *amblygonite* is from $\alpha\mu\beta\lambda\acute{\iota}\varsigma$, *blunt*, and $\gamma\acute{o}\nu\upsilon$, *angle*.

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. 507.

Olivinite Group. Orthorhombic.

		$\alpha : \beta : \epsilon$
Olivinite	$Cu_2(OH)AsO_4$	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	$(Pb,Zn)_2(OH)VO_4$	
	$\alpha : \beta : \epsilon = 0.6368 : 1 : 0.8045$ or $\frac{2}{3}\alpha : \beta : \epsilon = 0.9552 : 1 : 0.8045$	
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 $(ROH)RPO_4$, $(ROH)RASO_4$,