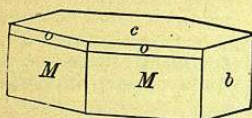


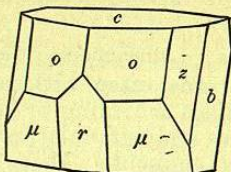
zone $\perp c$. Often in disseminated scales, sometimes in massive aggregations of cleavable scales.

$$\begin{array}{ll} co, & 001 \wedge 112 = 73^\circ 1'. \\ cM, & 001 \wedge 221 = 85^\circ 38'. \\ c\mu, & 001 \wedge \bar{1}11 = 81^\circ 19'. \end{array} \quad \begin{array}{ll} cr, & 001 \wedge \bar{1}01 = 80^\circ 0'. \\ cz, & 001 \wedge 132 = 80^\circ 0'. \\ MM', & 221 \wedge \bar{2}21 = 59^\circ 48\frac{1}{2}'. \end{array}$$

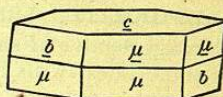
904.



905.



906.



Cleavage: basal, highly perfect; planes of separation shown in the percussion-figure; also gliding-planes ρ (205), ζ (135) shown in the pressure-figure inclined about 66° to c and yielding pseudo-crystalline forms (Fig. 475, p. 148). $H. = 2.5-3$. $G. = 2.7-3.1$. Luster splendid, and more or less pearly on a cleavage surface, and sometimes submetallic when black; lateral surfaces vitreous when smooth and shining. Colors usually green to black, often deep black in thick crystals, and sometimes even in thin laminae, unless the laminae are very thin; such thin laminae green, blood-red, or brown by transmitted light; also pale yellow to dark brown; rarely white. Streak uncolored. Transparent to opaque.

Pleochroism strong; absorption $b = c$ nearly, for a much stronger. Hence sections $\parallel c$ (001) dark green or brown to opaque; those $\perp c$ lighter and deep brown or green for vibrations $\parallel c$, pale yellow, green or red for vibrations $\perp c$. Pleochroic halos often noted, particularly about microscopic inclusions. Optically —. Ax. pl. usually $\parallel b$, rarely $\perp b$. $Bx_a (= a)$ nearly coincident with the normal to c , but inclined about half a degree, sometimes to the front, sometimes the reverse. Axial angle usually very small, and often sensibly uniaxial; also up to 50° . Birefringence high, $\gamma - \alpha = 0.04$ to 0.06 .

Comp., Var.—In most cases an orthosilicate, chiefly ranging between $(H,K)_2(Mg,Fe)_4(Al,Fe)_2(SiO_4)_4$ and $(H,K)_2(Mg,Fe)_3Al_2(SiO_4)_3$. Of these the second formula may be said to represent typical biotite. The amount of iron varies widely.

Biotite is divided into two classes by Tschermak:

I. MEROXENE. Axial plane $\parallel b$. II. ANOMITE. Ax. pl. $\perp b$. Of these two kinds, meroxene includes nearly all ordinary biotite, while anomite is, so far as yet observed, of restricted occurrence, the typical localities being Greenwood Furnace, Orange Co., N. Y., and L. Baikal in E. Siberia. *Meraxene* is a name early given to the Vesuvian biotite. Anomite is from *anomos*, contrary to law.

Haughtonite and *Siderophyllite* are kinds of biotite containing much iron.

Manganophyllite is a manganesian biotite. Occurs in aggregations of thin scales. Color bronze- to copper-red. Streak pale red. From Pajsberg and Långban, Sweden; Piedmont, Italy.

The following are typical analyses of biotite: 1, by Berwerth; 2, by Rammelsberg; 3, by Smith and Brush.

	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	FeO	MgO	CaO	K ₂ O	Na ₂ O	H ₂ O	F
1. Vesuvius	39.30	16.95	0.48	8.45	21.89	0.82	7.79	0.49	4.02	0.89
									[= 101.08	
2. Miask, black	32.49	12.34	6.56	25.13	5.29	—	9.59	0.88	2.42	1.61
									[TiO ₂ 4.03 = 100.34	
3. Anomite, Greenwood F.	39.88	14.99	7.68	—	23.69	—	9.11	1.12	1.30	0.95
									[Cl 0.44 = 99.16	

Pyr., etc.—In the closed tube gives a little water. fluorine in the open tube; some kinds give little or no reaction for iron with the fluxes, while others give strong reactions for iron. B.B. whitens and fuses on the thin edges. Completely decomposed by sulphuric acid, leaving the silica in thin scales.

Diff.—Distinguished by its dark green to brown and black color and micaceous structure, usually nearly uniaxial.

Recognized in thin sections by its brown (or green) color; strong pleochroism and strong absorption parallel to the elongation (unlike tourmaline). Sections $\parallel c$ are non-pleochroic, commonly exhibit more or less distinct hexagonal outlines and yield a negative sensibly uniaxial figure. Sections $\perp c$ are strongly pleochroic and are marked by fine parallel cleavage lines (Fig. 907); they also have nearly parallel extinction, and show high polarization colors; by reflected light they exhibit a peculiar mottled or watered sheen which is very characteristic and aids in distinguishing them from brown hornblende.

Obs.—Biotite is an important constituent of many different kinds of igneous rocks, especially those formed from magmas containing considerable potash and magnesia. Common in certain varieties of granites, syenite, diorite, etc., of the massive granular type; also in rhyolite, trachyte, and andesite among the lavas; in minettes, kersantites, etc. It occurs also as the product of metamorphic action in a variety of rocks. It is not infrequently associated in parallel position with muscovite, the latter, for example, forming the outer portions of plates having a nucleus of biotite.

Some of the prominent localities of crystallized biotite are as follows: Vesuvius, common particularly in ejected limestone masses on Monte Somma, with augite, chrysoilite, nephelite, humite, etc. The crystals are sometimes nearly colorless or yellow and then usually complex in form; also dark green to black; Mt. Monzoni in the Fassathal; Schwarzenstein, Zillerthal; Rezbánya and Morawitz in Hungary; Schelingen and other points in the Kaiserstuhl; the Laacher See; on the west side of L. Ilmen near Miask, etc.

In the United States ordinary biotite is common in granite, gneiss, etc.; but notable localities of distinct crystals are not numerous. It occurs with muscovite (wh. see) as a more or less prominent constituent of the pegmatite veins in the New England States; also Pennsylvania, Virginia, North Carolina. *Siderophyllite* is from the Pike's Peak region.

CASWELLITE. An altered biotite from Franklin Furnace, N. J.

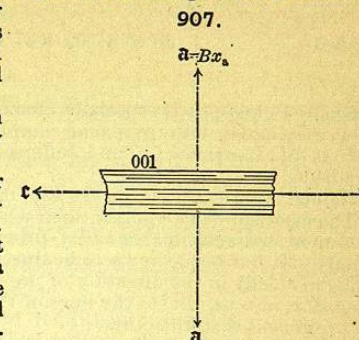
PHLOGOPITE.

Monoclinic. In form and angles near biotite. Crystals prismatic, tapering; often large and coarse; in scales and plates.

Cleavage: basal, highly eminent. Thin laminae tough and elastic. $H. = 2.5-3$. $G. = 2.78-2.85$. Luster pearly, often submetallic on cleavage surface. Color yellowish brown to brownish red, with often something of a copper-like reflection; also pale brownish yellow, green, white, colorless. Often exhibits asterism in transmitted light, due to regularly arranged inclusions. Pleochroism distinct in colored varieties: c brownish red, b brownish green, a yellow. Absorption $c > b > a$, Burgess. Optically —. Ax. pl. $\parallel b$. Bx_a nearly $\perp c$. Axial angle ($2E$) small but variable even in the same specimen, from 0° to $17^\circ 25'$ for red. Dispersion $\rho < v$. The axial angle appears to increase with the amount of iron.

A magnesium mica, near biotite, but containing little iron; potassium is prominent as in all the micas, and in most cases fluorine. Typical phlogopite, according to Clarke, is $\bar{R}_2Mg_3Al(SiO_4)_3$, where $\bar{R} = H, K, Mg, F$. Analyses: 1 by Penfield; 2 by Clarke and Schneider.

Some varieties give the reaction for

Section $\perp c$.

	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	FeO	MgO	BaO	K ₂ O	Na ₂ O	H ₂ O	F	ign (100°)
Edwards	2.792	44.81	10.87	—	0.31	28.90	—	8.40	0.46 ^a	5.42	—
Burgess	39.66	17.00	0.27	0.20	26.49	0.62	9.97	0.60	2.99	2.24	Ti ₂ O 0.56

^a With 0.08 Li₂O.

Obs.—Phlogopite is especially characteristic of crystalline limestone or dolomite. It is often associated with pyroxene, amphibole, serpentine, etc. Thus as at Pargas, Finland; in St. Lawrence Co. and Jefferson Co., N. Y.; also Burgess, Ontario, and elsewhere in Canada.

Named from *φλογώπος*, *fire-like*, in allusion to the color.

The asterism of phlogopite, seen when a candle-flame is viewed through a thin sheet, is a common character, particularly prominent in the kinds from northern New York and Canada. It has been shown to be due to minute acicular inclusions, rutile or tourmaline, arranged chiefly in the direction of the rays of the pressure-figure, producing a distinct six-rayed star; also parallel to the lines of the percussion-figure, giving a secondary star, usually less prominent than the other.

Lepidomelane. Near biotite, but characterized by the large amount of ferric iron present. *Annite* from Cape Ann, Mass., belongs here. In small six-sided tables, or an aggregate of minute scales. H. = 3. G. = 3.0-3.2. Color black, with occasionally a leek-green reflection.

Alurgite. A manganese mica from St. Marcel, Piedmont.

Roscoelite. A vanadium mica; formula doubtful. In minute scales; structure mica ceous. G. = 2.92-2.94. Color clove-brown to greenish brown. Occurs at the gold mine at Granite Creek, El Dorado Co., California.

2. Clintonite Group. Monoclinic.

The minerals here included are sometimes called the Brittle Micæ. They are near the micæ in cleavage, crystalline form and optical properties, but are marked physically by the brittleness of the laminae, and chemically by their basic character.

In several respects they form a transition from the micæ proper to the chlorites. Margarite, or calcium mica, is a basic silicate of aluminium and calcium, while Chloritoid is a basic silicate of aluminium and ferrous iron (with magnesium), like the chlorites.

MARGARITE. Kalkglimmer *Germ.*

Monoclinic. Rarely in distinct crystals. Usually in intersecting or aggregated laminae; sometimes massive, with a scaly structure.

Cleavage: basal, perfect. Laminae rather brittle. H. = 3.5-4.5. G. = 2.99-3.08. Luster of base pearly, of lateral faces vitreous. Color grayish, reddish white, pink, yellowish. Translucent, subtranslucent.

Optically —. Ax. pl. \perp b. Bx_a approximately \perp c, but varying more widely than the ordinary micæ. $a c = + 6\frac{1}{2}^\circ$. Dispersion $\rho < v$. Axial angle large, from 100° to 120° in air. Refractive index $\beta = 1.64-1.65$.

Comp. — H₂CaAl₂Si₂O₁₂ = Silica 30.2, alumina 51.3, lime 14.0, water 4.5 = 100.

Pyr., etc.—Yields water in the closed tube. B.B. whitens and fuses on the edges. Slowly and imperfectly decomposed by boiling hydrochloric acid.

Obs.—Associated commonly with corundum, and in many cases obviously formed directly from it; thus at the emery deposits of Gumuch-dagh in Asia Minor, the islands Naxos, Nicaria, etc. Occurs in chlorite of Mt. Greiner, Sterzing, Tyrol. In the U. S., at the emery mine at Chester, Mass.; at Unionville, Chester Co., Pa.; with corundum in

Madison Co. and elsewhere in North Carolina; at Gainesville, Hall Co., Georgia; at Dudleyville, Alabama.

Named *Margarite* from *μαργαρίτης*, *pearl*.

SEYBERTITE. Clintonite. Brandisite.

Monoclinic, near biotite in form. Also foliated massive; sometimes lamellar radiate.

Cleavage: basal, perfect. Structure foliated, micaceous. Laminae brittle. Percussion- and pressure-figures, as with mica. H. = 4-5. G. = 3-3.1. Luster pearly submetallic. Color reddish brown, yellowish, copper-red. Streak uncolored, or slightly yellowish or grayish. Pleochroism rather feeble. Optically —. Ax. pl. \perp b *seybertite*; \parallel b *brandisite*. Bx_a nearly \perp c. Axial angles variable, but not large. Birefringence high.

Var.—1. The Amity *seybertite* (*clintonite*) is in reddish-brown to copper-red brittle foliated masses; the surfaces of the folia often marked with equilateral triangles like some mica and chlorite. Axial angle 3°-13°.

2. *Brandisite* (*disterrite*), from the Fassathal, Tyrol, is in hexagonal prisms of a yellowish-green or leek-green color to reddish gray; H. = 5 of base; of sides, 6-6.5. Ax. plane \parallel b. Axial angle 15°-30°. Some of it pseudomorphous, after fassaite.

Comp.—In part H₂(Mg,Ca)₂Al₂Si₂O₁₂ = 3H₂O.10(Mg,Ca)O.5Al₂O₃.4SiO₂.

Pyr., etc.—Yields water. B.B. infusible alone, but whitens. In powder acted on by concentrated acids.

Obs.—*Seybertite* occurs at Amity, N. Y., in limestone with serpentine, associated with amphibole, spinel, pyroxene, graphite, etc.; also a chlorite near leuchtenbergite. *Brandisite* occurs on Mt. Monzoni in the Fassathal, Tyrol, in white limestone, with fassaite and black spinel.

Xanthophyllite. Perhaps H₂(Mg,Ca)₂Al₂Si₂O₁₂. The original *xanthophyllite* is in crusts or in implanted globular forms. Optically negative. Ax. angle usually very small, or sensibly uniaxial; sometimes 20°. From near Zlatoust in the Ural.

Walzevite is the same species occurring in distinct pseudo-rhombohedral crystals. Folia brittle. H. = 4.6. G. = 3.093. Luster vitreous; on cleavage plane pearly. Color leek- to bottle-green. Transparent to translucent. Pleochroism rather feeble: \parallel c fine green; \perp c reddish brown. Optically —. Ax. pl. \parallel b. Bx sensibly \perp c. 2E = 20°-40°. Axial angle 17° to 32°. Found with perovskite and other species in chloritic schists near Achmatovsk, in the southern Ural.

CHLORITOID. Chloritspath. Ottrelite. Phyllite.

Probably triclinic. Rarely in distinct tabular crystals, usually hexagonal in outline, often twinned with the individuals turned in azimuth 120° to each other. Crystals grouped in rosettes. Usually coarsely foliated massive; folia often curved or bent; and brittle; also in thin scales or small plates disseminated through the containing rock.

Cleavage: basal, but less perfect than with the micæ; also imperfect parallel to planes inclined to the base nearly 90° and to each other about 60°; b difficult. Laminae brittle. H. = 6.5. G. = 3.52-3.57. Color dark gray, greenish gray, greenish black, grayish black, often grass-green in very thin plates. Streak uncolored, or grayish, or very slightly greenish. Luster of surface of cleavage somewhat pearly.

Pleochroism strong: c yellow-green, b indigo-blue, a olive-green. Optically +. Ax. pl. nearly \parallel b. Bx_a inclined about 12° or more to the normal to c (001). Dispersion $\rho > v$, large, also horizontal. Axial angles large, in air 100° to 118°. Birefringence low, $\gamma - \alpha = 0.015$.

Comp.—For chloritoid H₂(Fe,Mg)Al₂SiO₇. If iron alone is present, this requires: Silica 23.8, alumina 40.5, iron protoxide 28.5, water 7.2 = 100.

Diff.—Recognized by the crystal outlines and general micaceous appearance; high relief; green colors; distinct cleavage; frequent twinning; strong pleochroism and low interference-colors. By the last character readily distinguished from the micas; also by the high relief and extinction oblique to the cleavage from the chlorites.

Obs.—Chloritoid (ottrelite, etc.) are characteristic of sedimentary rocks which have suffered dynamic metamorphism, especially in the earlier stages; thus found in argillites, conglomerates, etc., which have assumed the schistose condition. With more advanced degree of metamorphism it disappears. Often grouped in fan-shaped, sheaf-like forms, also in irregular or rounded grains.

The original *chloritoid* from Kosoibrod, near Ekaterinburg in the Ural, is in large curving laminae or plates, grayish to blackish green in color, often spotted with yellow from mixture with limonite. Other localities are Ile le Groix (Morbihan); embedded in large crystals at Vanlup, Shetland; Ardennes in schists with ottrelite; also from Upper Michigan; Leeds, Canada, etc.

Sismondine ($H_2FeAl_2Si_2O_8$) is from St. Marcel; it occurs also with glaucophane at Zermatt in the Valais, Switzerland, and elsewhere.

Salmite is a manganese variety occurring in irregular masses, having a coarse saccharoidal structure and grayish color. $G. = 3.38$. From Vielsalm, Belgium.

Masonite, from Natic, R. I., is in very broad plates of a dark grayish-green color, but bluish green in very thin laminae parallel to c , and grayish green at right angles to this; occurs in argillaceous schist.

Ottrelite is generally classed with chloritoid, though it is not certain that they are identical; it seems to have the composition $H_2(Fe,Mn)Al_2Si_2O_8$. It occurs in small, oblong, shining scales or plates, more or less hexagonal in form and gray to black in color; in argillaceous schist near Ottrez, on the borders of Luxembourg, and from the Ardennes; also near Serravezza, Tuscany; Tintagel in Cornwall. *Venasquite* is from Venasque in the Pyrenees, and from Teulé, Finistère. *Phyllite* is from the schists of New England.

3. Chlorite Group. Monoclinic.

The CHLORITE GROUP takes its name from the fact that a large part of the minerals included in it are characterized by the *green* color common with silicates in which ferrous iron is prominent. The species are in many respects closely related to the micas. They crystallize in the monoclinic system, but in part with distinct monoclinic symmetry, in part with rhombohedral symmetry, with corresponding uniaxial optical character. The plane angles of the base are also 60° or 120° , marking the mutual inclinations of the chief zones of forms. The mica-like basal cleavage is prominent in distinctly crystallized forms, but the laminae are tough and comparatively inelastic. Percussion- and pressure-figures may be obtained as with the micas and have the same orientation. The etching-figures are in general monoclinic in symmetry, in part also asymmetric, suggesting a reference to the triclinic system.

Chemically considered the chlorites are silicates of aluminium with ferrous iron and magnesium and chemically combined water. Ferric iron may be present replacing the aluminium in small amount; chromium enters similarly in some forms, which are then usually of a pink instead of the more common green color. Manganese replaces the ferrous iron in a few cases. Calcium and alkalis—characteristic of all the true micas—are conspicuously absent, or present only in small amount.

The only distinctly crystallized species of the Chlorite Group are Clinocllore and Penninite. These seem to have the same composition, but while the former is monoclinic in form and habit, the latter is pseudo-rhombohedral and usually uniaxial. Prochlorite (including some ripidolite) and Corundophilite also occur in distinct cleavage masses.

Besides the species named there are other kinds less distinct in form, occurring in scales, also fibrous to massive or earthy; they are often of more or less undetermined composition, but in many cases, because of their extensive occur-

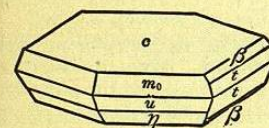
rence, of considerable geological importance. These latter forms occur as secondary minerals resulting from the alteration especially of ferro-magnesian silicates, such as biotite, pyroxene, amphibole; also garnet, vesuvianite, etc. They are often accompanied by other secondary minerals, as serpentine, limonite, calcite, etc., especially in the altered forms of basic rocks.

The rock-making chlorites are recognized in thin sections by their characteristic appearance in thin leaves, scales or fibers, sometimes aggregated into spherulites; by their greenish color; pleochroism; extinction parallel to the cleavage (unlike chloritoid and ottrelite); low relief and extremely low interference-colors, which frequently exhibit the "ultra-blue." By this latter character they are readily distinguished from the micas, which they strongly resemble and with which they are frequently associated.

CLINOCHLORE. Ripidolite *pt.*

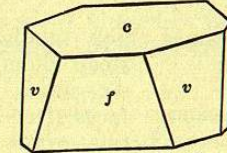
Monoclinic. Axes: $a : b : c = 0.57735 : 1 : 2.2772$; $\beta = 89^\circ 40'$.

908.



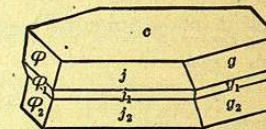
Pfitsch.

909.



Schwarzenstein.

910.



Zillerthal.

Crystals usually hexagonal in form, often tabular $\parallel c$. Plane angles of the basal section = 60° or 120° , and since closely similar angles are found in the zones which are separated by 60° , the symmetry approximates to that of the rhombohedral system.

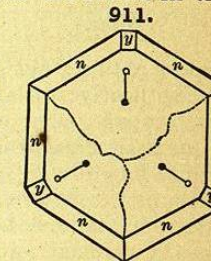
Twins: (1) *Mica law*, tw. pl. $\perp c$ in the zone cm_0 ; sometimes contact-twins with c as comp.-face, the one part revolved 60° or a multiple of 60° in azimuth with reference to the other; also in threefold twins. (2) *Penninite law*, tw. pl. c , contact-twins also united by c (Fig. 910); here corresponding faces differ 180° in position. Massive, coarse scaly granular to fine granular and earthy.

Cleavage: c highly perfect. Laminae flexible tough, and but slightly elastic. Percussion-figure and pressure-figures orientated as with the micas (p. 464). $H. = 2-2.5$. $G. = 2.65-2.78$. Luster of cleavage-face some what pearly. Color deep grass-green to olive-green; pale green to yellowish and white; also rose-red. Streak greenish white to uncolored. Transparent to translucent. Pleochroism not strong, for green varieties usually a green, c yellow. Optically usually +. Ax. pl. in most cases $\parallel b$. Bx_2 inclined somewhat to the normal to c , forward; for Achmatovsk $2^\circ 30'$. Dispersion $\rho < v$. Axial angles variable, even in the same crystal, $2E = 20^\circ-90^\circ$; sometimes sensibly uniaxial. Birefringence low. $\beta = 1.588$; $\gamma - \alpha = 0.011$.

Var.—1. *Ordinary*; green clinocllore, passing into bluish green; (a) in crystals, as described, usually with distinct monoclinic symmetry; (b) foliated; (c) massive.

Leuchtenbergite. Contains usually little or no iron. Color white, pale green, yellowish; often resembles talc. From near Zlatoust in the Ural.

Kotschubeite. Contains several per cent of chromium oxide. Crystals rhombohedral in habit. Color rose-red. From the southern Ural.



Achmatovsk.

Manganiferous. Manganchlorite. A chlorite from the Harstig mine near Pajsberg, Sweden, is peculiar in containing 2.3 p. c. MnO.

Comp.—Normally $H_2Mg_2Al_2Si_2O_{10} = 4H_2O.5MgO.Al_2O_3.3SiO_2 =$ Silica 32.5, alumina 18.4, magnesia 36.1, water 13.0 = 100. Ferrous iron usually replaces a small part of the magnesia, and the same is true of manganese rarely; sometimes chromium replaces the aluminium.

Pyr., etc.—Yields water. B.B. in the platinum forceps whitens and fuses with difficulty on the edges to a grayish-black glass. With borax, a clear glass colored by iron, and sometimes chromium. In sulphuric acid wholly decomposed.

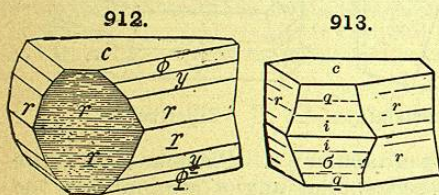
Obs.—Occurs in connection with chloritic and talcose rocks or schists and serpentine; sometimes in parallel position with biotite or phlogopite. Prominent localities are: Achmatovsk in the Ural; Ala in Piedmont; the Zillertal; Zermatt, Switzerland; Marienberg, Saxony; Zöptau, Moravia. A manganese variety occurs at Pajsberg, Sweden.

In the U. States, at Westchester, Penn., in large crystals and plates; also Unionville and Texas, Penn.; at the magnetic iron mine at Brewster, N. Y., in part changed to serpentine.

PENNINITE. Pennine.

Apparently rhombohedral in form but strictly pseudo-rhombohedral and monoclinic.

Habit rhombohedral: sometimes thick tabular with *c* prominent, again steep rhombohedral; also in tapering six-sided pyramids. Rhombohedral faces often horizontally striated. Crystals often in crested groups. Also massive, consisting of an aggregation of scales; also compact cryptocrystalline.



912. Texas.

913. Zermatt.

easy to obtain; not elastic. $H. = 2-2.5$. $G. = 2.6-2.85$. Luster of cleavage-surface pearly; of lateral plates vitreous, and sometimes brilliant. Color emerald- to olive-green; also violet, pink, rose-red, grayish red; occasionally yellowish and silver-white. Transparent to subtranslucent. Pleochroism distinct: usually $\parallel c$ green; $\perp c$ yellow. Optically +, also -, and sometimes both in adjacent laminae of the same crystal. Usually sensibly uniaxial, but sometimes distinctly biaxial (occasionally $2E = 61^\circ$) and both in the same section. Sometimes a uniaxial nucleus while the border is biaxial with $2E = 36^\circ$, the latter probably to be referred to clinocllore. Indices 1.576 and 1.579 Lévy-Lex.

Var.—1. *Penninite*, as first named, included a green crystallized chlorite from the Pennine Alps.

Kämmererite. In hexagonal forms bounded by steep six-sided pyramids. Color kermes-red; peach-blossom-red. Pleochroism distinct. Optically - from L. Itkul, Bisersk, Perm, Russia; + Texas, Pa. Uniaxial or biaxial with axial angle up to 20° . Rhodophyllite from Texas, Pa., and rhodochrome from L. Itkul belong here.

Pseudophite is compact massive, without cleavage, and resembles serpentine.

Comp.—Essentially the same as clinocllore, $H_2(Mg,Fe)_2Al_2Si_2O_{10}$.

Pyr., etc.—In the closed tube yields water. B.B. exfoliates somewhat and is difficultly fusible. With the fluxes all varieties give reactions for iron, and many varieties react for chromium. Partially decomposed by hydrochloric and completely by sulphuric acid.

Obs.—Occurs with serpentine in the region of Zermatt, Valais, near Mt. Rosa, especially in the moraines of the Findelen glacier; crystals from Zermatt are sometimes 2 in. long and $1\frac{1}{2}$ in. thick; also at the foot of the Simplon; at Ala, Piedmont, with clinocllore; at Schwarzenstein in Tyrol; at Taberg in Wermland; at Snarum, greenish and foliated.

Kämmererite is found at the localities already mentioned; also near Miask in the Ural;

at Haroldswick in Unst, Shetland Isles. In large crystals enclosed in the talc in crevices of the chromite from Kraubat, Styria. Abundant at Texas, Lancaster Co., Pa., along with clinocllore, some crystals being embedded in clinocllore, or the reverse. Also in N. Carolina, with chromite at Culsagee, Macon Co.; Webster, Jackson Co.; and other points.

PROCHLORITE. Ripidolite pt.

Monoclinic. In six-sided tables or prisms, the side planes strongly furrowed and dull. Crystals often implanted by their sides, and in divergent groups, fan-shaped, vermicular, or spheroidal. Also in large folia. Massive, foliated, or granular.

$H. = 1-2$. $G. = 2.78-2.96$. Translucent to opaque; transparent only in very thin folia. Luster of cleavage surface feebly pearly. Color green, grass-green, olive-green, blackish green; across the axis by transmitted light sometimes red. Streak uncolored or greenish. Laminae flexible, not elastic. Pleochroism distinct. Optically + in most cases. Bx inclined to the normal to *c* some 2° . Axial angle small, often nearly uniaxial; again $2E = 23^\circ-30^\circ$. Dispersion $\rho < v$.

Comp.—Lower in silicon than clinocllore, and with ferrous iron usually, but not always, in large amount. Analysis by Egger:

	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	FeO	MgO	CaO	H ₂ O	
Zillertal	26.02	20.16	1.07	28.08	15.50	0.44	9.65	= 100.92

Obs.—Like other chlorites in modes of occurrence. Sometimes in implanted crystals, as at St. Gothard, enveloping often adularia, etc.; Mt. Greiner in the Zillertal, Tyrol; Rauris in Salzburg; Traversella in Piedmont; at Mtn. Sept Lacs and St. Christophe in Dauphiné; in Styria, Bohemia. Also massive in Cornwall, in tin veins; at Arendal in Norway; Salberg and Dannemora, Sweden; Dognacska, Hungary. Occasionally formed from amphibole. In Scotland at various points. In the U. States, near Washington; on Castle Mt., Batesville, Va., a massive form resembling soapstone, color grayish green, feel greasy; Steele's mine, Montgomery Co., N. C.; also with corundum at the Culsagee mine, in broad plates of a dark green color and fine scaly; it differs from ordinary prochlorite in the small amount of ferrous iron.

Corundophilite. A chlorite occurring in deep green laminae resembling clinocllore but more brittle; contains but 24 p. c. SiO₂. Occurs with corundum at Chester, Mass.

AMESITE. $H_2(Mg,Fe)_2Al_2Si_2O_{10}$. Silica 21.4 p. c. In hexagonal plates, foliated, resembling the green talc from the Tyrol. $H. = 2.5-3$. $G. = 2.71$. Color apple-green. Luster pearly on cleavage face. Optically +, sensibly uniaxial. Occurs with diaspore at Chester, Mass.

OTHER CHLORITES. Besides the chlorites already described which occur usually in distinct crystals or plates, there are, as noted on p. 472, forms varying from fine scaly to fibrous and earthy, which as already noted are prominent in rocks. In some cases they may belong to the species before described, but frequently the want of sufficient pure material has left their composition in doubt. These chlorites are commonly characterized by their green color, distinct pleochroism and low birefringence (p. 473).

The following are names which have been given particularly to the chlorites filling cavities or seams in basic igneous rocks: *aphrosiderite*, *diabantite*, *delessite*, *epichlorite*, *evralite*, *chlorophæite*, *hullite*.

The following are other related minerals.

Cronstedite. $4FeO.2Fe_2O_3.3SiO_2.4H_2O$. Occurs tapering in hexagonal pyramids; also in diverging groups; amorphous. Cleavage: basal, highly perfect. Thin laminae elastic. $G. = 3.34-3.35$. Color coal-black to brownish black; by transmitted light in thin scales emerald-green. Streak dark olive-green. From Píbram in Bohemia; also in Cornwall.

Thuringite. $8FeO.4(Al,Fe)_2O_3.6SiO_2.9H_2O$. Massive; an aggregation of minute pearly scales. Color olive-green to pistachio-green. From near Saalfeld, in Thuringia; Hot Springs, Arkansas, etc.; from the metamorphic rocks on the Potomac, near Harper's Ferry (*ovenite*).

CHAMOSITE. Contains iron (FeO) with but little MgO. Occurs compact or oölitic with H. about 3; G. = 3-3.4; color greenish gray to black. From Chamoson, near St. Maurice, in the Valais.

Stilpnomelane. An iron silicate. In foliated plates; also fibrous, or as a velvety coating. G. = 2.77-2.96. Color black, greenish black. Occurs at Obergrund and elsewhere in Silesia; also in Moravia; near Weilburg, Nassau. *Chalcodite*, from the Sterling Iron mine, in Antwerp, Jefferson Co., N. Y., coating hematite and calcite, is the same mineral in velvety coating of mica-like scales with a bronze color.

Strigovite. $H_2Fe_3(Al,Fe)_2Si_2O_{10}$. In aggregations of minute crystals. Color dark green. Occurs as a fine coating over the minerals in cavities in the granite of Striegau in Silesia.

Rumpfite. $H_2Mg_7Al_1Si_{10}O_{66}$. Massive; granular, consisting of very fine scales. Color greenish white. Occurs with talc near St. Michael in Upper Styria.

APPENDIX TO THE MICA DIVISION.—VERMICULITES.

The VERMICULITE GROUP includes a number of micaceous minerals, all hydrated silicates, in part closely related to the chlorites, but varying somewhat widely in composition. They are alteration-products chiefly of the micas, biotite, phlogopite, etc., and retain more or less perfectly the micaceous cleavage, and often show the negative optical character and small axial angle of the original species. Many of them are of a more or less indefinite chemical nature, and the composition varies with that of the original mineral and with the degree of alteration.

The laminae in general are soft, pliable, and inelastic; the luster pearly or bronze-like, and the color varies from white to yellow and brown. Heated to 100°-110° or dried over sulphuric acid most of the vermiculites lose considerable water, up to 10 p. c., which is probably hygroscopic; at 300° another portion is often given off; and at a red heat a somewhat larger amount is expelled. Connected with the loss of water upon ignition is the common physical character of exfoliation; some of the kinds especially show this to a marked degree, slowly opening out, when heated gradually, into long worm-like threads. This character has given the name to the group, from the Latin *vermiculari*, to breed worms. The minerals included can hardly rank as distinct species and only their names can be given here: *Jefferisite*, *vermiculite*, *culsageite*, *kerrite*, *lennilite*, *hallite*, *philadelphite*, *vaalite*, *maconite*, *dualeite*, *pyrosclerite*.

III. Serpentine and Talc Division.

The leading species belonging here, Serpentine and Talc, are closely related to the Chlorite Group of the Mica Division preceding, as noted beyond. Some other magnesium silicates, in part amorphous, are included with them.

SERPENTINE.

Monoclinic. In distinct crystals, but only as pseudomorphs. Sometimes foliated, folia rarely separable; also delicately fibrous, the fibers often easily separable, and either flexible or brittle. Usually massive, but microscopically finely fibrous and felted, also fine granular to impalpable or cryptocrystalline; slaty. Crystalline in structure but often by compensation nearly isotropic; amorphous.

Cleavage *b* (010), sometimes distinct; also prismatic (50°) in chrysotile. Fracture usually conchoidal or splintery. Feel smooth, sometimes greasy. H. = 2.5-4, rarely 5.5. G. = 2.50-2.65; some fibrous varieties 2.2-2.3; retinalite, 2.36-2.55. Luster subresinous to greasy, pearly, earthy; resin-like, or wax-like; usually feeble. Color leek-green, blackish green; oil- and siskin-green; brownish red, brownish yellow; none bright; sometimes nearly white. On exposure, often becoming yellowish gray. Streak white, slightly shining. Translucent to opaque.

Pleochroism feeble. Optically —, perhaps also + in chrysotile. Double refraction weak. Ax. pl. $\parallel a$ (100). Bx (a) $\perp b$ (010) the cleavage surface; c \parallel elongation of fibers. Biaxial, angle variable, often large; $2V = 20^\circ$ to 90° . Indices:

Antigorite $\alpha = 1.560$ $\beta = 1.570$ $\gamma = 1.571$ $\gamma - \alpha = 0.011$ Lévy-Lcx.

Var.—Many unsustained species have been made out of serpentine, differing in structure (massive, slaty, foliated, fibrous), or, as supposed, in chemical composition, and these now, in part, stand as varieties, along with some others based on variations in texture, etc.

A. IN CRYSTALS—PSEUDOMORPHS. The most common have the form of chrysolite. Other kinds are pseudomorphs after pyroxene, amphibole, spinel, chondrodite, garnet, phlogopite, etc. *Bastite* or *Schiller Spar* is enstatite (hypersthene) altered more or less completely to serpentine. See p. 386.

B. MASSIVE. 1. *Ordinary massive.* (a) *Precious* or *Noble Serpentine* is of a rich oil-green color, of pale or dark shades, and translucent even when in thick pieces. (b) *Common Serpentine* is of dark shades of color, and subtranslucent. The former has a hardness of 2.5-3; the latter often of 4 or beyond, owing to impurities.

Resinous. Retinalite. Massive, honey-yellow to light oil-green, waxy or resin-like luster.

Bowenite (Nephrite *Bowen*). Massive, of very fine granular texture, and much resembles nephrite, and was long so called. It is apple-green or greenish white in color; G. = 2.594-2.787, Bowen; and it has the unusual hardness 5.5-6. From Smithfield, R. I.; also a similar kind from New Zealand.

C. LAMELLAR. *Antigorite*, thin lamellar in structure, separating into translucent folia; H. = 2.5; G. = 2.622; color brownish green by reflected light; feel smooth, but not greasy. From Antigorio valley, Piedmont.

D. THIN FOLIATED. *Marmolite*, thin foliated; the laminae brittle but separable. G. = 2.41; colors greenish white, bluish white to pale asparagus-green. From Hoboken, N. J.

E. FIBROUS. *Chrysotile.* Delicately fibrous, the fibers usually flexible and easily separating; luster silky, or silky metallic; color greenish white, green, olive-green, yellow and brownish; G. = 2.219. Often constitutes seams in serpentine. It includes most of the silky *amianthus* of serpentine rocks and much of what is popularly called *asbestos* (asbestos). Cf. p. 401.

Picrolite, columnar, but fibers or columns not easily flexible, and often not easily separable, or affording only a splintery fracture; color dark green to mountain-green, gray, brown. The original was from Taberg, Sweden. *Baltimoreite* is picrolite from Bare Hills, Md.

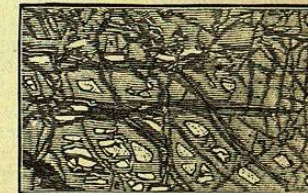
F. SERPENTINE ROCKS. Serpentine often constitutes rock-masses. It frequently occurs mixed with more or less of dolomite, magnesite, or calcite, making a rock of clouded green, sometimes veined with white or pale green, called *verd antique*, *ophiolite*, or *opicalcite*. Serpentine rock is sometimes mottled with red, or has something of the aspect of a red porphyry; the reddish portions containing an unusual amount of oxide of iron. Any serpentine rock cut into slabs and polished is called *serpentine marble*.

Microscopic examination has established the fact that serpentine in rock-masses has been largely produced by the alteration of chrysolite, and many apparently homogeneous serpentines show more or less of this original mineral. In other cases it has resulted from the

alteration of pyroxene or amphibole. Sections of the serpentine derived from chrysolite often show a peculiar structure, like the meshes of a net (Fig. 914); the lines marked by grains of magnetite also follow the original cracks and cleavage directions of the chrysolite (Fig. 915, a). The serpentine from amphibole and pyroxene commonly shows an analogous structure; the iron particles following the former cleavage lines. Hence the nature of the original mineral can often be inferred. Cf. Fig. 915, a, b, c (Pirsson).

Comp.—A magnesium silicate, $H_2Mg_3Si_2O_{10}$, or $3MgO.2SiO_2.2H_2O =$ Silica 44.1, magnesia 43.0, water 12.9 = 100. Iron protoxide often replaces a small part of the magnesium; nickel in small amount is sometimes present. The water is chiefly expelled at a red heat.

Pyr., etc.—In the closed tube yields water. B.B. fuses on the edges with difficulty.



914.