I. Oxides of Silicon

QUARTZ.

Rhombohedral-trapezohedral. Axis: $c = 1{\cdot}09997$.

rr', $10\bar{1}1 \wedge \bar{1}101 = 85°\ 46'$. mz, $10\bar{1}0 \wedge 01\bar{1}1 = 66°\ 52'$.
rz, $10\bar{1}1 \wedge 01\bar{1}1 = 46°\ 16'$. ms, $10\bar{1}0 \wedge 11\bar{2}1 = 37°\ 58'$.
mr, $10\bar{1}0 \wedge 10\bar{1}1 = 38°\ 13'$. mx, $10\bar{1}0 \wedge 51\bar{6}1 = 12°\ 1'$.

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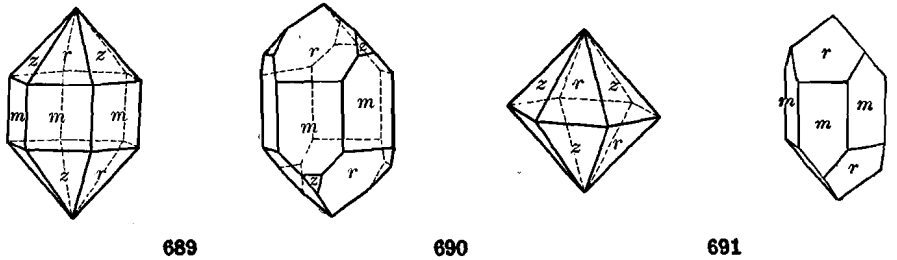

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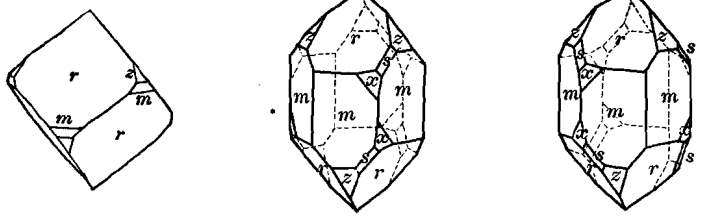

Crystals commonly prismatic, with the $m(10\bar{1}0)$ faces horizontally striated; terminated commonly by the two rhombohedrons, $r(10\bar{1}1)$ and $z(01\bar{1}1)$, in nearly equal development, giving the appearance of a hexagonal pyramid; when one rhombohedron predominates it is in almost all cases r. Often in double six-sided pyramids or *quartzoids* through the equal development of r and z; when r is relatively large the form then has a cubic aspect ($rr' = 85°\ 46'$). Crystals frequently distorted, when the correct orientation may be obscure except as shown by the striations on m. Crystals often elongated to acicular forms, and tapering through the oscillatory combination of successive rhombohedrons with the prism. Occasionally twisted or bent. Frequently in radiated masses with a surface of pyramids, or in druses.

Simple crystals are either right- or left-handed. On a *right-handed* crystal (Fig. 690) the right trigonal pyramid, $s(11\bar{2}1)$, if present, lies to the right of the m face, which is below the predominating positive rhombohedron r, and with this belong the positive right trapezohedrons, as $x(51\bar{6}1)$. On a *left-handed* crystal (Fig. 691), s lies to the left of the m below r. The right- and left-handed forms occur together only in twins. In the absence of trapezohedral faces the striations on s ($\|$ edge r/m), if distinct, serve to distinguish the faces r and z, and hence show the right- and left-handed character of the crystals. The right- and left-handed character is also revealed by etching (Art. **286**) and by pyro-electricity (Art. **438**).

Thermal study of quartz shows that it exists in two modifications, known as α- and β-quartz. α-quartz is apparently hexagonal, trapezohedral-tetartohedral and is formed at temperatures below 575° while β-quartz is hexagonal, trapezohedral-hemihedral and forms at temperatures ranging from 575° to 800°. Above 800° tridymite is formed. The crystal angles of α-quartz change with increase of temperature up to 575°, the inversion point to β-quartz, while beyond this point they remain nearly constant. In a similar

manner at this point there is a sudden marked lowering of the refractive indices and birefringence. α-quartz occurs in veins and geodes and large pegmatites while the β modification is found in graphite granite, granite pegmatites, and porphyries. Tridymite when heated to about 1470° passes over into cristobalite. Quartz, tridymite and cristobalite are probably to be considered as polymers of the fundamental molecule, SiO_2.

Twins: (1) tw. axis c, all axes parallel. (2) Tw. pl. a, sometimes called the *Brazil law*, usually as irregular penetration-twins (Fig. 692). (3) Tw. pl. ξ $(11\bar{2}2)$, contact-twins, the axes crossing at angles of 84° 33′ and with a prism face in common to the two individuals. (4) Tw. pl. $r(10\bar{1}1)$. See further p. 168 and Figs. 427–429. Massive forms common and in great variety, passing from the coarse or fine granular and crystalline kinds to those which are flint-like or cryptocrystalline. Sometimes mammillary, stalactitic, and in concretionary forms; as sand.

Cleavage not distinctly observed; sometimes fracture surfaces ($\| r(10\bar{1}1)$, $z(01\bar{1}1)$ and $m(10\bar{1}0)$, developed by sudden cooling after being heated (see Art. **279**). Fracture conchoidal to subconchoidal in crystallized forms, uneven to splintery in some massive kinds. Brittle to tough. H. = 7. G. = 2·653–2·660 in crystals; cryptocrystalline forms somewhat lower (to 2·60) if pure, but impure massive forms (*e.g.*, jasper) higher. Luster vitreous, sometimes greasy; splendent to nearly dull. Colorless when pure; often various shades of yellow, red, brown, green, blue, black. Streak white, of pure varieties; if impure, often the same as the color, but much paler. Transparent to opaque.

Optically +. Double refraction weak. Polarization circular; right-handed or left-handed, the optical character corresponding to right- and left-handed character of crystals, as defined above; in twins (law 2), both right and left forms sometimes united, sections then often showing Airy's spirals in the polariscope (cf. Art. **394,** p. 270, and Fig. 692). Rotatory power proportional to thickness of plate. Refractive indices for the D line, $\omega = 1{\cdot}54418$, $\epsilon = 1{\cdot}55328$; also rotatory power for section of 1^{mm} thickness, $\alpha = 21{\cdot}71$ (D line). Pyroelectric; also electric by pressure or piezo-electric. See Arts. **438, 439.** On etching-figures, see Arts. **286, 287.**

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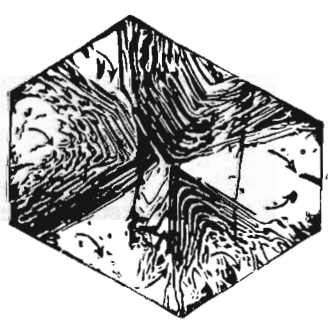


Basal section in polarized light, showing interpenetration of right- and left-handed portions. Des Cloizeaux.

Comp. — Silica, or silicon dioxide, SiO_2 = Oxygen 53·3, silicon 46·7 = 100.

In massive varieties often mixed with a little opal silica. Impure varieties contain iron oxide, calcium carbonate, clay, sand, and various minerals as inclusions.

Artif. — Quartz has been produced artificially in numerous ways. Recently crystals have been obtained at temperatures below 760° from melts containing dissolved silica which were composed of (1) a mixture of potassium and lithium chlorides, (2) vanadic acid, (3) sodium tungstate. At higher temperatures tridymite crystals formed.

Var. — A. PHENOCRYSTALLINE: Crystallized, vitreous in luster. B. CRYPTOCRYSTALLINE: Flint-like, massive.

The first division includes all ordinary vitreous quartz, whether having crystalline faces or not. The varieties under the second are in general acted upon somewhat more by attrition, and by chemical agents, as hydrofluoric acid, than those of the first. In all kinds made up of layers, as agate, successive layers are unequally eroded.

A. Phenocrystalline or Vitreous Varieties

Ordinary Crystallized; Rock Crystal. — Colorless quartz, or nearly so, whether in distinct crystals or not. Here belong the Bristol diamonds, Lake George diamonds, Brazilian pebbles, etc. Some variations from the common type are: (*a*) cavernous crystals; (*b*) cap-quartz made up of separable layers or caps; (*c*) drusy quartz, a crust of small or minute quartz crystals; (*d*) radiated quartz, often separable into radiated parts, having pyramidal terminations; (*e*) fibrous, rarely delicately so, as a kind from Griqualand West, South Africa, altered from crocidolite (see *cat's-eye* below, also crocidolite, p. 493).

Asteriated; Star-quartz. — Containing within the crystal whitish or colored radiations along the diametral planes. Occasionally exhibits distinct asterism.

Amethystine; Amethyst. — Clear purple, or bluish violet. Color perhaps due to manganese.

Rose. — Rose-red or pink, but becoming paler on exposure. Commonly massive. Luster sometimes a little greasy. Color perhaps due to titanium.

Yellow; False Topaz or *Citrine.* — Yellow and pellucid; resembling yellow topaz.

Smoky; Cairngorm Stone. — Smoky yellow to dark smoky brown, and often transparent; varying to brownish black. Color is probably due to some organic compound (Forster). Called *cairngorms* from the locality at Cairngorm, southwest of Banff, in Scotland. The name *morion* is given to nearly black varieties.

Milky. — Milk-white and nearly opaque. Luster often greasy.

Siderite, or *Sapphire-quartz.* — Of indigo or Berlin-blue color; a rare variety.

Sagenitic. — Inclosing acicular crystals of rutile. Other included minerals in acicular forms are: black tourmaline; göthite; stibnite; asbestus; actinolite; hornblende; epidote.

Cat's-eye exhibits opalescence, but without prismatic colors, especially when cut *en cabochon*, an effect sometimes due to fibers of asbestus. Also present in the siliceous pseudomorphs, after crocidolite, called *tiger-eye* (see crocidolite). The highly-prized Oriental cat's-eye is a variety of chrysoberyl.

Aventurine. — Spangled with scales of mica, hematite, or other mineral.

Impure from the presence of distinct minerals distributed densely through the mass. The more common kinds are those in which the impurities are: (*a*) *ferruginous*, either red or yellow, from anhydrous or hydrous iron sesquioxide; (*b*) *chloritic*, from some kind of chlorite; (*c*) *actinolitic;* (*d*) *micaceous;* (*e*) *arenaceous*, or sand.

Containing liquids in cavities. The liquid, usually water (pure, or a mineral solution), or some petroleum-like compound. Quartz, especially smoky quartz, also often contains inclusions of both liquid and gaseous carbon dioxide.

B. Cryptocrystalline Varieties

Chalcedony. — Having the luster nearly of wax, and either transparent or translucent. G. = 2·6–2·64. Color white, grayish, blue, pale brown to dark brown, black. Also of other shades, and then having other names. Often mammillary, botryoidal, stalactitic, and occurring lining or filling cavities in rocks. It often contains some disseminated opal-silica. The thermal study of *chalcedony* shows that it differs from quartz and may be therefore a distinct species. The name *enhydros* is given to nodules of chalcedony containing water, sometimes in large amount. Embraced under the general name chalcedony is the crystalline form of silica which forms concretionary masses with radial-fibrous and concentric structure, and which, as shown by Rosenbusch, is optically *negative*, unlike true quartz. It has $n = 1{\cdot}537$; G. = 2·59–2·64. Often in spherulites, showing the spherulitic interference-figure. *Lussatite* of Mallard has a like structure, but is optically + and has the specific gravity and refractive index of opal. It may be a fibrous form of *tridymite*. See also quartzine, p. 407.

Carnelian. Sard. — A clear red chalcedony, pale to deep in shade; also brownish red to brown.

Chrysoprase. — An apple-green chalcedony, the color due to nickel oxide.

Prase. — Translucent and dull leek-green.

Plasma. — Rather bright green to leek-green, and also sometimes nearly emerald-green, and subtranslucent or feebly translucent. *Heliotrope*, or *Blood-stone*, is the same stone essentially, with small spots of red jasper, looking like drops of blood.

Agate. — A variegated chalcedony. The colors are either (*a*) banded; or (*b*) irregularly clouded; or (*c*) due to visible impurities as in moss agate, which has brown moss-like or dendritic forms, as of manganese oxide, distributed through the mass. The bands are delicate parallel lines, of white, pale and dark brown, bluish and other shades; they are sometimes straight, more often waving or zigzag, and occasionally concentric circular.

The bands are the edges of layers of deposition, the agate having been formed by a deposit of silica from solutions intermittently supplied, in irregular cavities in rocks, and deriving their concentric waving courses from the irregularities of the walls of the cavity. The layers differ in porosity, and therefore agates may be varied in color by artificial means, and this is done now to a large extent with the agates cut for ornament. There is also *agatized wood;* wood petrified with clouded agate.

Onyx. — Like agate in consisting of layers of different colors, white and black, white and red, etc., but the layers in even planes, and the banding straight, and hence its use for cameos.

Sardonyx. — Like onyx in structure, but includes layers of carnelian (sard) along with others of white or whitish, and brown, and sometimes black colors.

Agate-jasper. — An agate consisting of jasper with veinings of chalcedony.

Siliceous sinter. — Irregularly cellular quartz, formed by deposition from waters containing silica or soluble silicates in solution. See also under opal, p. 408.

Flint. — Somewhat allied to chalcedony, but more opaque, and of dull colors, usually gray, smoky brown, and brownish black. The exterior is often whitish, from mixture with lime or chalk, in which it is embedded. Luster barely glistening, subvitreous. Breaks with a deeply conchoidal fracture, and a sharp cutting edge. The flint of the chalk formation consists largely of the remains of diatoms, sponges, and other marine productions. The coloring matter of the common kind is mostly carbonaceous matter. Flint implements play an important part among the relics of early man.

Hornstone. — Resembles flint, but is more brittle, the fracture more splintery. *Chert* is a term often applied to hornstone, and to any impure flinty rock, including the jaspers.

Basanite; Lydian Stone, or *Touchstone.* — A velvet-black siliceous stone or flinty jasper, used on account of its hardness and black color for trying the purity of the precious metals. The color left on the stone after rubbing the metal across it indicates to the experienced eye the amount of alloy. It is not splintery like hornstone.

Jasper. — Impure opaque colored quartz; commonly red, also yellow, dark green and grayish blue. *Striped* or *riband jasper* has the colors in broad stripes. *Porcelain jasper* is nothing but baked clay, and differs from true jasper in being B.B. fusible on the edges.

C. Besides the above there are also:

Granular Quartz, Quartz-rock, or *Quartzite.* — A rock consisting of quartz grains very firmly compacted; the grains often hardly distinct. *Quartzose Sandstone, Quartz-conglomerate.* — A rock made of pebbles of quartz with sand. The pebbles sometimes are jasper and chalcedony, and make a beautiful stone when polished. *Itacolumite,* or *Flexible Sandstone.* — A friable sand-rock, consisting mainly of quartz-sand, but containing a little mica, and possessing a degree of flexibility when in thin laminæ. *Buhrstone,* or Burrstone. — A cellular, flinty rock, having the nature in part of coarse chalcedony.

Pseudomorphous Quartz. — Quartz appears also under the forms of many of the mineral species, which it has taken through either the alteration or replacement of crystals of those species. The most common quartz pseudomorphs are those of calcite, barite, fluorite, and siderite. *Silicified wood* is quartz pseudomorph after wood (p. 326).

Pyr., etc. — B.B. unaltered; with borax dissolves slowly to a clear glass; with soda dissolves with effervescence; unacted upon by salt of phosphorus. Insoluble in hydrochloric acid, and only slightly acted upon by solutions of fixed caustic alkalies, the cryptocrystalline varieties to the greater extent. Soluble only in hydrofluoric acid. When fused and cooled it becomes opal-silica having G. = 2·2.

Diff. — Characterized in crystals by the form, glassy luster, and absence of cleavage; also in general by hardness and infusibility.

Micro. — Easily recognized in rock sections by its low refraction ("low relief," p. 212) and low birefringence ($\epsilon - \omega = 0{\cdot}009$); the interference colors in good sections not rising above yellow of the first order; also by its limpidity and the positive uniaxial cross yielded by basal sections (p. 270, note), which remain dark when revolved between crossed nicols. Commonly in formless grains (granite), also with crystal outline (porphyry, etc.).

Obs. — *Quartz* is an essential component of certain igneous rocks, as granite, granite-porphyry, quartz-porphyry and rhyolite in the granite group; in such rocks it is commonly in formless grains or masses filling the interstices between the feldspar, as the last product of crystallization. Further it is an essential constituent in quartz-diorite, quartz-diorite porphyry and dacites in the diorite group; in the porphyries frequently in distinct crystals. It occurs also as an accessory in other feldspathic igneous rocks, such as syenite and trachyte. Among the metamorphic rocks it is an essential component of certain varieties of gneiss, of quartzite, etc. It forms the mass of common sandstone. It occurs as the vein-stone in various rocks, and forms a large part of mineral veins; as a foreign min-

eral in some limestones, etc., making geodes of crystals, or of chalcedony, agate, carnelian, etc.; as embedded nodules or masses in various limestones, constituting the flint of the Chalk formation, the hornstone of other limestones — these nodules sometimes becoming continuous layers; as masses of jasper occasionally in limestone. It is the principal material of the pebbles of gravel-beds, and of the sands of the seashore, and sandbeds everywhere. In graphic granite (*pegmatite*) the quartz individuals are arranged in parallel position in feldspar, the angular particles resembling written characters. The quartz grains in a fragmental sandstone are often found to have undergone a secondary growth by the deposition of crystallized silica with like orientation to the original nucleus. From a general study of the chemical and mineralogical character of the rocks of the earth's crust it has been estimated that quartz forms about twelve per cent of their constituents.

Switzerland; Dauphiné, France; Piedmont, Italy; the Carrara quarries, Italy; and numerous other foreign localities afford fine specimens of rock crystal; also Japan, from which are cut the beautiful crystal spheres, in rare cases up to 6 inches in diameter; also interesting twin crystals from Kai, Japan; Bourg d'Oisans, Dauphiné, France. *Smoky quartz* crystals of great beauty, and often highly complex in form, occur at many points in the central Alps, also at Cairngorm, Scotland. The most beautiful *amethysts* are brought from India, Ceylon, and Persia, Nova Scotia, Brazil, Guanajuato, Mexico; inferior specimens occur in Transylvania. The finest *carnelians* and *agates* are found in Arabia, India, Brazil, Uruguay, Surinam, also formerly at Oberstein and Saxony. Scotland affords smaller but handsome specimens (Scotch pebbles). The banks of the Nile afford the Egyptian jasper; the striped jasper is met with in Siberia, Saxony, and Devonshire.

In N. Y., quartz crystals are abundant in Herkimer Co., at Middleville, Little Falls, etc., loose in cavities in the Calciferous sand-rock, or embedded in loose earth. Fine quartzoids, at the beds of hematite in Fowler, Herman, and Edwards, St. Lawrence Co., also at Antwerp, Jefferson Co. On the banks of Laidlaw Lake, Rossie, large implanted crystals; at Ellenville lead mine, Ulster Co., in fine groups. At Paris, Me., handsome crystals of brown or smoky quartz. Beautiful colorless crystals occur at Hot Springs, Ark. Alexander Co., N. C., has afforded great numbers of highly complex crystals, with rare modifications. Fine crystals of smoky quartz come from the granite of the Pike's Peak region, Col. Geodes of quartz crystals, also enclosing calcite, sphalerite, etc., are common in the Keokuk limestone of the west.

Rose quartz occurs at Hebron, Albany, Paris, Me.; Acworth, N. H.; Southbury, Conn.; Custer Co., S. D. *Amethyst*, in trap, at Keweenaw Point, Lake Superior; Specimen Mt., Yellowstone Park; Jefferson Co., Mon.; in Pa., at East Bradford, Chester, and Providence (one fine crystal over 7 lbs. in weight), in Chester Co.; at the Prince vein, Lake Superior; large crystals, near Greensboro, N. C.; crystallized green quartz, in talc, at Providence, Delaware Co., Pa. *Chalcedony* and *agates* abundant and beautiful on northwest shore of Lake Superior. Red jasper is found on Sugar Loaf Mt., Me.; in pebbles on the banks of the Hudson at Troy, N. Y.; yellow, with chalcedony, at Chester, Mass. Agatized and jasperized wood of great beauty and variety of color is obtained from the petrified forest called Chalcedony Park, near Carrizo, Apache Co., Ariz.; also from the Yellowstone Park; near Florissant and elsewhere in Col.; Amethyst Mt., Utah; Napa Co., Cal. Moss agates from Humboldt Co., Nev., and many other points.

The word quartz is of German provincial origin. Agate is from the name of the river Achates, in Sicily, whence specimens were brought, as stated by Theophrastus.

Use. — In its various colored forms as ornamental material; for abrading purposes; manufacture of porcelain, of glass; as wood filler; in paints, scouring soaps, etc.; as sand in mortars and cements; as quartzite, sandstone, etc., for building stone, etc.; as an acid flux in certain smelting operations.

QUARTZINE is a name which has been given to a form of silica which is present in chalcedony and is inferred to be triclinic in crystalline structure. *Lutecite* belongs here.

TRIDYMITE.

Hexagonal or pseudo-hexagonal. Axis $c = 1{\cdot}6530$. Crystals usually minute, thin tabular $\parallel c(0001)$; often in twins; also united in fan-shaped groups.

Cleavage: prismatic, not distinct; parting $\parallel c$, sometimes observed. Fracture conchoidal. Brittle. H. = 7. G. = 2·28–2·33. Luster vitreous, on c pearly. Colorless to white. Transparent. Optically +. $\omega = 1{\cdot}477$. $\epsilon = 1{\cdot}479$. Often exhibits anomalous refraction phenomena.

Comp. — Pure silica, SiO_2, like quartz.

Tridymite is formed above 800° C. See further under Quartz, p. 403.

Pyr., etc. — Like quartz, but soluble in boiling sodium carbonate.

Obs. — Occurs chiefly in acidic volcanic rocks, rhyolite, trachyte, andesite, liparite, less often in dolerite; usually in cavities, often associated with sanidine, also hornblende, augite, hematite; sometimes in opal. First observed in crevices and druses in an augite-andesite from the Cerro San Cristobal, near Pachuca, Mexico; later proved to be rather generally distributed. Thus in trachyte of the Siebengebirge, Germany; of Euganean Hills in northern Italy; Puy Capucin (Mont-Dore) in Central France, etc. In the ejected masses from Vesuvius consisting chiefly of sanidine. In the lavas of Mt. Etna, Sicily, and Mt. Pelée, Martinique. From Kibōsan, Prov. Higo, Japan. With quartz, feldspar, fayalite in lithophyses of Obsidian cliff, Yellowstone Park. In the andesite of Mt. Rainier, Washington.

Named from *τριδυμος, threefold*, in allusion to the common occurrence in trillings.

ASMANITE. A form of silica found in the meteoric iron of Breitenbach, in very minute grains, probably identical with tridymite; by some referred to the orthorhombic system.

CRISTOBALITE. Christobalite. Silica in white octahedrons (pseudo-isometric?). G. = 2·27. n = 1·486. With tridymite in andesite of the Cerro S. Cristobal, Pachuca, Mexico. Also noted in lava at Mayen, Germany, and in meteorites. For thermal relations to quartz and tridymite see under quartz, p. 403.

MELANOPHLOGITE. In minute cubes and spherical aggregates. Occurring with calcite and celestite implanted upon an incrustation of opaline silica over the sulphur crystals of Girgenti, Sicily. Consists of SiO_2 with 5 to 7 p. c. of SO_3, perhaps SiO_2 with SiS_2. The mineral turns black superficially when heated B.B.

OPAL.

Amorphous. Massive; sometimes small reniform, stalactitic, or large tuberose. Also earthy.

H. = 5·5–6·5. G. = 1·9–2·3; when pure 2·1–2·2. Luster vitreous, frequently subvitreous; often inclining to resinous, and sometimes to pearly. Color white, yellow, red, brown, green, gray, blue, generally pale; dark colors arise from foreign admixtures; sometimes a rich play of colors, or different colors by refracted and reflected light. Streak white. Transparent to nearly opaque. n = 1·44–1·45.

Often shows double refraction similar to that observed in colloidal substances due to tension. The cause of the play of color in the precious opal was investigated by Brewster, who ascribed it to the presence of microscopic cavities. Behrends, however, has given a monograph on the subject (Ber. Ak. Wien, **64** (1), 1871), and has shown that this explanation is incorrect; he refers the colors to thin curved lamellæ of opal whose refractive power may differ by 0·1 from that of the mass. These are conceived to have been originally formed in parallel position, but have been changed, bent, and finally cracked and broken in the solidification of the groundmass.

Comp. — Silica, like quartz, with a varying amount of water, $SiO_2.nH_2O$. The water is sometimes regarded as non-essential.

The opal condition is one of lower degrees of hardness and specific gravity, and, as generally believed, of incapability of crystallization. The water present varies from 2 to 13 p. c. or more, but mostly from 3 to 9 p. c. Small quantities of ferric oxide, alumina, lime, magnesia, and alkalies are usually present as impurities.

Var. — *Precious Opal.* — Exhibits a play of delicate colors.

Fire-opal. — Hyacinth-red to honey-yellow colors, with fire-like reflections, somewhat irised on turning.

Girasol. — Bluish white, translucent, with reddish reflections in a bright light.

Common Opal. — In part translucent; (*a*) *milk-opal*, milk-white to greenish, yellowish, bluish; (*b*) *Resin-opal*, wax-, honey- to ocher-yellow, with a resinous luster; (*c*) dull olive-green and mountain-green; (*d*) brick-red. Includes *Semiopal;* (*e*) *Hydrophane*, a variety which becomes more translucent or transparent in water.

Cacholong. — Opaque, bluish white, porcelain-white, pale yellowish or reddish.

Opal-agate. — Agate-like in structure, but consisting of *opal* of different shades of color.

Menilite. — In concretionary forms; opaque, dull grayish.

Jasp-opal. Opal-jasper. — Opal containing some yellow iron oxide and other impurities, and having the color of yellow jasper, with the luster of common opal.

Wood-opal. — Wood petrified by opal.

Hyalite. Muller's Glass. — Clear as glass and colorless, constituting globular concretions, and crusts with a globular or botryoidal surface; also passing into translucent, and whitish. Less readily dissolved in caustic alkalies than other varieties.

Schaumopal. — A porous variety from the Virunga district, German East Africa.

Fiorite, Siliceous Sinter. — Includes translucent to opaque, grayish, whitish or brownish incrustations, porous, to firm in texture; sometimes fibrous-like or filamentous, and, when so, pearly in luster (then called *Pearl-sinter*); deposited from the siliceous waters of hot springs.

Geyserite. — Constitutes concretionary deposits about the geysers of the Yellowstone Park, Iceland, and New Zealand, presenting white or grayish, porous, stalactitic, filamentous, cauliflower-like forms, often of great beauty; also compact-massive, and scaly-massive.

Float-stone. — In light porous concretionary masses, white or grayish, sometimes cavernous, rough in fracture.

Tripolite. — Formed from the siliceous shells of diatoms (hence called *diatomite*) and other microscopic species, and occurring in extensive deposits. Includes *Infusorial Earth*, or *Earthy Tripolite*, a very fine-grained earth looking often like an earthy chalk, or a clay, but harsh to the feel, and scratching glass when rubbed on it.

Pyr., etc. — Yields water. B.B. infusible, but becomes opaque. Some yellow varieties, containing iron oxide, turn red. Soluble in hydrofluoric acid somewhat more readily than quartz; also soluble in caustic alkalies, but more readily in some varieties than in others.

Obs. — Occurs filling cavities and fissures or seams in igneous rocks, as trachyte, porphyry, where it has probably resulted from the action of hot, magmatic waters upon the silicates of the rocks, the liberated silica being deposited in the cavities in the form of opal. Also in some metallic veins. Also embedded, like flint, in limestone, and sometimes, like other quartz concretions, in argillaceous beds; formed from the siliceous waters of some hot springs; often resulting from the mere accumulation, or accumulation and partial solution and solidification, of the siliceous shells of infusoria, of sponge spicules, etc., which consist essentially of opal-silica. The last mentioned is the probable source of the opal of limestones and argillaceous beds (as it is of flint in the same rocks), and of part of that in igneous rocks. It exists in most chalcedony and flint.

Precious opal occurs in porphyry at Czerwenitza, near Kashau in Hungary; at Gracias a Dios in Honduras; Queretaro in Mexico; a beautiful blue opal on Bulla Creek, Queensland; from White Cliffs, New South Wales, as filling openings in sandstone, in fossil wood, in the material of various fossil shells and bones and in aggregates of radiating pseudomorphic crystals. *Fire-opal* occurs at Zimapan in Mexico; the Faroe Islands; near San Antonio, Honduras. Gem opal, often of "black opal" type, comes from Humboldt Co., Nev. *Common opal* is abundant at Telkebánya in Hungary; near Pernstein, etc., in Moravia; in Bohemia; Stenzelberg in Siebengebirge, Germany; in Iceland. *Hyalite* occurs in amygdaloid at Schemnitz, Hungary; in clinkstone at Waltsch, Bohemia; at San Luis Potosi, Mexico; Kamloops, British Columbia.

In the United States, *hyalite* occurs sparingly in connection with the trap rock of N. J. and Conn. A water-worn specimen of fire-opal has been found on the John Davis river, in Crook Co., Ore.

Common opal is found at Cornwall, Lebanon Co., Pa.; at Aquas Calientes, Idaho Springs, Col.; a white variety at Mokelumne Hill, Calaveras Co., Cal., and on the Mt. Diablo range. Geyserite occurs in great abundance and variety in the Yellowstone region (cf. above); also siliceous sinter at Steamboat Springs, Nev.

Use. — In the colored varieties as a highly prized gem-stone.

II. Oxides of the Semi-Metals; also Molybdenum, Tungsten

Arsenolite. Arsenic trioxide, As_2O_3. In isometric octahedrons; in crusts and earthy. Colorless or white. G. = 3·7. n = 1·755. Occurs with arsenical ores.

Claudetite. Also As_2O_3, but monoclinic in form. In thin plates.

Senarmontite. Antimony trioxide. Sb_2O_3. In isometric octahedrons; in crusts and granular massive. G. = 5·3. Colorless, grayish. n = 2·087. Occurs with ores of antimony. From Algeria; South Ham, Quebec.

Valentinite. Sb_2O_3, in prismatic orthorhombic crystals. Index = 2·34. From South Ham, Quebec.

Bismite. Bismuth trioxide, Bi_2O_3. Pulverulent, earthy; color straw-yellow. From Goldfield, Nevada, in minute silvery white, pearly scales that are hexagonal, rhombohedral; optically −. Analyses of a number of so-called bismites show them to be bismuth hydroxide or other compounds.

Tellurite. Tellurium dioxide, TeO_2. In white to yellow slender prismatic crystals.

Molybdite. Molybdenum trioxide, MoO_3. In capillary tufted forms and earthy. Color straw-yellow. Analyses of molybdic ocher from various localities show it to be not the oxide but a hydrous ferric molybdate, $Fe_2O_3.3MO_3.7H_2O$. Indices, 1·78–1·90.

Tungstite. Tungsten trioxide, WO_3. Pulverulent, earthy; color yellow or yellowish green. Indices, 2·09–2·26. Analysis of tungstic ocher from Salmo, B. C., prove it to have the composition $WO_3.H_2O$; perhaps identical with *meymacite* (a hydrated tungstic oxide from Meymac, Corrèze, France).

Cervantite. $Sb_2O_3.Sb_2O_5$. In yellow to white acicular crystals; also massive, pulverulent.

Stibiconite. $H_2Sb_2O_5$. Massive, compact. Color pale yellow to yellowish white. Index, 1·83.

III. Oxides of the Metals

A. Anhydrous Oxides

I. Protoxides, R_2O and RO.

II. Sesquioxides, R_2O_3.

III. Intermediate, $\overset{II}{R}\overset{III}{R}_2O_4$ or $RO.R_2O_3$, etc.

IV. Dioxides, RO_2.

The Anhydrous Oxides include, as shown above, three distinct divisions, the Protoxides, the Sesquioxides and the Dioxides. The remaining Intermediate division embraces a number of oxygen compounds which are properly to be regarded chemically as salts of certain acids (aluminates, ferrates, etc.); here is included the well-characterized Spinel Group.

Among the Protoxides the only distinct group is the Periclase Group, which includes the rare species Periclase, MgO, Manganosite, MnO, and Bunsenite, NiO. All of these are isometric in crystallization.

The Sesquioxides include the well-characterized Hematite Group, R_2O_3. The Dioxides include the prominent Rutile Group, RO_2. Both of these groups are further defined later.

I. Protoxides, R_2O and RO

CUPRITE. Red Copper Ore.

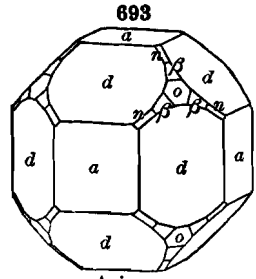
Isometric-plagiohedral. Commonly in octahedrons; also in cubes and dodecahedrons, often highly modified. Plagiohedral faces sometimes distinct (see p. 71). At times in capillary crystals. Also massive, granular; sometimes earthy.

Cleavage: $o(111)$ interrupted. Fracture conchoidal, uneven. Brittle. H. = 3·5–4. G. = 5·85–6·15. Luster adamantine or submetallic to earthy. Color red, of various shades, particularly cochineal-red, sometimes almost black; occasionally crimson-red by transmitted light. Streak several shades of brownish red, shining. Subtransparent to subtranslucent. Refractive index, n = 2·849.

Var. — 1. *Ordinary.* (*a*) Crystallized; commonly in octahedrons, dodecahedrons, cubes, and intermediate forms; the crystals often with a crust of malachite; (*b*) massive.

2. *Capillary; Chalcotrichite.* Plush Copper Ore. In capillary or acicular crystallizations, which are sometimes cubes elongated in the direction of the cubic axis.

3. *Earthy; Tile Ore.* Brick-red or reddish brown and earthy, often mixed with red oxide of iron; sometimes nearly black.



Arizona

Comp. — Cuprous oxide, Cu_2O = Oxygen 11·2, copper 88·8 = 100.

Pyr., etc. — Unaltered in the closed tube. B.B. in the forceps fuses and colors the flame emerald-green. On charcoal first blackens, then fuses, and is reduced to metallic copper. With the fluxes gives reactions for copper. Soluble in concentrated hydrochloric acid, and a strong solution when cooled and diluted with cold water yields a heavy, white precipitate of cuprous chloride.

Diff. — Distinguished from hematite by inferior hardness, but is harder than cinnabar and proustite and differs from them in the color of the streak; reactions for copper, B.B., are conclusive.

Micro. — In polished sections shows white with shining surface, usually pitted. With oblique illumination, transparent deep red. With HNO_3 instantly plated with metallic copper which blackens and dissolves. On drying a thin film of copper remains. With HCl darkens and is coated with white, seen by oblique light.

Obs. — Cuprite is a mineral of secondary origin. It is often formed as a furnace product and has been noted as a coating upon ancient copper or bronze objects. Occurs at Kamsdorf in Thuringia; in Cornwall, in fine crystals, at Wheal Gorland and other mines; in Devonshire near Tavistock; in isolated crystals, more or less altered to malachite, at Chessy, near Lyons, France; in the Ural Mts.; South Australia; also abundant in Chile, Peru, Bolivia.

In the United States observed at Somerville, etc., N. J.; at Cornwall, Lebanon Co., Pa.; in the Lake Superior region. From Ariz. with malachite, limonite, etc., at the Copper Queen mine, Bisbee, sometimes in fine crystals; beautiful *chalcotrichite* at Morenci; at Clifton, Graham Co., in crystals, and massive.

Use.— An ore of copper.

Ice. H_2O. Hexagonal. Familiarly known in six-rayed snow crystals; also coating ponds in winter, further as glaciers and icebergs.

Periclase Group

Periclase. Magnesia, MgO. In cubes or octahedrons, and in grains. Cleavage cubic. H. = 6. G. = 3·67–3·90. n = 1·74. Artif.— Crystallized from a melt containing magnesium chloride and silica. Occurs in white limestone at Mte. Somma, Vesuvius; at the Kitteln manganese mine, Nordmark, Sweden.

Manganosite. Manganese protoxide, MnO. In isometric octahedrons. Cleavage cubic. H. = 5–6. G. = 5·18. n = 2·18. Color emerald-green, becoming black on exposure. From Långban and Nordmark, Sweden; Franklin Furnace, N. J.

Bunsenite. Nickel protoxide, NiO. In green octahedrons. From Johanngeorgenstadt, Germany.

Cadmium oxide. Isometric. In minute octahedrons. Forms a thin coating of black color and brilliant metallic luster upon calamine from Monte Poni, Sardinia. Also formed artificially.

ZINCITE. Red Oxide of Zinc.

Hexagonal-hemimorphic. Axis c = 1·5870. Natural crystals rare (Fig. 44, p. 22); usually foliated massive, or in coarse particles and grains; also with granular structure.

Cleavage: $c(0001)$ perfect; prismatic, sometimes distinct. Fracture subconchoidal. Brittle. H. = 4–4·5. G. = 5·43–5·7. Luster subadamantine. Streak orange-yellow. Color deep red, also orange-yellow. Translucent to subtranslucent. Optically +.

Comp. — Zinc oxide, ZnO = Oxygen 19·7, zinc 80·3 = 100. Manganese protoxide is sometimes present.

Pyr., etc. — B.B. infusible; with the fluxes, on the platinum wire, gives reactions for manganese, and on charcoal in R.F. gives a coating of zinc oxide, yellow while hot, and white on cooling. The coating, moistened with cobalt solution and treated in O.F., assumes a green color. Soluble in acids.

Diff. — Characterized by its color, particularly that of the streak; by cleavage; by reactions B.B.

Artif. — Zincite is often formed as a furnace product. It is also produced when zinc chloride and water vapor act upon lime at red heat.

Obs. — Occurs with franklinite and willemite, at Sterling Hill near Ogdensburg, and at Mine Hill, Franklin Furnace, Sussex Co., N. J., sometimes in lamellar masses in pink calcite. Has been reported from Poland. A not uncommon furnace product.

Use. — An ore of zinc.

Massicot. Lead monoxide, PbO. Massive, scaly or earthy. Color yellow, reddish. Probably orthorhombic. Index, 1·735. Optically −.

Tenorite. Cupric oxide, CuO. In minute black scales with metallic luster; from Vesuvius. Also black earthy massive (*melaconite*); occurring with ores of copper as at Ducktown, Tenn., and Keweenaw Point, Lake Superior. Pitchy black material associated with cuprite, chrysocolla and malachite from Bisbee, Ariz., has been called *melanochalcite*.

Paramelaconite is essentially cupric oxide, CuO, occurring in black pyramidal crystals referred to the tetragonal system. From the Copper Queen mine, Bisbee, Ariz.

Montroydite. HgO. Orthorhombic. In minute highly modified crystals. H. = 1·5–2. Color and streak orange-red. Index, 2·55. Volatile. Found at Terlingua, Tex.

Hematite Group. R_2O_3. Rhombohedral

			rr'	c
Corundum	Al_2O_3		93° 56′	1·3630
Hematite	Fe_2O_3		94° 0′	1·3656
Ilmenite	$(Fe,Mg)O.TiO_2$	Tri-rhombohedral	94° 29′	1·3846
Pyrophanite	$MnO.TiO_2$	"	94° 5½′	1·3692

The HEMATITE GROUP embraces the sesquioxides of aluminium and iron. These compounds crystallize in the rhombohedral class, hexagonal system, with a fundamental rhombohedron differing but little in angle from a cube. Both the minerals belonging here, Hematite and Corundum, are *hard*.

To these species the titanates of iron (and magnesium) and manganese, Ilmenite and Pyrophanite, are closely related in form though belonging to the tri-rhombohedral class (phenacite type); in other words, the relation between hematite and ilmenite may be regarded as analogous to that between calcite and dolomite. It is to be noted, further, that hematite often contains titanium, and an artificial isomorphous compound, Ti_2O_3, has been described. Hence the ground for writing the formula of ilmenite $(Fe,Ti)_2O_3$, as is done by some authors. It is shown by Penfield, however, that the formula $(Fe,Mg)TiO_2$ is more correct.

CORUNDUM.

Rhombohedral. Axis $c = 1{\cdot}3630$.

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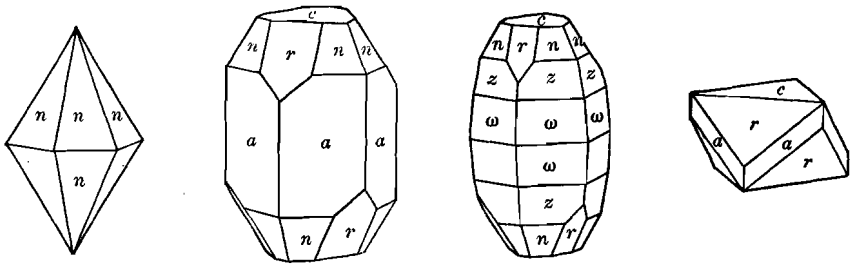

cr, $0001 \wedge 10\bar{1}1 = 57° 34'$.
cn, $0001 \wedge 22\bar{4}3 = 61° 11'$.
rr', $10\bar{1}1 \wedge \bar{1}101 = 93° 56'$.
nn', $22\bar{4}3 \wedge \bar{2}4\bar{2}3 = 51° 58'$.
vv', $44\bar{8}3 \wedge \bar{4}8\bar{4}3 = 57° 38'$.
zz', $22\bar{4}1 \wedge \bar{2}4\bar{2}1 = 58° 55'$.

Twins: tw. pl. $r(10\bar{1}1)$, sometimes penetration-twins; often polysynthetic, and thus producing a laminated structure. Crystals usually rough and rounded. Also massive, with nearly rectangular parting or pseudo-cleavage; granular, coarse or fine.

Parting: $c(0001)$, sometimes perfect, but interrupted; also $r(10\bar{1}1)$ due to twinning, often prominent; $a(11\bar{2}0)$ less distinct. Fracture uneven to conchoidal. Brittle, when compact very tough. H. = 9. G. = 3·95–4·10. Luster adamantine to vitreous; on c sometimes pearly. Occasionally showing asterism. Color blue, red, yellow, brown, gray, and nearly white; streak uncolored. Pleochroic in deeply colored varieties. Transparent to translucent. Normally uniaxial, negative; for sapphire $\omega = 1{\cdot}7676$ to $1{\cdot}7682$ and $\epsilon = 1{\cdot}7594$ to $1{\cdot}7598$. Often abnormally biaxial.

Var. — There are three subdivisions of the species prominently recognized in the arts, but differing only in purity and state of crystallization or structure.

Var. 1. Sapphire, Ruby. — Includes the purer kinds of fine colors, transparent to translucent, useful as gems. Stones are named according to their colors: *Sapphire* blue; true *Ruby*, or *Oriental Ruby*, red; *Oriental Topaz*, yellow; *Oriental Emerald*, green; *Oriental Amethyst*, purple. The term *sapphire* is also often used as a general term to indicate corundum gems of any color except red. A variety having a stellate opalescence when viewed in the direction of the vertical axis of the crystal is the *Asteriated* Sapphire or Star Sapphire.

2. Corundum. — Includes the kinds of dark or dull colors and not transparent, colors light blue to gray, brown, and black. The original *adamantine spar* from India has a dark grayish smoky brown tint, but greenish or bluish by transmitted light, when translucent.

3. Emery. — Includes granular corundum, of black or grayish black color, and contains magnetite or hematite intimately mixed. Sometimes associated with iron spinel or hercynite. Feels and looks much like a black fine-grained iron ore, which it was long considered to be. There are gradations from the evenly fine-grained emery to kinds in which the corundum is in distinct crystals.

Comp. — Alumina, Al_2O_3 = Oxygen 47·1, aluminium 52·9 = 100. The crystallized varieties are essentially pure; analyses of emery show more or less impurity, chiefly magnetite.

Artif. — Crystallized corundum has been produced artificially in a number of different ways. Alumina dissolved in molten sodium sulphide, in a fused mixture of a fluoride and potassium carbonate or in fused lead oxide, will separate out as crystallized corundum.

Gem material has been produced in this way, colored red, with a chromium salt, or blue by cobalt. Crystallized material can also be produced by fusing alumina in an electric arc. The artificial abrasive, *alundum*, is made by heating bauxite to 5000°–6000° in an electric furnace. Pear-shaped drops of gem material are made by fusing together small fragments of natural or artificial stones. Gems cut from them are known as "reconstructed" stones and have the crystalline and other physical properties of the natural mineral.

Pyr., etc. — B.B. unaltered; slowly dissolved in borax and salt of phosphorus to a clear glass, which is colorless when free from iron; not acted upon by soda. The finely pulverized mineral, after long heating with cobalt solution, gives a beautiful blue color. Not acted upon by acids, but converted into a soluble compound by fusion with potassium bisulphate.

Diff. — Characterized by its hardness (scratching quartz and topaz), by its adamantine luster, high specific gravity and infusibility. The massive variety with rhombohedral parting resembles cleavable feldspar but is much harder and denser.

Micro. — In thin sections appears nearly colorless with high relief and low interference colors.

Obs. — Usually occurs in crystalline rocks, as granular limestone or dolomite, gneiss, granite, mica slate, chlorite slate. The associated minerals often include some species of the chlorite group, as prochlorite, corundophilite, margarite, also tourmaline, spinel, cyanite, diaspore, and a series of aluminous minerals, in part produced from its alteration. Occasionally found as an original constituent of igneous rocks containing high percentages of alumina. In the Ural Mts. are found an anorthite rock containing nearly 60 per cent of corundum, a corundum syenite with 18 per cent, and a pegmatite with 35 per cent. A corundum anorthosite and corundum syenites are found in Canada. Important deposits of corundum in North Carolina and Georgia are associated with dunite rocks. Rarely observed as a contact-mineral. The fine sapphires are usually obtained from the beds of rivers, either in modified hexagonal prisms or in rolled masses, accompanied by grains of magnetite, and several kinds of gems, as spinel, etc. The emery of Asia Minor occurs in granular limestone.

The best rubies come from the mines in Upper Burma, north of Mandalay, in an area covering 25 to 30 square miles, of which Mogok is the center. The rubies occur *in situ* in crystalline limestone, also in the soil of the hillsides and in gem-bearing gravels of the Irrawaddy River. Blue sapphires are brought from Ceylon from the Ratnapura and Rakwena districts, often as rolled pebbles, also as well-preserved crystals. Corundum occurs in the Carnatic on the Malabar coast, on the Chantibun hills in Siam, and elsewhere in the East Indies; also near Canton, China; from Naegi, Mino, Japan. At St. Gothard, Switzerland, it occurs of a red or blue tinge in dolomite, and near Mozzo in Piedmont, Italy, in white compact feldspar. Adamantine spar is met with in large, coarse, hexagonal pyramids in Gellivara, Sweden. Other localities are in Bohemia, near Petschau, in Russia, in the Ilmen mountains, not far from Miask and in the gold-washings northeast of Zlatoust. Corundum, sapphires, and less often rubies occur in rolled pebbles in the diamond gravels on the Cudgegong river, at Mudgee and other points in New South Wales. Emery is found in large bowlders at Naxos, Nicaria, and Samos of the Grecian islands; also in Asia Minor, 12 m. E. of Ephesus, near Gumuchdagh and near Smyrna, associated with margarite, chloritoid, pyrite.

In North America, in Mass., at Chester, with magnetite, diaspore, ripidolite, margarite, etc., was mined for use as emery. In Conn. near Litchfield. In N. Y., at Warwick, bluish and pink, with spinel; Amity, in granular limestone; emery with magnetite and green spinel (hercynite) in Westchester Co., near Cruger's Station, and elsewhere. In N. J., at Newton, blue crystals in granular limestone; at Vernon, at Sparta and elsewhere in Sussex Co. In Pa., in Delaware Co., in Aston, near Village Green, in large crystals; at Mineral Hill, in loose crystals; in Chester Co., at Unionville, abundant in crystals; in large crystals loose in the soil at Shimersville, Lehigh Co. In Va., in the mica schists of Bull Mt., Patrick Co.

Common at many points along a belt extending from Virginia across western North and South Carolina and Georgia to Dudleyville, Alabama; especially in Madison, Buncombe, Haywood, Jackson, Macon, Clay, and Gaston counties in N. C. The localities at which most work has been done are the Culsagee mine, Corundum hill, near Franklin, Macon Co., N. C., and 26 miles S. E. of this, at Laurel Creek, Ga. The corundum occurs in beds in chrysolite (and serpentine) and hornblendic gneiss, associated with a species of the chlorite group, also spinel, etc., and here as elsewhere with many minerals resulting from its alteration. Some fine rubies have been found. Fine pink crystals of corundum occur at Hia-

wassee, Towns Co., Ga. In Col., small blue crystals occur in mica schist near Salida, Chaffee Co. Gem sapphires are found near Helena, Mon., in gold-washings and in bars in the Missouri river, especially the Eldorado bar; at Yogo Gulch on the Judith river and at other points in the state. These latter occur embedded in an igneous dike that cuts through the limestone formation. In Cal., in Los Angeles Co., in the drift of San Francisqueto Pass. In Canada, at Burgess, Ontario, red and blue crystals; in a syenite from Renfrew Co., Ontario.

Use. — Clear varieties of corundum form valuable gem stones as noted above. Also formerly largely used as an abrasive; at present various artificial abrasives are mostly used instead.

HEMATITE.

Rhombohedral. Axis $c = 1{\cdot}3656$.

cr, $0001 \wedge 10\bar{1}1 = 57° 37'$.	uu', $10\bar{1}4 \wedge \bar{1}104 = 37° 2'$.
rr', $10\bar{1}1 \wedge \bar{1}101 = 94° 0'$.	nn', $2\bar{2}43 \wedge \bar{2}4\bar{2}3 = 51° 59'$.
dd', $01\bar{1}2 \wedge \bar{1}012 = 64° 51'$.	cn, $0001 \wedge 2\bar{2}43 = 61° 13'$.

Twins: tw. pl. (1) $c(0001)$, penetration-twins; (2) $r(01\bar{1}2)$, less common, usually as polysynthetic twinning lamellæ, producing a fine striation on $c(0001)$, and giving rise to a distinct parting or pseudo-cleavage $\|$ $r(10\bar{1}1)$. Crystals often thick to thin tabular $\|$ c, and grouped in parallel position or in rosettes; c faces striated $\|$ edge c/d $(01\bar{1}2)$ and other forms due to oscillatory combination; also in cube-like rhombohedrons; rhombohedral faces $u(10\bar{1}4)$ horizontally striated and often rounded over in convex forms. Also columnar to granular, botryoidal, and stalactitic shapes; also lamellar, laminæ joined parallel to c, and variously bent, thick or thin; also granular, friable, earthy or compact.

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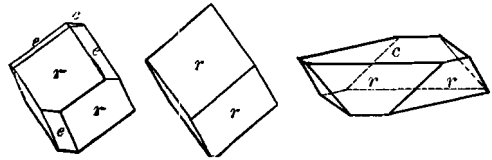

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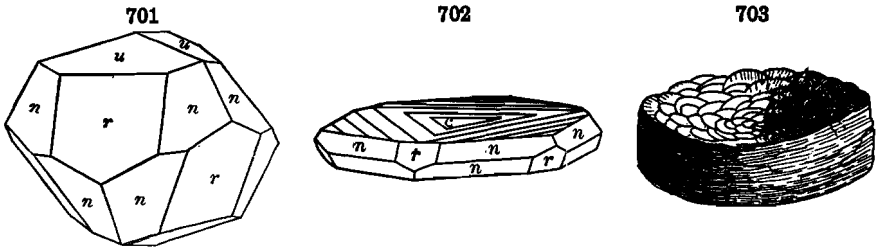


Parting: $c(0001)$, due to lamellar structure; also $r(10\bar{1}1)$, caused by twinning. Fracture subconchoidal to uneven. Brittle in compact forms; elastic in thin laminæ; soft and unctuous in some loosely adherent scaly varieties. H. = 5·5–6·5. G. = 4·9–5·3; of crystals mostly 5·20–5·25; of some compact varieties, as low as 4·2. Luster metallic and occasionally splendent; sometimes dull. Color dark steel-gray or iron-black; in very thin particles blood-red by transmitted light; when earthy, red. Streak cherry-red or reddish brown. Opaque, except when in very thin laminæ.

Var. 1. *Specular.* Luster metallic, and crystals often splendent, whence the name *specular iron.* When the structure is foliated or micaceous, the ore is called *micaceous* hematite: some of the micaceous varieties are soft and unctuous. Some varieties are magnetic, but probably from admixed magnetite (Arts. **441, 443**).

2. *Compact Columnar;* or fibrous. The masses often long radiating; luster submetallic to metallic; color brownish red to iron-black. Sometimes called *red hematite*, to contrast it with limonite and turgite. Often in reniform masses with smooth fracture, called *kidney ore*.

3. *Red Ocherous.* Red and earthy. *Reddle* and *red chalk* are red ocher, mixed with more or less clay.

4. *Clay Iron-stone; Argillaceous hematite.* Hard, brownish black to reddish brown, often in part deep red; of submetallic to nonmetallic luster; and affording, like all the preceding, a red streak. It consists of oxide of iron with clay or sand, and sometimes other impurities.

Comp. — Iron sesquioxide, Fe_2O_3 = Oxygen 30, iron 70 = 100. Sometimes contains titanium and magnesium, and is thus closely related to ilmenite, p. 417.

Pyr., etc. — B.B. infusible; on charcoal in R.F. becomes magnetic; with borax gives the iron reactions. With soda on charcoal in R.F. is reduced to a gray magnetic powder. Slowly soluble in hydrochloric acid.

Diff. — Distinguished from magnetite by its *red streak*, also from limonite by the same means, as well as by its not containing water; from turgite by its greater hardness and by not decrepitating B.B. It is *hard* in all but some micaceous varieties (hence easily distinguished from the black sulphides); also *infusible*, and B.B. becomes strongly magnetic.

Micro. — In polished sections shows white color with a shining, pitted surface. Unaffected by reagents.

Artif. — Crystals of hematite have been made by decomposing ferric chloride by steam at a high temperature; also by the action of heated air and hydrochloric acid upon iron. Hematite has been crystallized from various artificial magmas, which must contain little or no ferrous iron.

Obs. — This ore occurs in rocks of all ages. The specular variety is mostly confined to crystalline or metamorphic rocks, but is also a result of igneous action about some volcanoes, as at Vesuvius. Many of the geological formations contain the argillaceous variety or clay iron-stone, which is mostly a marsh-formation, or a deposit over the bottom of shallow, stagnant water; but this kind of clay iron-stone (that giving a red powder) is less common than the corresponding variety of limonite. The beds that occur in metamorphic rocks are sometimes of very great thickness, and, like those of magnetite in the same situation, have resulted from the alteration of stratified beds of ore, originally of marsh origin, which were formed at the same time with the enclosing rocks, and underwent metamorphism, or a change to the crystalline condition, at the same time.

Beautiful crystallizations of this species are brought from the island of Elba, which has afforded it from a very remote period; the surfaces of the crystals often present an irised tarnish and brilliant luster. St. Gothard in Switzerland affords beautiful specimens, composed of crystallized tables grouped in the form of rosettes; near Limoges, France, in large crystals; fine crystals are the result of volcanic action at Etna and Vesuvius. Arendal in Norway, Långban and Nordmark in Sweden; Dognácska, Hungary; Framont in Lorraine, Dauphiné, France; Binnental and Tavetsch, Switzerland; also Cleator Moor in Cumberland, and Minas Geraes, Brazil, afford splendid specimens. Crystals from Ascension Island and from Cernero do Campo, Brazil. Red hematite occurs in reniform masses of a fibrous concentric structure, near Ulverstone in Lancashire, in Saxony, Bohemia, and the Harz Mts., Germany.

In North America, widely distributed, and sometimes in beds of vast thickness in rocks of the Archæan age. Very extensive and important hematite deposits are found along the southern and northwestern shores of Lake Superior. The various districts are known as *ranges* and are located as follows: The Marquette and Menominee Ranges in northern Mich., the Penokee-Gogebic Range in Northern Wis., the Mesabi, Vermilion and Cuyuna Ranges in Minn. Another district, the Michipicoten, is farther north in Canada. The ore bodies are the results of the concentration in favorable localities of the iron content of the original sedimentary rocks. These rocks contained cherty iron carbonates, pyrite-bearing iron carbonates and ferrous silicates. The ore bodies vary widely in form, many of them lying in trough-like structures formed by the deformation of an impervious rock strata. The character of the ores varies from hard specular hematites to soft earthy ores. The latter are often mined by the use of steam shovels. Hematite is found in Wyoming in schist formations in Laramie and Carbon Counties.

In N. Y., in Oneida, Herkimer, Madison, Wayne Cos., a lenticular argillaceous variety, constituting one or two beds in the Clinton group of the Upper Silurian; the same in Pa., and as far south as Ala., and in Canada, and Wis., to the west; in Ala. there are extensive

beds; prominent mines are near Birmingham. Besides these regions of enormous beds, there are numerous others of workable value, either crystallized or argillaceous. Some of these localities, interesting for their specimens, are in northern N. Y., at Gouverneur, Antwerp, Hermon, Edwards, Fowler, Canton, etc.; Woodstock and Aroostook, Me.; at Hawley, Mass., a micaceous variety; in N. and S. C. a micaceou variety in schistose rocks, constituting the so-called *specular schist*, or *itabirite*. Hematite is mined in Nova Scotia and Newfoundland.

Named *hematite* from *αιμα, blood.*

Use. — The most important iron ore. Used also in red paints, as polishing rouge, etc.

MARTITE. Iron sesquioxide under an isometric form, occurring in octahedrons or dodecahedrons like magnetite, and believed to be pseudomorphous after magnetite; perhaps in part also after pyrite. Parting octahedral like magnetite. Fracture conchoidal. H. = 6–7. G. = 4·8–5·3. Luster submetallic. Color iron-black, sometimes with a bronzed tarnish. Streak reddish brown or purplish brown. Not magnetic, or only feebly so. The crystals are sometimes embedded in the massive sesquioxide. They are distinguished from magnetite by the red streak, and very feeble, if any, action on the magnetic needle. Found in the Marquette iron region south of Lake Superior, where crystals are common in the ore; Monroe, N. Y.; Twin Peaks, Milliard Co., Utah; Digby Co., N. S.; at the Cerro de Mercado, Durango, Mexico, in large octahedrons; in the schists of Minas Geraes, Brazil; near Rittersgrün, Saxony.

ILMENITE or MENACCANITE. Titanic Iron Ore.

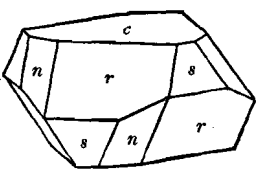
Tri-rhombohedral; Axis $c = 1{\cdot}3846$.

cr, $0001 \wedge 10\bar{1}1 = 57° 58\frac{1}{2}'$.
rr', $10\bar{1}1 \wedge \bar{1}101 = 94° 29'$.
cn, $0001 \wedge 22\bar{4}3 = 61° 33'$.

Crystals usually thick tabular; also acute rhombohedral. Often in thin plates or laminæ. Massive, compact; in embedded grains, also loose as sand.

Fracture conchoidal. H. = 5–6. G. = 4·5–5. Luster submetallic. Color iron-black. Streak submetallic, powder black to brownish red. Opaque. Influences slightly the magnetic needle.

704



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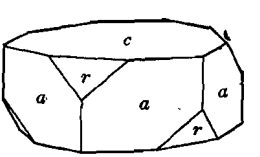


Comp. — If normal, $FeTiO_3$ or FeO,TiO_2 = Oxygen 31·6, titanium 31·6, iron 36·8 = 100. Sometimes written $(Fe,Ti)_2O_3$, but probably to be regarded as an iron titanate. Sometimes also contains magnesium (*picrotitanite*), replacing the ferrous iron; hence the general formula $(Fe,Mg)O.TiO_2$ (Penfield). (Compare *geikielite*, p. 586.)

Pyr., etc. — B.B. infusible in O.F., although slightly rounded on the edges in R.F. With borax and salt of phosphorus reacts for iron in O.F., and with the latter flux assumes a more or less intense brownish red color in R.F.; this treated with tin on charcoal changes to a violet-red color when the amount of titanium is not too small. The pulverized mineral, heated with hydrochloric acid, is slowly dissolved to a yellow solution, which, filtered from the undecomposed mineral and boiled with the addition of tin-foil, assumes a beautiful blue or violet color. Decomposed by fusion with bisulphate of sodium or potassium.

Diff. — Resembles hematite, but has a submetallic, nearly black, streak; not magnetic like magnetite.

Obs. — Occurs, as an accessory component, in many igneous rocks in grains, assuming the place of magnetite, especially in gabbros and diorites. In these occurrences, it is often found in veins or large segregated masses near the borders of the igneous rock where it is supposed to have formed by local differentiation or fractional crystallization in the molten mass. It is also found at times in metamorphic rocks. Some principal European localities are St. Cristophe, Dauphiné, France (*crichtonite*); Miask in the Ilmen Mts. (*ilmenite*); in

the form of sand at Menaccan, Cornwall (*menaccanite*); Gastein in Tyrol (*kibdelophane*); Binnental, Switzerland. One of the most remarkable is at Kragerö, Norway, where it occurs in veins or beds in diorite, which sometimes afford crystals weighing over 16 pounds. Others are Egersund, Arendal, Snarum in Norway; St. Gothard, Switzerland, etc.

Fine crystals, sometimes an inch in diameter, occur in Warwick, Amity, and Monroe, Orange Co., N. Y.; Litchfield, Conn. (*washingtonite*). Crystals from Chester and Quincy, Mass. Vast deposits or beds of titanic ore occur at Bay St. Paul in Quebec, Canada, in syenite; also in the Seigniory of St. Francis, Beauce Co. Grains are found in the gold sand of California.

The titanic iron of massive rocks is extensively altered to a dull white opaque substance, called *leucoxene* by Gümbel. This for the most part is to be identified with titanite.

Senaite. $(Fe,Mn,Pb)O.TiO_2$. Tri-rhombohedral. H. = 6. G. = 5·3. Color black. Streak brownish black. Found in the diamond-bearing sands of Diamantina, Brazil.

Arizonite. $Fe_2O_3.3TiO_2$. Monoclinic? Crystal faces rough. H. = 5·5. G. = 4·25. Color dark steel-gray. Streak brown. Decomposed by hot concentrated sulphuric acid. Found with gadolinite, 25 miles southeast of Hackberry, Ariz.

Pyrophanite. Manganese titanate, $MnTiO_3$. In thin tabular rhombohedral crystals and scales, near ilmenite in form (p. 417). H. = 5. G. = 4·537. Luster vitreous to submetallic. Color deep blood-red. Streak ocher-yellow. From the Harstig mine, Pajsberg, Sweden.

SITAPARITE. $9Mn_2O_3.4Fe_2O_3.MnO_2.3CaO$. Not crystallized. Good cleavage. H. = 7. G. = 5·0. Color deep bronze. Streak black. Weakly magnetic. Found at Sitapár, District Chhindwára, India.

VREDENBURGITE. $3Mn_3O_4.2Fe_2O_3$. Cleavage parallel to octahedron or tetragonal pyramid. H. = 6·5. G. = 4·8. Color bronze to dark steel-gray. Streak dark brown. Strongly magnetic. Completely soluble in acids. Found at Beldóngri, District Nágpur and at Gravidi, District Vizagapatam, India.

III. Intermediate Oxides

The species here included are retained among the oxides, although chemically considered they are properly oxygen-salts, aluminates, ferrates, manganates, etc., and hence in a strict classification to be placed in section 5 of the Oxygen-salts. The one well-characterized group is the Spinel Group.

Spinel Group. $\overset{II\ III}{RR_2O_4}$ or $\overset{II}{RO}.\overset{III}{R_2O_3}$. Isometric	
Spinel	$MgO.Al_2O_3$
Ceylonite	$(Mg,Fe)O.Al_2O_3$
Chlorospinel	$MgO.(Al,Fe)_2O_3$
Picotite	$(Mg,Fe)O.(Al,Cr)_2O_3$
Hercynite	$FeO.Al_2O_3$
Gahnite (Automolite)	$ZnO.Al_2O_3$
Dysluite	$(Zn,Fe,Mn)O.(Al,Fe)_2O_3$
Kreittonite	$(Zn,Fe,Mg)O.(Al,Fe)_2O_3$
Magnetite	$FeO.Fe_2O_3$
	$(Fe,Mg)O.Fe_2O_3$
Magnesioferrite	$MgO.Fe_2O_3$
Franklinite	$(Fe,Zn,Mn)O.(Fe,Mn)_2O_3$
Jacobsite	$(Mn,Mg)O.(Fe,Mn)_2O_3$
Chromite	$FeO.Cr_2O_3$
	$(Fe,Mg)O.(Cr,Fe)_2O_3$

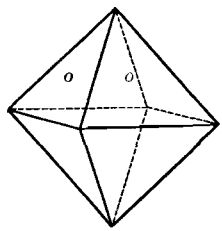
The species of the Spinel Group are characterized by isometric crystallization, and, further, the octahedron is throughout the common form. All of the species are *hard;* those with nonmetallic luster up to 7·5–8, the others from 5·5 to 6·5.

SPINEL.

Isometric. Usually in octahedrons, sometimes with dodecahedral truncations, rarely cubic. Twins: tw. pl. and comp. face $o(111)$ common (Fig. 707), hence often called *spinel-twins;* also repeated and polysynthetic, producing tw. lamellæ.

Cleavage: $o(111)$ imperfect. Fracture conchoidal. Brittle. H. = 8. G. = 3·5–4·1. Luster vitreous; splendent to nearly dull. Color red of various shades, passing into blue, green, yellow, brown and black; occasionally almost white. Streak white. Transparent to nearly opaque. Refractive index: $n = 1·7155$.

706



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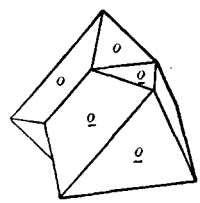


Comp. — Magnesium aluminate, $MgAl_2O_4$ or $MgO.Al_2O_3$ = Alumina 71·8, magnesia 28·2 = 100. The magnesium may be in part replaced by ferrous iron or manganese, and the aluminium by ferric iron and chromium.

Var. — Ruby Spinel or *Magnesia Spinel.* — Clear red or reddish; transparent to translucent; sometimes subtranslucent. G. = 3·63–3·71. Compo ition normal, with little or no iron, and sometimes chromium oxide to which the red color has been ascribed. The varieties are: (*a*) *Spinel-Ruby,* deep red; *b*) *Balas-Ruby,* rose-red; (*c*) *Rubicelle,* yellow or orange-red; (*d*) *Almandine,* violet.

Ceylonite or *Pleonaste, Iron-Magnesia Spinel.* — Color dark green, brown to black, mostly opaque or nearly so. G. = 3·5–3·6. Contains iron replacing the magnesium and perhaps also the aluminium, hence the formula $(Mg,Fe)O.Al_2O_3$ or $(Mg,Fe)O.(Al,Fe)_2O_3$.

Chlorospinel or *Magnesia-Iron Spinel.* — Color grass green, owing to the presence of copper. G. = 3·591–3·594. Contains iron replacing the aluminium, $MgO.(Al,Fe)_2O_3$.

Picotite or *Chrome-Spinel.* — Contains chromium and also has the magnesium largely repla ed by iron $(Mg,Fe)O.(Al,Cr)_2O_3$, hence lying be ween spinel prope and chromite. G. = 4·08. Color dark yellowish brown or greenish brown. Translucent to nearly opaque.

Pyr., etc. — B.B. alone infusible. Slowly soluble in borax, more readily in salt of phosphorus, with which it gives a reddish bead while hot, becoming faint chrome-green on cooling. Black varieties give reactions for iron with the fluxes. Soluble with difficulty in concentrated sulphuric acid. Decomposed by fusion with potassium bisulphate.

Diff. — Distinguished by its octahedral form, hardness, and infusibility; zircon has a higher specific gravity; the true ruby (p. 413) is harder and is distinguished optically; garnet is softer and fusible.

Micro. — In thin section shows light color and high relief. Isotropic.

Artif. — Artificial spinel crystals may be obtained by direct crystallization from the pure melt fused in the electric arc. They also form from melts of the oxides or fluorides of magnesium and aluminium dissolved in boric acid. The addition of chromium and iron oxides will produce various colors.

Obs. — Spinel occurs embedded in granular limestone, and with calcite in serpentine, gneiss, and allied rocks. Ruby spinel is a common associate of the true ruby. Common spinel is often associated with chondrodite. It also occupies the cavities of masses ejected from some volcanoes. Spinel (common spinel, also picotite and chromite, occurs as an accessory constituent in many basic igneous rocks especially those of the peridotite group; it is the result of the crystallization of a magma very low in silica, high in magnesia and containing alumina; since, as in many of the peridotites alkalies are absent, feldspars cannot form, and the Al_2O_3 and Cr_2O_3 (also Fe_2O_3 perhaps) are compelled to form spinel (or corundum). The serpentines which yield spinel are altered peridotites.

In Ceylon, in Siam, and other eastern countries, occurs with beautiful colors, as rolled pebbles; in upper Burma with the ruby (cf. p. 414). Pleonaste is found at Candy, in Ceylon; at Åker, in Sweden, a pale blue and pearl-gray variety in limestone; small black splendent crystals occur in the ancient ejected masses of Monte Somma, Vesuvius; also at Pargas, Finland, with chondrodite, etc.; in compact gehlenite at Monzoni, in the Fassa valley, Austria.

From Amity, N. Y., to Andover, N. J., a distance of about 30 miles, is a region of granular limestone and serpentine, in which localities of spinel abound; colors, green, black, brown, and less commonly red, along with chondrodite and other minerals. Localities are numerous about Warwick, and also at Monroe and Cornwall; Gouverneur, 2 m. N. and ¾ m. W. of Somerville, St. Lawrence Co.; green, blue, and occasionally red varieties occur at Bolton, Boxborough, etc., Mass. Franklin, N. J., affords crystals of various shades of black, blue, green, and red: Newton, Sterling, Sparta, Hamburgh and Vernon, N. J., are other localities. With the corundum of N. C. as at the Culsagee mine, near Franklin, Macon Co.; similarly at Dudleyville, Ala. Spinel ruby at Gold Bluff, Humboldt Co., Cal.

Good black spinel is found in Burgess, Ontario; a bluish spinel having a rough cubic form occurs at Wakefield, Ottawa Co.; blue with clintonite at Daillebout, Joliette Co., Quebec.

Use. — The colored transparent varieties are used as gems.

Hercynite. Iron Spinel, $FeAl_2O_4$. Isometric; massive, fine granular. H. = 7·5–8. G. = 3·91–3·95. Color black. From Ronsberg, at the eastern foot of the Böhmerwald, Bohemia. A related iron-alumina spinel, with about 9 p. c. MgO, occurs with magnetite and corundum in Cortlandt township, Westchester Co., N. Y. From the tin drift, Moorina, Tasmania.

GAHNITE. Zinc-Spinel.

Isometric. Habit octahedral, often with faces striated || edge between dodecahedron and octahedron; also less commonly in dodecahedrons and modified cubes. Twins: tw. pl. $o(111)$.

Cleavage: $o(111)$ indistinct. Fracture conchoidal to uneven. Brittle. H. = 7·5–8. G. = 4·0–4·6. n_{gr} = 1·82 (Finland). Luster vitreous, or somewhat greasy. Color dark green, grayish green, deep leek-green, greenish black, bluish black, yellowish, or grayish brown; streak grayish. Subtransparent to nearly opaque.

Comp. — Zinc aluminate, $ZnAl_2O_4$ = Alumina 55·7, zinc oxide 44·3 = 100. The zinc is sometimes replaced by manganese or ferrous iron, the aluminium by ferric iron.

Var. — Automolite, or *Zinc Gahnite.* — $ZnAl_2O_4$, with sometimes a little iron. G. = 4·1–4·6. Colors as above given.

Dysluite, or *Zinc-Manganese-Iron Gahnite.* — $(Zn,Fe,Mn)O.(Al,Fe)_2O_3$. Color yellowish brown or grayish brown. G. = 4–4·6.

Kreittonite, or *Zinc-Iron Gahnite.* — $(Zn,Fe,Mg)O.(Al,Fe)_2O_3$. In crystals, and granular massive. H. = 7–8. G. = 4·48–4·89. Color velvet-black to greenish black; powder grayish green. Opaque.

Pyr., etc. — Gives a coating of zinc oxide when treated with a mixture of borax and soda on charcoal; otherwise like spinel.

Obs. — Occurs at Falun and Färila parish, Helsingland, Sweden (*automolite*); Träskböle, Finland; at Tiriola, Calabria, Italy; at Bodenmais, Bavaria (*kreittonite*); Minas Geraes, Brazil; Ambatofisikely, Madagascar. In the United States, at Franklin Furnace, N. J., with franklinite and willemite; also at Sterling Hill, N. J. (*dysluite*); with pyrite at Rowe, Mass.; at a feldspar quarry in Delaware Co., Pa.; sparingly at the Deake mica mine, Mitchell Co., N. C.; at the Canton Mine, Ga.; with galena, chalcopyrite, pyrite at the Cotopaxi mine, Chaffee Co., Col. In Canada at Raglan, Renfrew Co., Ontario.

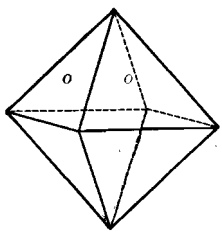
Named after the Swedish chemist Gahn. The name *Automolite,* of Ekeberg, is from *αὐτόμολος, a deserter,* alluding to the fact of the zinc occurring in an unexpected place.

MAGNETITE. Magnetic Iron Ore.

Isometric. Most commonly in octahedrons, also in dodecahedrons with faces striated || edge between dodecahedron and octahedron (Fig. 710); in dendrites between plates of mica; crystals sometimes highly modified; cubic

forms rare. Twins: tw. pl. *o*(111), sometimes as polysynthetic twinning lamellæ, producing striations on an octahedral face and often a pseudo-cleavage (Fig. 474, p. 176). Massive with laminated structure; granular, coarse or fine; impalpable.

708



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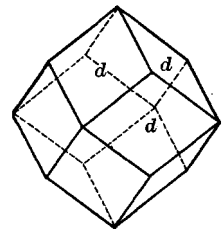

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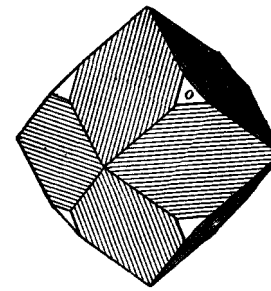
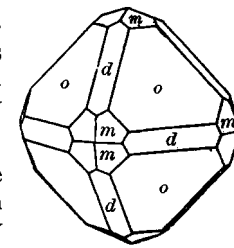


Cleavage not distinct; parting octahedral, often highly developed. Fracture subconchoidal to uneven. Brittle. H. = 5·5–6·5. G. = 5·168–5·180, crystals. Luster metallic and splendent to submetallic and rather dull. Color iron-black. Streak black. Opaque, but in thin dendrites in mica nearly transparent and pale brown to black. Strongly magnetic; sometimes possessing polarity (lodestone).

711



Comp. — $\overset{II}{Fe}\overset{III}{Fe_2}O_4$ or $FeO.Fe_2O_3$ = Iron sesquioxide 69.0, iron protoxide 31·0 = 100; or, Oxygen 27·6, iron 72·4 = 100. The ferrous iron sometimes replaced by magnesium, and rarely nickel; also sometimes contains titanium (up to 6 p. c. TiO_2).

Var. — *Ordinary.* — (*a*) In crystals. (*b*) Massive, with pseudo-cleavage, also granular, coarse or fine. (*c*) As loose sand. (*d*) Ocherous: a black earthy kind. Ordinary magnetite is attracted by a magnet but has no power of attracting particles of iron itself. The property of polarity which distinguishes the *lodestone* (less properly written loadstone) is exceptional.

Magnesian. — G. = 4·41–4·42; luster submetallic; weak magnetic; in crystals from Sparta, N. J., and elsewhere.

Manganesian. — Containing 3·8 to 6·3 p. c. manganese (*Manganmagnetite*). From Vester Silfberg, Sweden.

Pyr., etc. — B.B. very difficultly fusible. In O.F. loses its influence on the magnet. With the fluxes reacts like hematite. Soluble in hydrochloric acid and solution reacts for both ferrous and ferric iron.

Diff. — Distinguished from other members of the spinel group, as also from garnet, by its being attracted by the magnet, as well as by its high specific gravity; franklinite and chromite are only feebly magnetic (if at all), and have a brown or blackish brown streak; also, when massive, by its black streak from hematite and limonite; much harder than tetrahedrite.

Micro. — In polished sections shows white color with a shining, pitted surface. With conc. HCl slowly turns brown.

Artif. — Magnetite is frequently formed as a furnace product. It is easily formed in artificial magmas when they are low in the percentage of silica. It is formed by the breaking down of various minerals or by interreactions among minerals in processes similar to those of contact metamorphism.

Obs. — Magnetite is mostly confined to crystalline rocks, and is most abundant in metamorphic rocks, though widely distributed also in grains in eruptive rocks. It is found most abundantly in the ferro-magnesian rocks, occurring at times in large segregated

masses. These are often highly titaniferous. In the Archæan rocks the beds are of immense extent, and occur under the same conditions as those of hematite. It is an ingredient in most of the massive variety of corundum called emery. The earthy magnetite is found in bogs like bog-iron ore. Occurs in meteorites, and forms the crust of meteoric irons.

Present in dendrite-like forms in the mica of many localities following the direction of the lines of the percussion-figure, and perhaps of secondary origin. A common alteration-product of minerals containing iron protoxide, *e.g.*, present in veins in the serpentine resulting from altered chrysolite.

The beds of ore at Arendal, Norway, and nearly all the celebrated iron mines of Sweden, consist of massive magnetite, as at Dannemora and the Täberg in Småland. Falun, in Sweden, and Corsica, afford octahedral crystals, embedded in chlorite slate. Splendid dodecahedral crystals occur at Nordmark in Wermland. The most powerful native magnets are found in Siberia, and in the Harz Mts., Germany; they are also obtained on the island of Elba. Other localities for the crystallized mineral are Traversella in Piedmont, Italy; Achmatovsk in the Ural Mts.; Scalotta, near Predazzo, at Rothenkopf and Wildkreuzjoch, Austrian Tyrol; the Binnental, Switzerland; Sannatake, Bufen, Japan.

In North America, it constitutes vast beds in the Archæan, in the Adirondack region, Warren, Essex, and Clinton Cos., in Northern N. Y., while in St. Lawrence Co. the iron ore is mainly hematite; fine crystals and masses showing broad parting surfaces and yielding large pseudo-crystals are obtained at Port Henry, Essex Co.; similarly in N J.; in Canada, in Hull, Greenville, Madoc, etc.; at Cornwall in Pa., and Magnet Cove, Ark. It occurs also in N. Y., in Saratoga, Herkimer, Orange, and Putnam Cos.; at the Tilly Foster iron mine, Brewster, Putnam Co., in crystals and massive accompanied by chondrodite, etc. In N. J., at Hamburg, near Franklin Furnace and elsewhere. In Pa., at Goshen, Chester Co., and at the French Creek mines; delineations forming hexagonal figures in mica at Pennsbury. Good lodestones are obtained at Magnet Cove, Ark. In Cal., in Sierra Co., abundant, massive, and in crystals; in Plumas Co.; and elsewhere. In Wash., in large deposits. In crystals from Millard Co., Utah. Fine crystals from Fiormeza, Cuba.

Named from the loc. *Magnesia* bordering on Macedonia. But Pliny favors Nicander's derivation from Magnes, who first discovered it, as the fable runs, by finding, on taking his herds to pasture, that the nails of his shoes and the iron ferrule of his staff adhered to the ground.

Use. — An important ore of iron.

FRANKLINITE.

Isometric. Habit octahedral; edges often rounded, and crystals passing into rounded grains. Massive, granular, coarse or fine to compact.

Pseudo-cleavage, or parting, octahedral, as in magnetite. Fracture conchoidal to uneven. Brittle. H. = 5·5–6·5. G. = 5·07–5·22. Luster metallic, sometimes dull. Color iron-black. Streak reddish brown or black. Opaque. Slightly magnetic.

Comp. — $(Fe,Zn,Mn)O.(Fe,Mn)_2O_3$, but varying rather widely in the relative quantities of the different metals present, while conforming to the general formula of the spinel group.

Pyr., etc.—B.B. infusible. With borax in O.F. gives a reddish amethystine bead (manganese), and in R.F. this becomes bottle-green (iron). With soda gives a bluish green manganate, and on charcoal a faint coating of zinc oxide, which is much more marked when a mixture with borax and soda is used. Soluble in hydrochloric acid, sometimes with evolution of a small amount of chlorine.

Diff. — Resembles magnetite, but is only slightly attracted by the magnet, and has a dark brown streak; it also reacts for zinc on charcoal B.B.

Obs. — In Germany occurs in cubic crystals near Eibach in Nassau; in amorphous masses at Altenberg, near Aix-la-Chapelle. Abundant at Mine Hill, Franklin Furnace, N. J., with willemite and zincite in granular limestone; also at Sterling Hill, two miles distant, associated with willemite.

Use. — An ore of zinc.

Magnesioferrite. Magnoferrite. $MgFe_2O_4$. In octahedrons. H. = 6–6·5 G. = 4·568–4·654. Luster, color, and streak as in magnetite. Strongly magnetic. Formed about the fumaroles of Vesuvius, and especially those of the eruption of 1855; also found at Mont Dore, France.

Jacobsite. $(Mn,Mg)O.(Fe,Mn)_2O_3$. Isometric; in distorted octahedrons. H. = 6. G. = 4·75. Color deep black. Magnetic. From Jakobsberg, in Nordmark, Wermland, and at Långban, Sweden. Reported from Bulgaria.

CHROMITE.

Isometric. In octahedrons. Commonly massive; fine granular to compact. Fracture uneven. Brittle. H. = 5·5. G. = 4·32–4·57. Luster submetallic to metallic. Color between iron-black and brownish black, but sometimes yellowish red in very thin sections. Streak brown. Translucent to opaque. Sometimes feebly magnetic.

Comp. — $FeCr_2O_4$ or $FeO.Cr_2O_3$ = Chromium sesquioxide 68·0, iron protoxide 32·0 = 100.

The iron may be replaced by magnesium; also the chromium by aluminium and ferric iron. The varieties containing but little chromium (up to 10 p. c.) are hardly more than varieties of spinel and are classed under picotite, p. 419.

Pyr., etc. — B.B. in O.F. infusible; in R.F. slightly rounded on the edges, and becomes magnetic. With borax and salt of phosphorus gives beads which, while hot, show only a reaction for iron, but on cooling become chrome-green; the green color is heightened by fusion on charcoal with metallic tin. Not acted upon by acids, but decomposed by fusion with potassium or sodium bisulphate.

Diff. — Distinguished from magnetite by feeble magnetic properties, streak and by yielding the reaction for chromic acid with the blowpipe.

Artif. — Chromite can be prepared artificially by fusing together chromic, ferric and boric oxides.

Obs. — Occurs in peridotite rocks and the serpentines derived from them, forming veins, or in embedded masses. It is one of the earliest minerals to crystallize in a cooling magma and its large ore bodies are probably formed during the solidification of the rock by the process of magmatic differentiation. It assists in giving the variegated color to verde-antique marble. Not uncommon in meteoric irons, sometimes in nodules as in the Coahuila iron, less often in crystals (Lodran).

Occurs in the Gulsen mountains, near Kraubat in Styria; in crystals in the islands of Unst and Fetlar, in Shetland; in the province of Trondhjem in Norway; in the Department du Var in France; in Silesia and Bohemia; abundant in Asia Minor; in the Eastern and Western Ural Mts.; in New Caledonia, affording ore for commerce.

In Md. at Baltimore, in the Bare Hills, in veins or masses in serpentine; also in Montgomery Co., etc. In Pa., Chester Co., near Unionville, abundant; at Wood's Mine, near Texas, Lancaster Co., very abundant. Massive and in crystals at Hoboken, N. J., in serpentine and dolomite. In various localities in N. C. In the southwestern part of the town of New Fane, etc., Vt. A magnesian variety (*mitchellite*) from Webster, N. C. In Cal., in Monterey Co.; also Santa Clara Co., near the New Almaden mine.

Use. — An ore of chromium; used in refractory bricks for metallurgical furnace linings; as source of certain red and yellow pigments and dyes.

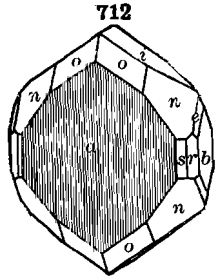
CHROMITITE. Material in minute octahedral crystals occurring in sand at Zeljin Mt., Servia, said to have composition, $FeCrO_3$.

CHRYSOBERYL. Cymophane.

Orthorhombic. Axes $a : b : c$ = 0·4701 : 1 : 0·5800.

mm''',	$110 \wedge 1\bar{1}0$ =	50° 21′.
ss',	$120 \wedge \bar{1}20$ =	93° 32′.
xx',	$101 \wedge \bar{1}01$ =	101° 57′.
ii',	$011 \wedge 0\bar{1}1$ =	60° 14′.
$\rho\rho'$,	$031 \wedge 0\bar{3}1$ =	120° 14′.
oo',	$111 \wedge \bar{1}11$ =	93° 44′.
oo''',	$111 \wedge 1\bar{1}1$ =	40° 7′.
nn',	$121 \wedge \bar{1}21$ =	77° 43′.

712



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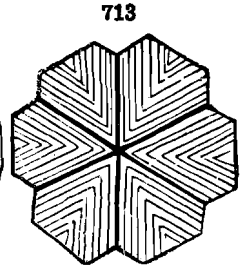


Twins: tw. pl. $\rho(031)$, both contact- and penetration-twins; often repeated and forming pseudo-hexagonal crystals with or without re-entrant

angles (Fig. 395, p. 164). Crystals generally tabular || $a(100)$. Face a striated vertically, in twins a feather-like striation (Fig. 713).

Cleavage: $i(011)$ quite distinct; $b(010)$ imperfect; $a(100)$ more so. Fracture uneven to conchoidal. Brittle. H. = 8·5. G. = 3·5–3·84. Luster vitreous. Color asparagus-green, grass-green, emerald-green, greenish white, and yellowish green; greenish brown; yellow; sometimes raspberry- or columbine-red by transmitted light. Streak uncolored. Transparent to translucent. Sometimes a bluish opalescence or chatoyancy, and asteriated. Pleochroic, vibrations || Y (= b axis) orange-yellow, Z (= c axis) emerald-green, X (= a axis) columbine-red. Optically +. Ax. pl. || $b(010)$. Bx. ⊥ $c(001)$. $\alpha = 1{\cdot}747$. $\beta = 1{\cdot}748$. $\gamma = 1{\cdot}757$. $2E = 84° 43'$.

Var. 1. *Ordinary.* — Color pale green, being colored by iron; also yellow and transparent and then used as a gem.

2. *Alexandrite.* — Color emerald-green, but columbine-red by transmitted light; valued as a gem. G. = 3·644, mean of results. Supposed to be colored by chromium. Crystals often very large, and in twins, like Fig. 395, either six-sided or six-rayed.

3. *Cat's-eye.* — Color greenish and exhibiting a fine chatoyant effect; from Ceylon.

Comp. — Beryllium aluminate, $BeAl_2O_4$ or $BeO.Al_2O_3$ = Alumina 80·2, glucina 19·8 = 100.

Pyr., etc. — B.B. alone unaltered; with soda, the surface is merely rendered dull. With borax or salt of phosphorus fuses with great difficulty. Ignited with cobalt solution, the powdered mineral gives a bluish color. Not attacked by acids.

Diff. — Distinguished by its extreme hardness, greater than that of topaz; by its infusibility; also characterized by its tabular crystallization, in contrast with beryl.

Obs. — In Minas Geraes, Brazil, in rolled pebbles; from Ceylon in pebbles and crystals; at Marschendorf in Moravia; in the Ural Mts., 85 versts from Ekaterinburg, in mica slate with beryl and phenacite, the variety *alexandrite;* in the Orenburg district, southern Ural Mts., yellow; in the Mourne Mts., Ireland.

In the United States at Haddam, Conn., in granite traversing gneiss, with tourmaline, garnet, beryl; at Greenfield, near Saratoga, N. Y., with tourmaline, garnet, and apatite; has been found in crystals in the rocks of New York City; in Me. at Norway, in granite with garnet and at Stoneham, with fibrolite, at Topsham, Buckfield and Greenwood.

Chrysoberyl is from *χρύσος, golden, βήρυλλος, beryl. Cymophane,* from *κῦμα, wave,* and *φαίνω, appear,* alludes to a peculiar opalescence the crystals sometimes exhibit. *Alexandrite* is after the Czar of Russia, Alexander I.

Use. — As a gem stone; see under **Var.** above.

Hausmannite. Mn_3O_4 or $MnO.Mn_2O_3$. In tetragonal octahedrons and twins (Fig. 414, p. 167); also granular massive, particles strongly coherent. H. = 5–5·5. G. = 4·856. Luster submetallic. Color brownish black. Streak chestnut-brown. Occurs near Ilmenau in Thuringia, Germany; Ilefeld in the Harz Mts., Germany; Filipstad, Långban, Nordmark, in Sweden; from Brazil.

Coronadite. $(Mn,Pb)Mn_3O_7$. Massive with delicate fibrous structure. H. = 4. G. = 5·2. Color black. Streak brownish black. Occurs in Coronado vein of the Clifton-Morenci district, Arizona. *Hollandite* is a similar manganate of manganese, barium and ferric iron from the *Káljlidongri manganese mine, Central India.*

Cesàrolite. $H_2PbMn_3O_8$. In cellular masses. Color, steel-gray. H. = 4·5. G. = 5·29. From Sidi-Amer-bers-Salem, Tunis.

Minium. Pb_3O_4 or $2PbO.PbO_2$. Pulverulent, as crystalline scales. G. = 4·6. Color vivid red, mixed with yellow; streak orange-yellow. Occurs in Germany at Bleialf in the Eifel; Badenweiler in Baden, etc.

Crednerite. $Cu_3Mn_4O_9$ or $3CuO.2Mn_2O_3$. Foliated crystalline. H. = 4·5. G. = 4·9–5·1. Luster metallic. Color iron-black to steel-gray. Streak black, brownish. From Friedrichroda, Germany.

Pseudobrookite. Probably $Fe_4(TiO_4)_3$. Usually in minute orthorhombic crystals, tabular || $a(100)$ and often prismatic || the macro-axis. G. = 4·4–4·98. Color dark brown to black. Streak ocher-yellow. Found with hypersthene (szaboite) in cavities of the andesite of Aranyer Berg, Transylvania, and elsewhere; on recent lava (1872) from Vesuvius; at Havredal, Bamle, Norway, embedded in kjerulfine (wagnerite) altered to apatite.

BRAUNITE.

Tetragonal. Axis $c = 0{\cdot}9850$. Commonly in octahedrons, nearly isometric in angle (pp' 111 $\wedge$ 1$\bar{1}$1 = 70° 7′). Also massive.

Cleavage : $p(111)$ perfect. Fracture uneven to subconchoidal. Brittle. H. = 6–6·5. G. = 4·75–4·82. Luster submetallic. Color and streak, dark brownish black to steel-gray.

Comp. — $3Mn_2O_3.MnSiO_3$ = Silica 10·0, manganese protoxide 11·7, manganese sesquioxide 78·3 = 100.

Pyr., etc. — B.B. infusible. With borax and salt of phosphorus gives an amethystine bead in O.F., becoming colorless in R.F. With soda gives a bluish green bead. Dissolves in hydrochloric acid leaving a residue of gelatinous silica. Marceline gelatinizes with acids.

Obs. — Occurs in veins traversing porphyry, at Oehrenstock, near Ilmenau, Thuringia, and near Ilefeld in the Harz Mts., Germany; St. Marcel in Piedmont, Italy; at Elba; at Botnedal, Upper Tellemark, in Norway; at the manganese mines of Jakobsberg, also at Långban, and at the Sjö mine, Grythyttan, Orebro, Sweden. *Marceline* (heterocline) from St. Marcel, Piedmont, is impure braunite.

Bixbyite. Essentially $FeO.MnO_2$. In black isometric crystals. H. = 6–6·5. G. = 4·945. Occurs with topaz in cavities in rhyolite; from Utah.

IV. Dioxides, RO_2.

Rutile Group. Tetragonal

		c			c
Cassiterite	SnO_2	0·6723	**Rutile**	TiO_2	0·6442
Polianite	MnO_2	0·6647	**Plattnerite**	PbO_2	0·6764

The Rutile Group includes the dioxides of the elements tin, manganese, titanium, and lead. These compounds crystallize in the tetragonal system with closely similar angles and axial ratio; furthermore in habit and method of twinning there is much similarity between the two best known species included here. Chemically these minerals are sometimes considered as salts of their respective acids, as stannyl metastannate, $(SnO)SnO_3$, for cassiterite and titanyl metatitanate, $(TiO)TiO_3$, for rutile.

With the Rutile Group is also sometimes included Zircon. ZrO_2SiO_2; $c = 0{\cdot}6404$. In this work, however, Zircon is classed among the silicates, with the allied species Thorite, $ThO_2.SiO_2$, $c = 0{\cdot}6402$.

A tetragonal form, approximating closely to that of the species of the Rutile Group, belongs also to a number of other species, as Xenotime, YPO_4; Sellaite, MgF_2; Tapiolite, $Fe(Ta,Nb)_2O_6$.

It may be added that ZrO_2, as the species Baddeleyite, crystallizes in the monoclinic system.

CASSITERITE. Tin-stone, Tin Ore

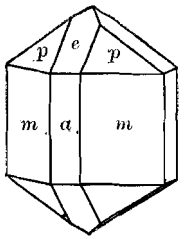
Tetragonal. Axis $c = 0{\cdot}6723$.

ee', 101 $\wedge$ 011 = 46° 28′.	ms, 110 $\wedge$ 111 = 46° 27′.
ee'', 101 $\wedge$ $\bar{1}$01 = 67° 50′.	zz', 321 $\wedge$ 231 = 20° 53½′
ss', 111 $\wedge$ $\bar{1}$11 = 58° 19′.	zz^{VII}, 321 $\wedge$ 3$\bar{2}$1 = 61° 42′.
ss'', 111 $\wedge$ 1$\bar{1}$1 = 87° 7′	

Twins common: tw. pl. $e(101)$; both contact- and penetration-twins (Fig. 717); often repeated. Crystals low pyramidal; also prismatic and acutely terminated. Often in reniform shapes, structure fibrous divergent; also massive, granular or impalpable; in rolled grains.

Cleavage: $a(100)$ imperfect; $s(111)$ more so; $m(110)$ hardly distinct. Fracture subconchoidal to uneven. Brittle. H. = 6–7. G. = 6·8–7·1. Luster adamantine, and crystals usually splendent. Color brown or black; some-

714



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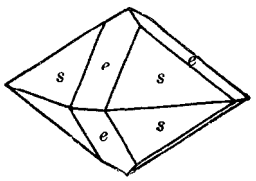

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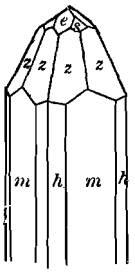

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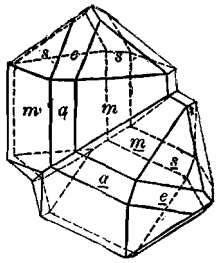


times red, gray, white, or yellow. Streak white, grayish, brownish. Nearly transparent to opaque. Optically +. Indices: $\omega = 1{\cdot}9966$, $\epsilon = 2{\cdot}0934$.

Var. — *Ordinary.* Tin-stone. In crystals and massive.

Wood-tin. In botryoidal and reniform shapes, concentric in structure, and radiated fibrous internally, although very compact, with the color brownish, of mixed shades, looking somewhat like dry wood in its colors. *Toad's-eye tin* is the same, on a smaller scale. *Stream-tin* is the ore in the state of sand, as it occurs along the beds of streams or in gravel.

Comp. — Tin dioxide, SnO_2 = Oxygen 21·4, tin 78·6 = 100. A little Ta_2O_5 is sometimes present, also Fe_2O_3.

Pyr., etc. — B.B. alone unaltered. On charcoal with soda reduced to metallic tin, and gives a white coating. With the fluxes sometimes gives reactions for iron and manganese. Only slightly acted upon by acids.

Diff. — Distinguished by its high specific gravity, hardness, infusibility, and by its yielding metallic tin B.B.; resembles some varieties of garnet, sphalerite, and black tourmaline. Specific gravity (6·5) higher than that of rutile (4); wolframite is easily fusible.

Artif. — Cassiterite has been artificially prepared by the action of aqueous vapor upon tin tetrachloride in a heated tube and by other similar methods employing heated vapors.

Obs. — Cassiterite has been noted as an original constituent of igneous rocks but usually it occurs in veins traversing granite, rhyolite, quartz porphyry, pegmatite, gneiss, mica schist, chlorite or clay schist; also in finely reticulated veins forming the ore-deposits called stockworks, or simply impregnating the enclosing rock. It is most commonly found in quartz veins traversing granite, accompanied by minerals containing boron and fluorine which indicates a pneumatolytic origin. The commonly associated minerals are quartz, wolframite, scheelite; also mica, topaz, tourmaline, apatite, fluorite; further pyrite, arsenopyrite, sphalerite; molybdenite, native bismuth, etc.

Formerly very abundant, now less so, in Cornwall, in fine crystals, and also as *wood-tin* and *stream-tin;* in Devonshire, near Tavistock and elsewhere; in pseudomorphs after feldspar at Wheal Coates, near St. Agnes, Cornwall; in fine crystals, often twins, at Schlackenwald, Graupen, Joachimstal, Zinnwald, etc., in Bohemia, and at Ehrenfriedersdorf, Altenberg, etc., in Saxony; at Limoges, France, in splendid crystals; Sweden, at Finbo; Finland, at Pitkäranta.

In the East Indies, on the Malay peninsula of Malacca and the neighboring islands, Banca, and Bilitong near Borneo. In New South Wales abundant over an area of 8500 sq. miles, also in Victoria, Queensland and Tasmania. In Bolivia in veins containing silver, lead, and bismuth; Mexico, in Durango, Guanajuato, Zacatecas, Jalisco.

In the United States, in Me., sparingly at Paris, Hebron, etc. In Mass., at Chesterfield and Goshen, rare. In N. H., at Jackson. In Va., on Irish Creek, Rockbridge Co., with wolframite, etc. In N. C. and S. C. In Ala., in Coosa Co. In S. D., near Harney Peak and near Custer City in the Black Hills, where it has been mined. In Wy., in Crook Co.; in Mon., near Dillon. In Cal., in San Bernardino Co., at Temescal. Has been mined in the York district, Seward Peninsula, Alaska.

Use. — The most important ore of tin.

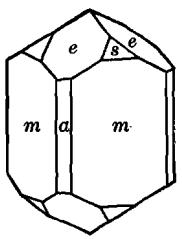
Polianite. Manganese dioxide, MnO_2. In composite parallel groupings of minute crystals; also forming the outer shell of crystals having the form of manganite. H. = 6–6·5. G. = 4·992. Luster metallic. Color light steel-gray or iron-gray. Streak black. From Platten, Bohemia. It is distinguished from pyrolusite by its hardness and its anhydrous character. Like pyrolusite it is often a pseudomorph after manganite.

RUTILE.

Tetragonal. Axis $c = 0{\cdot}64415$.

ll^{VII}, $310 \wedge 3\bar{1}0 = 36° 54'$.
ee', $101 \wedge 011 = 45° 2'$.
ee'', $101 \wedge \bar{1}01 = 65° 34\frac{1}{2}'$.
ss', $111 \wedge \bar{1}11 = 56\ 25\frac{1}{2}'$.
ss'', $111 \wedge \bar{1}\bar{1}1 = 84° 40'$.
tt', $313 \wedge 133 = 29° 6'$.

718



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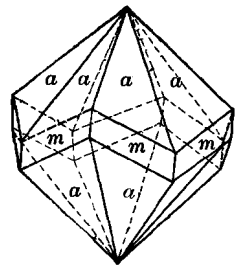

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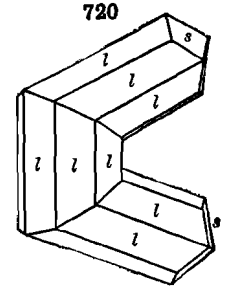


Twins: tw. pl. (1) $e(101)$; often geniculated (Figs. 720, 721); also contact-twins of very varied habit, sometimes sixlings and eightlings (Fig. 399, p. 164; Fig. 413, p. 166). (2) $v(301)$ rare, contact-twins (Fig. 415, p. 167). Crystals commonly prismatic, vertically striated or furrowed; often slender acicular. Occasionally compact, massive.

721

Cleavage: $a(100)$ and $m(110)$ distinct; $s(111)$ in traces. Fracture subconchoidal to uneven. Brittle. H. = 6–6·5. G. = 4·18–4·25; also to 5·2. Luster metallic-adamantine. Color reddish brown, passing into red; sometimes yellowish, bluish, violet, black, rarely grass-green; by transmitted light deep red. Streak pale brown. Transparent to opaque. Optically +. Refractive indices high: $\omega = 2{\cdot}6158$, $\epsilon = 2{\cdot}9029$. Birefringence very high. Sometimes abnormally biaxial.

Comp. — Titanium dioxide, TiO_2 = Oxygen 40·0, titanium 60·0 = 100. A little iron is usually present, sometimes up to 10 p. c. While the iron present is often reported as ferric the probability is that in the unaltered mineral it existed in the ferrous state.

The formula for rutile may be written as a titanyl metatitanate $(TiO)TiO_3$. With this the ferrous titanate $FeTiO_3$ may be considered isomorphous and so account for the iron frequently present. It has been suggested that the tapiolite molecule, $FeO.Ta_2O_5$ is also isomorphous and that tapiolite belongs in the same group as rutile and cassiterite, see *ilmenorutile*, below.

Var. — *Ordinary.* Brownish red and other shades, not black. G. = 4·18–4·25. Transparent quartz (*sagenite*) is sometimes penetrated thickly with acicular or capillary crystals. Dark smoky quartz penetrated with the acicular rutile or "rutilated quartz," is the Flêches d'amour *Fr.* (or Venus hair-stone). Acicular crystals often implanted in parallel position on tabular crystals of hematite; also somewhat similarly on magnetite.

Ferriferous. (*a*) *Nigrine* is black in color, whence the name; contains up to 30 p. c. of ferrous titanate. (*b*) *Ilmenorutile* is a black variety from the Ilmen Mts., Russia; containing iron in the form of ferrous titanate, niobate and tantalate. G. = 5·14. *Strüverite* is the same mineral with greater amounts of the niobate present. (*c*) *Iserine* from Iserweise, Bohemia, formerly considered to be a variety of ilmenite is probably also a ferriferous rutile.

Pyr., etc. — B.B. infusible. With salt of phosphorus gives a colorless bead, which in R.F. assumes a violet color on cooling. Most varieties contain iron, and give a brownish yellow or red bead in R.F., the violet only appearing after treatment of the bead with metallic tin on charcoal. Insoluble in acids; made soluble by fusion with an alkali or alkaline carbonate. The solution containing an excess of acid, with the addition of tin-foil, gives a beautiful violet color when concentrated.

Diff. — Characterized by its peculiar sub-adamantine luster and brownish red color. Differs from tourmaline, vesuvianite, augite in being entirely unaltered when heated alone B.B. Specific gravity about 4, of cassiterite 6·5.

Micro. — In thin sections shows red-brown to yellow color, very high relief and high order of interference color.

Artif. — Rutile has been formed artificially by heating titanic oxide with boric oxide, with sodium tungstate, etc. Rutile, octahedrite and brookite have all been formed by heating potassium titanate and calcium chloride in a current of hydrochloric acid gas and air. Rutile is formed at the highest temperature, brookite at lower temperatures, and octahedrite at the lowest of all.

Obs. — Rutile occurs as an accessory mineral in granite, gneiss, mica schist, and syenitic rocks, and sometimes in granular limestone and dolomite; common, as a secondary product, in the form of microlites in many slates. A dike rock from Nelson Co., Va., consists essentially of rutile and apatite. It is generally found in embedded crystals, often in masses of quartz or feldspar, and frequently in acicular crystals penetrating quartz; also in phlogopite (which see), and has been observed in diamond. It has also been met with in hematite and limenite, rarely in chromite. It is common in grains or fragments in many auriferous sands.

Prominent localities are: Arendal and Kragerö in Norway; Horrsjöberg, Sweden, with lazulite and cyanite; Saualpe, Carinthia; in the Ural Mts.; in the Tyrol, Austria; at St. Gothard and Binnental, Switzerland; at Yrieux, near Limoges in France; at Ohlapian in Transylvania, *nigrine* in pebbles; in large crystals in Perthshire, Scotland; in Donegal Co., Ireland.

In Me., at Warren. In Ver., at Waterbury; also in loose bowlders in middle and northern Vermont, acicular, some specimens of great beauty in transparent quartz. In Mass., at Barre, in gneiss; at Shelburne, in mica slate, at Chester. In N. Y., in Orange Co., Edenville; Warwick; east of Amity. In Pa., at Sudsbury, Chester Co., and the adjoining district in Lancaster Co.; at Parksburg, Concord, West Bradford, and Newlin, Chester Co.; at the Poor House quarry, Chester Co. In N. J., at Newton, with spinel. In N. C., at Crowder's Mountain; at Stony Point, Alexander Co., in splendent crystals. In Ga., in Habersham Co.; in Lincoln Co., at Graves' Mountain, with lazulite in large and splendent crystals. In Ark., at Magnet Cove, commonly in twins, with brookite and perovskite, also as paramorphs after brookite.

Fine specimens of "rutilated quartz," from Minas Geraes, Brazil; Madagascar; Tavetch and elsewhere, Switzerland; West Hartford, Ver.; Alexander Co., N. C.

Use. — A source of titanium.

Plattnerite. Lead dioxide, PbO_2. Rarely in prismatic crystals, usually massive. H. = 5–5·5. G. = 8·5. Luster submetallic. Color iron-black. Streak chestnut-brown. From Leadhill and Wanlockhead, Scotland. Also at the "As You Like" mine, Mullan, Cœur d'Alêne Mts., Idaho.

Baddeleyite. Zirconium dioxide, ZrO_2. In tabular monoclinic crystals. H. = 6·5. G. = 5·5–6·0. Colorless to yellow, brown and black. Index, 1·74. From Ceylon; from Brazil near Caldas, Minas Geraes and Jacupiranga, (*brazilite*) where it is associated with *zirkelite*, $(Ca,Fe)0.2(Zr,Ti,Th)O_2$. Noted at Mte. Somma, Vesuvius. Also near Bozeman, Mon. Various minerals occurring as rolled pebbles in the diamond sands of Brazil are known as *favas* (*beans*). Some of them consist of nearly pure TiO_2 others of nearly pure ZrO_2, while others are various phosphates. *Paredrite* is a "fava," composed of TiO_2 with a little water.

Uhligite. $Ca(Ti,Zr)O_3.Al(Ti,Al)O_3$. Isometric. Octahedral. Color black. Brown and transparent on thin edges. Found in a nepheline syenite on the shore of Lake Magad, East Africa.

OCTAHEDRITE. Anatase.

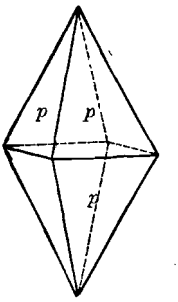
Tetragonal. Axis $c = 1·7771$.

Commonly octahedral in habit, either acute (p, 111), or obtuse (v, 117);

also tabular, $c(001)$ predominating; rarely prismatic crystals; frequently highly modified.

ee', $101 \wedge 011 = 76° 5'$.
ee'', $101 \wedge \bar{1}01 = 121° 16'$.
pp', $111 \wedge \bar{1}11 = 82° 9'$.
pp'', $111 \wedge \bar{1}\bar{1}1 = 136° 36'$.
zz', $113 \wedge \bar{1}13 = 54° 1'$.
vv', $117 \wedge \bar{1}17 = 27° 39'$.

722



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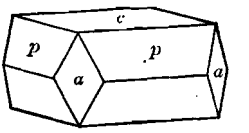

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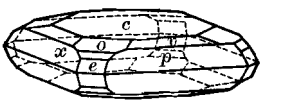


Cleavage: $c(001)$ and $p(111)$ perfect. Fracture subconchoidal. Brittle. H. = 5·5–6. G. = 3·82–3·95; sometimes 4·11–4·16 after heating. Luster adamantine or metallic-adamantine. Color various shades of brown, passing into indigo-blue, and black; greenish yellow by transmitted light. Streak uncolored. Transparent to nearly opaque. Optically −. Birefringence rather high. Indices: $\omega = 2{\cdot}554$, $\epsilon = 2{\cdot}493$. Sometimes abnormally biaxial.

Comp. — Titanium dioxide, TiO_2 = Oxygen 40·0, titanium 60·0 = 100.

Pyr., etc. — Same as for rutile.

Artif. — See under rutile.

Obs. — Most abundant at Bourg d'Oisans, in Dauphiné, France, with feldspar, axinite, and ilmenite; near Hof in the Fichtelgebirge, Germany; at Selva and Naderanertal, Switzerland; Norway; the Ural Mts.; in chlorite in Devonshire, near Tavistock; with brookite at Tremadoc, in North Wales; in Cornwall, near Liskeard and at Tintagel Cliffs; in Brazil in quartz, and in detached crystals. In Switzerland in the Binnental the variety *wiserine*, long supposed to be xenotime; also Cavradi, Tavetsch; Rauris, Salzburg, in the Eastern Alps; also at Pfitsch Joch.

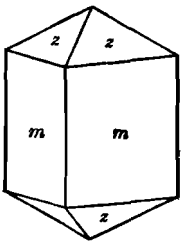
In the United States, at the Dexter lime rock, Smithfield, R. I., in dolomite; from granite pegmatite, Quincy, and from Somerville, Mass.; in the washings at Brindletown, Burke Co., N. C., in transparent tabular crystals; at Magnet Cove, Ark.; in unusual crystals from Beaver Creek, Gunnison Co., Col.

BROOKITE.

Orthorhombic. Axes $a : b : c = 0{\cdot}8416 : 1 : 0{\cdot}9444$.

mm''', $110 \wedge 1\bar{1}0 = 80° 10'$.
zz', $112 \wedge \bar{1}12 = 53° 48'$.
zz''', $112 \wedge 1\bar{1}2 = 44° 46'$.
ee', $122 \wedge \bar{1}22 = 44° 23'$.
ee''', $122 \wedge 1\bar{2}2 = 78° 57'$.
me, $110 \wedge 122 = 45° 42'$.

725



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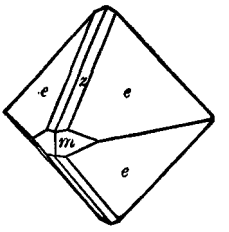

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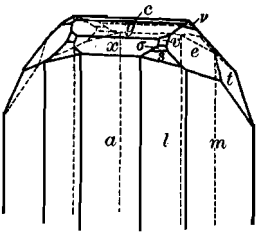


Only in crystals, of varied habit.

Cleavage: $m(110)$ indistinct; $c(001)$ still more so. Fracture subconchoidal to uneven. Brittle. H. = 5·5–6. G. = 3·87–4·08. Luster metallic-adamantine to submetallic. Color hair-brown, yellowish, reddish, reddish

brown, and translucent; also brown to iron-black, opaque. Streak uncolored to grayish or yellowish. $\alpha = 2{\cdot}583$. $\beta = 2{\cdot}586$. $\gamma = 2{\cdot}741$. Other optical characters, see p. 298.

Comp. — Titanium dioxide, TiO_2 = Oxygen 40·0, titanium 60·0 = 100.

Pyr. — Same as for rutile.

Artif. — See under rutile.

Obs. — Occurs at Bourg d'Oisans in Dauphiné, France; in Switzerland at St. Gothard, with albite and quartz, and Maderanertal; in the Ural Mts.; district of Zlatoust, near Miask, and in the gold-washings in the Sanarka river and elsewhere; at Fronolen, near Tremadoc, Wales. From Companhia, Lençoes, Bahia, Brazil.

In the United States in thick black crystals (*arkansite*) at Magnet Cove, Ozark Mts., Ark., with elæolite, black garnet, schorlomite, rutile, etc.; in small crystals from the gold-washings of N. C.; at the lead mine at Ellenville, Ulster Co., N. Y., on quartz, with chalcopyrite and galena; at Paris, Me., Somerville, Mass.

Named after the English mineralogist, H. J. Brooke (1771–1857).

PYROLUSITE.

Orthorhombic, but perhaps only pseudomorphous. Commonly columnar, often divergent; also granular massive, and frequently in reniform coats.

Soft, often soiling the fingers. H. = 2–2·5. G. = 4·73–4·86. Luster metallic. Color iron-black, dark steel-gray, sometimes bluish. Streak black or bluish black, sometimes submetallic. Opaque.

Comp. — Manganese dioxide, MnO_2, like polianite (p. 427). Commonly contains a little water (2 p. c.), it having had usually a pseudomorphous origin (after manganite).

It is uncertain whether pyrolusite is an independent species, with a crystalline form of its own, or only a secondary mineral derived chiefly from the dehydration of manganite; also from polianite (Breith.). Pseudomorphous crystals having distinctly the form of manganite are common.

Pyr., etc. — Like polianite, but most varieties yield some water in the closed tube.

Diff. — Hardness less than that of psilomelane. Differs from iron ores in its reaction for manganese B.B. Easily distinguished from psilomelane by its inferior hardness, and usually by being crystalline. Its streak is black; that of manganite is more or less brown.

Obs. — Manganese ore deposits in general are secondary in origin, the manganese content of the rocks having been concentrated in favorable places. They often occur as irregular bodies in residual clays. Pyrolusite is extensively worked at Elgersberg near Ilmenau, and other places in Thuringia, Germany; at Vorderehrensdorf in Moravia; at Platten in Bohemia, and elsewhere; near Johanngeorgenstadt, at Hirschberg in Westphalia, Germany; Matzka, Transylvania; in Australia; in India.

Occurs in the United States with psilomelane, abundantly in Ver., at Brandon, etc.; at Plainfield and West Stockbridge, Mass.; Augusta Co., Va.; Pope, Pulaski, Montgomery Cos., Ark. Negaunee, Mich.; Lake Co., N. M. In New Brunswick, 7 m. from Bathurst. In Nova Scotia, at Teny Cape; at Walton, etc.

The name is from πῦρ, *fire*, and λούειν, *to wash*, because used to discharge the brown and green (FeO) tints of glass; and for the same reason it is whimsically entitled by the French *le savon de verriers*.

Use. — An ore of manganese; as an oxidizing agent in manufacture of chlorine, bromine and oxygen; as a drier in paints, a decolorizer in glass and in electric batteries, as coloring material in bricks, pottery, glass, etc.

B. Hydrous Oxides.

Among the hydrous oxides the Diaspore Group is well characterized. Here belong the hydroxides of aluminium, iron and manganese. The general formula is properly written $\overset{III}{R}O(OH)$. The three species here included are

orthorhombic in crystallization with related angles and axial ratios; this relation is deviated from by manganite in the prismatic zone.

Another less prominent group is the BRUCITE GROUP, including the rhombohedral species Brucite, Mg(OH), and Pyrochroite, Mn(OH).

Gibbsite, $Al(OH)_3$, and Sassolite, $B(OH)_3$, are also related, and further Hydrotalcite and Pyroaurite.

Diaspore Group. $\overset{III}{R}O(OH)$ or $R_2O_3.H_2O$. Orthorhombic.

		$a : b : c$	$\frac{c}{a}$
Diaspore	$Al_2O_3.H_2O$	0·9372 : 1 : 0·6039	or 0·6443
Göthite	$Fe_2O_3.H_2O$	0·9185 : 1 : 0·6068	or 0·6606
Manganite	$Mn_2O_3.H_2O$	0·8441 : 1 : 0·5448	or 0·6463

DIASPORE.

Orthorhombic. Axes: $a : b : c = 0{\cdot}9372 : 1 : 0{\cdot}6039$. Crystals prismatic, mm''', $110 \wedge 1\bar{1}0 = 86° 17'$; usually thin, flattened $\parallel b(010)$; sometimes acicular. Also foliated massive and in thin scales; sometimes stalactitic.

Cleavage: $b(010)$ eminent; $h(210)$ less perfect. Fracture conchoidal, very brittle. H. = 6·5–7. G. = 3·3–3·5. Luster brilliant; pearly on cleavage-face, elsewhere vitreous. Color whitish, grayish white, greenish gray, hair-brown, yellowish, to colorless. Pleochroic. Transparent to subtranslucent. Optically +. Birefringence high. Ax. pl. $\parallel b(010)$. Bx. $\perp a(100)$. Dispersion $\rho < v$, feeble. $2V = 84°$. $\alpha = 1{\cdot}702$. $\beta = 1{\cdot}722$. $\gamma = 1{\cdot}750$.

Comp. — $AlO(OH)$ or $Al_2O_3.H_2O$ = Alumina 85·0, water 15·0 = 100.

Pyr., etc. — In the closed tube usually decrepitates strongly, separating into white pearly scales, and at a high temperature yields water. Infusible; ignited with cobalt solution gives a deep blue color. Not attacked by acids, but after ignition soluble in sulphuric acid.

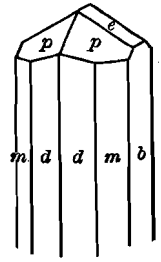
Diff. — Distinguished by its hardness and pearly luster; also (B.B.) by its decrepitation and yielding water; by the reaction for alumina with cobalt solution. Resembles some varieties of hornblende, but is harder.

Artif. — Diaspore crystals have been artificially formed by heating in a steel tube aluminium oxide in sodium hydroxide to temperatures less than 500°.

Obs. — Commonly found with corundum or emery. Occurs near Kossoibrod, in the Ural Mts.; at Schemnitz, Hungary; with corundum in dolomite at Campolongo, Tessin, in Switzerland; Greiner in the Zillertal, Austria. In the United States, with corundum and margarite at Newlin, Chester Co., Pa.; at the emery mines of Chester, Mass.; in cavities in massive corundum at the Culsagee mine, near Franklin, Macon Co., N. C.; with alunite forming rock masses at Mt. Robinson, Rosita Hills, Col.

Named by Haüy from *διασπείρειν, to scatter*, alluding to the usual decrepitation before the blowpipe.

GÖTHITE.



Orthorhombic. Axes $a : b : c = 0{\cdot}9185 : 1 : 0{\cdot}6068$.

mm''', $110 \wedge 1\bar{1}0 = 85° 8'$. pp', $111 \wedge \bar{1}11 = 58° 55'$.
ee', $011 \wedge 0\bar{1}1 = 62° 30'$. pp'', $111 \wedge 1\bar{1}1 = 53° 42'$.

In prisms vertically striated, and often flattened into scales or tables $\parallel b(010)$. Also fibrous; foliated or in scales; massive, reniform and stalactitic, with concentric and radiated structure.

Cleavage: $b(010)$ very perfect. Fracture uneven. Brittle. H. = 5–5·5. G. = 4·28. Luster imperfect adamantine. Color yellowish, reddish, and blackish brown. Often blood-red by transmitted light. Streak brownish yellow to ocher-yellow. $\alpha = 2{\cdot}26$. $\beta = 2{\cdot}39$. $\gamma = 2{\cdot}4$. Only weakly pleochroic.

Var. — In thin scale-like or tabular crystals, usually attached by one edge. Also in acicular or capillary (not flexible) crystals, or slender prisms, often radiately grouped: the *Needle-Ironstone*. It passes into a variety with a velvety surface; the *Przibramite (Sammetblende)* of Přibram, Bohemia, is of this kind. Also columnar, fibrous, etc., as above.

Comp. — FeO(OH) or $Fe_2O_3.H_2O$ = Oxygen 27·0, iron 62·9, water 10·1 = 100, or Iron sesquioxide 89·9, water 10·1 = 100.

Pyr., etc. — In the closed tube gives off water and is converted into red iron sesquioxide. With the fluxes like hematite; most varieties give a manganese reaction, and some, treated in the forceps in O.F., after moistening in sulphuric acid, impart a bluish green color to the flame (phosphoric acid). Soluble in hydrochloric acid.

Diff. — Distinguished from hematite by its yellow streak; from limonite by crystalline nature; it also contains less water than limonite.

Obs. — Found with the other oxides of iron, especially hematite or limonite. Occurs at Eiserfeld near Siegen, in Nassau, Germany; Přibram, Bohemia; at Clifton, near Bristol, England; in Cornwall. In the United States, at the Jackson Iron mine, Negaunee, Lake Superior; in Conn., at Salisbury; in Pa., near Easton; in the Pike's Peak region and at Crystal Peak, Col. Named *Göthite* (Goethite) after the poet-philosopher Goethe (1749–1832).

A colloidal form of iron hydroxide having the composition of *goethite* and occurring as pseudomorphs after pyrite has been called *ehrenwerthite*.

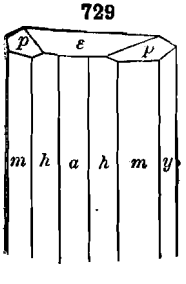
Use. — An ore of iron.

Lepidocrocite. A dimorphous form of goethite. Orthorhombic but with different axial ratio. Scaly, fibrous. G = 4·09. β = 2·20. Strongly pleochroic.

MANGANITE.

Orthorhombic. Axes $a : b : c = 0{\cdot}8441 : 1 : 0{\cdot}5448$.

729



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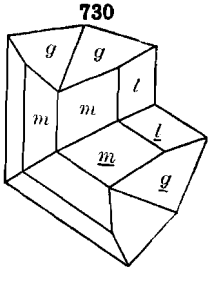

hh''', $410 \wedge 4\bar{1}0 = 23° 50'$.
mm''', $110 \wedge 1\bar{1}0 = 80° 20'$.
$\epsilon\epsilon'$, $205 \wedge \bar{2}05 = 28° 57'$.
ee', $011 \wedge 0\bar{1}1 = 57° 10'$.
pp', $111 \wedge \bar{1}11 = 59° 5\frac{1}{2}'$.

Crystals commonly prismatic, the faces deeply striated vertically; often grouped in bundles. Twins: tw. pl. *e*(011). Also columnar; stalactitic.

Cleavage: *b*(010) very perfect; *m*(110) perfect. Fracture uneven. Brittle. H. = 4. G. = 4·2–4·4. Luster submetallic. Color dark steel-gray to iron-black. Streak reddish brown, sometimes nearly black. Opaque; in minute splinters sometimes brown by transmitted light.

Comp. — MnO(OH) or $Mn_2O_3.H_2O$ = Oxygen 27·3, manganese 62·4, water 10·3 = 100, or Manganese sesquioxide 89·7, water 10·3 = 100.

Pyr., etc. — In the closed tube yields water; manganese reactions with the fluxes, p. 339.

Obs. — Occurs in Germany at Ilefeld in the Harz Mts.; Ilmenau in Thuringia; Långban and Bölet, Sweden; Cornwall, at various places: also in Cumberland, etc. In the Lake Superior mining region at the Jackson mine, Negaunee; Devil's Head, Douglas Co., Col. In Nova Scotia, at Cheverie, Hants Co., and Walton. In New Brunswick, at Shepody mountain, Albert Co., etc.

Sphenomanganite is a variety of manganite from Långban, Sweden, showing sphenoidal forms.

Use. — An ore of manganese.

LIMONITE. Brown Hematite.

Not crystallized. Usually in stalactitic and botryoidal or mammillary forms, having a fibrous or subfibrous structure; also concretionary, massive; and occasionally earthy.

H. = 5–5·5. G. = 3·6–4·0. Luster silky, often submetallic; sometimes dull and earthy. Color of surface of fracture various shades of brown, commonly dark, and none bright; sometimes with a nearly black varnish-like exterior; when earthy, brownish yellow, ocher-yellow. Streak yellowish brown. Opaque.

Var. — (1) *Compact.* Submetallic to silky in luster; often stalactitic, botryoidal, etc. (2) *Ochrous* or earthy, brownish yellow to ocher-yellow, often impure from the presence of clay, sand, etc. (3) *Bog ore.* The ore from marshy places, generally loose or porous in texture, often petrifying leaves, wood, nuts, etc. (4) *Brown clay-ironstone,* in compact masses, often in concretionary nodules.

Comp. — Approximately $2Fe_2O_3.3H_2O$ = Oxygen 25·7, iron 59·8, water 14·5 = 100, or Iron sesquioxide 85·5, water 14·5 = 100. The water content varies widely and it is probable that limonite is essentially an amorphous form of goethite with adsorbed and capillary water. In the bog ores and ochers, sand, clay, phosphates, oxides of manganese, and humic or other acids of organic origin are very common impurities.

Pyr., etc. — Like göthite. Some varieties leave a siliceous skeleton in the salt of phosphorus bead, and a siliceous residue when dissolved in acids.

Diff. — Distinguished from hematite by its yellowish streak, inferior hardness, and its reaction for water. Does not decrepitate B.B., like turgite. Not crystallized like göthite and yields more water.

Obs. — In all cases a result of the alteration of other ores, or minerals containing iron, through exposure to moisture, air, and carbonic or organic acids; derived largely from the change of pyrite, magnetite, siderite, ferriferous dolomite, etc.; also various species (as mica, pyroxene, hornblende, etc.), which contain iron in the ferrous state (FeO). Waters containing iron in solution when brought into marshy places deposit the metal usually in the form of limonite. The evaporation of the carbonic acid in the water which held the iron in solution is one cause for the separation of the iron oxide. This separation is also aided by the so-called "iron bacteria" which absorb the iron from the water and later deposit it again as ferric hydroxide. Limonite consequently occupies, as a bog ore, marshy places, into which it has been borne by streamlets from the hills around. It is also found in deposits associated with iron-bearing limestones where the original iron content of the rock has been largely dissolved and redeposited later in some favorable spot. Limonite forms the capping or *gossan, iron hat,* of many metallic veins. It is often associated with manganese ores. Limonite is a common ore in Bavaria, the Harz Mts., Germany, Luxemburg, Scotland, Sweden, etc.

Abundant in the United States. Extensive beds exist at Salisbury and Kent, Conn., also in the neighboring towns of N. Y., and in a similar situation in Berkshire Co., Mass., and in Ver.; in Pa., widely distributed; also in Tenn., Ala., Ohio, etc.

Named *Limonite* from λειμών, *meadow.*

Use. — An ore of iron; as a yellow pigment.

TURGITE. Hydrohematite. Approximately $2Fe_2O_3.H_2O$. Probably to be considered as a solid solution of goethite with hematite together with enclosed and adsorbed water. Resembles limonite but has a red streak. G. = 4·14–4·6. Decrepitates B.B. From the Turginsk mine in the Ural Mts., etc.; also from Salisbury, Conn. Intermediate between hematite and limonite.

HYDROGOETHITE. $3Fe_2O_3.4H_2O$. Orthorhombic, radiating fibrous. H. = 4. G. = 3·7. Color and streak brick-red. With limonite at various localities in Tula, Russia.

Xanthosiderite. $Fe_2O_3.2H_2O$. In fine needles or fibers, stellate and concentric; also as an ocher. Color golden yellowish, brown to brownish red. Associated with manganese ores at Ilmenau, Thuringia, Germany, etc.

Esmeraldaite. $Fe_2O_3.4H_2O$. In small pod-shaped masses enclosed in limonite. Conchoidal fracture. H. = 2·5. G. = 2·58. Color coal black. Yellow-brown streak. From Esmeralda Co., Cal.

BAUXITE. Beauxite.

In round concretionary disseminated grains. Also massive, oölitic; and earthy, clay-like. G. = 2·55. Color whitish, grayish, to ocher-yellow, brown, and red.

Var. — 1. In concretionary grains, or oölitic; *bauxite.* 2 Clay-like, *wocheinite;* the purer kind grayish, clay-like, containing very little iron oxide; also red from the iron oxide present.

Comp. — Essentially $Al_2O_3.2H_2O$ = Alumina 73·9, water 26·1 = 100; some analyses, however, give $Al_2O_3.H_2O$ like diaspore.

Bauxite is probably a mixture of varying character but containing large amounts of a colloidal form of $Al_2O_3.H_2O$. This substance has been called *sporogelite* or *diasporogelite, cliachite* and *alumogel.*

Iron sesquioxide is usually present, sometimes in large amount, in part replacing alumina, in part only an impurity. The name *hematogelite* has been suggested for this colloidal form of ferric oxide. Silica, phosphoric acid, carbonic acid, lime, magnesia are common impurities.

Obs. — Bauxite is a product of the decomposition of certain rocks, particularly those rich in plagioclase feldspars, and has been found under various conditions. The laterites of India, etc., are probably similar in origin and might be considered as iron-rich bauxites. Bauxite is certainly not a definite mineral species but consists of a mixture of several different materials. From Baux (or Beaux), near Arles, and elsewhere in France, disseminated in grains in compact limestone, and also oölitic. *Wocheinite* occurs in Carniola, Austria, between Feistritz and Lake Wochein. The purest bauxite is used for the manufacture of aluminium (aluminum), and is called *aluminum ore.* In the United States, bauxite occurs in Saline and Pulaski Cos., Ark.; also in Cherokee and Calhoun Cos., Ala., and in Floyd, Barton and Walker Cos., Ga.

Use. — As an aluminum ore.

Brucite Group. $R(OH)_2$. Rhombohedral

BRUCITE.

Rhombohedral. Axis $c = 1·5208$; cr $0001 \wedge 1011 = 60° 20\frac{1}{2}'$, rr' $10\bar{1}1 \wedge \bar{1}101 = 97° 37\frac{1}{2}'$.

Crystals usually broad tabular. Also commonly foliated massive; fibrous, fibers separable and elastic.

H. = 2·5. G. = 2·38–2·4. Cleavage: $c(0001)$ eminent. Folia separable and flexible, nearly as in gypsum. Sectile. Luster $\parallel c$ pearly, elsewhere waxy to vitreous. Color white, inclining to gray, blue, or green. Transparent to translucent. Optically +. Indices: $\omega_r = 1·559$, $\epsilon_r = 1·5795$.

Comp. — Magnesium hydroxide, $Mg(OH)_2$ or $MgO.H_2O$ = Magnesia 69·0, water 31·0 = 100. Iron and manganese protoxide are sometimes present.

Var. — *Ordinary,* occurring in plates, white to pale greenish in color; strong pearly luster on the cleavage surface. *Nemalite* is a fibrous variety containing 4 to 5 p. c. iron protoxide, with G. = 2·44. *Manganbrucite* contains manganese; occurs granular; color honey-yellow to brownish red. *Ferrobrucite* contains iron.

Pyr., etc. — In the closed tube gives off water, becoming opaque and friable, sometimes turning gray to brown; the manganesian variety becomes dark brown. B.B. infusible, glows with a bright light, and the ignited mineral reacts slightly alkaline to test-paper. Ignited with cobalt solution gives the pale pink color of magnesia. The pure mineral is soluble in acids without effervescence.

Diff. — Distinguished by its infusibility, softness, cleavage, and foliated structure. Is harder than talc and differs in its solubility in acids; the magnesia test and optical characters separate it from gypsum, which is also somewhat softer.

Obs. — A secondary mineral accompanying other magnesian minerals in serpentine, also found in limestone. At Swinaness in Unst, Shetland Isles; at the iron mine of Cogne, Aosta, Italy; near Filipstadt in Sweden. At Hoboken, N. J., in serpentine; at the Tilly Foster iron mine, Brewster, N. Y., well crystallized; Richmond Co., N. Y.; at Wood's mine, Texas Pa., in large plates or masses, and often crystallizations several inches across, also at Low's mine with hydromagnesite. From Crestmore, Riverside Co., Cal. *Nemalite,* the fibrous variety, occurs at Hoboken, N. J., and at Xettes in the Vosges Mts. *Mangan-*

brucite occurs with hausmannite and other manganese minerals in the granular limestone of Jakobsberg, Nordmark, Sweden.

Named after the early American mineralogist, A. Bruce (1777–1818).

Pyrochroite. — Manganese hydroxide, $Mn(OH)_2$. Usually foliated, like brucite. Luster pearly. Color white, but growing dark on exposure. $\omega = 1{\cdot}723$. $\epsilon = 1{\cdot}681$. In Sweden occurs in magnetite at Pajsberg, also at Nordmark and Långban; in N. J. at Franklin Furnace.

Bäckströmite. Manganese hydroxide, $Mn(OH)_2$. Orthorhombic. From Långban, Sweden.

GIBBSITE. Hydrargillite.

Monoclinic. Axes $a : b : c = 1{\cdot}7089 : 1 : 1{\cdot}9184$; $\beta = 85° 29'$. Crystals tabular $\parallel c(001)$, hexagonal in aspect. Occasionally in spheroidal concretions. Also stalactitic, or small mammillary, incrusting, with smooth surface, and often a faint fibrous structure within.

Cleavage: $c(001)$ eminent. Tough. H. = 2·5–3·5. G. = 2·3–2·4. Color white, grayish, greenish, or reddish white. Luster of $c(001)$ pearly; of other faces vitreous; of surface of stalactites faint. Translucent; sometimes transparent in crystals. Indices, 1·535–1·558. A strong argillaceous odor when breathed on.

Comp. — Aluminium hydroxide, $Al(OH)_3$ or $Al_2O_3.3H_2O$ = Alumina 65·4, water 34·6 = 100.

Pyr., etc. — In the closed tube becomes white and opaque, and yields water. B.B. infusible, whitens, and does not impart a green color to the flame. Ignited with cobalt solution gives a deep blue color. Soluble in concentrated sulphuric acid.

Artif. — When solutions of sodium aluminate are slowly decomposed by carbon dioxide gibbsite is precipitated.

Obs. — The crystallized gibbsite (hydrargillite) occurs in the Shishimsk mountains near Zlatoust in the Ural Mts.; also in crystals filling cavities in natrolite at Langesundfiord, Norway; Ouro Preto, Minas Geraes, Brazil. Occurs in nodular plates at Kodikanal, Palni Hills, Madras, and at Talevadi, Bombay, India. In the United States, in stalactitic form at Richmond, Mass., in a bed of limonite; at the Clove Mine, Union Vale, Dutchess Co., N. Y., on limonite; in Orange Co., N. Y.

Named after Col. George Gibbs.

Sassolite. Boric acid, $B(OH)_3$. Crystals tabular $\parallel c(001)$ (triclinic). Usually small, white, pearly scales. G. = 1·48. Index, 1·46. From the waters of the Tuscan lagoons of Monte Rotondo and Castelnuovo, Italy. Exists also in other natural waters, as at Clear Lake, in Lake Co., Cal. Occurs also abundantly in the crater of Vulcano, Lipari isles.

Hydrotalcite. Perhaps $Al(OH)_3.3Mg(OH)_2.3H_2O$. Lamellar-massive, or foliated, somewhat fibrous. H. = 2. G. = 2·04–2·09. Color white. Luster pearly. Uniaxial, −. $\omega = 1{\cdot}47$. Occurs at the mines of Shishimsk, district of Zlatoust, Ural Mts.; at Snarum, Norway, in serpentine.

Pyroaurite. Perhaps $Fe(OH)_3.3Mg(OH)_2.3H_2O$. Rhombohedral. Thin tabular crystals. H. = 2–3. G. = 2·07. Luster pearly to greasy. Color yellow to yellow-brown. Optically −. Occurs at the Långban iron-mine, Wermland, Sweden, in gold-like submetallic scales (*pyroaurite*). From the Moss mine, Norway. In thin seams of a silvery white color in serpentine in the island Haaf-Grunay, Scotland (*igelströmite*).

Chalcophanite. Hydrofranklinite. $(Mn,Zn)O.2MnO_2.2H_2O$. In druses of minute tabular rhombohedral crystals; sometimes octahedral in aspect. Also in foliated aggregates; stalactitic and plumose. G. = 3·907. Luster metallic, brilliant. Color bluish black to iron-black. Streak chocolate-brown, dull. Occurs at Sterling Hill, near Ogdensburg, Sussex Co., N. J. From Leadville, Col.

Hetærolite. $2ZnO.2Mn_2O_3.1H_2O$. In radiating botryoidal masses. Black. Brown-black streak. H. = 5. G. = 4·85. From Franklin, N. J., and Leadville, Col. (*Wolftonite*).

ALAÏTE. $V_2O_5.H_2O$. Rare. Found in dark bluish red moss-like masses in Alai Mts., Turkestan.

SHANYAVSKITE. $Al_2O_3.4H_2O$. Amorphous, transparent material found in dolomite, near Moscow, Russia.

PSILOMELANE.

Massive and botryoidal; reniform; stalactitic. H. = 5–6. G. = 3·7–4·7. Luster submetallic, dull. Streak brownish black, shining. Color iron-black, passing into dark steel-gray. Opaque.

Comp. — A hydrous manganese manganate in which part of the manganese is often replaced by barium or potassium, perhaps conforming to H_4MnO_5. The material is generally very impure, and the composition hence doubtful.

Pyr., etc. — In the closed tube most varieties yield water, and all lose oxygen on ignition; with the fluxes reacts for manganese. Soluble in hydrochloric acid, with evolution of chlorine.

Obs. — A common but impure ore of manganese; frequently in alternating layers with pyrolusite. From Devonshire and Cornwall. In Germany at Ilefeld in the Harz Mts., at Ilmenau, Siegen, etc. From the Crimea, Russia; also various localities in India. Forms mammillary masses at Brandon, etc., Vt. In Independence Co., and elsewhere in Ark. With pyrolusite at Douglas, Hants Co., Nova Scotia. Named from *ψιλός, smooth* or *naked*, and *μέλας, black*.

Use. — An ore of manganese.

The following mineral substances here included are mixtures of various oxides, chiefly of manganese (MnO_2, also MnO), cobalt, copper, with also iron, and from 10 to 20 p. c. water. These are results of the decomposition of other ores — partly of oxides and sulphides, partly of manganesian carbonates, and can hardly be regarded as representing distinct mineral species.

WAD. In amorphous and reniform masses, either earthy or compact; also incrusting or as stains. Usually very soft, soiling the fingers; less often hard to H. = 6. G. = 3·0–4·26; often loosely aggregated, and feeling very light to the hand. Color dull black, bluish or brownish black.

BOG MANGANESE consists mainly of oxide of manganese and water, with some oxide of iron, and often silica, alumina, baryta.

ASBOLITE, or *Earthy Cobalt*, contains oxide of cobalt, which sometimes amounts to 32 p. c.

LAMPADITE, or *Cupreous Manganese*, is a wad containing 4 to 18 p. c. of oxide of copper, and often oxide of cobalt also.

SKEMMATITE. $3MnO_2.2Fe_2O_3.6H_2O$. Color black. Streak dark brown. H. = 5·5–6. Fusible to magnetic globule. Alteration product of *pyroxmangite*. From Iva, Anderson Co., S. C.

BELDONGRITE. $6Mn_3O_5.Fe_2O_3.8H_2O$. Luster pitchy. Color black. From Beldongri, District Nágpur, India.

VI. OXYGEN-SALTS

The Sixth Class includes the salts of the various oxygen acids. These fall into the following seven sections: 1. Carbonates; 2. Silicates and Titanates; 3. Niobates and Tantalates; 4. Phosphates, Arsenates, etc.; also the Nitrates; 5. Borates and Uranates; 6. Sulphates, Chromates and Tellurates; 7. Tungstates and Molybdates.

1. CARBONATES

A. Anhydrous Carbonates

The Anhydrous Carbonates include two distinct isomorphous groups, the CALCITE GROUP and the ARAGONITE GROUP. The metallic elements