

V. OXIDES.

I. Oxides of Silicon.

II. Oxides of the Semi-Metals: Tellurium, Arsenic, Antimony, Bismuth; also Molybdenum, Tungsten.

III. Oxides of the Metals.

The Fifth Class, that of the OXIDES, is subdivided into three sections, according to the positive element present. The oxides of the non-metal silicon are placed by themselves, but it will be noted that the compounds of the related element titanium are included with those of the metals proper. This last is made necessary by the fact that in one of its forms TiO_2 is isomorphous with MnO_2 and PbO_2 .

A series of oxygen compounds which are properly to be viewed as salts, e.g., the species of the Spinel Group and a few others, are for convenience also included in this class.

I. Oxides of Silicon.

QUARTZ.

Rhombohedral-trapezohedral. Axis: $c = 1.09997$.

$rr', 10\bar{1}1 \wedge \bar{1}101 = 85^\circ 46'$

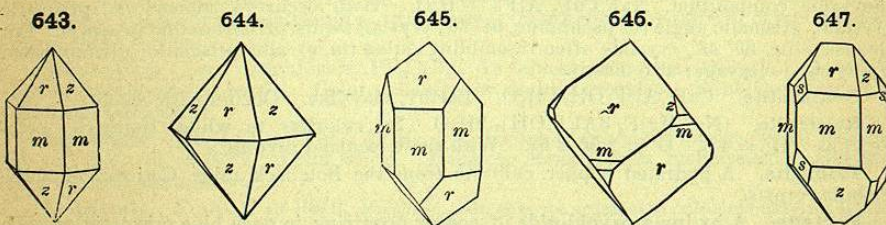
$rz, 10\bar{1}1 \wedge 01\bar{1}1 = 46^\circ 16'$

$mr, 10\bar{1}0 \wedge 10\bar{1}1 = 38^\circ 13'$

$mz, 10\bar{1}0 \wedge 01\bar{1}1 = 66^\circ 52'$

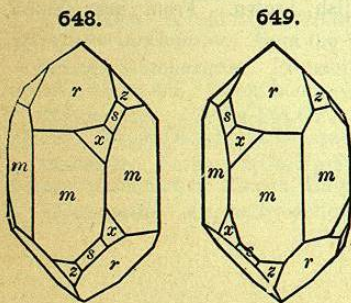
$ms, 10\bar{1}0 \wedge 11\bar{2}1 = 37^\circ 58'$

$mx, 10\bar{1}0 \wedge 51\bar{6}1 = 12^\circ 1'$



Crystals commonly prismatic, with the m faces horizontally striated; terminated either by both rhombohedrons, or by one only; the predominating rhombohedron is in almost all cases r ($10\bar{1}1$). 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 ($rr' = 85^\circ 46'$). 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. 648), s , if present, lies to the right of the m face, which is below the predominating plus rhombo-



hedron r , and with this belong the plus right trapezohedrons, as z , and minus left trapezohedrons (cf. Fig. 270, p. 83), also a (left). On a left-handed crystal (Fig. 649), s lies to the left of the m below r , and with it the plus left and minus right trapezohedrons, also a (right). The right- and left-handed forms occur together only in twins. In the absence of trapezohedral faces the striations on s (\parallel 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. 265) and by pyro-electricity (Art. 420).

Twins: (1) tw. axis c , axes parallel. (2) Tw. pl. a , sometimes called the Brazil law, usually as irregular penetration-twins (Fig. 650). (3) Tw. pl. \bar{x} ($11\bar{2}2$), contact-twins, the axes crossing at an angle of $84^\circ 33'$. See further p. 127 and Figs. 392-394. 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 (\parallel r , z and m) developed by sudden cooling after being heated (see Art. 258). 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. 366, p. 202, and Fig. 650). Rotatory power proportional to thickness of plate. Refractive indices for the D line, $\omega = 1.54418$, $\epsilon = 1.55328$; also rotatory power for section of 1mm thickness, $\alpha = 21.71$ (D line). Pyroelectric; also electric by pressure or piezo-electric. See Arts. 420, 421. On etching-figures, see Arts. 265, 266.

Comp.—Silica, or silicon dioxide, $SiO_2 =$ Oxygen 53.3, silicon 46.7 = 100.

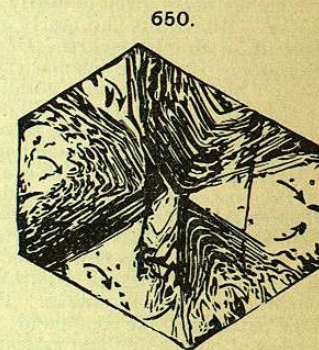
In massive varieties often mixed with a little opal silica. Impure varieties contain iron oxide, calcium carbonate, clay, sand, and various minerals as inclusions

Var.—1. PHENOCRYSTALLINE: Crystallized, vitreous in luster. 2. 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-



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

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. 404)

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. Common 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, S.W. 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; asbestos; actinolite; hornblende; epidote. *Cat's-Eye* (Katzenauge *Germ.*, *Œil de Chat Fr.*) exhibits opalescence, but without prismatic colors, especially when cut *en cabochon*, an effect sometimes due to fibers of asbestos. 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.

Acuturine.—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* (Eisenkiesel *Germ.*), 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 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 $n_r = 1.537$; $G. = 2.59-2.64$. 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. See also quartzine, p. 328.

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. 329.

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 kinds 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 laminae. *Bulrstone, or Eurrstone*.—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. 253).

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 crystalline 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.

Easily recognized in rock sections by its low refraction ("low relief," p. 170) and low birefringence ($\epsilon - \omega = 0.009$); 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 axial sections (p. 203, 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-porphry, quartz-porphry 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-porphry 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 for a large part of mineral veins; as a foreign mineral 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.

Switzerland Dauphiné, Piedmont, the Carrara quarries, and numerous other foreign

localities, afford fine specimens of rock crystal; also Japan, whence the beautiful crystal spheres, in rare cases up to 6 inches in diameter. *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, also from Brazil; inferior specimens occur in Transylvania. The finest *carnelians* and *agates* are found in Arabia, India, Brazil, 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 New York, 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, Arkansas. 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, Colorado. Geodes of quartz crystals, also enclosing calcite, sphalerite, etc., are common in the Keokuk limestone of the west.

Rose quartz occurs at Albany and Paris, Me.; Acworth, N.; H. Southbury, Conn. *Amethyst*, in trap, at Keweenaw Point, Lake Superior; Specimen Mt., Yellowstone Park; in Pennsylvania, in 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., Penn. *Chalcedony* and *agates* abundant and beautiful on N. W. shore of Lake Superior. Red jasper is found on Sugar Loaf Mt., Maine; in pebbles on the banks of the Hudson at Troy; 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., Arizona; also from the Yellowstone Park; near Florissant and elsewhere in Colorado; Amethyst Mt., Utah; Napa Co., California. Moss agates from Humboldt Co., Nevada, and many other points.

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

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 $c = 1.6530$. Crystals usually minute, thin tabular $\parallel c$; 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 +. Often exhibits anomalous refraction phenomena.

Comp.—Pure silica, SiO_2 , like quartz.

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

Obs.—Occurs chiefly in acidic volcanic rocks, 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; of Euganean Hills in N. Italy; Puy Capucin (Mont-Dore) in Central France, etc. In the ejected masses from Vesuvius consisting chiefly of sanidine. With quartz, feldspar, fayalite in lithophyses of Obsidian cliff, Yellowstone Park. In the andesite of Mt. Rainier, Washington.

Named from *τρίδυμος*, *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. Cristobalite. Silica in white octahedrons (pseudo-isometric?). $G. = 2.27$. With tridymite in andesite of the Cerro S. Cristobal, Pachuca, Mexico.

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 . The mineral turns black superficially when heated B.B.

OPAL.

Amorphous. Massive; sometimes small reniform, stalactitic, or large tuberos. 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. $n_r = 1.44-1.45$.

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. Behrens, 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 alkalis 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 ochre-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.

Merrillite.—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. Holz-opal *Germ*.—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 alkalis than other varieties.

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.

Geyselite.—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 alkalis, but more readily in some varieties than in others.

Obs.—Occurs filling cavities and fissures or seams in igneous rocks, as trachyte, porphyry, 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 Czerwenitz, near Kashau in Hungary; at Gracias a Dios in Honduras; Queretaro in Mexico; a beautiful blue opal on Bulla Creek, Queensland. *Fire-opal* occurs at Zimapan in Mexico; the Färöer; near San Antonio, Honduras. *Common opal* is abundant at Telkebánya in Hungary; near Pernstein, etc., in Moravia; in Bohemia; Stenzelberg in Siebengebirge; in Iceland. *Hyalite* occurs in amygdaloid at Schemnitz, Hungary; in clinkstone at Walsch, Bohemia; at San Luis Potosi, Mexico.

In U. S., *hyalite* occurs sparingly in connection with the trap rock of New Jersey and Connecticut. A water-worn specimen of fire-opal has been found on the John Davis river, in Crook Co., Oregon.

Common opal is found at Cornwall, Lebanon Co., Penn.; at Aquas Calientes, Idaho Springs, Colo.; a white variety at Mokelumne Hill, Calaveras Co., Cal., and on the Mt. Diablo range. Geyselite occurs in great abundance and variety in the Yellowstone region (cf. above); also siliceous sinter at Steamboat Springs, Nevada. Other localities are given by Kunz, Gems and Precious Stones of N. A., 1890.

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. $G. = 3.7$. Occurs with arsenical ores.

Claudetite. Also As_2O_3 , but monoclinic in form.

Senarmontite. Antimony trioxide, Sb_2O_3 . In isometric octahedrons; in crusts and granular massive. $G. = 5.3$. Colorless, grayish. Occurs with ores of antimony.

Valentinite. Also Sb_2O_3 , but in prismatic orthorhombic crystals.

Bismite. Bismuth trioxide, Bi_2O_3 . Pulverulent, earthy; color straw-yellow.

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.

Tungstite. Tungsten trioxide, WO_3 . Pulverulent, earthy; color yellow or yellowish green.

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

Stibiconite. $H_2Sb_2O_5$. Massive, compact. Color pale yellow to yellowish white.

III. Oxides of the Metals.

A. Anhydrous Oxides.

I. Protoxides, R_2O and RO .

II. Sesquioxides, R_2O_3 .

III. Intermediate, RR_2O_3 , or $RO \cdot R_2O_3$, 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. Rothkupererz *Germ.*

Isometric-plagihedral. Commonly in octahedrons; also in cubes and dodecahedrons, often highly modified. Plagihedral faces sometimes distinct (see pp. 50, 51). Also massive, granular; sometimes earthy.

Cleavage: o 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, $n_r = 2.849$ Fizeau.

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, Ziegelerz *Germ.* Brick-red or reddish brown and earthy, often mixed with red oxide of iron; sometimes nearly black.

Comp.—Cuprous oxide, $Cu_2O = \text{Oxygen } 11.2, \text{ copper } 88.8 = 100$.

Fyr., 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 subchloride of copper.

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.

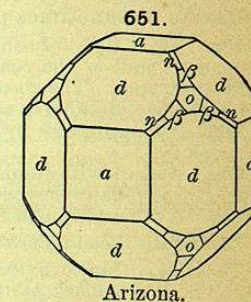
Obs.—Occurs at Kamsdorf in Thuringia; in Cornwall, in fine crystals, at Wheal Gorland and other mines; in Devonshire near Tavistock; in isolated crystals, more or less altered to malachite, at Chessy, near Lyons, France; in the Ural; South Australia; also abundant in Chili, Peru, Bolivia.

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

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. $H. = 6$. $G. = 3.67-3.90$. Occurs in white limestone at Mt. Somma; at the Kitten manganese mine, Nordmark, Sweden.



Manganosite. Manganese protoxide, MnO . In isometric octahedrons. Cleavage cubic. $H. = 5-6$. $G. = 5.18$. Color emerald-green, becoming black on exposure. From Långban and Nordmark, Sweden.

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

ZINCITE. Red Oxide of Zinc. Red Zink Ore. Rothzinkerz *Germ.*

Hexagonal-hemimorphic. Axis $c = 1.6219$. Natural crystals rare (Fig. 50, p. 18); usually foliated massive, or in coarse particles and grains; also with granular structure.

Cleavage: c 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.

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. A not uncommon furnace product.

Massicot. Lead monoxide, PbO . Massive, scaly or earthy. Color yellow, reddish.

Tenorite. Cupric oxide, CuO . In minute black scales with metallic luster; from Vesuvius. Also black earthy massive (*melanconite*); occurring with ores of copper as at Ducktown, Tenn., and Keweenaw Point, Lake Superior.

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

Hematite Group. R_2O_3 . Rhombohedral.

| | | rr' | c |
|-------------|--|--------------------------|--------|
| Corundum | Al_2O_3 | $93^\circ 56'$ | 1.3630 |
| Hematite | Fe_2O_3 | $94^\circ 0'$ | 1.3656 |
| Ilmenite | $(Fe, Mg)O \cdot TiO_2$, Tri-rhombohedral | $94^\circ 29'$ | 1.3846 |
| Pyrophanite | $MnO \cdot TiO_2$, " | $94^\circ 5\frac{1}{2}'$ | 1.3692 |

The HEMATITE GROUP embraces the sesquioxides of aluminium and iron. These compounds crystallize in the rhombohedral 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 group (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 $c = 1.3630$.

$cr, 0001 \wedge 10\bar{1}1 = 57^\circ 34'$.

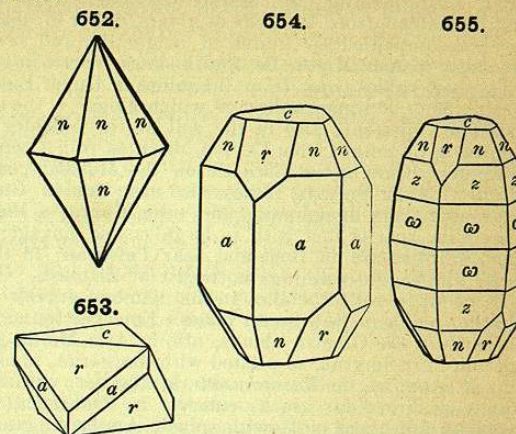
$cn, 0001 \wedge 2243 = 61^\circ 11'$.

$rr', 10\bar{1}1 \wedge \bar{1}101 = 93^\circ 56'$.

$nn', 2243 \wedge \bar{2}4\bar{2}3 = 51^\circ 58'$.

$vv', 44\bar{8}3 \wedge 4843 = 57^\circ 38'$.

$zz', 2241 \wedge \bar{2}4\bar{2}1 = 58^\circ 55'$.



Twins: tw. pl. r ; sometimes penetration-twins; often polysynthetic, and thus producing a laminated structure. Crystals usually rough and rounded. Also massive, with nearly rectangular parting or pseudocleavage; granular, coarse or fine.

Parting: c , sometimes perfect, but interrupted; also r due to twinning, often prominent; a 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 $\omega_r = 1.7676$ to 1.7682 and $\epsilon_r = 1.7594$ to 1.7598 Dx. 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; *O. Topaz*, yellow; *O. Emerald*, green; *O. Amethyst*, purple. 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. *Schmirgel Germ.*—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.

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.

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,