

I. NATIVE ELEMENTS

The NATIVE ELEMENTS are divided into the two distinct sections of the Metals and the Non-metals, and these are connected by the transition class of the Semi-metals. The distinction between them as regards physical characters and chemical relations has already been given (Art. 453).

The only *non-metals* present among minerals are carbon, sulphur, and selenium; the last, in one of its allotropic forms, is closely related to the semi-metal tellurium.

The native *semi-metals* form a distinct group by themselves, since all crystallize in the rhombohedral class of the hexagonal system with a fundamental angle differing only a few degrees from 90° , as shown in the following list:

Tellurium, $rr' = 93^\circ 3'$.	Arsenic, $rr' = 94^\circ 54'$.
Antimony, $rr' = 92^\circ 53'$.	Bismuth, $rr' = 92^\circ 20'$.

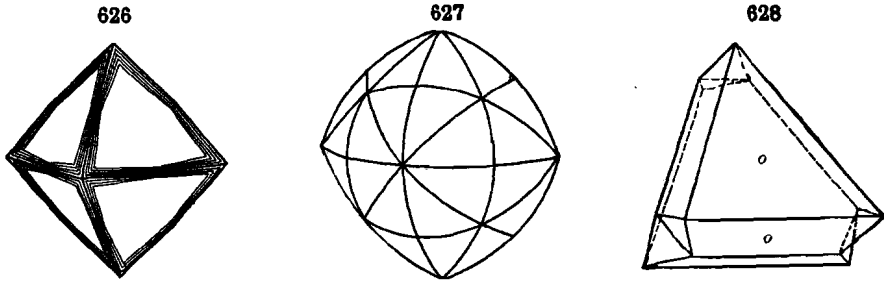
An artificial form of selenium is known with metallic luster and rhombohedral in crystallization, with $rr' = 93^\circ$. Zinc (also only artif.) is rhombohedral ($rr' = 93^\circ 46'$) and connects the semi-metals to the true metals. Metallic tantalum has been described in cubic crystals.

Among the *metals* the isometric GOLD GROUP is prominent, including gold, silver, copper, mercury, amalgam (AgHg), and lead.

Another related isometric group includes the metals platinum, iridium, palladium, and iron. An allotropic form of palladium and also iridosmine (IrOs) are both rhombohedral.

DIAMOND.

Isometric, tetrahedral, but with the + and - forms usually equally developed and not to be distinguished from each other. Commonly showing octahedral, hexoctahedral, and other forms; faces frequently rounded or striated and with triangular depressions (on $o(111)$). Twins common with tw. pl. $o(111)$. Crystals often distorted. In spherical forms; massive.



Cleavage: $o(111)$ highly perfect. Fracture conchoidal. Brittle. $H. = 10$. $G. = 3.516-3.525$ crystals. Luster adamantine to greasy. Color white or colorless; occasionally various pale shades of yellow, red, orange, green, blue, brown; rarely deeply colored; sometimes black. Usually transparent; also translucent, opaque. Refractive and dispersive power high; index $n = 2.4195$. (See Art. 328.)

Var. — 1. *Ordinary*. In crystals usually with rounded faces and varying from those which are colorless and free from flaws (*first water*) through many faint shades of color, yellow being the most common; often full of flaws and hence of value only for cutting purposes.

2. *Bort* or *Boort*; rounded forms with rough exterior and radiated or confused crystalline structure.

3. *Carbonado* or *Carbon*; black diamond. Massive, crystalline, granular to compact, without cleavage. Color black or grayish black. Opaque. Obtained chiefly from Bahia, Brazil.

Comp. — Pure carbon; the variety carbonado yields on combustion a slight ash.

Pyr., etc. — Unaffected by heat except at very high temperatures, when (in an oxygen atmosphere) it burns to carbon dioxide (CO_2); out of contact with the air transformed into a kind of coke. Not acted upon by acids or alkalis.

Diff. — Distinguished (*e.g.*, from quartz crystal) by its extreme hardness and brilliant adamantine luster; the form, cleavage, and high specific gravity are also distinctive characters; it is optically isotropic; transparent to X-rays.

Artif. — Minute diamonds have been formed artificially in several ways. Moissan first produced them by dissolving carbon in molten iron and then cooling the mass suddenly under pressure; they have been formed by dissolving graphite in fused olivine or artificial magnesium silicate melts; they have been formed when an electric current was passed through an iron spiral embedded in carbon while under high pressure in an atmosphere of hydrogen.

Obs. — The diamond occurs chiefly in alluvial deposits of gravel, sand, or clay, associated with quartz, gold, platinum, zircon, octahedrite, rutile, brookite, hematite, ilmenite, and also andalusite, chrysoberyl, topaz, corundum, tourmaline, garnet, etc.; the associated minerals being those common in granitic rocks or granitic veins. Also found in quartzose

conglomerates, and further in connection with the laminated granular quartz rock or quartzose hydromica schist, *tiacolumite*, which in thin slabs is more or less flexible. This rock occurs at the mines of Brazil and the Ural Mts.; and also in Georgia and North Carolina, where a few diamonds have been found.

It has been reported as occurring *in situ* in a pegmatite vein in gneiss at Bellary in India. It occurs further in connection with an eruptive peridotite in South Africa and in a similar formation in Pike County, Ark. It has been noted as grayish particles forming one per cent of the meteorite which fell at Novo-Urei, Russia, Sept. 22, 1886; also in the form of black diamond (H. = 9) in the meteorite of Carcote, Chile; in the meteoric iron of Cañon Diablo, Ariz.

India was the chief source of diamonds from very early times down to the discovery of the Brazilian mines; the yield is now small. Of the localities, that in southern India, in the Madras presidency, included the famous "Golconda mines." The diamond deposits of Brazil have been worked since the early part of the 18th century, and have yielded very largely, although at the present time the amount obtained is small. The most important region was that near Diamantina in the province of Minas Geraes; also from Bahia, etc.

The discovery of diamonds in South Africa dates from 1867. They were first found in the gravel of the Vaal river; they occur from Potchefstroom down to the junction with the Orange river, and along the latter as far as Hope Town. More recently they have been found in gravels in the Somabula Forest, Rhodesia and at Lüderitzbucht, German South West Africa. These *river diggings* are now of much less importance than the *dry diggings*, discovered in 1871.

The latter are chiefly in Griqualand-West, south of the Vaal river, on the border of the Orange Free State. There are here near Kimberley a number of limited areas approximately spherical or oval in form, with an average diameter of some 200 to 300 yards, of which the Kimberley, De Beer's, Dutoitspan and Bultfontein mines are the most important. A circle $3\frac{1}{2}$ miles in diameter encloses these four principal mines. The general structure is similar: a wall of nearly horizontal black carbonaceous shale with upturned edges enclosing the diamantiferous area. The upper portion of the deposit consists of a friable mass of little coherence of a pale yellow color, called the "yellow ground." Below the reach of atmospheric influences, the rock is more firm and of a bluish green or greenish color; it is called the "blue ground" or simply "the blue." This consists essentially of a serpentine breccia: a base of hydrated magnesian silicate penetrated by calcite and opaline silica and enclosing fragments of bronzite, diallage, also garnet, magnetite, and ilmenite, and less commonly smaragdite, pyrite, zircon, etc. The diamonds are rather abundantly disseminated through the mass, in some claims to the amount of 4 to 6 carats per cubic yard. The original rock seems to have been a peculiar type of peridotite. These areas are believed to be volcanic pipes, and the occurrence of the diamonds is obviously connected with the eruptive outflow, they having probably been brought up from underlying rocks. Other important mines, similar in character to those near Kimberley, are the Jagersfontein mine in Orange Free State and the Premier, near Pretoria, Transvaal.

The South African mines up to the beginning of 1914 are estimated to have yielded about 120 million carats (26 tons) of diamonds valued at nearly 900 million dollars.

Diamonds are also obtained in Borneo, associated with platinum, etc.; in Australia, and the Ural Mts.

In the United States a few stones have been found in gravels in N. C., Ga., Va., Col., Cal. and Wis. Reported from Idaho and from Oregon with platinum. In 1906 diamonds were found in Pike County, Ark., both loose in the soil and enclosed in a peridotite rock. Considerable exploration work has been done at this locality and probably between two and three thousand stones found. The stones have been of good color but usually small.

Some of the famous diamonds of the world with their weights are as follows: the Kohinoor, which weighed when brought to England 186 carats, and as recut as a brilliant, 106 carats; the Orloff, 194 carats; the Regent or Pitt, 137 carats; the Florentine or Grand Duke of Tuscany, 133 carats. The "Star of the South" found in Brazil weighed before and after cutting respectively 254 and 125 carats. Also famous because of the rarity of their color are the green diamond of Dresden, 40 carats, and the deep blue Hope diamond from India, weighing 44 carats.

South Africa has yielded some very large stones. Among these may be mentioned the following: From the Jagersfontein mine the Excelsior weighing 969 carats; the Jubilee, 634 carats; and the Imperial, 457 carats. The largest diamond known was found in 1905 at the Premier mine. It was named the Cullinan and was presented by the Transvaal Assembly to King Edward VII of England. When found it weighed 3,025 carats or over $1\frac{1}{2}$ lbs. It has since been cut into 105 separate stones, the two largest weighing 516 and 309

carats, respectively, being the largest cut stones in existence. The history of the above stones and of others is given in many works on gems.

Use. — In addition to its use as a gem, the diamond is extensively used as an abrasive. Crystal fragments are used to cut glass. The fine powder is employed in grinding and polishing gem stones. The noncrystalline, opaque varieties, especially the carbonado, are used in the bits of diamond drills. The diamond is also used in wire drawing and in the making of tungsten filaments for electric lights.

CLIFTONITE. — Carbon in minute cubic and cubo-octahedral crystals. $H. = 2.5$. $G. = 2.12$. Color and streak black; from the Youndeggin, West Australia, meteoric iron, found in 1884, and other meteoric irons.

GRAPHITE. Plumbago. Black Lead.

Rhombohedral. In six-sided tabular crystals. Commonly in embedded foliated masses, also columnar or radiated; scaly or slaty; granular to compact; earthy.

Cleavage: basal, perfect. Thin laminae flexible, inelastic. Feel greasy. $H. = 1-2$. $G. = 2.09-2.23$. Luster metallic, sometimes dull, earthy. Color iron-black to dark steel-gray. Opaque. A conductor of electricity.

Comp. — Carbon, like the diamond; often impure from the presence of ferric oxide, clay, etc.

Pyr., etc. At a high temperature some graphite burns more easily than diamond, other varieties less so. B.B. infusible. Unaltered by acids.

Diff. — Characterized by its extreme softness (soapy feel); iron-black color; metallic luster; low specific gravity; also by infusibility. Cf. molybdenite, p. 360.

Artif. — It is a common furnace product being formed from the fuel. It is produced extensively by heating coke in the electric furnace.

Obs. — Graphite is most commonly formed through the metamorphism of carbonaceous deposits and is most frequently found in metamorphic rocks, contact metamorphic deposits, etc. Coal beds may be largely converted into graphite by intense metamorphism. It is not always of organic origin, however, as is shown by its occurrence in meteorites, in pegmatite deposits and as a magmatic separation in various igneous rocks. Frequently its origin is obscure. Found as beds and embedded masses, as laminae or scales in granite, gneiss, mica schist, quartzite, crystalline limestone. The deposits of crystalline graphite which are of the greatest commercial importance have formed as veins along rock fractures.

Important localities are: Island of Ceylon from which the largest part of the world's supply comes; Passau district in Bavaria; southern Bohemia; Korea; Madagascar; Sonora in Mexico; eastern Ontario and adjacent portions of Quebec in Canada. The most productive locality in the United States is in the eastern and southeastern Adirondack region in Essex, Warren, Saratoga and Washington Counties, N. Y. It occurs here in graphitic quartzites, with quartz in small veins running through gneiss and in pegmatite veins. Also found in metamorphosed Carboniferous rocks near Providence and Tiverton, R. I.; in granite and schists in Clay, Chilton and Coosa Counties, Ala.; as amorphous graphite near Raton, N. M.; in irregular veins near Dillon, Mon.; near Turret, Chaffee Co., Col.

Use. — Its chief uses are for making crucibles and other refractory products, in lubricants, paint, stove polish, "lead" pencils and for foundry facings.

The name *black lead*, applied to this species, is inappropriate, as it contains no lead. The name *graphite*, of Werner, is derived from *γράφειν*, to write, alluding to its use for pencils.

QUISQUEITE. — A black lustrous material composed chiefly of carbon and sulphur from the vanadium ores of Minasragra, Peru.

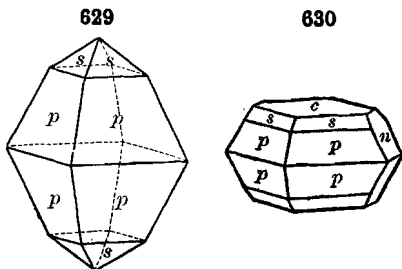
SULPHUR.

Orthorhombic. Axes $a : b : c = 0.8131 : 1 : 1.9034$.

Crystals commonly acute pyramidal; sometimes thick tabular $\parallel c(001)$. See also Fig. 79, p. 47. Also massive, in reniform shapes, incrusting, stalactitic and stalagmitic; in powder.

Cleavage: $c(001)$, $m(110)$, $p(111)$ imperfect. Fracture conchoidal to uneven. Rather brittle to imperfectly sectile. $H. = 1.5-2.5$. $G. = 2.05-$

2·09. Luster resinous. Color sulphur-yellow, straw- and honey-yellow, yellowish brown, greenish, reddish to yellowish gray. Streak white. Transparent to translucent. A non-conductor of electricity; by friction negatively electrified. A poor conductor of heat. Optically +. Double refraction strong. Ax. plane $\parallel b(010)$. Bx $\perp c(001)$. Dispersion $\rho < \nu$. $2V = 69^{\circ}5'$. Refractive indices, $\alpha = 1.958$, $\beta = 2.038$, $\gamma = 2.245$.



Comp. — Pure sulphur; often contaminated with clay, bitumen, and other impurities.

Sulphur may also be obtained in the laboratory in other allotropic forms; a monoclinic form is common.

Pyr., etc. — Melts at 108°C ., and at 270° burns with a bluish flame yielding sulphur dioxide. Insoluble in water, and not acted on by the acids, but soluble in carbon disulphide.

Diff. — Readily distinguished by the color, fusibility and combustibility.

Obs. — The great repositories of sulphur are either beds of gypsum and the associate rocks, or the regions of active and extinct volcanoes.

Sulphur may have several different modes of origin. At times it is a volcanic sublimate formed by reactions between sulphur dioxide and hydrogen sulphide gases. It occurs frequently around mineral springs where it has been formed by the incomplete oxidation of hydrogen sulphide. Where such waters act upon limestone rocks both gypsum and sulphur may be formed. In a small way it is formed in many coal deposits and elsewhere by the slow decomposition of pyrite and other sulphides.

Found in large amounts on the Island of Sicily, often in fine crystals and associated with celestite, calcite, aragonite, gypsum, and barite. Important deposits are found in the volcanic districts of Japan, Hawaii, Mexico, and western South America. In the United States the most productive deposits are in Louisiana and Texas. In Calcasieu Parish, Louisiana, a bed of sulphur 100 ft. in thickness is found at a depth of between 300 and 400 ft. It is underlain by beds of gypsum and salt. A similar deposit occurs near Freeport in Brazoria Co., Texas. It is found in numerous other western localities; Utah, at Sulphurdale, Beaver Co., in a rhyolitic tuff; Wy., in limestones near Cody and Thermopolis and about the fumeroles of the Yellowstone Park; Nev., in Esmeralda Co. near Luning and Cuprite, near Rosebud, Humboldt Co., sometimes in crystals and at Eureka, Eureka Co.; Cal., in Colusa, Lake, San Bernadino and other Counties, at the geysers of Napa Valley, Sonoma Co., on Lassen Peak, Tehema Co.; Col., at Vulcan, Gunnison Co., and in Mineral Co.

Use. — In manufacture of sulphuric acid, in the process of making paper from wood pulp, in making matches, gun powder, fireworks, insecticides, for vulcanizing rubber, for medicinal purposes, etc. Sulphuric acid is now largely derived from the oxidation of pyrite.

Selensulphur. — Contains sulphur and selenium, orange-red or reddish brown; from the islands Vulcano and Lipari.

ARSENIC.

Rhombohedral. Generally granular massive; sometimes reticulated, reniform, stalactitic.

Cleavage: $c(0001)$ highly perfect. Fracture uneven and fine granular. Brittle. H. = 3.5. G. = 5.63–5.73. Luster nearly metallic. Color and streak tin-white, tarnishing to dark gray.

Comp. — Arsenic, often with some antimony, and traces of iron, silver, gold, or bismuth.

Pyr. — B.B. on charcoal volatilizes without fusing, coats the coal with white arsenic trioxide, and affords a garlic odor; the coating treated in R.F. volatilizes, tingeing the flame blue. In the closed tube gives a volatile sublimate of arsenic.

Micro. — In polished section shows white color similar to galena. Smooth surface. With HNO_3 slowly effervesces, turning dark. Changes color in same way with FeCl_3 . Unaffected by KCN and HCl .

Obs. — Occurs in veins in crystalline rocks and the older schists, often accompanied by ores of antimony, the ruby silvers, realgar, sphalerite, and other metallic minerals. Thus in the silver mines of Saxony; also Andreasberg, Harz Mts., Germany; Joachimstal and Příbram, Bohemia; in Hungary; Norway; Zmeov, Siberia; Prov. Echizen, Japan, etc. Abundant at Chafarillo, Chile. In the United States sparingly at Haverhill and Jackson, N. H.; near Leadville, Col.; Washington Camp, Santa Cruz Co., Ariz. In Canada at Watson Creek, British Columbia; Montreal, Quebec.

Use. — An ore of arsenic.

Allemontite. — Arsenical Antimony, SbAs_3 . In reniform masses. $G. = 6.203$. Luster metallic. Color tin-white or reddish gray. From Allemont, France; Příbram, Bohemia, etc.

Tellurium. Rhombohedral. In prismatic crystals; commonly columnar to fine-granular massive. Perfect prismatic cleavage. $H. = 2-2.5$. $G. = 6.2$. Luster metallic. Color and streak tin-white. B.B. wholly volatile. In warm concentrated sulphuric acid gives red solution. From Transylvania, West Australia, and a number of places in Colorado.

ANTIMONY.

Rhombohedral. Generally massive, lamellar and distinctly cleavable; also radiated; granular.

Cleavage: $c(0001)$ highly perfect; also other cleavages. Fracture uneven; brittle. $H = 3-3.5$. $G. = 6.65-6.72$. Luster metallic. Color and streak tin-white.

Comp. — Antimony, containing sometimes silver, iron, or arsenic.

Pyr. — B.B. on charcoal fuses very easily and is wholly volatile giving a white coating. The white coating tinges the R.F. bluish green. Crystallizes readily from fusion.

Obs. — Occurs near Sala in Sweden; Andreasberg in the Harz Mts., Germany; Allemont, Dauphiné, France; Příbram, Bohemia; Mexico; Chile; Borneo. In the United States, at Warren, N. J., rare; in Kern Co., and at South Riverside, Cal. At South Ham, Quebec; Prince William parish, York Co., New Brunswick.

Use. — An ore of antimony.

BISMUTH.

Rhombohedral. Usually reticulated, arborescent; foliated or granular.

Cleavage: $c(0001)$ perfect. Sectile. Brittle, but when heated somewhat malleable. $H. = 2-2.5$. $G. = 9.70-9.83$. Luster metallic. Streak and color silver-white, with a reddish hue; subject to tarnish. Opaque.

Comp. — Bismuth, with traces of arsenic, sulphur, tellurium, etc.

Pyr., etc. — B.B. on charcoal fuses very easily and entirely volatilizes, giving a coating orange-yellow while hot, lemon-yellow on cooling. With potassium iodide and sulphur B.B. on charcoal gives a brilliant red coating. Dissolves in nitric acid; subsequent dilution causes a white precipitate. Crystallizes readily from fusion.

Micro. — In polished section shows creamy white color with pink tinge. Smooth and metallic surface. With HCl slowly darkens and dissolves. Rapidly darkens with effervescence with HNO_3 and aqua regia.

Obs. — Occurs in veins in gneiss and other crystalline rocks and clay slate, accompanying various ores of silver, cobalt, lead and zinc. Thus at the mines of Saxony and Bohemia, etc.; Meymac, Corrèze, France. Also at Modum, Norway; at Falun, Sweden. In Cornwall and Devonshire; near Copiapo, Chile; Bolivia.

Occurs at Monroe, Conn.; Brewer's mine, Chesterfield district, S. C.; near Cummins City, and elsewhere in Col. Abundant with silver ores at Cobalt, Ontario.

Use. — An ore of bismuth.

Zinc. — Probably does not occur in the native state. In the laboratory it is obtained in hexagonal prisms with tapering pyramids; also in complex crystalline aggregates. It also appears to crystallize in the isometric system, at least in various alloys.

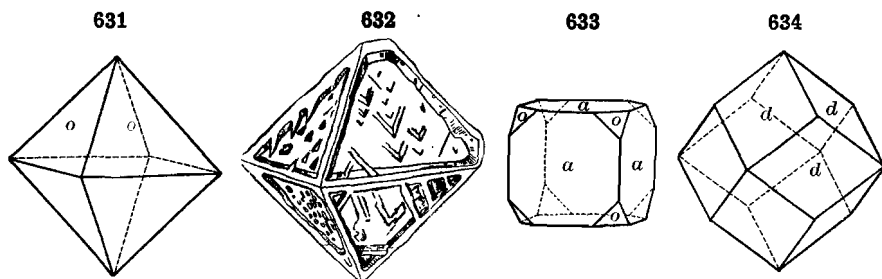
Tantalum. Isometric. In cubic crystals and fine grains. Color grayish yellow.

Found containing small amounts of niobium in the gold washings of the Ural and Altai Mts.

Gold Group

GOLD.

Isometric. Distinct crystals rare, $o(111)$ most common, also $d(110)$ and $m(311)$; crystals often elongated in direction of an octahedral axis, giving rise to rhombohedral-like forms, and arborescent shapes; also in plates flattened $\parallel o(111)$, and branching at 60° parallel either to the edges or diagonals of an o face (see pp. 172, 173). Twins: tw. plane o . Skeleton crystals



common; edges salient or rounded; in filiform, reticulated, dendritic shapes. Also massive and in thin laminae; often in flattened grains or scales.

Cleavage none. Fracture hackly. Very malleable and ductile. $H. = 2.5-3$. $G. = 15.6-19.3, 19.33$ when pure. Luster metallic. Color and streak gold-yellow, sometimes inclining to silver-white and rarely to orange-red. Opaque.

Comp. — Gold, but usually alloyed with silver in varying amounts and sometimes containing also traces of copper or iron.

Var. — 1. *Ordinary*. Containing up to 16 p. c. of silver. Color varying accordingly from deep gold-yellow to pale yellow, and specific gravity from 19.3 to 15.5. The ratio of gold to silver of 3 : 1 corresponds to 15.1 p. c. silver. For $G. = 17.6, Ag = 9$ p. c.; $G. = 16.9, Ag = 13.2$; $G. = 14.6, Ag = 38.4$. The purest gold which has been described is that from Mount Morgan, in Queensland, which has yielded 99.7 to 99.8 of gold, the remainder being copper with a little iron; silver is present only as a minute trace.

2. *Argentiferous; Electrum*. Color pale yellow to yellowish white; $G = 15.5-12.5$. Ratio for the gold and silver of 1 : 1 corresponds to 36 p. c. of silver; $1\frac{1}{2} : 1$, to 26 p. c.; 2 : 1, to 21 p. c.; $2\frac{1}{2} : 1$, to 18 p. c. The word in Greek means also *amber*; and its use for this alloy probably arose from the pale yellow color it has as compared with gold.

Varieties have also been described containing copper up to 20 p. c. from the Ural Mts.; palladium to 10 p. c. (*porpezite*), from Porpez, Brazil; bismuth, including the black gold of Australia (*maldonite*); also rhodium(?).

Pyx., etc. — B.B. fuses easily (at $1100^\circ C.$). Not acted on by fluxes. Insoluble in any single acid; soluble in aqua regia, the separation not complete if more than 20 p. c. Ag is present.

Diff. — Readily recognized (*e.g.*, from other metallic minerals, also from scales of yellow mica) by its malleability and high specific gravity, which last makes it possible to separate it from the gangue by washing; distinguished from chalcopyrite and pyrite since both sulphides are brittle and soluble in nitric acid.

Micro. — In polished section shows a golden yellow color with a smooth, metallic surface. Unaffected by reagents except KCN, with which it quickly darkens and its surface becomes rough.

Obs. — Gold is widely distributed in the earth's crust. It has been found in various igneous rocks, more commonly in the acid types, and sometimes in visible particles. It occurs in sedimentary rocks and quite frequently in connection with metamorphic rocks.

It is a constituent of sea water. It is most frequently found in notable amounts in quartz veins and in the various forms of placer deposits.

The gold, when occurring in quartz, is often irregularly distributed, in strings, scales, plates, and in masses which are sometimes an agglomeration of crystals. Frequently the scales are invisible to the naked eye. The associated minerals are: pyrite, which far exceeds in quantity all others, and is generally *auriferous*; next, chalcopyrite, galena, sphalerite, arsenopyrite, each frequently auriferous; often tetradymite and other tellurium ores, native bismuth, native arsenic, stibnite, cinnabar, magnetite, hematite; sometimes barite, scheelite, apatite, fluorite, siderite, chrysocolla. The quartz at the surface, or in the upper part of a vein, is usually cellular and rusted from the more or less complete disappearance of the pyrite and other sulphides by decomposition; but below, it is commonly solid.

The gold of the world was early gathered, not directly from the quartz veins (the "quartz reefs" of Australia and Africa), but from the gravel and sand deposited in the valleys in auriferous regions, or on the slopes of the mountains or hills, whose rocks contain in some part, and generally not far distant, gold bearing veins. Such deposits are known as placer deposits. The gold is obtained by some method involving the use of a current of water and the separation of the gold from the sand and gravel by means of its high specific gravity. These hydraulic methods have been very extensively used in California and Alaska and indeed most of the gold of the Ural Mts., Brazil, Australia, and many other gold regions has come from such alluvial washings. At the present time, however, placer deposits are much less depended upon and in many regions all the gold is obtained directly from the rock.

The alluvial gold is usually in flattened scales of different degrees of fineness, the size depending partly on the original condition in the quartz veins, and partly on the distance to which it has been transported and assorted by running water. The rolled masses when of some size are called *nuggets*; in rare cases these occur very large and of great value. The Australian gold region has yielded many large nuggets; one of these found in 1858 weighed 184 pounds, and another (1869) weighed 190 pounds. In the auriferous sands, crystals of zircon are very common; also garnet and cyanite in grains; often also monazite, diamond, topaz, corundum, iridosmine, platinum.

Besides the free gold of the quartz veins and gravels, much gold is also obtained from auriferous sulphides or the oxides produced by their alteration, especially pyrite, also arsenopyrite, chalcopyrite, sphalerite, marcasite, etc. The only minerals containing gold in combination are the rare tellurides (sylvanite, calaverite, etc.).

Gold is widely distributed over the earth. It occurs under many different conditions and with many different rocks, being, however, more commonly associated with the acid types. A brief summary of the more important districts follows.

Europe. The gold deposits of Europe are to be found chiefly in three great districts, namely the Ural mountains, eastern Hungary and a less important Alpine district reaching from Carinthia through the Austrian Tyrol and the Italian Alps to the Pyrenees. There are three gold districts in Hungary. Two of these are of minor importance and lie one to the north of Buda-Pesth and the other near the Galician frontier. The third district, which is the most important district in Europe, is in Transylvania, lying in the southeastern portion of the Bihar mountains. Its important centers are Offenbanya, Verespatak, Nagyág (largely tellurides), Boicza and Ruda.

Asia. In Siberia gold is found on the eastern slope of the Ural mountains for a distance of 500 miles. The important districts from north to south are Bogoslov, Nizhni Tagilsk, Beresov and other localities near Ekaterinburg, Syserstk and Kyshtimsk, the Miask district including Zlatoust and Mt. Ilmen, Kotchkar and at the southern limit of the fields, Orsk. Siberia also has the important placer districts in Tomsk, which include Altai and Marinsk, and in Yeniseisk, the Atchinsk, Minusinsk and the north and south Yenisei districts. Farther east there are deposits in Transbaikalia and the Lena district in Yakutsk. In India the chief districts are the Kolar field near Bangalore in Mysore and the Gadag and Hutti districts a little further north. Gold has been mined in China in Chili, Shantung, Weihaiwei, Szechuen, Yuman and Fo-Kien. In Manchuria on the Luau-tung Peninsula. In Korea principally at Unsan. Gold-quartz veins, many of which have been worked for a long time, occur on a number of the Japanese islands.

Australasia. The most important districts in New Zealand lie on the Hauraki Peninsula with the Waihi mine as the most famous. Other districts are the West Coast area on the western slopes of the Alps of the South Island and the Otago area. In Queensland the districts of Charter Towers and the Mount Morgan mine are important. There are many gold districts in New South Wales among which are Hillgrove, Mount Boppy and Hill End. Rich districts in Victoria are the Bendigo and Ballarat. The principal gold fields of Tasmania are Beaconsfield, Mathinna and the copper deposits at Mount Lyell. The chief gold field in West Australia is near Kalgoorlie where the ores are largely tellurides.

Africa. Gold is found in Egypt in the section between the Nile and the Red Sea. Some of these deposits were worked in very early days. Gold has been produced for a long time from the Gold Coast district on the Gulf of Guinea. Important deposits are found in Matabeleland and Mashonaland in Southern Rhodesia. The most important gold district in the world is that of the Witwatersrand in the Transvaal. The mines occur in an east and west belt, some sixty miles in length, near Johannesburg. The gold is found scattered in small amounts through a series of steeply dipping quartz conglomerate rocks.

South America. Colombia has in the past produced large amounts of gold. The chief districts today are in the states of Antioquia and Cauca. Comparatively small amounts are produced at the present time in the other northern countries. The important deposits of Brazil lie 200 miles to the north of Rio de Janeiro in Minas Geraes along the Sierra do Espinhaco. The gold deposits in Chile lie chiefly in the coast ranges in the northern and central parts of the country.

Mexico. While Mexico is chiefly noteworthy for its silver output it produces also considerable gold. Important districts are as follows: Altar, Magdalena and Arizpe in Sonora; various places in Chihuahua, especially about Parral, and the Dolores mine on the western border of the state; the El Oro mines in the state of Mexico; the Pachuca district in Hidalgo; also various places in Guanajuato and Zacatecas.

Canada. The three important placer districts of Canada are the Klondike in Yukon Territory and the Atlin and Cariboo in British Columbia. The most productive vein deposits are found in British Columbia in the West Kootenay and Yale districts. Gold is also found in Ontario and Nova Scotia.

United States. Gold occurs in the United States chiefly along the mountain ranges in the western states. Smaller amounts have been found along the Appalachians in the states of Virginia, North and South Carolina and Georgia. The more important localities in the western states are given below, the states being arranged approximately in the order of their importance. California. At the present time about two thirds of the state's output comes from the lode mines and one third from placer deposits. The quartz veins are chiefly found in what is known as the Mother-Lode belt that lies on the western slope of the Sierra Nevada and stretches from Mariposa County for more than 100 miles toward the north. The veins occur chiefly in a belt of slates. The lode mines are found chiefly in Amador, Calaveras, Kern, Nevada, Shasta, Sierra and Tuolumne Counties. The important placer mines are located in Butte, Sacramento and Yuba Counties. About 90 per cent of the placer gold is obtained by the use of dredges. Colorado. Gold is mined in various districts in Gilpin County, from the Leadville district and others in Lake County, in the region of the San Juan mountains in the Sneffels, Silverton and Telluride districts, Cripple Creek district (telluride ores) in Teller County, placer deposits in the Breckenridge district in Summit County. Alaska. The most important lode mines are in the Juneau district, while the chief placer deposits are those of Fairbanks and Iditarod in the Yukon basin and the Nome district on the Seward Peninsula. Nevada. The most important districts are those of Goldfield in Esmeralda County and Tonopah in Nye County. South Dakota. The output is chiefly from the Homestake mine at Lead in Lawrence County. Montana. There are various producing districts, the more important being in Madison (largely placers), Deer Lodge and Silver Bow Counties. Arizona. The important counties are Mohave and Cochise. Utah. Gold is produced chiefly from the Bingham and Tintic districts in Salt Lake County and from Juab County.

Use. — The chief ore of gold.

SILVER.

Isometric. Crystals commonly distorted, in acicular forms, reticulated or arborescent shapes; coarse to fine filiform; also massive, in plates or flattened scales.

Cleavage none. Ductile and malleable. Fracture hackly. $H. = 2.5-3.$ $G. = 10.1-11.1,$ pure 10.5. Luster metallic. Color and streak silver-white, often gray to black by tarnish.

Comp. — Silver, with some gold (up to 10 p. c.), copper, and sometimes platinum, antimony, bismuth, mercury.

Pyr., etc. — B.B. on charcoal fuses easily to a silver-white globule, which in O.F. gives a faint dark red coating of silver oxide; crystallizes on cooling; fusibility about $1050^{\circ} C.$ Soluble in nitric acid, and deposited again by a plate of copper. Precipitated from its solutions by hydrochloric acid in white curdy forms of silver chloride.

Diff. — Distinguished by its malleability, color (on the fresh surface), and specific gravity.

Micro. — In polished section shows a creamy white color with a metallic, smooth surface. With aqua regia and FeCl_3 tarnishes quickly with bright iridescent colors. Blackens with HNO_3 .

Obs. — Native silver occurs in masses, or in arborescent and filiform shapes, in veins traversing gneiss, schist, porphyry, and other rocks. Also occurs disseminated, but usually invisibly, in native copper, galena, chalcocite, etc. It is commonly of secondary origin, having been derived from the reduction of sulphides and other compounds of silver.

Native silver is found at a great many localities, some of the most famous of which follow: Kongsberg, Norway, in magnificent specimens and in very large masses; Freiberg, Schneeberg, etc., in Saxony; Pflibram and Joachimstal in Bohemia; Andreasberg in the Harz Mts., Germany; Allemont in Dauphiné, France; at various points in Cornwall, England. At Chañarillo and other localities in Chile; in large masses at Huantaya, Peru. In many places in Mexico, especially at Batopilas in Chihuahua; in Zacatecas and Guanajuato. A very important district is at Cobalt, Ontario, where native silver occurs in masses up to 1000 pounds in weight; it occurs there associated with various cobalt and nickel minerals.

In the United States it has been found with native copper in the Lake Superior copper district; at Silver Islet, Lake Superior; at Butte and the Elkhorn mine in Mon.; at the Poor Man's Lode in Idaho; in Col., with various sulphide deposits, especially at Aspen.

Use. — An ore of silver.

COPPER.

Isometric. The tetrahedron a common form (Fig. 635); also in octahedral plates. Distinct crystals rare. Frequently irregularly distorted and passing into twisted and wirelike forms; filiform and arborescent. Massive; as sand. Twins: tw. pl. o (111), very common, often flattened or elongated to spear-shaped forms. Cf. p. 173.

Cleavage none. Fracture hackly. Highly ductile and malleable. $H. = 2.5-3$. $G. = 8.8-8.9$. Luster metallic. Color copper-red. Streak metallic shining. Opaque. An excellent conductor for heat and electricity.

Comp. — Pure copper, often containing some silver, bismuth, mercury, etc.

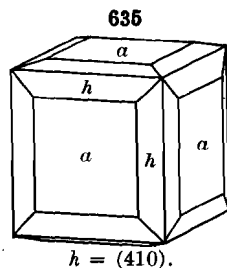
Pyr., etc. — B.B. fuses readily; on cooling becomes covered with a coating of black oxide. Dissolves readily in nitric acid, giving off red nitrous fumes, and produces a deep azure-blue solution with excess of ammonia. Fusibility 780°C .

Micro. — In polished section shows pink color with smooth, metallic surface. With conc. HNO_3 dissolves and shows iridescent tarnish. With FeCl_3 blackens and shows a solution pit.

Obs. — Copper is usually, if not always, secondary in its origin. It has either been deposited from solution by some reducing agent which is commonly a compound of iron or by the gradual reduction of some solid compound. Pseudomorphs of copper after cuprite, azurite, chalcocite, etc., are well known. It is associated with other copper ores, especially cuprite, malachite and azurite in the upper zone of copper veins; also with the sulphides, chalcopyrite, chalcocite, etc.; often abundant in the vicinity of dikes of igneous rocks; also in clay slate and sandstone.

Occurs in crystals at Bogoslovsk, Nijni Tagilsk and elsewhere in the Ural Mts. In Nassau, Germany. Common in Cornwall, England. Occurs in Brazil, Chile, and Peru. Found in pseudomorphs after the pseudo-hexagonal twins of aragonite at Corocoro, Bolivia. Abundant at Wallaroo, South Australia and at Broken Hill, New South Wales. Occurs at various places in Mexico.

Occurs native throughout the red sandstone region of the eastern United States, sparingly in Mass., Conn., and more abundantly in N. J. Near New Haven, Conn., a mass was found in the drift weighing nearly 200 pounds; smaller isolated masses have also been found. Found in minor amounts at Bisbee, Ariz. (in branching crystal groups); at George-



town, N. M. (pseudomorphs after azurite); Ducktown, Tenn.; Cornwall, Pa.; and Franklin, N. J. The most important region in the world for native copper is the Lake Superior copper district on the Keweenaw peninsula, northern Mich. The rocks of this district consist of a series of interbedded lava flows, sandstones and conglomerates which dip steeply to the northwest. The copper is obtained practically all in the native state, sometimes in immense masses. It occurs as (1) a cement filling the interstices in the sandstone and conglomerate, sometimes replacing in large part the grains and pebbles themselves, (2) filling the amygdaloidal cavities in the diabase and (3) in veins that traverse all kinds of rock. The copper was probably brought into the district by the igneous rocks. It is associated with native silver, calcite, prehnite, datolite, analcite, etc.

Use. — An ore of copper.

MERCURY. Quicksilver.

In small fluid globules scattered through its gangue. $G = 13.6$. Luster metallic, brilliant. Color tin-white. Opaque.

Comp. — Pure mercury (Hg); with sometimes a little silver.

Pyr., etc. — B.B. entirely volatile, vaporizing at 350°C . Becomes solid at -40°C ., crystallizing in regular octahedrons with cubic cleavage; $G = 14.4$. Dissolves in nitric acid.

Obs. — Mercury in the metallic state is a rare mineral, and is usually associated with the sulphide cinnabar, from which the supply of commerce is obtained. The rocks affording the metal and its ores are chiefly clay shales or schists of different geological ages. Also found in connection with hot springs. See cinnabar.

LEAD.

Isometric. Crystals rare. Usually in thin plates and small globular masses. Very malleable, and somewhat ductile. $H = 1.5$. $G = 11.4$. Luster metallic. Color lead-gray. Opaque.

Comp. — Nearly pure lead; sometimes contains a little silver, also antimony.

Pyr. — B.B. fuses easily, coating the charcoal with a yellow to white oxide. Fusibility 330°C . Dissolves easily in dilute nitric acid.

Obs. — Of rare occurrence. Found at Pajsberg, Harstig, and Långban in Sweden; similarly at Nordmark; also in the gold washings of the Ural Mts.; reported elsewhere, but localities often doubtful. In the United States, occurs at Breckinridge and Gunnison, Col.; Wood River district, Idaho; Franklin, N. J.

AMALGAM.

Isometric. Common habit dodecahedral. Crystals often highly modified. Also massive in plates, coatings, and embedded grains.

Cleavage: dodecahedral in traces. Fracture conchoidal, uneven. Rather brittle to malleable. $H = 3-3.5$. $G = 13.75-14.1$. Luster metallic, brilliant. Color and streak silver-white. Opaque.

Comp. — (Ag_2Hg), silver and mercury, varying from Ag_2Hg_3 to Ag_{36}Hg .

Var. — *Ordinary amalgam*, Ag_2Hg_3 (silver 26.4 p. c.) or AgHg (silver 35.0); also Ag_2Hg , etc. *Arquerite*, Ag_{12}Hg (silver 86.6); $G = 10.8$; malleable and soft. *Kongsbergite*, Ag_{32}Hg or Ag_{36}Hg .

Pyr., etc. — B.B. on charcoal the mercury volatilizes and a globule of silver is left. In the closed tube the mercury sublimates and condenses on the cold part of the tube in minute globules. Dissolves in nitric acid. Rubbed on copper it gives a silvery luster.

Obs. — From Germany in the Rhine-Palatinate at Moschel-Landsberg and at Friedrichsseen, Nassau; from Sala, Sweden; Kongsberg, Norway; Allemont, Dauphiné, France; Almaden, Spain; Chile; Vitale Creek, British Columbia (*arquerite*).

Tin. — Native tin has been reported from several localities. The only occurrence fairly above doubt is that from the washings at the headwaters of the Clarence river, near Oban, New South Wales. It has been found here in grayish white rounded grains, with platinum, iridosmine, gold, cassiterite, and corundum.

Platinum-Iron Group

PLATINUM.

Isometric. Crystals rare; usually in grains and scales.

Cleavage none. Fracture hackly. Malleable and ductile. $H. = 4-4.5$. $G. = 14-19$ native; 21-22 chem. pure. Luster metallic. Color and streak whitish steel-gray; shining. Sometimes magnetic and occasionally shows polarity.

Comp. — Platinum alloyed with iron, iridium, rhodium, palladium, osmium, and other metals.

Most platinum yields from 8 to 15 or even 18 per cent of iron, 0.5 to 2 p. c. palladium, 1 to 3 p. c. each of rhodium and iridium, a trace of osmium and finally 0.5 to 2 p. c. or more of copper.

Var. — 1. *Ordinary. Non-magnetic* or only slightly magnetic. $G. = 16.5-18.0$ mostly. 2. *Magnetic.* $G.$ about 14. Much platinum is magnetic, and occasionally it has polarity. The magnetic property seems to be connected with high percentage of iron (iron-platinum), although this distinction does not hold without exception.

Pyr., etc. — B.B. infusible. Not affected by borax or salt of phosphorus, except in the state of fine dust, when reactions for iron and copper may be obtained. Soluble only in heated aqua regia.

Diff. — Distinguished by its color, malleability, high specific gravity, infusibility and insolubility in ordinary acids.

Obs. — The platinum of commerce comes almost exclusively from placer deposits. Its original source, however, is in the basic igneous rocks, usually peridotites. The associated minerals are commonly chrysolite, serpentine and chromite. Platinum was first found in pebbles and small grains, associated with iridium, gold, chromite, etc., in the alluvial deposits of the river Pinto, in the district of El Choco, Colombia; South America, where it received its name *platina* (platina del Pinto) from *plata*, silver. The greater part of the world's supply comes from Russia (discovered in 1822) where it occurs in alluvial material in the Ural Mts. at Nijni Tagilsk, and with chromite in a serpentine probably derived from a peridotite; also in the Goroblagodat and Bisersk districts. Also found in Borneo; in New Zealand, from a region characterized by a chrysolite rock with serpentine; in New South Wales, at the Broken Hill district, and in gold washings at various points.

In Cal. in small amounts in the gold placers, chiefly in Trinity Co.; at Port Orford in Ore. At various points in Canada, the most important being the Tulameen District in British Columbia

Use. — Practically the only ore of platinum.

Iridium: Platin-iridium. Iridium alloyed with platinum and other allied metals. Occurs usually in angular grains of a silver-white color. $H. = 6-7$. $G. = 22.6-22.8$. With the platinum of the Ural Mts. and Brazil.

IRIDOSMINE. Osmiridium.

Rhombohedral. Usually in irregular flattened grains.

Cleavage: $c(0001)$ perfect. Slightly malleable to nearly brittle. $H. = 6-7$. $G. = 19.3-21.12$. Luster metallic. Color tin-white to light steel-gray. Opaque.

Comp. — Iridium and osmium in different proportions. Some rhodium, platinum, ruthenium, and other metals are usually present.

Var. — 1. *Nevyanskite.* $H. = 7$; $G. = 18.8-19.5$. In flat scales; color tin-white. Over 40 p. c. of iridium. 2. *Sisverskite.* In flat scales, often six-sided, color grayish white, steel-gray. $G. = 20-21.2$. Not over 30 p. c. of iridium. Less common than the light-colored variety.

Diff. — Distinguished from platinum by greater hardness and by its lighter color.

Obs. — Occurs with platinum in South America; in the Ural Mts.; in auriferous drift in New South Wales. Rather abundant in the auriferous beach-sands of northern California and Oregon.

Palladium. — Isometric. Palladium, alloyed with a little platinum and iridium.

Mostly in grains. H. = 4·5-5. G. = 11·3-11·8. Color whitish steel-gray. Occurs with platinum in Brazil; also from the Ural Mts.

Allopladium. — Palladium under the hexagonal-rhombohedral class(?). From Tilkerode in the Harz Mts. in small hexagonal tables with gold.

IRON.

Isometric. Usually massive, rarely in crystals.

Cleavage: $a(100)$, perfect; also a lamellar structure $\parallel o(111)$ and $\parallel d(110)$. Fracture hackly. Malleable. H. = 4-5. G. = 7·3-7·8. Luster metallic. Color steel-gray to iron-black. Strongly magnetic.

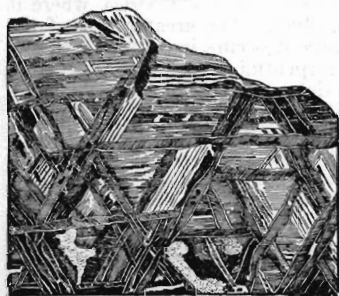
Var. — 1. Terrestrial Iron. — Found in masses, occasionally of great size, as well as in small embedded particles, in basalt at Blaafield, Ovifak (or Uifak), Disko Island, West Greenland; also elsewhere on the same coast. This iron contains 1 to 2 p. c. of Ni. In small grains with pyrrhotite in basalt from near Kassel, Hesse Nassau, Germany. In minute spherules in feldspar from Cameron Township, Nipissing Dist., Ontario. Some other occurrences, usually classed as meteoric, may be in fact terrestrial.

A nickeliferous metallic iron (FeNi_2) called *awaruite* occurs in the drift of the Gorge river, which empties into Awarua Bay on the west coast of the south island of New Zealand; associated with gold, platinum, cassiterite, chromite; probably derived from a partially serpentinized peridotite. *Josephinite* is a nickel-iron (FeNi_3) from Oregon, occurring in stream gravel. Similar material from near Lilloet on the Fraser river, British Columbia, has been called *souesite*. Native iron also occurs sparingly in some basalts; reported from gold or platinum washings at various points.

2. Meteoric Iron. — Native iron also occurs in most meteorites, forming in some cases (a) the entire mass (*iron meteorites*); also (b) as a spongy, cellular matrix in which are embedded grains of chrysolite or other silicates (*siderolites*); (c) in grains or scales disseminated more or less freely throughout a stony matrix (*meteoric stones*).

Rarely a meteorite consists of a single crystalline individual with numerous twinning lamellæ $\parallel o(111)$. Cubic cleavage sometimes observed; also an octahedral, less often dodecahedral, lamellar structure. Etching with dilute nitric acid (or iodine) commonly develops a crystalline structure (called *Widmanstätten figures*) (Fig. 636); usually consisting of lines or bands crossing at various angles according to the direction of the section, at 60° if $\parallel o(111)$, 90° $\parallel a(100)$, etc. They are formed by the edges of crystalline plates, usually $\parallel o$, of the nickeliferous iron of different composition (*kamacite*, *tænite*, *pllessite*), as shown by the fact that they are differently attacked by the acid. Irons with cubic structure and with twinning lamellæ have a series of fine lines corresponding to those developed by etching (*Neumann lines*). A damascene luster is also produced in some cases, due to quadrilateral depressions. Some irons show no

636



Glorieta Mt., New Mexico

distinct crystalline structure upon etching.

The exterior of masses of meteoric iron is usually more or less deeply pitted with rounded thumblike depressions, and the surface at the time of fall is covered with a film of iron oxide in fine ridges showing lines of flow due to the melting caused by the heat developed by the resistance of the air; this film disappears when the iron is exposed to the weather.

Meteoric iron is always alloyed with nickel, which is usually present in amounts varying from 5 to 10 p. c., sometimes much more; small amounts of other metals, as cobalt, manganese, tin, copper, chromium, are also often present. Occluded gases can usually be detected. Graphite, in seams or nodules, also troilite (iron sulphide), schreibersite (iron-nickel phosphide) are common in masses of meteoric iron; diamond, daubreelite, etc., are rare. *Cohenite*, sometimes identified, is $(\text{Fe}, \text{Ni}, \text{Co})_3\text{C}$ in tin-white crystals.

Moissanite. — CSi . This material, originally produced artificially as *carborundum*, has been found occurring naturally as small green hexagonal plates in the meteoric iron of Cañon Diablo, Ariz