

Pyr., etc.—B.B. decrepitates and fuses below 2. With salt of phosphorus in O.F. gives a yellowish-green glass, which in R.F. becomes dark green. With soda on charcoal yields metallic lead. Decomposed on evaporation with hydrochloric acid, with the formation of lead chloride and molybdic oxide; on moistening the residue with water and adding metallic zinc, it gives an intense blue color, which does not fade on dilution of the liquid.

Obs.—Occurs in veins with other ores of lead. At Bleiberg, Carinthia; Rezbánya, Hungary; Příbram; Moldava in the Banat; Annaberg, Schneeberg, etc.

In the U. States, sparingly at the Southampton lead mine, Mass., and near Sing Sing, N. Y.; near Phenixville, Pa.; at the Comstock lode in Nevada; in large thin orange-yellow tables at the Tecamah mine, Utah. In New Mexico, pale yellow crystals in the Organ Mts. In Arizona, large deep red crystals at the Hamburg and other mines, Yuma Co., often with red vanadinite; also at the Castle Dome district, 30 miles distant; at the Mammoth gold mine near Oracle, Pinal Co., with vanadinite and descloizite.

Named after the Austrian mineralogist Wulfen (1728-1805).

Reinite. Ferrous tungstate, FeWO_4 . In blackish-brown tetragonal pyramids, perhaps pseudomorphous. $H. = 4$. $G. = 6.64$. Kimbosan, Japan.

Belonesite. Perhaps MgMoO_4 . In minute acicular crystals at Vesuvius.

VII. SALTS OF ORGANIC ACIDS.

Oxalates, Mellates.

Whewellite. Calcium oxalate, $\text{CaC}_2\text{O}_4 + \text{H}_2\text{O}$. In small colorless monoclinic crystals. From Saxony, with coal.

Oxammite. Ammonium oxalate, $(\text{NH}_4)_2\text{C}_2\text{O}_4 + 2\text{H}_2\text{O}$. From the guano of the Guañape Islands, Peru.

Humboldtine. Hydrous ferrous oxalate, $2\text{FeC}_2\text{O}_4 + 3\text{H}_2\text{O}$. Color yellow. From near Bilin, Bohemia.

Mellite. Hydrous aluminium mellate, $\text{Al}_2\text{C}_{12}\text{O}_{12} + 18\text{H}_2\text{O}$. In square pyramids; also massive, granular. $G. = 1.55-1.65$. Color honey-yellow. Occurs in brown coal in Thuringia, Bohemia, etc.

VIII. HYDROCARBON COMPOUNDS.

The Hydrocarbon compounds in general, with few exceptions, are *not homogeneous substances*, but mixtures, which by the action of solvents or by fractional distillation may be separated into two or more component parts. They are hence not definite mineral species and do not strictly belong to pure Mineralogy, rather, with the recent gums and resins, to Chemistry or, so far as they are of practical value, to Economic Geology. In the following pages they are treated for the most part with great brevity.

1. Simple Hydrocarbons. Chiefly members of the Paraffin Series $\text{C}_n\text{H}_{2n+2}$.

SCHEEERERITE. In whitish monoclinic crystals. Perhaps a polymer of marsh-gas (CH_4). Found in brown coal at Uznach, Switzerland.

HATCHETTITE. Mountain Tallow. In thin plates, or massive. Like soft wax. Color yellowish. Ratio of C to H = nearly 1 : 1. From the Coal-measures near Merthyr-Tydvil in Glamorganshire, England.

PARAFFIN. A native crystallized paraffin has been described as occurring in cavities in basaltic lava near Paterno, Sicily.

OZOCERITE. Mineral wax pt. Like wax or spermaceti in appearance and consistency. Colorless to white when pure; often leek-green, yellowish, brownish yellow, brown. Essentially a paraffin, and consisting chiefly of one of the higher members of the series. Occurs in beds of coal, or associated bituminous deposits, as at Slanik, Moldavia; Boryslaw in the Carpathians. Also occurs in southern Utah on a large scale.

Zietrisikite, Chrismatite, Urpethite are near ozocerite.

FICHELITE. In white monoclinic tabular crystals. Perhaps C_8H_8 . Occurs in thin layers of pine wood from peat-beds near Redwitz, in the Fichtelgebirge, Bavaria. *Hartite* has a similar occurrence.

NAPALITE. A yellow bituminous substance of the consistency of shoemaker's wax. C_8H_8 . From the Phoenix mercury mine in Pope Valley, Napa county, California.

2. Oxygenated Hydrocarbons.

AMBER. Bernstein, *Germ.* In irregular masses, with conchoidal fracture. $H. = 2-2.5$. $G. = 1.096$. Luster resinous. Color yellow, sometimes reddish, brownish, and whitish, often clouded, sometimes fluorescent. Transparent to translucent. Heated to 150° begins to soften, and finally melts at $250^\circ-300^\circ$. Ratio for C, H, O = 40 : 64 : 4.

Part of the so-called amber is separated mineralogically as *succinite* (yielding succinic acid). Other related fossil resins from many other regions (e. g., the Atlantic coast of the United States) have been noted. Some of them have been called *retinite, gedanite, glessite, rumänite, simelite, krantzite, chemawinite*, etc.

Amber occurs abundantly on the Prussian coast of the Baltic from Dantzic to Memel; also on the coasts of Denmark, Sweden, and the Russian Baltic provinces. It is mined extensively, and is also found on the shores cast up by the waves after a heavy storm. Amber and the similar fossil resins are of vegetable origin, altered by fossilization; this is inferred both from its native situation with coal, or fossil wood, and from the occurrence of insects incased in it. Amber was early known to the ancients, and called *ἤλεκτρον, electrum*, whence, on account of its electrical susceptibilities, has been derived the word *electricity*.

COPALITE, or Highgate resin, is from the London blue clay. It is like the resin copal in hardness, color, luster, transparency, and difficult solubility in alcohol. Color clear pale yellow to dirty gray and dirty brown. Emits a resinous aromatic odor when broken.

The following are oxygenated hydrocarbons occurring with coal and peat deposits, etc.:

BATHVILLITE. Occurs in dull, brown, porous lumps in the torbanite or Boghead coal (of the Carboniferous formation) adjoining the lands of Torbane Hill, Bathville, Scotland.

It may be an altered resin, or else material which has filtrated into the cavity from the surrounding torbanite.

TASMANITE. In minute reddish brown scales disseminated through a laminated shale; average diameter of scales about 0.03 in. Not dissolved at all by alcohol, ether, benzene, turpentine, or carbon disulphide, even when heated. Remarkable as yielding 53 p. c. sulphur. From the river Mersey, north side of Tasmania; the rock is called *combustible shale*.

DYSODILE. In very thin folia, flexible, slightly elastic; yellow or greenish gray. Analysis gave 2.3 p. c. sulphur and 1.7 p. c. nitrogen. From lignite deposits at Melilli, Sicily, and elsewhere.

GEOCERITE. A white, wax-like substance, separated from the brown coal of Gesterwitz, near Weissenfels. *Geomyricite* and *geocerellite* are other products from the same source.

LEUCOPETRITE. Also from the Gesterwitz brown coal. Between a resin and wax in physical characters.

PYRORETINITE. From brown coal near Aussig, Bohemia.

DOPPLERITE. In elastic or partly jelly-like masses; brownish black. An acid substance, or mixture of different acids, related to humic acid. Ratio for C, H, O, nearly 10 : 12 : 5. From peat beds near Aussee in Styria, etc.

IDRIALITE. Occurs with the cinnabar of Idria. In the pure state white and crystalline in structure. In nature found only impure, being mixed with cinnabar, clay, and some pyrite and gypsum in a brownish-black earthy material, called, from its combustibility and the presence of mercury, *inflammable cinnabar* (*Quecksilberbranderz*).

POSEPNYTE. Occurs in hard, brittle plates or nodules, light green in color. From the Great Western mercury mine, Lake Co., California. See also napalite, p. 543.

The following are still more complex native hydrocarbon compounds of great importance from an economic standpoint.

Petroleum. NAPHTHA; PETROLEUM. Mineral oil. Kerosene. Erdöl, Bergöl, Steinöl, *Germ.*

PITTASPHALT; Maltha. Mineral Tar. Bergtheer *Germ.*

Liquids or oils, in the crude state of disagreeable odor; varying widely in color, from colorless to dark yellow or brown and nearly black, the greenish-brown color the most common; also in consistency from thin flowing kinds to those that are thick and viscous; and in specific gravity from 0.6 to 0.9. Petroleum, proper, passes by insensible gradations into *pittasphalt* or *maltha* (viscid bitumen); and the latter as insensibly into *asphalt* or solid bitumen.

Chemically, petroleum consists for the most part of members of the paraffin series, C_nH_{2n+2} , varying from marsh gas, CH_4 , to the solid forms. The olefines, C_nH_{2n} , are also present in smaller amount. This is especially true of the American oils. Those of the Caucasus have a higher density, the volatile constituents are less prominent, they distill at about 150° and contain the benzenes, C_nH_{2n-6} , in considerable amount. There are present also members of the series C_nH_{2n-8} . The German petroleum is intermediate between the American and the Caucasian. The Canadian petroleum is especially rich in the solid paraffins.

Petroleum occurs in rocks or deposits of nearly all geological ages, from the Lower Silurian to the present epoch. It is associated most abundantly with argillaceous shales, sands, and sandstones, but is found also permeating limestones, giving them a bituminous odor, and rendering them sometimes a considerable source of oil. From these oleiferous shales, sands and limestones the oil often exudes, and appears floating on the streams or lakes of the region, or rises in oil springs. It also exists collected in subterranean cavities in certain rocks, whence it issues in jets or fountains whenever an outlet is made by boring. The oil which fills the cavities has ordinarily been derived from the subjacent rocks; for the strata in which the cavities exist are frequently barren sandstones. The conditions required for the production of such subterranean accumulations would be therefore a bituminous oil-bearing or else oil-producing stratum at a greater or less depth below; cavities to receive the oil; an overlying stratum of close-grained shale or limestone, not allowing of the easy escape of the naphtha vapors.

The two regions which now furnish the chief part of the petroleum are, first in importance, western Pennsylvania, with parts of New York and Ohio, and, second, the Baku region on the Caspian Sea, at the eastern end of the Caucasus. The oil has been known to

exist at the latter locality since early times, but only since 1876 has its economic importance been recognized. Petroleum is also obtained in this country in West Virginia; near Cañon City, Colorado; and in California, especially in Los Angeles, Ventura and Santa Cruz counties. Numerous localities where it occurs in limited amount have been noted in other States. In Canada, oil is produced in Lambton county, Ontario. Other oil-producing regions are found in Burma, Japan, New Zealand, etc.

Asphaltum. Mineral Pitch. Asphalt, Bergpech, Erdpech, *Germ.*

Asphaltum, or mineral pitch, is a mixture of different hydrocarbons, part of which are oxygenated. Its ordinary characters are as follows: Amorphous. $G. = 1.18$; sometimes higher from impurities. Luster like that of black pitch. Color brownish black and black. Odor bituminous. Melts ordinarily at 90° to 100°, and burns with a bright flame. Soluble mostly or wholly in oil of turpentine, and partly or wholly in ether; commonly partly in alcohol. The more solid kinds graduate into the pittasphalts or mineral tar, and through these there is a gradation to petroleum. The fluid kinds change into the solid by the loss of a vaporizable portion on exposure, and also by a process of oxidation, which consists first in a loss of hydrogen, and finally in the oxygenation of a portion of the mass. The action of heat, alcohol, ether, naphtha and oil of turpentine, as well as direct analyses, show that the so-called asphaltum from different localities is very various in composition.

Asphaltum belongs to rocks of no particular age. The most abundant deposits are superficial. But these are generally, if not always, connected with rock deposits containing some kind of bituminous material or vegetable remains. Some of the noted localities of asphaltum are the region of the Dead Sea, or Lake Asphaltites, whence the most of the asphaltum of ancient writers; a lake on Trinidad, $1\frac{1}{2}$ m. in circuit, which is hot at the center, but is solid and cold toward the shores, and has its borders over a breadth of $\frac{2}{3}$ m. covered with the hardened pitch with trees flourishing over it; at various places in South America; in California, near the coast of St. Barbara; also in smaller quantities, elsewhere.

ELATERITE. Elastic Bitumen. Mineral Caoutchouc. Soft, elastic, sometimes much like india-rubber; occasionally hard and brittle. Color usually dark brown. Found at Castleton in Derbyshire, and elsewhere.

ALBERTITE. Differs from ordinary asphaltum in being only partially soluble in oil of turpentine, and in its very imperfect fusion when heated. $H. = 1.2$. $G. = 1.097$. Luster brilliant, pitch-like; color jet-black. Occurs filling an irregular fissure in rocks of the Lower Carboniferous in Nova Scotia.

GRAHAMITE. Resembles albertite in its pitch-black, lustrous appearance. $H. = 2$. $G. = 1.145$. Soluble mostly in oil of turpentine; partly in ether, naphtha or benzene; not at all in alcohol; wholly in chloroform and carbon disulphide. Melts only imperfectly; and with a decomposition of the surface. Occurs in W. Virginia, about 20 m. S. of Parkersburg, filling a fissure in a Carboniferous sandstone.

GILSONITE, also called *Uintalite* or *Uintaite*. A variety of asphalt from near Ft. Duchesne, Utah, which has found many applications in the arts. Occurs in masses several inches in diameter, with conchoidal fracture; very brittle. $H. = 2.25$; $G. = 1.065-1.070$. Color black, brilliant and lustrous; streak and powder a rich brown. Fuses easily in the flame of a candle and burns with a brilliant flame, much like sealing-wax. Named after Mr. S. H. Gilson of Salt Lake City.

Mineral Coal. Compact massive, without crystalline structure or cleavage; sometimes breaking with a degree of regularity, but from a jointed rather than a cleavage structure. Sometimes laminated; often faintly and delicately banded, successive layers differing slightly in luster. Fracture conchoidal to uneven. Brittle; rarely somewhat sectile. $H. = 0.5-2.5$. $G. = 1-1.80$. Luster dull to brilliant, and either earthy, resinous or sub-metallic. Color black, grayish black, brownish black, and occasionally iridescent; also sometimes dark brown. Opaque. Infusible to subfusible; but often becoming a soft, pliant or paste-like mass when heated. On distillation most kinds afford more or less of oily and tarry substances, which are mixtures of hydrocarbons and paraffin.

The varieties recognized depend partly (1) on the amount of the volatile ingredients afforded on destructive distillation; or (2) on the nature of these volatile compounds, for ingredients of similar composition may differ widely in volatility, etc.; (3) on structure, luster and other physical characters.

Coal is in general the result of the gradual change which has taken place in geological history in organic deposits, chiefly vegetable, and its form and composition depend upon the extent to which this change has gone on. Thus it passes from forms which still retain the original structure of the wood (peat, lignite) and through those with less of volatile or bituminous matter to anthracite and further to kinds which approach graphite.

1. ANTHRACITE. Glanzkohle *Germ.* H. = 2.2.5. G. = 1.32-1.7. Luster bright, often submetallic, iron-black, and frequently iridescent. Fracture conchoidal. Volatile matter after drying 3-6 p. c. Burns with a feeble flame of a pale color. The anthracites of Pennsylvania contain ordinarily 85-93 per cent. of carbon; those of South Wales, 88-95; of France, 80-83; of Saxony, 81; of southern Russia, sometimes 94 per cent. Anthracite graduates through semi-anthracite into bituminous coal, becoming less hard and containing more volatile matter; and an intermediate variety is called *free-burning* anthracite.

2. BITUMINOUS COAL. Burns in the fire with a yellow, smoky flame, and gives out on distillation hydrocarbon oils or tar; hence the name *bituminous*. The *ordinary* bituminous coals contain from 5-15 p. c. (rarely 16 or 17) of oxygen (ash excluded); while the so-called *brown coal* or *lignite* contains from 20-36 p. c., after the expulsion, at 100°, of 15-36 p. c. of water. The amount of hydrogen in each is from 4-7 p. c. Both have usually a bright, pitchy, greasy luster, a firm compact texture, are rather fragile compared with anthracite, and have G. = 1.14-1.40. The *brown* coals have often a brownish-black color, whence the name, and more oxygen, but in these respects and others they shade into ordinary bituminous coals. The ordinary bituminous coal of Pennsylvania has G. = 1.26-1.37; of Newcastle, England, 1.27; of Scotland, 1.27-1.32; of France, 1.2-1.33; of Belgium, 1.27-1.3. The most prominent kinds are the following:

(a) *Caking* or *Coking Coal*. A bituminous coal which softens and becomes pasty or semi-viscid in the fire. This softening takes place at the temperature of incipient decomposition, and is attended with the escape of bubbles of gas. On increasing the heat, the volatile products which result from the ultimate decomposition of the softened mass are driven off, and a coherent, grayish-black, cellular or fritted mass (*coke*) is left. Amount of coke left (or part not volatile) varies from 50-85 p. c.

(b) *Non-Caking Coal*. Like the preceding in all external characters, and often in ultimate composition; but burning freely without softening or any appearance of incipient fusion. There are all gradations between caking and non-caking bituminous coals.

(c) *Cannel Coal* (Parrot Coal). A variety of bituminous coal, and often caking; but differing from the preceding in texture, and to some extent in composition, as shown by its products on distillation. It is compact, with little or no luster, and without any appearance of a banded structure; and it breaks with a conchoidal fracture and smooth surface; color dull black or grayish black. On distillation it affords, after drying, 40 to 66 p. c. of volatile matter, and the material volatilized includes a large proportion of burning and lubricating oils, much larger than the above kinds of bituminous coal; whence it is extensively used for the manufacture of such oils. It graduates into oil-producing coaly shales, the more compact of which it much resembles. *Torbanite* is a variety of cannel coal of a dark brown color, from Torbane Hill, near Bathgate, Scotland; also called *Boghead Cannel*.

(d) *Brown Coal* (Braunkohle *Germ.*, Lignite). The prominent characteristics of brown coal have already been mentioned. They are non caking, but afford a large proportion of volatile matter; sometimes pitch-black, but often rather dull and brownish black. G. = 1.15-1.3. Brown coal is often called *lignite*. But this term is sometimes restricted to masses of coal which still retain the form of the original wood. *Jet* is a black variety of brown coal, compact in texture, and taking a good polish, whence its use in jewelry.

Coal occurs in beds, interstratified with shales, sandstones, and conglomerates, and sometimes limestones, forming distinct layers, which vary from a fraction of an inch to 30 feet or more in thickness. In the United States, the anthracites occur east of the Alleghany range, in rocks that have undergone great contortions and fracturings, while the bituminous coals are found extensively in many States farther west, in rocks that have been less disturbed; and this fact and other observations have led geologists to the view that the anthracites have lost their bitumen by the action of heat. The *origin* of coal is mainly vegetable, though animal life has contributed somewhat to the result. The beds were once beds of vegetation, analogous, in most respects, in mode of formation to the peat beds of modern times, yet in mode of burial often of a very different character. This vegetable origin is proved not only by the occurrence of the leaves, stems and logs of plants in the coal, but also by the presence throughout its texture, in many cases, of the forms of the original fibers; also by the direct observation that peat is a transition state between unaltered vegetable debris and brown coal, being sometimes found passing completely into true brown coal. *Peat* differs from true coal in want of homogeneity, it visibly containing vegetable fibers only partially altered; and wherever changed to a fine-textured homogeneous material, even though hardly consolidated, it may be true brown coal.

For an account of the chief coal fields, and of the geological relations of the different coal deposits, reference is made to works on Economic Geology.

APPENDIX A.

ON THE DRAWING OF CRYSTAL FIGURES AND OF PROJECTIONS.

In the representation of crystals by drawings, the object may be either to show the entire form in perspective or to give simply a projection of the faces upon a single plane. The first of these cases is the more important, and must be treated here in some detail. Two points are to be noted in regard to it. In the first place, in the drawings of crystals the point of view is supposed to be at an infinite distance, and it follows from this that all lines which are parallel on the crystal appear *parallel* in the drawing.

In the second place, in all ordinary cases, it is the complete ideal crystal which is represented, that is, the crystal with its full geometrical symmetry as explained on pp. 9 to 11 (cf. note on p. 11).

PROJECTION OF THE AXES.

The projection of the axes of a crystal is the first step preliminary to the drawing of the form of the crystal itself. The projection of the axes in the isometric system, which are equal and intersect at right angles, is here first given. The projection of the axes in the other systems, with the exception of the hexagonal, may be obtained by varying the lengths of the projected isometric axes, and also, when oblique, their inclinations, as shown beyond.

Isometric System.—When the eye is directly in front of a face of a cube, neither the sides nor top of the crystal are visible, nor the faces that may be situated on the intermediate edges. On turning the crystal a few degrees from right to left a side lateral face is brought in view, and by elevating the eye slightly the terminal face becomes apparent. In the following demonstration the angle of revolution is designated δ , and the angle of the elevation of the eye, e . Fig. 989 represents the normal position of the horizontal axes, supposing the eye to be in the direction of the axis BB; BB is seen as a mere point, while CC appears of its actual length. On revolving the whole through a number of degrees equal to BMB' (δ) the axes have the position exhibited in the dotted lines. The projection of the semiaxis MB is now lengthened to MN, and that of the semiaxis MC is shortened to MH.

If the eye be elevated (at any angle, e), the lines B'N, BM, and C'H will be projected respectively below N, M, and H, and the lengths of these projections (which we may designate b'N, bM, and cH) will be directly proportional to the lengths of the lines B'N, BM, and C'H.

It is usual to adopt such a revolution and such an elevation of the eye as may be expressed by a simple ratio between the projected axes. The ratio between the two axes, MN : MH, as projected after the revolution, is designated by 1 : r; and the ratio of b'N to MN by 1 : s. Suppose r to equal 3 and s to equal 2, then proceed as follows:

Draw two lines AA', H'H (Fig. 990), intersecting one another at right angles. Make MH = MH' = b. Divide HH' into 3 (r) parts, and through the points, N, N', thus determined, draw perpendiculars to HH'. On the left hand vertical, set off, below H', a part H'R, equal to $\frac{1}{s}b = \frac{1}{2}HM$; and from R draw RM, and extend the same to the vertical N'. B'B is the projection of the front horizontal axis.

Draw BS parallel with MH' and connect SM. From the point T in which SM intersects BN, draw TC parallel with MH. A line (CC') drawn from C through M, and extended to the left vertical, is the projection of the side horizontal axis.

Lay off on the right vertical a part HQ equal to $\frac{1}{3}MH$, and make MA = MA' = MQ;

