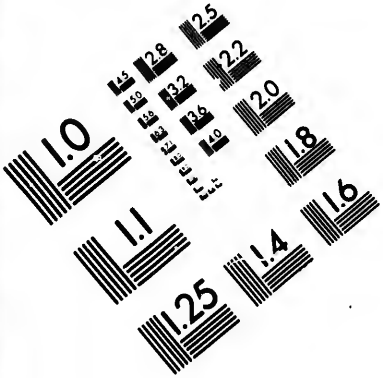
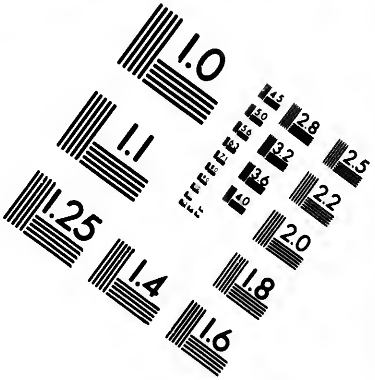

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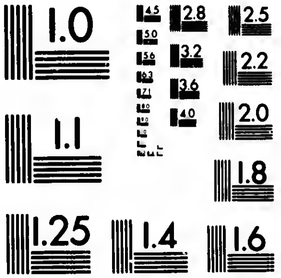

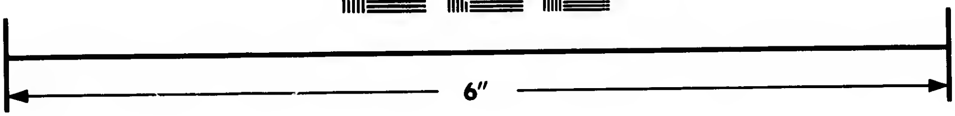

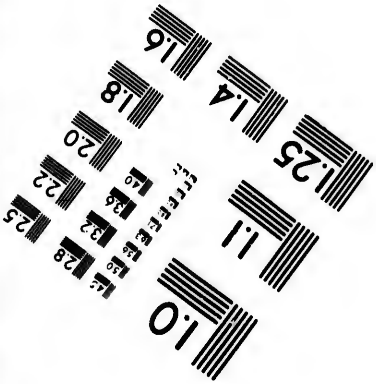
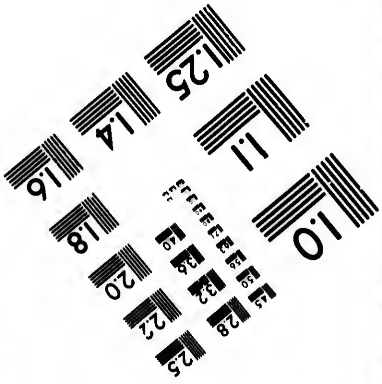

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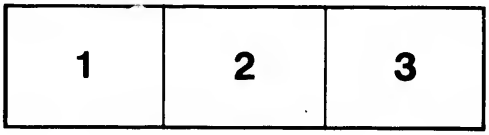

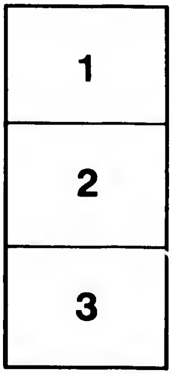

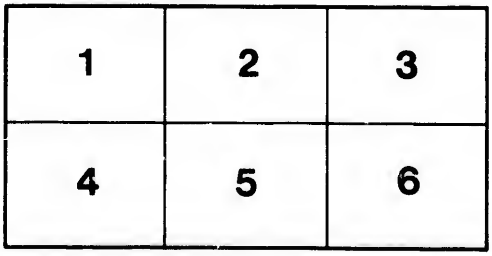

THE

GOLD-SEEKER'S HANDBOOK

AND

Practical Assayist;

INTENDED TO BE USED IN THE DETE[illegible] OF GOLD, SILVER,
COPPER, AND OTHER METALS FOU[illegible]HE DOMINION
OF CANADA, UNITED STATES, AND BRITISH
COLUMBIA.

SO SIMPLIFIED AS TO BE UNDERSTOOD BY ANY MAN OF
ORDINARY CAPACITY.

BY

THOMAS HUGHES,

CIVIL ENGINEER AND P.L.S.

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PRICE TWENTY-FIVE CENTS.
1867.

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PREFACE.

THIS little work does not claim to rank high as a scientific production. It is indebted for its origin to the recent discoveries of various minerals, and especially gold, in different parts of the Dominion of Canada, now added to the splendid developments of California and British Columbia, and is intended chiefly for the use of those not deeply read in the lore of our colleges. But whilst it shall be the constant aim of the author to state all facts in the plainest admissible terms, yet he trusts that he will not be suspected of a desire to ignore or despise the learning of the scientific. Far from this; inasmuch as it is said that "simplicity is the perfection of art." He hopes that this unpretending work will be found to be based upon true science, although clothed in a plain and simple garb.

Whilst it is the design of the author to furnish to the public a safe and reliable guide as to the searching for, and detection of, minerals, he does not profess to establish any new theories. His only merit, if such there be, consists in presenting in a cheap and accessible form what otherwise could only be got from books of much cost and deep research.

It is by no means the intention of this work to supersede the labours of the analytical chemist, whose researches often call for an amount of scientific training, as well as of manual dexterity and costly apparatus, much exceeding the means of those for whom this work is intended. It is hoped, however, that through its means the public will be able to form a tolerably correct idea as to the prevalence, in paying quantities, of valuable metals in certain localities, so that, should they be doomed in some cases to disappointment as regards a "golden future," they may, at least, be spared the unavailing sacrifice of valuable time and means; whilst those to whom the prospects seem brighter may be encouraged to persevere in more extended and complete examinations.

Should this work be the means either of aiding in the development of our hidden mineral wealth, or of preserving unsuspecting men from certain ruin, through a want of knowledge in searching for mineral treasure, the object of the author, as well as of the Publisher, will have been amply attained.

In conclusion, the author desires to acknowledge his indebtedness to several writers, from whom he has derived much valuable information.

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Amongst those deserving of especial mention is a "Manual of Mineralogy" by James Nicol, F.R.S.E., F.G.S.; also the "Book of Science," by John M. Moffatt, Esq., and the "Gold-seeker's Manual," by Professor Ansted, F.R.S.

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THE GOLD-SEEKER'S HANDBOOK.

CHAPTER I.

PHYSICAL PROPERTIES OF MINERALS; HARDNESS; COLOUR; WEIGHT; TASTE AND ODOUR; CRYSTALLINE FORM, &C.

ALTHOUGH it is not intended to write a treatise upon MINERALOGY, yet as the metals at present under consideration are, of course, also MINERALS, it will be needful to give some general marks of a physical nature, whereby, as well as by varieties of chemical constitution, minerals are distinguished from each other.

We shall begin with *hardness.* By it is generally implied the ability to resist abrasion or scratching, and it is to be carefully distinguished from *consistency*, which signifies *tenacity* rather than *hardness.* Thus, a substance may be at the same time *very hard* and *very brittle;* or it may be extremely *soft*, and at the same time *tough*, or tenacious.

One substance is said to be harder than another when it will scratch, but cannot be scratched by that other. Thus, flint is said to be harder than chalk.

Minerals are usually ranged in nine or ten classes as regards hardness No. 1, or the lowest step in the scale, is usually occupied by talk, a soft kind of mica (isinglass); whilst at the other end of the scale is placed the diamond, as the hardest known substance.

Colour is also sometimes useful in distinguishing minerals; but it is by no means an infallible guide, inasmuch as many substances, naturally colourless, are often, through accidental impurities, found presenting every imaginable colour.

Lustre is associated with colour, and is often of much importance. The principal kinds of lustre are the adamantine (diamond), vitreous (glassy), oily, resinous, fatty, pearly, and metallic.

Weight is an essential and valuable element in the determination of mineral species, and particularly in the case of metals, many of which differ greatly in this respect.

The usual mode of estimating the weight of minerals is by stating what is termed their "specific gravity," or the proportion that their weight bears to that of an equal bulk of water; the latter being always put at 1. Thus gold being, upon the average, eighteen times as heavy as distilled water, its specific gravity is said to be 18.

Taste and odour are obvious qualities of some minerals, but cannot be very extensively applied to practical purposes.

Taste is chiefly confined to saline minerals, and is very evident in most cases where it exists, as in rock salt (chloride of sodium), and alum (sulphate of alumina).

Hornblendic species are distinguished by a bitter clayey smell when breathed upon; and a particular kind of limestone, called stinkstone or swinestone, has, as its name significantly indicates, *a very disagreeable odour.*

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Crystalline form, although mentioned last, is by no means the least important amongst the distinguishing features of minerals, inasmuch as there are few indeed of the mineral bodies, especially amongst the metals, that do not at times present themselves in the crystalline form.

A crystal form may be defined to be a regularly formed geometrical solid; such, for example, as the cube, as seen in grains of common salt, or the octahedron in crystals of alum, familiar to most people.

Crystal forms are generally divided into six systems. These are the tesseral, or cubic; the tetragonal, or four-sided; the hexagonal; the rhombic; the monoclinohedric and the triclinohedric.

To the first of these systems belong all such forms as may be created by modification of the cube, or octahedron, such as the cutting off of angles, edges, &c. Hence arise a great variety of regular figures; as, for instance, the tetrahedron, or figure of four triangular faces; four kinds of dodecahedrons, or figures of twelve faces, having different forms, such as triangular, rhombic, &c. In addition to these are created in the cubic system five figures of twenty-four faces, and one of forty-eight; the form of the faces being triangles, and four-sided figures of various kinds.

The tetragonal system comprehends a variety of four-sided, and also prismatic and pyramidal figures of four and eight sides, derived by modifying causes from what may be termed a double regular pyramid, or two pyramids joined at their bases, the plane of junction of these pyramids being a rectangle.

The hexagonal and rhombic systems are in like manner based upon the supposition of double regular pyramids, the plane of the base being in the one case a hexagon, and in the latter a rhomb.

From these systems also proceed a great number of pyramids and prisms, having from three to twelve sides.

The hexagonal system likewise produces the well-known figure termed a "rhombohedron," so frequently seen in some kinds of calc-spar. This figure may be described as a solid bounded by six equal and parallel rhombs.

The monoclinohedric and triclinohedric systems are somewhat more complicated in their developments than those of the rhombic, although they are based upon precisely similar principles, the differences of form arising from the fact that instead of the fundamental pyramid being perpendicular, as in the rhombic system, it is in the monoclinohederic inclined in one direction, and in the triclinohedric in two directions to the base.

Of the six systems of crystalography, the triclinohedric is the least represented among mineral bodies, and is, consequently, the least deserving of lengthened notice.

It may be further remarked of crystals, that they are seldom *perfectly formed;* the sides and edges being often curved and distorted, whilst portions of the figure are often wanting.

They are often, also, grouped together in apparently great confusion, although in reality all the varying

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combinations are the result of the most certain and unchanging principles.

In general, the smallest crystals are by far the most perfect, both as regards symmetry of form and completeness of development.

CHAPTER II.

GOLD ; ITS LITHOLOGICAL POSITION ; TREATMENT UPON A LARGE SCALE ; MODE OF ASSAYING &C.

GOLD, in a state of perfect purity, does not seem to exist in nature.

It appears always to be more or less mixed with silver, as also copper, iron and other metals ; but frequently these latter ingredients are so limited in quantity as to be practically disregarded, and the compound is termed "native gold."

Gold, in its natural state, varies much in colour, according as it is alloyed with silver and other metals. It is found presenting many variations of yellow, from a pale light to a deep gold yellow, or to a bronze yellow. This metal is remarkably ductile and malleable.

Gold crystallizes in forms of the tesseral system, the usual figures being the octahedron, cube, and some varieties of twelve and twenty-four sided figures. The crystals are generally quite small, and the lustre of native gold is generally bright, although sometimes it is rather dull.

Gold is also common in wire-like, arborescent, interlacing, or moss-like forms, and in plates and folio. Very frequently it is found disseminated, often in particles of microscopic minuteness. It is also found in the form of nuggets of varying shape and size, some of them weighing nearly 100 lbs.

As regards *hardness*, gold stands very low, being only put at from 2½ to 3 in the scale of 10, the diamond being at the head of the scale.

The specific gravity of gold is from 17. to 19.4.

Gold is one of the most widely-distributed minerals, being found not only in beds, nests, and veins, usually of small extent, occurring in various rocks, such as granite, syenite, greenstone, claystone-porphyry, trachyte, the crystalline slates, and transition strata, but also disseminated through these rocks.

It is likewise often found in connection with iron pyrites, quartz, carbonaceous matter, mica, calc-spar, and even in coal strata, and sometimes in volcanic rocks, and the lower sandstones.

Gold is also sometimes found in great abundance in the sand and gravel deposits of rivers, and in some of these deposits in the East India islands it is often accompanied by platina, iridium, magnetite, nigrine, rutile, anatase, chromite, zircon, and diamond.

As gold is not found mineralized, or in the state of ore, like the generality of metals, but either pure or else combined with some other metals to form an alloy, the metallurgic processes for reducing it are, generally, simpler than in most other cases.

This metal is derived from two general sources; being either mixed with sand, gravel, and earthy matter, in valleys, ravines, and the beds of rivers; or in veins, mostly of quartz, and is then obtained by mining, like minerals in general.

The modes of treatment required to obtain gold in a state of purity vary according to the state in which it is found in the situations just mentioned.

Gold obtained from alluvial soils in nuggets and grains, may be separated more or less from the substances by which it is contaminated by washing. This operation is often performed on the spot where it is procured. Thus the gold-seekers sometimes wash the auriferous sands in a sieve held in the hand, or else use inclined tables covered with coarse woollen cloth, &c. The sandy material then being placed upon the table in small quantities, over which a stream of water is conducted, the lighter particles are washed away, and the particles of gold detained by their superior weight upon the surface of the cloth. A rocking motion being given to the table renders this process more complete. The gold thus obtained may be further purified by amalgamation with mercury, or by cupellation.

Gold is also found pure in veins, but sometimes in a state of minute division, and so blended with other bodies as to require various operations for its extraction. It is thus procured in Hungary; and in this case the whole contents of the vein, holding small particles or strings, or little nests of native gold, are broken into small pieces, and carefully examined; the grains, where perceptible, being detached from the matrix, which is chiefly quartz. The poorer parts are then stamped by beams of wood, shod with iron, and worked by machinery, and thus the ore is crushed to a powder upon an iron plate.

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This powder is then damped by throwing water containing salt upon it, and a quantity of mercury being put into a bag of porous leather, is forced through the pores, and dropping on the damped powder in a minutely divided state, is kneaded up with it. This paste, containing mercury and gold thus incorporated, is afterwards heated in a proper vessel, to about the temperature of boiling water, for three or four days. The mixture is then washed carefully in small parcels at a time, so that the earthy particles are washed off, leaving only the amalgam of mercury and gold. Part of the mercury is then separated by pressure in a leathern bag, and the rest is driven off by distillation, leaving behind the gold, and also a portion of silver with which it may be alloyed.

When gold occurs in a matrix, consisting of iron pyrites (sulphuret of iron), galena (sulphuret of lead), &c., in which the gold exists in invisible particles, the masses of ore are broken by hand into small pieces, and then reduced by the stamps to powder, which is carried by a stream of water to a series of pits, in which the heaviest particles subside, the lighter earthy matter being carried away by the current.

After repeated washings, the metallic parts, consisting chiefly of iron pyrites and galena, are roasted in a reverberatory furnace, with a proportion of quick lime, at a read heat, but not so as to fuse the mass, until part of the sulphur is driven off; the fire is then increased, and the whole brought to a state of thin fusion, and then let out into a mould of sand.

During the fusion, the iron, on account of its strong affinity for sulphur, resumes the portion of which it had been deprived by previous roasting, by decomposing the sulphurets of lead, copper, &c., with which it is mixed; in consequence of which these metals, by specific gravity, fall in drops through the vitreo-ferruginous scoriæ, carrying with them the gold and silver, and unite at the bottom, in a dense metallic mass. Hence the "pig," that is formed in the mould of sand, is found to consist of two parts, adhering to each other, but easily separable by the hammer; the uppermost, and largest portion, is composed of cellular scoriæ, beneath which is a black, heavy, compact mass, containing the gold and silver, together with lead, copper, some sulphur and iron; this is now broken into small pieces, roasted and fused once or twice more, until the sulphur and other impurities are separated, leaving nothing but the gold, silver, lead and copper.

The separation of gold from lead is effected by "cupellation." The cupel, or test, is a porous infusible earthy mass, with a hollow concavity at the top for the reception of the metal; this being placed in a furnace, so as not to be in contact with the burning fuel, and a current of air at the same time passing over the surface of the test, the metal is brought almost to a state of boiling; at this temperature, the lead becomes changed to the state of a vitreous oxide, which sinking into the pores of the test, leaves the gold behind; and if the ore contained silver and copper, subsequent processes will be required to effect their separation.

Having glanced at the distinguishing features of gold, as also the methods of treating it upon a large scale, we shall now proceed to explain to the reader how he may, by observation and simple experiments, satisfy himself as to the presence or absence of gold in certain localities.

Gold is the *heaviest* of all metals except platina, and one or two very rare metals; it is more than twice as heavy as iron or copper, and six or seven times the weight of quartz or other non-metallic minerals. It is also, as we have stated, one of the *softest* of metals, and sometimes of dullish lustre, and it can be beaten into thin plates. By bearing these marks in view, it will not be hard to distinguish gold from the substances that most nearly resemble it, such as iron and copper pyrites, and various tinted micas; the pyrites being *harder* and far *lighter* than gold, and also very *brittle*, whilst their lustre is greater. The different kinds of mica are but one-sixth part of the weight of gold, and have a brighter lustre.

In making examinations of sand for gold, the material may first be well roasted in an ordinary iron ladle, or common crucible. This will have the effect of expelling the sulphur from all pyritous substances, and thus destroying their gold-like appearance, and the material may then be washed upon a board, covered with cloth as above described, and quicksilver may be afterwards added, if it is suspected that gold exists in the form of fine dust, as is sometimes the case. The mercury may be very easily discharged from an amalgam of gold and mercury by distillation, as previously mentioned, or it may be simply driven off, or volatilized by the application of heat to an open vessel.

Where quartz or other minerals are to be tested for gold, it is a good plan to expose the material to a read heat for several hours. This, besides expelling the sulphur as before mentioned, if such be present, will, in general, much faciliate the subsequent crushing of the material, which forms the next process. The crushed matter, now being in the state of sand, is to be dealt with accordingly.

Supposed gold may be tested by applying to it nitric acid, which acts with more or less violence upon all metals, save *gold only;* the latter being affected by "aqua regia" (nitro muriatic acid) alone. By means of these two acids gold may be separated from its alloy of silver. If the gold forms only a fourth part, or less of the mixture, it must be heated with nitric acid, which gives it a black colour, and gradually removes the silver. If the proportion of gold is greater, the nitro muriatic acid must be used, which holds the gold in solution; from this solution, the sulphate of iron (green vitriol) being added, throws down metallic gold.

As regards the crushing of quartz, &c., for experimental purposes, although the agate mortar and porcelain pestle furnish the completest means, yet the operation may be performed tolerably well by means of a common hammer and any hard and smooth surface, the material being first broken into small pieces, and then crushed to a powder by a rotary motion of the hammer.

Gold in combination with silver, copper, &c., may be assayed in the following simple manner:—

The material is first ground to powder, and is then mixed with three times its weight of pure lead, obtained by melting "sugar of lead;" the whole is then fused, and nitric acid is added, which dissolves the silver, &c., leaving the gold behind. The gold is afterwards washed and dried.

It may be observed that the gold-bearing rocks of the United States are frequently micaceous, or talcose chists, with veins or beds of quartz—the gold extending into the rock on either side from the quartz.

The veins worked in Orange Co., Virginia, appear to run N. N. E. and S. S. W., and dip to N. E., the ores consisting of iron pyrites, various oxides and hydrous oxides of iron, and sulphuret of copper, all rich in native gold.

In Brazil, gold is found in a soft kind of gneiss, which is traversed by a great number of quartz veins, running in planes nearly perpendicular to the horizon. In these veins alone the gold is found in its matrix, traversing the spar in small threads or filling up every interstice between the crystals so completely as to seem like metal fused and poured into a mould.

CHAPTER III.

SILVER.

SILVER, like gold, is seldom found in a state of complete purity, being more or less mixed with gold, platina, lead and copper, and sometimes antimony, bismuth and arsenic.

The colour of native silver is pure metallic white, but it is often tarnished yellow, red, brown, or black.

The crystals of silver are very similar in form to those of gold, consisting of the cube, octahedron, and twelve and twenty-four-sided figures. They are usually small, and often wedge or segment-shaped, from the shortening or lengthening of one of the sides.

Silver is also common in capillary, filiform, moss-like, arborescent, or tooth-like forms ; in leaves, plates, or crusts, and also massive or disseminated. It is, like gold, very malleable and ductile.

This metal requires a great heat to melt it, but by a fierce and long-continued fire it may be volatilized. It does not tarnish in the air from the absorption of oxygen ; but when sulphurous vapours are present its surface becomes tinged with purple, from the formation of sulphuret of silver ; and the same effect is produced when a silver spoon is dipped in the yolk of an egg, which contains sulphur.

Silver also resembles gold in its extreme *softness*, ranging only from two to three in the scale of hardness. It is from ten to eleven times as heavy as water.

By means of the blowpipe it may be fused, and on cooling sometimes crystallizes in octahedrons. Easily soluble in nitric acid; the solution colours the skin black; and with hydrochloric (muriatic) acid gives a voluminous white precipitate (deposit), which in the light becomes first bluish, then brown, and black.

Silver is found in veins, and occasionally in beds in crystalline or primitive rocks, such as gneiss (stratified granite), mica and hornblende slates; in granite, syenite and pophyry; also in the transition and older secondary rocks, along with various ores of lead, copper, &c., and mixed with calc-spar, fluor-spar, quartz, and hornstone.

Silver is found more frequently pure, or in the state of alloy, than most other metals, but it is most plentiful in the state of native silver. The metal is occasionally found in immense masses; the silver mines of Kongsberg, Norway, formerly afforded specimens weighing from 100 to 150 pounds, and in the mine called Nye Forhaabning one was raised 560 pounds in weight, which is still preserved in the royal cabinet at Copenhagen.

Silver is extracted from its ores either by smelting, in a manner similar to that practised with regard to other metals, or by amalgamation with mercury.

Silver, like gold, frequently requires to be subjected to the process of cupellation to separate it from oxidizable metals. This method of purifying silver is adopted in Persia, and is thus described in Brande's "Journal of Science," Vol. 8:—

"A sort of basin is made, either by excavating the ground or by arranging stones in a circle.

"This is from nine to twelve or fourteen inches wide, and is incomplete at the side in one place for the reception of the fuel, which by its combustion is to melt the metal.

"The fuel consists of two large and long logs of wood, which are placed with their ends in the aperture, on the edge of the basin.

"These ends are lighted by placing on them burning fuel; and then the blast from a pair of bellows is directed so as to pass across the fire, and thus drive the flame and heat into the basin, acting as a large blowpipe.

"Lead containing silver, or impure silver, with the addition of lead, is then placed in the basin; and being soon melted and heated by the flame, it is purified as by common cupellation.

"The litharge (vitrified oxide of lead) is forced off to the sides as it is formed, and either absorbed or lost; and as the wood burns away before the blast of air, the logs are thrust onward, until all is consumed; then fresh logs are supplied, if necessary, or the process stopped, as may be found convenient."

Silver ores are often smelted in the following simple manner:—

The ore is first calcined in a puddle furnace, a proportion of lime having been added to act as a flux, that is, to assist the melting process. This process is continued for sixteen hours, during which time the mass is stirred continually.

A black lead pot, of about two gallons capacity, is then nearly filled with the melted ore, to which is added, nitre $\frac{1}{2}$ lb. and flour 2 lbs.

It is allowed to remain in the hot furnace one hour, at a white heat and is then poured into a mould.

The silver sinks to the bottom, and the "slag" remains at the top; which, when cold, is easily separable from the pure metal.

Silver may be assayed by either of the three methods, viz.: the "mechanical," the "dry," or "moist" assay.

Where native silver, in a state of comparative purity, is only mechanically mixed with certain mineral ingredients, the mechanical assay may be resorted to. This is essentially the same process as that described in the case of Gold; such as crushing, washing, amalgamation with mercury, &c. For assaying by the dry method, the blowpipe is an essential agent.

The assay (or mineral to be tried) is reduced to powder, and kneaded up with moist soda, or other suitable flux, into a small ball, not larger than a peppercorn—which being placed in a hollow formed in a piece of charcoal, is then in a fit state to be acted on by the blowpipe.

Silver, in its metallic state, is at once known, and from many combinations can be readily extracted on charcoal.

Other combinations, and the metallic sulphurets in which it is incidentally present, are thus tested:

The pulverized assay, mixed with borax, glass and lead, is melted by the "reducing" flame, and then kept for some time in the oxidating flame, by which a granule of argentiferous (silver) lead is obtained. This lead is then melted by the oxidating flame in a small cupel of bone ashes, previously ignited, and the heat continued until it is nearly changed to litharge.

The very argentiferous lead grain is now heated in another cupel, into which the lead sinks, and leaves behind a grain of silver, sometimes cupreous or auriferous.

From its solution in nitric acid, silver is thrown down by muriatic acid, as a white chloride, which in the light soon becomes black, is soluble in ammonia, and can be again precipitated from the solution, by nitric acid, as chloride of silver.

Silver ore may be assayed in the moist way by reducing a small quantity of it to powder, digesting it in nitric acid, and mixing the filtered liquid with a solution of common salt (chloride of sodium.) A chloride of silver will then be precipitated, containing, when dried, 75 per cent. of metal; or the chloride may be reduced by fusing it with three times its weight of sub-carbonate of soda.

Chloride of silver may also be reduced in the following manner:

Put the chloride into a small vessel of zinc, or cast iron, containing a little water, and leave it there a short time. If the vessel be clean the decomposition will soon take place; otherwise a little muriatic or sulphuric acid may be added. The metallic product may be washed with muriatic acid.

Silver may also be precipitated from its acid solution by means of copper plates immersed in the solution.

CHAPTER IV.

LEAD.

THIS metal is not found very abundantly in a state of purity, or as native lead; but is more common in ores and associated with other metals and minerals, such as silver, sulphur, copper, &c.—as in galena, the various lead salts, &c., of which, however, galena is the most important, as well as the most common of the ores of lead, being the principal source from which it is derived.

Native lead does not appear in the crystal form, only capillary, filiform, or branched, and in thin plates, or disseminated. It is ductile and malleable. Its colour is bluish grey, with a blackish tarnish.

Lead is still softer than gold, the degree of hardness being only 1.5. Its specific gravity is 11.3, or more than eleven times as heavy as water. It is a readily fusible metal, and though mealleable and ductile, is deficient in tenacity.

Lead has been found in considerable abundance in vesicular cavities of lava, on the island of Madeira. It is much associated with silver, and is met with in the carboniferous limestone. Galena, as the most important ore of lead, may be thus described:—

It crystallizes in the tesseral system; the usual forms being the cube, octahedron, and twelve and twenty-four-sided figures. The crystals, of various sizes, are seldom perfectly formed.

Galena occurs most frequently massive, and disseminated in granular, compact, and striated laminar aggregates. This metal has a very perfect hexahedral cleavage; that is, in all cases of fracture or division, it has a strong tendency to preserve a cubical or rectangular form.

Its colour is lead-grey, and when tarnished, becomes darker, or rarely iridescent. The lustre is often brilliant. The degree of hardness is 2.5; and specific gravity 7.5.

It is soluble in nitric acid, with evolution of nitrous acid, and residue of sulphur.

Galena usually contains a small proportion of silver, generally from 0.01 to 0.05, and very rarely 1 per cent. or more.

The pure galena in the Hartz mountains contains from 60 to 71 per cent. of lead, the remainder being chiefly sulphur.

Some galena contains selenium and antimony; copper and platina are occasionally found in it.

Galena is very common in rocks of all ages and formations. It is found in veins of gneiss; in mica slate; in transition clay-slate, and greywacke; in the Killas in Cornwall, and in the carboniferous limestones of many countries. It also occurs in sandstone; in veins in granite; and in claystone porphyry; and in the Western States of North America, it occurs in immense abundance in the cliff limestone.

In the usual process for the smelting of lead ore, the galena being freed by the hand and hammer from all such impurities as can be readily separated from it, is beaten into small pieces, and after thorough washing is placed in a reverberatory furnace, at a low red heat, for some hours.

The effect of this roasting is to drive off the sulphur and arsenic, without melting the lead, and when the flame on the surface has changed from blue to a reddish white, the roasting is considered as finished, the lead being converted into an oxide.

The roasting being completed in a moderate heat, a small quantity of charcoal is added, the doors of the furnace closed, and the reduction completed.

The lead is then found, in a reduced state, lying at the bottom of the furnace, covered by a slag, two or three inches in thickness; the slag is then tapped, and runs off.

Some quicklime, in powder, is now thrown down upon the fused metal, which serves to raise and cake the remaining slag, which, by means of a rake, is taken from the surface.

This slag is nearly black, and is very heavy.

The lead is then suffered to run out of the furnace into a pan, and the scum or dross being taken from its surface, is thrown back into the furnace. The lead is lastly ladled from the pan, into iron moulds, and left to cool.

The ores of lead may be tested by means of the blowpipe, the assay having first been prepared as described in the case of silver.

Lead, in union with other metals, is known by the sulphur-yellow deposit of the oxide, left on the charcoal, when heated in the oxidating flame.

Its salts, treated with soda, in the reducing flame, on charcoal, are known both by the mark of the oxide, and the reduction of the metallic lead.

The solutions of the lead salts are colourless, but give a black precipitate with sulphuretted hydrogen.

The moist method of assay may also be used in testing the ores of lead.

The roasted ore must be dissolved in nitric acid, somewhat lowered, and the solution is to be diluted with water, and precipitated by a sufficient quantity of some soluble sulphate. This forms, with the oxide of lead, sulphate of lead.

The precipitate, being washed and dried, always contains 68 per cent. of metal.

In this mode of assay the silver which may be contained in the ore will also be precipitated in the form of sulphate.

When it is necessary to assay sulphates of lead, either alone or mixed with other substances, the muriatic acid must be used instead of the nitric acid.

CHAPTER V.

COPPER.

COPPER crystallizes in the tesseral system, in forms nearly similar to those of gold. The crystals are small, and generally irregular, deformed and grown together.

It often occurs filiform, moss-like, and arborescent; or in plates, and laminæ; also investing, massive and disseminated, and sometimes in loose grains and lumps.

It is malleable and ductile. Hardness=2.5 to 3, and specific gravity=8.7.

The colour is copper-red, with yellow or brown tarnish.

This metal is rather easily fusible, colouring the flame green.

It is readily soluble in nitric acid, and in ammonia, with access of air, forms a blue solution.

Native copper sometimes contains a little iron or other metals.

Copper occurs in veins and beds; or disseminated in granite, serpentine, and the crystalline schists; as also in the transition and secondary strata.

Some fine crystals have been found in fibrous mesotype, in amygdaloidal trap rock.

Large masses of copper, with silver adhering to them, weighing from 1,630 lbs. to 4,000, have been found near Lake Superior; and a solid mass from Cachoeira in Bahia, now in the museum of Lisbon, weighed 2,600 lbs.

Fused copper, in favourable circumstances, crystallizes in regular octahedrons. It seems, sometimes, to be deposited in mines from water containing the sulphate, and especially upon pieces of wood.

Copper exists in considerable variety in the form of ore, as in the different copper salts, amongst which is ranked the "malachite;" also in the red and green copper ores, and in the sulphuretted metal known as copper pyrites.

The copper ores of Cornwall, England, from which the metal is generally procured, are the yellow sulphuret, a mixture of copper, sulphur and iron; also the sulphuret, or copper pyrites, containing about 80 per cent. of copper.

The reduction of the ore of copper, upon a large scale, is completed by means of eight processes, consisting of roasting, melting and refining, or toughening.

Copper may, in general, be detected by means of the blowpipe.

The assay, if apparently metallic, should be first roasted, and then melted, with borax, or salt of phosphorus in the oxidating flame, when an opaque reddish brown glass is produced, a small addition of tin aiding in the result.

In the reducing flame, the glass, when warm, is green, and when cold, blue. With soda, metallic copper is produced.

A small proportion of copper may often be detected by heating the assay, moistened with muriatic acid, in the oxidating flame, when it is tinged of a beautiful green colour. Solutions of its salts are blue or green, and produce a brownish-black precipitate with sulphuretted hydrogen. Ammonia, at first, throws down a pale green, or blue precipitate, but in excess, again produces a very fine blue colour.

Cyanate of iron and potassium, even in weak solutions, give a dark, reddish-brown precipitate; and iron throws down copper, in the metallic state.

CHALCOPYRITE (Copper Pyrites), as the most important ore of copper, may be thus described:—

It crystallizes in the tetragonal system, the usual forms being various combinations of three-sided pyramids and four-sided prisms. The crystals, generally small and deformed by the shortening or elongation of one side, are attached singly or in druses.

Most commonly it is found compact and disseminated, and sometimes also botryoidal and reniform. The hardness is = 3.8, and gravity = 4.2. Colour brass-yellow, often with a gold-yellow or iridescent tarnish; streak, greenish-black.

Before the blowpipe, this mineral upon charcoal becomes darker, or black, and on cooling, red. Fuses easily to a steel-grey globule, which at length becomes magnetic, brittle, and greyish-red on the fractured surface. With borax and soda it yields a grain of copper, and in the open tube evolves sulphurous acid, but no sublimate.

Moistened with hydrochloric acid, it colours the flame blue. Soluble in nitrochloric acid, leaving sulphur; also, with more difficulty, in nitric acid.

Chalcopyrite usually contains, besides copper, about a third part of iron, and also of sulphur.

Is found in primary and transition rocks, in porphyry, sienite, &c.

REDRUTHITE, or Copper-glance, is another important ore of copper. This mineral crystallizes in rhombic forms. These are usually combinations of rhombic and rectangular prisms and pyramids.

The crystals are generally thick tabular, attached singly or in druses.

It usually occurs massive, disseminated, in plates or lumps. Hardness=3, and gravity=5.6. Lustre rather dull, brighter on the streak. Colour, blackish lead-grey, with a blue or other tarnish.

Acted upon by the blowpipe, it colours the flame blue; on charcoal, in the oxydating flame, sputters and fuses easily, and in the reducing flame becomes solid. With soda gives a grain of copper.

It is soluble in warm nitric acid, depositing sulphur. The composition is about $\frac{4}{5}$ copper and $\frac{1}{5}$ sulphur.

This mineral occurs with various other ores of copper and iron in the metamorphic and stratified rocks.

CHAPTER VI.

IRON.

THE crystal form of iron is generally that of the regular octahedron. Its hardness is 4.5; gravity from 7 to 7.8, and colour steel-grey, or iron-black, often with a blackish tarnish.

Native iron is very magnetic—cannot be acted upon by the blowpipe, except in thin plates and a strong heat, but is soluble in muriatic acid.

Iron, though one of the most common of metallic bodies, is not often found in the native state, in consequence of its powerful tendency to unite with oxygen, sulphur, and other substances.

Most of the existing specimens of native iron are supposed to have derived their origin from meteoric stones.

But few mineral bodies are found so abundantly, or in so many forms as iron. It occurs in the forms of "sparry iron ores," oxidized ores, sulphurets, &c., and appears, in one shape or another, in *every kind of rock*, from the volcanic or overlying rock down to the granite, or foundation of the stratified system.

Iron being found in a state of nature so variously combined, different processes, according to circumstances, are requisite to reduce it to the metallic state.

These consist, in general, of roasting, smelting, &c., after the ore is broken into moderately sized pieces, as in the cases of lead and copper.

The roasting is intended to drive off the sulphur, carbonic acid, water, or inflammable matters, and often lasts several days. In the smelting process, which lasts about forty-eight hours, limestone or some other flux is largely used.

In assaying iron ores by means of the blowpipe, it is observed that the peroxide and hydrated peroxide become black and magnetic in melting.

Ferruginous minerals form with borax, or salt of phosphorus, in the oxidating flame, a dark red glass, becoming bright yellow when cold, and in the reducing flame, especially on adding tin, an olive-green, or mountain-green glass. Yet some precautions are necessary when cobalt, copper, nickel, chrome, or uranium are also present; and when the presence of sulphur or arsenic is suspected the assay should be first roasted.

Salts of protoxide of iron form a green solution, from which potassa or ammonia throws down the protoxide as a hydrate, which is first white, then dirty green, and finally yellowish brown.

Carbonate of lime produces no precipitate. Ferrocyanide of potassium produces a voluminous bluish-white precipitate, becoming deep blue in the air; whilst the ferridcyanide of potassium causes a beauful blue precipitate.

The salts of the peroxide, on the other hand, form yellow solutions, from which the peroxide is thrown down by potassa or ammonia, as a flaky brown hydrate.

Carbonate of lime also causes a precipitate.

Ferrocyanide of potassium produces a very fine blue precipitate; the ferridcyanide, no precipitate.

From the clay iron-stone, or impure varieties of ore, most of the British iron is manufactured.

This mineral is generally of blue, brown or black colours, with gravity=3, and hardness=4.

It is found chiefly in slate-clay or marls, in layers or nodular masses, often containing fossil plants or other organic bodies, which seem to have attracted the carbonate of iron. Is also common in brown coal strata.

The oxidized ores, however, appear to be the most important in this country, the principal of these being:—

MAGNETITE (Magnetic Iron), which is crystallized in tesseral forms, being chiefly unions of portions of eight, twelve and twenty-four sided figures.

It is generally found massive, in granular or almost compact aggregates; often also in loose grains, forming magnetic sand. Its hardness is=6, and gravity=5. Lustre, metallic, sometimes imperfect; colour, iron-black, occasionally inclining to brown or grey, and is highly magnetic.

Before the blowpipe, it becomes brown and non-magnetic, and fuses with great difficulty. Its powder is soluble in hydrochloric acid.

Magnetite occurs chiefly in igneous or metamorphic rocks, or, as in many basalts, disseminated through the mass. It also forms beds in gneiss, in chlorite, mica, hornblende and clay slates; also in marble, greenstone, &c., but seldom appears in veins.

HEMATITE, OR SPECULAR IRON, is also a highly important and valuable oxidized iron ore.

It is found crystallized in various rhombohedral forms, the crystals being imbedded, or oftener attached and united in groups and druses. Hematite also appears in granular, foliated and scaly masses, or botryoidal, reniform, columnar or fibrous. The hardness is=6, and gravity=5.2. In their laminæ, translucent and deep blood-red. Lustre, metallic. Colour, iron-black to steel-grey, but often tarnished, also various tints of red. Streak, cherry-red or reddish-brown. Usually weak magnetic.

Before the blowpipe, in the reducing flame, it becomes black and magnetic. Slowly soluble in acids.

The reddle or "*red chalk*," and the jaspery, columnar and lenticular clay iron, are impure varieties of this mineral.

Hematite occurs chiefly in the older crystalline rocks, in large beds or veins, often with pyrites and quartz, and is also found in volcanic rocks.

PYRITE (Iron Pyrites), although not of much importance in itself, is nevertheless, from its frequent association with other valuable minerals, deserving of some notice here.

It is crystallized in complicated forms of the tesseral system, in which triangular faces chiefly predominate. The crystals often occur imbedded singly and also united in druses and various groups, or in spheroidal, reniform and other aggregates.

Most often it is massive and disseminated. It is brittle. Hardness=6.3, and gravity=5. Colour, a peculiar bronze-yellow, sometimes inclining to gold-yellow, at other times with a brown or rarely variegated tarnish. Streak, brownish-black. Yields sulphur in the closed tube. On charcoal, before the blowpipe, burns with a bluish flame and a strong smell of sulphur. In the reducing flame, fuses to a black magnetic bead.

It is soluble in nitric acid, with deposition of sulphur; but is scarcely affected by hydrochloric acid.

Pyrite consists of about equal parts of sulphur and iron, and in addition it often contains gold, silver, or silicum. It is one of the most common minerals in rocks of all ages and classes. Its presence is regarded as injurious when mixed with iron ores, or the coal used in their reduction, rendering the metal brittle.

CHAPTER VII.

TIN. TUNGSTEN.

ALTHOUGH Tin, as well as many of the metals still to be described, have as yet not been found in Canada, the presence of certain associate minerals—as tungsten in case of tin—gives hopes that many of these metals may yet be found here, as also in other parts of our continent. A short notice of them is therefore deemed advisable.

Tin has not "certainly" been found in the native state, although some authors affirm such to be the case.

This metal, in its pure state, is easily recognized. It is not very hard nor ductile, but extremely malleable. It has a characteristic odour, and a faint, disagreeable taste.

Although tin, like most metals, is variously associated with mineral bodies, yet the pure metal is derived from but one source, which is thus described:

Cassiterite, or tin ore, is an oxide of tin. It crystallizes in the tetragonal system, the usual forms being regular prisms, and pyramids of varying forms and combinations. It also occurs massive in granular aggregates, or finely fibrous (wood tin); also in loose, angular fragments and grains (stream tin).

The hardness is from 6 to 7, and gravity from 6.3 to 7.

It is translucent, or opaque; lustre adamantine, or resinous. When pure, the colour is white; but usually various shades of grey, yellow, red, brown and black; rarely wine-yellow, or hyacinth red; streak white, light grey, or brown.

This mineral is infusible in the forceps, by the blowpipe; but on charcoal, in the inner flame, with a strong heat, and mixed with soda, it is reduced to tin.

Tin ore occurs chiefly in granite, syenite, felspar-porphyry, and in the crystalline and transition strata.

It is frequently accompanied by rock-crystal, fluor-spar, apatite, topaz, tourmaline, wolfram, molybdenite, mispickel, and ores of lead and copper.

To obtain tin in the pure state, the ore is roasted, pounded, and finally smelted in a manner somewhat similar to that described in the case of lead.

Tin occurs chiefly as pyrites (sulphuret), and tin ore (oxide), and is easily detected by the blowpipe—which causes a white deposit to be left upon the charcoal, behind the assay, and which is not driven off either by the reducing or oxidating flame, but takes a blueish-green colour from the solution of cobalt. The oxide is reduced by soda, and this even when a very small proportion of tin is present as a mere accidental element.

TUNGSTEN.

This metal crystallizes in tetragonal forms, such as regular prisms and pyramids of various dimensions.

Its hardness is 4.3, gravity 6, and lustre vitreous, resinous, or adamantine.

It is colourless, but usually tinged grey, yellow or brown, rarely orange-yellow or green ; streak, white.

Before the blowpipe, it fuses difficultly to a translucent glass ; with borax to a clear colourless bead, which if not fully saturated remains clear when cold, but if again slowly heated becomes opaque, and enamel-like ; if fully saturated it becomes milk-white, and crystalline upon cooling.

With salt of phosphorus it forms a glass, which in the oxydating flame is clear and colourless ; in the reducing flame, green when warm, and blue when cold.

It is decomposed in muriatic or nitric acid, leaving tungstic acid ; also in solution of potash, with precipitate of lime.

This mineral occurs with wolfram ; especially in veins of tin ore ; sometimes in beds with gold or magnetic iron ; and also with galena and quartz.

Tungstic acid forms a fine yellow pigment, but the mineral is too rare to be generally used.

CHAPTER VIII.

ZINC, ARSENIC, MANGANESE AND PLUMBAGO.

THESE substances being often associated in a state of nature, we purpose to describe them together, commencing with

ZINC.

This metal in appearance resembles lead, but is, when untarnished, of a lighter colour. It speedily attracts oxygen when exposed to air and moisture, and it is easily dissolved by acids and alkalies, both in the metallic state and when oxidated.

Zinc is not found in the native state.

It is malleable and ductile when heated to between 210° and 300°, Fahrenheit. At about 725° it melts, and crystallizes on cooling.

If exposed to a temperature beyond its melting point, with the access of air, it burns with a bright bluish flame, forming the oxide formerly called "flowers of zinc."

The principal ores of zinc are the carbonate (calamine), and the sulphuret (blende); the latter of these, however, has not generally been used with much success as an ore.

Calamine crystallizes in rhombohedric forms, and in six-sided prisms. The crystals are generally small, obtuse-edged, and apparently rounded. Usually it occurs in reniform, botryoidal, stalactitic, and laminar aggregates; or fine, granular, and almost compact.

It is brittle; hardness =5; gravity =4.3. Translucent or opaque; lustre pearly, or vitreous; colourless, but often tinged pale greyish yellow, brown or green.

Calamine before the blowpipe becomes white, and loses its carbonic acid. It sometimes forms in the reducing flame a dark yellow or red ring on the charcoal, from cadmium oxide.

It is soluble in acids, with effervescence; and also in solution of potash.

This mineral occurs in beds and veins in the crystalline and transition rocks, and also in the carboniferous and oolite formations. It is most common in limestone, and is often associated with calc-spar, quartz, blende, and ores of iron and lead.

Zinc is obtained from this mineral chiefly by distillation.

Blende crystallizes in tesseral and tetrahedral forms, such as the octahedron, cube, four and twelve-sided figures; but the crystals are so contracted as to seem distorted.

Frequently it occurs massive and granular, rarely radiating, and very fine fibrous, &c.

A very perfect "dodecahedral cleavage" is remarked in this mineral.

It is brittle; Hardness=3.7, and Gravity=4. Semi-transparent to opaque. Lustre, adamantine and resinous. Colour, commonly brown, or black; also red, yellow, or green.

Before the blowpipe, in the oxidating flame, in a strong heat, deposits zinc oxide on the charcoal, which appears yellow, when hot, but becomes paler when cold.

It is soluble in concentrated nitric acid, leaving sulphur.

ARSENIC.

In the metallic, or uncombined state arsenic is of a greyish-white colour, with brilliant lu ; but it is soon tarnished by absorbing oxygen from the air.

Arsenic fuses readily, and volatilizes when heated to 360°.

When thrown upon a red hot iron, in the open air, it burns with a blue flame, subliming in the form of a white vapour, having an odour like garlic. The sublimate, when cooled, crystallizes in octahedrons.

Arsenic is not found "native;" but arsenical pyrites (Mispickel) occurs principally in veins of primitive rocks, and is common in the copper mines of Cornwall, England.

It is often iridescent. Some varieties are argentiferous.

Mispickel crystallizes in rhombic forms, generally of prisms. It is also found massive, granular, or columnar, and disseminated. Brittle. Hardness=5.7. Gravity=6.1. Colour, silver white, or almost steel-grey, with a greyish or yellowish tarnish. Streak, black.

In the closed tube, mispickel yields first a red, then a brown sublimate of sulphuret of arsenic, and then metallic arsenic. With the blowpipe, on charcoal, fuses to a black magnetic globule, which sometimes shows traces of cobalt, colouring borax glass-blue.

It is soluble in nitric acid, also in muriatic, with a residue of sulphur, and arsenious acid.

Mispickel is used as an ore of silver, sometimes.

MANGANESE.

This metal, in some of its properties, resembles iron. It is of a dusky-whitish colour, and finely granular texture; softer than iron, and very brittle. Difficult of fusion, and is readily acted on by the air, tarnishing, and at length crumbling into a powder. The peroxide, or "black oxide of manganese," is frequently found native, and is the chief source whence the metal is obtained.

This mineral (Pyrolusite) crystallizes in short rhombic prisms; but generally it occurs massive and disseminated, or in botryoidal, reniform masses, with radiating, columnar, or fibrous structure.

It is rather brittle. Hardness=2.3. Gravity, 4.8. Lustre semi-metallic, or silky when fibrous; colour, dark steel-gray, bluish, or iron black; streak, black, and soiling. Infusible by the blowpipe, but when strongly ignited on charcoal, it loses 12 per cent. oxygen, and is converted into the brown protoperoxide; with borax, and salt of phosphorus, it shows reaction for manganese.

It is soluble in muriatic acid, with large evolution of chlorine. Found chiefly in beds in gneiss, clay-slate, porphyry, and the older rocks; or in veins, often with calc-spar, heavy-spar, and ores of iron and manganese.

PLUMBAGO.

Graphite, or plumbago, although not now regarded as a metal, has been so long associated with them as to merit a place here.

This mineral crystallizes in tabular or short hexagonal prisms, but is usually massive and foliated, radiating, scaly, or compact. It is also disseminated, or as a constituent of many rocks.

It has a very perfect "basal" cleavage. Is very sectile, flexible, in thin laminæ, and sometimes slightly malleable; feels greasy. Hardness=0.5 to 1. Gravity =2. Lustre metallic, and colour iron-black. Leaves a mark on paper.

Plumbago burns with much difficulty before the blowpipe; in oxygen gas, even less easily than the diamond. Heated with nitre in a platina spoon, only partially detonates.

Plumbago was long regarded as a compound of carbon and iron, but is now known to be pure carbon.

It has been found in gneiss, with garnets, also in the coal formation, where it seems to have resulted from coal, altered by contact with trap rock.

CHAPTER IX.

MERCURY. ANTIMONY. TELLURIUM.

MERCURY, or quicksilver, is at ordinary temperatures a fluid; but at 40° below zero it congeals, and forms tesseral crystals.

Its specific gravity is 13.5 when fluid, and 15.6 solid. The lustre is bright metallic, and colour tin-white. Before the blowpipe it is wholly volatile, or leaves a little silver.

Mercury sometimes occurs native in globules, disseminated in coarse sandstones and rocks of all ages, chiefly with cinnabar, in veins and fissures; and native amalgams of the metal, with silver, occur both in the semi-fluid and solid states.

Cinnabar is the principal ore of mercury, which is obtained from it either by sublimation or distillation. The purer varieties of cinnabar are used as a pigment.

This mineral crystallizes in small rhombohedrons and hexagonal prisms. It also occurs disseminated and granular. Compact and earthy. Fracture uneven and splintery. Sectile. Hardness=2.3. Gravity=8.1. Semi-transparent, or opaque. Lustre adamantine, and colour cochineal-red, with a lead-grey and scarlet-red tarnish. The streak is scarlet-red.

In the closed tube it entirely sublimes; and in the open tube sublimes partly, without decomposition; partly as metallic mercury, whilst sulphuric acid escapes.

In the closed tube, with soda, it yields only mercury. It is perfectly soluble in nitrochloric acid, but not in muriatic acid, or solution of potash.

Cinnabar occurs in the crystalline, transition, and secondary strata, in beds and veins, with native mercury, iron pyrites, and other ores.

ANTIMONY.

This metal is sometimes, although rarely, found crystallized in rhombohedrons.

It is generally massive and disseminated; sometimes in spherical, botryoidal, and reniform aggregates, with a granular texture. The basal and rhombohedral cleavages are perfect, especially the former.

Rather brittle, and somewhat sectile. Hardness =3.3, and gravity=6.7. Its colour is tin-white, with a greyish or yellowish tarnish.

It is easily fusible by the blowpipe, and on cooling crystallizes into rhombohedrons. On charcoal, burns with a weak flame, and volatilizes, forming a white deposit. In the closed tube, yields a white sublimate.

Native antimony is usually mixed with a small amount of silver, iron, or arsenic. If rubbed on the fingers, it gives out a peculiar smell and taste.

It is a somewhat rare metal, being only worked in a few parts of Europe; but is also known in Mexico and Borneo.

TELLURIUM

Rarely crystallizes in hexagonal pyramids and prisms. It is usually found massive or disseminated, and fine granular—cleaves perfectly into hexagonal prisms, and is slightly sectile. Hardness=2.3, and gravity=6.2. Its colour is tin-white; and is easily fusible by the blowpipe, when it burns with a greenish flame, and much smoke, which forms a white ring with a reddish margin on charcoal.

In the open tube, burns with a greenish-blue flame, and forms a white sublimate, which can be fused to clear colourless drops. The vapour has often a smell of radish from selenium.

Soluble in nitric acid with evolution of nitrous vapours, and in concentrated sulphuric acid forms a bluish-red solution. Tellurium often contains a little gold or iron.

It occurs with quartz, iron pyrites, and gold.

CHAPTER X.

PLATINA. PALLADIUM. OSMIUM-IRIDIUM. IRIDIUM.

NATIVE platina occurs rarely in small cubes; commonly in minute, flat, or obtuse-angled grains, with smooth, shining surfaces; sometimes in larger grains, and roundish lumps, with an irregular, granular structure. It is malleable and ductile. Hardness=4.5, and gravity=17.5. to 19. The colour is steel-grey, inclining to silver-white. Sometimes slightly magnetic. Very difficultly fusible.

In nitrochloric acid, forms a red-coloured solution, from which ammonia throws down yellow ammoniate of platina, which on ignition is changed into spongy platina.

Native platina is generally alloyed with iron, iridium, and other metals.

When dissolved in nitrochloric acid, it leaves a residuum, sometimes of quartz or other stony minerals, sometimes of chromate of iron; but, when metallic, chiefly osmium-iridium.

Platina is found in veins of quartz and limonite, sometimes with the diamond; also in diluvial sands, where it seems to have been originally disseminated in serpentine.

PALLADIUM.

This metal sometimes crystallizes in very minute octahedrons; more frequently it occurs in small loose grains or scales.

It is malleable. Hardness=4.7, and Gravity=12. The colour is light steel-grey to silvery-white. Infusible before the blowpipe. In nitric acid, forms a brownish-red solution.

Palladium is generally alloyed with platinum and iridium. It has been found with platina and gold, near seleniuret of lead, in greenstone, in the Hartz, forming very small, brilliant hexagonal tables; also in the sands of rivers, &c.

OSMIUM-IRIDIUM.

Occasionally crystallizes in very minute tabular, hexagonal crystals; but is more common in small flat grains. It is slightly malleable, but soon breaks under the hammer, and may then be beaten to powder. Is not affectedby acids. Two varieties are distinguished.

OSMIRIDIUM.—Colour, tin-white Hardness=7—Gravity=19.4. Is not altered by the blowpipe. Fused with nitre in the closed tube, it yields osmium vapours, known by their peculiar, unpleasant smell, and forms a green saline mass, which, boiled in water, leaves blue iridium oxide.

IRIDOSMIUM.—Colour, lead-grey—Hardness=7—Gravity=21. Before the blowpipe, on charcoal, becomes black, with a very strong odour of osmium. In the flame of a spirit-lamp shines brightly, and colours it yellowish red.

Both these minerals occur in the Ural, the former especially, in gold sand, and the latter in platina sand, but rarer.

The first, also, is found in Brazil, and a mixture of these metals has been met with in Borneo.

IRIDIUM.

The crystal forms of this metal are the cube and octahedron; usually small. It is also found in small rounded grains. Slightly malleable. The hardness is = 6.5, and gravity = 22.7. Colour, silver-white, inclining to yellow on the surface, and to grey in the interior.

It is unalterable by the blowpipe, and is insoluble in acids, even the nitrochloric.

This metal is generally alloyed with platina, palladium, copper, or iridosmium, and has been found in gold sands, and the sands of rivers.

Iridium is used in porcelain painting, to produce black and grey colours.

CHAPTER XI.

NICKEL. BISMUTH. COBALT. MOLYBDENA.

NICKEL is not found "native." When pure, it is a hard metal, of a white colour; malleable and ductile, but difficult of fusion.

It is not acted on by the atmosphere or water at common temperatures. May be rendered magnetic like iron. If exposed to intense heat, with access of air, it becomes slowly oxidated; and it burns with vivid scintillations in oxygen gas.

Nickel is chiefly found in the form of "pyrites," and variously combined with bismuth, arsenic, iron, cobalt, antimony, lead, copper, and sulphur.

NICKELINE is one of the chief ores of nickel.

This mineral hardly occurs crystallized, being generally massive and disseminated. It is brittle. Hardness=5.5, and gravity=7.6. The colour is light copper-red, with a tarnish, first grey, then blackish. It forms no sublimate in the closed tube. On charcoal, fuses, with strong arsenic fumes, to a white, brittle metallic globule.

It is soluble in concentrated nitric acid, with deposit of arsenious acid; and more easily and completely in nitrochloric acid.

Nickeline occurs in veins, or rarely in beds, in granite, and in the crystalline, transition and secondary strata, mixed with cobalt, silver and copper.

BISMUTH

Crystallizes in octahedrons and dodecahedrons—often misshapen, or rendered indistinct by their union in groups. It also occurs arborescent, feathery, or reticulated, rarely filiform, or in plates. It is often massive, or disseminated, and granular.

This metal has a perfect octahedral cleavage. Is not malleable, but very sectile. Hardness = 2.5 and gravity = 9.7.

Its colour is reddish silver-white; often with a yellow, red, brown, or parti-colour tarnish. Very easily fusible even in the flame of a candle.

On charcoal, it volatilizes, leaving a citron-yellow coating. Soluble in nitric acid, when much water throws down a white precipitate from the solution. Native bismuth often contains a little arsenic.

Bismuth is found in granite and the crystalline slates; also in transition strata, chiefly with ores of cobalt and silver.

COBALT,

When pure, is of a reddish-grey colour; has a fibrous, or laminated texture, is brittle, and difficultly fusible. Like iron and nickel, it may be rendered magnetic. Air or water does not act on it at a low temperature; but when heated to redness, in an open vessel, it forms an oxide of a very deep blue colour. If the heat be intense the metal takes fire, and burns with a red flame.

Cobalt is found chiefly in the form of pyrites, one of its principal ores being :—

Cobaltine.—This mineral crystallizes in tesseral forms. It also occurs massive, granular, or disseminated, and has a perfect cubical cleavage. Brittle Hardness=5.5, and gravity=6.2.

Its colour is silver-white, inclining to red; often with a grey or yellowish tarnish. Streak, greyish-black, and lustre brilliant.

In the open tube, in a strong heat, yields arsenious acid, and sulphurous fumes. On charcoal, fuses with a strong smell of arsenic, to a grey, weak magnetic globule.

After roasting, it shows reaction for cobalt with borax. Soluble in warm nitric acid, depositing arsenious acid. Cobalt, in this mineral, is associated with iron, arsenic and sulphur.

Cobaltine is found chiefly in the crystalline slates, in beds.

MOLYBDENA.

This metal is said to have been obtained in the state of small grains, of a brittle texture, and a light grey colour; but its complete reduction has been questioned, as it is exceedingly difficult of fusion.

When heated in contact with oxygen gas, or in the air, it becomes converted into a white crystalline sublimate, which is the molybdic acid.

Molybdena occurs chiefly as a "sulphuret" known as

Molybdenite.—This mineral sometimes appears in tabular and short hexagonal prisms. Generally, it occurs massive and disseminated, in scaly or curved foliated aggregates.

It is very sectile, and has a perfect "basal" cleavage. Is flexible in thin laminæ and feels greasy. Hardness=1.3, and gravity=4.7. The colour is reddish lead-grey. Makes a grey mark on paper; greenish on porcelain.

Before the blowpipe, in the platina forceps, colours the flame siskin-green, but is infusible. On charcoal, yields sulphurous fumes, and forms a white coating, but burns slowly and imperfectly.

Is decomposed in nitric acid, leaving a white powder of molybdic acid; in warm nitrochloric acid forms a greenish, and in boiling sulphuric acid a blue solution.

This mineral is common, in small quantities, in granite, gneiss, and chlorite slate; and in veins with tin and other ores. It much resembles graphite, but is readily distinguished by its "streak," lustre, gravity and action before the blowpipe.

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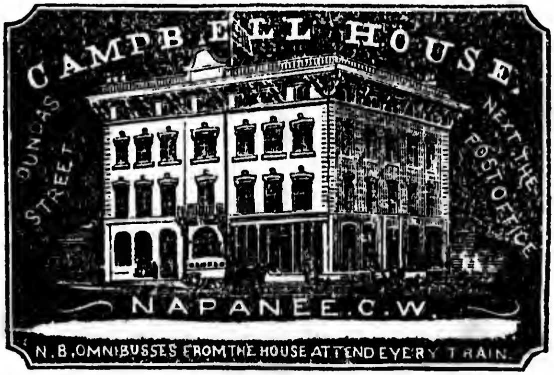

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