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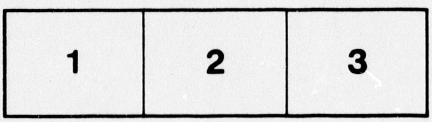
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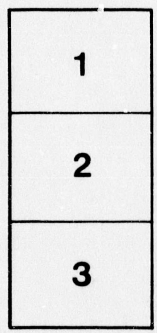
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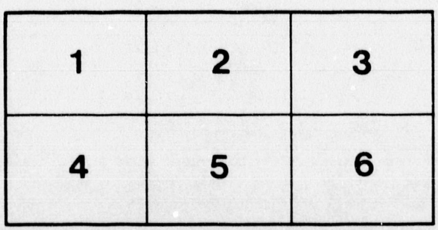
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MANUAL OF MINING

FOR THE USE OF

MINING MEN, LAWYERS, BUSINESS MEN, PROSPECTORS, AND THOSE INTERESTED IN THE MINERAL RESOURCES OF CANADA.

BY

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AND

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TORONTO:
THE COPP, CLARK COMPANY, LIMITED.
1897.

PREFACE.

In presenting this small manual, which has been prepared more particularly for Canadian readers, the editors disclaim any attempt at writing a book. Herein will be found, on the other hand, a compilation from the best authorities on the various subjects treated, together with some portion of original matter.

Throughout, as far as possible, technical phraseology has been avoided, for the convenience of lawyers, business men, prospectors, and others having an interest in Mining.

Dana's Classification of Minerals has been closely adhered to, the rarer minerals being omitted, save where they occur in Canada, and for that reason are of interest. It is hoped that this condensed but accurate section, as well as those on Geology and Mining, may commend the book to mining men and others who need a handy, reliable pocket-book of reference.

Among other works consulted were Ihlseng's Manual of Mining; Ore and Stone Mining, by C. Le Neve Foster; Bowie on Hydraulic Mining; Lock's Miners' Pocket-book; Dana's Geology; Jukes and Geikie on Geology; Chapman's Mineralogy and Geology; Geological Survey Reports of Canada; Reports of Ontario Bureau of Mines; Kemp's Ore Deposits, and various Trade Catalogues.

TORONTO, February, 1897.

CONTENTS.

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ERRATUM.

In the first table on page 15, in the column of "RESULTS," insert opposite "Antimony, Lead, Bismuth (Zinc, Molybdenum)," the words, "Coating on charcoal"; the reactions being the same as for the succeeding table.

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POCKET MANUAL OF MINING.

GEOLOGY.

STRUCTURAL.

Geology for the purposes of this hand book may be considered to be the study of the structure of rocks, and the agencies which have participated in their formation, and also their classification according to the sequence of that formation.

Of the various theories on the creation and development of the earth's surface there seems to be a preponderance of belief in the supposition that originally the globe was a molten mass, and that a rock crust was formed by a more or less lengthy period of cooling. Subsequent to this appearance of the primitive—or Archean—rocks, and simultaneous with a strengthening of the crust by a still further internal cooling of the molten mass (into unstratified rock) began a process of working-over of the external rock, in which the atmosphere, heavily burdened with carbonic acid gas and other vapors, greatly assisted. In those, creation's early days, the seas although shallow were, as compared with now, of vastly greater extent than the land, and their formation was no doubt owing to the condensation of igneous vapors once the first crust was cooled. From the start, according to the generally accepted theory, shrinkage due to cooling and volcanic action kept the earth's surface in a constant state of bending and contortion. All in its due time, ensued the disintegration of the hard rock, through the decomposing action of carbonic acid gas in the rains and atmosphere, alternate heat and cold, and other causes, such as are in fact observable in our own day. The hard rock passed in due course into broken fragments, then into pebbles, sand, mud, and clay, finding its way by the agency of streams and rivers into the surrounding shallow seas, where, as also from observation the same process is seen at this time, it was deposited in layers to form sedimentary beds, which in turn from pressure and other causes were to harden subsequently into rock. The contortion above alluded to was on a grand scale, and the best reasons exist to believe that, whether the periods of rising and falling occupied thousands or billions of years, various portions of the globe's exterior varied at intervals in elevation from the portions adjoining, resulting in countless alterations of the area covered by water. The sea, which formerly contained much more of the destructive carbonic acid gas than now, thus over different areas and at divers times, had opportunity to further disintegrate and work over into beds the rock masses which had been already decomposed by atmospheric influence.

From stratified rock, or that formed by the successive layers of deposition, geologists have evolved a system of classification (see table) according to their age, starting with the reasonable supposition that the lower layer was deposited prior to the next above. While rocks have been forming through action of the sea in one region, in another—because it was not submerged—more were in progress, so that nowhere is the complete series found. Careful study of the fossils or organic remains furnished a means of identification with beds occurring elsewhere, not necessarily of the same composition, but containing fossils of the same animals and plants. The following facts have been learned:

1. At first there was an age when no life existed in the globe, and the rocks formed during that age are called *Archean* or *Azoic*.

2. Next came an age when shells, corals, and other low forms of sea-life, but none of terrestrial life, appeared. It is the *Silurian*.

3. An age when, besides shells, corals, etc., fish abounded and low forms of earth vegetation flourished is next, and gets the name of the *Devonian*.

4. Dense land vegetation, and evidences of many succeeding alternations of luxuriant growth and submergence beneath the waters mark the next period. The forms of life, in sea and on land, were more advanced. It is the coal-plant era, or *Carboniferous* Age.

5. The succeeding era was remarkable for the variety and size of reptiles that abounded, so that it received the name of *Reptilian* Age.

6. The next age, when reptiles gave place to mammals or quadrupeds in equal abundance and variety, the continents having by this time grown to something like their present area, is termed the *Mammalian* Age.

7. Then came man, the highest type of animal life, ushering in the present, or *Quaternary* Age.

GEOLOGICAL CLASSIFICATION.

- I. ARCHEAN TIME—No life.
  - 1. Laurentian.
  - 2. Huronian.
    - 1. Keewatin.
    - 2. Couchiching.
- II. PALAEOZOIC TIME
  - 1. Age of Invertebrates, or Silurian.
    - 1. Lower.
      - 1. Cambrian Period.
      - 2. Canadian Period.
      - 3. Trenton Period.
    - 2. Upper.
      - 1. Niagara Period.
      - 2. Salina Period.
      - 3. Lower Helderberg Period.
      - 4. Oriskany Period.
  - 2. Age of Fishes, or Devonian.
    - 1. Lower, including Corniferous Period.
    - 2. Upper.
      - 1. Hamilton Period.
      - 2. Chemung Period.
      - 3. Catskill Period.
  - 3. Age of Coal Plants, or Carboniferous.
- III. MESOZOIC TIME
  - Age of Reptiles, or Reptilian.
    - 1. Triassic Period.
    - 2. Jurassic Period.
    - 3. Cretaceous Period.
- IV. CENOZOIC TIME
  - 1. Age of Mammals, or Mammalian or Tertiary Age.
    - 1. Eocene Period.
    - 2. Miocene Period.
    - 3. Pliocene Period.
  - 2. Age of Man, or Quaternary Age.
    - 1. Glacial Period.
    - 2. Champlain Period.
    - 3. Recent or Terrace Period.

METAMORPHISM.

Just as bricks are made from wet clay, under the action of fire, moisture and pressure, rocks like sandstones and limestones, uncrystalline in texture, under certain conditions are metamorphosed, *i.e.*, changed, into granite and marble, or others which are crystalline, and the area of action may be either circumscribed or extensive. Many of the Canadian rocks are metamorphic. Sometimes metamorphism has resulted in no chemical change, while in other cases the ingredients subjected to the process entered into new combinations, perhaps giving rise to various crystalline minerals disseminated through the mass. The water necessary for metamorphism is that contained in the rocks themselves, for the most part; the heat may either be derived from the earth's interior, or that resulting from the friction created when the rocks were shoved or folded by causes already referred to; while the pressure, which may or may not be necessary for metamorphic changes, could be furnished by the overlying ocean or rocks.

VEINS.

Veins are the filling of spaces in the rocks, which may be cracks made by uplifting forces, by shrinkage from cooling or drying, by the separating of layers in a rock, or by cavern-action. The forces producing metamorphism were responsible for much of the rending of the rocks, and the filling of the spaces with quartz or other stony material was probably effected as a result of such action. Quartz is the most abundant of all rock-making minerals and it, therefore, was the material set free in the majority of cases when, under action of the vapors attending metamorphism, the rock mass below or on either side of the fissure was decomposed. The same fluids that carried this quartz into the vein took with it the gold freed by the decomposition of the rock—provided it was in the first place gold-bearing—so that in forming veins nature found a way of collecting in small area the rich minerals which were before thinly scattered. Similarly other minerals came into veins, ores of lead, zinc, copper, iron, etc. Fissures filled by deposition from above, and sometimes carrying mineral, are not true veins. Metallic ores, likewise, have often been deposited when a sedimentary bed was forming, and the strata may then have been tilted, exposing to view—edgewise—the once horizontal bed. It may resemble, but is not a true vein. Many deposits shew evidence of being a series of parallel fissures close together, produced by compression ("crushed zones"). The metalliferous fluids are supposed to have flowed along these fissures, attacking the country rock on each side, dissolving the rock and replacing it gradually with the metal sulphides (this has been termed metasomatic replacement). The gold bearing iron and copper sulphides of the Trail Creek district give strong indications that

Veins.

they are of this character. This will explain the irregular width of many of the veins and gradual fading away of the mineral into the country rock, without shewing defined walls, though many parallel slickensided surfaces will be noticed throughout the deposit.

Veins are often "faulted" by another fissure cutting across it and breaking its continuity. In four cases out of five the continuation will be found by assuming that the narrow-based body has slipped down the faulting plane.

GLACIERS.

If not unanimous on the reasons why a glacial climate came to exist, geologists agree that late in geological history the more northerly continents underwent great surface changes through a movement of vast glaciers from the polar regions towards the equator. In Canada the surface of the ancient rocks, long exposed to atmospheric influences and badly decomposed, underwent great alterations through the southerly moving rivers of ice, which picked up a "shoe" of boulders on their lower surface and deeply scoured the area traversed. Upon melting, the attached boulders, mud, clay and gravel were dropped—to form the till or drift that comprises the present surface over a large area of the country. The network of lake and river so distinctive of an extensive part of Canada results from the glacial erosion and damming which went on. The rock scratches (striae)—often deep and wide, and occurring frequently in several parallel lines—are due to the same cause, as well as the rounded appearance characteristic of the rock masses of the eastern half of the Dominion. A notable exception to this last is seen in north-eastern Labrador, where identically the same Archean rocks are angular, but soft from decomposition to considerable depth, showing that they escaped glaciation.

ROCK MAKING MINERALS.

Rocks consist essentially of minerals, and the minerals of the common rocks are of four groups:—1. Quartz, called in chemistry silica. 2. Silicates, or compounds of silica. 3. Carbon. 4. Carbonates, or compounds of carbon.

1. *Quartz* is the most common of all species, and being one of the hardest minerals, and nearly insoluble and infusible, withstands various destroying agencies proportionately better. The sands and pebbles of the seashores and gravel-beds are mainly quartz, because it resists wearing action of the waters more than any other common mineral. Similarly, most sandstones and conglomerates consist largely of quartz.

Rock Making Minerals.

2. *The Silicates.*—Pure Alumina—which is very hard, infusible and insoluble, and therefore adapted to its place as second in abundance to quartz; magnesia—hard as quartz when crystallized and equally infusible and insoluble; lime—common quicklime; potash and soda—the common alkalies; and iron oxide, complete the list of the most important bases that combine with silica to make silicates. The principal silicates are (*a*) Feldspar. Varieties:—Orthoclase (most common), a potash feldspar; albite, a soda feldspar; oligoclase and labradorite, soda-lime feldspars. (*b*) Mica. Varieties:—Muscovite, white; biotite, black from presence of iron. (*c*) Chlorite, resembling black mica in constitution, and when well crystallized, in its cleavage. (*d*) Hornblende and pyroxene. (*e*) Talc and Serpentine. (*f*) Various silicates which occur distributed in crystals through many crystalline rocks, such as garnet, tourmaline, andalusite, cyanite and staurolite.

3. *Carbon* only occurs pure among the minerals in diamond and graphite, although it is the principal constituent of mineral coal, charcoal and petroleum.

4. *The Carbonates* include Calcite—a carbonate of calcium, and Dolomite—a carbonate of calcium-magnesium. They burn to quicklime without melting and are the material of limestone and marble.

5. *Common or Rock Salt* is the only chloride forming rock masses.

6. *Iron ores* are widely distributed in rocks, sometimes in thick beds. They are:—(*a*) Hematite. The usual iron-black color of its crystals becomes deep red when earthy or impure, and hematite furnishes the color in red sandstones and other red rocks. (*b*) Limonite (a hematite containing water), which is the coloring ingredient in a large part of the brown and brownish yellow rocks and clays. The water present evaporates on heating, and the mineral changes to hematite and to red. (*c*) Magnetite is iron-black but magnetic, and, instead of being red when powdered, like hematite, is black. It commonly occurs in grains in a large part of rocks and in sand and soils, although also occurring in great beds in some of the older rocks.

Pyrite and pyrrhotite (iron sulphides) and siderite (iron carbonate) also occur extensively.

KINDS OF ROCKS.

The minerals composing a rock may be either (1) in broken or worn grains or pebbles, forming a *fragmental* rock, or (2) in crystalline grains which are angular and, quartz excepted, generally exhibit cleavage surfaces. Examples, common white marble and granite.

Kinds of Rocks.

Fragmental rocks are the most common of all, and include sandstones, shales, and conglomerates, these being formed in each succeeding age out of the material produced by the wear and decomposition of the rocks of the age preceding. They are *stratified* rocks also, because they are in beds, and *sedimentary* because deposited for the most part as a sediment.

Of the *Crystalline Rocks* some are *metamorphic*, some *igneous*.

Metamorphic rocks are those ordinary fragmental rocks and limestones which have been changed by heat or pressure into crystalline rocks, and usually without fusion, examples being architectural marble, mica schist, gneiss and much granite, etc.

Igneous rocks have come up melted through volcanic fissures which connected with some subterranean seat of melted rock, and include lavas, porphyry and granite, etc., and those which have formed at great depths, and have afterward been exposed by the wearing away (denudation) of the upper strata,—granites, syenites, diorites, gabbro, etc.

Calcareous rocks are the limestones, largely originating from pulverized shells, corals and other animal relics.

Siliceous rocks are those composed mostly of silica (quartz).

Porphyritic rocks are those having distinct feldspar crystals disseminated throughout so as to appear spotted with a light colored mineral when polished.

Massive is a term applied to rocks when they do not break into slabs or plates, *e.g.*, granite and most conglomerates; *schistose*, when if crystalline, they break into slabs or plates owing to the arrangement in layers of the mica, hornblende or other mineral ingredients; *laminated*, when splitting into slabs or flags, but not owing to a crystalline structure; *slaty*, when separating easily into thin, even, hard slates; *shaly*, when splitting easily into thin slate-like plates of irregular shape, and fragile. A schist is a schistose rock, a flag a laminated one, while slate and shale are applied to slaty and shaly rocks respectively.

FRAGMENTAL ROCKS, NOT CALCAREOUS.

The classification of fragmental rocks depends on the constituents, which are:—

1. *Sand-beds; Gravel-beds.*—Most sand or gravel is composed mainly of quartz, but some beds are made of granite sand or pebbles, or of fragments of other rocks. If containing much clay they are *argillaceous;* some are red or brownish yellow owing to presence of iron and are *ferruginous.* Some contain lime and are *calcareous.* Beach sand often contains red grains of garnet and also magnetite.

2. *Mud; Earth; Clay.*—Mud and earth contain, besides

Kinds of Rocks.

grains of quartz, some powdered feldspar, or else clay, with more or less of other minerals. When black the color is due to carbonaceous material derived from vegetable or animal decomposition. Common clay is pure clay mixed with grains of quartz, feldspar and usually traces of iron. Owing to the iron it burns red, making red brick. Clays free from iron are required for white pottery, and free from feldspar for fire brick because the potash of feldspar makes clay fusible.

3. *Sandstone.*—A rock made of sand, and of red, grey, brown, white and other colors. When of quartz sand it is a quartzose or siliceous sandstone, when of granite sand, a granitic ; if fine earthy or clayey, an argillaceous sandstone.

4. *Conglomerate.*—Consolidated gravel. If the stones are rounded the rock is a puddingstone ; if angular, a breccia ; if the pebbles are quartz, a siliceous conglomerate ; if limestone pebbles, a calcareous conglomerate. The stones may be a foot or more in diameter, but usually are much smaller.

5. *Shale.*—A somewhat slaty rock made of clay or clayey earth or fine mud. Carbonaceous shale is the blackish variety, yielding mineral oil when heated.

6. *Tufa.*—Volcanic sandstone, usually brownish, brownish-yellow, grayish or reddish.

METAMORPHIC ROCKS.

1. *Granite.*—A crystalline rock of quartz, feldspar, and mica or hornblende. Color usually light or dark gray, or flesh-red, the latter shade from a flesh-colored feldspar ; the quartz—uncleavable, usually grayish white ; the feldspar—white to flesh-red, and yielding smooth shining surfaces by cleavage ; the mica—white to black, and affording thin, flexible leaves by cleavage. *Protogine* is an altered granite having chlorite, talc or hydrous mica instead of mica or hornblende. It is usually greenish in color.

2. *Gneiss.*—Like granite in constitution, but having a bedded structure, due to the mica or one of the other minerals taking parallel lines along which it easily and evenly fractures.

3. *Mica Schist.*—Is a rock like the last, but with more mica and quartz and less feldspar ; breaks into plates along the mica layers.

Syenite.—Is like granite in appearance and composition, but contains little or no quartz.

Hydromica Schist.—A slaty, fine grained mica schist, feeling somewhat greasy ; sometimes mistakenly called *talcose slate,* but containing hydrous mica instead of talc.

Chlorite Schist.—A slaty rock containing the olive green mineral, chlorite. Much hydromica schist is chloritic.

Kinds of Rocks.

Slate, Argillite, Phyllite.—Roofing slate and allied slaty rocks, hardly crystalline to the naked eye. The most perfect kinds are hard, smooth, and do not absorb water. Color, blue-black, purple, red, green and other shades. Much slate is fine grained hydromica schist.

Quartzite.—A metamorphosed sandstone, usually very hard, differing from massive quartz in consisting of grains of quartz.

Diorite.—Like syenite, but contains the striated feldspars oligoclase, labradorite, etc., instead of orthoclase. Coarse or fine grained. Color, grayish-white to dark green, sometimes almost black.

CALCAREOUS ROCKS.

Common Limestone.—Consists of calcite or dolomite, often impure from clay. Color, dull shades from gray to black. See calcite.

Oölyte.—Limestone consisting of concretions, small as fish-roe.

Travertine.—Stalactites are limestone concretions shaped and formed like icicles, and corresponding formations on the floor are stalagmites (dripstone). A similar deposit from streams and ponds is called travertine.

Crystalline Limestone, Architectural and Statuary Marble, unlike the last three, are metamorphic, crystalline, and therefore glisten on a broken face.

IGNEOUS ROCKS.

Massive Igneous rocks may be subdivided thus:—Abyssal or deep-seated, solidified under pressure. Dyke, solidified in wide fissures near the surface. Volcanic, solidified on the surface. The structure of these rocks depends upon the rate of cooling as well as their chemical constitution; rapid cooling gives fine grained or glassy rocks. When the fine grained rocks have well defined crystals scattered through them they are termed "porphyritic." Slow cooling gives coarse crystals crowded together—granitic structure.

ABYSSAL ROCKS—(*having a granitic structure*).

Granite—consisting of quartz, feldspar and some basic or dark colored mineral (mica, hornblende, or pyroxene).

Syenite—as in the metamorphic syenite, contains little or no quartz. Hornblende is most frequent, and pyroxene often occurs as the dark mineral.

Diorite—contains the striated feldspar (plagioclase) and mica or more frequently hornblende; seldom carries quartz.

Gabbro—consists of the striated feldspars and pyroxene (augite, diallage, or hypersthene). If it contains olivine it is termed an olivine gabbro; or if the dark mineral is absent it is called an anorthosite.

Kinds of Rocks.

Pyroxenite—consisting nearly altogether of pyroxene.

Peridotite—made up of olivine—bottle glass green in appearance.

DYKE ROCKS—(*usually porphyritic in structure*).

Granite porphyry, *Syenite porphyry*, and *Diorite porphyrite*, similar to the Abyssal rocks of the same constitution, but finer grained, with occasional large crystals scattered through.

Diabase, consisting of pyroxene and lath shaped crystals of feldspar ; sometimes contains olivine.

VOLCANIC ROCKS—(*porphyritic and glassy*).

These rocks may be divided into two classes : (1) the old, usually porphyritic ; (2) the young, glassy.

Porphyry (old), very fine grained, light colored ground mass, with crystals of feldspar and sometimes quartz (quartz porphyry).

Felsite, like porphyry, but without defined crystals of feldspar or quartz.

Porphyrite (old), the ground mass dark and fine grained (hornblende or biotite) with crystals of feldspar and sometimes quartz (quartz porphyrite).

Diabase (old), like the same dyke rock.

Basalts (young), compact, almost flinty rocks made up of hornblende, pyroxene, olivine and feldspars ; the feldspar usually well crystallized in small crystals.

Lavas (young). Any rock that has flowed in streams from a volcano, and of various constitution ; when glassy it is known as *Obsidian ;* when more stony as *Pitchstone* and *Pearlstone ;* if full of cavities, *Scoria ;* and white scoria with long slender cavities is *Pumice*.

Below is given a condensed table of the igneous rocks.

	ABYSSAL ROCKS.	DYKE ROCKS.	VOLCANIC ROCKS. (OLD)	VOLCANIC ROCKS. (YOUNG)
Orthoclase feldspar (white and red), mica or hornblende, quartz	Granite.	Granite porphyry.	Porphyry.	Lavas.
Ditto, with little or no quartz	Syenite.	Syenite porphyry.		
Plagioclase feldspar (striated), hornblende or mica.	Diorite.	Diorite porphyrite.	Porphyrite.	Basalts.
Ditto, with pyroxene, etc.	Gabbro.	Diabase.	Diabase.	

MINERALOGY.

Physical Properties of Minerals.

Hardness.—Determine what number represents the examined neral by reference to the following table :—

Standard.		Chapman's Convenient Scale.
lc	= 1	Yields to the finger nail.
ck Salt	= 2	Does not yield to the finger nail, nor scratch copper coin.
lcite	= 3	Scratches copper coin, and is also scratched by one.
ıor Spar	= 4	Not scratched by copper coin. Does not scratch glass.
patite	= 5	Scratches glass feebly, yields to knife easily.
thoclase	= 6	Scratches glass easily, difficult to scratch with knife.
ck Crystal	= 7	Does not yield to knife. Difficult to scratch with file.
paz	= 8	Harder than flint or rock crystal, not touched by a hand file.
rundum	= 9	
amond	=10	

Tenacity.—If a mineral breaks or powders easily it is *brittle ;* hen slices may be cut off, and these slices hammered flat like tive gold, silver and copper, it is *malleable ;* if thin slices may cut off with a knife it is *sectile ;* if a mineral will bend and mains bent, like talc, it is *flexible ;* if after it is bent it springs ck to its original position, like mica, it is *elastic.*

Specific Gravity.—The specific gravity of a mineral is its eight compared with that of water, which is taken as a standd. Divide the weight in air by the difference between the eight in air and the weight in water; the result will be the ecific gravity of the mineral.

Diaphaneity.—The property of transmitting light. When the tlines of objects, seen through the mineral, are distinct it is *ansparent ;* when objects are seen but their outlines indistinct is *subtransparent ;* when light passes through, but objects are t seen, it is *translucent ;* when merely the edges transmit light

Physical Properties of Minerals.

faintly it is *subtranslucent ;* when no light is transmitted mineral is *opaque.*

Lustre.—The lustre (or aspect) of minerals depends on nature of their surfaces, which causes more or less light to be flected. The varieties are as follows :—

1. Metallic—the usual lustre of metals. If imperfectly me lic it is submetallic.
2. Vitreous—the lustre of broken glass. Subvitreous app similarly. Quartz is vitreous. This kind of lustre may be hibited by minerals of any color.
3. Resinous—lustre of the yellow resins. Example, opal, zinc blende.
4. Pearly—like pearl. Talc, etc.
5. Greasy—oily.
6. Silky—like silk.
7. Adamantine—like diamond.

The intensity of the lustre of minerals may be graduated in descending order :—Splendent, Shining, Glistening, Glimmer

Color.—In distinguishing minerals, both the external and the color of a rubbed or scratched surface are noted. latter is called the *streak ;* and the powder scraped off, the *st powder.* When there is a milky or pearly reflection from interior of a specimen, as in a cat's eye, it is *opalescent.* If matic colors are seen within a crystal it is *iridescent.* Min that give out light during friction or gentle heating are p phorescent (as seen in the dark).

Electricity and Magnetism.—Many minerals become trified on being rubbed, and attract cotton and other light stances. If the mineral is not electric unless heated it is ca *pyroelectric.* Several ores, chiefly of iron, are attracted by magnet and are *magnetic.*

Taste and Odor.—Taste belongs only to the soluble min and is classified under the terms *astringent* = the taste of al *saline* = taste of salt, *alkaline* = taste of soda, *cooling* = tast saltpetre or nitre, *bitter* = taste of Epsom salts, and *sour* = tast sulphuric acid.

Cleavage.—Mica has *eminent* cleavage, that is, it rea yields sheets thinner than paper, but other minerals only af plates somewhat thicker and thus range from a *perfect* clea to difficult cleavage according to the ease with which the pl can be separated. Other minerals have *no* cleavage, and t crystals cannot be subdivided. Cleavable minerals usually af even, and frequently, polished surfaces.

Fracture is the appearance of a mineral when broken, may be either hackly or crystalline like iron, slaty or even conchoidal—breaking with shallow concavities or convexi over the surface—like flint, or hard coal.

BLOWPIPE TRIALS.

The blowpipe is a bent tube, about ten inches long, which, when blown through while the smaller end is held just within the flame, concentrates it. In using the blowpipe it is necessary to breathe and blow at the same time, that the flame may be steady. By breathing a few moments through the nostrils while the cheeks are inflated, and then inserting the blowpipe between the lips, this knack may be easily acquired. By holding the blowpipe point close to the candle flame, and blowing gently, a yellow pointed flame is produced which is the reducing flame (R. F.); and when the point is placed just inside the flame and more force used in blowing, a pale blue flame is made, being the oxidizing flame (O. F.). The mineral is held either in platinum-tipped forceps or on a firm and well burnt piece of charcoal. For ascertaining a mineral's fusibility in the forceps, a thin piece, the size of a pin head, is preferred. The fusible metals alloy readily with platinum, so compounds of lead, arsenic, antimony, etc., must be tested on charcoal. Platinum wire, cut to three inch lengths and bent into a loop at one end, is used to observe the action of the fluxes (commonly borax or soda) on the mineral, and also the colors that the oxides give to the fluxes when dissolved in them. In practice, the loop is highly heated and dipped in the soda or borax till it is filled with a bead, and then one or more grains of the powdered mineral is dissolved in it. The bead obtained in both oxidizing and reducing flames is watched closely for color and degree of transparency, both when hot and cold. Use too little rather than too much substance for the bead test. Dilute sulphuric acid cleans the wire after using. Glass tubing of ¼ in. bore, cut into 3 in. lengths, and used in some cases with both ends open, in others with one end closed, are employed to test whether vaporization of volatile ingredients occurs, and to examine for odor, acidity and alkalinity. Acid fumes redden litmus paper. If the mineral is a sulphide, arsenide or antimonide, it should be roasted on charcoal in the oxidizing flame before using a flux. Sulphides, in such a case, give out fumes of burning sulphur; arsenides give an onion odor; selenides, the odor of decaying horse radish; while antimony fumes are dense white and odorless. The color given to the flame in blowpipe trials is important. If the mineral contains sodium the flame is bright yellow; potassium, pale violet; calcium, a pale reddish yellow; lithium, a deep purple red; strontium, a bright red; copper, emerald green; phosphates, bluish green; boron, yellowish green; copper chloride, azure blue. Beads should be examined by daylight only. It is also to be noted whether the substance heats quietly or with a crackling noise (decrepitation), whether it fuses with effervescence, or with boiling (intumescence). Alkalies

Blowpipe Trials.

change the yellow of tumeric paper to brown, or red litmu blue, when heated in a glass tube.

Blowpipe Outfit.—Blowpipe; steel or platinum-tipped force small hammer; steel anvil, about 2 inches square and $\frac{1}{2}$ i thick; magnet; platinum wire; glass tubing; a few pieces charcoal; cupel mould; file; candles.

Reagents.—Sodium bicarbonate, borax, bone-ash, blue and litmus paper, tumeric paper, assay litharge. These may be k in small wooden pill-boxes, and the whole outfit convenie carried in a flat tin, or cigar box.

The following table is a scheme of analysis for the purpose determining the presence of certain elements in the mineral t tested. As all minerals are chemical compounds, two or th reactions may be noticed from the same mineral; exam mispickel, a compound of iron, arsenic and sulphur, gives arse fumes, sulphur reactions, and a magnetic residue of iron.

METALLIC LUSTRE.

Ignite before blowpipe on charcoal.

RESULTS.	METALS.
Emission of odor—	
Garlic..........................	Arsenic.
Matches	Sulphur.
Decaying horse-radish.............	Selenium.
Emission of copious white fumes.......	Arsenic, Antimony, Zinc.
	Antimony, Lead, Bismuth (Zinc, Molybdenum).
Flame coloration—	
Blue..............................	Lead, Arsenic.
Pale green........................	Antimony, Molybdenum, Tellurium.
Green, blue, or greenish white.....	Zinc.
Magnetic residue......................	Iron, Nickel, Cobalt.

Fuse substance with soda on charcoal.

RESULTS.	METALS.
Emission of odor......................	Arsenic, Selenium.
Coating on charcoal—	
White............................	Antimony.
Yellow............................	Lead.
Dark yellow......................	Bismuth.
Pale yellow and phosphorescent, hot White, cold......................	Zinc.
Yellow, hot...................... White, cold......................	Molybdenum.
Metallic globule—Brittle..............	Antimony, Bismuth, Tin.
Malleable..........	Lead, Silver, Copper.
Forms a slag—	
Powder the slag and moisten it. If it blackens a silver coin......	Sulphur, Selenium, Tellurium.

Roast some of powdered substance and fuse a little with borax in platinum wire loop.

RESULTS.	METALS.
Formation of colored bead—	
Violet	Manganese.
Green while hot, in oxidizing flame Blue while cold, in oxidizing flame. Brown, opaque, in reducing flame.	Copper.
Yellow in oxidizing flame Green in reducing flame	Iron, Chromium.
Brown in oxidizing flame Gray, opaque, in reducing flame	Nickel.
Blue	Cobalt.
Yellow in reducing flame	Titanium.
Yellow in oxidizing flame Brown or gray in reducing flame	Molybdenum.
Formation of colorless bead—	
If much mineral is used, and the bead becomes opaque white on cooling	Barium, Calcium, Strontium, Magnesium, Zinc.

NON-METALLIC LUSTRE.

Fuse a particle by itself in platinum forceps.

RESULTS.	METALS.
Colored Flame—	
Pale green	Barium, Borates and Phosphates.
Rich green	Copper.
Crimson	Strontium, Lithium.
Pale red	Calcium.
Bright yellow	Sodium.
Violet	Potassium.
Magnetic mass or bead	Iron, Nickel, Cobalt.

Fuse substance with soda and a little borax on charcoal.

RESULTS.	METALS.
Odor of garlic	Arsenic.
Fumes, white	Arsenic.
Metallic globule—Brittle	Antimony, Bismuth, Tin.
Malleable	Lead, Silver, Copper.
Coating on charcoal—	
White	Antimony.
Yellow	Lead.
Dark yellow	Bismuth.
Pale yellow and phosphorescent—hot .... White—cold	Zinc.
Slag (blackens silver coin when crushed and moistened)	Sulphur (a sulphate).
Absorption in the charcoal	Barium, Strontium, Lithium, Sodium, Potassium.
Formation of opaque blue or greenish blue enamel	Manganese.

Fuse a small particle with some borax on platinum wire loop.

Formation of colored bead. The bead reactions are similar to those described under "Metallic Lustre."	

CUPELLATION.

Ores rich in gold and silver may be tested in this way. The mineral is powdered and mixed with soda and pure lead or litharge and reduced on charcoal with the blowpipe to a lead button. When cooled and cleaned the button is placed on the cupel. A good cupel may be made thus: fill a clay pipe bowl three-quarters full of clay, and in the cup-shaped cavity left on top press some dry bone ash, and smooth the surface with the rounded end of a glass stopper. The lead button is treated by the oxidizing flame, and is kept moving on the cupel to bring it in contact with fresh bone ash all the time. The lead is absorbed in the bone ash and finally, when the cupellation is finished, the little silver or gold button gives a flash or gleam of light. Galena ores, of course, require no addition of lead, but a lead button containing the silver for cupellation is obtained by fusing with soda on charcoal.

CHARACTERISTICS OF SOME OF THE COMMON MINERALS.

METALLIC LUSTRE--COLOR.

RED.	YELLOW.	WHITE.	GREY.	BLACK.	
Copper. Bornite. Arsenical Nickel	Gold. Iron Pyrites. Copper Pyrites.	Silver. Arsenical Iron Pyrites. Mercury. Bismuth.	Molybdenite. Stibnite. Argentite. Galena.	Graphite. Pyrolusite. Magnetite. Hematite.	

SUB-METALLIC LUSTRE—STREAK.

BLACK OR DARK GREY.	BROWN.	RED.	YELLOW.	GREEN.	BLUE.
Anthracite Coal.	Lignite. Zinc Blende. Limonite. Cassiterite.	Cinnabar. Hematite	Sulphur. Realgar. Orpiment.	Malachite.	Azurite.

NON-METALLIC LUSTRE—HARDNESS.

VERY SOFT. From 1 to 3.	SOFT. From 3 to 4.	HALF HARD. From 4 to 5.	HARD. From 5 to 7	VERY HARD. From 7 to 10	
Talc. Gypsum. Mica.	Calcite. Aragonite. Barite. Fluorite.	Calamine. Apatite.	Opal. Analcite. Hornblende. Turquois. Feldspar.	Topaz. Corundum. Diamond. Quartz. Zircon.	

CHAPMAN'S SYLLABUS FOR DETERMINATION OF COMMONLY OCCURRING CANADIAN MINERALS.

CLASS I.

Malleable.

1. Native silver and black silver sulphide.
2. Native gold.
3. Native copper.

CLASS II.

Soft, i.e., scratched by the knife.

(*II a.*) *Metallic Lustre.*

1. Yellow. Copper pyrites. Reducible to a metallic bead. Magnetic after ignition.
2. Bronze-yellow, or reddish. Magnetic pyrites. Magnetic before fusion.
3. Flesh-red, but with blue or other tarnish. Bornite.
4. Lead-gray. Galena. Reducible to metallic bead of lead, and covering support yellow.
   Molybdenite. Infusible. Tinges flame green; soils paper like graphite.
   Stibnite. Fuses in candle flame. Gives dense, white fumes.
5. Gray or black. Graphite. Infusible, no color to flame, marks paper.
   Pyrolusite. Turquois enamel with sodium carbonate. With hydrochloric acid gives odor of chlorine.
   Hematite. Red streak, magnetic after ignition.

(*II b.*) *Non-Metallic Lustre.*

Streak red or brown.

6. Hematite. Streak red. No water on ignition in the bulb-tube, magnetic after ignition.
7. Limonite. Streak brownish red. Yields water in bulb-tube, magnetic after ignition.
8. Zinc blende. Streak light brown. Yields no water. Infusible by itself, yields coating of oxide on the support. Yellow hot, white cold, and green after ignition with cobalt nitrate solution.

Streak uncolored.

(*1*). *With sodium carbonate blackens silver.*

9. Gypsum. White, very soft, yields water in bulb-tube, easily fusible.

MINERALOG

From 7 to 10	Topaz. Corundum. Diamond. Quartz. Zircon.
From 5 to 7	Opal. Analcite. Hornblende. Turquois. Feldspar.
From 4 to 5.	Calamine. Apatite.
From 3 to 4.	Calcite. Aragonite. Barite. Fluorite.
From 1 to 3.	Talc. Gypsum. Mica.

Determination of Common Minerals.

10. Barite. Fusible with difficulty, yields no water, ti flame green.
11. Celestite. Fusible ; colors flame red, yields no water.
12. Zinc blende (some varieties). Yields no water, no fla coloration (see 8 above).

(2). *No sulphur reaction.*

13. Rock salt. Taste is distinctive.
14. Fluorite. Fusible, occurs mostly in cubes.
15. Apatite. Infusible, occurs in six-sided prisms.
16. Mica. Fusible on edges, can be easily divided into she
17. Calcite.

CLASS III.

Hard, *i.e.*, not scratched by knife.

(*III a.*) *Metallic Lustre.*

1. Yellow. Iron Pyrites. Magnetic after ignition, fusi gives off sulphur odor ; cubical.
2. Brownish yellow. Reddish. Magnetic Pyrites. Magn before ignition.
3. Silver-white. Arsenical Pyrites. Gives off odor of arse and becomes magnetic.
4. Black. Magnetic iron ore. Anhydrous, streak black, netic before ignition.
5. Dark steel-gray or red. Hematite. Magnetic only ignition. Streak red, yields no water.
6. Brown. Reddish-yellow. Limonite. Yields water in tube. Streak yellow, magnetic only after ignition.

(*III b.*) *Non-Metallic Lustre.*

7. Hexagonal pyramids or prisms, yields no water, infus Quartz.
8. Hard, cleavable in various directions, fusible on the e Feldspar.
9. White or pale green, fusible with strong intumesce Prehnite.
10. Dark red, opaque or semi-transparent ; yields no wa fusible, regular system. Garnet.

DANA'S CLASSIFICATION OF MINERALS.

(Condensed with but slight alteration.)

In the following classification these abbreviations are used: =color, S=streak color, L=lustre, H=hardness, G=specific ravity, B.B.=before blowpipe. The figures given with the omposition indicate the percentage of each component part.

SULPHUR GROUP.

NATIVE SULPHUR.—Orthorhombic, octahedrons. Also massive. and S=canary yellow, sometimes orange yellow. L=resinous. ransparent to translucent. Brittle. H=1.5-2.5. G=2.07. urns with blue flame and sulphurous odor. In closed tube holly volatilized and redeposited on walls of tube. Uses: gunowder, bleaching, medicines, and for manufacturing sulphuric cid.

NATIVE TELLURIUM.—Rhombohedral. Sometimes in six-sided risms, but usually granular massive. C and S=tin-white. rittle. H=2-2.5. G=6.2. Sometimes contains a little iron, nd also a trace of gold.

MOLYBDENUM does not occur native.

MOLYBDENITE.—Molybdenum Sulphide. Hexagonal plates or asses, in thin leaves like graphite, and resembling it. H=1.5. G=4.45-4 8. C=pure lead gray. S=same, slightly reen. Thin sheets very flexible, but not elastic. Leaves mark n paper, but its mark is slightly bluish gray. B.B. infusible, ulphur fumes given off. Sulphur 41, molybdenum 59. Occurs equently in Canada.

MOLYBDITE.—Yellow oxide of molybdenum, is found in Canada.

BORON.

SASSOLITE.—Boracic Acid. Hydrogen Borate. Occurs in small ales, white or yellowish. Feels smooth and greasy. Tastes cid or a little salty and bitter. The borax of commerce is hiefly derived from native borax, but also from ulexite and ssolite. G=1.48. Fuses easily, tinges flame green.

ARSENIC.

NATIVE ARSENIC.—Rhombohedral. Also massive, columnar or anular. C and S=tin-white, but usually dark grayish from rnish. Brittle. H=3.5. G=5.7. Found near Port Arthur.

ORPIMENT.—Yellow Arsenic Sulphide. In leaf-like masses, d sometimes in prismatic crystals. C and S=fine yellow. L=illiant pearly or metallic pearly on cleavage face. Subtransarent to translucent. Sectile. H=1.5-2. G=3.4. Used as aint. Burns with garlic odor and bluish flame. Sulphur 39, senic 61.

Arsenic.

REALGAR.—Arsenic Sulphide. C=fine clear red to orang Transparent or translucent. H=1.5-2. G=3.35-3.65. Us in manufacturing fireworks and King's yellow pigment. Sa characteristics as last. Arsenic 70, sulphur 30.

ARSENOLITE, WHITE ARSENIC.—Arsenous Acid. Isometri In minute hair-like crystals, botryoidal or stalactitic. C=whit H=1.5. G=3.7. Used for alloys in small portions, as with le for shot making. Arsenic 76, oxygen 24.

ANTIMONY.

NATIVE ANTIMONY.—Rhombohedral. Usually massive, wi very distinct plate-like structure, sometimes granular. C and =tin white. Brittle. H=3-3.5. G=6.6-6.75. B.B. fus easily, passes off in white fumes. Occurs in New Brunswic Uses, alloys and medicine.

STIBNITE, GRAY ANTIMONY.—Antimony Sulphide. Orth. Rig rhombic prisms with striated lateral faces. Cleavage high perfect. Commonly divergent columnar or fibrous. Sometim massive granular. C and S=lead gray, liable to tarnish. L shining. Brittle, but thin plates a little flexible. Somewh sectile. H=2. G=4.5-4.62. Fuses readily in the flame of candle; B.B. on charcoal it is absorbed, giving off white fum and sulphur odor. Distinguished by extreme fusibility and i vaporizing B.B. Antimony, 71.8; sulphur, 28.2. Affords t antimony of shops, and is principally used for Britannia a Babbitt metals and pewter. Frequent in Canada.

KERMESITE, RED ANTIMONY.—An antimony oxide and sulphi in red tufts of hair-like crystals. L=adamantine. Mostly acco panying stibnite. B.B. wholly volatilizes.

BISMUTH.

NATIVE BISMUTH.—Cleavage rhombohedral perfect. Gene ally massive with distinct cleavage, sometimes granular. C and =silver-white with slight red tinge, subject to tarnish. Britt when cold; somewhat malleable, heated. H=2-2.5. G=9. 9.8. Used as alloy. Occurs in Hastings Co., etc.

BISMUTHINITE.—Bismuth Sulphide. In needle-shaped cryst of lead gray, also massive; found in the Mikado mine near R Portage, Ontario, and elsewhere.

TETRADYMITE.—Bismuth Telluride. Hex. Crystals oft tabular, with very perfect basal cleavage. Also massive a leaf-like or granular. Plates flexible. L=splendent metalli C=pale steel gray. A little sectile. H=1.5-2. G=7.2-7. Soils paper. The metal is mostly derived from native bismut the most valuable mines being in Saxony, Hungary, Bade Cornwall and Australia. Tellurium 48.1, bismuth 51.9.

CARBON.

DIAMOND.—Isometric. Octahedrons, dodecahedrons, and more complex forms; faces often curved. Cleavage octahedral, perfect. C = white or colorless; also yellowish, red, orange, blue, green, brown or black. L = adamantine. Transparent; translucent when dark colored. H = 10. G = 3.48–3.55. Pure carbon. Burns at high temperature. Electric. Distinguished by hardness, electricity, and brilliant reflection of light. Coarse diamonds (borts) used in diamond drill. In view of recent discoveries in the neighboring States the diamond may yet be found in Canada.

GRAPHITE, BLACK LEAD, PLUMBAGO.—Hexagonal. Sometimes in six-sided prisms or tables with transversely leaf-like structure. Usually leaf-like, and massive. Also granular and compact. L = metallic. C = iron-black to dark steel gray. B. B. infusible, not affected by acids. Thin plates flexible. H = 1–2. G = 2.25–2.27. Graphite may be distinguished from molybdenite by streak, and from the latter giving sulphur fumes. Soils paper and feels greasy. Commonly 95 to 99 of carbon. Uses: pencils, lubricant, crucibles and furnaces, electrotyping, stove polish. Found frequently in Canada.

GOLD.

NATIVE GOLD.—Isometric. Octahedrons, etc. Tree-shaped, thread-like, net-form, and in grains, scales, or masses. C = yellow. H = 2.5–3. G = when pure 19–19.3 varying to 15 and 12 according to impurity. Eminently ductile and malleable. Iron and copper pyrites, often mistaken for gold, are brittle; while gold may be cut or flattened under a hammer.

NAGYAGITE, FOLIATED TELLURIUM.—Like graphite. C and S = blackish lead-gray. H = 1–1.5. G = 7.08. Contains, tellurium 32.2, lead 54, gold 9, often with silver, copper, and some sulphur. Occurs at Huronian mine, Ont.

SILVER.

NATIVE SILVER.—In octahedrons and other forms. No cleavage. Often in threads and tree-like shapes, threads having a crystalline character. Also in plates and massive. C and S = silver-white and shining, often black from tarnish. Sectile. Malleable. H = 2.5–3. G = 10.1–11.1. B.B. fuses easily into white globule. Distinguished by being malleable; from bismuth and other white metals by giving no B.B. fumes, and by affording a precipitate with hydrochloric acid (yields chloride of silver, which becomes black on exposure).

ARGENTITE, SILVER GLANCE.—Silver Sulphide. Isometric. In dodecahedrons more or less modified. Cleavage sometimes

Silver.

apparent, parallel to faces. Also net-form and massive. L=metallic. C and S=blackish lead gray. S=shining. Very sectile. H=2-2.5. G=7.19-7.4. B.B. bubbles and gives odor of sulphur and finally affords silver globule. Resembles some ores of copper and lead, and other ores of silver, but distinguished by being easily cut with knife, like lead; and also by giving globule of silver on charcoal by heat alone. Specific gravity much higher than that of any copper ores. Sulphur 12.9, silver 87.1. Common in Canada.

HESSITE.—Silver Telluride. C=lead and steel-gray. Sectile. G=8.3-8.6. B.B. on charcoal with soda gives silver globule. Silver 62.8, tellurium 37.2. Found at Pine Portage, Ontario, and in Kootenay.

STROMEYERITE.—Silver-Copper Sulphide. C=steel-gray. B.B. fuses with sulphur odor and gives silver globule only by cupellation. Found in British Columbia, at Hall mines. Sulphur 15.7, silver 53.1, copper 31.2.

STERNBERGITE.—Silver-Iron Sulphide. Highly leaf-like, resembling graphite and leaving mark on paper. Thin sheets flexible. C=brassy brown. S=black. Contains from 30 to 35 silver.

ARQUERITE.—An amalgam containing 86 silver, mercury 14. Found in British Colum ia.

SYLVANITE, GRAPHIC TELLURIUM.—Gold-Silver Telluride. C and S=steel gray to silver white, sometimes brassy yellow. H=1.5-2. G=7.9-8.3. The crystals arranged like writing characters. Tellurium 55.8, gold 28.5, silver 15.7. Occurs west of Lake Superior.

HUNTILITE.—Silver Arsenide. C=dark gray to black. Amorphous. When impure called McFarlanite. Huntilite and Animikite occur at Silver Islet, Lake Superior.

ANIMIKITE.—Silver Antimonide.

PYRARGYRITE, RUBY SILVER, DARK RED SILVER ORE.—A silver sulph-antimonite. Rhombohedral, also massive. C=black to dark red. S=dark red. L=splendent metallic to adamantine. Its red streak and reactions for antimony and silver are distinctive. B.B. fuses easily, on charcoal, sulphur and antimony fumes, reddening litmus paper. Silver 59.8, sulphur 17.7, antimony 22.5. Found in Slocan district.

STEPHANITE, BLACK SILVER, BRITTLE SILVER ORE.—A silver sulph-antimonite. Orthorhombic. Often in compound crystals. Also massive. C and S=iron black. H=2-2.5. G=6.27. Silver 68.5, sulphur 16.2, antimony 15.3. B.B. gives odor of sulphur, and dense white fumes, like last.

CERARGYRITE, HORN SILVER.—Silver Chloride. Isometric. Cubical with no distinct cleavage. Also massive, often incrust-

Silver.

ing. H=1.5-2. G=5.3-5.5. C=gray passing into green and blue, looking like horn or wax and cutting like it. L=resinous to adamantine. S=shining. Translucent to nearly opaque. B.B. affords silver easily on charcoal. Fuses in candle flame with acrid fumes. Silver 75.3, chlorine 24.7.

PLATINUM.

NATIVE PLATINUM.—Isometric. Usually in flattened or angular grains or irregular masses. No cleavage. C and S=pale or dark steel gray. L=metallic shining. Malleable. H=4-4.5. G=16-19. Often slightly magnetic. Soluble in heated aqua regia. Platinum is at once distinguished by malleability, specific gravity and extreme infusibility. Found in Canada.

IRIDOSMINE.—A compound of iridium and osmium. Found sparingly in alluvials in Quebec.

PALLADIUM.

NATIVE PALLADIUM.—Isometric. In minute octahedrons. Occurs mostly in grains, sometimes of divergent fibres. C=steel gray to silver white. Malleable. H=4.5-5. G=11.3-12.2.

MERCURY.

NATIVE MERCURY.—In fluid globules scattered through the gangue. C=tin white. Entirely volatile B.B. and dissolves in nitric acid. G=13.58. Native amalgam, see arquerite.

CINNABAR.—Mercury Sulphide. Rhombohedral. Cleavage lateral, highly perfect. Crystals often tabular, or six-sided prisms. Also massive, sometimes in earthy coatings. L=unmetallic, of crystals adamantine; often dull. C=bright red to brownish red and brownish black. S=scarlet. Subtransparent to nearly opaque. H=2-2.5. G=9. Sectile. Distinguished from red oxide of iron and chromate of lead by vaporizing B.B.; from realgar by garlic fumes on charcoal. Chief source of metal. When pure identical with vermillion. Mercury 86.2, sulphur 13.8. Found in British Columbia.

COPPER.

NATIVE COPPER.—Isometric. No cleavage apparent. In plates or masses, and in large or small tree-like and thread-like shapes, consisting usually of a string of crystals. Malleable. H=2.5-3. G=8.8-8.95 B.B. fuses readily and on cooling is covered with black oxide. Dissolves in nitric acid and produces deep azure blue solution on addition of ammonia. Occurs in Lake Superior region.

Copper.

CHALCOCITE, COPPER GLANCE, VITREOUS COPPER ORE.—Copper Sulphide. Orthorhombic. Also in compound crystals like aragonite. Often massive. C and S = blackish lead gray, often tarnished blue or green. S = sometimes shining. H = 2.5-3. G = 5.5-5.8. B.B. gives fumes of sulphur, fuses easily, yields copper globule. Resembles argentite, but is not sectile, and affords different results B.B. Copper 79.8, sulphur 20.2. Occurs frequently in Canada.

CHALCOPYRITE, COPPER PYRITES.—Copper and Iron Sulphide. Tetragonal. Tetrahedral or octahedral crystals. Also massive. C = brass yellow, often tarnished deep yellow and also iridescent. S = unmetallic greenish black, and but little shining. H = 3.5-4. G = 4.2. B.B. fuses to magnetic globule, gives sulphur fumes. Distinguished from gold by crumbling under a knife, and from iron pyrites in its deeper yellow color and in yielding easily to point of knife, instead of striking fire with steel. Copper 34.6, iron 30.5, sulphur 34.9. Common in Canada.

BORNITE, ERUBESCITE, VARIEGATED COPPER PYRITES.—Isometric. In octahedrons and dodecahedrons. Also massive. C = copper red to brassy brown but tarnishes to bluish and reddish shades rapidly on exposure. S = pale grayish black and but slightly shining. Brittle. H = 3. G = 4.4-5.5. B.B. on charcoal fuses to brittle magnetic globule. Dissolves in nitric acid with separation of sulphur. Copper 55.5, iron 16, sulphur 28.5. Fairly common in Canada; also *bournonite*, a sulph-antimonite of copper; and *domeykite*, a copper arsenide.

TETRAHEDRITE, GRAY COPPER, FAHLERZ.—Isometric. In tetrahedral crystals. C = steel gray to blackish. S = nearly same, to brown and cherry red. H = 3-4.5. G = 4.7-5. Frequently found with galena in the Slocan, B. C., and elsewhere in Canada.

ATACAMITE.—Copper Oxichloride. Orthorhombic. In rhombic prisms, etc., also granular massive. C = green to blackish green. L = adamantine to vitreous. S = apple green. Translucent to subtranslucent. H = 3-3.5. G = 3.8. Chlorine 16.64, oxygen 11.25, copper 11.25, water 12.66.

CUPRITE, RED COPPER ORE.—Copper Oxide. Isometric. In regular octahedrons, also massive, sometimes earthy. C = deep red of various shades. S = brownish red. L = adamantine or sub-metallic. Brittle. H = 3.5-4. G = 6. Subtransparent to nearly opaque. B.B. affords copper globule. Dissolves in nitric acid. Differs from cinnabar in not being volatile; from hematite in yielding copper bead. Copper 88.8, oxygen 11.2. Occurs in Canada.

MELACONITE, BLACK COPPER.—Copper Oxide. A black powder, and in dull black masses and botryoidal concretions. Contains 60-70 of copper.

Copper.

CHALCANTHITE, BLUE VITRIOL.—Sulphate of Copper. Triclinic. In oblique rhomboidal prisms. Also as efflorescence or incrustation and stalactitic. C=deep sky blue. S=uncolored. Subtransparent to translucent. L=vitreous. Soluble. Taste nauseous and metallic. H=2-2.5. G=2.21. Sulphuric acid 32.1, copper oxide 31.8, water 36.1.

OLIVENITE.—Hydrous Copper Arsenate. Orthorhombic. In prismatic crystals, also fibrous and granular massive. C and S= olive green to liver and wood brown. Subtransparent to opaque. Brittle. H=3. G=4.13-4.38. B.B. fuses with deflagration, garlic odor, and yields brittle globule which with soda gives metallic copper. Copper oxide 56.15, arsenic pentoxide 40.66, water 3.19.

MALACHITE.—Green Copper Carbonate. Monoclinic, usually in incrustations. Structure finely and firmly fibrous; also earthy. C=light green. S=paler. Usually nearly opaque, crystals translucent. L=of crystals, adamantine inclined to vitreous; but fibrous incrustations silky on cross fracture; earthy varieties dull. H=3.5-4. G=3.7-4. B.B. decrepitates and blackens, colors flame green, and becomes partly a black scoria. With borax, fuses to deep green globule; finally affords a bead of copper. Malachite is not bluish green like chrysocolla, which it resembles; moreover the former has complete solution and effervescence in nitric acid. Copper oxide 71.9, carbon dioxide 19.9, water 8.2. Common in Canada.

AZURITE.—Blue Copper Carbonate. Monoclinic. In modified oblique rhombic prisms, the crystals rather short and stout. Lateral cleavage perfect. Also massive; often earthy. C=deep blue, azure blue. Transparent to nearly opaque. S=bluish. L=vitreous, almost adamantine. Brittle. H=3.5-4.5. G=3.5-3.83. It makes a poor pigment as it is liable to turn green. B.B. same as preceding. Copper oxide 69.2, carbon dioxide 25.6, water 5.2. Occurs in Canada.

DIOPTASE.—Copper Silicate. Rhombohedral. Occurs in six-sided prisms with rhombohedral terminations. C=emerald green. L=vitreous. Transparent to nearly opaque. H=5, G=3.28-3.35. B.B. with soda on charcoal yields copper. Hardness distinctive. Copper oxide 50.4, silica 38.1, water 11.5.

CHRYSOCOLLA.—Hydrous Copper Silicate. Usually as incrustations, botryoidal and massive; in thin seams and stains; no fibrous or granular structure apparent, nor sign of crystallization. C=clear bluish green. L=smoothly shining, also earthy. Translucent to opaque. H=2-4. G=2-2.4. B.B. blackens in reducing flame, gives water without melting. Copper oxide 45.3, silica 34.2, water 20.5. Occurs in Lake Superior region.

LEAD.

NATIVE LEAD is rare, occurs in thin sheets or globules. G=11.35. Found near Kaministiquia, Ontario.

GALENA. GALENITE.—Lead Sulphide. Isometric. Cleavage cubic, eminent and very easily obtained; also coarse or fine granular, rarely fibrous. C and S=lead gray. L=shining metallic. Fragile. H=2.5. G=7.25–7.35. The lead of commerce obtained from galena; used in glazing common stoneware, being ground to impalpable powder and mixed in water with clay; into this the vessel is dipped and then baked. B.B. decrepitates unless heated with caution, fuses, gives sulphur odor, coats the charcoal yellow and yields lead globule. Lead 86.6, sulphur 13.4. Common in Canada.

MINIUM.—Oxide of Lead. Powdery. C=bright red mixed with yellow. G=4.6. Identical with red lead, but for arts is artificially prepared. B.B. affords lead globule in reducing flame.

MENEGHINITE.—A lead sulphantimonite, occurs in Canada.

ANGLESITE. — Lead Sulphate. Orthorhombic. In rhombic prisms and other forms. Also massive, plate-like or granular. C=white or slightly gray or green. L=adamantine, sometimes a little resinous or vitreous. Transparent to nearly opaque. Brittle. H=2.75–3. G=6.35-6.4. Distinguished by specific gravity and by yielding lead on charcoal with soda B.B. Differs from lead carbonate in lustre and in not dissolving with effervescence in acid. B.B. fuses in candle flame. Affords 73 of lead oxide. Usually found as a decomposition-product of galena.

CROCOITE.—Lead Chromate. Monoclinic. In oblique rhombic prisms, massive. C=bright red. S=orange yellow. Translucent. H=2.5–3. G=5.9–6.1. B.B. blackens and fuses, forms a shining slag containing lead globules. Lead oxide 68.9, chromium trioxide 31.1. This is the chrome yellow of painters.

PYROMORPHITE.—Lead Phosphate. Hexagonal. In hexagonal prisms, often in crusts made of crystals with a radiated structure. C=bright green to brown, sometimes fine orange-yellow, owing to presence of lead chromate. S=white. L=more or less resinous. Nearly transparent to subtranslucent. Brittle. H=3.5–4. G=6.8–7.1. B.B. fuses easily, colors flame bluish green, charcoal coating is white at edges and yellow nearer mineral. Has some resemblance to beryl and apatite but differs B.B. and is higher in spec. grav. and is softer. Phosphorus pentoxide 15.7, lead oxide 82.3, chlorine 2.6.

CERUSSITE, WHITE LEAD ORE.—Lead Carbonate. Orthorhombic. In modified right rhombic prisms; often in compound crystals, two or three crossing one another; also in six-sided prisms like aragonite; also massive; rarely fibrous. C=white, grayish, light or dark. L=adamantine. Brittle. H=3–3.5. G=6.46–6.48. B.B. decrepitates, fuses, and with care gives lead globule

Lead.

on charcoal. Effervesces in dilute nitric acid. Distinguished by spec. grav. and by yielding lead when heated. From anglesite it differs in giving lead alone on charcoal B. B., as well as by solubility, effervescence with nitric acid, and less glassy lustre. Associated usually with galena. Cerussite is identical with white lead, but for arts and commerce is artificially prepared. In rare instances cerussite and anglesite are mined for lead. Lead oxide 83.5, carbon dioxide 16.5. Found in Canada.

ZINC.

ZINC is a brittle metal, but admits of being rolled into sheets at 212° F., and is thus extensively used for roofing and other purposes, being less corrosive, harder, and lighter than lead. Used for coating (galvanizing) iron. Also alloyed with copper to make brass, muntz and spelter metals. Obtained chiefly from smithsonite, willemite, calamine, zincite, sphalerite, and franklinite.

SPHALERITE, BLENDE, BLACK JACK.—Zinc Sulphide. Isometric. Perfect dodecahedral cleavage. Also massive, sometimes fibrous. C=wax yellow, brownish yellow to black, sometimes green, red, and white. S=whitish to reddish brown. L=resinous or waxy, and brilliant on a cleavage face; sometimes submetallic. Transparent to subtranslucent. Brittle. H=3.5-4. G=3.9-4.2. Some specimens become electric and give off a yellow light when rubbed with a feather. This ore characterized by lustre, cleavage, and by being almost infusible. Some dark varieties look a little like tin ore, but their cleavage and inferior hardness distinguish them; some clear red crystals, which resemble garnet, are distinguished by the same characters, and also by their difficult fusibility. Zinc 67, sulphur 33. Common in Canada.

ZINCITE, RED ZINC ORE.—Zinc Oxide. Hexagonal. Usually in foliated masses, or in disseminated grains; cleavage nearly like that of mica, but the plates brittle and not so easily separated. C=deep or bright red; by transmitted light, deep yellow. S=orange yellow. L=brilliant, subadamantine. Translucent or subtranslucent. H=4-4.5. G=5.68-5.74. B.B. infusible alone, but yields yellow glass with borax, coating on charcoal yellow while hot, white cold. Zinc 80.3, oxygen 19.7.

GOSLARITE, WHITE VITRIOL.—Zinc Sulphate. Orthorhombic. C=white. L=vitreous. Easily soluble. Taste astringent, metallic and nauseous. Brittle. H=2-2.5. G=2. Extensively used in medicine and dyeing. Prepared to a large extent from zinc blende by decomposition. B.B. coating on charcoal as preceding. Zinc oxide 28.2, sulphur trioxide 27.9, water 43.9.

SMITHSONITE.—Zinc Carbonate. Rhombohedral. Massive or incrusting; reniform and stalactitic. C=impure white, some-

Zinc.

times green or brown. S=uncolored. L=vitreous or pearly. Subtransparent to translucent. Brittle. H=5. G=4.3–4.45. B.B. infusible, electric. Occurs commonly with galena or blende. Distinguished by effervescence with acids. Zinc oxide 64.8, carbon dioxide 35.2.

WILLEMITE.—Zinc Silicate. Rhombohedral. In hexagonal prisms, also massive. C=whitish, greenish yellow, apple green, flesh red, yellowish brown. S=uncolored. Transparent to opaque. Brittle. H=5.5. G=3.9–4.2. B.B. fuses with difficulty to white enamel, more easily on adding soda; yields coating yellow hot, white cold. With cobalt nitrate this coating becomes green after heating in oxidizing flame. Zinc oxide 72.9. silica 27.1.

CALAMINE.—Hydrous Zinc Silicate. Orthorhombic. Rhombic prisms, cleavage perfect, also massive and incrusting, mammilated or stalactitic. C=white or whitish, sometimes bluish, greenish, or brownish. S=uncolored. Transparent to translucent. L=vitreous or subpearly. Brittle. H=4.5–5. G=3.16–3.9. B.B. alone almost infusible. Forms clear glass with borax. Dissolves in heated sulphuric acid, solution gelatinizing on cooling. Pyroelectric. Differs from calcite and aragonite by action with acids; from a salt of lead, or any zeolite, by its infusibility; from chalcedony by its inferior hardness, and its gelatinizing with heated sulphuric acid; from smithsonite by not effervescing with acids, and by the rectangular aspect of its crystals over a drusy surface. Zinc oxide 67.5, silica 25, water 7.5.

FRANKLINITE.—An ore of iron containing zinc and manganese.

CADMIUM.

CADMIUM.—Only two ores known: *Greenockite* and *Eggonite*, but it exists with zinc in sphalerite, smithsonite and calamine.

TIN.

TIN.—Tin is used for coating other metals, especially iron and copper. Also alloyed with copper. Lead plates, coated with tin and rolled thin, get the name tin-foil. With mercury, tin is used for mirrors. The chlorides of tin are used in the precipitation of many colors, and in fixing and changing colors in dyeing and calico printing. "Bronze powder," much employed for ornamental purposes, like in paper hangings, is the bisulphide of tin.

STANNITE, TIN PYRITES.—Tin Sulphide. Commonly massive or in grains. C=steel gray to iron black. S=blackish. Brittle. H=4. G=4.3–4.6. Tin 27, copper 30, iron 13, sulphur 30.

CASSITERITE, TIN ORE.—Tin Oxide. Tetragonal. In square prisms and octahedrons, also massive and in grains. C=brown, *Tin.*

black, yellow. L=of crystals high adamantine. S=pale gray to brownish. Nearly transparent to opaque. H=6-7. G=6.4 to 7.0. Has some resemblance to dark garnets, to black zinc blende, and to some varieties of tourmaline. Distinguished by infusibility and its yielding tin B.B. on charcoal with soda. Harder than blende. It is the chief ore of tin. Stream tin is the gravel-like ore found in alluvials. Tin 78.67, oxygen 21.33.

TITANIUM.

TITANIUM.—Never found native.

RUTILE.—Titanium Oxide. Tetragonal, in prisms of 4, 8 or more sides; often needle-shaped, and penetrating quartz; often twinned and in groupings; sometimes massive. C=reddish brown to nearly red. S=very pale brown. L=submetallic-adamantine. Transparent to opaque. Brittle. H=6-6.5. G=4.18-4.25. Sometimes contains iron and then very nearly black. B.B. alone, unaltered. The peculiar subadamantine lustre of rutile, and brownish red color (in splinters much lighter red) are striking. It differs from tourmaline, idocrase and augite by being unaltered when heated alone B.B.; and from tin ore in not affording tin with soda; from sphene in its crystals. Rutile used for porcelain painting, and coloring artificial teeth. Titanium 61, oxygen 39.

COBALT AND NICKEL.

COBALT AND NICKEL.—Not yet found native.

LINNÆITE.—Cobalt Sulphide, Cobalt and Nickel Sulphide. Isometric. In octahedrons and cubo-octahedrons; also massive. C=pale steel gray, tarnishing copper red. S=blackish gray. H=5.5. G=4.8-5. B.B. on charcoal yields sulphur odor and magnetic globule.

MILLERITE.—Nickel Sulphide. Rhombohedral. Usually in hair-like or needle-like crystallizations, sometimes like wool, often in divergent tufts; also in fibrous crusts. C=brass yellow, inclining to bronze yellow, with often a gray iridescent tarnish. S=bright. Brittle. H=3-3.5. G=5.65. B.B on charcoal fuses to globule; after roasting gives, with borax and salt of phosphorus, a violet bead in oxidizing flame, which in reducing flame becomes gray from reduced metallic nickel. A valuable ore. Nickel 64.4, sulphur 35.6. Found at Sudbury (?)

FOLGERITE.—Massive, plate-like, no crystals. Brittle. C=light bronze yellow to tin white. L=metallic. S=grayish black. H=3 5. In minute grains only, magnetic. Nickel 32.8, iron 31.3, sulphur 35.8. Found at Sudbury, Ont.

BLUEITE, JACK'S TIN.—Massive, no crystals observed. Brittle. C=pale olive gray inclining to bronze. S=black. L=metallic, *Cobalt and Nickel.*

somewhat silky. H=3-3.5. G=4.2. Not magnetic. Nickel 3.7, iron 43, sulphur 53.3. Found at Sudbury, Ont. *Whartonite* is allied to blueite.

SMALTITE, COBALT GLANCE, CHLOANTHITE.—Cobalt or Cobalt Nickel Arsenide, graduating into Nickel Arsenide called Chloanthite. Isometric. In octahedrons, cubes, dodecahedrons and other forms. Cleavage octahedral, somewhat distinct. Also reticulated; often massive. C=tin white, sometimes inclining to steel gray. S=grayish black. Brittle. Fracture granular and uneven. H=5.5-6. G=6.4-6.9. In closed tube affords metallic arsenic; in open tube, a white sublimate of arsenous oxide, and sometimes traces of sulphurous acid. B.B. on charcoal gives garlic odor, fuses to globule which gives reaction for iron, cobalt and nickel. Arsenopyrite is white like smaltite, but yields sulphur as well as arsenic, and in closed tube affords the arsenic sulphides, orpiment and realgar. Cobalt varies from 23.5 to none. Found at Sudbury.

COBALTITE.—Cobalt Sulph-Arsenide. Isometric. Crystals similarly shaped to those of pyrite, but silver white with red tinge, or inclined to steel gray. S=grayish black. Brittle. H=5.5. G=6-6.3. B.B. gives sulphur and garlic odor, and magnetic bead; with borax a cobalt-blue globule. Distinguished from smaltite by yielding sulphur. Cobalt 35.5, arsenic 45.2, sulphur 19.3.

NICCOLITE, COPPER NICKEL, ARSENICAL NICKEL. Hexagonal, usually massive. C=pale copper red. S=pale brownish red. L=metallic. Brittle. H=5-5.5. G=7.35-7.67. B.B. gives garlic odor and fuses to pale globule, which darkens on exposure. Assumes a green coating in nitric acid, and soluble in aqua regia. Distinguished from pyrite and linnæite by its pale reddish shade, and also its arsenical fumes, and from much of latter by not giving a blue color with borax. None of the ores of silver with metallic lustre have a pale color, excepting native silver itself. Nickel 44, arsenic 56. Found at Sudbury.

ASBOLITE, EARTHY COBALT.—Black Cobalt Oxide. Earthy, massive. C=black or blue black. Soluble in hydrochloric acid, giving chlorine fumes. Occurs in an earthy state mixed with oxide of manganese as a bog ore. This ore is purified and made into smalt for arts.

ERYTHRITE, COBALT BLOOM.—Hydrous Cobalt Arsenate. Monoclinic. In oblique crystals, cleavage like mica. Plates flexible in one direction. Also as incrustation; kidney-shaped; star-shaped. C=peach red, crimson, rarely grayish or greenish. S=a little paler, the dry powder lavender blue. L=of plates pearly, earthy varieties without lustre. Transparent to subtranslucent. H=1.5-2. G=2.95. Resembles red antimony but

Cobalt and Nickel.

that species wholly volatilizes B.B. Red copper ore differs in color and in giving blue glass with borax, moreover the color of the copper ore is somewhat sombre. Valuable as cobalt ore when abundant. B.B. garlic odor given off, fuses; a blue glass with borax. Cobalt oxide 37.6, arsenic pentoxide 38.4, water 24.

MORENOSITE (Nickel Vitriol) is found in Canada.

GENTHITE.—A hydrous magnesium-nickel silicate. C=pale apple green.

GARNIERITE.—A variety of genthite occurring in serpentine rocks from New Caledonia, and worked for nickel. Most of the world's supply formerly came from that locality, but Sudbury now outrivals it.

URANIUM.

URANINITE, PITCH BLENDE, CORACITE. Uranium Oxide. Isometric. In octahedrons and related forms, also massive and botryoidal. C=grayish, brownish or velvet black. L=submetallic or dull. S=black, opaque. H=5.5. G=9.2 (when unaltered). Used for painting on porcelain, yielding a fine orange in enamelling fire and a black in baking fire. Obtained mostly in Bohemia. B.B. infusible, gives gray slag with borax. Slowly soluble in nitric acid when powdered. Uranium 81.5, oxygen 13.5, lead 4, water 0.8, iron 0.4.

URACONITE.—A Uranium Sulphate, found in Canada.

TORBERNITE, URANITE, URAN-MICA, CHALCOLITE.—Tetragonal. In square tables, thin plates like mica; plates brittle. C=emerald and grass green. S=a little paler. L=of plates pearly. Transparent to subtranslucent. H=2–2.5. G=3.3–3.6. B.B. fuses to black mass, colors flame green. The micaceous structure, bright green color and square tabular form of crystals are striking. Uranium trioxide 61.2, phosphorus pentoxide 15.1, copper oxide 8.4, water 15.3.

IRON.

NATIVE IRON.—Usually massive with octahedral cleavage. C and S=iron gray. Fracture hackly. Malleable. H=4.5. G=7.3–7.8. Acts strongly on magnet. Native iron is the chief constituent of most meteors.

PYRITE, IRON PYRITES.—Isometric. Usually in cubes, the striae of one face at right angles with those of either adjoining faces. Many other forms also. Massive. C=brass yellow. S=brownish black. L=often splendent metallic. Brittle. H=6–6.5. B.B. gives sulphur odor, yields magnetic globule. Will strike fire with steel. G=4.8–5.2. Distinguished from copper pyrites in being too hard to cut with knife and also in paler color. The ores of silver at all resembling pyrite are steel

Iron.

gray or nearly black, and besides are easily scratched with knife and are quite fusible. Gold is sectile and malleable. Pyrite is the "*mundic*" of miners. Iron 46.7, sulphur 53.3. Common in Canada.

MARCASITE, WHITE IRON PYRITES.—Like the former in constitution, but orthorhombic. C and H=little paler. When in crested shapes called *cockscomb pyrites*. Found in Canada.

PYRRHOTITE, MAGNETIC PYRITES.—Hexagonal. In tabular hexagonal prisms, massive. C=between bronze yellow and copper red. S=dark grayish black. Brittle. H=3.5-4.5. G=4.5-4.65. B.B. like iron pyrites. Its inferior hardness, shade of color, and magnetic quality distinguish it from pyrites and its bronze color from copper pyrites. Iron 60.5, sulphur 39.5. It is the important ore of nickel at Sudbury, being workable when it contains upwards of 2% of nickel. At Rossland it is intimately associated with the gold deposits.

ARSENOPYRITE—MISPICKEL, ARSENICAL IRON PYRITES.—Orthorhombic. In rhombic prisms. Crystals sometimes elongated horizontally; also massive. C=silver white. S=dark grayish black. L=shining. Brittle. H=5.5-6. G=5.67-6.3. Resembles smaltite, but is much harder (giving fire with steel). B.B. gives garlic odor, and magnetic globule. Arsenic 46, iron 34.4, sulphur 19.6. Occurs in Canada.

HEMATITE. SPECULAR IRON ORE.—Rhombohedral. Crystals occasionally thin tabular. Cleavage usually indistinct; often massive granular; sometimes plate-like or micaceous; also earthy. C=dark steel-gray or iron-black. L=when crystallized, splendent. Streak powder cherry-red or reddish-brown. H=of crystals 5.5—6.5. G=4.5—5.3. Sometimes slightly magnetic. Iron, 70, oxygen, 30. Common in Canada. Varieties: *Specular Iron.* L=perfectly metallic. *Micaceous Iron.* Structure foliated. *Red Hematite.* Submetallic, or unmetallic. Brownish red. *Red Ochre.* Soft and earthy, often containing clay. *Red Chalk.* More firm and compact than red ochre and of fine texture. *Jaspery Clay Iron.* A hard impure siliceous clayey ore, having a brownish-red jaspery look and compactness. *Clay Iron Stone.* Same as last, but color and appearance less like jasper. *Martite* is hematite occurring in octahedrons, and derived from oxidation of magnetite. Hematite's red powder and the magnetism which is so easily induced in it by the reducing flame distinguish it from all other ores. Magnetite powder is black.

MENACCANITE, ILMENITE, TITANIC IRON. — Rhombohedral. Often in thin plates or seams in quartz; also in grains; crystals sometimes very large and tabular. C=iron-black. S=submetallic. L=metallic or submetallic. H=5-6. G=4.5-5. Resembles hematite, but streak is black. Acts slightly on magnetic

Iron.

needle. In composition like hematite, but titanium replaces some of the iron. Found in Quebec and elsewhere in Canada.

MAGNETITE, MAGNETIC IRON ORE.—Isometric. Also granular, massive; occasionally in frost-like forms between the sheets of mica. C=iron-black. S=black. H=5.5-6.5. G=5 0-5.1 B.B. infusible. Strongly attracted by magnet and thus differing from preceding. The black streak and strong magnetism distinguish it from franklinite and chromite. Iron 72.4, oxygen 27.6. Very common in Canadian igneous rocks.

FRANKLINITE. Isometric. In octahedral and dodecahedral crystals; also coarse granular, massive. C=iron-black. S=dark reddish-brown. Brittle. H=5.5-6.5. G=4.5-5.1. Usually feebly attracted by magnet. B.B. with soda gives zinc coating to charcoal. Soda bead in oxidizing flame is colored green by the manganese. Resembles magnetic iron, but is more decided black. Streak and B.B. reactions distinctive. Composition same as magnetite, but zinc and manganese replace part of iron.

CHROMITE, CHROMIC IRON.—Isometric. Composition same as magnetite, but chromium replaces part of iron. Octahedrons usually massive, and breaking with rough unpolished surface. C=iron-black, brownish-black. S=dark brown. L=submetallic, often faint. H=5.5. G=4.32-4.6. In small fragments attracted by magnet. The compounds of chromium, extensively used for pigments, are chiefly obtained from chromite. B.B. infusible alone; with borax, a beautiful green bead. Found in Canada.

LIMONITE, BROWN HEMATITE.—Hydrous Sesquioxide of Iron. Usually massive; often smooth botryoidal or stalactitic with compact fibrous structure within; also earthy. C=dark brown and black to ochre yellow. S=yellowish brown to dull yellow. L=when black sometimes submetallic; often dull and earthy; on surface of fracture frequently silky. H=5-5.5. G=3.6-4. B.B. blackens and becomes magnetic. Varieties: *Brown Hematite.* The botryoidal, stalactitic and associated compact ore. *Brown Ochre, Yellow Ochre.* Earthy ochreous varieties of brown or yellow color. *Brown and Yellow Clay Iron Stone.* An impure ore, hard and compact, of brown or yellow color. *Bog Iron Ore.* A loose, brownish black earthy ore occurring in low grounds. Limonite affords water when heated in glass tube. Same composition as hematite, but containing 14% water. Common in Canada.

MELANTERITE, COPPERAS, GREEN VITRIOL.—Sulphate of Iron. Monoclinic, in acute oblique rhombic prisms. Cleavage basal, perfect. Generally powdery or massive. C=greenish to white. L=vitreous. Subtransparent to translucent. Taste astringent and metallic. Brittle. H=2. G=1.83. This species is the result of decomposition, from exposure to atmosphere, of pyrite,

Iron.

marcasite and pyrrhotite. Copperas is much used by tanners and dyers because it affords a black color with tannic acid, the latter being an ingredient in nut galls and many kinds of bark. Similarly employed in manufacture of ink. Also used in making prussian blue. Sulphur trioxide 28.8, iron protoxide 25.9, water, 45.3.

WOLFRAMITE.—Iron-Manganese Tungstate. Monoclinic. Also massive. C=dark grayish black. S=dark reddish brown. L=Submetallic, shining, or dull. H=5-5.5. G=7.1-7.5. The metal tungsten is employed to some extent in making with iron a steel harder than ordinary steel. Soluble tungstates have also some uses in the arts. Found in Canada.

COLUMBITE.—Iron Niobate. Orthorhombic. In rectangular prisms more or less modified; also massive. C=iron black, brownish black often with characteristic iridescence on surface of fracture. S=dark brown, slightly reddish. L=submetallic, shining. Opaque. Brittle. H=5.6. G=5.4-6.5. Infusible. Its dark color, submetallic lustre and slight iridescence, together with its breaking readily into angular fragments will generally distinguish it from the minerals it resembles.

VIVIANITE.—Hydrous Iron Phosphate. Monoclinic. In modified oblique prisms, cleavage in one direction highly perfect. Also radiated, kidney-shaped and globular, or as coatings. C=deep blue to green and white. S=bluish. L=pearly to vitreous. Transparent to translucent. Opaque on exposure. Thin plates flexible. H=1.5-2. G=2.6-2.7. Deep blue color and little hardness, distinctive. B.B. fuses easily to magnetic globule, coloring flame greenish blue; affords water in glass tube. Phosphorus pentoxide 28.3, iron protoxide 43, water 28.7. Abundant at Vaudreuil, Quebec.

CACOXENITE.—A phosphate, near vivianite.

SIDERITE, SPATHIC IRON.—Iron Carbonate. Rhombohedral. Faces often curved. Usually massive with foliated structure somewhat curving; sometimes in globular concretions or implanted globules. C=grayish-white to brown, often dark brownish red. Becomes nearly black on exposure. S=uncolored. L=pearly. Translucent to nearly opaque. H=3-4.5. G=3.7-3.9. B.B. blackens and becomes magnetic, but alone infusible. Dissolves in heated hydrochloric acid with effervescence. Siderite cleaves like calcite and dolomite, but its specific gravity is higher. Iron protoxide 62.1, carbon dioxide 37.9. Common in Canada, often as a gangue in B. C. silver-lead ores. *Humboldtine*, a hydrous iron oxalate, occurs in Canada.

MANGANESE.

MANGANOSITE.—Oxide of Manganese. Isometric. Cleavage ubic. C=emerald green, but brown after exposure. L=vitre-ous. H=5-6. G=5.2.

PYROLUSITE.—Black Oxide of Manganese. Orthorhombic. n small rectangular prisms. Sometimes fibrous and radiated. Often massive and in kidney-shaped coatings. C=iron-black. S=black, non-metallic. H=2-2.5. G=4.8. With a minute portion, affords bead, deep amethystine while hot, red-brown on cooling. Differs from iron ores by violet glass with borax. Manganese 63.2, oxygen 36.8. Occurs in Canada.

PSILOMELANE.—Dioxide of Manganese with water and some aryta or potassa. Massive and botryoidal. C=black or greenish-lack. S=reddish or brownish-black, shining. H=5-6. G=-4.4.

WAD, BOG MANGANESE.—From 30 to 70% dioxide of man-ganese with water and some hematite. Massive, reniform, arthy; in coatings and frost-like markings. C and S=black or rownish-black. L=dull, earthy. H=1-6. G=3-4. Soils the ingers. Like preceding it may be used in bleaching, but too mpure to afford good oxygen. Sometimes used for making mber paint. Occurs in Canada.

MALLARDITE.—Hydrous Manganese Sulphate. Fine fibrous. C=white. Easily soluble.

TRIPHYLITE.—Hydrous Phosphate of Iron, Manganese and Lithium. Orthorhombic. In rhombic crystals. Massive. C=reenish-gray to bluish-gray, but often brownish-black externally rom oxidation of manganese present.

TRIPLITE.—A Phosphate of Manganese and Iron, containing luorine. Orthorhombic, usually massive. Cleavage in three irections. C=blackish-brown. S=yellowish-gray. L=resin-ous. Nearly or quite opaque. H=5-5.5. G=3.4-3.8. B.B. gives violet color to hot borax bead, fuses to magnetic globule. Affords 30% manganese oxide and 8% fluorine.

RHODOCHROSITE. — Manganese Carbonate. Rhombohedral. Like calcite in having three easy cleavages, and in lustre. C=rose-red. H=3.5-4.5. G=3.4-3.7. Manganese oxide 61.4, carbonic acid 38.6. Occurs in Canada.

ALUMINIUM.

ALUMINIUM.—Obtained by different methods from alumina and cryolite, and from corundum and bauxite by electric heating.

CORUNDUM.—Rhombohedral. Usually in six-sided prisms with uneven surfaces and very irregular. Also granular massive. C=blue and grayish-blue (most common), gray, red, yellow, brown and nearly black; often bright. Transparent to trans-lucent. H=9. G=4 when pure. Exceedingly tough when

Aluminium.

compact. B.B. unaltered alone and with soda. In fine powder with cobalt nitrate becomes blue. Aluminium 53.2, oxygen 46.8. Varieties: the name *sapphire* is usually restricted to clear crystals of bright colors, used as gems; while dull-colored crystals and masses are called *corundum*; the granular variety of bluish gray and blackish colors containing much disseminated magnetite (whence its dark color) is termed *emery*. Found in Ontario.

BAUXITE.—Aluminium-Iron Hydrate. In concretionary forms and grains. Alumina 50 to 70. An important source of the metal.

SPINEL.—Isometric. In octahedrals more or less modified. Occurs only in crystals. Cleavage octahedral, but difficult. C= red, passing into blue-green, yellow, brown and black. The red shades are often transparent and bright, the dark usually opaque. L=vitreous. H=8. G=3.5–4.1. Alumina 72, magnesia 28. The aluminium is sometimes replaced in part by iron, and the magnesium often in part by iron, calcium, manganese and zinc. Infusible, insoluble in acids. Occurs in Canada.

CHRYSOBERYL.— Orthorhombic, also in compound crystals; crystals sometimes thick, often tabular. C=bright green, from light to emerald, and brown; rarely raspberry red by transmitted light. S=uncolored. L=vitreous. Transparent to translucent. H=8.5. G=3.7–3.86. B.B. infusible and unaltered. Alumina 80.2, beryllium oxide 19.8.

CRYOLITE, ICE STONE.—Aluminium-Sodium Fluoride. Monoclinic; rectangular cleavages; usually massive. C=white. Translucent. H=2.5–3. G=2.9–3.1. Fusible in candle flame and thus easily distinguished. Used in making soda, porcelain-like glass. A source of the metal. Aluminium 13, sodium 32.8, fluorine 54.2.

ALUNOGEN.—Hydrous Aluminium Sulphate. In silky efflorescences and crusts of white color. Taste of alum. H=1.5–2. G=1.6–1.8. Sulphur trioxide 36, alumina 15.4, water 48.6.

KALINITE, or Common Alum, is a product of the foregoing. Occurs in Canada.

ALUNITE, ALUM STONE.—Rhombohedral with perfect basal cleavage. Also massive. C=white, grayish or reddish. L=of crystals vitreous or a little pearly on basal plane. Transparent to translucent. H=4. G=2.6. B.B. decrepitates, infusible, gives reaction for sulphur. Distinguished by infusibility and complete solubility in sulphuric acid without forming jelly. Sulphur trioxide 38.5, alumina 37.1, potash 11.4, and water 13.

AMBLYGONITE. — Lithium-Aluminium Phosphate. Triclinic, with cleavages unequal in two directions. L=vitreous to pearly and greasy. C=pale green or sea green to white. Translucent

Aluminium.

to subtransparent. H=6. G=3–3.1 B.B. fuses very easily with bubbling, coloring flame yellowish red to carmine, with traces of green.

LAZULITE.—Monoclinic in crystals, also massive. C=azure blue. H=5–6. G=3. B.B. whitens, yields water in closed tube. Found in Canada. Phosphorus pentoxide 46.8, alumina 34, magnesia 13.2, and water 6.

TURQUOIS.—Massive, kidney-shaped, without cleavage. C=bluish green. L=somewhat waxy. H=6. G=2.6–2.8. Soluble in hydrochloric acid. B.B. infusible, but becomes brown, colors flame green. Differs from bluish green feldspar in infusibility and reactions for phosphorus. Phosphorus pentoxide 22.6, alumina 46.9, water 20.5. Used as gem.

WAVELLITE.—Orthorhombic, usually in small hemispheres $\frac{1}{3}$ or $\frac{1}{2}$ inch across, finely radiated within; when broken off they leave a star-like circle on the rock. Sometimes in rhombic crystals, also stalactitic. C=white, green or yellowish and brownish, with somewhat pearly or resinous lustre. Sometimes gray or black. Translucent. H=3.5–4. G=2.3–2.34. B.B. becomes dark reddish brown. Distinguished from zeolites, some of which it resembles, by giving phosphorus reaction, and also by dissolving in acids without gelatinizing. Phosphorus pentoxide 35.2, alumina 38.1, water 26.7.

CERIUM, YTTRIUM, ERBIUM, LANTHANUM, DIDYMIUM.

YTTROCERITE.—B.B. alone infusible. Massive. C=violet blue (somewhat resembling purple fluorite); also reddish brown. L=glistening. Opaque. H=4–5, G=3.4–3.5. Fluorine=25.1, lime 47.6, cerium protoxide 18.2, yttria 9.1.

SAMARSKITE.—Orthorhombic. Usually massive, without cleavage. C=velvet black. L=shining submetallic. S=dark reddish brown. Opaque. H=5.5–6. G=5.6–5.8. Composed of niobic and tantalic pentoxide, sesquioxides of yttrium, cerium, didymium, lanthanum, iron, and oxide of uranium.

MONAZITE.—Monoclinic. Perfect and brilliant basal cleavage. Observed only in imbedded crystals. C=brown, brownish red. Subtransparent to nearly opaque. L=vitreous, inclining to resinous. Brittle. H=5. G=4.8–5.1. The brilliant easy transverse cleavage distinguishes monazite from sphene. B.B. colors flame green when moistened with sulphuric acid. Difficultly soluble in acids. Has now a high commercial value on account of its use in Auer and Welsbach lights. The best light is obtained from a mixture of thorium oxide $\frac{2}{3}$, yttrium $\frac{1}{3}$. A phosphate of cerium, lanthanum, yttrium, didymium and thorium.

MAGNESIUM.

PERICLASITE.—Magnesium Oxide. Isometric, in small imbedded crystals with cubic cleavage. C=grayish to dark green. H=6. G=3.7. B.B. infusible. Soluble in acids with effervescence. Magnesium 60, oxygen 40.

BRUCITE.—Magnesium Hydrate. Rhombohedral. In hexagonal prisms and plates, thin foliated, thin plates easily separated; also fibrous. Translucent. Flexible, but not elastic. L=pearly. C=white, often grayish or greenish. H=2.5. G=2.35–2.45. B.B. infusible, but becoming opaque and alkaline. Soluble in hydrochloric acid without effervescence. It resembles talc and gypsum, but is soluble in acids. Magnesia 69, water 31.

EPSOMITE, EPSOM SALT.—Magnesium Sulphate. Orthorhombic. Cleavage perfect. Usually in fibrous crusts or botryoidal masses. C=white. L=vitreous to earthy. Very soluble. Taste, salty-bitter. Liquefies in its water of crystallization when heated. Gives much water, acid in reaction, in closed tube. The fine needle-shaped crystalline grains of Epsom salt, as it appears in shops, distinguish it from Glauber salt, which occurs usually in thick crystals. Occurs as efflorescence in mine galleries and elsewhere. Sulphur trioxide 32.5, magnesia 16.3, water 51.2. Occurs in Canada.

BORACITE.—Magnesium Borate. Isometric. Usually in small cubes. Cleavage only in traces. Also massive. In crystals, translucent. C=white or grayish, yellowish or greenish. L=vitreous. H=of crystals 7, when massive softer. G=2.97. Electric when heated. Distinguished readily by form, high hardness, and pyro-electric properties. Boron trioxide 62, magnesia 31, chlorine 7.

MAGNESITE.—Magnesium Carbonate. Rhombohedral. Cleavage same, perfect. Often massive, either granular or compact and porcelain-like, in tuberose forms; also fibrous. C=white, yellowish or grayish white, brown. L=vitreous, fibrous varieties often silky. Transparent to opaque. H=3–4.5. G=3. Resembles some calcite and dolomite, but from a concentrated solution no calcium sulphate is precipitated on adding sulphuric acid. The fibrous variety is distinguished from most other fibrous minerals by effervescence in hot acid, which shows it to be a carbonate. Used in manufacture of Epsom salts. B.B. infusible, and after ignition an alkaline reaction. Magnesia 47.6, carbon dioxide 52.4.

CALCIUM.

FLUORITE, FLUOR SPAR.—Calcium Fluoride. Isometric, cubes most common. Cleavage octahedral, perfect. Rarely fibrous, often compact, coarse or fine granular. C=usually bright; white, or some shade of light green, purple, or clear yellow most

Calcium.

common ; rarely rose red and sky blue ; colors of massive varieties often banded. Transparent, translucent or subtranslucent. H=4. G=3-3.25. Brittle. Phosphoresces when heated gently (as seen in dark), affording light of different colors, as emerald, purple, blue, rose red, pink, orange. B.B. decrepitates and ultimately fuses to an enamel, having alkaline reaction. Powdered and treated with sulphuric acid, hydrofluoric acid is given off, which corrodes glass, hence its use in etching glass, seals, or any siliceous stone. In its bright colors, fluorite resembles some of the gems, but its softness and easy octahedral cleavage when crystallized distinguish it. Its strong phosphorescence is striking. Used as a flux in reducing copper and other ores. Fluorine 48.7, calcium 51.3. Found in Canada ; with silver ores in Port Arthur region.

GYPSUM.—Hydrous Calcium Sulphate. Monoclinic. Commonly in arrow-head crystals. Easy cleavage, affording thin, pearly, flexible plates. Also in plate-like masses ; fibrous, with satin lustre ; in star-shaped or radiating forms consisting of narrow plates ; also granular and compact. When crystallized usually transparent or nearly so ; the massive, translucent to opaque. L=pearly. C=white, gray, yellow, reddish, brownish, and even black. H=1.5-2. G=2.33. The plates bend in one direction and are brittle in another. Varieties :—

Selenite.—Transparent plates or crystals. *Satin Spar.* White and delicately fibrous, used for trinkets. *Alabaster.* White or light-colored compact gypsum having a very fine grain. Cuts into vases, statues, ornaments, etc. Foliated gypsum resembles some varieties of heulandite, stilbite, talc and mica ; the fibrous looks like fibrous carbonate of lime, asbestus, and some of the fibrous zeolites ; but gypsum in all varieties is readily distinguished by softness, by becoming B.B. opaque white through loss of water without fusion, by not effervescing or gelatinizing with acids. Moreover, by adding a little water to powder obtained by heating, the water is taken up and the whole becomes solid. Gypsum when burnt and powdered is plaster of Paris. Used for casts, models, and giving hard finish for walls. Ground gypsum used as fertilizer (land plaster). Found near Paris, Ont., and elsewhere. Lime 32.6, sulphur trioxide 46.5, water 20.9.

ANHYDRITE.—Anhydrous Calcium Sulphate. Orthorhombic. In rectangular and rhombic prisms. Cleaves easily in three directions into square blocks. Also fibrous and in layers, often contorted ; coarse and fine granular, and compact. C=white, or tinged with gray, red or blue. L=more or less pearly. Transparent to subtranslucent. H=3-3.5. G=2.95-2.97. Its square forms of crystallization and its breaking into square

Calcium.

blocks are good distinctive features. Lime 41.2, sulphur trioxide 58.8. Found in Canada.

ULEXITE.—Calcium-Sodium Borate. In interwoven fibres, or hair-like crystals, making small rounded masses. Tasteless. H=1. G=1.65. L=silky. C=white to gray. Hydrous. Valuable as source of borax. B.B. fuses very easily. Wetted with sulphuric acid the flame is momentarily deep green.

SCHEELITE.—Calcium Tungstate. Tetragonal, also massive. L=vitreous. C=white, pale yellowish, brownish, greenish, reddish. Transparent to translucent. H=4.5-5. G=5.9-6.1. Unlike calcite, and other minerals resembling it, in its high specific gravity and non-effervescence with acids.

APATITE.—Calcium Phosphate. Hexagonal. Usually in hexagonal prisms. Cleavage imperfect. Occasionally massive, sometimes mammillary with a compact fibrous structure. C=usually greenish, often yellowish green, bluish green, and grayish green, sometimes yellow, blue, reddish, brownish, colorless. L=vitreous to subresinous. Transparent to opaque. H=5. G=3.18-3.25. Brittle. When chlorine is present in place of fluorine it is called chlor-apatite, and when the reverse, fluor-apatite. B.B. infusible except on edges. Dissolves slowly in nitric acid without effervescence. Massive apatite is called *Phosphorite.* Distinguished from beryl by inferior hardness (easily scratched by knife); from calcite by no effervescence with acids; from pyromorphite by difficult fusibility and by giving B.B. no metallic reaction. Useful as fertilizer. Phosphorus pentoxide 40.92, lime 53.80, chlorine (or fluorine) 6.82. Extensive in Ottawa valley.

CALCITE, CALC SPAR.—Calcium Carbonate. Rhombohedral. Cleavage easy. Often fibrous. L=silky, sometimes plate-like, often coarse or fine granular and compact. When transparent, colorless. C=topaz-yellow, and rarely rose or violet; other crystalline varieties white, gray, reddish, yellowish, rarely deep red, often mottled; when massive uncrystalline, of various dull shades, chalk-white, grayish-white, gray, ochre-yellow, red, brown and black. L=vitreous; of the finely fibrous, silky; of uncrystalline, dull, often earthy. H=3. G=of pure crystals 2.7. Distinguished by being scratched easily by knife, strong effervescence in dilute acids, complete infusibility. Less hard than aragonite, unlike it also in having distinct cleavage. B.B. colors flame reddish, gives alkaline reaction. Lime 56, carbon dioxide 44. Common in Canada. Limestone is burnt to make quicklime.

Principal varieties: *Iceland Spar.* Transparent crystalline calcite. *Dog-tooth Spar.* *Satin Spar.* Finely fibrous, with satin lustre, usually in veins. *Limestone.* A general name for massive

Calcium.

calcite as well as for massive dolomite. *Granular Limestone.* Has glistening lustre, owing to its consisting of crystalline grains; the grains show the cleavages of calcite crystals, hence called crystalline limestone. The better kinds, valuable in the arts, are called marble; the coarser, architectural marble; the finer white, statuary marble. *Compact Limestone.* Dull in lustre unless polished, and not distinctly granular in texture. *Chalk.* White and earthy; without lustre; soft enough to mark a board. *Hydraulic Limestone.* An impure limestone affording, on burning, a quicklime that makes a cement which sets under water. *Oölite.* Compact, consisting of small round concretionary grains. *Rock Milk.* White and earthy like chalk, but still softer. Deposited from waters containing lime in solution. *Stalactite, Stalagmite, Travertine.* Deposits from calcareous waters.

ARAGONITE.—Composition like Calcite. Orthorhombic. In rhombic prisms; usually in compound crystals having form of hexagonal prisms, with uneven or striated sides; or in star-like forms consisting of two or three flat crystals crossing one another. Cleavage not very distinct. Also globular and like coral; also fibrous seams in rocks. C=white or with light tinges of gray, yellow, green and violet. L=vitreous. Transparent to translucent. H=3.5-4, G=2.93. B.B. falls to powder readily when heated, otherwise acts same as calcite. Differs in cleavage from calcite. Found in Canada.

DOLOMITE, MAGNESIAN LIMESTONE.—Calcium-Magnesium Carbonate. Rhombohedral. Cleavage perfect. Faces of rhombohedrons sometimes curved. Often granular and massive, constituting extensive beds. C=white, or tinged with yellow, red, green, brown, and sometimes black. L=vitreous or pearly. Nearly transparent to translucent. Brittle. H=3.5-4; G=2.8-2.9. Some iron or manganese often present replacing part of the magnesium or calcium. Iron-bearing varieties become brown on exposure, and the manganese-bearing black. Chemical analysis often required to distinguish dolomite from calcite. Calcium carbonate 54.35; magnesium carbonate, 45.65. Found in Canada. Used for making quick-lime.

BARIUM.

BARITE, BARYTES, HEAVY SPAR.—Barium Sulphate. Orthorhombic. Cleavage perfect. Massive varieties often in coarse layers; also columnar, fibrous, granular and compact. C=white, sometimes tinged yellow, red, brown, blue, or dark brown. L=vitreous, sometimes pearly. Transparent or translucent. H=2.5-3.5; G=4.3-4.7. Strontium and calcium are sometimes present, replacing a little barium. B.B. fuses to bead having alkaline reaction, imparts green color to flame. Gives sulphur reac-

Barium.

tion. Distinguished by spec. grav., inaction of acids and hardness. Ground barite used to adulterate white lead to make different whites; also to weight paper. Baryta 65.7; sulphur trioxide, 34.3. Found in Canada.

WITHERITE.—Barium Carbonate. Orthorhombic. Cleavage imperfect. Also in globular or botryoidal forms; often massive, and either fibrous or granular. C=yellowish or grayish white to white when in crystals. Translucent to transparent. L=a little resinous when massive. H=3-4; G=4.3-4.35. Brittle. B.B. decrepitates, fuses easily, tingeing flame green to translucent globule which becomes opaque on cooling and gives alkaline reaction. Effervesces in hydrochloric acid. Distinguished by spec. grav. and fusibility from calcite and aragonite; by its action with acids from allied minerals that are not carbonates; by yielding no metal, from cerussite; and by tingeing flame green, from strontianite. Used in manufacture of plate glass, and in France for making beet sugar. Baryta, 77.7; carbon dioxide, 22.3. Found in Canada.

STRONTIUM.

CELESTITE.—Strontium Sulphate. Orthorhombic. Crystals rhombic prisms or tabular, often long and slender. Cleavage distinct. Also columnar, or fibrous, rarely granular. C=white, slightly bluish, sometimes clear white or reddish. L=vitreous or a little pearly. Transparent to translucent. H=3-3.5; G=3.9-4. Brittle. B.B. decrepitates and fuses, tingeing flame bright red, to a milk-white globule, giving alkaline reaction. Sulphur reaction. Distinguished from barite by the bright red color of flame B.B. and its less specific gravity; and from the carbonates by not effervescing with acids. Used in arts for making nitrate of strontia for red fireworks. Strontia, 56.4; sulphur trioxide, 43.6. Found in Canada.

STRONTIANITE.—Strontium Carbonate. Orthorhombic. Cleavage perfect. Also fibrous and granular; sometimes in globular shapes, radiated within. C=pale greenish white; also white, gray and yellowish brown. L=vitreous, or somewhat resinous. Transparent to translucent. H=3.5-4. G=3.6. Brittle. Some strontium often replaced by calcium. B.B. swells, throws out little sprouts, but does not fuse. Colors flame bright red. Effervesces in cold dilute acid. Its effervescence with acids distinguish it from minerals that are not carbonates; the flame color B.B. from witherite and other carbonates; calcium salts also give red color to flame, but the shade is yellowish and less brilliant. Strontianite employed in preparation of strontium nitrate. Strontia 70.3, carbon dioxide 29.7.

POTASSIUM.

SYLVITE.—Potassium Chloride. Isometric. Crystals often cubes with octahedral planes. C=white or colorless. L=vitreous. Tastes salt. H=2. G=1.9-2. Potassium 52.5, chlorine 47.5.

NITRE.—Potassium Nitrate. Orthorhombic. In modified right rhombic prisms. Usually in thin white crusts, and in needle shaped crystals. Tastes salt and cooling. H=2. G=1.97. Distinguished by taste and vivid action on live coal. Potash 46.6, nitrogen pentoxide 53.4. Uses: gunpowder, as a fertilizer, and in manufacture of sulphuric and nitric acid.

SODIUM.

HALITE, ROCK SALT, COMMON SALT.—Sodium Chloride. Isometric. In cubes and related forms. Cleavage perfect. C=white or grayish, sometimes rose-red, yellow and of amethystine tints. H=2. G=2.26. Distinguished by solubility and taste. Sodium 39.3, chlorine 60.7. Found in Canada.

MIRABILITE, GLAUBER SALT.—Hydrous Sodium Sulphate. Monoclinic. In efflorescent crusts of white or yellowish white color; also in many mineral waters. Tastes cool, then feebly salt and bitter. Distinguished from Epsom salt by its coarse crystals, and the yellow color given to blowpipe flame. Soda 19.3, sulphur trioxide 24.8, water 55.9.

BORAX, TINKAL.—Hydrous Sodium Biborate. Monoclinic. Cleavage perfect. Crystals white or colorless, often transparent. L=vitreous. H=2-2.5. G=1.7. Taste sweetish alkaline. B.B. swells to many times its bulk, becomes opaque white, finally fuses to glassy globule. Boron trioxide 36.6, soda 16.2, water 47.2.

NITRATINE.—Sodium Nitrate. Rhombohedral. Also in crusts or efflorescences of white, grayish and brownish colors. Taste cooling. Soluble and very deliquescent. Burns vividly on charcoal, with yellow light. Resembles nitre but deliquesces. Soda 36.5, nitrogen pentoxide 63.5. Uses same as nitre.

NATRON, CARBONATE OF SODA.—Hydrous Sodium Carbonate. Monoclinic. Generally in white efflorescent crusts, sometimes yellowish or grayish. Tastes alkaline. Effloresces on exposure, surface becoming white and powdery. Carbon dioxide 26.7, soda 18.8, water 54.5. Used in manufacture of soap and glass.

SILICA.

QUARTZ.—Rhombohedral. Usually in six-sided prisms terminating in six-sided pyramids. No cleavage apparent, but sometimes obtained by heating and plunging the crystal into cold

Silica.

water. Sometimes in coarse radiated forms; also coarse and fine granular (like sandstone); also compact, flint like, either amorphous or presenting stalactitic and mammillary shapes. Often colorless, sometimes topaz yellow, amethystine, rose, smoky or other tints; also of various shades of yellow, red, green, blue, and brown to black; in some varieties the colors in bands, stripes or clouds Of all degrees of transparency to opaque. L=vitreous; of crystals splendent; of some massive forms dull, often waxy. H=7. G=2.5–2.8; pure crystals 2.65. The common mineral impurities are chlorite, rutile, asbestus, actinolite, tourmaline, hematite, limonite. Hematite (red iron oxide) is the usual red coloring matter; limonite (mostly yellow ochre) the yellow and brownish yellow; chlorite and actinolite give a green color; an oxide or silicate of nickel an apple green tint; manganese an amethystine; carbonaceous matters, such as color marsh waters, smoke-brown shades. Quartz crystals often contain liquid in cavities, either water, petroleum, or naphtha-like material, or liquid carbonic acid. Chalcedony usually has more or less of disseminated opal; and clear quartz is sometimes spangled with scales of mica or rendered opaline by means of asbestus. Flint or chert often colored by mixture with material of the enclosing rock. Quartz is exceedingly varied in color and form, but may be distinguished by absence of true cleavage, hardness, infusibility B.B., insolubility with either of common acids, its effervescence when heated B.B. with soda, and (when crystallized) by form. Silicon 46.67, oxygen 53.33.

Vitreous Varieties are:—*Rock Crystal*=Pure clear quartz. G=2.65. *Amethystine*=Purple or bluish violet, often of great beauty. If finely and uniformly colored, highly esteemed as a gem. G=2.65. *Rose Quartz*=Pink; seldom occurs in crystals, generally in masses, much fractured and imperfectly transparent. Color fades on exposure. *False Topaz* (*Citrine*)=Light yellow, clear crystals. Absence of cleavage distinguishes it from true topaz. *Smoky Quartz*=Color sometimes so dark as to be nearly black, and opaque except in splinters. It is the cairngorm stone. *Milky Quartz*=Nearly opaque; massive and of common occurrence. Has often a greasy lustre and called *greasy quartz*. *Prase*=Leek-green, massive; resembling some shades of beryl in tint, but has no cleavage and is infusible. *Aventurine Quartz*=Common quartz spangled with scales of golden yellow mica. Usually translucent, and gray brown, or reddish brown. *Ferruginous Quartz*=Opaque and either yellow, brownish-yellow or red from presence of iron oxide.

Chalcedonic Varieties are:—*Chalcedony*=Translucent. Massive, with glistening and somewhat waxy lustre; usually of pale

Silica.

rayish, bluish, whitish, or light brownish shade. Often occurs ining or filling cavities in amygdaloidal and other rocks. *Chrysoprase*=Apple-green chalcedony, colored by nickel. *Carnelian*=Bright red chalcedony. Of clear rich tint, cut and polished and much used in cheaper grades of jewellery, and for seals and beads. *Sard*=A deep brownish-red chalcedony, of blood-red color by transmitted light. *Agate*=A variegated chalcedony. The colors distributed in clouds, spots or concentric bands, which take straight, circular or zig-zag forms, the last mentioned being called "Fortification Agate." These bands are the edges of chalcedony layers, the layers being the successive deposits during formation process. *Mocha Stone* or *Moss Agate* is a brownish agate consisting of chalcedony with frost-work or moss-like markings of an opaque yellowish brown color. Agates are sometimes artificially colored blue and other shades. *Onyx*=A kind of agate having colors arranged in flat horizontal layers; the colors are usually light clear brown and an opaque white. Onyx used for cameos, the figure being carved out of one layer and standing in relief on another. *Cat's-eye*=Greenish gray translucent chalcedony, having a peculiar interior reflection (whence the name) when cut with a spheroidal surface; effect due to filaments of asbestus. *Flint, Hornstone, Chert*=Massive, compact silica of dark shades of smoky gray, brown, or even black; feebly translucent; break with sharp cutting edges and conchoidal surface. Flint occurs as nodules in chalk. Hornstone is more brittle than flint; chert is an impure hornstone. *Plasma*=A faintly translucent variety of chalcedony, approaching jasper, of green color, sprinkled with yellow and whitish dots.

Jaspery Varieties are :—*Jasper*=Dull opaque red; yellow or brownish siliceous rock. It also occurs of green and other shades. *Riband Jasper*=A jasper consisting of broad stripes of green, yellow, gray, red or brown. *Egyptian Jasper* has these colors in irregular concentric zones, and occurs in nodules which are often cut across and polished. *Ruin Jasper*=With markings resembling ruins, of some brownish or yellowish shade on a darker ground. *Porcelain Jasper*=Baked clay, differing from jasper in being fusible B.B. Red felsyte resembles red jasper, but felsyte is fusible. Jasper admits of high polish, and is a handsome stone for inlaid work; very little used as a gem. *Bloodstone* or *Heliotrope*=Deep green, slightly translucent, containing red spots (colored by iron). *Lydian Stone, Touchstone*=Velvet black and opaque, and on account of hardness and color used for trying the purity of the precious metals. *Granular Quartz*=A rock consisting of compactly cemented quartz grains. *Silicified Wood*=Petrified wood, consisting of quartz, quartz having replaced original wood.

Silica.

OPAL.—Same composition as quartz. Compact and amorphous, also kidney shaped and stalactitic; earthy. C=white, yellow, red, brown, green, blue and gray. Finest varieties exhibit from within, on being turned, a rich play of colors of delicate shades. L=waxy to subvitreous. H=5.5-6.5. G=1.9-2.3. Soluble in strong alkaline solution, especially if heated. Also differs from quartz in lustre, which is more waxy than chalcedony; also in total absence of crystalline texture. Infusible B. B. is the best character for distinguishing opal from pitchstone, pearlstone and other resembling species. *Tripolite*, *Diatomaceous* or *Infusorial Earth*—A white or grayish white variety; earthy, massive, slaty. Forms beds and often occurs below peat. Sold as a polishing powder under the name of electro-silicon. Formerly took the place of wood-pulp as the absorbent in manufacturing dynamite.

SILICATES—I. ANHYDROUS BISILICATES.

ENSTATITE, BRONZITE.—A Magnesium Silicate. Orthorhombic. Cleavage easy. Usually of fibrous appearance on cleavage surface. Also massive and in layers. C=grayish, yellowish or greenish white, or brown. L=pearly. H=5.5. G=3.1-3.3. B.B. infusible. Insoluble. Bronzite has a portion of the magnesium replaced by iron. Resembles hornblende and pyroxene, but infusible and orthorhombic. Silica 60, magnesia 40.

HYPERSTHENE.—Near bronzite in form and composition, but containing more iron and B.B. fuses; on charcoal becomes magnetic.

WOLLASTONITE, TABULAR SPAR.—A Calcium Silicate. Monoclinic. Rarely in oblique flattened prisms, usually massive. Cleaves easily in one direction, affording a lined or indistinctly columnar surface. Usually white, but sometimes tinged with yellow, red or brown. Translucent or rarely subtransparent. L=vitreous, pearly. Brittle. H=4.5-5. G=2.85-2.9. B.B. fuses with difficulty to subtransparent, colorless glass; in powder decomposed by hydrochloric acid, solution gelatinizes on evaporation; often effervesces when heated with acid from presence of calcite. Differs from asbestus and tremolite in more vitreous appearance and fracture, and by gelatinizing; from the zeolites by the absence of water which all zeolites give in closed tube; from feldspar in fibrous appearance of cleavage surface and action of acids. Silica 52, lime 48. Occurs in Canada.

PYROXENE, AUGITE.—Monoclinic. Usually in thick and stout prisms. Massive varieties are of coarse lamellar structure; also fibrous, fibres often fine and hair-like. Also granular, usually coarse granular and friable; grains usually angular

Anhydrous Bisilicates.

sometimes round. Also compact massive. C=green of various shades, dark and light, passing through blue shades but not yellow. L=vitreous, inclining to resinous or pearly, the latter in fibrous varieties. Transparent to opaque. H=5-6. G=3.2-3.5. B.B. fuses and the iron-bearing varieties are most fusible. Insoluble in acids. The crystalline form and ready cleavage in two planes nearly at right angles to each other are the best distinction. Silica 55, lime 23.5, magnesia 16.5, iron protoxide 4.5, manganese oxide 0.5. Common in Canada. Varieties are:—*Malacolite, White Augite*=A calcium-magnesium pyroxene; includes white or grayish white crystals or crystalline masses. *Diopside*=Same composition, in greenish white, or grayish green crystals; and masses cleaving with a bright smooth surface. *Sahlite*, containing iron in addition, like last, but color dingy. *Asbestus*=Fibrous varieties of both pyroxene and hornblende, but pyroxene is rarely asbestiform. *Augite*=The black and greenish black crystals, which contain a larger amount of iron or iron and magnesium. G=3.3. It is the common pyroxene of eruptive rocks. *Diallage*=A thin foliated variety often occurring imbedded in serpentine and some other rocks. Differs from bronzite and hypersthene in crystallization, and greater fusibility.

RHODONITE, MANGANESE SPAR, FOWLERITE.—A Manganese Silicate. Triclinic, but nearly of same form as pyroxene; also massive. C=reddish, commonly deep flesh-red, also brownish, greenish or yellowish when impure; very often black on surface. S=uncolored. L=vitreous. Transparent to opaque. Becomes black on exposure. H=5.5-6.5. G=3.4-3.7. Commonly contains a little iron and lime replacing manganese. Becomes dark brown when heated; with borax in oxidizing flame gives deep violet color to bead while hot, red brown cold. Resembles somewhat a flesh-red feldspar, but has greater spec. grav. and differs in blackening on exposure, and in the glass with borax. Used in making a violet colored glass, and also for a colored glazing on stoneware. Takes a high polish for inlaid work. Silica 45.9, manganese oxide 54.1.

SPODUMENE.—Monoclinic. Cleavage easy. Surface of cleavage pearly. C=grayish or greenish; pale amethystine; rarely emerald. Translucent to subtranslucent. H=6.5-7. G=3.15-3.19. B.B. becomes white and opaque, fuses, swells up, and gives purple red flame. Unaffected by acids. Resembles feldspar and scapolite, but has higher specific gravity and more pearly lustre, and gives rhombic prisms by easy cleavage. Silica 64.9, alumina 27.6, lithia 7.5. Occurs in Canada.

PETALITE.—Monoclinic. In imperfectly cleavable masses. C=white, gray, pale reddish, greenish. L=vitreous to subpearly. Translucent. H=6-6.5. G=2.5. B.B. phosphoresces when

Anhydrous Bisilicates.

gently heated; fuses with difficulty on edges; gives purple flame. Differs from spodumene in lustre, specific gravity and greater fusibility. Silica 77.9, alumina 17.7, lithia 3.1, soda 1.3. Occurs in Canada.

AMPHIBOLE, HORNBLENDE.—Monoclinic. Cleavage perfect. Often in long, slender, flat, rhombic prisms, breaking easily transversely. Frequently columnar and blade-like; long. pearly or silky fibrous; fibres coarse or fine; also in layers; also granular, either coarse or fine. C=white to black, passing through bluish green, grayish green, green and brownish green shades. L=vitreous, with cleavage face inclining to pearly; fibrous varieties silky. Nearly transparent to opaque. H=5–6. G=2.9–3.4. B.B. similar to pyroxene; fusibility easiest in black varieties. Distinguished from pyroxene by very ready cleavage.

Light-colored varieties. *Tremolite, Grammatite.* White and grayish, in blade-like crystallizations and long crystals penetrating the gangue, or aggregated in coarse columnar forms. Sometimes nearly transparent. Silica 57.7, magnesia 28.85, lime 13.45. *Actinolite.* A calcium-magnesium-iron hornblende. Bright green. Fibrous. Columnar and prismatic, also massive. The varieties include glassy, radiated and fibrous actinolite. *Asbestus.* In slender fibres easily separable and sometimes like flax. Green or white. The asbestus of commerce is usually fibrous serpentine, which contains water, and is thus distinguishable from true asbestus. *Nephrite.* A tough compact variety, related to tremolite. C=light green or blue. Breaks with splintery fracture and glistening lustre. H=6–6.5. G=3. It is a magnesium-calcium hornblende. Made by the Chinese into images.

Dark-colored variety. *Hornblende.* Black and greenish black crystals and massive; often in slender crystallizations like actinolite; also short and stout. Color due to iron. Tough, especially when massive. Silica 48.8, alumina 7.5, magnesia 13.6, lime 10.2, iron protoxide 18.8, manganese oxide 1.1. Common in syenite, diorite and hornblende schist.

BERYL, EMERALD.—Hexagonal. In hexagonal prisms. Cleavage basal, not very distinct. Rarely massive. C=green, pale blue and yellow, emerald. S=uncolored. L=vitreous, sometimes resinous. Transparent to subtranslucent. Brittle. H=7.5–8. G=2.67–2.75. B.B. becomes clouded, but infusible. The emerald is the rich green variety, owing its color to chromium. Hardness distinguishes beryl from apatite; and this character and its crystal form, from green tourmaline. The composition is complex, principal constituents being silica 62.1, alumina 18.9, and beryllium oxide 16.3. Occurs in Canada.

II.—Anhydrous Unisilicates.

Chrysolite, Olivine, Peridot.—Orthorhombic. In rectangular prisms. Usually in imbedded grains of olive green color; also yellowish green. L=vitreous. Cleavable. Transparent to translucent. H=6-7. G=3.3-3.6. B.B. whitens but is infusible; with borax a yellow bead, color due to iron. Decomposed by hydrochloric acid, solution gelatinizing when evaporated. Distinguished from green quartz by cleavage and by occurring disseminated in basaltic rocks; quartz never does. From obsidian or volcanic glass differs in infusibility. Silica 41.39, magnesia 50.9, iron protoxide 7.71.

Garnet.—*Almandite*, *Essonite* and *Melanite* are varieties. Isometric. Dodecahedrons and trapezohedrons, both common and sometimes variously modified. Cleavage sometimes rather distinct. Also massive granular, and coarse lamellar. C=deep red to cinnamon brown, also brown, black, green, emerald, rarely colorless. Transparent to opaque. L=vitreous. Brittle. H=6.5-7.5. G=3.1-4.3. B.B. fuses to brown or black glass. Not decomposed by hydrochloric acid; but if ignited and then powdered and treated with acid it is decomposed, and solution usually gelatinizes when evaporated. Composition varies; mainly a silicate of aluminium and iron, calcium or magnesium. Common in Canada.

Zircon.—Tetragonal. Cleavage imperfect. Usually in crystals, but also granular. C=red to brown; also yellow, gray and white. S=uncolored. L=more or less adamantine. Often transparent, also nearly opaque. Fracture is conchoidal, brilliant. H=7.5. G=4-4.9. B.B. infusible, but loses color. Crystals, spec. grav., and adamantine lustre distinguish zircon. Silica 33, zirconia 67. Common in Canada.

Vesuvianite, Idocrase.—Tetragonal. Cleavage indistinct. Also massive granular and subcolumnar. C=brown, sometimes verging to green. S=uncolored. L=vitreous. Subtransparent to nearly opaque. H=6.5. G=3.33. B.B. fuses easily with effervescence to greenish or brownish globule. Resembles some brown garnet, tourmaline and epidote, but differs in crystallization and greater fusibility. Chiefly a silicate of aluminium and lime with iron. Found in Canada.

Epidote.—Monoclinic. Also massive granular and forming rock masses; sometimes columnar or fibrous C=yellowish green and ash gray or brown. S=uncolored. Translucent to opaque. L=vitreous. Often brilliant on faces of crystals. Brittle. H=6-7. G=3.25-3.5. B.B. fuses with effervescence to black glass, which is usually magnetic. Partly decomposed by hydrochloric acid, but if first ignited is decomposed, and the solution gelatinizes on evaporation. The peculiar yellowish green

Anhydrous Unisilicates.

color of ordinary epidote distinguishes it. A silicate of aluminium, iron and calcium, with water. Found in Canada.

ZOISITE, LIME EPIDOTE.—Orthorhombic. Columnar and massive. Cleavable. C=ash gray to white, also greenish gray, red. L=vitreous to subpearly. H=6.6. G=3.11–3.38. B.B. swells and fuses. Like epidote, with little or no iron.

ILVAITE.—A calcium-iron silicate, occurs in Canada.

AXINITE. — Triclinic. In acute-edged oblique rhomboidal prisms. Cleavage indistinct. Also rarely massive or in layers. C=dark brown, differing somewhat in shade in three directions. L=vitreous. Transparent to subtranslucent. Brittle. H=6.5–7. G=3.27. Electric after ignition. B.B. fuses easily, bubbles and yields dark green or black glass, giving pale green flame. Remarkable for sharp thin edges of crystals, their glassy brilliant appearance and absence of cleavage ; implanted and not disseminated like garnet. Occurs in Canada.

DANBURITE. — A calcium silicate containing much boron. Orthorhombic, resembles topaz in its crystals ; also massive. C=pale yellow. Transparent. L=vitreous, slightly greasy when massive. H=7–7.25. G=2.98. B.B. fuses to colorless glass ; green flame.

IOLITE, DICHROITE.—Orthorhombic. Six and twelve sided prisms ; also massive. Cleavage indistinct. C=shades of blue and yellowish gray. S=uncolored. L=vitreous. Transparent to translucent. Brittle. H=7–7.5. G=2.6–2.7. Resembles blue quartz, distinguished by fusing on edges. A silicate of aluminium, magnesium and iron.

MICA GROUP.

MUSCOVITE.—Monoclinic. Usually in plates or scales, sometimes radiated groups of scales. C=from white through green, yellowish and brownish shades ; rarely rose-red or reddish violet. L=pearly. Transparent to translucent. Tough and elastic. H=2–2.5. G=2.7–3. B.B. whitens and fuses on thin edges, with difficulty. Differs from talc and chlorite in being elastic; leaves tougher and harder. *Sericite* is related to muscovite but it has 4 or 5% water. A component of granite, gneiss, and mica schist. Common in Canada. Uses : in stoves, etc., decorating wall paper, lubricant, insulating for electrical purposes, boiler and pipe covering, etc. A silicate of aluminium, iron, potassium, etc.

PHLOGOPITE. — Monoclinic. C=often yellowish brown with copper-like reflection, also brownish yellow to white. B.B. like muscovite. Common in Canada.

BIOTITE. — Monoclinic. Crystals usually short rhombic or hexagonal prisms. Common in scattered scales and scale masses.

Mica Group.

C=dark green, black. Transparent to opaque. Cleavage eminent. L=more or less pearly on cleavage surface. H=2.5–3. G=2.7–3.1. B.B. whitens and fuses on thin edges. In mica schist, gneiss and granite, much more common than muscovite; often in syenite. Mainly a silicate of aluminium, magnesium, potassium and iron. Common in Canada. Clear varieties valuable for insulating purposes, as above.

LEPIDOMELANE.—Allied to last, but with more iron and less magnesia. Found in Canada.

SCAPOLITE GROUP.

WERNERITE, SCAPOLITE.—Tetragonal. Also massive, or sometimes faintly fibrous. Cleavage indistinct. C=white, gray, pale blue, greenish or reddish, brown when impure. S=uncolored. Transparent to nearly opaque. L=usually a little pearly. H=5–6. G=2.65–2.8. The square prisms are characteristic. In cleavable masses resembles feldspar except for a slight fibrous appearance usually distinguished on the cleavage surface. More fusible than feldspar and spec. grav. higher. Spodumene has much higher spec. grav. and differs also B.B. Wollastonite is more fibrous in appearance of surface, is less hard, and gelatinizes with acids. B.B. fuses easily and boils to white glass; imperfectly decomposed by hydrochloric acid. Silica 48.4, alumina 28.5, lime 18.1, soda 5. Occurs in Canada.

NEPHELITE, ELEOLITE.—Hexagonal. Also massive, rarely thin columnar. C = white, or gray, yellowish, greenish, bluish red. L=vitreous to greasy. Transparent to opaque. H=5.5–6. G=2.55–2.62. Distinguished from most scapolites and feldspars by the greasy lustre when massive, and the facility of gelatinizing with acids; from apatite by the last character and also greater hardness. A silicate of aluminium, sodium and potassium, containing iron, manganese and lime.

SODALITE.—Isometric. In dodecahedrons. Cleavage dodecahedral. C=brown, gray, or blue. L=vitreous, sometimes greasy. H=6. G=2.25–2.4. B.B. fuses, bubbles, gives a colorless glass. Decomposed with hydrochloric acid, solution gelatinizing on evaporation. A silicate of aluminium and sodium, containing chlorine. Occurs in Canada.

LAPIS-LAZULI, ULTRAMARINE.—Isometric, rarely in crystals (dodecahedrons). Cleavage imperfect. Usually massive. C=rich azure blue. L=vitreous. Translucent to opaque. H=5.5. G=2.3–2.5. B.B. fuses to white translucent or opaque glass, and if burnt and powdered loses color in acids. Color supposed to be due to sodium sulphide. A silicate of aluminium, sodium, and calcium, containing sulphuric acid, sulphur, iron and chlorine. Used for the valuable blue paint called ultramarine.

Scapolite Group.

LEUCITE, AMPHIGENE.—Isometric. Cleavage imperfect. Trapezohedron. Usually in dull glassy white to gray crystals, disseminated through lava. Translucent to opaque. H=5.5-6. G=2.45-2.5. Brittle. B.B. infusible. Moistened with cobalt nitrate and ignited assumes blue color. Decomposed by hydrochloric acid without gelatinizing. Distinguished from analcite by hardness and infusibility. Silica 55, alumina 23.5, potash 21.5.

FELDSPAR GROUP.

Triclinic feldspars get the general term PLAGIOCLASE. ANORTHITE. INDIANITE. — Lime Feldspar. Triclinic. Crystals tabular. Also massive, granular, or coarse layers. C = white, grayish, or reddish. H=6. G=2.66-2.78. B.B. fuses with difficulty to colorless glass. Decomposed by hydrochloric acid and solution gelatinizes on evaporation. Silica 43.1, alumina 36.8, lime 20.1. *Huronite*, an altered anorthite, occurs near Sudbury.

LABRADORITE.—Lime-soda Feldspar. Triclinic. Usually in cleavable massive forms. Dark gray, brown, or greenish brown, also white or colorless. Often a series of bright colors from internal reflections, especially blue and green, with more or less yellow and pearl gray. H=6. G=2.67-2.70. B.B. fuses easily to colorless glass. Only partially decomposed by hydrochloric acid. Silica 52.9, alumina 30.3, lime 12.3, soda 4.5. Occurs in Canada.

OLIGOCLASE.—Soda-lime Feldspar. Triclinic. Commonly in cleavable masses. Also massive, usually white, grayish white, grayish green, greenish, reddish. Transparent, subtranslucent. H=6-7. G=2.5-2.7. A portion of soda usually replaced by potash. B.B. fuses without difficulty ; not decomposed by acids. Silica 61.9, alumina 24.1, soda 8.8, lime 5 2. Occurs in Canada, in granite, gneiss and syenite rocks.

ALBITE.—Soda Feldspar. Triclinic. Crystals more or less thick tabular ; also massive, granular or plate-like structure. C= white, occasionally light tints of bluish white, gray, reddish and greenish. Transparent to subtranslucent. H=6-7. G=2.61. B.B. fuses to colorless or white glass ; intense yellow flame. Not acted on by acids. Silica 68.6, alumina 19.6, soda 11.8. Occurs in Canada, in granite and gneiss.

MICROCLINE.—Potash Feldspar. Triclinic. In angles and physical characters like orthoclase, but cleavage surface shows sometimes fine striations. C=white, flesh red, copper green. Occurs in Canada.

ORTHOCLASE, COMMON FELDSPAR.—Potash Feldspar. Monoclinic. Cleavage angle is 90°. Usually in thick prisms, often rectangular and also in modified tables ; also massive with granular structure or in coarse plates ; also fine grained, massive, flint-

Feldspar Group.

ike. C=light; white, gray and flesh red, common; also greenish nd bluish white and green. H=6. G=2.55-2.58. B.B. fuses with difficulty; not acted on by acids. Silica 64.7, alumina 18.4, potash 16.9. An important constituent of granite, syenite, gneiss, porphyry. Extensively used for porcelain. Found in Canada.

SUBSILICATES.

CHRONDRODITE.—Monoclinic. Cleavage indistinct. Usually n imbedded grains or masses. C=light yellow to brownish yellow, yellowish red and garnet red. L=vitreous, inclining a little to resinous. S=white or slightly yellowish or grayish. Translucent to subtranslucent. Fracture uneven. H=6-6.5. G=3.1-3.25. B.B. infusible. Decomposed by hydrochloric acid, solution gelatinizing on evaporation. Unlike tourmaline or garnet, some brownish yellow varieties of which it resembles, it does not fuse. A silicate of magnesium, with small quantities of iron, fluorine and aluminium. Found in Canada.

TOURMALINE.—Hexagonal. Usual in prisms of 3, 6, 9 or 12 sides, terminating in a low three-sided pyramid; sides of the prisms often rounded and striated. Also compact massive, and coarse columnar, radiating or divergent. C=black, blue black, and dark brown, common; also ruby red, pale red, rich grass green, brown, yellow, gray and colorless. Transparent, usually translucent to nearly opaque. L=vitreous, inclining to resinous on surface of fracture. S=uncolored. Brittle, the crystals often fractured across and breaking very easily. H=7-7.5. G=2.9-3.3. B.B. dark varieties fuse with ease, the lighter with difficulty. On mixing the powdered mineral with potassium bisulphate and fluorspar, and heated B.B., the flame colors green owing to boron. The presence of boron trioxide is a remarkable feature of this mineral in all varieties. The electric properties of the crystals, when heated, is another remarkable character. A silicate of aluminium, boron, iron and magnesium, etc. Common in Canada, in granite, gneiss, chlorite schist, quartzite, granular limestone, etc.

ANDALUSITE.—Orthorhombic. In nearly square prisms. Cleavage sometimes distinct. Also massive; indistinctly coarse columnar. C=gray and flesh red, pink. L=vitreous or inclining to pearly. Translucent to opaque. Tough. H=7.5. G=3.1-3.3. B.B. infusible. Ignited, after being moistened with cobalt nitrate, assumes a blue color. Insoluble in acids. Distinguished from pyroxene, scapolite, spodumene and feldspar by its infusibility, hardness and form. Silica 36.9, alumina 63.1. Found in Canada.

Subsilicates.

FIBROLITE.—Orthorhombic. In long slender rhombic prisms, often much flattened, penetrating the gangue. Cleavage brilliant. Also in masses, consisting of aggregated crystals or fibres. C= brown or grayish brown. L=vitreous, inclining to pearly. Translucent crystals break easily. H=6-7. G=3.2-3.3. Moistened with cobalt nitrate and ignited assumes a blue color. Infusible alone and with borax. Distinguished from tremolite and the varieties of hornblende generally by brilliant diagonal cleavage and infusibility; from kyanite and andalusite by its brilliant cleavage, fibrous structure, and orthorhombic crystals. Composition same as last.

KYANITE.—Triclinic. Usually in long knife-like crystals, aggregated, or penetrating the gangue. Sometimes in short, stout crystals. Lateral cleavage distinct. Sometimes fine fibrous. C=usually light blue, sometimes having a blue centre with white margin; sometimes white, gray, green, or even black. Lustre of flat face a little pearly. H=5-7.5. G=3.55-3.7. Distinguished by infusibility from varieties of hornblende. Short crystals have some resemblance to staurolite, but their sides and terminations are usually irregular; also differs in cleavage and lustre. The thin-bladed characteristic of kyanite is distinctive. Composition same as last. Occurs in Canada.

TOPAZ.—Orthorhombic. Rhombic prisms, usually differently modified at the extremities. Cleavage perfect basal. C=pale yellow, sometimes white, greenish, bluish, or reddish. S=white, L=vitreous. Transparent to subtranslucent. Electric after ignition. H=8. G=3.4-3.65. B.B. infusible; some kinds become yellow or pink when heated; moistened with cobalt nitrate and ignited assumes fine blue color. Insoluble in acids. Readily distinguished from minerals resembling it by brilliant and easy basal cleavage. Silica 16.2, alumina 55.7, silicon fluoride 28.1. Used as gem.

EUCLASE.—Monoclinic. In oblique rhombic prisms. Cleavage highly perfect, affording smooth polished faces. C=pale green to white or colorless, pale blue. L=vitreous. Transparent. Brittle. H=7.5. G=3.1. Electric after ignition. The cleavage of this glassy mineral is very perfect like topaz, but is not basal. Used as gem. Silica 41.2, alumina 35.2, beryllia 17.4, water 6.2.

DATOLITE.—Monoclinic. Crystals small and glassy. Distinct cleavage. Also botryoidal, and columnar within; also massive and porcelain-like in fracture. C=white, occasionally grayish, greenish, yellowish or reddish. Translucent. H=5-5.5. G= 2.9-3. Its glassy complex crystallizations without cleavage distinguish it from other minerals that gelatinize with acid; so also in tingeing blowpipe flame green. B.B. becomes opaque, bubbles, melts easily to glassy globule, coloring flame green. Decomposed

Subsilicates.

by hydrochloric acid; solution gelatinizing on evaporation. Silica 37.5, boron trioxide 21.9, lime 35, water 5.6. Found in Canada.

TITANITE, SPHENE.—Monoclinic. Crystals usually very oblique thin-edged prisms. Cleavable in one direction, sometimes perfect. Occasionally massive. C=grayish brown, ash gray, brown to black; sometimes pale yellow to green. S=uncolored. L=adamantine to resinous. Transparent to opaque. H=5–5.5. G=3.4–3.56. In dark brown and black crystals, some iron replaces part of the calcium. B.B. fuses and bubbles. Imperfectly decomposed by hydrochloric acid. The thin wedge-shaped crystal is generally a distinguishing character. Silica 30.6, titanium oxide 40.82, lime 28.57. Common in Canada.

STAUROLITE.—Orthorhombic. Cleavage imperfect. Usually in cross-shaped twin crystals. Never massive or in slender crystallizations. C=brown to black. L=vitreous, inclining to resinous, sometimes bright, but often dull. Translucent to opaque. H=7–7.5. G=3.4–3.8. B.B. infusible, excepting a manganese variety. Insoluble in acids. Distinguished from tourmaline and garnet by infusibility and form. Silica 28.3, alumina 51.7, iron oxide 15.8, magnesia 2.5, water 1.7.

HYDROUS SILICATES.

PECTOLITE.—Monoclinic. Usually in aggregations of needle-shaped crystals, or fibrous-massive, radiate, star-shaped. C=white or grayish. Translucent to opaque. Tough. H=5. G=2.86. B.B. fusible. In closed tube yields water. Decomposed by hydrochloric acid; solution gelatinizes on evaporation. Resembles fibrous varieties of tremolite, natrolite, wollastonite. Silica 54.2, lime 33.8, soda 9.3, water 2.7. Found in Canada.

LAUMONTITE.—Monoclinic, like pyroxene in form. Massive, with radiating or divergent structure, not fine fibrous. C=white, passing into yellow or gray, sometimes red. L=vitreous, inclining to pearly on cleavage face. Transparent to translucent. H=3.5–4. G=2.25–2.36. Becomes opaque on exposure through loss of water, and readily crumbles. B.B. swells up and fuses easily to white enamel. Decomposed by hydrochloric acid; solution gelatinizes on evaporation. The alteration this species undergoes on exposure to the air distinguishes it. A hydrous silicate of aluminium and calcium. Found in Canada.

APOPHYLLITE.—Tetragonal. In square octahedrons, prisms and tables. Cleavage basal, highly perfect. Massive and foliated. C=white or grayish, sometimes with shade of green, yellow or red. L=of one face pearly; of rest vitreous. Transparent to opaque. H=4.5–5. G=2.3–2.4. B.B. exfoliates, colors flame

Hydrous Silicates.

violet (owing to potash) and fuses very easily to white enamel. In closed tube yields water which has acid reaction. Decomposed by hydrochloric acid with separation of slimy silica. The easy basal cleavage, and basal pearly lustre and form of crystals distinguish it from the preceding species. It is never fibrous. Silica 52.97, lime 24.72, potash 5.2, fluorine 2.1, water 15.9. Occurs in Canada.

PYRALLOLITE.—An altered variety of pyroxene. Found in Canada.

PREHNITE.—Orthorhombic. Cleavage basal. Sometimes in six-sided prisms, rounded so as to be barrel-shaped, and looking as if made up of a series of united plates ; also in thin rhombic or hexagonal plates. Usually kidney-shaped and botryoidal, with crystalline surface. Never fibrous. C=apple green to colorless. L=vitreous, except one face, which is somewhat pearly. Subtransparent to translucent. H=6-6.5. G=2.8-2 96. B.B. fuses very easily to enamel-like glass. Decomposed by hydrochloric acid, leaving residue of silica, but does not gelatinize. Yields a little water in closed tube. Distinguished from beryl, green quartz, and chalcedony by fusing B.B. ; and from the zeolites by hardness. Receives a handsome polish and is sometimes used for inlaid work. Silica 43.6, alumina 24 9, lime 27.1, water 4.4. Occurs in Canada.

ZONOCHLORITE AND CHLORASTROLITE.—Greenish varieties of prehnite. Found in Canada.

ALLOPHANE.—In amorphous incrustations, with a smooth, small mammillary surface, and sometimes powdery. C=pale bluish white to greenish, and deep green ; also brown, yellow, colorless. Translucent. H=3. G=1.85-1.89. In closed tube yields much water. B.B. infusible but crumbles. Gives a blue color with cobalt solution and a jelly with hydrochloric acid. Silica 23.75, alumina 40.62, water 35.63.

ZEOLITE SECTION.

So called because they generally fuse easily. B.B. with bubbling. (Greek zeo=to boil). Sometimes called trap minerals, because often found in cavities or fissures of amygdaloidal trap as well as related basic eruptive rocks. Yet they occur occasionally in fissures or cavities in gneiss, granite and other metamorphic rocks. They are not the original minerals of any of these rocks, but the result of alteration of portions of them near the little cavities or fissures in which the minerals occur, and part were made while the rock was still hot and as cooling went forward.

THOMSONITE.—Orthorhombic. In right rectangular prisms. Usually in masses having a radiated structure within, and con-

Zeolite Section.

sisting of long fibres, or needle-shaped crystals ; also amorphous. C=snow white ; impure varieties brown. L=vitreous, inclining to pearly. Transparent to translucent. H=5. G=2.3-2.4. Brittle. B.B. fuses very easily to white enamel. Decomposed by hydrochloric acid, solution gelatinizing on evaporation. Distinguished from natrolite by its fusion to an opaque and not glassy globule. Silica 38.1, alumina 31.6, lime 12.6, soda 4.6, water 13.4. Occurs in Canada.

NATROLITE.—Orthorhombic. Prisms very slender and aggregated. Also in globular, star-shaped and divergent groups of delicate needle-shaped fibres (often terminating in needle-shaped prismatic crystals). C=white, or inclining to yellow, gray, red. L=vitreous. Transparent to translucent. H=5-5.5. G=2.2. Brittle. B.B. fuses easily and quietly to a clear glass ; a fine splinter melts in candle flame. Decomposed by hydrochloric acid, solution gelatinizing on evaporation. Silica 47.29, alumina 26.03, soda 16.3, water 9.45. Found in Canada.

ANALCITE.—Isometric. Usually in trapezohedrons. C=often colorless and transparent ; also milk white, grayish, and reddish white. Sometimes opaque. L=vitreous. H=5-5.5. G=2.25. B.B. fuses easily to colorless glass. Decomposed by hydrochloric acid, the silica separating in gelatinous lumps. Characterized by crystallization and absence of cleavage. Distinguished from quartz and leucite by giving water in closed tube ; from calcite by its fusibility and by not effervescing with acids ; from chabazite and varieties by fusing *without* bubbling to a *glassy* globule, and by crystalline form. Silica 54.47, alumina 23.29, soda 14.07, water 8.17. Found in Canada.

CHABAZITE.—Rhombohedral. Often in rhombohedrons, much resembling cubes. Never massive or fibrous. C=white, yellowish, flesh-red, or red. L=vitreous. Transparent to translucent. H=4-5. G=2.08-2.19. B.B. bubbles and fuses to nearly opaque bead. Decomposed with hydrochloric acid. In closed tube gives water. The nearly cubical form when crystallized is striking. Distinguished from analcite as stated under that species ; from calcite by yielding water and action with acids ; from fluorite by form and cleavage, and by showing no phosphorescence. Silica 52.2, alumina 18.3, lime, soda and potash 8.7, water 20.5. Found in Canada.

HARMOTOME.—Monoclinic. Unknown except in compound crystals. C=white ; sometimes gray, yellow, red or brownish. Subtransparent to translucent. L=vitreous. H=4.5. G=2.45. B.B. whitens, crumbles and fuses quietly to white translucent glass. Gives water in closed tube. Partially decomposed by hydrochloric acid, and if sulphuric acid be added to solution a heavy white precipitate of barium sulphate is formed. Some

Zeolite Section.

varieties phosphoresce when heated. Much more fusible than glassy feldspar or scapolite; does not gelatinize like thomsonite. Silica 46.5, alumina 15.9, baryta 23.7, water 13.9.

STILBITE.—Monoclinic. In crystals. Also in sheaf-like aggregations, and spheres, thin pearly lamellar-columnar in structure, also in radiated crystallizations; never fine fibrous. C=white, sometimes yellow, brown, or red. Subtransparent to translucent. L=highly pearly on cleavage surface. H=3.5–4. G=2.1–2.15. B.B. swells up, and curves into fan-like forms, and fuses to white enamel. Decomposed by hydrochloric acid without gelatinization. Cannot be scratched with thumbnail like gypsum. Unlike heulandite in crystals. Silica 57.4, alumina 16.4, lime 8.9, water 17.2. Found in Canada.

HEULANDITE.—Monoclinic. In right rhombic prisms with perfect pearly cleavage, other planes vitreous in lustre. C=white, sometimes reddish, gray, brown. Transparent to subtranslucent. Leaves brittle. H=3.5–4. G=2.2. B.B. like stilbite. Bubbles and fuses, and becomes phosphorescent. Dissolves in acid without gelatinization. The very pearly lustre of cleavage face is a marked character. Distinguished from gypsum by hardness; from apophyllite and stilbite by crystals; and from latter species also in not occurring in radiated, sheaf-like or spherical crystallizations. Silica 59.1, alumina 16.9, lime 9.2, water 14.8. Found in Canada.

MARGAROPHYLLITE SECTION.

TALC.—Orthorhombic. In right rhombic or hexagonal prisms. Usually in pearly leafy masses, separating easily into thin translucent pearly leaves. Sometimes star-shape, or divergent, consisting of radiating sheets. Often massive, consisting of minute pearly scales; also crystalline granular; also flint-like. L=eminently pearly. Feels greasy. C=some shade of light green or greenish white, occasionally silvery or pearly white; also grayish green and dark olive green. H=1–1.5. G=2.5–2.8. Leaves flexible, but not elastic. The extreme softness, greasy feel, leaf-form crystallization, and pearly lustre are good characteristics. Differs from mica in being inelastic, although flexible; from chlorite, kaolin, and serpentine in yielding little water when heated in glass tube. Only the massive varieties resemble serpentine, and chlorite has a dark olive green color. Pyrophyllite, which cannot be distinguished in some varieties, by eye alone, from talc, becomes dark blue when moistened with cobalt nitrate and ignited. Silica 62.8, magnesia 33.5, water 3.7. Found in Canada.

Varieties: *Foliated Talc*, white to greenish white, leafy. *Soapstone* or *Steatite*, white, gray, grayish green. Massive, gran-

Margarophyllite Section.

lar or impalpable. Greasy to touch. *French Chalk*, milk-white with pearly lustre. *Potstone*, impure soapstone, grayish green or dark green. Talc is ground, and used largely for adulterating soap, and to some extent in making paper. *Soapstone*, sawn into slabs, is used for lining furnaces, also in making porcelain. Used as lubricator, and for polishing serpentine, alabaster and glass.

PYROPHYLLITE.—Like talc in crystallization, cleavage and occurrence in leafy and fine grained massive forms, its greasy feel, its white to pale green colors, varying to yellowish, its feeble degree of hardness. The leaves are sometimes radiated. H=1-2. G=2.75-2.92. B.B. whitens and fuses with difficulty on edges; deep blue color with cobalt nitrate; yields water in closed tube. Radiated varieties take fan-like forms, heated. Silica 64.82, alumina 24.48, iron, magnesium, and calcium oxides 1.84, water 5.25.

SEPIOLITE, MEERSCHAUM.—Usually compact, of fine earthy texture, with smooth feel, and white or whitish color; also fibrous. C=white to bluish green. H=2-2 5. B.B. infusible, much water in closed tube, pink color with cobalt solution. The earthy variety floats on water. Silica 60.8, magnesia 27.1, water 12.1.

GLAUCONITE, GREEN EARTH.—Essentially a silicate of iron and potassium. In dark olive green to yellowish green grains, or granular masses. L=dull. H=2. G=2.2. Mixed with sand it forms thick beds called greensand. B.B. fuses easily to magnetic glass, yields water in closed tube.

SERPENTINE.—A hydrous magnesium silicate, like talc, but containing more water and less silica. Usually massive and compact; also in layers or leafy, the leaves brittle; also columnar, asbestiform, and delicately silky fibrous. C=light to dark green, to olive green and blackish green; also greenish yellow, brownish yellow, brownish red; rarely white. L=weak; resinous, inclining to greasy. Translucent to nearly opaque. H=2.5-4. G=2.5. Feel, especially of powder, a little greasy. Tough. Fracture conchoidal. B.B. fuses with much difficulty on thin edges; yields water in closed tube. Decomposed by hydrochloric acid, leaving residue of silica. In some kinds, iron replaces some of magnesium. The distinctive features of the compact mineral are no cleavage, feeble lustre, slightly waxy or oily lustre, little hardness; yielding much water and low specific gravity. When polished has much beauty. Silica 43.5, magnesia 43.5, water 13. *Asbestus. Chrysotile* is fibrous serpentine; and is usually the asbestus of commerce. Unlike true asbestus it affords much water in closed tube. The bulk of the world's supply of asbestus comes from Quebec. Uses: fire-proof articles of all kinds, piston packing, covering for steam pipes and boilers; made into yarn, cloth and paper.

Margarophyllite Section.

DEWEYLITE.—Composition near Serpentine, but containing 2[…] per cent. of water. Massive. C=whitish, yellowish, brownish yellow, greenish, reddish. Has the aspect of gum arabic. Very brittle. H=2–3.5. G=1.9–2.25. *Genthite* and *Garnierite* are varieties containing much nickel.

SAPONITE.—Soft, clay-like; of the consistence, before drying, of cheese or butter, but brittle when dry. C=white, yellowish, grayish green, bluish, reddish. Does not adhere to tongue. Found in Canada.

KAOLINITE, KAOLIN, PURE CLAY.—Composition: silica, alumina, water. Orthorhombic. Massive. Clay-like; either compact, friable or mealy. Feels greasy. C=white, grayish white, yellowish; sometimes brownish, bluish or reddish. Scales flexible, inelastic. H=1–2.5. G=2.4–2.6. B.B. infusible. A blue color with cobalt nitrate. Yields water in closed tube. Insoluble in acids. Kaolin is used for white porcelain of fine quality and for giving weight and body to paper. Silica 46.4, alumina 39.7, water 13.9. Found in Canada.

PINITE.—Amorphous, and usually flint-like. C=grayish, greenish, brownish, sometimes reddish. L=feeble; waxy. Translucent to opaque. H=2.5–3.5. G=2.6–2.85. Silica 46.83, alumina 27.65, iron, potassium oxides, etc., containing water. Occurs in Canada. *Wilsonite* is a variety.

HYDROMICA SECTION.

FAHLUNITE.—A hydrous silicate of aluminium and iron with little or no alkali, and in this last point differing from pinite. In 6 and 12 sided prisms, usually leafy, parallel with the base, but owing the prismatic form to the mineral from which it was derived. Leaves soft and brittle, of grayish green to dark green color and pearly lustre. G=2.7. B.B. fuses to white glass. In closed tube gives water. Insoluble in acids. Distinguished from talc by affording much water B.B., and readily by its association with iolite, and its large hexagonal forms, with brittle leaves.

CHLORITE GROUP.

HISINGERITE.—Massive, kidney-shaped. C=Black to brownish black. S=yellowish brown. L=greasy, inclining to vitreous. H=3. G=3.045. B.B. fuses with difficulty to magnetic slag. Silica 35.9, iron sesquioxide 42.6, water 21.5.

PYROSCLERITE—Orthorhombic or monoclinic. Mica-like cleavage; sheets flexible, not elastic. C=apple green to emerald green. L=pearly. H=3. G=2.74. B. B. fuses to grayish glass; gelatinization with hydrochloric acid. Silica 38.9, alumina 14.8, magnesia 34.6, water 11.7.

Chlorite Group.

VERMICULITE.—Mica-like cleavage. In aggregated scales. Also in large mica-like crystals or plates. Flexible, not elastic. C=gray, brown, yellowish brown. L=pearly. B.B. fuses finally to gray mass. When scaly-granular the scales open out into worm-like forms.

PENNINITE.—Hexagonal. Cleavage basal, highly perfect, mica-like. Also massive, consisting of scale aggregations, and flint-like. C=green of various shades; yellowish to silver white; rose red to violet. L=pearly on cleavage surface. Transparent to translucent. Sheets flexible, not elastic. H=2–2.5 on edges. G=2.6–2.75 B.B. leaves separate somewhat and fuse with difficulty. Partially decomposed by hydrochloric acid, and wholly so by sulphuric acid. Silica 33.6, alumina 10.6, iron sesquioxide 8.8, magnesia, 34.9, water 12.4.

RIPIDOLITE.—Monoclinic. Similar in cleavage and mica-like character to penninite, and also in color, lustre, hardness, and spec. grav. B.B. and with acids nearly like penninite. Composition similar to last, but it has less iron and a little chromium.

PROCHLORITE.—Hexagonal. Similar in cleavage and mica-like characters to last. C=green to blackish green; sometimes red across by transmitted light. G=2.75–3. Sheets not elastic. B.B. same as last. Silica 25.4, alumina 18.6, iron protoxide 28.8, magnesia 17.1, water 9.

MARGARITE, EMERYLITE, DIPHANITE, CLINGMANITE, CORUNDELLITE.—Orthorhombic. Mica-like. Sheets rather brittle. C=white, grayish, reddish. L=of cleavage surface strong pearly and brilliant, of sides of crystals, vitreous. H=3.5–4.5. G=2.99. B.B. whitens and fuses on edges. Silica 30.1, alumina, 51.2, lime 11.6, soda 2.6, water 4.5.

CHLORITOID, MASONITE, PHYLLITE, OTTRELITE.—Monoclinic. Cleavage basal perfect. Also coarse foliated massive; and in thin disseminated scales. Brittle. C=dark gray, greenish to black. L=of cleavage face somewhat pearly. H=5.5–6. G=3.5–3.6 B.B. becomes darker and magnetic, but fuses with difficulty. Decomposed by sulphuric acid. Silica 24, alumina 40.5, iron oxide 28.4, water 7.1. Found in Canada.

HYDROCARBONS.

PETROLEUM.—Mineral oils varying in density from 0.6 to 0.85. Soluble in benzine or camphene. Petroleum occurs in rocks of all ages, from the lower silurian to the most recent; in limestones, porous or compact sandstones, and shales; but it is mostly obtained from cavities existing among the earth's strata or more probably from the porous strata themselves. Black shales and much bituminous coal afford it abundantly when heated. Surface oil springs occur in many places. Petroleum is obtained

Hydrocarbons.

chiefly at the present time from porous oil "sands" (coarse sandstones), or cavities reached by boring. Being under pressure from the gas associated with it, it rises to the surface in the boring, and sometimes makes a "spouting well" or "gusher." It is thought to be due to decomposition of animal and vegetable substances. Occurs abundantly in Ontario at Petrolea and Oil Springs at depths, respectively of about 460 and 360 feet. The crude oil is distilled in sheet-iron retorts, and at the various stages yields gasoline and naphtha, illuminating oil, intermediate and wool oils, and lubricating oils, in order named, the residue being carbonaceous matter locally sold as coke. Vaseline, axle grease, paraffine wax, etc., are by-products.

HATCHETTITE, MOUNTAIN TALLOW.—Like soft wax in appearance and hardness. Yellowish white to greenish yellow color. Related to paraffine in composition.

ELATERITE, MINERAL CAOUTCHOUC, ELASTIC BITUMEN.—In soft flexible masses somewhat resembling india-rubber. C=brownish black, sometimes orange red by transmitted light. G=0.9-1.25. Carbon 85.5, hydrogen 13.3. Burns readily with yellow flame and bituminous odor.

AMBER.—In irregular masses. C=yellow, sometimes brownish or whitish. L=resinous. Transparent to translucent. H=2-2.5. G=1.18. Electric. A resin.

ASPHALTUM.—Amorphous and pitch like. Burns with bright flame, melts at 90°-100° F. Soluble mostly or wholly in camphene. A mixture of hydrocarbons. Much used in road-making.

ALBERTITE.—Coal like in hardness, but little soluble in camphene, and only imperfectly fusing when heated; but having the lustre of asphaltum, and softening a little in boiling water. H=1-2. G=1.1. Occurs in Nova Scotia.

ANTHRAXOLITE.—Black, lustrous, and resembling anthracite or albertite in general characters. H=2.25-2.5. G=1.4-1.6. Composition essentially carbon. Forms small plates or irregular cubic blocks between which is generally more or less quartz. Found in Eastern Townships and north of Lakes Superior and Huron. The pure mineral yields fixed carbon 90 to 95%, volatile matter and ash 5 to 10.

MINERAL COAL.—Massive, uncrystalline. C=black or brown. Opaque. Brittle. H=0.5-2.5. G=1.2-1.8. Contains carbon, with some oxygen and hydrogen, more or less moisture, and traces also of nitrogen, besides some earthy material which constitutes the ash. Coals differ in the amount of volatile ingredients given off when heated. These ingredients, besides moisture and some sulphur, are hydrocarbon oils and gas, derived

Hydrocarbons.

from the same class of insoluble hydrocarbons that is the source of the oil in shales and other rocks.

Varieties: ANTHRACITE.—L=high, not resinous, sometimes submetallic. C=black. H=2-2.5. G=1.57-1.67, if pure. Fracture often conchoidal. Good anthracite contains fixed carbon 78-88% (83 average), hydrogen 2-3.5, oxygen 1.5-3.5, with 4-12 of earthy impurities. The amount of volatile matter is but 3-7%, and there is a trace of sulphur. Burns with feeble blue flame. Occurs in the Rocky Mountains and in Queen Charlotte Island.

BITUMINOUS COAL.—Color and powder black. L=usually somewhat resinous. H=1.5-2. G=1.2-1.4, if pure. Contains usually carbon 75-85%, hydrogen 4-6, oxygen 4-15, with mostly 2-9 of moisture. The volatile hydrocarbon ingredients 20-45%, with 50 to over 60 in some kinds; sulphur in the best coals below 1, but often 2-2.5. Ash impurities 1.4-7.5 (average 5 or 6). Burns with bright yellow flame. Yields little to, or colors slightly, a potash solution. Occurs in Nova Scotia, Vancouver Island and in Rocky Mountains.

CAKING COAL includes that part of bituminous coal which softens when heated and becomes viscid, so that adjoining pieces unite into a solid mass. Burns readily with lively yellow flame, but requires frequent stirring to prevent its agglutinating, and so clogging the fire. Non-caking coal resembles the caking in appearance, but does not soften and cake.

CANNEL COAL.—Very compact and even in texture. L=weak. Fracture large conchoidal. Takes fire readily, and burns without melting with a yellow flame. Volatile hydrocarbon compounds given out when heated amount to 40 to 50%, and even 60; and hence valued for the manufacture of gas as well as for fuel; also yield much mineral oil.

BROWN COAL, LIGNITE.—Color black to brownish black; of powder, brown. Contains oxygen 15 to 20%, and often 8 to 10 of moisture; fixed carbon mostly 52 to 65. Gives a brownish or brownish red color to a solution of potash. Usually non-caking. The kinds having more or less of the structure of wood are called *lignite;* and in these kinds the oxygen present may be 25 to over 30%, and the moisture 15 to 20. Between the brown coals and bituminous there is a gradual passage in constitution and in color of powder. Occurs in Canadian North-West, British Columbia, and James' Bay region.

JET resembles cannel coal but is harder; deeper black and higher lustre; takes brilliant polish, and is used in jewellery.

5

PROSPECTING.

General Principles.

The search for minerals is attended by many difficulties ; the outcrops are frequently covered with soil, and the appearance of the ore is completely changed at the surface. General rules for guidance may be given as follows :

1. The prospector should look for natural rock exposures occurring in cliffs, gorges, etc., and be guided by stains, if any, on the rocks. Iron sulphides are about the commonest minerals in nearly all ore deposits, and when oxidized by exposure to the weather, the stains imparted to the surface will be yellow or brown. Copper, in like manner, gives blue and green surface stains, and in some regions, like the Slocan, such green and blue discolorations are an indication, usually, of high values in silver.

2. Watch for natural raised ledges and sags. Often the vein matter is harder than the enclosing rock and resists weathering better, so that it projects above the country. Or, if the vein matter is softer, a more or less defined trough results.

3. In a region where soil covers the rock, the prospector may come upon large boulders (*float*) of vein matter containing minerals. This must have come down-hill, and the parent ledge is to be sought in the direction of the drainage. Good judgment is needed. Examine matter composing river-beds for traces of heavy ore of metals. If the float be pebbly or rounded it is a sign that it has travelled far ; if the edges are angular, the ledge is not very distant. Where the clue has been traced, for instance, part way up a steep incline, the prospector may arrive at a point where no float is to be seen, for it naturally congregated at the bottom ; then the ledge is close at hand above, in the form, maybe, of huge crags of quartz. Often from the point of quitting the float a trench, dug to bed rock, exposes the vein.

4. Where grade permits, dams are sometimes built to hold back a stream, and when suddenly broken, the rushing water strips the rock of overlying soil and allows mineral to be looked for with comparative ease. This is called *booming*.

5. Timber of better grade than the general run of a particular area frequently is evidence of iron ore ; and, in Ontario at least, springs of superior quality are apt to exist where extensive iron deposits underlie. Magnetic iron ore is sometimes discovered by the wavering or variation of a compass or dip-needle. When the needle's agitation continues over any extended number of feet

General Principles.

the deposit is of some extent, and, if unexposed, can not be far below. Iron springs often accompany coal outcrops.

6. The contact of two different formations ought to be carefully examined on both sides. Pay heed to sudden changes in the strike of the ridge followed, likewise faults or other variations from the ordinary, and where eruptive dykes interrupt the formation.

If a prospector has some acquaintance with geology he is the better equipped, and the more he knows of mineralogy the better use he makes of his time. Tables, elsewhere, give a rough and simple means of identifying some common Canadian minerals, and the chapter on blowpipe work can be understood by anyone of average intelligence.

The surface of a vein bears little resemblance to the matter below. Oxides change with depth to sulphides, as oxide of iron to pyrites. A vein consisting largely of pyrites and quartz, therefore, on the surface becomes a cindery mixture of quartz and impure iron oxide, known as *gossan* or *iron-cap;* so that this capping often affords important evidence of what the vein matter will be below where unaltered. Example: limonite, being mostly derived from iron pyrites, when occurring on the surface with blue and green stains due to azurite and malachite, gives evidence of iron and copper sulphides.

Masses of highly oxidized matter (*blow-outs*) are common in galena regions. A peculiar purple tarnish very often is seen in rich galena.

Examine for silver all sulphide veins of copper, antimony, zinc or lead. When once found it is necessary to determine the value of the deposit. If the mineral occurs in a mass, as in beds, boring may be resorted to. Veins are rather more freaky and require careful examination. Those with sharp well-defined walls are best, as they offer some evidence of continuity below surface.

Gold often occurs in pyrites and in veins of crystalline quartz. When the quartz resembles *coarse*-grained white sugar, or is rust-stained and filled with small angular cells having iron rust in them, it is a good sign, particularly when the quartz streaks are sandwiched between layers of yellow and brown iron oxides, with a surface strewing of brown, spongy gossan. The vein's length along the top, as far as traceable, should be measured, as well as breadth at many different points, the distance between all these points being entered in a book.

Pits or trenches, sunk at right angles to the direction of the vein, are needful to determine the general *strike* (direction) and *dip* (its angle with horizon) with enough accuracy to furnish an idea of the future workings. Note any difference in the opposite walls of the vein and where occurring. Often a result of that

General Principles.

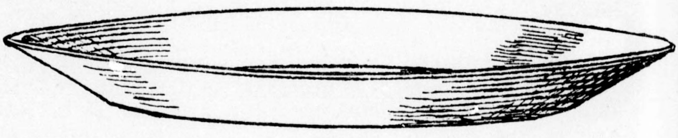
oxidation of the ore, before alluded to, is to rot and soften it so that the adjoining rock mass crushes inwards, leaving an outward show of merely a small streak; or the outcrop may fold back (tail-out) and give false idea of thickness. If the rock be rich, the more thorough this part of examination is, the better in the end.

SAMPLING.

A vein may be 30 or 40 ft. thick, but the poverty of the ore such that it is not worth working; or its richness may make a vein of but few inches repay mining. Disaster ensues, commonly, from testing at one point only; better many small, than one big sample. This is particularly true when precious metal occurs nuggety. Having selected the richest looking portion of a wide vein, at every 50 or 100 feet, shallow cuts or pits should be made across the vein; or, if it is a narrow one, a common practice is to break out a trench along the exposure. In both cases, at measured points on the vein, and chosen with a view of correct averages, take samples at intervals across it, number them, and record the breadth of the vein in each case.

PANNING.

If gold is searched for, remember that nearly always a pocket-lens fails to show the metal owing to its fineness, and panning is necessary. A pan is a round shallow dish, shaped after the frying



Gold Pan.

pan (which will answer if wholly free from grease), about 15 in. wide, 3 in. deep, with sloping sides. The ore is ground to powder fine enough to pass the sieve, by means of an iron mortar and pestle, which for prospecting need not weigh over ten pounds. The process gives lower results than a careful fire assay but shows closely what a mill would save. From the samples broken from one of the transverse cuts, select a few which seem to give a fair average, and powder them. Make it a rule always to pan the same quantity, 8 oz. being a convenient weight. By noticing the colors of gold obtained in a pan from a never-varied weight of ore, a prospector acquires an accurate idea of the yield per ton, after his judgment of the colors is corrected a few times by the assayer's figures.

If too much has been powdered, thoroughly mix the whole before weighing out the half-pound required. For the latter and

Panning.

other purposes it is handy to know that some necessary part of the kit weighs an even pound—a tin of condensed milk, for instance.

Panning is best done at the edge of a still pool or stream. The powdered ore is placed in the pan, which is then filled with water. The ore is stirred round with the hand (which must be free from grease) and the muddy water poured off carefully; this is repeated until the water remains fairly clean. The pan is then tilted so as to bring all the remaining sand with the heavy minerals, gold and particles of iron ground off the mortar, to one side; by shaking the pan in this position the heavy particles settle to the bottom. Part of the top sand is then washed away, the remaining ore is settled by shaking as before and the top sand washed off again. Finally, there is nothing left but the iron, heavy minerals, gold, and a very small quantity of sand. By now using just enough water to cover this residue, as it lies in the angle of the tilted pan, and by washing it carefully round in this angle with a vibrating motion, the gold will collect at the upper end in a little "tail" (or elongated patch of colors), or a few grains, according to the richness of the ore. If doubt is felt as to whether the grains are gold, they may be tested by the point of a knife to determine if they are malleable, as they should be. The final stages of panning require great skill in manipulation, which can only be acquired by practice.

Rough Method of Assay for Free-Milling Gold Ores.—After panning down exactly 8 ounces of rock, as previously described, there will be left in the pan the gold and concentrates (which should not exceed a thimbleful, except in a very heavily mineralized ore). By collecting this to one spot in the angle of the pan and pouring off all the water, the residue may be made into a paste with assay litharge, sodium bicarbonate, and a little borax. This is then carefully transferred to a hole cut in a piece of charcoal, and fused until nothing remains but slag and a button of lead. If the paste is too bulky for one test, it may be divided and treated in two or three operations, and the resulting buttons fused into one. This button of lead will contain all the gold, and is then treated on a cupel as described elsewhere. The lead is volatilized and absorbed, leaving a bead of gold containing whatever silver may be present. If the bead is very yellow, it is probably all gold, if pale yellow it contains some silver: a bead containing half gold and half silver is almost silver-white. For weighing this bead a balance, sensitive to $\frac{1}{10}$ grain, can be obtained, cost $4 to $5. One grain of gold is worth 4.166 cents, or one ounce worth $20.00. The following table gives the value per ton when 8 oz., and 1 lb. are taken, respectively.

Panning.

Grains.	8 Oz. of Pulp Taken. Ton of 2000 Lbs. Oz.	Dwt.	Grs.	Value Per Ton.	1 Lb. of Pulp Taken. Ton of 2000 Lbs. Oz.	Dwt.	Grs.	Value Per Ton.
$\frac{1}{10}$		16	16	$16.66		8	8	$8.33
$\frac{2}{10}$	1	13	8	33.33		16	16	16.66
$\frac{3}{10}$	2	10	0	50.00	1	5	0	25.00
$\frac{4}{10}$	3	6	16	66.66	1	13	8	33.33
$\frac{5}{10}$	4	3	8	83.33	2	1	16	41.66
$\frac{6}{10}$	5	0	0	100.00	2	10	0	50.00
$\frac{7}{10}$	5	16	16	116.66	2	18	8	58.33
$\frac{8}{10}$	6	13	8	133.33	3	6	16	66.66
$\frac{9}{10}$	7	10	0	150.00	3	15	0	75.00
1	8	6	16	166.66	4	3	8	83.33

This table is based on the value of pure gold, therefore if the bead contains silver the value of the ore is proportionately reduced; thus if the bead weighed $\frac{1}{10}$ grain, and contained half gold and half silver, since silver is worth about 66 cents per oz., the value per ton would be only $8.60.

With a little ingenuity a torsion balance may be made to measure $\frac{1}{100}$ grain. A fine platinum wire about 2 ft. long is stretched between staples. One end of a very thin sliver of wood, or a straw (used as a lever), is attached to the centre of the wire by a small clip. When the balance is at rest the outer end should be slightly elevated above the horizontal. Beside the point of the lever is placed an upright, and the position of the lever point marked thereon. A $\frac{1}{10}$ grain weight is now put in the weighing cavity near the point of the lever and the second position marked: by dividing this space into 10 equal parts, beads from $\frac{1}{100}$ to $\frac{1}{10}$ grain may be weighed. By using longer and finer wire, and by regulating the tension carefully, the balance can be made sensitive to weights of less than $\frac{1}{100}$ grain. With this balance, values of $1.60 or even 80c. per ton may be detected.

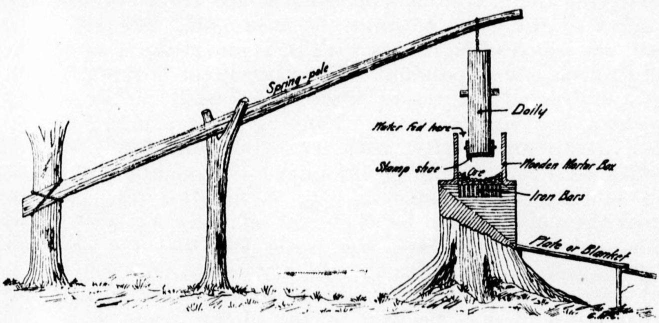
Parting.—If it is thought necessary to determine the proportionate values of gold and silver in the beads obtained from th

Panning.

tests, this may be done as follows: take two or three of the beads, note their total weight, then fuse them together with about twice their weight of pure silver and some test lead, into a button. Cupel this and dissolve the bead in nitric acid in a small porcelain cup, the gold will be left as a dark brown powder which can be weighed (after washing and drying) by carefully brushing it into the weighing pan with a camel's hair brush. The result will be the weight of pure gold in the original beads taken. Thus, if original beads weighed 0.7 gr., and resulting gold 0.6 gr., then 1 oz. bullion = $\frac{6}{7}$ gold + $\frac{1}{7}$ silver, = $17.15 gold + $0.10 silver = $17.25 per oz. bullion.

PROSPECTING MILL.

Dollying.—If the prospector desires to test the surface value of his property more carefully, it may be done by constructing a prospecting stamp mill as shown in the cut.



Prospecting Stamp Mill.

It will be seen that in principle the contrivance is a large mortar, with a heavy pestle which is balanced on a spring pole. The "Dolly" is a round stick of timber fitted with a shoe, the latter made of a piece of wrought iron boiler plate bent round its lower end, and spiked. The mortar may be constructed of a heavy log or a suitable stump. The iron bars upon which the ore is crushed should be 18 in. long, about $\frac{1}{2}$ in. × 3 in. section, and laid on edge close together. Water is fed continuously. When the ore is crushed fine enough it is washed through, helped by the jarring, and flows through a riffled sluice, or over a blanket or amalgamated copper plate (see stamp mill). If a blanket is used the gold and heavy minerals become entangled, tailings being washed away. At intervals the blanket is removed and shaken

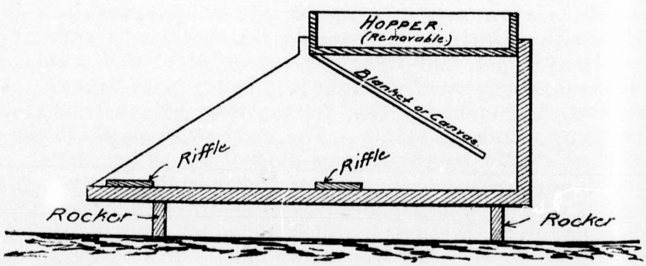
Prospecting Mill.

in a tub of water, the gold in the tub being collected with mercury, while the concentrates may be saved for assay.

Should favourable results induce the prospector to further examination, he may sink a shallow shaft where the best ore is found on the line of outcrop by panning. Sample all the way and expose both sides of the vein, if possible, to be certain that, to that depth at least it does not pinch out or otherwise vary. Having staked his claim, and noted the general features of the locality, the prospector is then in the best position, if his find is worth anything, of interesting people with capital, provided he does not wish, or lacks means, to develop the property himself.

ALLUVIAL PROSPECTING.

Prospecting for river or alluvial gold is done by panning the sand, from which the pebbles must first be removed. The sands underlying the gravel beds of streams are those to search, also crevices of the rock bottoms, because gold, like the valuable platinum which often occurs with it, is one of the heaviest metals and sinks as low as possible. The bottom of a rapid is a likely spot, and bends of rivers where the speed of the current is checked, and eddies occur. Panning gives a product of black sand, usually magnetite, with whatever gold may occur. The results of several pannings are mixed thoroughly with mercury and squeezed in a buckskin bag, saving the quicksilver as it comes through. It can be used over and over again by cleaning with nitric acid one part, and water two to three parts. The mixture left in the bag is then highly heated on a shovel or pan, and the gold, if present, is easy to detect. When a rich bar is struck the gold may be won by any of the placer methods: by pan, by *cradle* (a small trough on rockers), etc.



Rocker or Cradle.

PROSPECTOR'S EQUIPMENT.

1. Long handled prospecting pick	4	lbs.
2. Mortar and pestle	10	"
3. Sieve of 40 mesh 4. Gold pan	2	"
5. Magnifying glass 6. Magnet 7. Canvas sample bags 8″ × 14″ (½ doz.) 8. Compass	1	"
9. Tent, small	10	"
10. Cooking utensils (frying pan, two tin pails, one fitting in the other, tin plates, cups, etc.)	3	"
	30	lbs.

Food Supplies.

1. Flour	per man	per week	5	lbs.
2. Bacon or pork	"	"	5	"
3. Beans	"	"	2	"
4. Oatmeal and rice	"	"	2	"
5. Sugar	"	"	2	"
6. Tea and coffee	"	"	½	"
7. Baking powder, salt, pepper, etc.	"	"	¼	"
Total per man per week, say			17	lbs.

The above list of food supplies includes only necessities, and can be varied or added to according to individual tastes.

If the prospector has acquired sufficient knowledge and skill to enable him to use the blowpipe he will often find such an outfit as that described in the mineralogy a very useful addition to his equipment.

When prospecting is to be done in mountainous regions, as in British Columbia, it is an object to make the "pack" as light as possible, and only absolute necessities can be taken. The explorer usually carries his pack on his back, though if he can afford it, it is better to take a cayuse or a pack mule to carry his supplies. A man can pack on an average about 60 lbs. It is possible for two men to carry sufficient to stay out three weeks. A pack mule will take 250 to 300 lbs. and can be obtained in British Columbia for about $20. Prospecting in Western Ontario is, as a rule, a much simpler matter. One can go almost anywhere in a canoe, with occasional portages. The surface, too, is usually freer from earth, gravel, etc., than in British Columbia, and the woods are also less dense. In a canoe two men can take more than twice the quantity of supplies that they could were they obliged to carry it on their backs.

FORM TO BE FILLED OUT IN DESCRIBING A PROSPECT.

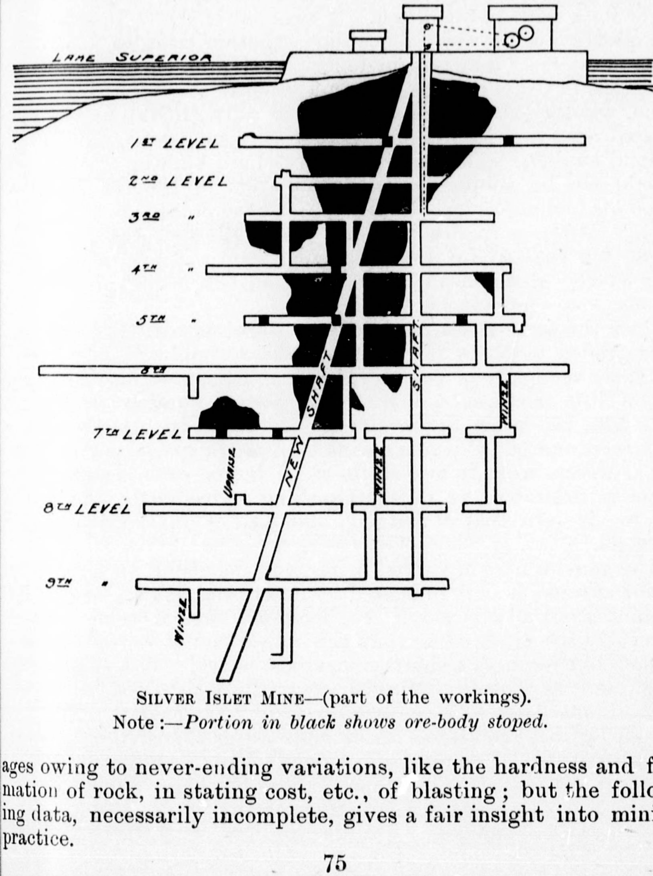
Date ....
Nature of the property ....
Area of the property ....
Location of the property ....
Application made by ....
Survey made by ....
Names and addresses of present owners ....
Nearest P.O. ....
References ....
How the property can be reached ....
....
....
What development is done ....
....
Approximate height of outcrop above nearest water ....
What advantages does the neighborhood offer for a mill-site ......
Facilities for shipping ore ....
What are the water rights and power, and distance from the property ....
Nature of country rock ....
Length of outcrop traceable ....
Strike of vein ....
Width of vein at different points ....
Width of pay streak ....
Dip of vein ....
Character of the walls ....
Character of ore (free milling, refractory or concentrating, etc.)
....
Result of assays, and by whom made ....
By whom, and how samples were made ....
Alluvial properties :
- Character of deposit ....
- Value per cub. yd. ....
- Depth to bedrock ....
- Facilities for dumping ....
- No. of working months per year ... ; from ...... to ......
- Water supply for hydraulicking, etc ....
- Approximate quantity and head obtainable ....

Is the property dry or wet ....
What fuel obtainable ....
What timber or lumber ; at what distance ....
General remarks ....

MINING.

General.

The cost of operation varies with conditions, and demands careful consideration. A given deposit may be valueless because its depth below the surface makes it too costly to mine and hoist; and close estimates are desirable down to the smallest and every detail. Figures, of necessity, can be but aver-



Silver Islet Mine—(part of the workings).
Note :—*Portion in black shows ore-body stoped.*

ages owing to never-ending variations, like the hardness and formation of rock, in stating cost, etc., of blasting; but the following data, necessarily incomplete, gives a fair insight into mining practice.

General.

Except in rare cases (by diamond-drill trials, for instance) the discovery of beds and veins depends on their exposure at the surface. The position, angle, etc., of the exposure (outcrop) with respect to the ground in the vicinity having been noted—after stripping of surface soil where necessary—some idea is gained as to the "lay" of the ore body beneath. Development work, with a view of determining extent and value, is the next step, and ought to be carried on that it may serve some useful purpose in the future working of the mine, should it become one. A hillside outcrop, for instance, may suggest either a tunnel or a shaft entry for development, whereas one might be better suited than the other for a mine in operation. A vein out of the vertical presents the question of the shaft's location; whether on it, or to one side, so as to intersect it at certain depth. Such problems occur in many varieties, but this may be said in a general way: the entry to a mine, whether shaft, slope, tunnel or adit, should be centrally located near the rich ore body and so as to aid drainage and underground hauling. The cases are few where sinking on the vein should not be adopted until examination of the ore along the slope (or incline) reveals its worth. By so doing you "pay your way." After a freaky vein has been followed, the slope may prove too twisted for use as a hoist-way, and the owners then may either abandon it for a new and better-chosen entry, or devote it to exploratory work.

Once the ore body is reached, levels are run (drifted) right and left, graded towards the outlet. These should be every 60 to 100 feet, vertically in veins. They cut the mine into horizontal layers (lifts or stopes) which are increased in number and lessened in height, the larger the proposed output is. In other words, an increased number of levels means increase in space open for blasting. Miners work in two shifts of 10 hours each, except where haste is desirable, as in shaft-sinking. Ordinarily, the cost of stoping is $\frac{1}{10}$th that of drifting, and $\frac{1}{30}$th of sinking, and $\frac{1}{15}$th of upraises.

The general uses of shafts, drifts, etc., as above, in getting ore to the surface, is best indicated by describing shortly the process of mining out an ore body. For example, take a vein—vertical, or nearly so—situated so that the mine cannot be opened by a tunnel, but requires a shaft as means of entry. This shaft is first sunk, and, as already described, along the vein levels are driven from it every 60 to 100 feet, vertically, as desired. The vein matter left between these levels constitutes the stoping ground. Suppose overhand stoping is to be employed. At a suitable distance from the shaft along one of these levels, in which a tramway exists, an upraise is begun through the ore body and carried to the next level above.

General.

Stoping.—The process of stoping now begins at the point where the winze meets the lower level. The ore constituting the roof of the level at this point is broken down, loaded on the tram-car, run to the shaft, and hoisted to the surface. Platforms are erected so that the now heightened roof can be reached, and more material is blown down and removed. Eventually the level is roofed in and, if needs be, platforms erected above it so that the roof of the stope is easily reached. This process continues till the whole of the ore body has been worked out, an artificial floor being built for the upper level as the stoping process removes the original one. By means of a box, or chute, built in the winze or at any convenient point, ore from the stope may be readily delivered to the level below, where a sliding gate prevents it from entering the level, except when loading cars.

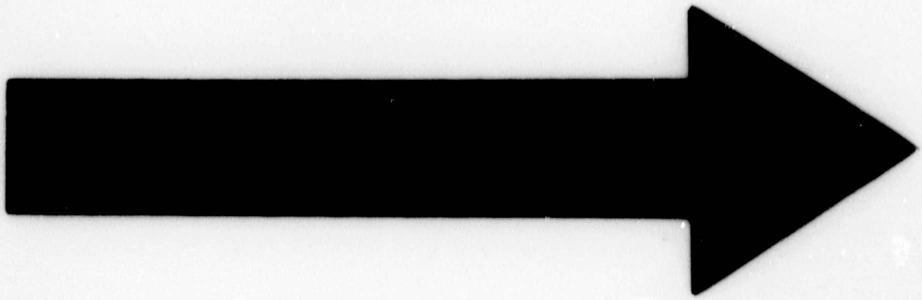
If underhand stoping is to be employed the process is begun at the junction of the winze and the upper level. Stoping may be carried on from both sides of a winze. It will readily be seen that the rate at which ore can be got from the mine depends upon the number of stopes working, which in turn depend upon the number of winzes connecting the levels, and the distance apart of the levels themselves.

Edmund B. Kirby, M.E., Colorado, gives the following yields and costs of stoping per ton of ore broken, being approximately correct for Canada:

Thickness of pay streak calculated for ore when 13 c. ft. = 1 ton.	*Tons per sq. fathom of ore sheet.*	*Cost per ton.*
A streak 4 in. wide yields	0.92	$17 33
" 6 " "	1.38	11 55
" 8 " "	1.85	8 67
" 10 " "	2.31	6 93
" 12 " "	2.77	5 78
" 14 " "	3.23	4 95

These costs are calculated, assuming wages of miners at $3.50 for 10 hours, timbermen $3.50 for 10 hours, foremen $4 to $5 per day, blacksmiths $3.50 to $4, trammers and surfacemen $2.50.

Shafts.—The size of these should increase proportionately with depth and intended output, and additional space provided for ventilation at the rate of 1 sq. ft. to 8 men. In soft ore the shaft should reach from wall to wall, and in hard rock veins is preferable on the footwall side for safety. Small shafts, say 5 by 7 ft., are sunk cheaper by hand than by power drills, and nearly as quickly, and cost $15 to $25 a running ft. for the first 100 ft. Only two miners can work on 20 sq. ft. area. In an 11 by 10 ft. shaft, 2 machine drills can work conveniently, and in ordinary rock sink from 3 ft. to 5 ft. per day. Sinking costs from $5



General.

to $18 per cubic yd., but below 100 ft. the cost increases each 100 feet as the square root of the depth. Rapid progress is made for 10 or 15 ft., the rock being shovelled up from platform to platform; below that, down to 100 ft., it may be hoisted by windlass, beyond which machine hoisting must be resorted to. Unless the country rock be very firm the shaft has to be timbered, and pumping is compulsory if water collects. If there exists any doubt as to whether timbering will be needed, trim up the shaft as you go.

Drifts, Tunnels, Adits.—The larger these are, the greater need for timbering. The average drift is 4½ by 6 ft. and offers good space for 1 drill, while in a 10 ft. width 2 may work. In hard rock 1 ft. per shift is fair work, in soft 3 ft. or more. Hauling through a tunnel is about twice as fast as shaft-hoisting. Tunnels over 8 ft. high are driven in benches. In the west, the cost of driving varies from $3 to $9 per running foot in stratified rocks, and from $7 to $10 in granite.

METHODS OF MINING.

Ore deposits may be thick or thin; and occur at any angle with the horizon. The mode of actual mining for different cases is shown by the following table.

Dip less than 45°	Under 6 ft. thick	Long-wall	Friable or soft roof
		Pillar and stall	Firm ore.
		Flat stopes	
		Panel	Gaseous coals.
	Over 6 ft. thick	Gallery and pillar	Hard ore.
		Method of caving	Yielding vein-matter.
		Method of filling	
		Square setts	
		Square work	Medium-firm ore.
Dip exceeding 45°	Under 8 ft. thick	Overhand stoping	Firm vein-matter.
		Underhand stoping	Friable ore.
	Over 8 ft. thick	Traverse with filling	
		Traverse with caving	Soft ore.
		Traverse with sq. sett	

From 30 to 60 ft. of unworked rock should surround shafts; haulage ways in beds, by pillars 60 ft. wide on either side; stopes by arches of 10 to 20 ft. thick. In beds the unworked matter for support nearly equals that mined in the rooms.

Long Wall.—In coal mines two or more parallel haulways, 20 ft. apart, are driven, one from each entry. Tramroads are then driven to the rise of the seam, and from each road the face of ore is undermined, and cut vertically to right and left so that its weight tumbles the overhanging portion; or, otherwise, makes its removal easy by blasting. The refuse is thrown behind the

Methods of Mining.

men. For ten feet in front of the working face the roof is kept well supported, and, to prevent the waste obstructing the ore cars, the tramway needs protection with pack walls and roof timbers. Long wall methods thus effect removal of the ore without leaving portions for support.

Pillar and Stall is the most common method for flat beds of any mineral. At right angles to the gangways and every 20 or 30 ft. along it, passages (from 6 to 8 ft. wide) are driven towards the rise of the bed. At a safe distance from the gangway, to leave stump pillars, the ore between every alternate pair of passages is rapidly mined, forming rooms 20 or 30 ft. wide and from 8 to 10 times their width in length, progress being backward up the slope. A chain pillar of solid ore 20 to 30 ft. wide is thus left between each room, clear to the upper level, for support. Every square foot of roof area receives a pressure of 8 tons per 100 ft. of overlying strata, and the relative width of pillar and stall varies with different ores. When the rooms reach the far edge of deposit, the pillars are robbed, retreating, sometimes by long wall.

Panel System.—From gangway to the upper level, roadways are run at suitable distances apart, and from it roads and breasts are driven horizontally. When the breasts are mined and the roof settled, the heavy barrier pillars which separate the panels, are rapidly robbed, as well as the stump pillars.

Square Work.—From the gangway, rooms 150 ft. square are opened, with 30 ft. thick pillars between. The rooms are divided by two sets of cross galleries, 20 ft. wide, which leave 9 pillars about 25 ft. square for supporting roof.

Gallery and Pillar is a wasteful system by which the mining is done by driving numerous galleries, as wide as the roof allows. The ore between is not recovered. Large irregular deposits are so treated.

Square Sett.—The deposit is alternately divided into rooms and pillars, both 20 to 30 ft. wide. The room is worked in 7 ft. breasts, and when each breast is blown out to depth of 7 ft. a square sett of timbers is built to the roof, replacing the ore. Each sett is framed to its neighbor, and the mining proceeds by slices each 7 ft. high. Little of the timbering is recovered. The setts are strong, easily erected, and admirably adapted to all thicknesses of ore deposits or variations in hanging or foot walls.

Quarrying is adopted for slate, building stone, iron, lead and zinc ores, peat coal and graphite. Larger masses may be taken out whole and from many points at once. All deposits near the surface can be thus worked, but at a certain point the retaining of the sides of the pit becomes too expensive. Drainage is, also, a factor to be dealt with.

DRILLS.

Hand drills include the churner and the ordinary drill, and both may be made by any blacksmith. The churn drill is a heavy iron bar pointed with steel at each end; it is lifted, dropped, and thus churns down a hole. A convex cutting bit is the most generally satisfactory, and when one end of the drill dulls, it is reversed, this second bit being a trifle smaller to prevent sticking. The ordinary drill is simply a bar of steel, circular or octagonal, sharpened at one end only and the other squared for the hammer. After each blow it is turned in the hole. Water is poured in to preserve the temper of the steel and to "mud" the powdered rock, which is scraped out frequently. If a single man works the drill the size is from $\frac{3}{4}$ to 1 in.; if one strikes while another holds and turns, 1 to $1\frac{1}{2}$ in.; if two strike, as large as 2 in.; but holes over $1\frac{1}{2}$ are exceptional. The hole is begun with a "starter" or short drill; longer ones are used as depth is gained. Each drill has a somewhat smaller bit than the previous one, so that a tapering hole is produced, the final diameter being about $\frac{1}{8}$ in. greater than that of the cartridge. The bit is larger than the rest of the bar to prevent sticking. Hard, brittle rock is best broken by long, narrow holes; tough or fissured material by short, wide ones. About 30 inches of holes per shift is the average in medium rock, single hand. The hammer is of 4 or 5 lbs., with short oval handle. Experience alone teaches the least amount of drilling necessary for taking out a given quantity of rock, and the proper angle for the holes. The consumption of steel in medium ground is about 25 cents per cubic yard removed. In soft schists and sandstones single hand drilling is from 20 to 30 per cent. cheaper than two hand drilling, and in hard rock more rapid progress can be made. In most cases, except for shaft sinking, it is better than two hand drilling. Drill steel costs about 16 cents per lb.

EXPLOSIVES AND BLASTING.

Common black powder and dynamite are favourite mining explosives. The dangers attending the use of nitroglycerine led to experiments on some safer form of the powerful explosive, and dynamite was brought out, which carries the nitro in some absorbent such as wood pulp, infusorial earth, etc. It is made in many grades.

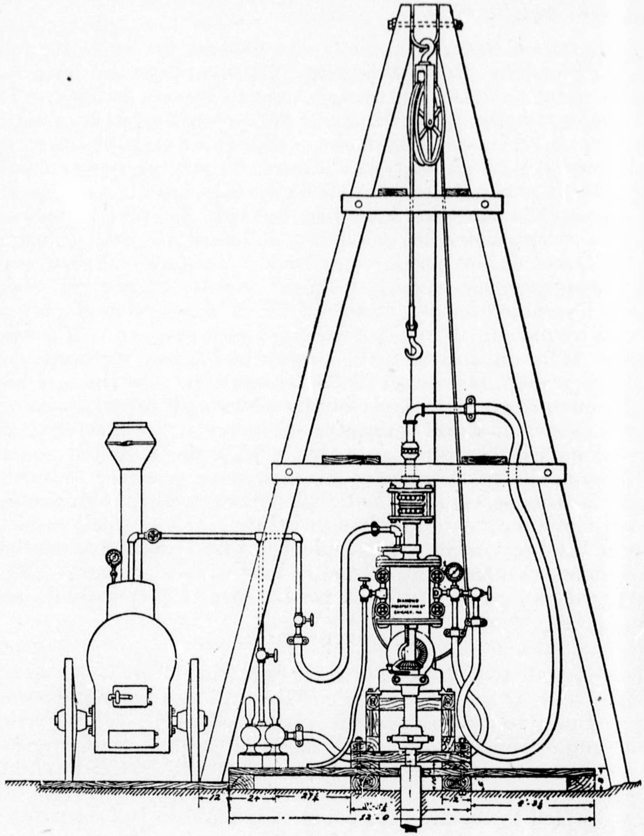
The explosive should not fill over one-third of the hole, the balance being filled with clay or other tamping and the tamping never placed except with a wooden bar. One foot of a one-inch hole can hold 5 oz. of powder. Black powder is used in heavy galena ores, in serpentine and similar rock, or wherever the quicker shattering powders would pulverize the ore too much; the

Explosives and Blasting.

highest grade of dynamite, No. 1, has 6 times the explosive force of black powder. Detonators (caps) are generally used for firing, and to them are attached fuses, or wires from a battery. The shooting is usually done at the end of the shift, so as to give the mine time to clear itself of smoke. Sandstone and limestone are best split by weak powder, as a strong one may pulverize a large portion of it without breaking stone. Trap, granite and syenite are firm and brittle—hard drilling but easy shooting; quartz is hard for both; dolomite, amygdaloid, limestone and porphyry drill easy but do not break to the back of the hole. Every cubic yard removed consumes $1 worth of powder in medium tough rock. Dynamite freezes at 40° to 44° F., and should only be thawed by placing it in a pot inserted in a larger pot of boiling water. It is difficult to make miners heed these warnings, and the only proper plan, on all scores, seems to be to make one man, the foreman of each shift, personally responsible for the dynamite from the moment it leaves the store-house until the holes are fired. Powder should be stored in a dry, cool, well-ventilated surface store-room. Caps should not be kept with powder. Jars sustained in wagons, etc., will not explode even well-thawed powder, and with ordinary care it is handled throughout as safely as black powder. Give "missed fires" plenty of time to fire; after that, carefully extract the tamping and re-load with a big charge. No. 1 giant costs about 18 to 22 cts. per lb., No. 2, $9 per 50 lb. box.

DIAMOND DRILL.

Some favour the diamond drill for exploring ground. Its motion is rotary and, as the bit may be circular and also hollow, a core of the rock may be brought to the surface when desired. From 6 to 20 rough diamonds (borts) are mounted around the lower face of the bit and, the revolutions being 400 to 800 per minute, progress averages from 1 to 2 ft. per hour, stops inclusive. The bit is coupled to tubing, that being added in 5 to 10 ft. lengths as the hole deepens. The wear of the diamonds costs 21 to 56 cts. per ft. Five men can keep 2 drills working. The only bad feature is that the comparatively small bit may happen to strike a particularly rich portion of the vein, or it may just miss fairly average rock altogether and mislead in either case. In estimating the exact position from which a core was obtained it is necessary to remember that even with expert superintendence the tubing is apt to deflect, perhaps corkscrew, in certain formations even at moderate depths. An 8 horse-power engine is suitable for 1,000 ft. holes. Laid down in Canada, a drill (suitable for underground or surface exploitation) capacity 300 ft., core 1 in., costs about $1,500; another of 500 ft. capacity, and also with full equipment, about $3,000.



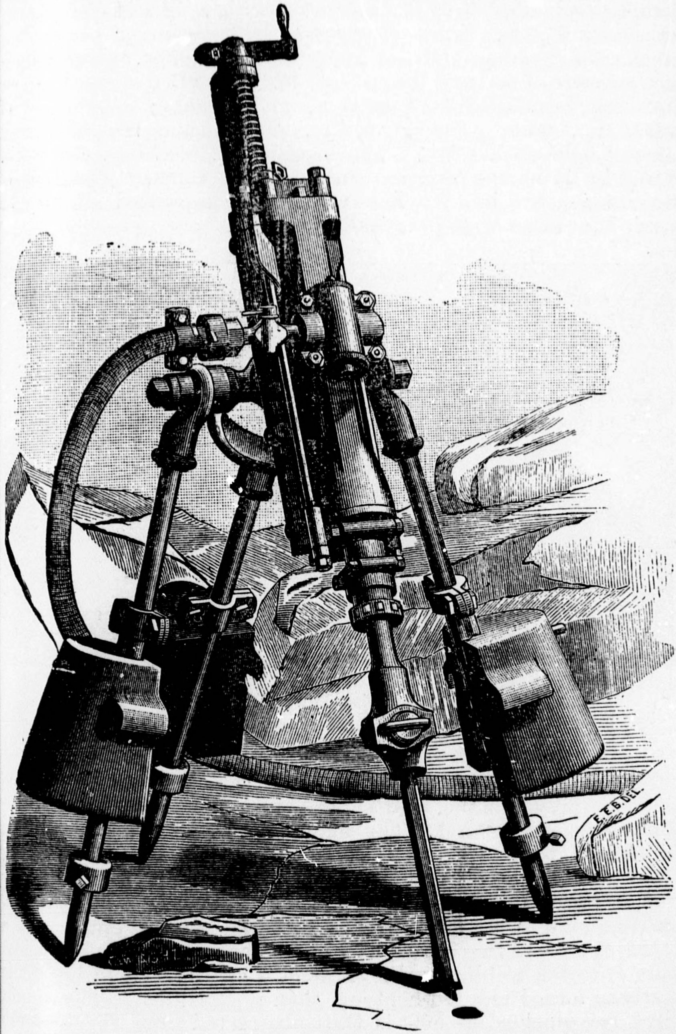
Diamond Drill.

MACHINE DRILLING.

Except for development work or where compression plants are too expensive, power drills have superseded hand drills. *Power drills* are pistons working in cylinders, mounted on tripod or column, and a bit which is clamped to the end of the piston-rod. The average mining size is the 3-in. piston, 1 to $1\frac{1}{4}$ in. steel, feeding 20 to 24 in., and usually having 8 bits to the set, the longest for a 10-ft. hole. It costs about $300, and weighs, exclusive of tripod or column, 270 lbs. Each bit has a life of about 275 ft. of

Machine Drilling.

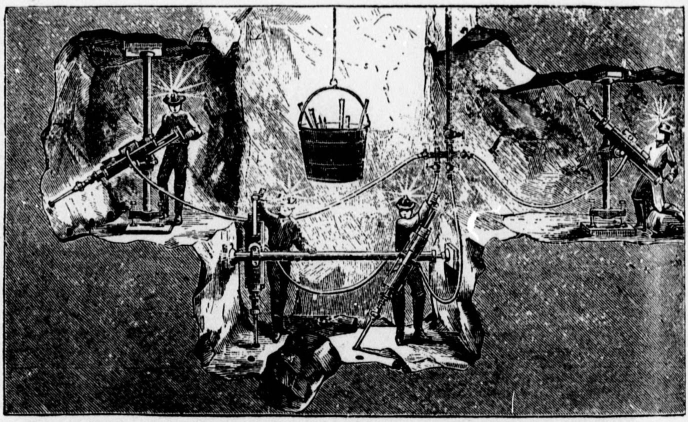
holes, and ordinarily drill from 1 to 2 feet before needing sharpening. In quartz 50 to 60 ft. of holes per day, 90 to 100 in slate, are averages. The cutter is usually of X-shape, but I, Z or S are



Power Drill.

Machine Drilling.

sometimes used. Holes should be started with short, light strokes, and a requisite of all drills is a capability for variable stroke and for mudding well. The speed averages 200 blows per min. A complete plant of 6 drills, as above, with a 16 × 24 compressor, etc., costs $7,000. In running power drills steam or compressed air is used above ground and compressed air below, with an average pressure of 50 to 80 lbs. per sq. in. Out of an average 8-hour shift the actual drilling time is about 5½ hours; the shifting of tools, etc., takes ½ hour; loading, blasting and removing rock about 1 hour each. In 7 × 7 ft. headings, 2 machines can work. Roughly, 11 horse-power is required to run 1 drill. The limit of steam is reached in a few hundred feet; compressed air may be carried for miles with practically no loss.



Mining with Power Drills.

BLACKSMITHING.

The blacksmith is a most necessary accessory to a developing claim or proven mine, and shows his ability when sharpening tools for hard ground. The shop should be supplied with a full kit of tools, good bellows and tuyeres, Peter's anvil, vise, taps and dies, twist drills, round and square ½ to 1¼ in. bar iron, strap and hoop iron, carriage and machine bolts, screws, spikes, nails, a few horse-shoeing tools, benches, etc., all in a space of 14 × 12 ft. Wrought iron is the most generally useful kind of metal, welding well. A steel is called hardened after it has been forged to a red heat and then plunged into cold water or oil. The quicker the heat is thus abstracted from the tool the

Blacksmithing.

harder it will be. *Tempering* properly is a process following hardening, the steel being given a lower re-heat, which softens it and removes the brittleness. The risk is in overheating and burning out the carbon essential to hardness. When the hardened iron is slowly re-heated it passes from light straw through shades of yellow, brown, purple, blue and red. At the red heat the effects of the chilling are practically removed. Tempering consists in carrying the re-heat to one of the above colors, according to the amount of brittleness to be annealed, depending on the use of the tool. In practice this re-heat is carried a little way beyond the desired color, the article is carefully plunged part way into the water, till the disappearance of the steam indicates that it is cold, when another portion of the distance is further immersed for a moment. The article is withdrawn, the scales rubbed off, and the heat of the remaining portion draws to the edge, until the proper tempering color appears. It is then thoroughly cooled. Wave the tool slightly when in the water to avoid the tendency to fracture at a certain color-line if held there too long. Experience teaches the proper color for a certain class of rock. Pieces that are to be tempered throughout are uniformly heated before plunging.

For forging and dressing machine bits a special kit of "dollys" and "swages" are used to give the X-shape to bits ; cost, $20. A good sharpener can dress tools for 8 or 10 gangs (3 men each) on medium rock, and swage I or X bits for 7 machine drills ; so, for a small mine employing 20 hands in all, one blacksmith is ample. With a striker he can make 12 heavy picks, 20 light ones, or weld 40 pick-stems in a shift.

Tempering Colors.—Very faint yellow to pale straw. Suitable for hard instruments, as hammer faces, drills, etc.

Full yellow to brown. For instruments requiring hard edges without elasticity, as shears, scissors, turning tools, etc.

Brown with purple spots, to purple. For tools for cutting wood and soft metals, as plane-irons, knives, etc.

Dark blue to full blue. For tools requiring strong edges without extreme hardness, as cold chisels, axes, cutlery, etc.

Grayish blue, verging on black. For spring-temper, which will bend before breaking, as saws, sword blades, etc.

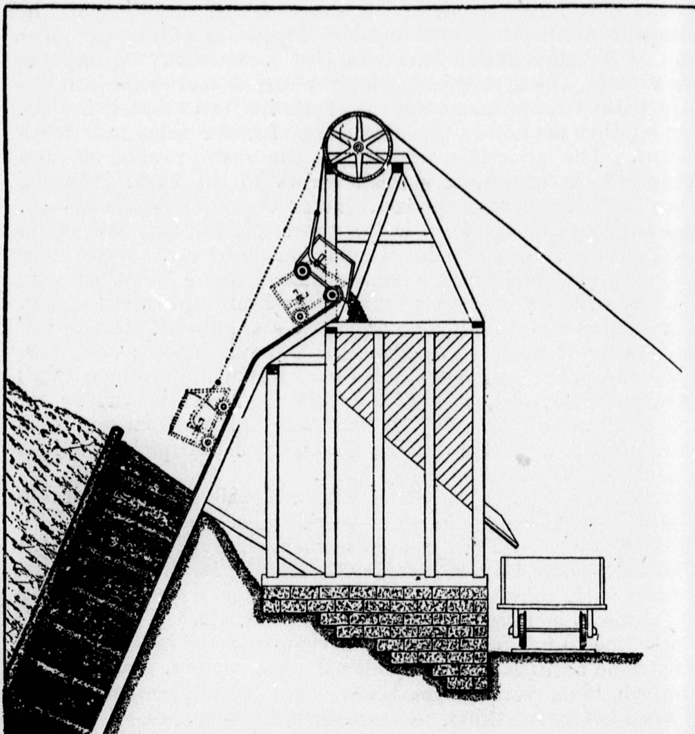
If the steel be heated higher than this, the effect of hardening process is destroyed.

HOISTING.

For shafts of moderate depth and for winzes a windlass is used, though in an 8-hour shift 2 men cannot raise over 4 tons through 100 feet. The windlass-barrel is of 6 to 10 in. diam., and long enough to cross the shaft. It is turned by 2 cranks, 15 in. long, set at right angles, and the simpler the mechanism the better.

Hoisting.

Properly, when the height is over 60 ft., or output over 5 tons per shift, horses should be used, a horse being able to raise 8 tons 200 feet per day. For greater depths or quantity 2 horses are used. A 28 horse-power engine can do as much work as 300 men on a windlass, or 35 horses on a whim, and at less cost. Rapid hoisting necessitates good shaft timbering and firm founda-



Skip-hoist.

tion for engines, etc. Wire rope is as pliable as hemp, and much stronger for same weight and money. A 1 in. wire rope, at 140 lbs. to the 100 ft., good for a working load of 9,000 lbs., requires at least a 4 ft. drum ; it takes a 3 in. hemp rope for same strength. Hoist ropes are only good for 18 mos. continuous service, and demand inspection weekly.

Hoisting.

Buckets (*kibbles*)—from 18 to 33 in. diam., 30 to 54 in. deep, weighing 150 to 900 lbs., and carrying 600 to 3,000 lbs. of ore—are used in shafts (or slopes, sliding on skids) where the developments are not extensive enough for more elaborate arrangements, and also during sinking. If wire rope is used a short piece of heavy chain is placed between the bucket hook and the rope socket. Strong iron boxes (*skips*), weighing 900 to 1,500 lbs., on four wheels, are used in slopes. *Cages* are simply platform lifts (running on wheels if in a slope) on which ore-cars are run and hoisted. At the several levels in metalliferous shafts, buckets land on a hinged door. When not used it is hooked up, closing the drift and leaving the hoistway clear. In deep shafts an ordinary rope, owing to its own weight, becomes unsafe for the added strain of the load, and recourse is had to one that tapers; but in slopes such cannot be used because the lowest and thinnest portion gets most wear over the wheels which lead the wire. Cages are being hoisted in vertical shafts at 2,500 feet per min.; skips at 1,000; buckets at not over 300. The diameter of the sheave should be 100 (48, at least) times that of the wire rope. The usual number of wires to the strand is 19, twisted about a hemp centre for durability and flexibility. Suitable mechanical appliances for indicating to the man in charge at the surface the position of the load in the slope or shaft, and for preventing over-hoisting, are required.

UNDERGROUND TRAFFIC.

This is done by cars, which in metal mines weigh from 600 to 1,500 lbs., and cost from $50 to $200; usually their weight is about half of contents. A shoveller can load into a 3 ft high car 20 tons per shift, into a 4 ft. only 14. In thin seams and steep veins cars are confined to main haulways, and are filled from chutes fitted at the lower end with a gate. The tracks are preferably of about 2 ft. gauge, of T rails running from 12 to 16 lbs. per yd. in gangways and levels, to 35 in slopes. The larger the output, or the smaller its value, the better needs be the roadbed, on the score of cheap, rapid hauling. Under certain conditions it is desirable to leave one or both wheels on an axle loose, loose wheels being best for short roads and sharp curves. A power that will pull 100 tons on the horizontal can only manage 47 up a slight grade of 20 ft. per mile; and 25 and 13.5, respectively, on a 1% and 2% incline. The maximum grade allowable is 3 ft. in 100. Men push the cars in small mines; but horses, or steam or electric power, are used in large ones.

It frequently pays to have long underground hauls to the main shaft, instead of going to the expense of sinking another, and the

Underground Traffic.

plan varies according to the grading of the haulway towards the shaft.

(1) If horizontal, power is needed both ways by man, horse, locomotive, motor, or rope-ways may be employed.

(2) If graded towards the shaft, the full train pulls the empty up on a self-acting tramway, the rope connecting the two trains passing round a sheave or drum fixed at the far end. The smallest grade is $10\frac{1}{2}\%$, the best 20% ; if over 33% brakes must be applied, while at one exceeding 70% the system is inapplicable. Self-acting tramways are equally good, underground or above, where the cost is not over 10 cts. per ton-mile. The rope is not as large as for shafts, length and load being equal. Two-car trips on 18% planes need $\frac{5}{8}$ in. rope, $\frac{7}{8}$ on 100%. When the slope cannot be self-acting, engine-planes are used—a stationary engine operating a drum which turns and pays out rope for descending cars, being geared to pull them back on the same or parallel track.

(3) If graded from the shaft, the tail-rope (for limiting grade of $3^\circ/_\circ$) or the endless rope systems are employed extensively in beds. The tail-rope is inexpensive to build and repair, and its greatest advantage is horizontally or on a slight grade. The engine is located at the shaft-end of haulway, and has two drums which are thrown alternately in and out of gear. The main rope, same length as the haulway, is fastened to the front end of the train, the tail-rope (twice as long) passes from its drum around the sheave at the other end, thence to rear end of cars. In operating, the main rope drum is thrown into gear—the other out—and the engine started, drawing the loaded cars to the shaft, dragging the tail-rope. Then the main drum is thrown off, the other on, and the emptied cars return, pulling the main rope off its drum.

The endless rope is very suitable for a double track with frequent stoppages and no branches. A continuous motion in one direction is given the rope by a single drum, the cars being attached or detached at will.

SURFACE TRANSPORTATION.

W. R. Carlyle, Provincial Mineralogist of British Columbia, gives the following figures for the Slocan district :—The cost of packing down ore on horses in the summer time varies from $5 to $8.50 per ton to railroad. In winter, by "rawhiding," $2.50 to $3.50 per ton. By waggons or sleighs, $1 to $2.50 per ton. Cost of transportation from shipping centres to smelters in the United States, from Sandon, $7.50 ; from Slocan City, $11.

Tramways, either surface or aerial, are resorted to when any considerable quantity is handled, as from shaft to mill, etc. The aerial varieties are either on the Bleichert or Hallidie systems.

Surface Transportation.

The Bleichert has one or two ropes stretched tightly and supported by standards; on this run travellers to which buckets are hooked, the motion being given by a single or endless rope, speed about 300 ft. per minute. The buckets carry 500-1000 lbs., and dump automatically. The Hallidie supports and moves the load by the same rope which has a continuous motion in one direction, at rate of 200 ft. per min. A ropeway, at such rate, carrying 100 lbs. per bucket (buckets 100 ft. apart) delivers 60 tons per shift; it may be built for $1.30 per ft., and $2,000 for terminal machinery. The cost of the Bleichert system is higher, about $1.75 per ft., but it is capable of handling larger quantities and operating over greater distances than the Hallidie, and running expenses are less. When the grade is above $14^{\circ}/_{0}$ it is self-acting, the speed being controlled by a brake; below this grade power is applied.

PUMPING.

Buckets may be hoisted by windlass or steam. For the latter service bailing tanks, holding 450 to 900 gals., with balanced valves and discharging pegs, give satisfaction for shafts, and similarly valved self-dumping skips for slopes. If such means are insufficient, a single-acting lift-pump, or a force-pump—single or double-acting—is advisable, the former for a vertical shaft less than 300 ft. only.

ILLUMINATION.

Lessened cost for plant has brought electric lighting into high favor in coal mines owing to reduced risk from explosions. In gold mining, such as in Rainy River region, sperm candles should be used, as grease hinders mercury amalgamation. Of sixes (6 per lb.), the consumption averages 3 per man per shift. In metal mines they are cheaper than lamps.

ENTRY AND EXIT.

Ladders.—Generally of 2 by 6 in. standards, 18 in. apart, with steps 1 ft. apart—should incline not less than 10° from vertical to enable men to carry tools; at every 20 to 40 ft. in vertical shafts, or more if inclined, they rest on 2 in. platforms. Buckets or cages are much better and save time.

BORING.

Punch-drills were, and are yet, "kicked" down by spring-pole with hand or foot labor, but not for holes over 3 in. diam. or 300 ft. deep; the iron rods are 1 in. square. With a derrick (tall enough to support the whole length of tools), having a sheave at its crown, and a 10 horse-power engine winding a rope on a bull-wheel drum and operating the tools by a walking beam through a pitman, 6 in. holes may be carried 1,000 ft. or more. The rope is of $1\frac{1}{2}$ in. hawser-laid cable. By another system the rope and tools are raised by a single-acting piston operating on a pulley; the up stroke raises, and the down stroke lets fall the tool. "Jars," for taking up the concussion injurious to material and joints, play an important part. Mud is removed by a sludger. Such borers are common in oil fields. In south-western Ontario the wells are drilled $4\frac{5}{8}$ in. diam., and a pump of $1\frac{1}{4}$ to $1\frac{1}{2}$ in. tubing is inserted. Wooden rods are now used there instead of cables. Pump rods attached to a horizontal wheel, so that their weights balance one another, enable a 12 horse-power engine to pump as many as 90 wells; this is the "jerker" system.

TIMBERING.

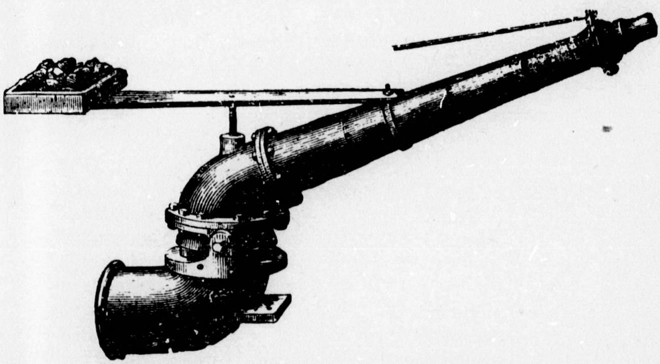
Lining for shafts, generally, consists of series of timber frames, preferably dressed, slightly smaller in outside dimensions than the shaft itself, and separated from one another by vertical posts which are boxed into the frame timbers. Between the shaft walls and these frames, planks (lagging) are placed, forming a close sheeting, and any spaces between the lagging and shaft-wall are packed with rock waste. The whole is supported at intervals as circumstances demand by long, heavy stulls extending beyond the side of the shaft into the country rock, and forming part of the frame at that point. If levels or tunnels need timbering the common method is by two vertical posts supporting a cap, with lagging on the outside; or if one of the walls is hard no vertical is needed on that side, and the cap may be supported on the rock at that end. In soft ground the difficulties encountered often call for expert supervision. Sandstone or conglomerate offers a good roof, soapstone a bad one, and fire-clay is the most dangerous.

HYDRAULIC MINING.

Working shallow placers (bar, creek, or gulch placers according to nature of occurrence) is still done by pan, cradle, or wing-damming in British Columbia, but those of the older districts are nearly worked out. The far more expensive method of hydraulicking is now in vogue for working the deep placers, or the beds of ancient rivers which have been diverted by volcanic or other action. Except on top, these are packed too hard for the simple methods, and water under sufficient head to give the needful pressure is employed to excavate and direct the gravel into a dump over sluices. *Sluices* are large troughs, generally

Hydraulic Mining.

frame, lying upon the ground, and paved with loose blocks of wood or stones to give a surface fit for catching gold and amalgam. Riffles fixed on the sluice bottom at intervals answer the same purpose. The source of water, gravel-bed, and dump must be situated at proper relative elevations before the claim can be advantageously worked, while the supply of water must be ample. Sluices are lengthened if a test of the tailings shows a loss in gold, the nature of the dirt washed being an important factor. Generally they are on a wide curve to prevent too great a current, which would wash the gold over the riffles. Dimensions vary with amount treated, and the latter is governed by water supply. The grade also varies with the water supply and cost of water, and the water in the sluice should cover the largest boulder met with. If the water is scarce and expensive a high grade is needed. The heavier the gravel, also, the steeper the grade. The water is generally considered capable of carrying away $\frac{1}{5}$ of its own weight of gravel. The water is led in ditches, flumes or pipes to the pressure-box (also called bulk-head or sand-box) which is a tank placed at sufficient elevation to give the jet requisite force. Ditches generally have sloping sides and a grade varying from 7 to 20 ft. per mile. Flumes are wooden troughs, carried across depressions on trestles, or along the sides



Monitor.

of canyons, if necessary, by iron brackets let into the rock. Pipes, either iron or steel, are used in crossing deep valleys. From the pressure box the water goes to the workings in pipes, which are forked if two points in the bank are worked at once. At the end is a nozzle (monitor) of 5 to 9 in. diameter, by which the water is pointed as required. Mercury is added several times daily at the sluice head. If the bed rock is below the drainage

Hydraulic Mining.

level, the hydraulic elevator is used, being a pipe through which a jet of water creates powerful upward suction of the gravel to the head of the sluice. Gravel worth only 5 or 10 cents per cubic yard under favorable circumstances can sometimes be made to pay.

Deep placers are otherwise exploited by drift mining. A tunnel is run after the position of the rich gravel is accurately located, and the mining is prosecuted from drifts run from the tunnel.

ORES AND ORE TREATMENT.

ORES.

An ore is a substance which gives on treatment one or more valuable metals. Ores are generally mixtures of rock material and the metal in a free state or combined with other elements. This rock material or gangue is usually *quartz*, *calcite*, *siderite*, *barite* or *fluorite*. Quartz is the most common, and is nearly always present when the other gangues are found. The metals are *gold*, *silver* and *copper*, and the various minerals those of *copper*, *lead*, *silver*, *antimony*, *zinc*, etc. Iron pyrites is almost universally present in ores.

The ores usually met with of commercial importance are :—

Native Metals (simple or alloys).

Gold, silver, platinum, copper.

Oxides.

Magnetite	worked for Iron.
Hematite	" " "
Limonite	" " "
Bog Iron Ore	" " "
Cuprite	" " Copper.
Cassiterite	" " Tin.
Zincite	" " Zinc.
Bauxite	" " Aluminium.

Sulphides.

Galena	worked for Lead and Silver.
Zinc Blende	" " Zinc.
Chalcocite	" " Copper.
Copper Pyrites	" " "
Bornite	" " "
Argentite	" " Silver.
Cinnabar	" " Mercury.
Pyrrhotite (sometimes)	" " Nickel.
Millerite	" " "
Stibnite	" " Antimony.
Orpiment	" " Arsenic.
Realgar	" " "

Arsenides.

Niccolite	worked for Nickel.
Smaltite	" " Cobalt.

Ores.

Sulph-Arsenide.

Proustite	worked for Silver.

Chlorides and Fluorides.

Cerargyrite	worked for Silver.
Atacamite	" " Copper.
Cryolite	" " Aluminium.

Carbonates.

Malachite	worked for Copper.
Azurite	" " "
Smithsonite	" " Zinc.
Cerussite	" " Lead.
Spathic Iron Ore	" " Iron.

Silicates.

Calamine	worked for Zinc.
Garnierite	" " Nickel.

These ores are workable, under ordinary circumstances, when they carry amounts of metal approximately as follows :—

Gold	from	5 dwt.	to 1 oz.	per ton.	Value	\$5 00 to \$20 00	
Silver	"	8 oz.	" 10 oz.	"	"	5 25 to 6 50	Milling ores.
"	"	5 oz.	" 10 oz.	"	"	3 00 to 6 00	Lead or Copper Sulphides.
Nickel	"	1 %	" 2 %	"	"	7 00 to 14 00	
Tin	"	2 %	" 3 %	"	"	5 00 to 8 00	
Copper	"	1 %	" 2 %	"	"	2 00 to 4 00	Free milling.
Copper	"	2 %	" 3 %	"	"	4 50 to 6 50	Smelting ores.
Zinc, Lead	"	15 %	" 20 %	"	"	10 00 to 15 00	
Iron	"	30 %	" 40 % for carbonate ores.				
Iron	"	50 %	" 60 % for oxide ores.				

The figures given in this table will vary with the locality, facilities of transportation, and the nature of included minerals or impurities.

Ores usually receive their names from the metal yielded which is commercially the most valuable ; *e.g.*, galenas frequently carry high values in silver, and are therefore called silver ores or silver lead ores, though the baser metal, lead, is largely in excess. These ores in British Columbia carry also zinc blende, ruby silver and gray copper, the last mineral being looked upon as particularly favorable, as it is nearly always found to be accompanied by high values in silver. The gold ores of Western Ontario consist of free gold in a quartz matrix (or gangue), together with scattered crystals of iron pyrites, copper pyrites, galena, or zinc blende. One of these accessory minerals is always present in "healthy ore," *Ores.*

and sometimes all of them. The gold, though of less bulk and weight than the accessory minerals, constitutes the chief value, and the ore is therefore called gold ore. Similarly the nickeliferous pyrrhotites of Sudbury, Ontario, and the auriferous pyrrhotites of Rossland, B. C., are termed respectively nickel and gold ores; both often carry appreciable values in copper, and the former yields a few dollars in gold.

The most commonly occurring metal in ore deposits is iron, associated with sulphur (pyrites); this compound is valueless as a source of iron, the supply coming entirely from magnetite, hematite, and spathic iron ore (carbonate). The pyritous ores, however, when they contain 40% upward of sulphur, are used for the manufacture of sulphuric acid (vitriol).

Gold and platinum are found native in gravels and sands of ancient and modern river channels. this character of deposit being known as an alluvion. Gold also occurs in segregated veins and intercalations between the sheets of slates, etc., and finely disseminated in eruptive rocks.

On both north and south shores of Lake Superior a most important ore of native copper occurs; native copper being found in grains, pellets and masses in an amygdaloidal trap or greenstone, and sandstone. In other parts of Western Ontario bands of heavily mineralized country rock—technically known as fahlbands—occur, which will possibly form sources of valuable ores of copper and, perhaps, gold.

GENERAL TREATMENT.

The choice of the proper treatment for a given ore requires careful consideration; no hard and fast lines can be laid down. Theories and practice must give way to the necessities of particular cases. The following synopsis, however, serves as a guide to indicate methods of dealing with various ores; combinations of two or more methods being sometimes adopted.

1. If free gold can be panned out and no sulphurets—*Free gold milling.*

2. Free gold found, but also sulphurets, which on being panned out after free gold is separated, assay sufficiently well to pay for treatment—*Free gold milling and concentrating with vanning machines for tailings; chlorination, cyanidation or smelting for the product (concentrates).*

3. Free gold in small quantities, but much silver present in sulphurets—*Roasting milling; or free gold milling, vanners and smelting; or copper plates, vanners and amalgamating pans.*

4. Chloride of silver ores and decomposed silver vein outcrops over 8 oz. per ton—*Free silver milling.*

General Treatment.

5. Silver ores consisting of part chloride or decomposed, and part silver bearing sulphurets—*Free silver milling, vanners and smelting, or if grade of ore is high—Roasting milling.*

6. Silver ore with base metal sulphurets, if low grade—Fine concentration and smelting ; if high grade—*Roasting milling.*

7. Low grade silver ores, with gray copper tellurides, ruby, brittle or native silver—*Fine concentration and smelting.*

8. Heavily mineralized ores of lead, copper, zinc, often carrying silver—*Coarse concentration and smelting.*

9. Lightly mineralized ores of lead, tin, copper and zinc—*Fine concentration and smelting.*

10. Carbonate or oxide of lead or copper—*Smelting.*

11. Solid galena ores—*Smelting, either after simple hand selection (cobbing), or hand selection and coarse concentration on rejected ore.*

12 Metallic copper ores—*Stamping with coarse concentration and melting to ingot.*

13. Antimony ores—*Hand picking, coarse or fine concentration and smelting.*

14. Zinc blende and zinc carbonates—*Coarse or fine concentration and reduction by a zinc smelting process.*

15. Tin ores—*Fine concentration, roasting and smelting.*

16. Copper pyrites and copper glance—*Hand-picking, coarse or fine concentration, partial roasting and matting.*

17. Heavy iron pyrites, carrying gold—*Chlorination process, or roasting and intermixture with smelting ores.*

18. Massive iron pyrites, pyrrhotite, chalcopyrite, marcasite, arsenopyrite, etc., carrying gold, silver, nickel or copper—*Sulphide (pyritic) smelting.*

FREE MILLING ORES.

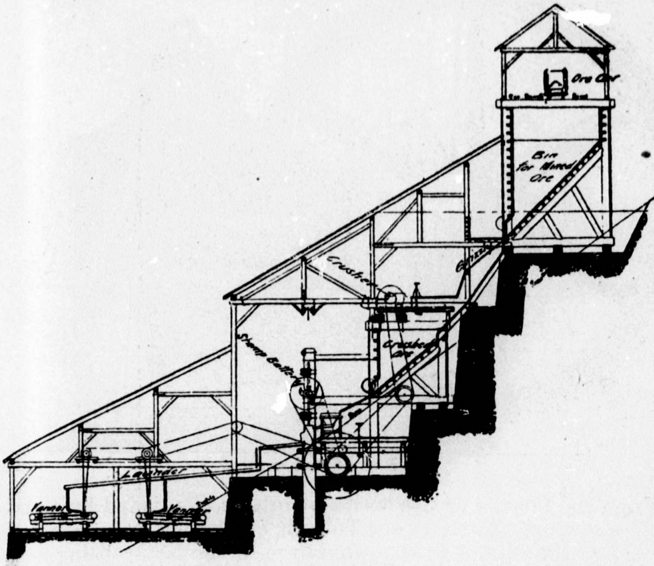
GOLD.—These comprise those mentioned under Sections 1, 2 and 3 of the preceding table. Under exceptionally favourable circumstances ores carrying as low as $2 per ton can be milled with profit. From this to $5 per ton, the ore body must be large and easy to mine, the milling machinery extensive and carefully designed, and management of the very best. In Nova Scotia where labor ($1.25 for 10 hours) and fuel (coal at $3 per ton) are very low, ores averaging $4 to $6 have been successfully treated. Under ordinary circumstances in Canada, free milling ores averaging about $10 per ton are to be looked upon as profitable.

The principles underlying the treatment of free milling ores are first, crushing to pulp fine enough to set free the smallest particles of gold ; sec nd, bringing every particle of the pulp into contact with mercury—the gold amalgamates with the mercury while the worthless pulp (tailings) is washed away.

Free Milling Ores.

Advantage should be taken of any natural slope in selecting a site for a mill, so as to permit the handling of the ore by gravity as far as possible.

The ore as delivered at the mill is in variously sized lumps. It

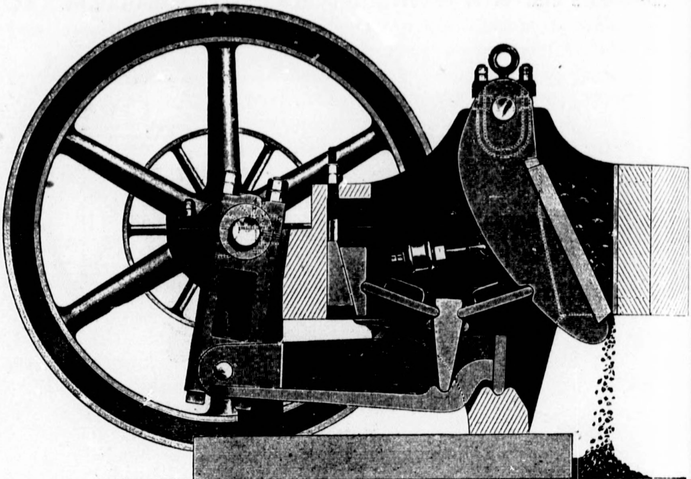


Gold Mill.

first passes over a grizzly to the crusher (rock-breaker). The *grizzly* is a frame, 3 to 4 ft. wide, 10 to 14 ft. long, made of wrought iron bars which are 1 in. wide, 2 to 4 in. deep, and placed $1\frac{1}{2}$ to 2 in. apart. The bars run with the slope, which is towards the crusher, allowing the "fines" to fall into the ore-bin —over which the rock-breaker is set—and thus relieving the latter of unnecessary work. The coarse ore is usually fed by hand to the crusher, which reduces it to walnut-size and drops it into the ore-bin. Among the *rock-breakers* in general use are the Blake, Dodge, Gates and Comet, the first two being jaw-crushers. The Comet's crushing is performed by an upright cone of chilled iron, fixed at the top (small) end, and given a circular swinging motion, the ore passing between it and the conical chilled iron shell which encircles it. The Comet has capacity of from 4 to 60 tons per hour, weighs 6,500 to 33,000 lbs. and costs f. o. b. $550

Free Milling Ores.

to $3,000. The largest Blake, No. 5, is calculated to feed 20 stamps when run 20 out of 24 hours. Its given capacity is 7 tons per hour.

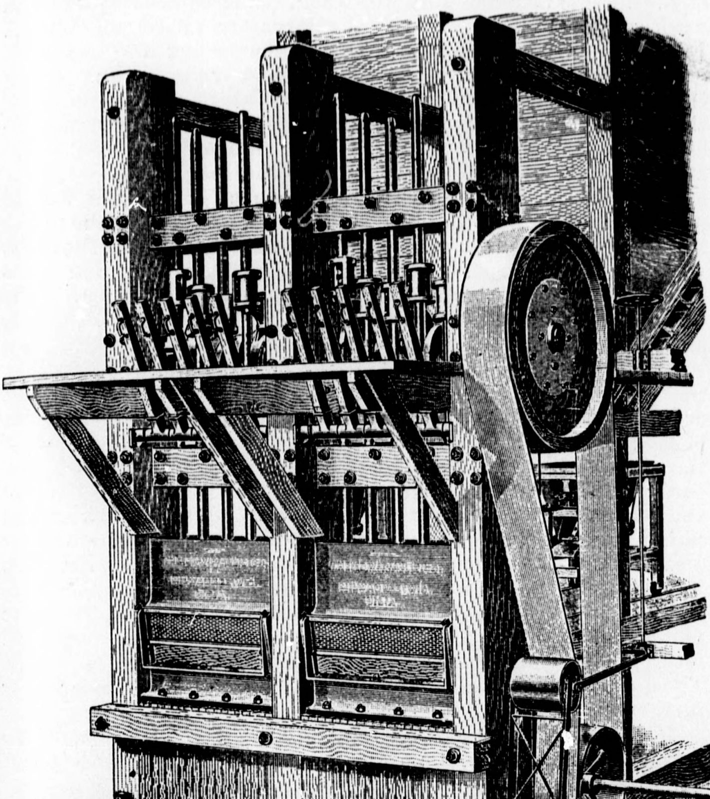


Blake Crusher.

From the bin the ore, in well appointed mills, is led by a chute to an *automatic feeder*, either Tulloch or Challenge, which feeds the ore to the stamps or Huntington mill, the latter being sometimes used. It cannot be too well understood that the *stamp mill*, although most simple in construction, cannot be rightly handled by a novice; yet in the hands of an experienced man astonishingly good results may be expected. On a given quality of ore there are many points to be considered: the right slope of the apron-plates, the proper feed of water and mercury, the correct height of discharge, the fineness of the screen, the weight of the stamps, the drop, the number of drops per minute, the order of drop, the frequency of cleaning up, together with what quantity of ore to keep between the dies and shoes; all these receive attention from the expert who is seeking to extract from any certain ore the greatest quantity of gold in the cheapest and quickest way. The stamp mill has been used for many years and, in consequence of its widely known capabilities, as well, remains prime favorite among mining men in spite of a lengthy list of alleged substitutes and improvements. The price at the maker's works is from $400 to $600 per stamp for small plants of 10 or 20 stamps.

Free Milling Ores.

The ore enters the *mortar* at the back near the top, and falling on the *dies* which are set in the bottom of the mortar, is crushed



Stamp Battery.

Free Milling Ores.

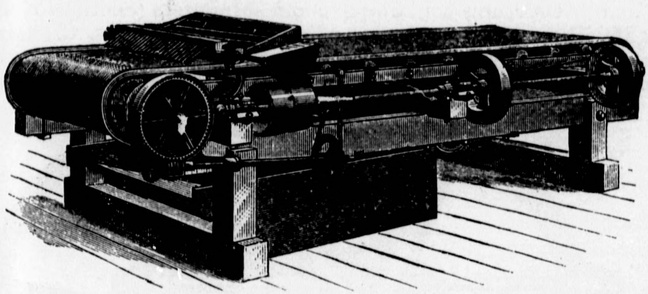
by the dropping stamps. The stamp *shoe* is attached to the *boss-head*, and the latter to the lower end of the *stem*. Near the top of the stem is fastened a *tappet*, which being worked by a cam on a horizontal shaft *(cam shaft)* is alternately raised and let fall. Five stamps generally work in one mortar box and the usual order of drop is 1, 3, 5, 2, 4. The stems move in guides. A firm foundation for the whole is essential. Water enters at the top of the mortar against each stamp, and they splash the pulverized ore against the screen which is placed over an opening in front. The average *screen* is of 30 or 40 mesh to the inch. The weight of each stamp is usually 850 lbs., the number of times it falls 90 per minute, the drop 6 in. When fine enough to pass the screen the pulp flows over a copper plate. This *apron plate*, made as wide as the discharge, is $\frac{3}{10}$ in. thick, 8 to 10 ft. long, and falls $\frac{1}{2}$ to 2 in. per ft., its surface being amalgamated with mercury to which the gold adheres in passing over. Copper plates, similarly amalgamated, are placed inside the mortar as well and capture the gold in the ore which is splashed against them by the stamps. *Quick silver* (mercury) is fed to the battery with a small wooden or horn spoon, the average amount being $1\frac{1}{2}$ ozs. to every ounce of gold extracted. The correct amount is known by the feel of the plates ; if hard and crumbly there is danger of amalgam being carried off by the pulp, and more mercury is needed ; if too soft and slippery less amalgam collects on the inside plates, and liquid amalgam may roll off the apron plates : on free milling ore $\frac{1}{6}$ oz. per ton of ore milled would be the expected average loss. As a rule it is better to use too little water than too much ; the right amount will just carry the pulp evenly over the apron plates. Periodically the *amalgam* is scraped from the plates and retorted, the gold thus gained being melted and run into moulds. The mercury vaporizes and, being condensed in water, is saved for further use.

Mercury traps, through which the pulp passes after leaving the apron plates, save the amalgam and quicksilver not collected on the plates.

Fine Concentration.—Ores mentioned in Section 1 require no concentration, practically all the gold being saved in the mortar and on the plates. Those under Sections 2 and 3 carry sulphurets which hinder amalgamation to a certain extent, and a portion of the gold escapes with the heavy minerals (usually sulphides of iron, copper, zinc, lead, etc.) in the tailings. When the loss is sufficiently high to warrant concentrating the tailings (*i.e.* separating out the heavy minerals with the gold from the worthless gangue), some form of concentrating machine is used, such as Frue vanners, Embrey concentrators, Rittinger percussion tables, Perfection, etc.

Free Milling Ores.

The *vanner* is most popular among mining men, and consists of an endless rubber belt, 4 ft. wide and 12 ft. long, with an up-slant of 1 in 35 to 50 in the direction of its motion, and passing from the high end around a lower drum which dips into a water tank. A steady shaking motion is imparted from side to side by a crank shaft. The pulp is fed on in water about 3 ft. from the head of belt and is washed slowly down. The slow, upward travel of the belt itself, 28 to 36 in. per min., brings up the heavy mineral, and a row of water jets at the head wash back the lighter sands while the concentrated minerals fall into the tank below, from which they are collected for subsequent treatment by smelting, chlorination or other processes.



Frue Vanner.

The Embrey is almost identical, but receives an end shake instead of one sideways. Two machines commonly go to each battery of 5 stamps, the pulp passing from the apron plates to the vanners. They take less than ½ horse-power apiece to drive, and one man can attend to 16 or 20. The ordinary kind (with 4 ft. belt) costs $575, not including tanks.

Pan Amalgamation.—By the old process the crushed ore is run into large shallow settling tanks, the pulp being removed by hand and further ground in amalgamating pans with mercury; by the Boss continuous system the pulp runs automatically through a row of pans and settlers connected by pipes. The pan, which holds 1 to 1½ tons of pulp, is generally of wood, with a cast iron bottom fitted with dies, upon which the muller works while grinding. The muller is adjusted by a hand wheel and may be raised for the necessary gentle circulation of the water. Steam enters the pans during the operation. Generally, pan amalgamation must be preceded by roasting.

Roasting.—There are various furnaces for roasting ore. The Brückner is a revolving cylinder, 6 to 8 ft. diam., and from 12 to 18 ft. long, being of smaller diameter at the ends than in the

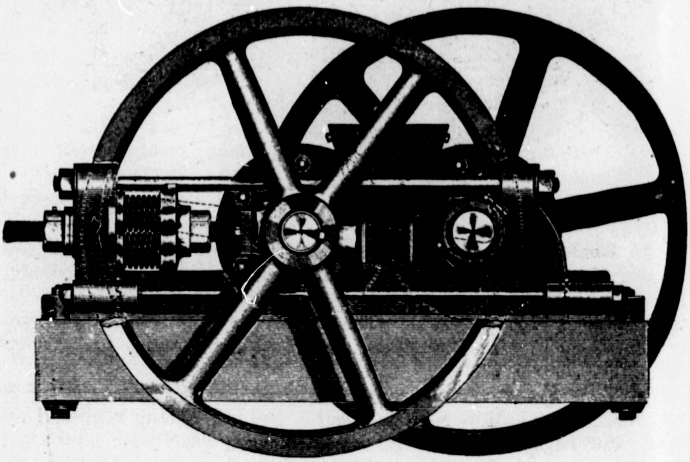
Free Milling Ores.

middle, so that the ore, being constantly turned over, exposes new surfaces to the fire. One weighing 25 tons costs about $3,000. The Stetefeldt is a vertical shaft, the pulverized ore being showered in and roasted. The White consists of a long cast iron revolving cylinder inclined towards the fire end ; still another common make is the Hofmann, somewhat similar. Reverberatory furnaces are also much employed.

Ore Dryers are, commonly, revolving cylinders, 44 in. diam. at one end and 36 in. at the other, 18 ft. long, and have 30 to 40 tons capacity per 24 hours.

CONCENTRATING ORES.

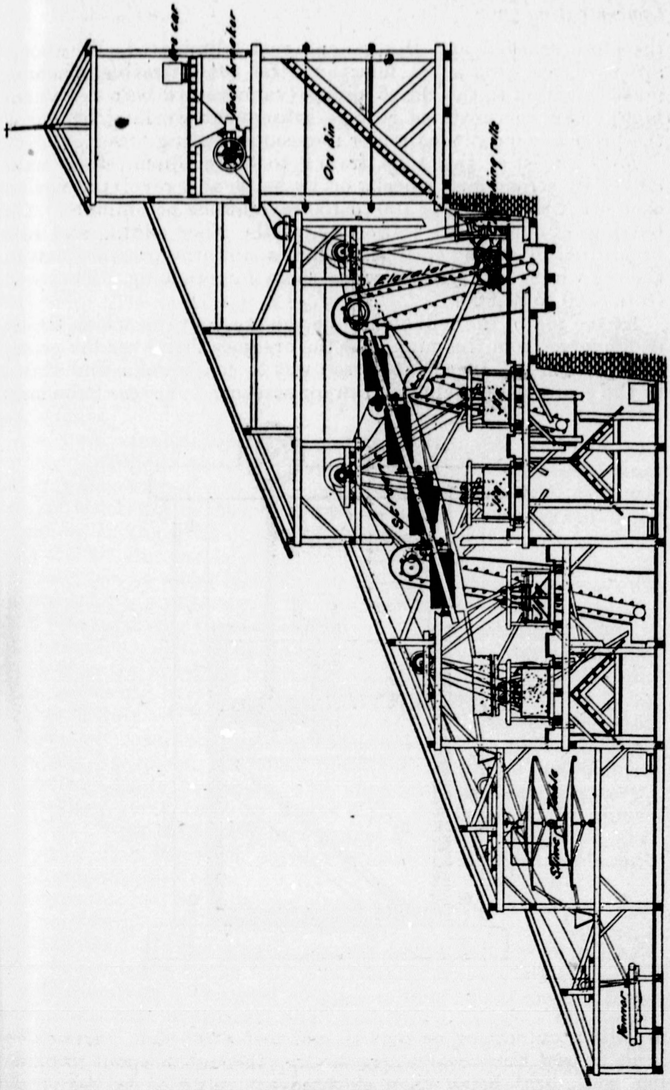
GOLD.—Gold ores containing much sulphurets (Sections 17 and 18) are either concentrating or non-concentrating ores, the latter when 40 per cent. are present, roughly speaking. The non-concentrating class require dry crushing by rolls, and either



Crushing Rolls.

chlorination (with fine crushing), smelting or pan amalgamation. Gold ore smelting embraces (1) complete smelting to silver lead bullion, (2) concentrating smelting to iron matte, (3) concentrating smelting to copper matte, (4) pyritic smelting.

Concentration may be divided into coarse and fine, the crushing in the former case being by rolls, in the latter by stamps. Most ores are not rich enough for smelting when taken from the deposit, on account of the gangue which is mixed with them. They are



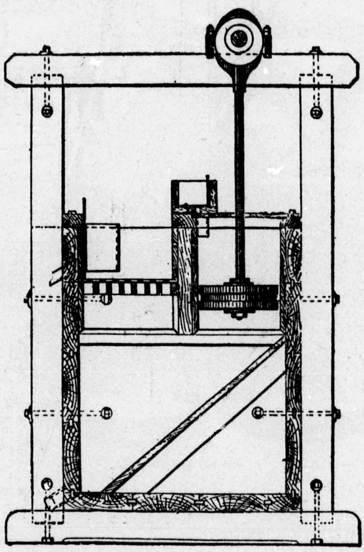
Concentrating Mill.

Concentrating Ores.

therefore crushed and the gangue rock eliminated. If stamps are used the product is finer and the concentrating machines must be suited to the finest slimes (vanners are best if value is high). All concentrates require subsequent working by one of the processes mentioned under non-concentrating ores.

Rolls consist of two rolls, from 9 to 36 in. diam., their axles driven by strong gear wheels, or by belts, and revolving against each other at a speed of 100 to 150 revolutions per minute. The bearings of one roll are stationary, of the other sliding and kept in position by strong springs, so that a uniform pressure acts on the ore which is placed between them for crushing. They cost from $200 to $1,800.

At the top of the mill should be the ore floor, on which the ore is delivered from the mine, and the ore goes then over the grizzly to the crusher. It is next passed wet to coarse rolls, and thence to the coarsest revolving screen (or screens). *Screens* (trommels)



Jig.

are either cylindrical or conical, and cost $200 each. Lumps too large to pass these coarse screens drop through a spout to finishing rolls, and being then elevated are returned to the coarse

Concentrating Ores.

screens. The ore which passes descends automatically to finer revolving screens, No. 2; the portion passing No. 2 to No. 3, still finer; that which passes No. 3 to No. 4, a degree finer still. The ore detained by each of these screens is of like size and graded according to the mesh of the particular screen which detains it. Each screen continuously drops its contents to its own jig, stationed below, while the material fine enough to pass the whole series flows either to settling tanks for ultimate treatment on slime dressing machines, or is run through hydraulic classifiers.

The *jig* is a water tank with a horizontal screen (on which the ore is placed) at one side, and a plunger working up and down, on the other. The pulsation of the water acting on the pieces of ore (of similar size but different specific gravity) causes the particles that are heavy from mineral to settled own through the lighter worthless material, and enables it to be separately discharged. Iron work for a jig costs about $35, the wood being usually found at the mine.

Hydraulic classifiers work on the same principle, and separate the heavy particles from the fine slimes. Evans' *slime-table* and Collom's *buddle* treat the sediment from settling tanks, and are circular revolving tables about 14 ft. diam. The ore is fed on at the centre in a current of water, the waste flows down and off, while the heavier particles remain and are eventually washed off by strong jets of water into launders. From 10 to 12 tons per 24 hours is a table's capacity. Sometimes they are stationary, the water jets revolving instead. They are often "double-decked."

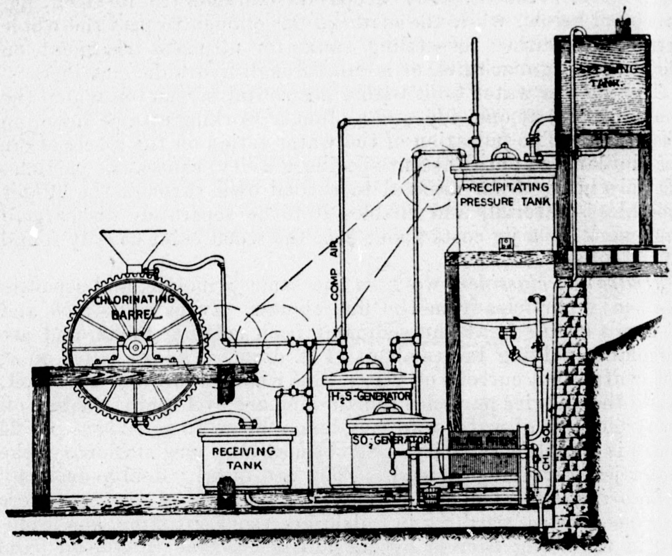
Chlorination.—The common process consists of drying the ore or concentrates, crushing in rolls if necessary, roasting, and leaching in revolving barrels by the aid of chlorine (produced from chloride of lime and sulphuric acid). The fluid chloride of gold is drawn off, and the gold precipitated as a sulphide by sulphuretted hydrogen. A small plant for working a few tons of concentrates daily is simple, and very few hands are necessary. A first class plant, capacity 5 tons daily, can be built for $5,000 or $5,500. Cost of treatment averages $8 to $10 per ton of concentrates. It is the most popular process; also used for hand-picked sulphuretted ores.

Bromination.—The bromine process is similar to above, but bromine is employed instead of chlorine.

Cyanidation.—In the cyanide process the ore, tailings, or concentrates, is treated in tanks with a potassium cyanide solution, and the gold dissolves. The gold solution is then run through a long narrow tank with partitions, filled with zinc shavings. The gold is precipitated in a fine powder upon the zinc, and can then be shaken off. In South Africa the consumption of cyanide was 1 to 2 lbs. per ton of tailings treated, and cost of treatment varied

Concentrating Ores.

from $1.20 to $2 per short ton. If the vanners yield iron pyrites, in which the gold occurs fine, cyanide consumption would be greater. If the gold is coarse, or occurs with most of the copper and antimony ores or chemically combined with base compounds, cyanidation is inapplicable.



Chlorination Plant.

SILVER.—When silver, as is usual, occurs in free milling gold ores in small quantities, it is amalgamated with the gold and also saved in the concentrates and extracted by smelting, pan amalgamation or chlorination method. If much silver is present the ore comes under the head of a silver ore. Silver ores—leaving aside such as require direct smelting, or concentrating before smelting—are usually divided into free milling and roasting milling.

Free milling silver ores are amalgamated at once in pans (as mentioned under gold ores). The process costs $3 to $10 per ton, the extraction varying from 60 to 80%.

Roasting milling ores call for dry crushing, roasting with salt, and final treatment in amalgamating pans. Cost, $8 to $15 per ton; extraction between 80 and 90%.

Concentrating Ores.

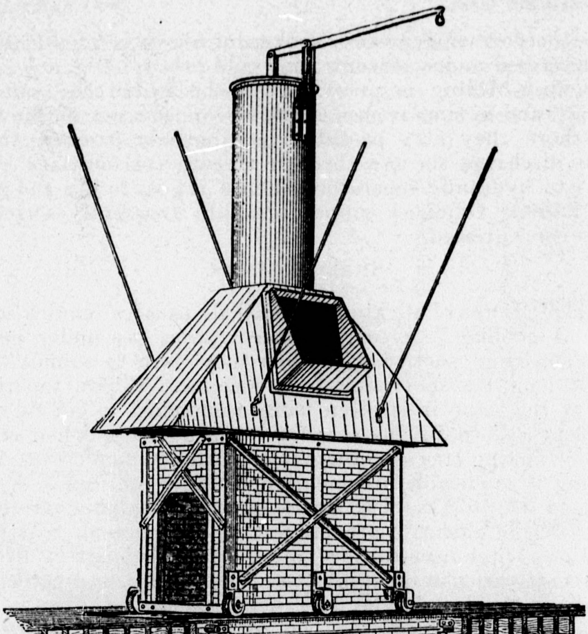
The concentrating process spoken of above is identical with that described under concentrating gold ores.

COPPER.—Milling is practiced on the south shore of Lake Superior, and as similar ores of native copper occur on the Canadian shore they may probably be similarly treated. Steam stamps discharge the ore through screens (perforations $\frac{3}{16}$ in. diam.) to hydraulic separators, thence it goes to jigs and rotary slime tables. Oxidized copper ores are frequently sorted but seldom concentrated.

SMELTING ORES.

General.—Ores of all kinds, as mined, usually require sorting by hand (cobbing), or coarse concentration (see under milling) before smelting, particularly when they have to submit to the cost of long transportation to a smelter. Where smelting is done at the mine it is often more economical to get rid of the worthless rock matter by *slagging* in the furnace, when suitable fluxes or fluxing ores are obtainable. The common ores to which smelting is applicable are mentioned under Sections 7, 8, 9, 10, 11, 13, 14, 15, 16, 17 and 18 before given. If sulphur, arsenic, or other volatile elements are present in the mineral, roasting or oxidation is first necessary. This is a simple matter, although the process varies in different cases. Generally, a reverberatory furnace is employed, the fuel being consumed upon a front hearth, separated from the bed for the ore; the heated fuel-gases ascend to the arched roof and so down upon the ore, and thence escape through a flue. The heat must not be high enough to melt the mineral. Stall-roasting and heap-roasting are among the other methods for oxidizing.

Reduction, or smelting proper, is applicable to most metallic oxides, natural or artificial. The aim is to remove the oxygen, by heating with a substance having a greater attraction for oxygen than the mineral itself. The furnaces are frequently very large, the form varying with the metal to be treated; the ore is intensely heated, together with coke or charcoal which unites with the oxygen and carries it off as a gas. The earthy and other impurities (often a large part of the ore), which have not been entirely eliminated owing to defects in the mechanical treatment, must now be got rid of. Certain fluxes, or substances which form fusible compounds with the earthy impurities, are added with the fuel; these melt, making a fluid (glass) through which the reduced metal sinks, and is thus shut off from the air. The metal is run off at intervals from the furnace bottom, while the melted slag is drawn from a hole in the side. Technical training and much judgment is necessary in selecting fluxes in their proper proportions; often this is accomplished by a proper



Water-jacket Smelting Furnace.

Smelting Ores.

mixture of different ores of the same metal, each supplying some ingredient needful to make the slag sufficiently fusible. The melting of barren fluxes is to be avoided if possible.

Copper and lead ores are the most important for smelting. Different methods are: 1. Simple reducing melting in reverberatory or water-jacket furnaces of carbonates of lead or copper, or metallic copper ores. Some flux is nearly always necessary to slag off the gangue rock (iron or lime, if quartz; or quartz if too limey). 2. Matting. That is, running the minerals out of the rock not in a fully metallic condition, but as a concentrated mineral or matte. This is done also in reverberatory or stack furnaces, usually after a partial preliminary roast. The matte or regulus is afterwards refined or shipped to refineries. 3. Partially roasting galena ores, and then a reducing smelting in which the oxidized lead reacts on any sulphides remaining, and only metallic lead results. Here, as in the first division, proper fluxes must be added to slag off the waste rock and keep all fluid in the furnace. 4. The addition of iron ore, or roasted iron pyrites, to galena ores in smelting, the iron capturing the sulphur of the galena and leaving metallic lead. This process necessitates roasting and re-melting a large quantity of matte formed.

Such are the general principles. The cost of smelting varies greatly ($5 to $30 per ton) according to locality and arrangements. The saving in gold and silver ores is from 90 to 98% of assay value; the lead in one case and copper in the other are also saved.

Furnaces (not water-jacketted) are usually lined with refractory materials to resist the action of the furnace charge. These are either

Acid—ganister (a highly silicious lining).
Neutral—graphite and fire-clay.
Basic—bauxite, dolomite and magnesite.

The acid lining resists silicious ores, and the basic resists metallic oxides.

Notwithstanding the resistance of these linings, they are gradually eaten out by the fluids in the furnace, which then requires re-lining. For this reason water-jacket furnaces are now in great favor for lead and copper ores. They are usually rectangular, of various size; capacity ranging from 15 to 40 tons per day.

The water-jacket consists of two sets of removable wrought-iron boiler-plates, one outside the other; in the space between them water circulates, keeping the inside plate at a temperature just below the boiling point of water. A small amount of fire-brick is necessary just above the jacket, resting upon or independent of it. A bustle-pipe, of galvanized iron, surrounds the furnace to receive the air-blast from the blowing engine, and distri-

Smelting Ores.

butes it to the tuyeres which enter the furnace through the water-jacket just above the slag opening.

The portion of the furnace below the tuyeres is the crucible in which the melted slag and metal separate.

Nickel and Copper.

Sudbury nickel ores (about 3% to 4% copper, nickel same) are roasted in heaps. The ore is crushed to 3 in. square size and graded by a screening cylinder into fines, ragging and coarse, although hand spalling gives less percentage of fines. The sulphur gases liberated may be converted into sulphuric acid. The beds are rectangular and 5 ft. to 15 ft. high, containing 600 to 3,000 tons of ore; chimneys are made by slanting sticks on end. About one cord of wood is used for 20 tons of ore. Roasting lasts 60 days or more. In Sudbury the smelting is done in large water-jacket furnaces, Herreschoff pattern, 9 ft. high and oval, being 6 ft. 6 in. × 3 ft. 3 in. at the tuyeres. Matte of nearly equal parts of copper, nickel, iron and sulphur is produced. Each furnace has a brick-lined fore-hearth into which flow the slag and matte. The slag, being lighter, overflows from a spout near the top, into a water trough under the floor; it is thus granulated and then conveyed to the dump. The matte every 20 minutes is drawn from the fore-hearth into conical iron pots of about 800 lbs. capacity. For one ton of ore 275 lbs. of coke is sufficient. About 15 tons of matte are produced from 110 tons of ore daily. This crude matte is taken to the Bessemer converters, adjoining the smelter, and the whole of the iron and about half the sulphur are removed. The result is *perfected matte.* The refining is done in the States at present.

The cost of smelting to perfected matte is about $3 per ton of ore, including Bessemerizing; refining $1.50 to $2 more per ton of ore.

The auriferous pyrrhotites of Trail Creek, containing copper, are matted like the foregoing, and cost about $10 per ton, when 95% of the assay value of the gold and silver is paid for and 1.3% is deducted from the copper present.

Silver Lead.

The silver lead ores of the Slocan, which are being extensively worked, are treated as described under *Reduction.* The greater bulk of the ore is treated in the States, freight costing from $7.50 to $11 per ton, and smelting $15 to $18 per ton for galena ores; while carbonate ores run from $10 to $15. The smelters pay for 95% of the silver and 90% of the lead; when zinc present exceeds 10%, $0.50 per unit is deducted.

Smelting Ores.

Iron.

The crushed ore is first smelted in a blast furnace, usually fire-brick lined cupolas, from 75 to 100 ft. high. The ore and flux is placed between successive layers of coke. The blast is generally heated. The pig iron is tapped every 8 hrs., and averages 3 to 5% of carbon.

Bessemer Process.—Pig is melted in cupolas or reverberatory furnaces, and is run fluid into converters. The air blast is turned on through tuyeres. In about 15 min. the carbon is dissipated and a calculated weight of spiegeleisen (ferro-manganese) is run in, and the blast turned on again for a few minutes to insure incorporation. The liquid malleable iron is then run into moulds.

Siemens Martin process consists in melting pig in a Siemens' regenerative furnace with malleable iron and Bessemer scrap, about 7% of spiegeleisen being added near the end of the process.

Puddling, to refine the iron. Dry puddling is the oldest and best method, produced by a strong current of air through the furnace. In wet puddling, or boiling, the oxidizing is effected by hematite, magnetite or basic slags. A charge of about 5 cwt. is placed in the hearth of the reverberatory furnace, in ½ hr. it is melted. It is stirred, and then begins to boil, with jets of blue flame over its surface. Pasty masses of iron are then seen to separate and are removed in balls of about 50 lbs. Siemens' reverberatory furnace, which can use inferior fuel, is also employed.

USEFUL INFORMATION AND TABLES.

List of Elements.

	Symbol.	*Combining Weight.*		*Symbol.*	*Combining Weight.*
Aluminium	Al	27.4	Molybdenum	Mo	96
Antimony	Sb	120	Nickel	Ni	59
Arsenic	As	75	Niobium	Nb	94
Barium	Ba	137	Nitrogen	N	14
Beryllium	Be	13.8	Osmium	Os	199
Bismuth	Bi	210	Oxygen	O	16
Boron	B	11	Palladium	Pd	106
Bromine	Br	80	Phosphorus	P	31
Cadmium	Cd	112	Platinum	Pt	197
Cæsium	Cs	133	Potassium	K	39
Calcium	Ca	40	Rhodium	Ro	104
Carbon	C	12	Rubidium	Rb	85.4
Cerium	Ce	92	Ruthenium	Ru	104
Chlorine	Cl	35.5	Selenium	Se	79.4
Chromium	Cr	52	Silver	Ag	108
Cobalt	Co	59	Silicon	Si	28
Copper	Cu	63.5	Sodium	Na	23
Didymium	D	95	Strontium	Sr	87.6
Erbium	E	166	Sulphur	S	32
Fluorine	F	19	Tantalum	Ta	182
Gallium	Ga	70	Tellurium	Te	128
Gold	Au	197	Thallium	Tl	204
Hydrogen	H	1	Thorium	Th	231
Indium	In	113.4	Thulium	Tm	170.7
Iodine	I	127	Tin	Sn	118
Iridium	Ir	198	Titanium	Ti	50
Iron	Fe	56	Tungsten	W	184
Lanthanum	La	139	Uranium	U	240
Lead	Pb	207	Vanadium	V	51.3
Lithium	Li	7	Ytterbium	Yb	173
Magnesium	Mg	24	Yttrium	Y	91
Manganese	Mn	55	Zinc	Zn	65
Mercury	Hg	200	Zirconium	Zr	90

ENGLISH MONEY.

Standard: gold.

4	farthings	=	1 penny, d.
12	pence	=	1 shilling, s.
20	shillings	=	1 pound, £.
21	"	=	1 guinea.

LONG MEASURE.

12	inches, in.	=	1 foot, ft.
3	feet	=	1 yard, yd. or y.
$5\frac{1}{2}$	yards	=	1 rod, pole, or perch.
40	rods	=	1 furlong.
8	furlongs	=	1 statute mile.
3	miles	=	1 league.

Miscellaneous.

6	feet	=	1 fathom, water measurement.
$1\frac{15}{100}$	statute mile	=	1 geographical mile, nautical.
3	geographical miles	=	1 league.
60	" "	=	1 degree.

SURVEYOR'S LONG MEASURE.

$7\frac{92}{100}$	inches	=	1 link, l.
25	links	=	1 rod.
4	rods; or 66 feet	=	1 chain, ch.
80	chains	=	1 mile.

SQUARE MEASURE.

144	square inches	=	1 square foot.
9	" feet	=	1 " yard.
$30\frac{1}{4}$	" yards	=	1 " rod.
40	" rods	=	1 rood.
4	roods	=	1 acre.

SURVEYOR'S SQUARE MEASURE.

625	square links	=	1 pole.
16	poles	=	1 square chain.
10	square chains	=	1 acre.
640	acres	=	1 square mile.
36	square miles	=	1 township.

8

CUBIC MEASURE.

1728 cubic inches	=	1 cubic foot.
27 " feet	=	1 " yard.
40 " "	=	1 ton of ship's cargo.
216 c.ft. = 8 c.y.	=	1 toise (Toronto.)
261½ c.ft. = 9.685 c.y.	=	1 " (Montreal.)
4 ft. × 4 ft. × 8 ft. = 128 c.y.	=	1 cord of wood.

BRITISH OR IMPERIAL MEASURE.

4 gills	=	1 pint.
2 pints	=	1 quart.
4 quarts	=	1 gallon.
2 gallons	=	1 peck.
4 pecks	=	1 bushel.

Imperial gallon, Great Britain and Canada: 277.274 cubic in., or 10 lbs. avoirdupois distilled water at 62° F., barometer 30 in.

Wine or U.S. gallon, 231 cubic in. = 8⅓ lbs., avoirdupois.

6.2321 Imperial gallon = 1 c.ft. } 62¼ lbs. of water.
7.48052 U. S. " = 1 c.ft. }

The Winchester (U.S.) bushel = 1.24445 cubic ft.; the Imperial bushel = 1.2837 cubic ft.

To reduce U.S. dry measures to British, divide by 1.032.

APOTHECARIES' WEIGHT.

20 grains	=	1 scruple.
3 scruples	=	1 drachm.
8 drachms	=	1 ounce.
12 ounces	=	1 pound. lb.

AVOIRDUPOIS WEIGHT.

16 drams	=	1 ounce, oz. = 437½ grains.
16 ounces	=	1 pound, lb. = 7000 "
25 pounds	=	1 quarter.
4 quarters	=	1 hundredweight, cwt.
20 hundredweight	=	1 ton (short ton, or 2,000 lbs.).

LONG TON WEIGHT.

When specified, used for coal, iron ore, etc.

14 pounds	=	1 stone.
28 pounds	=	1 quarter.
4 quarters	=	1 hundredweight (cwt.) or 112 lbs.
20 hundredweight	=	1 ton, or 2,240 lbs.

TROY WEIGHT.

Troy Weight is used for gold and silver.

24 grains	=	1 pennyweight (dwt.)
20 pennyweights	=	1 ounce.
12 ounces	=	1 pound.

Comparative.

1 oz. Avoir.	=	.91146 oz. Troy, or Apoth.
1 lb. "	=	1.2153 lbs. " "

In Troy, Apothecary, and Avoirdupois, the grain is the same.

United States standard pound = 27.7015 cub. in. distilled water at 39° 83″ F. Barometer 30°.

British and Canadian = 27.692 cub. in.

TABLE FOR CONVERSION FROM BRITISH TO METRIC MEASURES.

1 inch	=	25.399 millimetres.
1 cub. in.	=	16.386 cub. centimetres.
1 metre	=	3.2809 feet.
1 cub. metre	=	35.316 cub. ft.
1 pint	=	.56755 litres.
1 litre	=	.22024 gallons.
1 grain	=	.064799 grammes.
1 kilogramme	=	2.6792 pounds.

ASTRONOMICAL AND NAVIGATION.

60 seconds,″	=	1 minute,′
60 minutes	=	1 degree,°
90 degrees	=	1 right angle.
360 degrees	=	1 circle.

PAPER.

24 sheets	=	1 quire, qr.
20 quires	=	1 ream, rm.
2 reams	=	1 bundle.
5 bundles	=	1 bale.

MISCELLANEOUS.

12 units	=	1 dozen.
12 dozens	=	1 gross, gro.
12 gross	=	1 great gross, gt. gro.
20 units	=	1 score.
720 feet	=	1 cable's length.

Miscellaneous.

Area of circle = square of diameter × .7854.
Circumference = diameter of a circle × 3.1416.
A mile of track (rails 16 lbs. per yd.) weighs 25 tons, 320 lbs.

Rule.—To find the number of gross tons of rail to the mile: divide the weight per yd. by 7 and multiply by 11.

A mile of track requires 9 kegs (1,780 lbs.) of 3 in. spikes.
" " " 15 kegs (3,110 lbs.) of 4½ in. spikes.
" " " 20 kegs (3,960 lbs.) of 4½ in. spikes.
" " " 2,640 cross-ties (2 ft. apart).
" " " 528 splice-joints (2 bars, 4 bolts and nuts per joint) each weighing 5 to 10 lbs.

An acre is 43,560 sq. ft.
1,000 ft. B.M. of dry white pine = 4,000 lbs.
1,000 ft. B.M. of green white pine = 6,000 lbs.
A column water, 1 sq. in. base, 27.7 in. high = 1 lb. pressure.

A miner's inch is 2260.8 cubic ft. in 24 hours, under 7 in. head, discharging through a 2 inch square opening in a 3 inch plank, the outer inch of the orifice being chamfered. This equals about 16,800 gals. The average miner's inch in California equals 100 cubic feet per hour.

Approximate rule for changing square feet into acres.—Multiply the number of square feet by 23, and place the decimal point between the 6th and 7th figure from the right.

WEIGHT OF A WINCHESTER BUSHEL IN LB. AVOIRDUPOIS.

	Lbs.
Apples, dried	22
Anthracite	80
Barley	48
Beans	60
Beets	60
Bituminous coal	76
Bran	20
Buckwheat	48
Carrots	60
Cement, Rosendale Hydraulic	76
" Louisville	62
" Portland	96
Charcoal, hard wood	30
Clover seed	60
Coke	40
Corn, in ear	70
Corn, shelled	56
Flax seed	56
Hemp seed	44

Weight of a Winchester Bushel in lb. Avoirdupois.

Lime, loose	70
Malt	38
Oats, U. S	32
" Canada	34
Onions	60
Peas	60
Potatoes	60
Rye	56
Salt	56
Timothy seed, U. S	45
" " Canada	48
Turnips	60
Wheat	60

1 Quintal fish	=100	pounds (avoir.).
1 Barrel flour	=196	"
1 Barrel salt	=280	"
1 Cental	=100	"
1 Barrel pork	=200	"
1 Barrel beef	=200	"
1 Keg powder	= 25	"
1 Pig of lead or iron = $21\frac{1}{2}$ stone	=301	"

LUMBER.

Sawn lumber and timber is almost universally sold in Canada by board measure. The foot board measure is the equivalent of a board 12 in. long, 12 in. wide, and 1 in. thick, and is denoted 1 ft. B.M. To find the contents of sawn lumber or timber in feet B.M., multiply the length in inches by the width in inches by the thickness in inches, and divide by 144. If the length is in feet, divide by 12. Illustration: Given 1 board 12 ft. long by 10 in. wide by 1 in. thick, we have $\frac{12 \times 10 \times 1}{12} = 10$ ft. B.M. Or, given a stick 20 ft. long by 10 in. wide by 8 in. thick, we have $\frac{20 \times 10 \times 8}{12} = 133\frac{1}{3}$ ft. B.M.

Logs and round timber are generally purchased and sold by board measure. Rule: From the diameter of the log in inches deduct 4 and multiply the remainder by half itself; multiply that product by the length of the log and divide by 8; the quotient is the feet, B.M., required. If the log is over 20 ft. long, find the average diameter; if less, take diameter at small end only.

Shingles—Best are of white cedar. Shingles are packed 250 to the bundle, or 4 bundles to 1,000.

1 bundle 16 inch shingles will cover 30 sq. ft.
1 " 18 " " " " 33 " "

WEIGHT IN POUNDS OF 1 CUBIC FOOT.

Aluminium	166	Anthracite coal	85–100
Antimony	419	Anthra. coal, broken	50– 55
Bismuth	613	Bituminous coal	80
Bronze	534	Bitum. coal, broken	50
Brass	524	Brick, common	100–125
Copper	540	" pressed & fire	150
Gold	1200	Clay	119
Iron, wrought	480	Charcoal, hardwood	20– 35
Iron, cast	450	" pine	18
Lead	708	Coke (loose)	30
Mercury	849	Glass	170
Platinum	1344	Granite	170
Silver	654	Gravel, in bank	111
Steel	490	" dry	74
Tin	455	Ice	$57\frac{1}{2}$
Zinc	437	Limestone	168
Barite	277	Marble	171
Cerussite	400	Oak, dry	55
Chalcocite	356	Pine, dry yellow	42
Chalcopyrite	262	Pine, dry white	30
Galena	468	Sandstone	140
Hematite	325	Slate	175
Limonite	250	Soil or sand (loose)	80– 95
Magnetite	338	Soil, common	90
Pyrites	312	Soil, strong	95
Zinc Blende	250	Tallow	59
Quartz	165	Water, pure	$62\frac{1}{4}$
Quartz, broken	95–100	" sea	46

POWER, FUEL, ETC.

A Horse Power (H.P.) = 33,000 lbs. raised 1 ft. per minute.

To find the H. P. of a steam engine, multiply together the area of piston in sq. in., the mean pressure of steam in lbs. per sq. in., the length of stroke in feet, and the number of strokes per min., and divide the product by 33,000.

One ton of coal = $1\frac{1}{2}$ cords of dry hard wood.
" " = 2 " " soft "

Compound engines use from $1\frac{3}{4}$ to 3 lbs. of coal per H. P. per hour; expansive condensing engines, 4 to 7 lbs.

RAINFALL.

1 in. rainfall per hour = 1 cubic ft. per sec. per acre.
Inches of rainfall × 2,323,200 = cubic feet per sq. mile.
" " × $14\frac{1}{2}$ = millions of gallons per sq. mile.

MEASUREMENT OF WATER.

To determine approximately the flow of water in a stream, the following method may be employed. When the cross-section of the channel is moderately uniform, depths are measured at regular intervals across the stream; the average depth thus determined, multiplied by the width, gives the sectional area of the flowing stream: multiply this product by the velocity in feet per min. and the result will be cubic feet per min. The velocity may be found by measuring off a distance of 100 or 200 ft. along the bank, throwing in floats, and noting the time they take in traversing it. Ex.—A stream which is 20 ft. wide is sounded every 2 ft. in a line from bank to bank, and gives depths of 3, 5, 7, 8, 10, 10, 9, 7, and 4 inches; the sum of the 9 soundings is 63 inches, or an average depth of 7 inches. The velocity is 300 ft. per min. Then the flow will be $\frac{7}{12} \times 20 \times 300$ cub. ft. per min. = 3500 c. ft. per min.

The following table gives the Horse Power of 1 cubic ft. of water per min. under heads from 1 to 1100 ft. (head being the vertical height through which the water falls). Table based on efficiency of 85%.

HEADS IN FEET.	HORSE POWER.	HEADS IN FEET.	HORSE POWER.
10	.0016098	320	.515136
20	.032196	330	.531234
30	.048294	340	.547332
40	.064392	350	.563430
50	.080490	360	.579528
60	.096588	370	.595626
70	.112686	380	.611724
80	.128784	390	.627822
90	.144892	400	.643920
100	.160980	410	.660018
110	.177078	420	.676116
120	.193176	430	.692204
130	.209274	440	.708312
140	.225372	450	.724410
150	.241470	460	.740508
160	.257568	470	.756606
170	.273666	480	.772704
180	.289764	490	.788802
190	.305862	500	.804900
200	.321960	520	.837096
210	.338058	540	.869292
220	.354156	560	.901488
230	.370254	580	.933684
240	.386352	600	.965880
250	.402450	650	1.046370
260	.418548	700	1.126860
270	.434646	750	1.207350
280	.450744	800	1.287840
290	.466842	900	1.448820
300	.482940	1000	1.609800
310	.499038	1100	1.770780

Pelton wheels are economical sources of power for heads over 30 ft., yet if not more than 10 to 20 horse-power is wanted they are cheaper and more efficient than turbine and other wheels under heads not higher than 15 to 20 ft. For high heads (over 100 ft.) peltons are unrivalled, and the largest to the smallest stream may then be utilized, and turned into electric power for hoisting and other purposes at a distance.

WORKSHOP RECIPES.

Cement for Cast Iron.—Two ounces of sal-ammoniac, one ounce sulphur, and 16 ounces of borings or filings of cast iron, to be mixed well in a mortar and kept dry. When required for use, take 1 part of this powder to 20 parts of clear iron borings or filings, mix thoroughly in a mortar; make the mixture into stiff paste with a little water, and then it is ready for use. A little fine grindstone sand improves the cement.

Red Lead Cement for Face Joints.—Equal parts of white and red lead, mixed with linseed oil to the proper consistency.

Cement—Steam Boiler.—Litharge in fine powder 2 parts, very fine sand and quicklime (that has been allowed to slack spontaneously in a damp place) of each 1 part. Mix and keep it from the air. Used to mend cracks in boilers and to secure steam joints. It is made into a paste with boiled oil before application.

Cement—Steam Pipe.—Good linseed oil varnish is ground with equal weights of white lead, oxide of manganese and pipe clay.

Cement—Hydraulic.—Made by slacking lime with water containing about 2 per cent. of gypsum, and adding a little sand to the product.

Cement—Cutlers'.—Black resin 4 parts, beeswax 1 part, finely powdered brick dust 1 part. Mix well. Used to fix tools in their handles.

Cement—Leather.—Gutta-percha 1 lb., caoutchouc 4 ozs., pitch 2 ozs., shellac 1 oz., linseed oil 2 ozs. Melted together. Must be melted before being applied. Used for uniting leather or rubber.

Brazing.—The edges filed or scraped clean and bright, covered with spelter and powdered borax, and exposed in a clear fire to a heat sufficient to melt solder.

Fluxes for Soldering or Welding.

For iron or steel, borax or sal-ammoniac.
For tinned iron, resin or chloride of zinc.
For copper and brass, sal-ammoniac or chloride of zinc.
For zinc, chloride of zinc.
For lead, tallow or resin.
For lead and tin pipes, resin and sweet oil.

Workshop Recipes.

ALLOYS.	COPPER.	TIN.	ZINC.	ANTIMONY.	LEAD.	BISMUTH.
Babbitt	1	10		1		
Bell-metal	3	1				
Brass, engine bearings	112	13	¼			
" locomotive bearings	64	7	1			
" tough, engine work	20	3	3			
" " heavy bearings	32	5	1			
" yellow, turning	2		1			
" straps and glands	65	8	½			
Metal which expands in cooling				2	9	1
Muntz' sheathing	3		2			
Pewter		4			1	
Spelter	1		1			
Statuary bronze	90	2	5		2	
Type metal		1		2	7	
For soldering—						
Brazing, hardest	3		1			
" hard	1		1			
" soft	4	1	3			
" "		2		1		
Lead		2			3	
Pewter		2			1	
Tin		1			1	

RULES FOR OBTAINING APPROXIMATE WEIGHT OF IRON.

For Round Bars.

Rule.—Multiply the square of the diameter in inches by the length in feet, and that product by 2.6. The product will be the weight in pounds, nearly.

For Square and Flat Bars.

Rule.—Multiply the area of the end of the bar in inches by the length in feet, and that by 3.32. The product will be weight in pounds, nearly.

TABLE OF VALUES.

Aluminium	50c. per lb.
Antimony	7c. per lb.
Copper	11½c. per lb.
Gold	$20 per oz.
Graphite (average)	4½c. per lb.
" (foundry)	2c. per lb.
Lead	2½ to 3½c. per lb.
Mercury	50c. per lb.

Table of Values.

Nickel	36c. per lb.
Platinum	$15 per oz.
Silver	65c. per oz.
Spelter	4c. per lb.
Tin	13$\frac{3}{4}$c. per lb.
Tungsten	70c. per lb.

FLY OIL.

Fill an 8 oz. bottle with equal parts of sweet oil and oil of tar, and add 20 to 25 drops of oil of creosote.

GLOSSARY.

Abyssal, applied to rocks formed under pressure at great depth, and cooled slowly.
Abstrich, a mass of black litharge appearing on the bath of lead early in cupelling.
Adit, a horizontal or slightly rising passage into a mine.
Afterdamp, a gas remaining along the vein after an explosion of fire-damp.
Aitch-piece, parts of a pump in which the valves are fixed.
Alive, productive.
Alloy, a mixture of two or more metals.
Alluvions, deposits of alluvium.
Alluvium, silt sand, gravel, etc., deposited by streams.
Amalgamation, absorption of gold and silver by mercury.
Amorphous, having no regular form.
Amygdaloid, igneous rock, in which the almond-shaped cells have been filled by kernels of quartz, calcite, etc.
Anhydrous, containing no water.
Anneal, toughening by first heating and then cooling slowly.
Anticlinal, a fold of rock, or strata, convex upwards—the reverse of synclinal.
Apex, edge of vein at the surface.
Aprons, copper plates in front of stamp battery.
Arch, portion of vein left, to support the hanging wall, or because it is too poor.
Arenaceous, sandy.
Argentiferous, silver bearing.
Argillaceous, clayey.
Arm, inclined leg of a set of timber.
Arrastra, a Mexican amalgamating mill. A round stone-paved pit in which the ore is ground and amalgamated by dragging heavy flat stones in a circle. Usually by mule power.
Assessment work, annual work necessary to hold a claim.
Auriferous, gold bearing.

Back, vein lying between a level and the surface.
Backing, timbers let into notches across the top of a level.
Back shift, afternoon shift.
Balance-bob, a counterweight for pump rods.
Bank, (1) surface at mouth of shaft, (2) deposit worked above water level, (3) coal face.
Bar-diggings, alluvial gold claims in shallow streams.
Barrel-work, native copper that can be hand-sorted.

Basque, furnace or crucible lining.
Batea, a bowl for separating metal from refuse.
Battery, a set of stamp-heads working in the same mortar-box.
Bed, a mineral seam between rock strata.
Bed-rock, solid rock beneath alluvions.
Bede, miner's pick.
Belt, a zone or band of strata of a particular kind exposed on the surface.
Black-band, a carbonate of iron found in coal deposits.
Black copper, impure smelted copper.
Black damp, carbonic (acid) oxide gas.
Black ends, refuse coke.
Black flux, charcoal and potassium carbonate.
Black jack, zinc blende.
Black lead, graphite.
Black sand, magnetite and dark minerals found with alluvial gold.
Blanched copper, copper alloyed with arsenic.
Blanket-strake, sloping tables or sluices lined with baize for catching gold.
Blick, a flash of light from the cooling gold or silver bead at the end of cupellation.
Blind level, (1) an incomplete drift; (2) drainage level.
Blind lead or lode, a vein having no outcrop.
Bloomary, a forge for making wrought iron.
Blossom, decomposed outcrop of a vein, etc.
Blower, a discharge of gas from coal; also a ventilating fan.
Blow-out, a decomposed mineral explosure of a vein.
Blue-billy, residue of copper pyrites after roasting with salt.
Blue lead, a rich blue stained stratum of gravel.
Blue stone, copper sulphate.
Booming, prospecting by laying ground bare by sudden discharges of dammed water.
Botryoidal, in grape-like clusters.
Brattice, used in levels or shafts; a partition to separate air currents.
Breast, face of a gallery or heading.
Buddle, a circular tub for separating fine ores from waste, by means of water.
Bulling-bar, a bar to pound clay into crevices crossing drill-holes.
Buntins, timbers placed horizontally across a shaft.
Butt, the end faces of coal.

Calcareous, limey.
Calciferous, lime-bearing.
Calcining, roasting applied to ores.
Cam, a curved projection on a revolving shaft for moving another part of the machinery.
Cam-shaft, the shaft to which cams are attached.

Cap, rock covering ore.
Carbonaceous, coaly.
Carboniferous, coal-bearing.
Casing, lining of shaft or well-hole to prevent caving.
Chimney, an ore shoot.
Choke-damp, carbonic acid gas.
Chute, shoot, shute, a timbered incline for throwing down ore and rock ; also a body of pay ore following a certain direction.
Claim, a portion of mining ground held under one grant.
Clastic, applied to rocks composed of pieces broken down from pre-existing rocks.
Clean-up, collecting the product periodically of a battery or sluice.
Cleat, a joint in rock ; a wedge.
Cob, to break up ore for sorting.
Column-pipe, pipe through which mine water is pumped.
Colors, particles of gold found in panning.
Concentrates, the heavy sulphide minerals, etc., which has been separated from the worthless rock matter by concentrators.
Concretions, particles compounded in one mass.
Contact-vein, a vein between rock masses of different characters.
Counter, a cross-vein.
Country, Country Rock, the main rock of the region through which the veins cut.
Course, horizontal direction : see Strike.
Crab, an iron windlass for moving heavy weights.
Cradle, a wooden trough for washing gold sands, usually on rockers.
Creep, a gradual movement of rock due to removal of support by excavation.
Crib, a timber frame.
Crop, outcrop, a surface exposure.
Cross-course, an intersecting vein.
Cross-cut, a horizontal passage driven through country rock to the vein.
Crow-foot, a tool for drawing broken boring rods.
Culm, fine waste coal and dirt.
Curb, a timber frame supporting the shaft lining.
Cupriferous, bearing copper.

Dam, a barrier for water or gases.
Damp, carbonic acid gas.
Day-shift, a gang of miners working during the day.
Dead, valueless, sluggish.
Dead quartz, that carrying no mineral.
Dead work, exploratory work not directly productive.
Dead roasting, roasting till all sulphur is driven off.

Deliquescent, liquefying in the air.
Dip, pitch, the angle made by a plane of rock with the horizontal.
Dolly, a primitive stamp for crushing ore.
Dowel, a straight pin of wood or metal inserted part way into each of two faces, which it unites.
Drag, the point of union of two veins which meet without crossing.
Drift, a subterraneous horizontal passage, properly with neither end to daylight.
Driving, excavating drifts, adits, or levels.
Dropper, a stringer leaving the vein on the foot-wall side.
Drum, the cylinder on which the hoist-rope is wound.
Dry Ores, applied to silver ores high in silver, low in lead.
Dump, a heap of ore or waste.
Dyke, a fissure filled with igneous rock.

Exfoliate, to break off in scales.
Efflorescent, to form dust or powder, or to be covered with a feathery incrustation.

Face, the exposure of rock at which work is being done.
Fahlband, a course of country impregnated with metallic sulphides.
Fault, a dislocation of the vein.
Feeder, a small vein leading into the main vein.
Ferruginous, iron-bearing.
Fire-damp, carburetted hydrogen gas.
Fire-setting, to break by exposing to great heat.
Fissure-vein, a vein cutting massive or stratified rocks (in latter case, independent of their bedding).
Float, pieces of vein matter lying upon the surface, distant from or near the vein.
Floor, the rock upon which a mineral bed rests.
Flouring, the breaking up and contamination of mercury, rendering it useless for amalgamating.
Foot-wall, the rock face on the lower side of the vein.
Flume, a water conduit, usually of wood.
Fossicking, casual and unsystematic mining.
Free-milling, gold or silver ores requiring no roasting or chemical treatment.

Gad, an iron or steel wedge for splitting rock.
Gallery, a horizontal passage.
Gallows-frame, frame supporting a pulley for hoisting-rope.
Gangue, the barren portion of a mineral deposit.
Gangway, the principal level of a coal mine.
Ganister, furnace lining composed of fire clay and quartz.

Gash-vein, one which extends only a short distance.
Gin, whim.
Goaf, worked out ground, usually filled with waste (gob).
Gobbing-up, filling with waste.
Gossan, the outcrop stained by decomposed sulphides of iron (limonite).
Gouge, a soft clayey material or decomposed rock between the vein and its wall.
Grass-roots, surface.
Grizzly, an iron grating for separating large pieces of rock from the finer.
Guide, timbers nailed to the shaft-timbers for guiding the cage.
Gun-boat, a skip ; a self-dumping box used in slopes.

Hanging-wall, the wall of rock above the vein.
Head-gear, a derrick.
Heave, see Fault.
Helve, an axe-handle.
Hewer, a coal miner.
Hitch, a dislocation of a vein. Also a shoulder cut in the rock to support the end of a stull or other timber.
Holing, grooving the lower part of a coal seam preparatory to breaking down the upper mass.
Hopper, a funnel-shaped box.
Horse, a mass of country rock in a vein.
H-piece, see Aitch-piece.
Hungry, worthless looking.
Hydraulicking, working auriferous gravel beds by a column of water directed under pressure against the bank.

Incline, an entry into a mine following the dip.
In place, applied to a vein or deposit in its original position.
Inter-bedded, lying between two beds of strata.
Intrusive, applied to igneous rocks forced into the midst of others.
Iron-hat, *iron-cap ;* gossan.

Jar, that part of the drilling apparatus which takes the shock when the tools hit the bottom of the hole.
Jigging, separating heavy from light particles by agitation in water on a jig.

Kibble, an iron ore bucket.
Kirving, see Holing.

Lagging, slabs of timber between the main timber sets and the roof or walls.
Launder, water trough.

Lead, a term applied to veins.
Level, a subterraneous horizontal passage.
Lift, all the mine workings connected with, opened from, and mined out at one level (stope). Also length of pump shaft between stations.
Live quartz, well-mineralized quartz.
Location, a mining claim.
Lode, a vein carrying mineral.
Longwall, a system of coal mining without leaving any pillars.
Long-tom, a gold washing trough.

Mattock, pick.
Mammilated, having little globules or beads.
Matrix, the rock matter enclosing any particular fragments, crystals or minerals.
Measures, a term embracing a strata of a geological series.
Metalliferous, carrying metal.
Metamorphic, applied to rocks altered by heat or pressure.
Miners' inch, the unit for measuring water, equals 90 to 100 cubic feet per hour, used mainly by hydraulic miners.
Moil, a wedge-pointed drill used for cutting hitches.
Mortar-box, the cast-iron box in which the stamps work in stamp mills.

Nitro, nitro-glycerine; dynamite.

Ore-shoot, ore-chute; same as Chute.
Outcrop, see Crop.
Output, product of a mine.

Panning, to obtain gold or heavy minerals by washing crushed rock or earth in a pan.
Parting, a joint, crevice or seam in the rock, filled with clay or slate; a switch to allow loaded and empty cars to pass one another.
Pay streak, the portion of a vein which possesses value.
Pike, a pick.
Pinch, a narrowing in a vein.
Pipe, an elongated body of ore; also fossil tree-trunks in coal seams.
Pitch, see Dip.
Pillars, portions of vein or bed left to support the roof.
Placer, mineral, usually gold, accumulated by the wash of streams.
Plane, an inclined tramway for lowering by gravity or raising by stationary engine.
Plat, a platform, a turn-table.

Pocket, a rich isolated body of ore in a vein.
Poling, a system of timbering for soft ground.
Poll-pick, pick and hammer head combined.
Poppet, puppet. Pulley frame or head gear over a shaft. Also an unhinged valve.
Power drill, a rock drill employing steam, air or electricity as a motor.
Prop, a timber or metal support for roof or wall.
Prospect, a property, the workings of which have not yet disclosed ore in paying quantities.
Pulp, crushed ore, wet or dry.

Quick, soft running ground. Ore is said to be quickening when the associated minerals indicate richer mineral ahead.

Reacher, a prop from one wall to another.
Reamer, a tool for enlarging holes.
Reef, a gold-bearing quartz vein; a vein projecting above the surface.
Refractory, not free-milling; also applied to ores difficult of reduction.
Reticulated, net-like.
Rib, a pillar of vein matter left to support roof or wall.
Rick, an open heap in which coal is coked.
Riddle, a perforated box used in alluvial mining for screening coarse gravel.
Riffle, a groove or check on the floor of a sluice to catch gold.
Rimrock, bed rock forming a boundary to gravel deposit.
Robbing, taking the mineral from pillars in a mine.
Rocker, see Cradle.
Room, a working place in a flat mine corresponding to stope in a steep vein.

Saddle, the ridge of a stratum or ore-bed; an anticline.
Sand pump, a valved cylinder for removing mud from bore-holes.
Scraper, a tool for cleaning out drill-holes.
Seam, a layer of mineral, generally interbedded, usually applied to coal.
Selvage, gouge.
Set, Sett, a timber frame.
Shaft, a vertical opening from the surface.
Sheave, a grooved wheel over which a rope is turned.
Shift, the time during which one gang works in a mine—from 6 to 10 hours.
Shoot, to break rock with explosives.
Shute, chute.
Sickening, flouring.

Sill, the floor-piece of a timber set.
Silt, soft fine mud deposited by water.
Skimpings, the poorest ore skimmed off the jig.
Skip, a car for raising ore.
Slack, small dirt or coal.
Slag, the refuse product from smelting.
Slickensides, the polished and striated surface of fissure walls.
Slimes, the mud produced from ore-crushing.
Slip, fault.
Slitter, a pick.
Slope, an incline, entry to a mine.
Sludge, slimes.
Sludger, see Sand pump.
Sluice-box, a long flume with riffles to catch gold in alluvial mining.
Smift, a slow burning fuse.
Sollar, platform, landing.
Spall, to break ore for dressing.
Spills, a temporary lagging driven ahead on levels, in loose ground.
Spears, pump-rods.
Spoon, a cup at end of a rod for cleaning out holes.
Sprag, a piece of wood used to block the wheels of a car and check its speed.
Spar, crystalline vein stones.
Spur, an offshoot or branch vein.
Square sett, a system of timbering in mines.
Squeeze, creep.
Squib, smift.
Stockwerke, country rock networked by veins and mined in the mass.
Stope, to excavate mineral in a series of steps.
Stowing, the waste thrown back by miners to support roof or hanging wall.
Strike, course. Horizontal direction, applied to veins or strata.
String-rods, a line of rigidly connected rods for transmitting power.
Stringer, a narrow vein.
Strake, an inclined table or trough for separating mineral from refuse.
Stamp-mill, a crushing mill for reducing ores of gold, silver, tin, copper, etc.
Stull, a stick of timber, or platform, for supporting miners or waste.
Stull-dirt, material supported on stulls.
Sulphurets, applied to sulphide minerals in milling ores.
Sump, the lowest point of the mine workings, from which the water is pumped.

Swab-stick, a stick frayed at one end for cleaning out holes.
Synclinal, the trough formed by folded strata, the reverse of anticlinal.

Tailings, the refuse from crushing-mills or concentrators.
Tamping, making a loaded hole tight with clay.
Terrane, a group of strata.
Throw, fault.
Till, hard pan, boulder clay.
Tribute, a system of paying miners according to value of ore which they extract.
Trouble, fault.
Tuberose, bulb-like.
Tunnel, a horizontal entry to a mine, across country rock.

Underholing, see Holing.
Upcast, an opening through which air rises.
Upraise, a secondary passage from one level up to another.

Van, to dress or concentrate ore.
Vanner, a concentrating machine.
Vug, a cavity in a rock.

Wall-plate, the long horizontal stick in a shaft-timbering frame and parallel with the vein.
Wet Ores, applied to silver ores, high in lead, and low in silver.
Whim, a horizontally revolving drum for winding hoisting rope, operated by a horse.
Whip, a hoisting rope supported by a pulley operated directly by a horse.
Winch, windlass, a hoisting drum operated by hand.
Winze, a secondary opening sunk from a level.

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Minerals described under MINERALOGY are printed in italics.

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