The A B C OF MINING

A HANDBOOK FOR PROSPECTORS

CHARLES A. BRAMBLE

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A Handbook for Prospectors

TREATING FULLY OF EXPLORATORY AND PREPARATORY WORK OF THE PHYSICAL PROPERTIES OF ORES, FIELD GEOLOGY, THE OCCURRENCE AND ASSOCIATIONS OF MINERALS, METHODS OF CHEMICAL ANALYSIS AND ASSAY, BLOW-PIPE TESTS, PROMISING INDICATIONS, AND SIMPLE METHODS OF WORKING VALUABLE DEPOSITS, TOGETHER WITH CHAPTERS ON QUARTZ AND HYDRAULIC MINING AND ESPECIAL DETAILED INFORMATION ON PLACER MINING, WITH AN ADDENDA ON CAMP LIFE AND MEDICAL HINTS.

BY

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PREFACE.

Owing to recent rich discoveries in more than one mining field, hundreds of shrewd, intelligent men without experience in prospecting are turning their attention to that arduous pursuit—to such this book is offered as a safe guide.

A complex subject has been treated as simply as its nature permitted, and when a scientific term could not be avoided, the explanation in the glossary has been offered.

CHARLES A. BRAMBLE, D. L. S.

PREFACE TO SECOND EDITION.

A steady demand for this work has shown that it fills a want, and serves the purpose for which it was written. In issuing this second edition, a few compositors' errors that had crept in, owing to the author being in a very remote region while the book was going through the press, have been corrected, but no material changes in the text were found desirable.

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CHAPTER I.

PROSPECTING.

Many men seem to think that should their destinies lead them into parts of the world where there is mineral wealth they will have little chance of discovering the deposits without the technical education of a mining engineer. This is wrong. The fact is that the sphere of the prospector does not cover that of the engineer. The work of the one ends where that of the other begins, and many of the most successful discoverers of metallic wealth have been entirely ignorant of the methods by which a great mine should be opened, developed, and worked.

A few simple tools and a not very deep knowledge of assaying, with an observant eye and a brain quick to deduce inferences from what that eye has seen, are the most valuable assets of a prospector. In time he will gain experience, and experience will teach him much that he could not learn in any college nor from any book. Each mining district differs from every other, and it has been found that certain rules which hold good in one region, and guide the seeker after wealth to the hidden treasure that has been stored up for eons of time, do not apply in another region.

To show what may be done with imperfect, improvised apparatus, an Australian assayer, who has since become famous, started up country in his youth with the following meager outfit: A cheap pair of scales, a piece of cheese cloth, a tin ring 1 1-2 inches by 1-2 inch, a small brass door-knob, some powdered borax, some carbonate of soda and argol, a few pounds of lead lining taken from a tea chest, an empty jam pot, a short steel drill, a red flower pot. With this modest collection of implements he made forty assays of gold ores that turned out to be correct when repeated in a laboratory.

About the best advice that can be given to a man who has determined to go to some out of the way region where there is a possibility of his discovering minerals is to recommend him to visit the nearest museum and gain an acquaintance with the common rocks. Should he be unable to do this he had better provide himself with small, inexpensive specimens from the shop of some dealer. It is almost impossible to teach a beginner to distinguish the various rocks by any amount of printed instruction; the only way to learn to recognize them is to handle them and note carefully their color, weight, and the minerals that go to make them up. The explorer should be able to recognize at a glance, or at any rate after a very short inspection, the sedimentary rocks, such as sandstone and limestone; the metamorphic rocks, that is, rocks that have been altered by the agency of great subterranean heat in ages long past, and which were probably stratified rocks at one period, such as granite and gneiss, and the truly igneous rocks—trap, diabase, diorite, etc. He must know also that mysterious rock which the western miner calls porphyry, and to which is ascribed most wonderful virtues in the way of ore attraction; while dolerite and dolomite must be to him familiar terms and substances. This sounds easy enough but the student will find that a good deal of hard work is necessary before he can readily recognize each of these rocks.

It is even more necessary that he should learn the metals thoroughly. Each one differs from all the rest in some particular. Often this difference will be an obscure one, but to the careful investigator the recognition of the substance will be in the end certain. They may differ in weight, in color, in hardness, in a dozen different ways, so that to the man who has made a study of this subject a determination is always possible.

On account of the wonderful discoveries in the Canadian Northwest and in Alaska, the eyes of thousands are turned towards those fields. Wonderfully rich placer ground has already been found and there can be no reason to doubt that very much larger areas remain unproved. Where this gold comes from is an open question; geologists, mineralogists and chemists, not to mention mining engineers and practical prospectors, have disputed over the source of the gold already found, but it must be confessed that there are almost as many theories as there are disputants. Could it be known with certainty how and under what conditions the gold got where it is found, the problem of seeking for it might be made easier. Unfortunately this is not the case, and all prospecting for the home of the precious metal is more or less a groping in the dark. We do know that the heaviest particles of gold do not travel far from where they were first deposited, because gold is so enormously heavy—its specific gravity being about nineteen times that of water—it seeks the bottom of the stream and stays there. It is not an invariable rule that the gold increases in coarseness as the stream is ascended, but it is a very general one. On some rivers rich and poor stretches of gold-bearing gravel succeed one another as the explorer makes his way up or down stream. This is difficult to account for, but in many cases is believed to be caused by the modern river robbing the bed of some one or more ancient water-courses whose beds crossed the valley of the present stream. This may or may not be the case. We only know that the miners who found coarse gold on the lower regions of such rivers as the Frazer were miserably disappointed when they reached stretches near the source and found nothing but flour gold. This same feature has been noticed in some of the Alaskan rivers. It is quite within the bounds of probability that no very rich quartz veins exist in Alaska. It does not follow from the richness of the placers that the gold is derived from very rich quartz lodes, because this amount of gold may really represent the product of a vast amount of rock that has been ground to powder and washed away in the course of ages. The gold would not travel far, and the deposits being unearthed to-day have been accumulating in these northern streams since the world was young; water-courses are nature's ground sluices.

It is possible that one stream has cut through the drainage of another. Sometimes this has impoverished the first and enriched the second, while in other cases the reverse has obtained. Upheavals have formed faults* and fractured the strata, and the gold may have been deposited by solution in these fractures. Often the soil will have been washed away from near the top of the mountain, so that layers of stratified rock are seen to be duplicated on each side while they are covered at the summit. The prospector keeps his eye open as he goes along and notes carefully the character of the fragments of rock he finds in the streams. Quartz, diorite, diabase, and porphyry pebbles are grounds for expecting a profitable result, but of course there is no certainty of such a happy issue. As soon as the district begins to be fairly well known certain discoveries are made that invariably render prospecting easier. Local peculiarities are noted; certain characters are found to be common to the ore-bearing bodies or deposits; the lines of deposits become known, and a good deal of light is then shed upon a very difficult problem. As a rule, when the fragments of quartz, pyrite, chalcopyrite, or galena are rough, they have not traveled far, and the lode from which they have been derived should be close at hand. Water and attrition soon round these minerals on their sharp edges, and thus show that they have come from some little distance.

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*Dislocation of the strata.

In some countries, especially where vegetation is scanty, the outcrop of a body of mineral may be traced by a difference in the vegetation. In South Africa a chain of pools usually follows the course of a line fault, which in its turn marks where an intrusive lode carrying mineral separates two different formations. As a rule, any heavy mineral is worth investigating. Even in remote regions silver, mercury, tin, nickel, platinum, copper, and several other metals are worth paying attention to. If they are too far away from the railroad or the steamboat to-day they may not be so next year, for civilization advances with giant stride in these days and never faster than when transportation companies are reaching forth to some newly discovered mineral field.

One of the greatest drawbacks to prospecting in the North is the dense growths of moss and forest that cover the ground. In most of the Western states, in South Africa, and in Australia this drawback does not exist and prospecting was by that much the easier. However, as a compensation, there is abundant water in Alaska and the Northwest, while it was and is almost entirely absent in several other regions that possess immense bodies of ore which are not available for this very reason.

Quartz has been called the mother of gold, and certainly quartz and gold are inseparably connected today. As to where gold may be found the best reply that can be given is in the words of the old miner, who, when asked that question, said: "Where it be's; there it be's," and then added, "and there ben't I."

Although most prospectors travel alone from sheer necessity, there can be no doubt that three or four men forming a party and working together have the advantage. They can do their work cheaper, more thoroughly, and more surely. By co-operating they may carry a more complete outfit. Should any accident happen help is at hand, whereas the solitary wanderer often dies as the result of some accident that would have been trivial had he had a companion. Three or four claims may be worked in conjunction with one another at far less proportionate expense than a single one could.

Nature's preparation for the reception of great ore deposits is somewhat as follows: The crust of the earth is prepared for the reception of the metals by great outbursts of igneous or melted rocks; the metals themselves being carried in suspension in the heated water that everywhere traverses the strata. These metals are deposited in the veins as soon as the waters begin to cool, and the pressure to which they were subjected from deep down in the earth's crust is removed. A great mineral country is usually marked by the outcrops of the veins being persistent in their courses and traceable for many miles, though very probably many breaks may occur in these outcrops. The rocks associated with great ore bodies are lime, porphyry, granite, shales, slates, quartzites, and diabase. Fragments of mineral and gangue, known to the miners as float, may be littered over the hills and encumber the courses of the stream. A central line of eruption may often be traced by masses of altered rock, and beds of lava or other volcanic products. We find the granite has been melted and the limestone has acquired magnesia, and thus become dolomatized.

Whenever a heavy deposit of pyrites, or mundic, is found mineral probably exists below. The cubes of pyrite are not always valueless, they may contain gold in addition to the iron and sulphur. When the pyrites decay under the influence of the weather, and leave the quartz honeycombed, these cavities often contain concentrated gold; for which reason you often get a higher assay from the surface than from any point lower down in the vein. In sinking the shaft soon gets below this altered quartz and the ores are then combined with sulphur. They have become sulphides, and are harder to treat. The prospector should therefore act very cautiously when trying to develop a mine with a small capital behind him; because, although the first ore may be adapted for stamping, he may find, before he has gone down fifty feet, that it can only be treated in a smelter, and that all the money he has put into crushing apparatus is wasted.

Without the prospector there would be no mining and the world would yet be in the stone age. He is not appreciated at anything like his real worth. He requires ability and experience, push and perseverance. Prospecting is a search for valuable minerals. He may not be very deeply learned in either geology or mineralogy, but he must have a keen eye and good natural powers of observation.

There are some sixty or seventy elements in the world, and the most common is oxygen. Nearly all the coloring matter of rocks comes from iron. Wind, frost, rain, snow, and heat, cause a crumbling of the different rocks, and running water wears them away, and carries off and distributes the particles. By this agency, and by floating ice, they are often removed to long distances. The action of internal heat renews the deposits of mineral by eruption, or by hot springs, but this means of renewal was much more powerful in the past than it is now.

Organic matter found in the crust of the earth was derived from animals or vegetables. Coal is a legacy from forests that flourished ages ago, while petroleum is all that remains of vast schools of fishes that swarmed in Devonian seas.

Stratified rocks are either sand, clay, or calcareous, which means lime-bearing. In their natural position they were horizontal, but owing to subsequent volcanic action they are, in some localities, tilted at all conceivable angles. The eruptive rocks have burst through them in places, changed their character, divided them by intrusive masses, and generally enriched them with mineral deposits.

Everything now known points to the theory that the contents of veins were deposited in the lodes by infiltration. In a few instances famous mines have no veins, but are literally hills of mineral; they are then of low grade, but much more remunerative than average high grade mines, owing the vast quantity of ore, and the ease with which it can be mined. The famous Treadwell mine, on Douglas Island, Alaska, has ore that is worth less than four dollars a ton, but it is quarried, and 640 stamps work day and night. There is about a dollar a ton profit, and hundreds of thousands of tons are treated annually. The tin mine known as Mount Bischoff, in Tasmania, and the Burra copper mine in Australia are other instances. Each of these deposits was found as an outcropping on the bare top of a low hill, and none of them has walls.

A fault may throw the vein up or down, and a good deal of exploration may have to be done before it is recovered.

A lenticular vein consists of a series of double pointed ore bodies like lenses which may be strung out, overlapping, or not.

The outcrop of a vein is never the same as its strike, except on a level surface.

A stringer of ore branching off from the main vein is known as a chute, shoot, or chimney.

In developing a ledge or lode, first find out what the ore is. Gold is shown in the mortar, especially after roasting. Silver may be recognized at sight, or by assay tests, or blow pipe; copper, by its vivid colors, —green or blue for carbonate and red for oxide or metallic copper. The ore often differs in various parts of the vein. Explore your lode along the surface, across, and down its dip. When you find it continuous it will be time enough to think of a vertical shaft. The top of a shaft must be timbered with logs, so as to give sufficient fall to get rid of the mineral when it is hoisted.

The first thing the prospector has to consider is his outfit. The more complete this is the better, but ninety-nine times out of a hundred the difficulties of transportation in a wild region are so enormous that he will have to do without a great many things that he would like to have. He must endeavor to make up for the lack of tools by ingenuity; then he may get along fairly well. A pan, he must have. In this he will wash carefully all his samples. Then, a flask of quicksilver is more precious to him even than gold; for, having it, he can resort to pan-amalgamation, which will save the precious metal even when it is in minute particles.

This process may be described as follows: A pound or two of the ore in powder is placed in the pan and water is added until the mass becomes a thin pulp. One ounce of quicksilver and a small piece of that deadly poison, known to the chemist as cyanide of potash, and as prussic acid to the ordinary man, should be added, and the mass should be stirred thoroughly, for two hours if you can stand it. Then turn in water and wash off the dirt and the amalgam will be found in the bottom of the pan. This you must collect very carefully. You should have a square piece of chamois skin or a piece of strong white cotton cloth. In either case the amalgam is put in the center of this square and the cloth twisted until all the superfluous quicksilver is pressed out and your amalgam remains nearly free from mercury. This amalgam placed on a shovel and held over a brisk fire will soon show the yellow color of gold. If you have no mould you may make one of clay, put your gold therein with a little borax, and very soon, the fire being hot enough, you will have a tiny ingot of the precious metal. But most prospectors are satisfied when they have obtained their sponge gold, and do not carry their operations further in these rough and ready tests.

The prospector of to-day is often a very different man from his predecessor of a generation ago. The old gold hunter used to sally forth armed with a pick, shovel and pan, and usually a very little grub. In his stead men are now taking the field who have had the benefits of a thorough education, both practical and theoretical, and provided with all the equipment necessary for their work. Some of these men carry an outfit somewhat as follows: An iron mortar holding half a gallon, together with a pestle a rough scale for pulp, a more delicate one showing troy grains and pennyweights, a 40-mesh sieve, a burro furnace and muffle, one cupel mould, a couple of dozen scorifiers, tongs to handle the cupel and scorifiers, two annealing cups, a spirit lamp, a dozen test tubes, a pouring mould, five or six pounds of borax and about as much carbonate of soda, five pounds of bone ash, ditto of granulated lead, a pint of nitric acid, ditto of hydrochloric acid, ditto sulphuric acid, ditto of ammonia, twice as much alcohol and two pounds or so of granulated zinc.

As a blow pipe outfit he will take a blow pipe, spirit lamp, nitrate of cobalt in solution, cyanide of potash, yellow prussiate of potash, red prussiate of potash, a sheet or two of filtering paper and a couple of three-inch glass filters. With this outfit he can determine any mineral he may come across.

By patience and observation the man who starts out to take up prospecting as a road to fortune may easily master the rudiments of his business. It will not take him long to become familiar with the commoner rocks, and the more valuable ores. His own rough tests in the field must be confirmed by competent assayers upon his return to civilization, and in this matter he should be very guarded. The most reliable assays are made either at the different government assay offices or by some of the large metallurgical works whose reputation is world wide. Prospecting is hard work, but the life is healthy and full of excitement, only the explorer should have courage, hope, and good temper, for each and every one will be as necessary in his chosen vocation as his pan and pick.

When alluvial or placer gold has been found it is reasonable to suppose that the vein from which it was derived may also reward diligent search, for it is undoubtedly true that most placer gold has come from quartz veins. This, however, is believed not to be invariably the case, a recent school of mineralogists contending that pure masses of alluvial gold have been formed from the accretion or growth of the gold deposited from certain gold salts. This is in any case probably exceptional, and the prospector who finds gold in gravel should seek in the adjacent country for the quartz lodes from which it came.

Important deposits may be expected at or about the line of unconformability where slates, shales, quartzites, sandstones, limestones, schists and other sedimentary deposits are pierced by intrusive masses of igneous rocks.

Veins filling the cracks that once existed between two differing rocks are known as contact veins. Such veins are often very rich. Curiously enough large masses of true igneous rock rarely contain valuable deposits of mineral, but where such intrusive masses cut dikes or walls of porphyry, or diorite, the region is worthy of careful investigation.

POCKET LENS.

In an open country the prospector should keep to the hill tops if on the lookout for veins, as the outcrops show more distinctly on the bare ridges, but alluvial deposits are only found in valleys and along the borders of streams. In any case, much of the northern part of this continent can only be prospected by following the streams, on account of the dense growth of forest with which the soil is covered. The true line of strike of a vein can be determined only on a level stretch. The line of strike and the line of dip are always at right angles to one another; the outcrop may follow the strike or it may not.

A pick, shovel, and pan, are absolutely necessary to a prospector's proper equipment. A good pocket lens, cheesecloth screen, and small iron pestle and mortar are often useful. The pan is the most essential part of the outfit, and is always bright from use.

The regular gold miner's pan is 13¾ inches in diameter across the top, 10 inches across the bottom and 2⅛ inches deep. The best are made of sheet iron and have a joint around the bottom rim which is of some assistance in retaining the spangles of gold.

A more primitive instrument than the pan is the batea. This requires more skill than the pan, and is much in favor with South American miners. It is made of hard wood, 20 inches in diameter, 2½ inches deep in the center, inside measurement, and sloping gradually to nothing at the sides.

The horn spoon has been handed on from antiquity. It is made from a black ox horn, at least a black one is the best as it shows the gold better; it is eight to ten inches long by three inches wide, cut off obliquely.

When gold is suspected in quartz, but there is visible to the naked eye more or less iron, copper, and other base metals, it is well to crush the quartz into coarse fragments. Roast on a shovel or other convenient tool over a hot fire, and finally pulverize in the mortar. If panned it will now reveal much of its gold, while, had these measures not been taken, the sample might have given negative results and been declared valueless.

After pulverizing, the ore should be passed through the cheese cloth screen before panning. If the approximate value of the ore is sought, the sample must be dried and weighed before crushing; and the resulting gold weighed. Thus:

Sample is to 2,000 lbs. as gold found is to Ans.

About 13 cubic feet of quartz weigh a ton before being disturbed; when broken to medium sized lumps 20 cubic feet may be taken as representing a ton. Although experience teaches the miner to estimate very closely the value of his sample, it is better for the tyro to have a small pair of scales with grain weights. A grain of gold, if tolerably pure, is equal to four cents. Above all things avoid the too common error of panning the pick of the rock, as a false estimate is bound to follow and only too probably eventual loss.

A yard of gravel before being dug makes one and a half yards afterwards. A pan of dirt is usually about 20 pounds, although it is not well to fill quite full in actual work.

Many a valuable mine has been found by following up "float" ore. Float is detached fragments of the vein or gangue, and it becomes more and more abundant as the lode is approached until it finally ceases abruptly. This indicates that the vein has been reached or passed, and a trench dug throughout the alluvial soil at right angles to the assumed line of the vein will probably reveal it. The float and mineral of course drift down hill; if the side of the mountain be saddle-shaped the float will spread out like a fan as it washes down, but if concave the force of gravity will concentrate it within a narrow space in the ravine. Float found at the foot of a hill has come, as a rule, from that hill. The nearer the vein the less worn will be the edges of the float and mineral. The gangue or vein-rock in which the metal is found may be calcite or calc spar, fluor spar, heavy spar or baryta, or quartz. Gold is almost always found in this last matrix. The upper parts of most quartz lodes are usually oxidized, that is to say, the atmosphere has acted upon the iron pyrites, freeing the sulphur and staining the quartz yellow, red, or brown, by oxide of iron. This is known as "gossan" or the "iron hat." Such quartz is frequently honeycombed and rotten. Below the water level these veins run to sulphides in which decomposition has not set in, and the gold contained in the quartz is no longer "free milling," i. e. will not give up its gold to mercury without a preliminary treatment.

Whenever the explorer comes across a mass of gossan he should sink a trial shaft to the vein, as it is almost certain that below the oxidized sulphides a body of mineral exists likely to encourage mining operations.

Native gold is malleable, will flatten out under the hammer, and a steel knife will cut it with ease. It almost invariably contains silver, sometimes to the extent of one-fifth. A little practice will enable the prospector to recognize it, for there is but one king metal. Much gold is derived from copper and iron pyrites, and silver and lead ores are a very large source of supply.

Gold is found in gravel of every variety, from finest pipe-clay to boulders weighing tons. Sometimes volcanic eruptions have covered these deposits since the ancient rivers laid them down, and in many cases their courses do not in the least agree with the valleys of the shrunken streams that have replaced them.

Gold may be distributed through the whole thickness of a bed, but ninety-nine times out of a hundred the richest layer of gravel is just above the bed rock upon which all the gravel rests. Gold may even be found among the grass roots, especially in dry localities where there has been little water to carry it downward. When the bed rock consists of upturned slates the gold frequently penetrates it for some little distance.

Sand is nearly always poorer than gravel.

The experience of miners in the Victoria gold fields is that gold is always found on the bars or points, and not in the deep pools and bends.

The great difficulty with which any but the very finest particles of gold can be moved by water accounts for the value of the deposits depending largely upon the local rocks. It is very fortunate that gold's specific gravity is so great, for were it less its recovery would be much more difficult. The sluices and other apparatus of the miner are really nothing but the operations of nature imitated on a much smaller scale. There is one thing, however, time, that nature can afford to expend in prodigious periods, while man must not waste a single minute.

It not being possible to point out where the ancient river beds lie, smothered as they are by hundreds of feet of overlying drift, lava, and other later deposits, the only feasible plan is a series of boring with the diamond drill.

When gold has been discovered the finder must act with the greatest prudence, for even gold may be bought too dear. The surest test is a mill run, that is passing 10 to 50 tons through all the operations of crushing, milling, roasting, amalgamating, etc., and so ascertaining what returns are likely to be obtainable when the deposit is worked on a commercial scale. True sampling is necessary. All parts of the vein should be included, and the lode cross-cut by galleries in more than one spot. It is the very great necessity of these expensive preparatory explorations that has given rise to the saying, "Quartz mining is for rich men."

Many gold mines have been abandoned as unprofitable that could have been mined at a profit had their owners been wealthy and enterprising enough to do a great deal of expensive prospecting by diamond drill, cross cuts, drifts and rises. In one instance that came to the writer's knowledge a clever mining engineer cleared nearly $200,000 profit by leasing for a term of years a gold mine that was supposed to be exhausted. A drill hole sunk less than 50 feet below the old workings revealed a pocket of ore in the vein, and paying quartz was found for many hundred feet below.

With the improvements in electricity made recently a cheap power has been provided that will permit many mines to be reopened. The saving in working expenses effected by introducing electricity is often very large; after the plant is once installed the cost is almost nil where turbines can be employed to furnish the power to the generators. Machinery capable of delivering power at a distance of several miles from the plant, may be operated at very reasonable cost as compared to that of other prime movers.

Discoveries of many deposits that have in time been successfully mined were the result of chance. No skill guided the finder; he merely stumbled upon his luck just as the wayfarer once in a while hits his toe against a well-filled pocketbook. For instance, a South Australian squatter picked up a piece of copper ore that a wombat had thrown out of his burrow, and the result was the discovery of the great Wallaroo lode. The first diamond from South Africa was picked up by an ignorant bush boy and kept with a lot of worthless pebbles in the private collection of the boy's master; no suspicion existed of its value until a passing trader had carried it away and obtained $2,500 for it in Capetown. Gold was first discovered in California in 1848 by the superintendent of a sawmill who saw it glistening in the flume. Similarly gold was discovered in both Australia and Brazil by the purest chance. Had not a tree been uprooted by the wind the vast deposits of soft hematite iron ore in the Biwabic iron mines of the Mesabi range, Minnesota, might have remained unknown for many a long year to come. In the desolate region to the northward of Lake Huron great stores of nickel ore exist. These mines, which may some day regulate the price of the metal all the world over, were exposed in a railway cutting; no one dreamed of their existence. The Redington quicksilver mine in California was discovered by some roadmakers. Tradition relates that the enormously rich silver mines of Potosi, in Bolivia, were discovered by the accidental uprooting of a bush having spangles of silver ore attached to its roots. This was in 1538, and two hundred years later a similar streak of luck revealed the wealth of the Catorce district of Mexico, from which in thirty years, ore to the value of $35,000,000 was taken.

Moreover, the search for one mineral often leads to the discovery of another. The Comstock lode was first worked for gold, and the miners threw away the black sulphide of silver worth $3,000 to the ton. The Broken Hill mine in Australia was claimed as a tin deposit by its finder; it is now the greatest silver producer in Australasia. Such instances could be multiplied almost indefinitely, chance entering into a majority of mineral discoveries. On the other hand, it has happened, not infrequently, that purely scientific deductions and calculations have brought to light stores of mineral wealth.

Certain minerals are likely to be found associated. Cassiterite goes with boron and tourmaline, topaz, fluor spar and lithia-mica; all containing fluorine. It is also found with wolfram, chlorite and arsenical pyrites. Magnetite is often accompanied by rocks containing garnet, epidote and hornblende. Zinc blend and galena may occupy the same vein, which is likely to be of baryta or heavy spar. Much galena carries silver. Gold is associated with many metallic sulphides such as iron, magnetic, and copper pyrites, mispickel, galena, blend, stibnite and tetrahedrite. Gypsum accompanies salt.

Surface indications may be described as: Form of ground, color, outcrop, decomposed and detached mineral, mineral deposits from springs, altered or peculiar vegetation and other similar guides. A hard quartz outcrop often stands up like a wall and is traceable for miles. The Rainbow silver bearing lode of Butte, Montana, stood 20 feet above the surface. Soft minerals, such as clay, are cut into and sunk below the surrounding level. Deposits of Kaolin or China clay are usually so found.

Any special bright coloration of the rocks of a district merits investigation. Copper gives green, blue, and red stains; iron, red or brown; manganese, black; lead, green, yellow or white; cobalt, pink; cinnabar or quicksilver, vermilion. The nickel deposits of New Caledonia were made known to the world by the explorer Garnier in 1863, his curiosity having been aroused by the delicate green coating given the rocks by an ore containing water, quartz, nickel and magnesium.

Hard beds of shale decompose on the surface into soft clay, and a still more noticeable change is the conversion of ores containing sulphur into oxides. This chemical change causes the gossan or "iron hat," for which token of underlying wealth the prospector should be eternally watchful. This alteration may extend downward four or five hundred feet from the surface, but in such cases the true weathering has ceased long before the limit of discoloration is reached, and the change of substance is due to the filtering of surface waters through the vein.

Gossan varies greatly in its nature. Galena becomes anglesite, cerussite, pyromorphite and mimetite. Copper pyrite changes into native copper, melaconite, cuprite, malachite, chessylite, or perhaps into a phosphate, arsenate, or silicate of the metal. Carbonate of manganese gives the black oxides and silver sulphide ores are, after weathering, known as native silver, kerargyrite and embolite.

The ore in the gossan is very generally more valuable than it will be below, and this is especially true of gold and silver ores. The gold having been set free from the close embrace in which the iron pyrite held it previous to the latter's oxidation, it is now readily caught by quicksilver. Silver under similar conditions becomes chloride, and likewise amalgamates without difficulty.

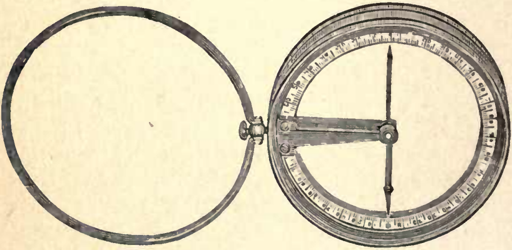
Seams containing native sulphur often show no trace of that element on the surface, having weathered into a soft, white, gray or yellowish-white granular, or pulverulent, variety of gypsum.

Veins of asbestos often decompose into a white powder found in the crevices of the rocks; fibrous asbestos existing in the interior.

Petroleum shows in an iridescent film upon still pools, and the odor is a sure guide to its nature.

A "dipping-needle" is valuable to the prospector on the lookout for iron ore; by its use he may discover masses of magnetic ore and trace their extent. As he carries the compass over the ground the needle dips toward any iron mass he approaches; directly over the ore it becomes vertical.

In a wilderness country strength of body and endurance are important qualifications. The prospector must, moreover, have such general knowledge of geology and mineralogy as to be able to recognize all valuable minerals and confirm his conjecture by simple



MINER'S DIPPING NEEDLE.

tests. Pick, shovel and pan must be handled skillfully, while the rifle, shotgun and paddle must also be understood. For in the unsettled parts of the country the traveler must even yet rely to some extent upon the fish and game he may be able to secure, and every old prospector becomes a trained hunter and camper. Knowing how to bake bread is sometimes more valuable than much mathematics; ability to build a rough boat is often the one hope of salvation.

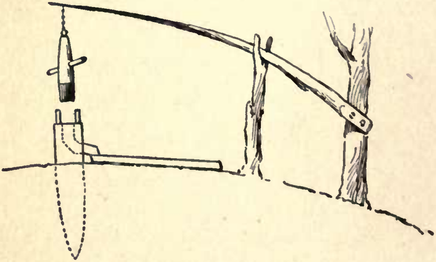
In sinking a short shaft in a sunny country a large mirror, inclined at a suitable angle over the shaft, will give sufficient light.

Lodes or veins following the general trend of the auriferous quartz are much more likely to be rich than are those that cross it. Gold is never distributed evenly in veins, though it may be in great beds of low grade material; but more often rich areas alternate with barren portions.

Where quartz veins are small and the rich pockets separated by wide intervals of poor gangue the gravel of the district will usually be similar in character. As this condition obtains in the upper Yukon district as far as the gravels are concerned, it will probably be found to hold good for the quartz leads, when they shall have been discovered.

The more nearly the gold formation approaches to the crystalline schists, the poorer will the quality of the gold be through the larger percentage of silver found in it. In slates the proportion may be 22 gold to 1 silver; in schists it has been known to be a ratio of 1 to 1.

With the discovery of valuable gold-bearing gravel on the bare hillsides of the Northwest, a vast region has been added to the area the prospector may explore to advantage. No experience acquired in ordinary American placer grounds is likely to be of much use in detecting these higher gold-bearing gravels of the Yukon, but they appear to be somewhat similar in character to the New Zealand terraces. Terrace-prospecting requires perseverance and the use of some brains, as it is infinitely harder than creek-prospecting. These terraces or benches are the remains of old river beds. The whole bench must be carefully scanned over because the gold is quite as likely to be in one part as in the other. Sometimes it is in half a dozen different layers one above the other. Sometimes the old river terraces are entirely covered by landslides, and the majority of such deposits are not likely ever



DOLLY.

to be found, as it is almost impossible to guess at locations.

In New Zealand gold has been found on table-lands nearly 6,000 feet above sea level, and according to recent information valuable claims have been discovered in Alaska on the very summits of the rounded hills on each side of El Dorado creek.

To understand how such deposits as those of the Northwest may have been made, suppose that such a vein as that of the Idaho, which has been worked for a depth 1,700 feet by a width of 1,000 feet, and from which $17,000,000 have been taken, to have been worn down by glacial or other forces. Is it not conceivable that the gold would gradually have accumulated in the nearest canyon?

To obtain suitable samples of the vein a dolly is an efficient apparatus.

This is practically a very simple, crude, stamp mill. On the end of a solid log, firmly fixed in the ground and standing four feet or so above the surface, a square 6-inch hole is cut in which are fitted wrought iron bars 3 inches deep by ½ inch wide, and separated by equal intervals. These bars taper below so as to permit free passage of the pounded mineral. A wooden box surrounding the grating keeps the ore in place. A block of wood, shod with iron, forms the stamper. The miner hauls on the handles at every blow. The gold is saved on the lower table.

No one of experience in mining would look for brown hematite in a granite range, nor for black band, though such might be a likely region for red hematite or magnatite.

The explorer should be familiar in theory at least with the locality where he may expect to find valuable minerals. For instance, should he be searching for some heavy, detached substance that is usually found in placer deposits he will keep to the low ground and examine carefully the beds of the streams. On the other hand, should his quest be for some ore that is more properly a component of a lode or vein he will examine the side hills and summits where denudation will certainly have exposed such deposits. Then he must know the appearance of each ore, and with the methods of making rough and ready tests he must be perfectly familiar.

Gold is always more or less intimately associated with quartz. Oxide of tin is said never to have been found more than two miles from some granite rock, one of the components of which was muscovite or white mica. The junction of slates and schists with igneous or metamorphic rocks often proves a valuable find of mineral.

Rocks for the purposes of the explorer may be grouped under three heads: Igneous; metamorphic; stratified. The first includes lavas; trachytes, grayish with rough fracture and mainly glassy; dark basalts; and traps, such as greenstone. Obsidian is a volcanic glass. Metamorphic rocks are thought to have once been stratified, but to have been altered by heat. They comprise granite, of quartz feldspar and mica; syenite, containing hornblende instead of mica; gneiss, like granite, but showing lines of stratification; mica schist, made up of mica and quartz and separating easily into layers; slates.

Stratified rocks are those deposits from water, such as sandstone, limestone, clay, etc.

A prospecting shaft need not be of large dimensions. One 4 feet square is amply large for any depth down to 30 feet, but it must be kept plumb.

Sometimes shafts are sunk through the pay streak in alluvial gravel, without it being detected. Frequent panning will guard against this mistake.

In the Klondike region it is said early prospectors missed very rich deposits, that have since been discovered, by stopping short of true bed rock, being misled by a bed of harder gravel that they thought was bottom.

Silver almost invariably carries some gold. The dark ironstone hat already referred to is a good indication of silver ore beneath; it is generally composed of conglomerates cemented by oxides of iron and manganese.

Galena, which is sometimes so rich in silver as to be worth working for that metal, may often be followed by surface indications; namely, a white limy track with detached fragments of float ore in the surface soil. The blowpipe or fire assay quickly determines silver ore.

Tin in lode, stream, or alluvial deposits occurs only as an oxide, but its appearance is varied. It may be almost any color and shape. It is always near granite, containing white mica known as muscovite.

The minerals for which it is most easily mistaken are:

	Sp. gravity.	Streak.
Wolfram	7 to 7½	Red, brown or black.
Rutile	4.2	Light brown.
Tourmaline	3.2	Whitish.
Black Jack	4.3	Yellow, white.

The magnetic or dipping needle is used in New Jersey, as follows, according to the State Geologist, W. H. Scranton, M. E.: "An attraction which is confined to a very small spot and is lost in passing a few feet from it, is most likely to be caused by a boulder of ore or particles of magnetite with rock. An attraction which continues on steadily in the direction of the strike of the rock for a distance of many feet or rods, indicates a vein of ore; and if it is positive and strongest towards the southwest, it is reasonable to conclude that the vein begins with the attraction there. If the attraction diminishes in going northwest, and finally dies out without becoming negative, it indicates that the vein has continued on without break or ending until too far off to move the compass needle. If, in passing towards the northwest, along the line of attraction, the south pole is drawn down, it indicates the end of the vein or an offset. If, on continuing further, still in the same direction, positive attraction is found, it shows that the vein is not ended, but if no attraction is shown, there is no indication as to the continuance of the ore.

"In crossing veins of ore from southwest to northwest, when the dip of the rock and ore is as usual to the southeast, positive attraction is first observed to come on gradually, and the northwest edge of the vein is indicated by the needle suddenly showing negative attraction just at the point of passing off it. This change of attraction will be less marked as the depth of the vein is greater, or as the strike is nearer north and south. The steadiness and continuance of the attraction is a much better indication of ore than the strength or amount of the attraction. The ore may vary in its susceptibility to the magnetic influence from impurities in its substance; it does vary according to the position in which it lies, that is according to its dip and strike; and it also varies very much according to its distance beneath the surface."

Further instructions are given in the paper from which the foregoing extract was taken, some of which follow:

"It is sufficient to say that the first examinations are made by passing over the ground with the compass in a northwest and southwest direction, at intervals of a few rods, until indications of ore are found. Then the ground should be examined more carefully by crossing the line of attraction at intervals of a few feet, and marking the points upon which observations have been made, and recording the amount of attraction. Observations with the ordinary compass should be made, and the variation of the horizontal needle be noted. In this way materials may soon be accumulated for staking out the line of attraction, or for constructing a map for study or reference.

"After sufficient exploration with the magnetic needle, it still remains to prove the value of the vein by uncovering the ore, examining its quality, measuring the size of the vein, and estimating the cost of mining and marketing it. Uncovering should first be done in trenches dug across the line of attraction, and carried quite down to the rock. When the ore is in this way proved to be of value regular mining may begin. In places where there are offsets in the ore, or where it has been subject to bends, folds, or other irregularities, so that the miner is at fault in what direction to proceed, explorations may be made with the diamond drill."

CHAPTER II.

HOW TO TEST FOR MINERALS.

When the mineralogist wishes to know the names of the specimen he holds in his hand, he, in the case of a mineral difficult to determine, considers all the following properties:

Crystalline form and structure,
Cleavage,
Fracture,
Tenacity,
Hardness,
Specific Gravity as compared with that of water,
Luster,
Color and Streak,
Transparency or otherwise,
Taste,
Odor,
Chemical Composition tested by analysis,
Pyrognostic characters as determined by the use of the blowpipe,
Mode of occurrence and associated minerals.

Crystalline Form and Structure. Unfortunately the science of crystallography is extremely complicated and long study is necessary to master it; once acquired, however, it is of paramount usefulness to the student. According to Dana there are six systems, to one of which every crystal may be referred. They are:

Isometric; (2) Tetragonal; (3) Hexagonal or Rhombohedral; (4) Orthorhombic; (5) Monoclinic; (6) Triclinic.

In the isometric system there are three equal axes at right angles to each other.

In the tetragonal system there are three axes at right angles to each other. Two of these are equal, while the third, or vertical angle, is longer or shorter.

There are two divisions of the hexagonal system; the hexagonal system properly so-called, and its rhombohedral division. All forms are referred to four axes, three equal axes inclined to each other at angles 60 degrees in a common horizontal plane, and a fourth vertical axis at right angles, and longer or shorter. The rhombohedral division comprises crystals having but three planes of symmetry, intersecting at angles of 120 degrees in the vertical axis. They are regarded as half forms of the corresponding hexagonal crystals.

In the orthorhombic system there are three unequal axes at right angles to each other.

In the monoclinic system there are three unequal axes, of which one, the lateral axis, is inclined to the vertical, while the angles between the others are right angles.

In the triclinic system there are three unequal axes and these intersections are all oblique. The student who wishes to pursue this subject further should consult Dana's System of Mineralogy.

Physical Mineralogy. Cleavage is the line of easiest separation in a mineral. It may be perfect, imperfect, interrupted, etc.

Fracture, referring to any surface except that of a cleavage fall, may be uneven, conchoidal (shell-like), hackly (rough), etc.

Tenacity refers to such qualities as brittle, sectile, malleable, flexible, or elastic.

Hardness is represented by the difficulty with which a smooth surface is scratched. The scale in general ore was devised by Mohs. It is:

1. Talc. Scratched by the finger nail.
2. Gypsum. Ditto, but with more difficulty. Will not scratch a copper coin.
3. Calcite. Scratched by a copper coin.
4. Fluorite. Is not scratched by a copper coin and does not scratch glass.
5. Apatite. Scratches glass, but with difficulty. Is readily scratched by a knife.
6. Feldspar. Scratches glass with ease. Is difficult to scratch by knife.
7. Quartz. Cannot be scratched by a knife and readily scratches glass.
8. Topaz. Harder.
9. Corundum. Harder.
10. Diamond. Scratches any other substance.

Hardness may be intermediate. For instance, any mineral that scratched quartz and is soft enough to be scratched by topaz, in turn would be rated at 7.5.

Specific Gravity. This is the density of mineral and other substances compared with that of water. It is particularly valuable in determining heavy metals.

To find the specific gravity of any solid body divide its weight in air by the loss of weight in water, at a temperature as near 60 degrees F. as possible, and the quotient will equal the specific gravity. In the case of gases, such as nitrogen, oxygen, etc., hydrogen is taken as the unit.

Luster. There are seven kinds of luster, viz: Metallic, the luster of metals; adamantine, that of the diamond; vitreous, of broken glass; resinous, of the yellow resins; greasy; pearly; silky. There are five degrees of intensity of luster recognized, viz: Splendent; shining; glistening; glimmering; dull.

Color and Streak. The streak is the color of the powder of the mineral when rubbed on unglazed porcelain, or scratched with a knife.

Transparency. Minerals may be transparent, sub-transparent, translucent, sub-translucent, opaque.

Taste. Minerals may be salt, bitter, sweet, etc.

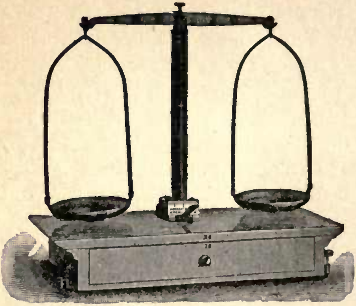
Odor. This test is not of much use with most minerals until heat is applied. All the petroleum oils, however, are often detected by their odor.

Chemical Composition. This may always be determined by suitable tests with reagents.

Pyrognostic Characters. As a means of readily determining the nature of a specimen the blowpipe is unrivalled—if in the hands of one who understands it.

Mode of occurrence and associated minerals. A knowledge of these matters often assists in a determination.

A regular fire assay is not within reach of many prospectors, for the necessary apparatus cannot, as a rule, be carried in the wilderness. Whenever possible, however, a fire assay gives the truest results, especially in the case of gold and silver.



SCALE FOR WEIGHING ORE.

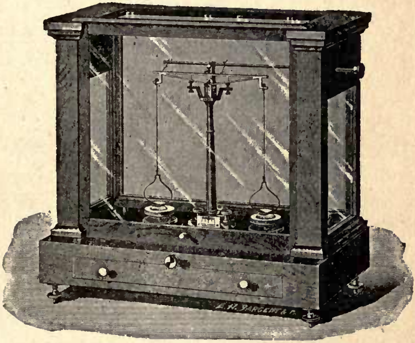
The operation includes testing the ore, sampling and pulverizing, weighing the ore and reagents, calcination and roasting, reduction and fusion, distillation and sublimation, scorification and cupellation, inquartation and parting the gold and silver, weighing and tabulating. "Notes on Assaying" by Dr. Ricketts is a very useful manual to have at hand.

A TOLERABLY COMPLETE OUTFIT INCLUDES:

A pair of scales for weighing ore and buttons of base metal. It should take 10 ounces in each pan, and show 1-20 of a grain.

A bullion scale to be kept strictly for the precious metals. Loaded with one gramme, it should show 1-20 of a milligramme.

Weights. Avoirdupois; troy, metric and "assay." Assay weights save much calculation. The unit of the system is a weight of 29.166 grammes. Its derivation is as follows:



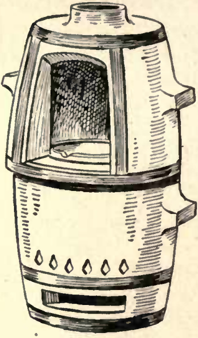
ASSAY BALANCE FOR BULLION.

2000 ℔s. : 1 A. T. :: 1 oz. Troy : 1 milligramme.

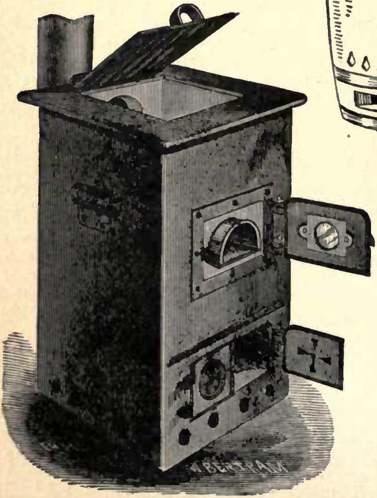
To use this system, weigh out one A. T. of the ore and whatever number of milligrammes of gold and silver the assay gives indicates an equal number of Troy ounces to the ton of 2000 ℔s. Avoirdupois.

A muffle and a melting furnace, portable and of medium size, are handy, though furnaces may be built of ordinary brick, lined with fire brick, that would be better for permanent use.

The fuels may be coke, anthracite or bituminous coal, charcoal, oil or gas.

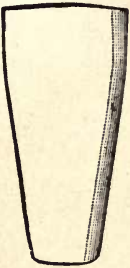


ASSAY FURNACE.



PORTABLE ASSAY FURNACE.

Crucibles of black lead, French clay, Hessian sand, and quicklime are necessary to hold the assay.



French Clay.

Hessian.

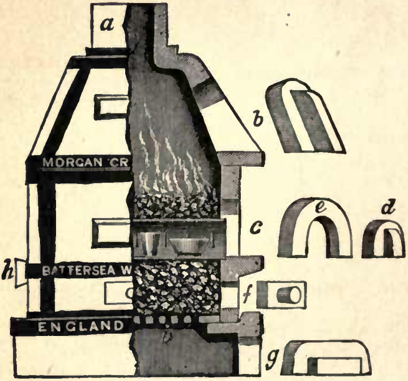
CRUCIBLES.

Roasting dishes, scorifiers and cupels are required. The cupel is made of the ashes of burnt bone, and it

SCORIFIER

STEEL CUPEL MOULD.

is better to make them on the spot, as the bone ash may be carried anywhere without damage, whereas the cupels are very fragile. The bone ash is moistened



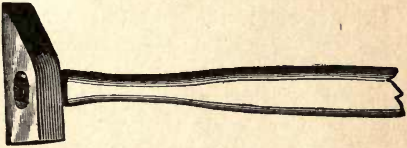
SCORIFICATION FURNACE.

with water, stamped in a cupel mould, and allowed to dry slowly. A good one will absorb its own weight


SCORIFICATION MOULD.

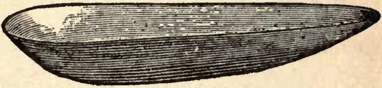
of lead, but it is better to calculate on its absorbing but three-quarters of that amount.

The crucible, scorification and cupel tongs, a couple of hammers, iron pestle and mortar, sieves from 20 to 100 mesh, and scorification mould complete the requisite tools.



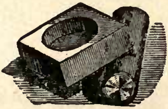
HAMMER.

In addition, however, the assayer will require quite a bulky lot of apparatus, reagents and chemicals. All dealers keep lists of assayers' supplies on hand, and a



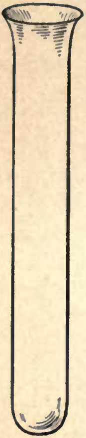
HORN SPOON.

full and complete assortment will cost about $200 in New York or Chicago. Quart bottles, with glass stoppers; ordinary corked bottles, ring stands, alcohol



STEEL MORTAR.

ALCOHOL LAMP.


TEST TUBE.

lamps, wash bottles, test tubes, horn spoons, iron pans, parting flasks, annealing cups, glazed black paper—these will suffice, provided the assayer has, as well, the outfit recommended for blow-pipe work.

Dry reagents, such as litharge, borax (crystallized), silica, cyanide of potassium, yellow prussiate of potash, argol, charcoal, starch, metallic iron, pure lead, nitre, powdered lime, sulphur, carbonate of ammonia and common salt are necessary. As solvents and precipitants, distilled water, sulphuric, nitric and hydrochloric acids, chloride of sodium, nitrate of silver and sulphuretted hydrogen are also indispensable.

This will seem rather a formidable list, and so, under certain conditions, it may be; indeed, where means of transport is limited, all regular assay work must be postponed until the return to civilization. Assaying is not, however, difficult, being mostly a matter of rule of thumb, and correct results may be arrived at without a deep knowledge of chemistry, although such knowledge will never come amiss.

A preliminary examination will show what the ore probably is. The blow-pipe is especially useful, though to the skilled assayer often unnecessary. The ore is first powdered, and any metallic flakes picked out and tested separately. A fair sample must be selected, otherwise all the work will be thrown away and the result be valueless.

The next step is weighing the ore and the reagents. Moisture is drawn off by heating in a crucible, a low heat being sufficient. Roasting will eliminate sulphur, antimony, arsenic, etc., and must take place in a flat dish, so that the air may have free access. The powder should be stirred frequently.

Reduction is the operation of removing oxygen, and it takes place usually in a crucible or scorifier.

Scorification consists in placing the ore in an open dish with proper reagents, and collecting all the volatile ingredients in the slag. Cupellation, on the other hand, collects them in the bone ash, of which the cupel is composed.

When silver must be separated from gold, it is sometimes convenient to increase its proportion by the addition of some known weight of the inferior metal. After fusing, the globule is placed in nitric acid, and the silver parted from the gold, which may then be weighed. This result subtracted from the weight of the original globule gives the amount of silver.

To test an ore for gold, take a pound of it, crush in mortar and pass through a fine sieve. Take one-fourth ounce Troy of the powder. Place in scorifier with an equal amount of litharge. Cover with borax that has been melted and powdered, and put the scorifier in the muffle of the furnace. A blacksmith's forge might do at a pinch. Heat until the mass has become a fluid, possibly twenty or thirty minutes. Next pour into the scorification mould, and, after the slag has set, remove it with a hammer. Hammer the button into a cube and place it in the cupel, which must first have been thoroughly heated. Heat until all the base metal has been absorbed by the cupel and the button has "brightened," or flashed; when this occurs, remove the cupel to the front of the muffle, cool, and remove the button with pincers. Weigh it, and you have the amount of gold and silver in ¼-ounce Troy. A simple sum in proportion gives the amount in a ton.

All ores containing sulphur, arsenic, antimony, or zinc, should be roasted.

There are three stages in the scorification process; roasting, fusion, and scorification. During the first, the heat should be moderate until fumes cease to be given off; during the second, the heat is raised and a play of colors is seen on the surface of the lead; in the closing stage, the heat is lowered for a time until the slag covers the lead, when it is again raised for a short time and the scorifier removed. Brittle buttons may be due to arsenic, antimony, zinc or litharge, and must be re-scorified before cupellation, with more lead.

Take the cupel slowly from the fire to avoid "spitting," by which portions of the buttons are lost. Watch closely for the brightening.

Silver is volatile at a high heat, but when the muffle is almost white, the metal well fused and clean, the fumes rising slowly, and the cupel a cherry red, all is going smoothly. If the fumes rise rapidly, the muffle is too hot. On the other hand, dense, falling fumes show the temperature is too low. Lead that is poor in silver stands the highest heat without vitiating the assay.

When the material in the cupel "freezes," i. e., the absorption by the cupel stops, reject the assay and try again, giving more heat or more lead.

Gold. Practically, the metal most prospectors seek is gold. It is so enormously valuable and constitutes so very small a percentage of any ore, that care must be taken or it may escape detection and be lost. Panning is the miner's method. He crushes his ore thoroughly, and places it in the pan with water; then, with a motion easy to learn but difficult to describe, he swirls the water around, allowing a little of it to escape at each revolution, carrying with it the rubbish, until finally he has a little black sand and perhaps a few grains of yellow substance, which is gold. Mica, or fool's gold, puzzles nobody but the ignoramus. True, it looks like gold in certain positions and lights, but gold will beat out thin under the hammer, just as lead would, while mica will break up into a floury powder. Mica is very light, while gold is very heavy; so there is no excuse for confounding the two. If an ore contains sulphurets and gold, the latter may be coated with some sulphur or arsenic, which would prevent the gold from amalgamating. The only remedy for this is roasting. No single acid will dissolve gold, but a solution known as aqua regia, made up of three parts of hydrochloric acid and one part of nitric acid, dissolves it. If to the solution so obtained you add some sulphate of iron, you will get a precipitate which is metallic gold, although it does not look like it, as it is brown in color; but if you place this precipitate in a crucible and heat, you will get a yellow bead of pure gold. Another test for gold is to take the solution as above obtained and add thereto a solution of chloride of tin, when you obtain a purple coloration that has been called the purple of Cassius.

Gold may be distinguished from all other metals by the three following tests: It is yellow; it may be flattened by the hammer; it is not acted upon by nitric acid.

Pure gold is soft, and the point of a knife will scratch it deeply. Pounded in a mortar, the pulverized mineral should be passed through a cheese-cloth screen stretched over a loop of wood. If the course contains much pyrite, it must be roasted before washing in the pan and amalgamating. Sample well, weigh out two pounds, put it in a black iron pan, with four ounces of mercury, four ounces of salt, four ounces of soda and a half gallon of boiling water. Stir with a green stick, and agitate until the mercury has been able to reach all the gold. Pan off into another dish so as to lose no mercury, squeeze the amalgam through chamois leather or new calico previously wetted. The pill of hard amalgam may be placed on a shovel over the fire or in a clay tobacco pipe and retorted.

Gold is readily acted upon by the mixture of nitric and hydrocloric acids known as aqua regia, or by any solution producing chlorine. Some of the mixtures which attack it are bisulphate of soda, nitrate of soda and common salt, hydrochloric acid and potassium chlorate, and bleaching powder. The action is more rapid in hot than in cold solutions, and impure gold is more easily dissolved than pure.

Mercury dissolves gold rapidly at ordinary temperatures, the amalgam being solid, pasty or liquid. Gold rubbed with mercury is immediately penetrated by it. An amalgam containing 90 per cent of mercury is liquid; 87.5 per cent., pasty; 85 per cent., crystalline. These amalgams heated gradually to a bright red heat lose all their mercury, and hardly any gold. About one-tenth of 1 per cent. of mercury remains in the gold until it is refined by melting.

The veins from which the gold of the world is won do not, on an average, hold the precious metal in greater proportion than one part of gold in 70,000 parts of veinstone. Under favorable conditions a proportion not one-fifth as rich as this, may yield a rich return. In hydraulic mining on a large scale, one part of gold in 15,000,000 parts of gravel has paid a dividend.

A test known as Darton's is believed to be a valuable means of detecting minute quantities of gold in rocks, ore tailings, etc.

"Small parts are chipped from all the sides of a mass of rock, amounting in all to about ¼ ounce. This is powdered in a steel mortar and well mixed. About half is placed in a capacious test tube, and then the tube is partly filled with a solution made by dissolving 20 gr. of iodine and 30 gr. of iodide of potassium, in about 1½ ounces water. The mixture thus formed is shaken and warmed. After all particles have subsided, dip a piece of fine white filter paper in it; allow it to remain for a moment; then let it drain, and dry it over the spirit lamp. It is next placed upon a piece of platinum foil held in a pincers, and heated to redness over the flame. The paper is speedily consumed; and after again heating to burn off all carbon, it is allowed to cool and is then examined. If at all purple, gold is present in the ore, and the relative amount may be approximately deduced. This method takes little time, and is trustworthy."

Black sand, which is iron, often with some platinum and iridium, sometimes interferes with the result of a gold assay. Attwood recommends the following method as applicable to such a case:

"Take 100 to 1000 grains and attack with aqua regia in a flask; cool for about thirty minutes or more; dilute with water and filter. If gold is present, it will now be held in solution in the filtrate. Remove the filter and evaporate the filtrates to dryness; then add a little hydrochloric acid, evaporate and re-dissolve the dry salt in warm water; add to the solution so formed proto-sulphate of iron; which will throw down the gold in the form of a fine, dark precipitate. The precipitate is seldom fine, being mixed with oxides of iron, and must now be dried in the filter paper, and both burned over the lamp in a porcelain dish. Then mix the dried precipitate with three times its weight of lead; fuse, scorify and cupel. In case platinum, iridium, etc., are found associated with the gold, an extra amount of fine silver should be added before cupellation, and the gold button will be found pure."

In one of his reports the State Mineralogist of California gives a most lucid description of a mechanical assay of gold-bearing sands, stamped ore, etc., etc. He states:

"It must be understood that this is only a working test. It does not give all the gold in the rock, as shown by a careful fire assay, but what is of equal importance to the mine-owner, mill-man, and practical miner, it gives what he can reasonably expect to save in a good quartz mill. It is really milling on a small scale. It is generally very correct and reliable, if a quantity of material be sampled. The only operation which requires much skill is the washing, generally well understood by those who are most likely to avail themselves of the instructions. These rules apply equally to placer gravels. Take a quantity of the ore —the larger the better—and break it into egg-sized pieces. Spread on a good floor, and with a shovel mix very thoroughly; then shovel into three piles, placing one shovelful upon each in succession until all is disposed of. Two of the piles may then be put into bags. The remaining pile is spread on the floor, mixed as before, and shovelled in the same manner into three piles. This is repeated according to the quantity sampled, until the last pile does not contain more than 30 pounds of ore. As the quantity on the floor becomes smaller, the lumps must be broken finer until at last they should not exceed one inch in diameter. The remainder is reduced by a hammer and iron ring to the size of peas. The whole 30 pounds is then spread out, and after careful mixing portions are lifted with a flat knife, taking up the fine dust with the larger fragments, until about 10 pounds have been gathered. This quantity is then ground down fine with the muller, and passed through a 40-mesh sieve. If the rock is rich, the last portion will be found to contain some free gold in flattened discs, which will not pass this sieve. These must be placed with the pulverized ore, and the whole thoroughly mixed, if the quantity is small, but if large must be treated separately, and the amount of gold allotted to the whole 10 pounds and noted when the final calculation is made.

"From the thoroughly-mixed sample, two kilogrammes (2000 grammes) must be carefully laid out. This is placed in a pan or, better, in a batea, and carefully washed down until the gold begins to appear. Clean water is then used, and, when the pan and the small residue are cleaned, most of the water is poured off and a globule of pure mercury (which must be free from gold) is dropped in, a piece of cyanide of potassium being added with it. As the cyanide dissolves, a rotary motion is given the dish, best done by holding the arms stiff and moving the body. As the mercury rolls over and ploughs through the sand, under the influence of the cyanide it will collect together all the particles of free gold. When it is certain that all is collected, the mercury may be carefully transferred to a small porcelain cup or test tube, and boiled with strong nitric acid, which must be pure. When the mercury is all dissolved the acid is poured off, more nitric acid applied cold, and rejected, and the gold is then washed with distilled water and dried.

"The object of washing with acid the second time is to remove any nitrate of mercury which might remain with the gold, and which is immediately precipitated if water is first used.

"The resulting gold is not pure, but has the composition of the natural alloy. Before accurate calculations of value are possible, the gold must be obtained pure and weighed carefully. To purify the gold it should be melted with silver, rolled out or hammered thin, boiled twice with nitric acid, washed, dried, and heated to redness.

"The method of calculating this assay is simple. It will be observed that 2000 grammes represent a ton of 2000 pounds; then each gramme will be the equivalent of one pound avoirdupois, or one 2000th part of the whole, and the decimals of a gramme to the decimals of a pound. Suppose the ore yielded by the assay just described, fine gold weighing .072 gramme, it must be quite evident that a ton of the ore would yield the same decimal of one pound. Now one pound of gold is worth $301.46, and it is only necessary to multiply this value by the weight of gold obtained in grammes and decimals to find the value of the gold in a ton of ore—$301.46 x .072—$21.70. The cyanide solution should be kept rather weak, as gold is slightly soluble in strong solutions of cyanide of potassium. Cyanide is a deadly poison."

Touchstones are useful in deciding the probable value of gold alloys. Several pieces of the metal under examination are cut with a cold chisel, and the fresh edges drawn over the touchstone. These streaks are touched with nitric acid on a glass rod. Should no reaction follow, the gold is at least 640 fine. Wipe the stone with soft linen and try with test acid, made by mixing 98 parts of chemically pure nitric acid with two parts of hydrochloric acid, adding 25 parts distilled water by measure. If this has no effect, take a touch needle marked 700, and make a similar streak on the stone samples. Compare, and, if necessary, continue with the other needles, using a higher number each time. An approximate estimate of the sample will soon be obtained. Should the gold seem poorer than 640 fine, try with the copper or silver needle. Practice and a good eye soon make this method very certain in its results.

Retorted amalgam is likely to contain mercury. To test for it, put a small fragment into a closed glass tube, taking care that it falls quite to the botom. Heat the gold over a spirit lamp, and a deposit of mercury will soon be seen upon the colder sides of the tube above the bottom. The tube may be broken and the mercury collected into a globule under water.

In mining regions gold dust passes current as coin, according to what is supposed to be its value. Occasionally counterfeit dust is offered. The readiest means by which it may be detected are as follows: The dust from any one district is always much alike, and any unusual appearance should create suspicion. Try any doubtful pieces on a small anvil, remembering that gold is extremely malleable. Test some of the gold with nitric acid; effervescence or evolution of red fumes, or coloration of the acid prove impurities to be present. Place two watch-glasses (most useful in chemical tests) on paper; the one on a white sheet, the other on a black, and with a glass rod convey a few drops of nitric acid from the dish to each. To the glass on white paper add a drop or two of ammonia; a blue color would indicate copper. To the other add hydrochloric acid; should a white precipitate form, it proves silver. If no action is noticed, even after heating the dish, the dust is genuine. As "dust" is sometimes merely copper coated with gold, the better plan is to cut all the larger grains in two, so that the acid may attack the copper should it be present.

Copper. Copper is a very easy mineral to test for. First crush the ore and dissolve it in nitric acid by heating. Then dilute with some water, and add ammonia. The solution should turn dark blue. The carbonate ores of copper do not extend deep in the mine. Their places are taken by copper pyrites. Sulphide ores are usually difficult to treat, and when they are to be tested it is better to roast them before trying the tests for color.

Test for copper may also be made as follows:

The sample must be pulverized. Take an ounce of the powder. and place in a porcelain cup. Add forty drops of nitric acid, twenty drops of sulphuric acid and twelve drops of hydrochloric acid. Boil over the spirit lamp until white fumes arise. When cool, mix with a little water. Filter and add a nail or two to the liquid. The copper will be precipitated, and may be gathered up and weighed. The amount of copper in the sample multiplied by 32,000 will be the copper in a ton of the ore.

Should copper be suspected, roast the powdered ore and mix with an equal quantity of salt and candle grease or other fat; then cast into the fire, and the characteristic flame of copper—first blue and then green—will appear. This test is better made at night.

Coal. Coal is often more valuable than gold, and the prospector should be prepared to estimate the value of any seams he may come across during his travels. The following is a very rough but wonderfully effective test for coal. Take a clay pipe, pulverize your sample, weigh off twenty pennyweights, and place it in the bowl of the pipe. Make a cover with some damp clay. Dry thoroughly, and put the bowl upside down over a flame. The gas in the coal will come out through the stem, and may be lit with a match. Let the pipe cool after the gas has all escaped, break off the covering of clay, and if the coal was adapted for coke the result will be a lump of that substance in the bowl. Weigh this. The difference in weight between the coke and the twenty pennyweights of coal that were placed in the bowl will represent the combustible matter forced out by the heat. Now take this coke and burn it on a porcelain dish over the lamp. You will have more or less ash left, and the difference in weight of the ash and the coke will be the amount of fixed carbon in the coal. Your test is complete, and it need not have cost you even the pipe. Sulphur is a detriment to coal, and if you notice much of it in the escaping fumes, you may be sure your sample is not worth much.

Mercury. Cinnabar, the common ore of mercury, is a sulphide. Scratch it with a knife, and the streak will be bright crimson. Dissolve the ore in nitric acid, add a solution of caustic potash, and you have a yellow precipitate. A very pretty test is to place the ore pulverized in a glass tube with some chloride of lime; close the top of the tube, and place a smaller one therein, so bent that it will pass into a basin of water; heat the bottom of the tube containing the ore and lime, keeping the upper part and the small tube cold with wet rags, and you will have a deposit of quicksilver in the basin.

Silver. Silver ore may be detected by dissolving a small quantity in a test tube with a few drops of nitric acid. Boil until all the red fumes disappear. Let the solution cool, and add a little water. Filter the whole, and add a few drops of muriatic acid, which will precipitate the white chloride of silver. Dissolve this precipitate with ammonia; then add nitric acid once more. Exposed to the light, the precipitate soon shows a violet tint. Pure silver is the brightest of metals, of a brilliant white hue, with rich luster. To detect chloride of silver in a pulp, rub harshly with a clean, bright and wet copper cartridge or coin, and if there be silver in the pulp the copper will be coated with it. Graphite will also whiten copper, but the film is easily rubbed off.

Nickel. Nickel may be determined as follows: A little of the powdered ore taken up on the point of a penknife, and dissolved in a mixture of ten drops of nitric and five drops of muriatic acid, should be boiled over a lamp for a few minutes, and ten or twelve drops of water added. A small quantity of ferro-cyanide of potash will throw down a whitish-green precipitate, indicating nickel.

Platinum. Platinum is a most refractory metal to treat, as it must be boiled for at least two hours in the mixture of muriatic and nitric acid, known as aqua regia. A small amount of alcohol is to be added to the solution, and the latter filtered. The platinum is precipitated with ammonia chloride.

Manganese. Manganese may be proved as follows: A few grains of powdered ore are placed in a test-tube, with three or four drops of sulphuric acid. Two or three grains of granulated lead or litharge being dropped in, the color will become pink should manganese be in the ore.

A preliminary examination of a mineral may be made with a pocket lens and a penknife. With the first, any conspicuous constituents may be recognized, while a scratch with the point of the latter will give an idea as to the softness or hardness of the mineral. Should much quartz (silica) be present, a sharp blow with the steel will cause sparks.

The next test should be with some ore powdered and held over a spirit flame. A drop or two of water and a drop of sulpho-cyanide of potash will reveal iron, should such be present, by a deep red coloration.

To another portion add one drop of hydrochloric acid, and a dense, curdy precipitate will indicate silver, if there be any.

Added to the same original nitric acid solution, several drops of ammonia water would detect copper by a blue color.

Antimony, tin, aluminum, zinc, cobalt and nickel, uranium and titanium are best shown by the blowpipe.

Carbonates, that is those minerals that contain carbon and oxygen in addition to the metal, effervesce when brought into contact with hydrochloric acid. Some sandstones have a small amount of lime carbonate, and must be tried under the lens, as the bubbles are microscopic. These tests are extremely useful, but by no means infallible, owing to so few ores being pure.

When the explorer wishes to know all the constituents of the ore he has found, he must analyze it. An analysis gives every substance in the ore. Such examinations may be either by the "dry" or "wet" methods, though usually the term "analysis" is restricted to the latter, and "fire assay" is used to describe the former. The wet assay for silver, lead or mercury is effected as follows:

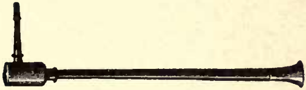
Drop a little powdered ore in a test tube; add nitric acid; dilute with $\frac{1}{8}$ water; warm gently over the spirit lamp. It may dissolve or it may not. In the latter case, add four times as much hydrochloric acid. Should all these attempts fail, a fresh sample must be taken, and equal parts of sodium carbonate and potassium carbonate added, and the whole strongly heated in a platinum crucible. The contents, after cooling, is dissolved in dilute nitric acid.

In any case the assay will now be dissolved, and will be in the solution. Filter. Pour ten drops into a test tube; add three or four drops of hydrochloric acid. A precipitate appears. It may be silver, lead or mercury. If silver, it grows dark violet after exposure to sunlight, or 30 or 40 drops of ammonia dissolves it in a few moments. Should it not dissolve, it is lead or mercury. Test for lead by filtering, and heating some of the precipitate on charcoal before the blow-pipe. A bead and yellow incrustation indicate lead. Should none of these things happen, then the metal is mercury. Filter; place in glass tubes; heat gently, and a mirror of quicksilver will appear on the sides of the glass.

This is as far as the prospector, without the various reagents and chemicals that the analyist has always at hand, will be able to go. More complex treatment must be reserved until a return to civilization.

CHAPTER III.

BLOW-PIPE TESTS.



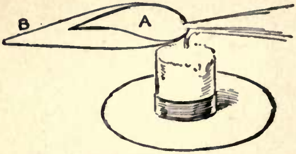
BLOW PIPE.

As a means of readily detecting the presence of minerals in their ores the blow-pipe, in the hands of a skillful operator, is unrivaled. Nor is this skill at all hard to come by; two or three weeks' patient study under a good master should teach a great deal, and subsequently proficiency would come by practice in the field. Unfortunately, some very clever men have become so enthusiastic as to blow-pipe work that they have devised methods by which the amount of metal in an ore as well as its nature may be determined, but in so doing have so enlarged the amount of apparatus, and complicated the tests so seriously that the simplicity of the blow-pipe outfit is in danger of being lost, and its chief advantage of being forgotten; for there are many better ways of determining the value of an ore. A good assay or, better still, a mill run, is worth incomparably more than any quantitative blow-pipe test, even when conducted by a Plattner.

The chemical blow-pipe is made of brass or German silver, with platinum tip.

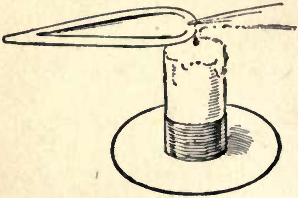
The best fuel, taking everything into consideration, is a paraffin candle in cold climates, and a stearine candle in hot ones. Tallow may do in an emergency, but it requires too much snuffing.

The blow-pipe can produce two flames. The one



REDUCING FLAME.

known as the reducing flame, and generally printed as R. F.; and the oxidizing flame, represented by the initials O. F. In the first the substance under exam-



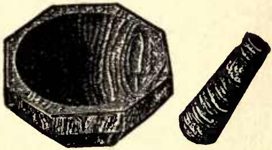
OXIDIZING FLAME.

ination is heated out of contact with the air and parts with its oxygen. In the second, it is heated in the air and absorbs oxygen.

Well-burnt pine or willow charcoal in slabs 3 inches by 1¾ inches is the material upon which the mineral to be tested is placed. A small shallow depression is scraped out of one side of it and the assay placed therein.

Platinum wire, some 3 inches long, conveniently fused into a piece of glass tube as a handle, is used to test the coloration of minerals in the flame. This should be cleaned occasionally in dilute sulphuric acid and then washed in water.

A small pair of forceps with platinum points serve a great variety of purposes, but the beginner must be careful not to heat metallic substances in them to a



AGATE MORTAR.

red heat, as he may thereby cause an alloy of the metal with the platinum and spoil them for future use.

Glass tubing one-twelfth to one-quarter inch in diameter and from four to six inches in length is used for a variety of purposes. From this material what are known as closed tubes may be made by heating a piece of the tubing at or about its center over a spirit lamp, and, when the glass has fused, pulling it apart. These closed tubes are used in heating substances out of contact with the air.

A small agate mortar is indispensable. It must be used for grinding substances softer than itself to a powder, but it will break if rapped sharply.

A small jeweler's hammer is used to flatten metallic globules upon any hard surface A regular blow-pipe outfit would include a small anvil for this purpose, but it is hardly necessary, as any iron or steel surface will do.

A magnet will detect the presence of any magnetic

MAGNET.

LENS.

NEST OF TEST TUBES.

mineral, especially if it is reduced to powder and the test made under water.

Two small files, one three-cornered and the other rat-tailed, must be included in the list of requisites. By means of the former, glass tubing may be notched and pulled or pushed apart, and the latter is necessary in fitting glass tubing to the cork of wash-bottles and other apparatus.

A good lens is indispensable. That known as the Coddington is as good as any.

A dozen test tubes of hard glass, with stand, in small and medium sizes, should not be forgotten.

A glass funnel 2½ inches in diameter is requisite in filtering. The circular filter papers are folded in four and placed in the funnel, point down, three thicknesses of the paper being on one side of the funnel and one thickness on the other.

A wash-bottle is made from a flask into which a sound cork has been placed with holes in it for two pieces of glass tubing. The one serves as a mouth-piece into which the operator blows, while the other, reaching almost to the bottom of the bottle and ending in a spout outside the cork, permits a stream of water to be forced out of the bottle when it is blown into.

A few glass rods in short lengths do for stirrers. A little ingenuity is better than much apparatus.

Of reagents, all those to be found in a well-appointed laboratory may occasionally be of service, but the rough and ready prospector can get along fairly well with the following: Carbonate of soda, borax, microcosmic salt, cobalt solution, cyanide of potassium, lead granulated, bone ash, test papers of blue litmus and turmeric, the former for proving the presence of acid in a solution and the latter that of an alkali.

The foregoing are all dry reagents. Among the wet reagents are: Water—clean rainwater—or, better still, distilled water; hydrochloric acid, sulphuric acid, nitric acid, ammonia, nitrate of cobalt.

Heating a mineral with carbonate of soda on charcoal is accomplished as follows: The pulverized mineral, intimately mixed with three times its bulk of carbonate of soda, is placed in the cavity on the coal. Tin ore, which is very difficult to reduce, should have a fragment of cyanide of potassium placed upon it after it has been heated for a few seconds, and the flame is then reapplied. A globule of metal should result, and perhaps an incrustation on the coal. The reaction is as follows:

Metal.	Globule.	Incrustation.
Gold.	Yellow, malleable.	None.
Silver.	White, malleable.	None.
Copper.	Red, malleable.	None.
Lead.	White, malleable.	Red when hot, yellow when cold.
Bismuth.	White, brittle.	Red when hot, yellow when cold.
Zinc.	None.	Yellow when hot, white when cold.
Antimony.	White, brittle, fumes.	White.

A small loop is made at the end of the platinum wire, and it is heated and dipped in borax; heated again, then touched while hot to the powdered mineral and heated once more. The following colors are obtained:

COLOR OF BEAD.

O. F.	R. F.	Metal.
Red or yellow, hot. Yellow or colorless, cold;	Bottle-green.	Iron.
Blue, hot or cold.	Blue.	Cobalt.
Green, hot; blue, cold.	Red.	Copper.
Amethyst.	Colorless.	Manganese.
Green.	Green.	Chromium.
Violet, hot; red-brown, cold.	Gray.	Nickel.

The substance to be tested is generally powdered and moistened, placed in the cavity and covered or not as circumstances may demand, with a pinch of carbonate of soda or other suitable reagent. The following results may be obtained:

Antimony. Place the mineral in the cavity with a little of carbonate of soda, and blow upon it with the inner or oxidizing flame. This is formed by inserting the blow-pipe an eighth of an inch into the flame and blowing steadily. A white incrustation on the coal, and a brittle button of antimony should be the result.

Lead. Treat the suspected lead ore the same way, and you will get a yellow incrustation on the coal and a button of malleable lead.

Zinc. Proceed as above, and after blowing for a few seconds moisten the incrustation with a drop of nitrate of cobalt. Heat once more, but this time use the outer or reducing flame, which is produced by keeping the point of the blow-pipe a little outside the flame and blowing more gently than before, so that the whole flame playing upon the coal may be yellow in color. A green incrustation will be an evidence of zinc.

Copper. As usual, mix the ore and the soda into a paste and fuse it with the oxidizing flame. Dig the mass out of the charcoal with the point of a knife and rub it in the mortar with water. Now decant into a test tube, and, allowing the sediment to settle, pour off the water. If there was copper in the ore, red scales will be found in the test tube.

Arsenic. Heat in the inner flame for a second or two, and if the ore contains arsenic you will notice an odor of garlic.

Tin. This is a very difficult ore to reduce, but the addition of a little cyanide of potash to the powdered ore will make it easier. Fuse, after moistening on the charcoal, in the oxidizing flame, and you will probably obtain small globules of tin.

Silver. Make a paste of the ore with carbonate of soda; add a small piece of lead and fuse into a button. Make a second paste of bone ash and water, and after you have dried it with a gentle flame place the button of silver and lead on the bone ash, and turn on the oxidizing flame. The lead will disappear, leaving a silver globule. Should it not be pure white, but more or less tinged with yellow, it probably contains gold; and if the button be dissolved in nitric acid, whatever remains behind is gold.

Sometimes it is desirable to determine whether tellurium is present in an ore. This is very easy to find out. All that is required is a blow-pipe, alcohol lamp and a porcelain dish. Break off a small piece of the ore, place it in the dish previously warmed, blow upon the ore with the blow-pipe until it is oxidized, then drop a little sulphuric acid on the ore and dish. If tellurium be present, carmine and purple colors on the assay will proclaim the fact.

Bismuth ores are very heavy; usually they have more or less antimony associated with them, which is a drawback, as the separation is an expensive matter and the returns are less than they would be from a low grade pure ore. In testing for this metal, dissolve a crushed sample in nitric acid and then add potash in excess. If the ore is one containing bismuth, you should have a white precipitate; if it contains cobalt, you will get a bluish-green coloration. Bismuth is worth about fifty cents a pound if pure and free from antimony.

Galena is often mistaken for other ores, specular iron ore for instance. If the ore be crushed and heated in nitric acid until dissolved, some water added, and an addition made to the solution of a few drops of ferrocyanide of potassium, a dark blood-red precipitate is thrown down. If the ore were galena, there would be no coloration. The so-called steel galena which carries a little zinc is generally richer in silver than the ordinary cube galena, though the reverse is sometimes the case.

If lead ore be dissolved in nitric acid, the solution diluted, and some hydrochloric acid added, a white precipitate is thrown down. Add ammonia and the precipitate remains unaltered.

The blow-pipe operator has to learn to breathe and blow at the same time; the breathing he does through the nostrils, the blowing is produced by the natural tendency of the cheeks to collapse when distended with air. A skillful operator can blow for many minutes at a time without the slightest fatigue.

To identify cinnabar, the ore from which quicksilver is obtained, make a paste of the substance in powder and carbonate of soda. Heat in the open tube, and a globule of mercury will result.

Sulphur turns silver black. Make a paste with carbonate of soda, heat on the charcoal, and removing the mass with the point of a knife lay it on a silver coin and moisten. A black sulphide of silver should show quickly on the coin if sulphur is present. Magnesia gives a faint pink color when heated and treated with nitrate of cobalt on coal. Alumina under the same circumstances give a blue color.

Roasting is an oxidizing process, the substance being heated in air, so that it may absorb oxygen.

The test by reduction with soda on coal in the R. F. is particularly valuable in the case of copper ore, as little as 1 per cent. being detected.

CHAPTER IV.

ECONOMIC ORES AND MINERALS.

Aluminum is derived from two ores, cryolite and bauxite. This metal has made rapid strides into favor during the past half-dozen years. Although known since 1827, it remained a rare substance in the metallic form, though it is the most abundant of any of the metals in its ore. In ordinary clay there is an inexhaustible source of aluminum. But the ores that yield the metal cheaply are few. Until recently, cryolite, found abundantly in Greenland, was the chief source of the metal, but now bauxite is used in its place. Bauxite is a limonite iron ore in which a part of the iron has been replaced by aluminum. It is found in Alabama, Georgia and Arkansas, as well as in Europe. Aluminum is white, and very light in weight. It does not tarnish easily.

The chemical composition of these ores is:

	Aluminum.
Cryolite, $Al_2F_6.6NaF$	12.8 per cent.
Bauxite, $Al_2O_3.3H_2O$	73.9 per cent.

In 1895 the production of this metal in the United States was 900,000 pounds. In 1899 it rose to 6,500,000 pounds. The only firm producing aluminum is the Pittsburg Manufacturing Company of Buffalo, N. Y., who reduce the metal from bauxite, which they obtain in the southern states. One of the latest uses for this metal is for gold miners' pans. The French seem to keep ahead of the rest of the world in finding new uses for aluminum.

Most of the supply of cryolite comes from Greenland, where it occurs in veins running through gneiss rocks. Glass-makers use it and pay good prices for it. Lately makers of aluminum also buy it, as it contains 13 per cent. of that metal.

A new aluminum-bearing mineral, discovered in New Mexico and in Ohio, is called native alum. It gives 50.16 per cent. alumina, and may be treated by solution in warm water, filtration, evaporation and roasting. No estimate has yet been made of the amount available.

As bauxite promises to be in greater demand in the future than in the present, owing to the ever-increasing demand for aluminum, the prospector will do well to make himself thoroughly familiar with its appearance. It is creamy white when free from iron, and the grains are like little peas, or pisolitic. It contains water, aluminum, silica, and generally iron. The French beds near the town of Baux are 30 miles long and 40 feet thick. In the United States, beds have been found in Alabama, Georgia and Arkansas. The Georgia beds are turning out three-fifths of the bauxite produced in America. The ore is in beds and pockets, and enough has been prospected to assure a supply for some years to come, unless the demand should grow very decidedly, in which case a scarcity might soon be felt. The American ore is easier to work than the

French, and manufacturers prefer it to any they can import, even though the cost is higher and the percentage of aluminum smaller. The Arkansas deposits are as thick as the French, and only 300 feet above the level of the tide. Imported bauxite cost $5 to $7 a ton in New York City. American ore costs $5 to $12 a long ton. Best selected Georgia brings $10.

Should the deposits of bauxite give out, the manufacturers of aluminum would probably fall back on cryolite. At Tvigtuk, on the west coast of Greenland, it exists, as a very heavy vein, in gneiss. It is semi-transparent, and snow-white. Impurities may stain it yellow or red or even black. Its specific gravity is 2.95, and its hardness 2.5 to 3. It is fusible in the flame of a candle, and yields hydrofluoric acid if treated with sulphuric acid. It is still used for making soda and aluminum salts, and an imitation porcelain. It is also in general use as a flux.

Amber. This is a fossil resin, or gum, and may often be found in lignite beds. Recent discoveries have been made on the coast of British Columbia that are expected to supply the world. All pipe-smokers know it.

Antimony. The commercial ore of this metal is the sulphide known as stibnite, or gray antimony. Its composition when pure is 72 per cent. antimony and 28 per cent. sulphur. Hardness is 2; gravity, 4.5; luster, metallic; opaque; gray; cleavage, perfect. Fracture, conchoidal. Texture, granular to massive. The ore tarnishes quickly, is easily melted, or dissolved in hydrochloric acid. The associated minerals are generally the ores of lead, zinc, and carbonate of iron. Baryta may be the gangue or veinstone. Antimony is worth from 10 to 15 cents a pound.

Although antimony occurs in many minerals, the only commercial source is the sulphide, stibnite. Antimony is used as an alloy in type metal, pewter, and babbitt metals. It is injurious to copper, even one-tenth of one per cent. reducing the value of that metal very considerably. The price varies greatly, being now about 10 cents a pound.

The composition of stibnite is:

	Antimony.
Stibnite, Sb_2S_3	71.8 per cent

The production of antimony in this country is not very large. The output of 1899 was but 1,250 tons, valued at $241,250. The ore is worth from $40 to $50 a ton delivered at Staten Island, N. Y.

Apatite suffered in demand when the cheap phosphates of South Carolina were discovered, and these in turn are being ousted from the markets of the world by Thomas slag, an artificial phosphate, and by the easily-mined natural phosphates of Algeria. The price varies with the quality of the rock, from $1.75 to $11 per ton, averaging in 1899, $3.86.

Apatite is a phosphate of lime, containing 43 per cent. of phosphoric acid. It occurs in the old crystalline and primary rocks of Canada, but although still of some value it has yielded the position it once occupied to the Carolina phosphate deposits, which, although not so rich in acid, are softer, and less expensive to utilize. Apatite is doubtless derived from the remains of animals or fishes that lived in the distant past. The colors are often beautiful—green, pink, gray, etc.—but the sheen is always white. Hardness of 4.8. Specific gravity, 3.1.

Asbestos. This fibrous silicate of magnesia and lime is to be looked for among primary rocks near serpentine dike. The fibers of this material may be woven into cloth that will be fire-proof. It is of considerable, though fluctuating, value.

The demand for this material is likely to increase, though at present the supply is fully equal to demand. It is being used in Germany to make fire-proof paper, and in Quebec to make asbestos plaster for covering wood-work. It is generally quarried in open pits, the rock being crushed in a rock-breaker, and the fiber freed from adhering particles of rock and dust. It is then sorted, the longest fibers going into the first quality heap. The production in 1899 in the United States was 912 tons, value $13,860; in Canada, 23,266 tons, value $598,736.

Borax. This mineral is borate of soda. Its composition is: 37 per cent. boric acid, 16 per cent. soda, and 47 per cent. water. Its gravity is 1.7. Hardness, 2.3. It is white, and has a sweetish taste. Borax is valuable, but occurring as it does as an incrustation upon the ground over large areas, a detailed description would be superfluous, as the explorer will surely recognize it should he find it.

Clay. A good bed of clay may be of value in an accessible region. Brick-clay contains silica, alumina, iron, etc. Potters' clay is made by suspending ordinary brick-clay in water, and running off the water and fine particles suspended therein. These are allowed to settle, and, when dry, are fine potters' clay. The better the clay, the larger the percentage of potters' clay. Fire-clay should contain 60 per cent. of silica, and 30 per cent of alumina. Mixed with sand and burnt into bricks, it will resist great heat. Light-colored clays are preferable for this purpose, as iron is prejudicial to a good fire-brick. Kaolin is the finest porcelain clay, and the best comes from China, Japan or France. It is a product of decay in feldspar rocks. The potash is washed out, and the silica and alumina left as parts of a white clay of fine grain.

Coal. Anthracite is bituminous coal that has been subjected to great heat and pressure; in plain language, baked. It contains over 90 per cent. of carbon. Specific gravity 1.5 to 1.8. Hardness, 2.3 to 2.6. The ash left after burning is white or red. There is little or no sulphur in anthracite. It does not coke.

There are three main divisions of coal, arranged according to their carbon, water and ash. They are:

	Carbon.	Water.	Ash.
Anthracite....	80—95 p. c.	2—3 p. c.	4—10 p. c.
Bituminous...	45—80 p. c.	1—5 p. c.	8—20 p. c.
Lignite.......	7—45 p. c.	15—36 p. c.	6—40 p. c.

Good bituminous coal contains about 85 per cent. of carbon, but the composition varies greatly. Cannel coal is a variety of bituminous that gives off much gas. It burns with a bright flame in an open grate, igniting as easily as a candle. Lignite is intermediate between coal and peat. All the Rocky Mountain coals are lignites. It is a very inferior coal at its worst, while at its best it is nearly the equal of a poor bituminous coal.

Some coals will coke and others will not; nothing but a trial can settle this matter in each individual case. Good coking coal is very valuable.

Cobalt. Cobalt ores are always found in veins with other metals. Pure cobalt is extremely rare. Cobalt colors are used for porcelain painting, glass-staining, etc.

Chromium. All chrome is obtained from chromite, which contains 68 per cent. of chrome sesqui-oxide, the remainder being iron protoxide. Hardness, 5.5; gravity, 4.4; luster, sub-metallic; opaque. Steel-gray to almost black. Harsh. Brittle. Cleavage, imperfect. Fracture, uneven. Texture, massive to granular. Chromite in gravel looks like shot. Serpentine often contains it, when it is apt to resemble a fine-grained magnetite. It is used chiefly in iron and steel alloys, and in making armor plate. It is also used in dyeing fabrics and in paint manufacture. But little chrome ore is produced in the United States. The importation in 1899 was 15,793 tons, value $18.03 per ton.

Chromite, $FeOCr_2O_3$........................47-68

This ore is merchantable at $22 to $25 per ton.

Domestic ore ranges from $10 to $12 a ton, while the pure imported ores are worth $21 a ton. The yearly consumption in the United States is about 16,000 tons, and the American production 100 tons. This ore is useful as a lining for furnaces, and the demand promises to become important. Newfoundland is said to contain large deposits.

Copper. Native copper occurs in the Lake Superior region, but the demands of commerce are supplied from chalcopyrite or copper pyrites, and tetrahedrite or gray copper ore. Many different ores of copper may exist in the same vein. On the surface an iron cap of gossan reveals the deposit; immediately below may be black oxide of copper with some malachite, lower down red oxide, and below the water-line copper sulphides. The following are the principal copper ores:

	Sp. Gravity.	Hardness.	P. C. Cu.
Native copper	8.8	2.8	100
Chalcopyrite	4.2	3.7	35
Enargite	4.4	3.0	48
Tetrahedite	5.0	3.5 to 4.5	35
Chalcocite	5.6	2.7	80
Bornite	5.0	3.0	55
Melaconite	6.2	2.0 to 3.0	80
Cuprite	6.0	3.6	89
Chrysocolla	2.2	3.0	45

The common ore is native copper, often associated with native silver, the two remaining, chemically, quite distinct. Some masses of copper occur that are too large to handle and must be cut by cold chisels, a method that costs more for labor than the value of the metal. The Lake Superior mines produce 140,000,000 pounds of copper a year, while those of Montana made the gigantic output of 228,000,000 pounds in 1896. The great Anaconda mine, of Butte, is the heaviest producer, yielding more than half the state's total.

During 1899 the New York copper market rate varied between 14.75 cents and 18.46 cents per pound. Copper is probably abundant in the shape of pyrites in many parts of Canada, especially in the Northwest, and prospectors in that region should search diligently for it. The Lake Superior mines are unique in being deposits of native copper.

Owing to the great demand for copper following upon the extraordinary spread of electricity, copper properties have become so enormously valuable that, possibly, the explorer will be quite as fortunate in finding copper as in finding gold. Moreover, with the exception of Spain and Chili, the United States has no serious rivals in copper production,—Montana and Michigan producing the greater part of the output. The famous Calumet and Hecla mine, in Michigan, is now down 4,000 feet and still yields ore. The most copper ores are not difficult to distinguish. Every one is familiar with the ruddy hue of pure copper, the color of the native metal. It may be flattened under the hammer or cut with the knife. A little of the ore mixed with grease colors a flame green. Copper ores are heavy, and generally of a bright color, either red, blue, green, yellow or brown.

Corundum. Nine hundred and seventy tons of this abrasive were produced in the United States in 1899; value, $78,570. Corundum is found in feldspar veins, and associated with chlorites in serpentine rock. North

Carolina furnishes half the corundum marketed. The presence of this substance is always indicated in the South by serpentine, chrysolite, or olivine rocks; experience being the only guide the miners have in finding new deposits. The contacts of the olivine rocks with gneiss usually produce rich deposits. Corundum is the hardest substance known, next to the diamond. It is used as a polishing powder. Emery is an impure corundum containing iron. Corundum is composed of 53 per cent aluminum and 47 per cent oxygen. Specific gravity is 4. Hardness, 9.

Feldspar. The Maine, Pennsylvania, New York, and Connecticut ores are worth $3 to $6 per long ton (2,240 pounds) at point of production.

Fluorspar. The American market is supplied by ore from Rosiclare, Ill., Marion, Ky., Hardin Co., Ill., and Liumpton Co., Ky., and imported spar. It is worth $6 a ton of 2,000 pounds. This spar is softer than quartz and of most brilliant colors, varying through the yellows, greens, blues and reds, to pure white. The streak is always white. Specific gravity, 3. Hardness, 4. It is worth mining when abundant and accessible.

Gems. Gems are to be looked for in a country of crystalline rock, such as granite, gneiss, dolomite, etc. Topaz and ruby are generally discovered in crystalline limestones, while turquoise is usually found in clay slate. It is not likely that the American prospector will come upon the true oriental ruby; he will more probably find the garnet. The ruby is next to the diamond in hardness and in value, and consists practically of pure alumina. The garnet is but as hard as quartz, and is a silicate of alumina with lime and a little iron. They crystallize in different systems, the more valuable gem belonging to the rhombohedral, and the less valuable to the isometric system.

The turquoise which has lately been found in Arizona is not a crystal. The blue color which distinguishes it is derived from copper. It is a phosphate of alumina with water in composition. In form it is kidney shaped or stalactitic. Lazulite, a far less valuable substance, is also blue, but as it crystallizes in the monoclinic system it should not be mistaken for turquoise. Moreover, lazulite is softer and contains magnesia and lime, which the turquoise does not. Lapis lazuli, which is also occasionally mistaken for turquoise, belongs to the regular or isometric system; it is commonly massive or compact, and is a silicate of alumina with some lime and iron. It is found in syenite, crystalline, limestone, and often associated with pyrites and mica.

Topaz belongs to the orthorhombic system. It is a silicate of alumina with fluorine. Powdered, mixed, and heated with microcosmic salt in the open tube, fluorine is disengaged with its characteristic odor, and etching action upon glass. With the blow pipe on charcoal, heated with the cobalt solution, it gives the fine blue color of alumina.

The explorer who comes upon any hard, brightly colored stone, that may possibly turn out a gem, should preserve it carefully until he returns to some city, when it should be submitted to an expert. The value of a gem depends upon so many qualities that it were hopeless for the tyro to endeavor to arrive at any just estimate of it. He might ruin a superb specimen, without becoming one bit the wiser. A few of the more prominent characters of valuable gems follow:

Name,	Sp. Gravity.	Hardness.	Color.
Aquamarine	2.7	7.7	Blue.
Emerald	2.7	7.5	Green.
Diamond	3.5	10.0	Colorless.
Garnet	4.1	7.0	Claret.
Opal	2.2	6.0	Opaline.
Ruby	3.5	8.0	Dark red.
Tourmaline	3.1	7.3	Various.
Turquoise	2.7	6.0	Blue, green.
Untramarine	2.5	5.8	Blue to green.

Graphite. This mineral is commonly known as black lead, or plumbago. It is the same in composition as the diamond, viz.: 100 per cent carbon. Specific gravity, 2 to 2.2. Hardness, 1.2 to 1.9. Color, black. Greasy. Of value when free from impurities. Used in making pencils, stove polish, crucibles, etc. Found in the earlier rocks.

Gypsum. A sulphate of lime occurring in great beds. Burnt, it becomes plaster of paris.

Iron. This, the most important of all metals, is found in various forms. The ores of iron are:

	Sp. Gravity.	Hardness.	P C. Fe.
Native ore	7.7	4.5	100
Magnetite	5.1	6.0	72
Hematite	4.8	6.0	70
Limonite	3.8	5.2	60
Siderite	3.8	4.0	62
Pyrite	5.0	6.3	47

Native iron is only found in meteorites that have come from space.

Magnetite is loadstone ore; the powder is reddish black, and the ore, dark brown to black. It is found in the older rocks and is an important ore.

Hematite varies from metallic to dull in luster. There are many varieties of it, known as ironstone, ocher, needle ore, etc. Hematite may be slightly magnetic. Immense beds exist in the triassic sandstones, and in the secondary rocks below the coal measures. The powder and streak of limonite are always yellow; it is an important ore. Siderite assumes many forms. It is called spathic ore, clay-ironstone, carbonate of iron, black band, etc. Most of these carbonate iron ores only range between 30 and 40 per cent of metallic iron, but are in demand as fluxes for other iron ores. The pyritic ores of iron, including marcasite, pyrrhotite and mispickel, are often taken for gold by the inexperienced. In an accessible region pyrites may be valuable, as they are bought by makers of sulphuric acid.

Iron is so low in price that vast deposits exist which cannot be made use of because they would be too expensive to mine. A deep bed, or a narrow one, or the slightest difficulty in transportation, would preclude any profitable development. It is known that enormous areas in northern Labrador, for instance, are full of iron deposits, yet there seems no chance of their having the slightest economic value for a long time, if ever. Conditions of commerce very different to those now obtaining will have to exist before they can be utilized.

Iron ore is most favorably situated for profitable extraction when it is near coking coal and beds of limestone; the former for fuel, the latter for flux. Occasionally such regions as that of Lake Superior may be able to compete successfully with others, although they do not possess the necessary smelting facilities, because these deficiencies are counterbalanced by inexhaustive stores of easily mined ores, and transportation facilities unrivaled in cheapness.

Lead. The two important sources of supply are galena and cerussite. The former contains 87 per cent of lead, and frequently some silver and gold. It is so distinctive as to be easily recognized. Luster, metallic; opaque; lead-gray; harsh. Brittle to sectile (may be cut). Cleavage, perfect. Fracture, even to sub-conchoidal. Structure, granular or foliated, tabular, or fibrous. Specific gravity is 7.5, and hardness, 2.6.

The carbonate cerussite contains about 79 per cent lead. Luster, vitreous to resinous. Translucent. Color, gray. Smooth. Brittle. Cleavage, perfect to imperfect. Fracture, conchoidal. Massive to granular. Rich carbonate ores look like clay, and are undoubtedly often passed by.

The economic ores of lead are:

		Lead.
Galena	PbS	86.6 p. c.
Cerusite	$PbCO_3$	77.5 p. c.
Anglesite	$PbSO_4$	67.7 p. c.
Pyromorphite	$Pb_3P_2O_8$ plus 1-3 $PbCl_2$	75.36 p.c.

Lead ores are frequently rich in silver. They occur in limestone, sandstone, granite and clay. The commercial ores are galena, which is easily recognized by its steel-like cubes, and the carbonates. These latter are like lightly colored clays when in powder and are very apt to be overlooked. Fluor spar is as favorable a gangue for lead as quartz is for gold.

The Rocky Mountains are the principal American sources of this metal, but a very large amount comes from the Mississippi valley. In the mountains the ore is a by-product, in silver smelting, being obtained from argentiferous galena, while in Missouri, Kansas, Wisconsin and Illinois lead and zinc are found free from any mixture with the precious metal. The age of these deposits varies from lower silurian or cambrian to the carboniferous.

The ore is found in limestone rocks,—sometimes in flat openings parallel to the almost horizontal beds, or else in gash veins almost at right angles to these. As lead is often found in dolomite limestone, that is, limestone carrying almost as much magnesia as lime, and this rock was undoubtedly deposited in a shallow sea, geologists incline to the belief that therefore the lead is due to a growth of seaweeds in whose ash this metal and zinc are known to occur. At any rate, these deposits now have great economic value, and the lead and zinc ore is easily got at.

Galena and zinc blende frequently resemble one another, but they may be distinguished by this infallible sign: the powder of galena is black, and that of blende brown, or yellow.

Lithographic Stone. This is a very fine grained compact limestone from Bavaria. So far nothing equal to the imported stone has been found in America. The distinguishing qualities are: Gray, drab or yellow; porous, yet not too soft; of fine texture, and free from veins and inequalities.

Manganese. Manganese ores in 1899 amounted in the United States to 143,256 tons, value $306,476. This mineral is used for bleaching and making oxygen, and in steel manufacture. Pyrolusite contains 63 per cent manganese. Hardness, 2.3. Specific gravity, 4.8. Luster, metallic. Opaque. Gray to bluish black. Harsh. Brittle. Cleavage, imperfect. Fracture, uneven. Granular, massive. Manganite is harder, 4.0; its specific gravity is 4.3. Luster, sub-metallic. Cleavage, perfect. Texture, fibrous. Wad is an impure ore of manganese found in bogs, of little or no value.

Pyrolusite	MnO_2	63.2
Braunite	Mn_2O_3	69.68
Psilomelane	(Variable)	?

Franklinite, a zinc-manganese ore, is also a common source of supply. An ore to be commercially valuable should contain from 40 to 60 per cent metallic manganese, and not over 0.2 to 0.25 per cent phosphorus.

To determine the value of manganese ores a somewhat intricate calculation is necessary. Delivered at Bessemer, Pa., the Carnegie Steel Company pays according to the following sliding scale:

Per cent	Mn.	Per Unit	
over	49 p. c.	Fe.	Mn.
46	49 p. c.	6c	28c
43	46 p. c.	6c	27c
40	43 p. c.	6c	26c
37	40 p. c.	6c	25c
34	37 p. c.	6c	24c
31	34 p. c.	6c	23c
		6c	22c

Moreover, for each one per cent of silica in excess of eight per cent a deduction of fifteen cents a ton is made, and a deduction of one cent per unit of manganese is made for each 2-100 of one per cent of phosphorous present in excess of 1-10 per cent. From which it is evident that there can be little profit in impure deposits of manganese.

Mercury. Quicksilver usually occurs in the form of cinnabar, though occasional deposits of pure metal are found in drops and small pockets, in limestone and the softer secondary rocks, including shales and slates. As the appearance of quicksilver must be familiar to all, cinnabar alone needs description. Its specific gravity is 9.0; its hardness, 2.2. It is a red brown earthy ore, the powder of which is a dull red. It is generally found in sandstone, though it occasionally occurs in slates, shales and serpentine. Heated gently with lime cinnabar yields quicksilver. If copper be held over the fumes of mercury it will be coated with a light film of the metal. An alloy with silver has been found. Mercury is heavy, extremely brilliant, and mobile. The composition of cinnabar is:

	Per cent Hg.
Cinnabar HgS	86.2

Although but three American states have supplied this metal, this country has held rank as second producer. Of these California is by far the most important. Oregon and Utah having never had any but a small and spasmodic output. Judging by Californian experience, the prospector is most likely to find cinnabar, the ore from which the quicksilver of commerce is derived, in metamorphic rocks. Mercury is always sold in flasks of 76½ pounds. The production of mercury by the United States (California) was 28,879 flasks in 1899, which were valued at $1,155,160.

The following table shows the rock in which the most famous Californian quicksilver mines are:

Mine.	County.	Rock.
Sulphur Creek	Colusa	Serpentine.
Abbott	Lake	Shale-serpentine.
Great Western	Lake	Serpentine. (?)
Ætna	Napa	Sandstone.
Corona	Napa	Sandstone-serpentine.
Aat Hill	Napa	Sandstone.
New Almaden	Santa Clara	Shale-serpentine.
Barton	Siskiyou	Shale-sandstone.
Cinnabar King	Sonoma	Sandstone-serpentine.
Altoona	Trinity	Porphyry-serpentine.

A study of the foregoing shows that serpentine is almost as intimately connected with quicksilver as is quartz with gold, or granite with tin. These are the things that prospectors should make a note of. With the great increase of gold mining and the limited store of cinnabar that is available that ore seems certain to rise in value before long.

Mica. The value of Indian mica varies from 90c a pound for sheets 4 in. x 1 in. to $13 a pound for sheets 10 in. x 8 in. The white mica in large sheets is valuable. The amber-colored, and spotted, are used for insulating purposes in electric plants, while the coarser sorts are ground and used as lubricants, or in fire-proof paint manufacture.

Nickel. This ore is never found in metallic form, but always in combination. Pyrrhotite, or magnetic pyrites, is the source of about all the nickel of commerce. This ore has been already noticed under iron. Rare but valuable ores of nickel are millerite, nickelite, glance, and nickel bloom.

		Per cent nickel.
Millerite	NiS	64.4
Niccolite	NiAs	44.0

Some of the nickel of commerce is derived from nickelliferous pyrrhotite.

Petroleum. Crude petroleum is never found in metamorphic or igneous rocks. The stratified rocks of the Devonian, Carboniferous and Cretaceous ages are most likely to hold it. The crude oil is almost black, and consists of about 85 per cent of carbon, and 15 per cent of hydrogen. A long iron-shod stick is all the prospector requires to take with him in his search for surface indications of oil. The warmer the day the easier the search, as the oil rises to the surface of the streams, and is found in greater quantities than on cold days.

Oil existing in the lower rocks ascends through them until it accumulates under some layer that will not let it pass through. In this condition deep boring finds it, the rod usually tapping gas first. Petroleum may be noticed oozing out of gravel banks, or floating as a scum on the surface, whenever abundant. It has been found in rocks of widely different age, from extremely ancient formations to some that did not precede man by so very long, geologically speaking.

Platinum. This metal is only found native. Its gravity is very high, from 16 to 22. Hardness, 4 to 4.5. Luster, metallic. Opaque. Whitish-gray. Smooth. Ductile. Cleavage, none. Fracture, hackly. Texture, granular, fine. Platinum is unaffected by acids, but if alloyed with 10 per cent of silver it dissolves in nitric acid. Almost infusible. Platinum occurs with placer gold in the beds of streams. Usually it is in small grains, but one or two large nuggets are on record from Brazil and Siberia. Serpentine rocks are believed to have originally held the platinum found in the beds of rivers, but none has been found in veins. The entire product of the United States was 300 ounces in 1898; valued at $3,837. In 1899 there was none produced.

Silver. Silver is generally found in serpentine, trap, sandstone, limestone, shale, or porphyry rocks, the gangue being quartz, calc, fluor, or heavy spar. All silver ores are heavy, and many of them are sectile, i. e., may be cut with the knife. Western men test for silver by heating the ore and dipping it into water.

Some metal comes to the surface in a greasy scum, should silver be present. Native silver is found occasionally. Owing to the fall in value of this metal its future is not assured. It has fallen, during the past year, once to forty-nine cents an ounce, and this has had a most disastrous effect upon many silver mines, forcing them to suspend operations. Should the fall continue, as seems likely, and the price of silver go down to forty cents an ounce, little will be produced except as a by-product in the treatment of argentiferous lead ores.

As silver enters into chemical combination with sulphur easily, as is seen by the black film that forms on silver articles in a room where gas is burnt, most silver ores are sulphides. The very abundance of silver has caused its great fall in value, and it does not appear that it is ever likely to remain for long at a price exceeding fifty cents an ounce, owing to the ease with which it may be produced, and the large quantities that must find their way to market through it being a by-product in lead smelting. From 1859 to 1891 the Comstock lode in Nevada produced $325,000,000. This lode is a belt of quartz, 10,000 feet long and several hundred wide, and is a contact vein between diorite and diabase. In America galena is the principal source of silver; the chlorides and oxides rank next; while, lastly, some silver is parted from gold when it reaches the mint, as gold always contains more or less of that metal. No precise statement as to the manner of its occurrence may be made since it is found in many different positions, and is associated with all sorts of minerals. It is never found in placer deposits, as it breaks up under the influence of water, air, etc. Its original source is doubtless the igneous rocks, where it occurs in association with augite, hornblende and mica. Silver may be expected in mountainous regions of recent origin. Between 1875 and 1891 the world's product rose from $82,000,000 to $185,599,600. Three quarters of this came from the western hemisphere.

The commercial ores of silver are:

		Silver.
Argentite	Ag_2S	87.1 per cent
Proustite	$3Ag_2SAs_2S_3$	65.5 per cent
Prysagyrite	$3Ag_2SSb_2S_3$	59.9 per cent
Stephanite	$5Ag_2SSb_2S_3$	68.5 per cent
Cesargerite	$AgCl$	75.3 per cent

The Anaconda mine in Butte is the largest producer of silver in the country. In 1896 its output was 5,000,000 ounces. The Anaconda is also the heaviest copper producer in the United States, its yield of copper being 125,350,693 pounds.

Sulphur. Brimstone is found native in the neighborhood of volcanoes, extinct or active. It is also derived from iron pyrites. Color, yellow. Hardness, 2. Specific gravity, 2. Luster, resinous. Smooth. Sectile. Texture, crystalline.

Talc. The scientific name of this mineral is steatite. It contains silica and magnesia. Its green color, pearly luster, and greasy feel, are very characteristic. It is not attacked by boiling sulphuric acid. Useful in the arts, but of no great value.

Tin. The composition of casseterite, the commercial ore of tin, is SnO_2; equal to 78.67 per cent of metallic tin. Cassiterite or tin stone is a heavy ore which occurs in alluvial deposits or in the beds of streams. It will be one of the latest ores the young prospector will find himself able to name with certainty. Granite, with white mica as one of its constituents, has so far always been associated with tin. The American continent yields little tin, and it is not likely the prospector in either the western states or in Canada will stumble upon it, though a good deposit of stream tin would enrich him in a short time, for the metal is in great demand. The streak, when the metal is scratched with a knife point, is whitey-gray and very distinctive.

Tin may some day be found in the northern Rockies, as there is plenty of granite, which is favorable to this metal. It is worth about thirteen cents a pound, and a vein must yield more than five per cent of metal to pay the cost of mining and dressing. Cassiterite, the principal tin ore, would have to be roasted. Most of the European tin mines were first worked for the copper they contained. The copper was found in the capping, but as they gained in depth they became more and more valuable for their tin. Some of the Cornish mines are three-quarters of a mile in depth. Very lately tin has been discovered and mined in vast quantities in the Straits Settlements, India. As it is found in the streams the expense of mining is very light, and it is killing the European mines. The Cornish miners put their tin ore on a shovel when they wish to test it. The sample is first crushed fine and a few skillful shakes get rid of all the gangue, leaving behind the tin and wolfram. This wolfram is always associated, in Cornwall, with the tin and it is got rid of by roasting. Australasia and Cornwall produce most of the tin used in commerce. Tin is not found native. Specific gravity of cassiterite is 6.5 to 7. Hardness, 6.5 to 7. Luster, vitreous to adamantine. Translucent to opaque. Brown, black, gray, red or yellow. Harsh. Brittle. Massive. The appearance of this metal is so variable that nothing but a test with reagents determines it with certainty. Granite is freqently the country rock in which tin is found.

Zinc. This is another ore that never occurs native. Calamine or silicate of zinc is the great producing ore. Composition: Zinc oxide, 67 per cent; silicate, 25 per cent; water, 8 per cent. Specific gravity, 3 to 3.7. Hardness, 4.6 to 5. Luster, vitreous. Translucent. White. Harsh. Brittle. Cleavage, perfect. Fracture, uneven. Texture, granular crystalline. Calamine is a difficult mineral to detect without experience, as when impure it does not look in the least like a metallic ore. It would be taken for clay or shale. This ore results from the decomposition of zinc blende. Blende contains 67 per cent zinc and 33 per cent sulphur. It is often dark brown or black from iron, otherwise it may be red, green or bluish. It is a troublesome impurity in silver ores. Smithsonite is a carbonate much resembling, and often found with, calamine. Other zinc ores are merely curiosities and do not affect the commercial value of the metal.

In the New Jersey mines the zinc ores are the oxides zincite and willemite, and the zinc-iron oxide franklinite. In the Missouri region, on the other hand, sphalerite and blende are the typical ores. Blende generally associates with the lead sulphide, galena. The Joplin district in southwestern Missouri and the adjoining region in Kansas are now mainly supplying the markets of the country, though the New Jersey deposits are very valuable.

Joplin ore assaying 58 to 62 per cent has varied greatly in price during the past four years. The lowest quotation was $20 a ton, the highest $51.50.

Zinc is derived mainly from the following half dozen ores:

		Zinc.
Sphalerite	ZnS.	67.0 per cent.
Zincite	ZnO	80.3 per cent.
Smithsonite	$ZnOCO_2$	51.9 per cent.
Franklinite	(Variable) (?)	5.54 per cent.
Willemite	$2ZnO.SO_2$	58.5 per cent.
Calamine	$2ZnO.SiO_2.HO_2$	54.2 per cent.

CHAPTER V.

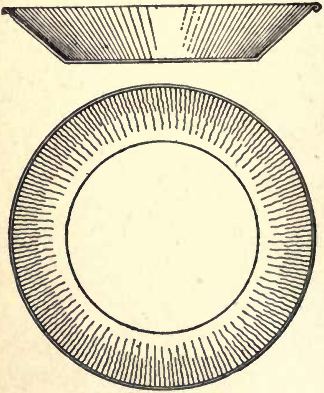
MINING.

Although the scope of this work does not include the very complex problem involved in the working of a great mine, prospecting and the simpler mining operations are so intimately connected that it would not be desirable to make mention of the one and ignore the other, because the prospector must perforce become a miner as soon as he discovers mineral, even though his operations should not go beyond a shallow trial shaft.

The simplest method of hoisting dirt or rock out of a shaft, after it has become too deep for the sinker to throw the stuff out with a spade, is by a bucket and windlass, which may be either single or double, according to the power required. In northwestern Canada, where the present gold excitement has attracted so many thousand pioneers, the miners have hitherto been content with a windlass. For their purpose it answers well, as they sink through gravel and not more than thirty feet at the most before reaching the bed rock. The alluvial flats in which the coarse gold of the upper Yukon has been discovered, are composed of gravel that is invariably frozen, summer as well as winter, and which requires to be thawed out before it can be worked with a pick. Strangely enough, dynamite cannot be used, as the ground is so elastic under the frost that the tamping simply blows out and the required effect is not produced. This peculiar condition has led the men, who are mining in that part of the continent, to adopt methods very similar to those used in Siberia, where, also, the ground is permanently frozen to a great depth. After scratching the surface of the soil, and removing the deep moss that invariably covers it, they light large fires over night and in the morning remove the few inches of thawed soil underneath the ashes. By this painfully slow method they eventually sink to the richer gravel, fifteen or twenty, or even thirty, feet below the surface, though there are few shafts of this depth on the Klondike and the other gold-bearing creeks about which we have heard so much. When the bed rock is reached and the few inches of decayed surface removed, the miner builds his fire against the side of the shaft, placing some inclined logs over it as a roof, and goes to bed. When he awakes next day several feet of the soil have fallen down over the logs, and this he has to hoist. It is at this stage that the windlass worked by his companion, or partner, demonstrates its value. In a very short time all the gravel that the fire has thawed out is hoisted to the surface, and added to the dump, where it must remain until the warmth of summer shall have thawed the streams and permitted sluicing.

A sluice is really nothing more nor less than a trough, open at the top, in which the gold is sorted from the lighter gravel and dirt by running water. The grade varies according to the coarseness of the gold. Very fine gold would be carried away by too swift a current, while coarse gold will resist almost a torrent.

The sluice is built in joints, usually a dozen feet in length; the sides may be six inches or a foot deep, and the width varies from one to two feet. There is no rule in this matter, but owing to the extravagant price of lumber—as much as a hundred and fifty dollars a thousand feet, board measure—the tendency is to make the sluices very small and very short, thereby saving nothing but the very coarsest gold. A prop-



MINER'S GOLD PAN.

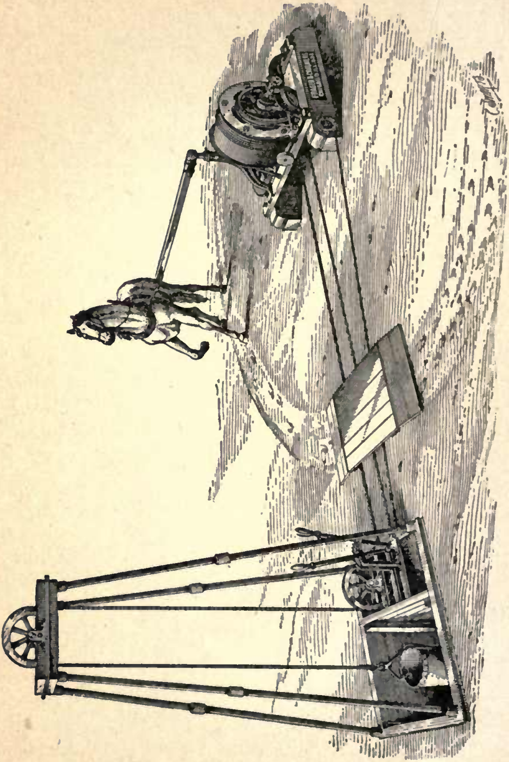
erly constructed sluice should be several hundred feet in length, and the inclination should not be more than one foot in twelve, while it may, in a case of fine gold, be advisable to diminish this inclination by at least a fourth. Riffles, or cross-pieces, are placed across the sluice at intervals of a few feet, and slats are placed lengthwise, filling up the intervals between the riffles. Into the crevices and interstices of these obstructions the heavy gold sinks by its own weight, and every few days, or weeks, as the case may warrant, the miner shuts off the water by closing the gate at the head of the sluice, removes the slats and riffles, beginning at the joint nearest the head and working towards the tail of the sluiceway, and collects all the gold that has accumulated.

This is a very simple form of mining, but it is not the simplest. Much gold has been recovered from the gravel in which nature has placed it by the aid of the pan, a sheet iron dish modeled on the housewife's bread pan.

Next to the pan the cradle is as little complicated as anything used in the winning of gold.

After this comes the long tom, a considerable improvement upon the cradle, but it necessitates more water and more men.

The horse whim is used in developing many a western prospect. The windlass does not work well below forty feet, and where fuel and water are to be had any sensible man will use steam power for deep mining, but there is a gap between the windlass and the steam hoist which the horse whim fills acceptably. To a depth of 300 feet a horse whim can usually handle the rock and water. It is inexpensive, in the first outlay, and costs but little to run. You can bring your bucket from a shaft a hundred and fifty feet deep in two and a half minutes, and with a seven hundred pound capac-



HORSE WHIM.

ity in the bucket, in forty-five trips you could raise fifteen tons a day. A shaft three hundred feet deep would require four hours' steady work to bring to surface the same amount. A fair speed with a one-horse whim from a three hundred foot shaft is one hundred buckets per shift of ten hours, but the prospector rarely has to figure on shafts of that depth. If the mine turns out well it is likely to be in the hands of a powerful company (of which he should be the principal shareholder) before the three hundred foot level is reached. The weight of the horse whim is about eight hundred pounds. It can be taken to pieces and packed anywhere that a mule can travel; the heaviest piece will not weigh more than a hundred pounds.

A small stamp mill, run by horse power, is a very favorite machine with western men, where the ore is free milling. The mortar in which the stamps work has copper plates amalgamated with mercury inside, and copper tables with amalgamated plates over which the pulp passes after oozing through a fine screen in front of the mortar. These little mills are so constructed that they can be taken apart or put together in an hour or two. They require but one horse power and will do good clean work up to their capacity. The following are the specifications of a good one:

Total weight	1,500 pounds.
Weight of heaviest piece	350 pounds.
Weight of stamp	100 pounds.
Drops per minute	60 to 80.
Capacity per hour	300 to 400 pounds.
Diameter of pulley	30 inches.
Price, with horse power,	about $350.

PROSPECTING MILL WITH HORSE POWER.

A diamond drill is a most useful adjunct to exploration of a mine or deposit. It is, essentially, a hollow drill which may be lengthened at will, rotating rapidly and carrying a crown of "bort" or black diamonds at its extremity, that eats into the strata very quickly. Holes 3,000 feet deep have been driven by the diamond drill, but such extensive investigations of the earth's crust are tremendously costly, and may only be undertaken by governments or rich companies. For a depth of 700 feet, however, the expense need not exceed $2,100. The cost of the plant for drilling would be $3,500 more. Water is pumped down the hollow center of the drill, to keep it cool. The great advantage of the diamond over the percussion drill is that it permits the saving of a core, so that the character of the rocks and minerals passed through may be known. The diamond drill does better work in hard strata than it does in soft. The rate, in limestone, may be about two feet an hour, down to a depth of 200 feet.

A complete outfit for boring with the diamond drill includes a steam engine and boiler, diamond crown, lining tubes, rods, and various minor accessories.

Hydraulic mining is the cheapest known method of recovering gold. In four years the North Bloomfield Mining Company of California worked 325,000,000 cubic yards, which yielded only 2.9 cents of gold per cubic yard, and realized some profit. Very poor gravel will pay when the conditions are good. Cheap water, grades of four inches in a hundred, ample dumping room, big banks of light gravel, large areas of deposits, labor at a dollar a day, and a clever superintendent, make a combination that will yield a profit out of three-cent gravel.

Miners speak of "surface" and "deep" placers; of "hill claims;" of "bench claims" on the old river terraces; of "gulch diggings;" of "bar claims" on the sand bars of existing rivers; of "beach sands" or those that in a few favored localities border the ocean. A "sluice" is a long boxway to catch the gold; a "drift" is a tunnel into the gold-bearing gravel; and hydraulic diggings are those in which water under pressure is used to disintegrate the gravel.

A ground-sluice is a trench cut through the bed rock. The roughness of the natural floor serves for riffles. Booming is a process requiring a large accumulation of water in a reservoir, which may be discharged at once, and carry all the material that has collected below the pass, with one full tide, into the sluices. This practice is extremely ancient; Pliny mentions it in his Natural History.

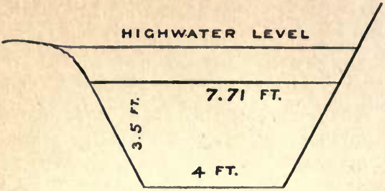
Deep mining may be divided into drifting and hydraulic mining. In the former the metal is wôn by means of tunnels and drifts or horizontal passageways along the length of the deposit. It is usually resorted to in districts where a flow of lava has covered the gold-bearing gravel, and made hydraulic mining impossible. It is followed in Alaska for another reason, viz., because the constantly frozen ground will not permit of the more remunerative method. The gravel is carried to the mouth of the tunnel and there dumped to be washed in the sluices. When "cemented" it must be broken up by stamps.

Rich deep placers may be worked by drifting, but whenever practicable hydraulicing is to be preferred as giving better results. It yields from four to six times the amount of gold that drifting does. Thorough exploration should precede the expenditure of large sums in a hydraulic plant. Even should the explorations result in finding barren gravels the money will have been well spent in saving the cost of an unproductive plant.

Black sand (magnetic iron) almost always accompanies gold, but this alone is no sign that gold is present, as black sand may usually be obtained by grinding and washing crystalline rocks.

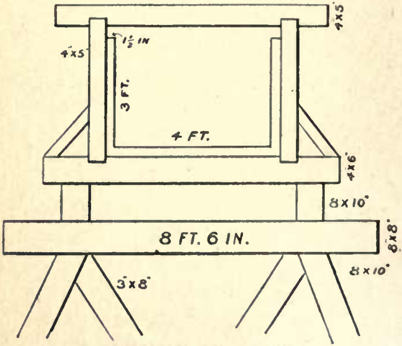
Ditches and flumes of wood or metal are used to bring the water for hydraulic mining from the region where it was impounded in a catch basin, often a distance of many miles. It is said $100,000,000 have been invested in ditches and flumes, mining and agricultural, in the western states, and new flumes are being planned every month. Some of them consist of wrought iron pipe carried over ravines by trestles 250 feet high.

In planning a ditch the miner must see to it that his water supply is at a sufficient elevation to command the ground. The more pressure the water works under the better. The supply should be continuous, or at least be available during the whole working season. Ditches in regions of deep snow should have a southern exposure. All streams crossed by the ditch should be diverted into it, to counteract leakage and other loss. Waste gates must be provided every half mile.



SECTION OF DITCH.

Ditches are better than flumes. Narrow, deep, and steep ditches are to be preferred in mountainous regions, and the reverse in valleys with soft soil. Some



SECTION OF FLUME.

Californian ditches with a capacity of 80 cubic feet per second and grades of 16 to 20 feet per mile have been built.

Sometimes the face of the country requires flumes;

they may even be hung along the face of a cliff. In shattered ground and where water is scarce flumes are better than ditches. The grade for a flume is usually 25 to 35 feet per mile and its capacity is smaller than that of a ditch. Pine planking 2½ inches by 12 to 24 inches, and 12 feet long, is the dimension stuff generally preferred. A flume 2 feet 6 inches square requires posts, caps, and sills of 3x4 inch; stringers 4x6 inch. Great care is needed at curves to avoid slack water and splashing. The boxes must be shortened and the outer side wedged up until the water flows as evenly as in the straight stretches. Should anchor ice form the water must be shut off at once. The life of a flume seldom exceeds a dozen years, whereas at the end of a similar period a ditch would be carrying 10 per cent more water than at first, owing to the sides and bottom having become consolidated.

Wrought iron pipes are employed largely in California to replace ditches and flumes. When the pipe crosses a ravine it is known as an inverted siphon. Piping is also used to convey water from the "pressure box" to the "gates" and "nozzle." Wrought iron pipes have to stand pressure varying from 34 pounds to 800 pounds to the square inch. Air valves or blow-offs must be provided at intervals to allow the escape of air from the pipe while filling, and to prevent a collapse of the pipe after a break. A covering of coal-tar should be given the pipe both inside and out. Cost varies from one dollar to two dollars a running foot.

The pressure box ends the ditch and from it the water passes into the supply pipe. The head of water is measured from this point. A box to catch sand and gravel, with a side opening and sunk below the level of the ditch, is called the "sand box."

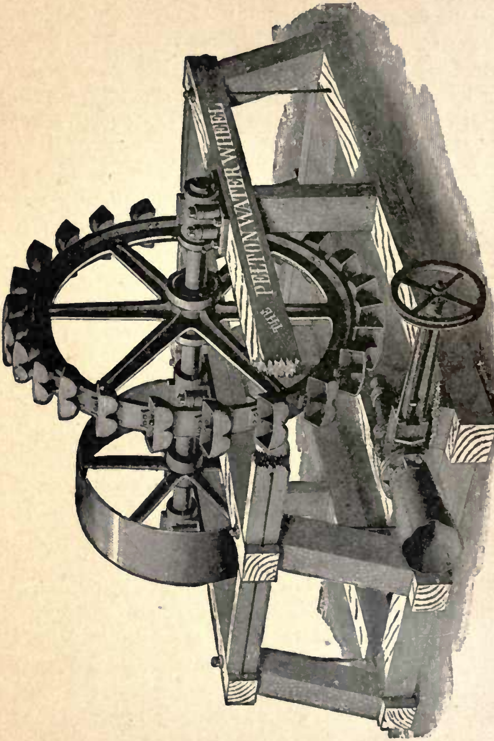
One and a half inch plank is generally the material out of which the pressure box is made. The depth of water in it is such that the mouth of the pipe is always under water. A grating in front of the pipe catches all rubbish. As no air must be allowed to get into the pipe the water must be kept quiet and deep at the pipe-head; this is insured by dividing the box into compartments, the first receiving the water and discharging it through suitable openings into the second. The water supply and the discharge should be equal. The water passes down the feed pipe, iron gates distributing it to the discharge pipes. Water must be turned on gradually, and the air valves must be open. The piping terminates in a nozzle with knuckle-joint and lateral movement. Nothing but the most secure bolting to heavy timber and the heavy weighting of the last length of pipe should be relied upon to keep the hydraulic giant in its place. Should it once begin bucking every man within reach of the powerful column of water is in imminent danger. The nozzle is directed by means of a larger deflecting nozzle, which receives the impact of the water and causes the main nozzle to swing right or left, up or down, as the case may demand.

A derrick capable of moving heavy boulders, and driven by water power, is a necessity in all hydraulic mining. Masts 100 feet high and booms 90 feet long are sometimes used, the motive power coming from a "hurdy gurdy" direct impact wheel. Experiments have shown that the bucket has much to do with the power of the wheel. For instance, when the water impinged against a flat bucket the efficiency of the wheel was less than 45 per cent of what it should have been in theory, whereas, with the Pelton bucket, it rose to 82.6 per cent.

There is a great amount of so-called cement, or in other words consolidated gravel, in all the northern placers, and in many California deposits, as well. In the old Cariboo diggings on the upper Frazer, strong companies are now pulverizing the ancient cements that resisted all the efforts of the 59 miners with powder and stamp mill, and are deriving large profits therefrom.

Black powder gives even better results than dynamite in gravel. The usual allowance of powder is 20 pounds in weight for every 1,000 cubic feet of ground to be moved. Make drifts T-shaped, and tamp the main drift almost to the junction with the arms, which should be parallel to the face it is required to dislodge.

Sluices have their maximum discharge when set straight. Increased grade may be given below any unavoidable curves with advantage, and the outer side of the sluice must always be raised. Steps or "drops" in the sluices help in the recovery of the gold. In general, a grade of 6-6½ inches to the 12-foot box is found best; this is equal to a 4-4½ per cent grade. Exceptional instances are on record, however, where grades ran from 1½ per cent to 8 per cent. In a 4 to 7 per cent grade the water in the sluice should be 10



PELTON WATER WHEEL.

inches deep at least. The following table gives useful details:

Sluice.	Grade.	Water.
6 ft. x 36 in.	4 to 5 p. c.	2,000 to 3,500 m. in.
4 ft. x 30 in.	4 p. c.	1,800 to 2,000 m. in.
3 ft. x 30 in.	1½ p. c.	600 to 1,000 m. in.

"The longer the better," is the sluice-builder's motto. The best "riffles" are made of blocks of pine 8 to 13 inches deep, wedged into the bottom of the sluices. They are laid in rows separated by a space of an inch or an inch and a half. Riffle strips keep them in position, these latter being laid crosswise on the bottom. When worn down to five inches, the blocks should be replaced. This amount of wear will probably require six months. Stone and longitudinal riffles running lengthwise of the box are often preferred.

An undercurrent is a broad sluice set at a heavy grade below the level of the main sluice. The fine stuff drops through a grating, while the coarse gravel continues on down the sluice.

Refuse material from quartz, hydraulic or other mines is known as tailings. Tailings are deposited on a dump, which in the case of a hydraulic claim must be sufficiently spacious to receive the thousands of yards of debris deposited on it each day. When available a narrow, deep canyon, or a tunnel, may take the places of dumps.

Quicksilver is used in the sluices, 14 to 18 flasks being used every fortnight in a long sluice. It is not placed in the last 300 or 400 feet.

In working, keep the face of the bank "square." Washing should be carried on continuously. Watches must be set over the sluices, or gold is likely to be missed. As an extra precaution, the sluices should be run full of gravel before shutting off the water. There is no fixed custom regulating "clean ups." Some managers do so every 20 days, others run two or three months, others again clean up but once in a season. In large operations, the first 2,000 feet of sluice are cleaned up every fortnight; the remaining boxes once a year.

Sluices are cleaned from the head downward, the blocks being taken up for that purpose. The amalgam of gold and quicksilver is collected in sheet iron buckets. The final step is reached when the amalgam is retorted and melted in a graphite crucible.

The principle of which the hydraulic miner takes advantage is the great specific gravity of gold as compared with water and rock. To illustrate this quality it may be noted that on a smooth surface inclined at an angle of 1 in 48, subjected to a heavy stream of water, 95 per cent of the fine gold in gravel does not travel three feet.

The loss of quicksilver fed into sluices will vary, even under good management, from 11 per cent to 25 per cent of the amount fed to the boxes.

Hydraulic mines under favorable conditions are very paying investments. Gravel yielding 10 cents a cubic yard has been worked for 6 cents a cubic yard, at the rate of a million cubic yards a year. On another large claim 600,000 cubic yards were worked for 6 cents a cubic yard, yielding 13 cents a cubic yard.

River dredging is another form of gold winning that has been brought to a great state of perfection in New Zealand. Although the dredge has not yet acquired the importance in America that was expected, it is successful on one or two western rivers, and as the subject becomes better understood it is conceivable that American mining engineers will be as successful in devising improved dredges as they have been in all other branches of their profession.

In New Zealand the bucket dredge has proved more satisfactory than the suction dredge, although a hasty conclusion would probably give the latter the palm. At Bannack, Mont., the Bucyrus Company has several dredges in successful operation. One is 102 feet long, 36 feet wide, and draws 36 inches of water. It is very substantially made, and weighs nearly 700,000 pounds. Before such a dredge is launched, a dam is built across the gulch to impound sufficient water. As the gravel is dredged and washed, it is dumped astern of the dredge, which, in the case of a shallow creek, moves up to the excavation made by the buckets. The boilers of this dredge are double, and together have 250 H. P. There are 36 buckets, and each one has a horizontal drag of eight feet, a capacity of five cubic feet, and travels at the rate of fourteen feet a minute. After treatment by trommels, or revolving screens, coppers, and sluices, and finally by a centrifugal pump, the now almost valueless gravel goes overboard again, leaving behind 98 per cent of the gold it once held.

The traction dredge is really a land-mining machine, as it is adapted for work on land nearly flat, where but little water is obtainable. The machine travels on bogia tracks. A 50-H. P. boiler supplies the water. A boom, 40 feet long, carries a shovel of 1.5 cubic yards' capacity, and moves 70 cubic yards each hour.

Mr. John W. Gray, one of the best authorities, has recently written to the Mining and Scientific Press of San Francisco a most interesting description of the progress made in saving the gold from the streams in New Zealand. He says, in part:

"After great effort, numerous trials, many failures and some large losses, this system of gaining gold has been evolved from crude beginnings into a systematic and satisfactory method of mining. Dredging for gold is now attracting attention and bids fair to become an established form of mining for that metal. In New Zealand, where more work of this nature has been done than elsewhere, the evolution of the industry has been the work of years. The rivers upon which dredging operations are carried on are swift-flowing streams, subject to frequent floods, having a considerable depth of gravel, with boulders and runs of pay dirt interstratified. The conditions are, therefore, not the best for economical and successful work, and it is not surprising that many failures have occurred. The runs of gold are, however, often extensive and rich, and operations carried on upon such reaches have in a number of cases given satisfactory results.

"The improved form of dredge is a double pontoon, with ladder and chain-bucket arrangement between.

Screens separate the coarse from the fine material. Wide sluicing tables catch the gold, centrifugal pumps supply the water, and waste material is handled by elevators. The power is usually steam, although electricity is used in a few instances, where conditions are favorable. The dredges vary in size and capacity, but are now built of large size and great strength. Twenty thousand dollars is the cost of a large dredge with all the latest contrivances. Under favorable conditions, material has been handled without loss that only yielded a grain of gold to the cubic yard. The real cost in actual continued working is believed to be very much in excess of that figure where average conditions exist.

"One dredge on the Clyde side of the Shotover, working to a depth of twenty feet below water level, lifted 40 tons per hour when operating. The profit on eleven dredges for the four weeks ending July 24, 1897, was an average of $2,686 for each dredge.

"So far in this country (United States), with a few exceptions, dredging operations for gold have not been financially successful. From crude beginnings, however, the machines have been rapidly improved and perfected, until now, in some localities, dredges believed to be the most complete yet constructed are being put in operation, and results are promised, not yet attained, in the way of economical working and high percentage of saving. During the last few years, a number of dredges have been operated in California, British Columbia, Idaho, Montana and Colorado, but with poor success. Very few prove themselves capable of paying their way. Some of the machines were faulty within themselves, others were entirely unable to cope with the swift currents and large boulders of the streams upon which they were operated. This latter is said to have notably proved the case with the dredges tried upon the Frazer and Ouesenelle rivers.

"Dredging operations on Grasshopper Creek, near Bannack, Mont., are now carried on successfully upon a large scale. The upper Sacramento river, in this state, has a dredge doing profitable work, and, in a small way, dredging is successful upon the Kzamath. A dredge upon that river, composed of two flat boats with a large steel scoop between, is able to cut and hoist the gravel and soft bed rock, and to handle boulders of from four to six tons' weight. The dredge is run day and night, has a 25-H. P. engine, and requires three men for each shift. In gravel 10 to 25 feet deep, 400 cubic yards can be handled every twenty-four hours. Cost of dredge, $8,000.

"A large dredge of the chain-bucket variety is operating in Northern Mexico, in a dry country, where there is little water. The actual capacities of these machines are 60, 100 and 150 yards per hour.

"Perhaps the most interesting dredge yet brought to the notice of the public is one lately built by the Risdon Iron Works, San Francisco, and now operating upon the Yuba river, near Smartsville, Cal. It is of the elevator, or chain-bucket, type, 96 feet long, composed of two pontoons, separated by a space five feet in width, in which is operated the ladder carrying the buckets. One man controls the dredge by means of a power winch with six drums. Four drums carry lines from the corners of the dredge to anchorages on shore—one a head-line and one the ladder line. The machine is to dredge to a depth of 45 feet, and is said to have a gross capacity of 93 cubic yards per hour. The material discharges from the buckets into a revolving and perforated screen. This segregates the large material, which is then conveyed away by the tailings elevator. Water (3,000 gallons per minute) is supplied to the revolving screen for washing and sluicing purposes by a centrifugal pump, and the fine stuff falls through the holes in the screen into a distributing box, from which it passes to a set of gold-saving tables and thence to a flume. The tables are covered with cocoa matting and expanded metal. The top tumbler of bucket-chain is operated by a vertical compound condensing engine indicating 35 H. P., which also operates the pump. It is claimed for this dredge that in any ground not deeper than 60 feet below water level or more than 20 feet above, and which contains boulders of not more than one ton weight, the material can be handled at from 3 to 5 cents per cubic yard. If the capacity of the machine is given without deduction for water raised, imperfect filling and general delays, and the increase in volume of the gravel when broken up in filling the buckets, the actual working capacity would be less, and from these causes and the losses from wear and tear, breakages and repairs, the cost of operating would be increased. The cost of the dredge complete upon the river is said to have been $25,000.

"In the evolution of the dredge into the elevator or chain-bucket machine, now the popular form, the various kinds of dredges were given trials. The dipper dredge is not adapted to dredging for gold, and some of the gold is lost. With agitation of the gravel the gold soon settles and is not recovered. It is also very difficult, if not impossible, to construct a dipper dredge that is water-tight. Another objection is that the material is supplied intermittently, thus making necessary certain undesirable arrangements for supplying the material in a continuous flow to the gold-saving tables. The same objections apply with greater force to the clam-shell form of dredge. It is by no means water-tight, and loses most of the gold in the act of dredging and bringing up the gravel. The objections would seem not to have the same force if applied to hard cemented gravel or to gravel with sufficient clay or other binding material to make it consistent. It is well to remember that these forms of dredges are, in many positions, economical of operation.

"The hydraulic dredge has had fair trials and proved a failure. Large storms greatly lessen the efficiency of this form of dredge, and numerous boulders hamper the pumping work. The suction force, being intense near the pipe and decreasing rapidly a short distance away, causes the sand and gravel to be carried off, leaving the gold behind. A centrifugal pump is therefore of little use to catch coarse gold, or to clear a hard, uneven bottom. Cutters do not remove the trouble, since the gravel is dispersed by the cutting, and the gold is separated therefrom.

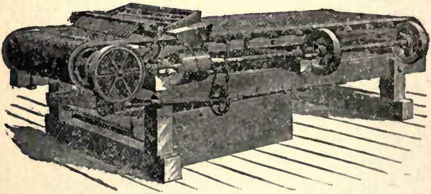
"These objections would not obtain under certain conditions, and it would seem quite possible that conditions might be found existing where the suction dredges might be arranged to do good work. A dredging company is now constructing, at Seattle, two dredges of the suction type to operate upon the Yukon river. This would indicate that there are those who believe that deposits occur in and along that river which can be successfully worked in this way.

"The chain-bucket machine, the popular form for operating under average conditions, is a combination of the following elements: An excavating apparatus which clears the bottom and handles the material with little agitation and slowly and continuously delivers a regular quantity of gravel to the gold-saving appliances; revolving screen to receive and wash the material and separate the coarse from the fine; an elevator or contrivance for carrying off the coarse gravel and stones; gold-saving arrangements, or tables, over which the fine material passes and upon which the gold is caught; a pumping apparatus to supply water for washing and sluicing.

"The proper capacity of a machine seems to be regulated by the capacity of the gold-saving appliances. The tables should be as wide as possible, with frequent drops, and the fine material should be distributed over the tables in a thin film. The tables are covered with plush or cocoa matting, and sufficient water supplied to keep the material clear. The material should be supplied evenly, continuously, and regularly to the tables. Care and attention are required to catch the fine gold. A disregard of the foregoing directions results in great loss, more particularly in the fine gold. Mechanical skill is required to properly design and construct a dredge, and the care of a competent mechanic is necessary to see that the machine is kept in order and economically operated. The saving of the gold, however, is what makes dredging operations a commercial success. A man skilled in these matters should be in charge of running operations. Dredges should be built of determined capacities, and should be designed to suit the conditions under which they are to operate. Careful examination and investigation of the ground to be worked should be made beforehand, and the surrounding conditions studied, and it goes without saying that these matters require engineering skill and experience.

"The field for dredging for gold seems large. Where the proper conditions exist, it is a system which commends itself, and which gives promise, in competent hands, of being an economical method of mining. There is probably a very large extent of country where dredging for gold will be carried on profitably. The ground need not be in a river, if there is seepage water sufficient to float the dredge and supply clear water for the saving of the gold. Dredging requires little water as compared with that required for sluicing and elevating, and this water can, in many dry localities, be supplied at small expense, where a supply for hydraulic work or elevating would cost a very large sum, or be impossible at any cost. Any power suitable for driving the prime motors can be utilized to run the dredge. Indeed, it would seem as if a system of mining was about to be perfected which may make possible the profitable working of many deposits not easy to be worked by other methods, and which may, in many instances, solve problems regarding the successful working of deposits which hitherto have seemed most perplexing and even impossible of solution. Some doubt exists as to possible economical dredging operations under the water of torrential streams. The strong currents, the frequent floods, and many large boulders found in the channels of such streams make the working of the machines difficult and costly. This would not be so much the case in the long stretches of less current, nor would it be so at all in the valley-like reaches in the lower portions of rich streams, nor in the wide, flat portions of country where the streams enter the plains."

Very few gold-bearing lodes contain nothing but free gold; on the contrary, they carry the bulk of their values in the form of sulphurets, having more or less gold incorporated, and even when the gold is native and free-milling at the surface, it is generally changed into sulphurets as depth is gained. So the miner has to consider methods of recovery more complicated and expensive than simple amalgamation with mercury, for upon gold included in pyrites mercury has no effect. Titanic iron, hematite, and tungstate of iron often hold gold, or soft clay ores carry it in their midst, and such combinations tax all the skill of the mining engineer merely to save a respectable percentage of the assay value. Sometimes chlorination and sometimes cyanization are the measures tried, but supposing the preliminary treatment to have been by stamps in the battery, concentrating is one of the main reliances of the mill man. The blanket table is undoubtedly the oldest type of concentrating machine, but it is very inferior to modern inventions. Percussion tables often do good work. In this system a sharp and frequently repeated blow is given the table, in such fashion as to make the heavy material separate from the light. "Shaking" and "rocking" tables are favored in some mills, and they give better results on fine gold than

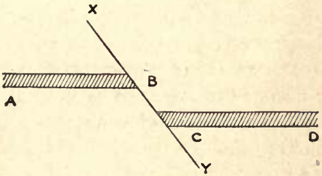


FRUE VANNER.

any of the previously mentioned devices. But the best machine so far invented is the Frue Vanner—an endless rubber band drawn over an inclined table, having both revolving and side motions. The lighter particles are carried off by water, and the heavier collected in a trough.

Veins, lodes, or ledges, may be found in stratified or unstratified rocks, and in the former they generally cut the beds at an angle. Veins are bounded by walls. The rock in which a vein is found is a country rock. Smooth walls are called "slickensides." The upper wall of an inclined vein is the hanging wall; the other the foot wall. A layer of clay between the veins and wall is a selvage. A mass of rock enclosed in the vein is a horse. The vein stone, or gangue, is all that part of a vein that is not mineral.

The throw of a fault in a vein is measured by the amount of vertical displacement. When the miner comes to a fault, he should follow the greater angle in his attempt to recover the lode. For instance, on min-



A FAULT.

ing along A B to the line of fault X Y, the exploration will be continued downward, because the angle A B Y is greater than the angle A B X.

Mercury that has been "sickened," that is to say, has lost its brightness and power of amalgamating, may often be cured by washing with an extremely weak solution of sulphuric acid and adding a little zinc.

As regards the comparative merits of chlorination and cyanization, it may be said the one is the equal of the other. Under certain conditions, chlorine gives a higher percentage of gold; under others the same may be said of cyanide. A description of either process would be out of place, however, in a simple elementary work.

Handed down through the centuries, the primitive arrastra is still useful in certain contingencies. It is like a cider mill in its principle, and was probably suggested by recollections of that machine, or else of the Spanish wine-press. A circular, shallow pit, a dozen feet or more in diameter, is first paved with hard, uncut stones of granite, basalt, or other hard rock. This pavement is a foot thick, and beneath it is a bed of puddled clay 6 inches deep. A vertical shaft with an arm, or arms, revolves in the center of the arrastra. Grinding blocks weighing 400, or perhaps even 1,000 pounds, are fastened to the arms by chains or rawhide strips. The forward part of each stone is raised a couple of inches off the floor. Mule, horse, water or steam power may be used, the speed ranging from 4 to 18 turns a minute.

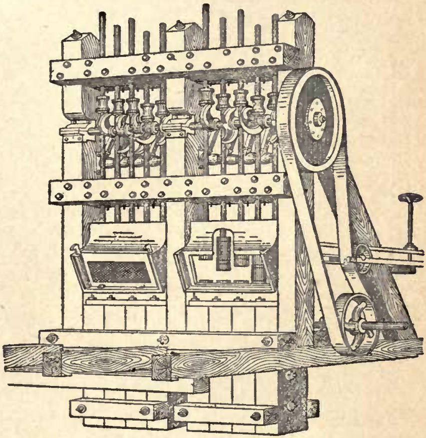
Nothing can be simpler, less expensive, or save a greater proportion of the value in the ore than the arrastra. Its limited capacity is its worst fault. An arrastra 10 feet in diameter will treat 500 or 600 pounds of ore at a charge, and handle one ton a day of 24 hours. Ores that were so poor they yielded nothing to the stamp mill have paid well with the arrastra.

This humble device may be used to advantage, probably in some of the poorer gold-bearing cemented gravels of the Northwest. The ore should be crushed to pigeon-egg size. Small quantities of mercury, about a tablespoonful to every five tons of gravel, has been found a satisfactory proportion in California.

In a permanent arrastra a layer of neatly-dressed and pointed stones is laid in hydraulic cement. A fair-sized arrastra will require 50 pounds of quartz to charge it, and the material must be broken into pigeon-egg size. After the machine has been started, and a little water added from time to time, little else need to be done for four or five hours, and this is perhaps one of the reasons for which it has always been so favored in indolent Mexico. At this stage, the quartz and ore will be very finely pulverized, and water should be added until the pulp is as thin as cream. Quicksilver must now be added in the proportion of 1¼ ounce for every supposed ounce of gold in the ore being treated. Two hours' further grinding is given, and water then admitted until the paste is quite thin, the speed of the arrastra being reduced at the same time so as to allow the amalgam and quicksilver to sink to the bottom. A half an hour of this treatment suffices and the thin mud is run off, leaving the gold and amalgam on the floor of the arrastra. A second charge of broken quartz is put in and the operation repeated, the clean-up not taking place oftener than every ten days, and sometimes only at intervals of a month or so. The rougher the bottom the longer the interval between clean-ups, as all the stone work must be taken up each time and all the sand and mud between them must be washed carefully. The arrastra is extremely valuable to the poor man who, having discovered a gold-bearing vein, wishes to transfer some of the metal into his own pocket, at the least possible outlay. Its cheapness places it within reach of all, while a stamp will cost a good deal. Then again the amalgamation being more perfect in the arrastra than in any other mill, it is particularly suited for the poor, lean ores. It is, however, only adapted to those that are free-milling, others not being suited to this form of apparatus, nor, indeed, to any save very costly plants. Some arrastras have been built to treat old tailings, and have paid well when water power could be used. Free-milling gold and high-grade silver and gold ores are those usually treated.

The flagging should be of tough, coarse rock; granite, basalt or compact quartz are all good. This flagging should be at the very least a foot thick. When the arms of a 10-foot arrastra are revolving 14 times a minute, the outer stone is traveling 400 feet a minute. Round holes closed by wooden plugs, or a side gate, lets the liquid mud out. Some mill men use chemicals in the arrastra; potassium cyanide, and wood ashes or lye are probably the most useful, as the latter cuts grease and the former gives life to the quicksilver. Rich silver ores are treated with blue stone and salt. When the pulp has been ground sufficiently, quicksilver is added, sometimes 250 pounds being put in a single charge. A 12-foot arrastra will never treat more than two tons a day, and often no more than one-half that. One man a shift can look after a couple of arrastras, and the owner, in case of one arrastra that is working on tailings, often does everything himself. Overshot wheels, or turbines, or hurdy-gurdies, furnish the power in many cases. A simple mule-power arrastra may be built for $150.

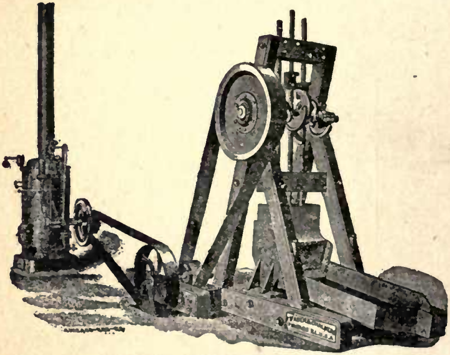
A side hill should be chosen for the site of a battery. Ample water power is necessary, though provision may be made for saving it in catch basins should such a course be desired. Moreover, there must be plenty of room below the mill for the tailings, as it may be de-



STAMP BATTERY.

sirable at some future time to put them through a second course of treatment.

Automatic ore-feeders are always put in by good mill men. In cold climates the water that goes through the mill should be heated, and this may be done by the exhaust steam, but care is necessary that no grease get into it, as it would prevent the gold from amalgamating. The stamps for a light mill may be 3 or 5 in number, and weigh from 700 to 850 pounds. Tables must be water-tight, with half an inch to one inch drop to the foot, according to the fineness of the gold. Below them tables, having the same inclination and covered with blanketing, are used to retain specks of gold that have passed over the plates without amalgamating.



THREE STAMP BATTERY.

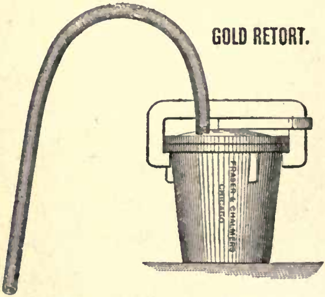
After the concentrated materials, always spoken of as the concentrates, have passed over the tables, they are often roasted to get rid of the sulphur, arsenic, etc., and afterwards treated with quicksilver in the pan, or tin, with chlorine or cyanide. These processes belong, however, to the domain of the professional chemist and metallurgist, and require the knowledge and experience of an expert to stand a chance of success.

The coarseness of the mortar screens is subject to infinite variety, according to individual preference. The number of holes to the square inch ranges between 60 and 800 in Australia, and between 900 and 10,000 in the United States. The holes, when round, agree in numbers with those of sewing-machine needles, from 0 to 10. When slots are preferred to holes, they are generally $\frac{3}{8}$-inch in length and No. 6 diameter. Russia sheet iron, or sheet steel 1-32-inch thick is the material of which they are made. It should weigh one pound to the square foot, be very soft and tough, have a clean, smooth surface, and show no rust or flaws. In Australia 1-16 sheet copper is preferred. The holes in any case must be punched in the sheet so that the rough edges are turned, and thus any pulp that finds its way into one of the holes is certain to get out again and not clog. A battery may require 13 sets of screens a year; each screen having a surface of about $1\frac{1}{2}$ square feet. Russia iron screens endure 15 to 40 days. As the work a stamp can do depends entirely upon how much pulp can escape through the screen in any given time, the latter is evidently a very important detail of a battery.

Prospecting stamp batteries differ from ordinary batteries, chiefly in being of light build and weight.

Amalgam coming from battery stamps is often mixed with all sorts of rubbish. After being gathered, it is dried with a sponge, foreign matter picked off the surface and clean quicksilver added. Soft unglazed paper thrust into the mercury removes the last vestiges of water, and then a card is drawn vertically or a piece of blanket horizontally across the mercury to clean it of iron. After squeezing, the amalgam is retorted.

All the amalgam is placed in one large kettle and, if possible, the latter is put on a strong table having an inclined surface with a groove and hole at the lower end to catch any stray globules of quicksilver. Sodium amalgam, one ounce to each 75 pounds of mercury, is put in the amalgam kettle and the whole stirred. This sodium amalgam is not absolutely necessary, but is



GOLD RETORT.

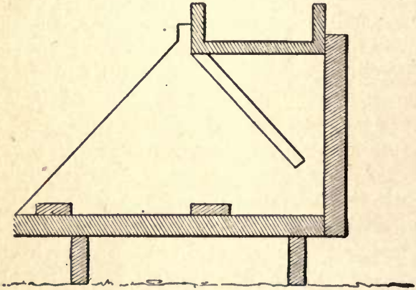
desirable. After some minutes, water is poured on the mercury and the whole stirred. All dirt rises to the surface and is removed with a sponge. The cleaning is continued until the mercury seems absolutely free from any impurity, when it is dried with a sponge. It is next turned into pointed bags of stout canvas and force applied until most of the quicksilver has squeezed through. The amalgam remains behind. The quicksilver still contains some gold, but it had better remain if the mercury is to be used again, as gold attracts gold; it can always be recovered by retorting.

Sodium amalgam is best made by the miner himself, enough for one clean-up at a time. Metallic sodium and quicksilver are the necessary ingredients; the former being kept in a wide-mouthed bottle covered with coal oil. A frying-pan makes a useful mixer. It must be dry and clean. Five pounds of clean mercury is poured into the pan, and dried with a sponge, and heated beyond the boiling-point of water, but not much above, or there will be a sensible loss of mercury. A piece of sodium is wiped dry, cut into ½-inch squares and placed with a long pair of tongs in the center of the warm quicksilver, which, by the way, is now off the fire and in the open air, the operator meanwhile keeping religiously to windward of it, unless he courts salivation and all its attendant ills. As soon as the sodium touches the mercury a flash and mild explosion will follow, but after a few cubes have been introduced into the frying-pan, always in the center, this will cease. As soon as a solid mass of amalgam forms in the middle of the pan, the contents must be stirred slowly, and a little more sodium added. The whole mass now crystallizes out, and if put into closely-stopped bottles it will keep without further protection for a little time. Once opened, each bottle must be used. Observe all these directions faithfully, then there will be no danger of inhaling mercurial fumes nor of being blown to atoms. After the amalgam is once made, it is safe as sugar.

In retorting amalgam never fill the flask too full, and apply the heat gradually, and always from the top of the flask downward.

The rocker is a box 40 inches long, 16 inches wide on the bottom, sloped like a cradle, and with rockers at each end.

A hopper 20 inches square and 4 inches deep, having an iron bottom perforated with $\frac{1}{2}$-inch holes, occupies the top. A light canvas-covered frame is stretched under this, forming a riffle. Riffles, and occasionally



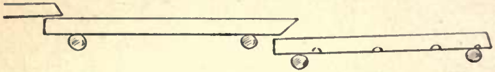
CROSS SECTION OF ROCKER.

amalgamated copper plates, are placed in the bottom. The gravel is fed into the hopper, the cradle being then rocked by one hand while water is fed by a dipper with the other.

The cradle must be placed on an inclination while being worked, and under the influence of the continued side-to-side rocking the dirt is quickly disintegrated, passes through the riddle and falls on the apron. From the apron it is conveyed to the inner end of the cradle floor, from which it flows over the riffles, or bars, and out at the mouth. The difference in level of the floor is generally about 2½ inches, but this may be varied according to the nature of the dirt treated. Large stones in the riddle or hopper must be thrown out, but smaller ones assist in breaking up the lumps of dirt. Every little while the pebbles are turned out and looked over for nuggets. Clean-ups are necessary two or three times a day. The hopper is taken off first, then the apron is slid out, and washed in a bucket or tub containing clean water, and finally the gold and amalgam are collected in an iron spoon from behind the riffle bars, and panned out. Gravel requires at least three times its own weight of water to wash it. The most convenient way is to lead the water from a stream through a pipe discharging directly over the hopper, but this is, of course, impracticable in some places. More often the water is led to a little pit on the right hand side of the operator, from which he ladles it up as required. One man can wash from one to three cubic yards daily according to the character of the dirt, but every time he stops the machine to feed it with gravel or to empty the riddle, the sand will pack, and must be removed before washing can go on. Two men can wash nearly three times as much dirt in a day as one man. But in any case, the rocker is only a primitive machine, having a capacity but one-fifth as great as that of the Long Tom, and but one-tenth that of a very poor sluice, but as it is cheap, requires but little water, and saves a high percentage of coarse gold, the rocker will continue to be used in many districts.

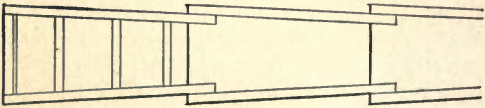
The Long Tom was invented many years ago by Georgia miners.

It is a trough 12 feet by 15 to 20 inches at the upper end, and 30 inches at the lower, and 8 inches deep. The grade is usually 1 in 12. A sheet iron plate forms the lower end of the trough. These figures refer to the



LONG TOM.

upper trough. The lower or riffle-box is 12 feet long by 3 feet wide, with a fall equal to that of the trough and a sufficient depth to keep the material and water from spilling over the sides. It should have four riffles. For this means of saving the gold, to work satisfactorily, the metal must be coarse and the water plentiful.



SLUICE BOXES.

Every sluice is an inclined channel through which flows a stream of water, carrying away all the lighter matter thrown into it, and separating it from the heavy. When the operations would not be permanent enough, or sometimes for other reasons, a ground sluice is preferred to the ordinary box sluice made of boards.

Ground sluicing requires, however, six times as much water as does a box sluice to do the same amount of work. It is simply a gutter in the bed rock, and if the bottom is hard and uneven its inequalities will arrest the gold; if not, a number of boulders too heavy to be moved by the stream are put into the sluice to act as riffles. No mercury is used. The water is turned off and the collected coarse gold washed in the pan.

Sluice boxes may be any length, from 30 to 5,000 feet. They vary in width from 1 to 5 feet, though generally 16 or 18 inches. The grade is proportioned to the fineness of the gold, varying from 8 inches to 2 feet to the 12-foot box or length. The bottom should be of 1½-inch plank, and the sides of 1-inch boards. The boxes are made 4 inches wider at the upper end than at the lower, so as to telescope.

The best method found yet for arresting fine gold is the copper plate amalgamated with mercury on its face. These plates are never used at the head of a sluice or other situation where there is much coarse gold, as they would be superfluous in such a situation, but are placed some distance down the sluice and are most efficacious in arresting the "flour," or excessively fine gold. Plates are always of copper above 1-16 inch thick, and may be 6 feet or more long, and of a width suited to the capacity of the sluice. When treated with quicksilver, they become as brittle as glass, and must be handled with care. The copper plate is first washed with a weak solution of nitric acid, and then mercury that has been treated with a weak nitric acid solution is rubbed on the plate. As this surface of quicksilver wears off, it may be replaced by a little fresh mercury. Any green slime on a plate is an evidence of copper salts in the water. It must be scraped off and the spot rubbed with fresh quicksilver. Gold attracts gold, therefore the plates should not be cleaned up too often.

Copper plates may be freed from gold by heating them over a fire and causing the quicksilver to evaporate slowly. The plates, after being cooled, are rubbed with dilute muriatic acid and covered with damp cloths for one night. They are then rubbed with a solution containing salt peter and sal ammoniac, and once more heated over some hot coals, but not allowed to get red hot. Soon the gold scale rises in blisters; the plates are then removed from the fire and scraped. Those parts of the plates that have not yielded up their gold must be re-treated and fired until they do so. All these scales of gold are then collected in a porcelain dish, the base metals are dissolved out with nitric acid, and the gold is then smelted. Corrosive sublimate should be placed in the crucible as long as any blue flame is seen to come from it.

Some mill men prefer to amalgamate their copper plates with silver amalgam, claiming that silver-coated plates save a higher percentage of gold. To amalgamate in this way take some silver bullion, or silver coin, and dissolve in weak nitric acid, only just strong enough to act upon the silver. (If you use too much nitric acid you will waste mercury and make the amalgam harder than it should be for the best results.) After crystals have formed, quicksilver must be added, heating gently meanwhile, until a thick, pasty amalgam has formed. Let this new compound stand for some hours, and squeeze through chamois as usual. The proportion of silver may be about 1 ounce to the square foot of copper to be plated.

In facing new copper plates with this amalgam, they should be washed first with dilute nitric acid; then in clear water; the ball of amalgam being rubbed over their surfaces, some little force being applied. Plates should not be used for 24 hours after coating. Porous copper plates of the best quality, and not too heavily rolled, should be used. Follow the amalgam with a swab, and rub the alloy well into the plate.

Zinc amalgam (preferable when mine water containing sulphuric acid is used in the battery) is applied to the plate after it has been cleaned with a moderately dilute mixture of sulphuric acid and water. The zinc-quicksilver ball is rubbed in and applied while the plate is still wet. Zinc amalgam is prepared as follows: Cut zinc-sheet into small pieces; wash in weak sulphuric acid; and dissolve in mercury. When the quicksilver will take no more zinc, squeeze through chamois and rub in. Zinc-coated plates should stand a week before being used. Very weak sulphuric acid will always clean these plates of any scum that may form before they have received a gold coat.

Sometimes the miner will be troubled with impure gold after retorting. If the metal is very dark this shade may come from the presence of large amounts of iron. A heavy proportion of mineral salts, such as chloride of calcium (CaCl), sodium (NaCl), and magnesium ($NgCl_2$), in the battery water sometimes accounts for this. In such cases amalgamate, retort, pulverize and roast. Then smelt with borax, the iron passing into the slag. If necessary smelt a second time, when the gold should be pure enough to dispose of. In extreme cases, the gold may weigh but one-fifth of the amalgam treated.

In districts where sufficient water for sluicing is not procurable, dry washing is resorted to. Nothing but rich, coarse gold can be worked by this method, and the dry washer rarely delves far below the surface for his gold. In the Mexican deserts the dirt is laid on raw hide, all the large pebbles picked out and the sand rubbed as fine as possible between the hands. The sand is placed in a batea and winnowed by tossing in the air, the lighter material being blown to leaward and the heavy gold falling into the batea. A form of winnowing machine has been patented, which may be driven by horse or hand-power, which is said to give satisfaction. It works by forcing a strong blast of air from a fan through a canvas screen. The inventor claims that it will do the work of three men, and work dirt for 2½ cents a cubic yard. When there is a tendency in the material to cake, dry washing is impossible.

CHAPTER VI.

CAMP LIFE.

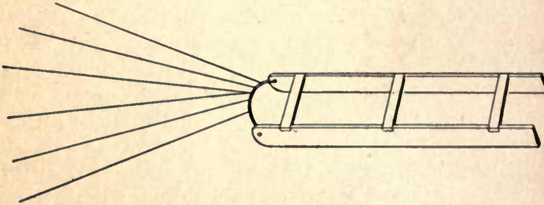
The Indian truthfully observes: "White man make heap big fire; keep far off. Indian make little fire; get close. All same." The small fire does best in the circular tepee tent, made of canvas or leather, in use on the plains. The tepee is quite an institution, but it is generally as full of smoke as a kitchen chimney, and for that reason cannot truthfully be recommended. In theory, the smoke should all pass out of the opening in the top.

By using no second skin and carefully excluding all air from around the lower rim of the tepee, it will become an admirable place to cure hams, fish, etc., by the original smoke-dried process. The Scripture declares that he that tarrieth over the wine cup has red eyes next morning, and so has he that sleeps in a smoky tepee. Properly made, however, the tepee is the thing where wood is scarce.

Some original spirits are said to have started for Dawson City, N. W. T., a few years ago with bicycles and push carts. If these means of transport had sufficed, the world would have learnt something, as heretofore a canoe and a sturdy pair of legs were supposed to help the wayfarer in that region better than anything else. That is in summer; in winter, the dog-train is the quickest mode of travel. In the western states and in British Columbia pack horses or mules do the most of the prospector's freighting, and in the far north he either carries his outfit on his back or else transports it by canoe in summer, or by dog-train after the rivers have frozen.

HUDSON'S BAY DOG SLED.

No amount of written instructions will teach a man to throw a diamond hitch, or handle a canoe in swift water. A lesson or two from an expert will, however, set his thoughts in the right direction, and in time he may become proficient. Canoeing, freighting and chopping are three things that are best begun in boy-


YUKON SLED AND HARNESS.

hood; no one ever yet became marvelously proficient in any one of them that began after reaching adult age.

Dog teams are made up of from three to six dogs; a full-sized team dragging a load of 200 pounds forty miles a day for a week at a time. In the Hudson Bay region the dogs are harnessed one behind the other, but on the Yukon each pulls by a separate trace, and the team spreads out like a fan when at work.

After Christmas the snow-shoe is generally a necessity in the north. Without "paddles" on the feet the explorer could hardly make his way through the woods, while with them on he sails along gayly, making a bee-line over frozen lake and water courses, and taking windfalls and down timber in his stride. The shoe in vogue in the forest is short and almost round, and flat, while that of the plains is very long, upturned at the toe, and narrow. There is a reason for these modifications, as the tyro will soon find out should he substitute the one for the other in the native habitat of either. But the loop by which the shoe is fastened on the foot is always the same. The string is made of moose hide; stretched, and greased before use. Caribou, or reindeer hide, makes the best filling, but horse or bull hide will do at a pinch. The frame is usually of ground ash, or some other tough, hard wood.

A camp kit of cooking utensils often begins and ends with a frying-pan and tin kettle. Certainly when traveling light, these things should be the last to go, as with them all things are possible, even to amalgamating and retorting the precious metals. The frying-pan must have a socket instead of a long handle, as the latter may be cut from a bush at any time. A low, broad kettle boils in less time than a deep, narrow one of the same cubic capacity.

All provisions should be kept in canvas bags. Matches in a leather case or safe, or in a corked bottle.

Blankets are never kicked off if sewn up at foot and side into a sleeping bag.

The existence of the prospector being passed in regions where the so-called benefits of civilization have not penetrated, he is generally a healthy, happy, hopeful man. Especially, hopeful. I do not remember ever meeting one that was not brimful of expectation and trust in the future. Possibly prospectors that have become pessimistic drop out of the ranks.

Now the man who elects to dwell with nature has only himself to thank if he does not like his lodgings. He can be comfortable or wretched, according to his knowledge of woodcraft and wilderness residence.

Whereas the tyro starts out with the avowed intention of "roughing it," the veteran is particularly careful to take matters as smoothly as he may, being well assured that in any case there will be enough inevitable discomfort in his lot to satisfy any reasonable craving. It is just the same in other walks of life; the sailor, the trapper and the soldier each learns to look after his own comfort and to seize every opportunity of making life as pleasant as possible.

The three prime wants are food, clothing and shelter, and their importance is in the order named. Now, food is something that is painfully scarce in many parts of the world, and one of the great problems of wilderness travel is to provide transport for the supplies that must be carried from civilization. A rigorous northern climate necessitates a large consumption of strong, heat-producing food, while in the tropics the explorer gets along very comfortably with rice or an occasional skinny fowl, with plantains for dessert, and plenty of boiled and filtered water. Compare such a diet with that of Nansen, the arctic explorer! He and his companion lived and waxed fat on a diet of lean bear's meat three times a day, washed down by draughts of melted snow water. Moreover, although government expeditions, provided with every canned and potted luxury the stores contain, have suffered the ravages of scurvy, these two adventurous Norwegians, living on the food their rifles had provided, did not know what sickness meant.

Other travelers have found that they fared better by copying to some extent the manner and customs of the natives. Fat seal blubber gives wonderful resisting power against cold, it is said; while a mild, unstimulating diet of rice suits the liver better under the Equator than the Bass ale and roast beef galore.

On this continent the working man found out long ago that pork and beans suits him nicely. The lumberman says: "It sticks to the ribs," by which robust, if not classical, phrase he means that he can chop longer without feeling hungry on pork and beans than on almost any other food. The laborer having found by experience that the side of a pig and a sack of beans was a good combination to have in the larder, the man of science after a couple of hundred years or so of deliberation confirms the discovery by announcing that the flesh of a swine mixed with the fruit of the bean contains all the carbo-hydrates, etc., necessary to sustain life. The moral of all this is that pork and beans must not be forgotten when outfitting. A few other things being desirable, the following list may be consulted to advantage by the prospective prospector. This list should suffice for feeding one man for 12 months:

Sugar	75 pounds.
Apples (evaporated)	50 pounds.
Salt	25 pounds.
Salt pork	212 pounds.
Pepper	1 pound.
Condensed milk	1 case.
Flour	2 barrels.
Candles	1 box.
Matches	12 boxes.
Soap	1 doz. bars.
Tea	½ case.
Beans	200 pounds.

The dictates of fashion being unheard on the mountain side, and beneath the pines, dress resolves itself into a mere question of warmth and comfort. Cut is of importance truly, but only insomuch as it allows free play to the limbs; to the arms in digging, and to the legs in climbing the stiff side of a canyon. Homespun, heavy tanned duck, corduroy or moleskin, and flannel underclothing should be the mainstays of a miner's wardrobe. Rubber boots and slickers are also necessary to his comfort, while for winter use a heavy Mackinaw overcoat, or even fur, for the extreme north, is advisable. When actually at work the miner is more often in his shirt sleeves than not, and cold indeed must the day be if an old woodsman is caught traveling through the forest with his burly form encased in furs. For arctic conditions akin to those found on the upper Yukon an outfit such as the following should be chosen:

2 heavy knitted undershirts.
2 flannel shirts.
6 pairs worsted socks.
2 pairs overstockings.
1 pair miner's boots.
1 pair gum boots.
2 pairs moccasins.
1 suit homespun.
1 horsehide jacket.
1 pair moleskin trousers.
1 broad-brimmed felt hat.
1 fur cap.
1 Mackinaw overcoat.
2 pairs flannel mitts.
1 pair fur mitts.
1 muffler.
1 suit oil slickers.
2 pairs blankets.

In cold weather the feet, fingers and face require the most care. The first should be stowed into two pairs of wool socks, and a long pair of knee-high oversocks be drawn over these. Boots must be replaced by moccasins. A pair of thick worsted mitts, and a pair of leather mitts outside, keep the hands warm enough even at 20 degrees below zero. At 50 degrees below put on an extra pair—or go home until the weather moderates.

The favorite style of architecture in the wilderness is neither Doric nor the Gothic nor yet the Renaissance. It is called the dugout. The beauty of the dugout is its extreme simplicity. A hole in the side of a dry bank, a few sods or logs for roof, and there you have it. A veteran miner goes to earth as easily as a rabbit, and, like bunny, is never at a loss for an habitation.

Next to the dugout the log cabin deserves mention, while the wattle and daub or 'dobe certainly secures third honors. The only drawback to the pre-eminence of the log cabin is that to make it you must have logs —just as the cook always insists on pigeons before she makes pigeon pie—and logs are in some districts only known as museum specimens. Now, the dugout or the 'dobe only require a gravel bank, or one of those deposits of argilite that the vulgar persist in calling clay; were it not for this fatal ease of getting, every miner and prospector would doubtless prefer living in a snug log hut, there to await in peace, comfort, and dignity the arrival of the representative of the "English syndicate" to whom he is destined to sell his claim.

Napoleon found, after fighting his way across Europe and back again, that his troops were more healthy bivouacking in the open than sheltered in tents. In truth, the tent is a very uncomfortable and unhealthy make-shift; cold, hot, and damp, by turns, and often badly ventilated. A simple lean-to shelter, and a roaring fire are infinitely preferable where wood is abundant. But it takes a lot of wood to keep a bivouac warm on a winter's night; as much perhaps as would feed a fair-sized family furnace for a month.

The trappers' fire is a most regal blaze. Two back logs; a pair of "hand junks" and a "forestick" are the foundation upon which the structure is reared, but the edifice itself often consumes a tall, full-limbed rock maple, or a stately birch between the setting of the sun and the rising of the same. There are three ways of making a fire; the first is suited for a "wooden" country; the second is used by "Lo," and other prairie travelers, where fuel is scarce.

If overtaken by storm in any wild northern region, do as the animals and Indians do under like circumstances: seek the nearest shelter and lie close until the weather has moderated. The secret is to conserve your energy, not to fritter it away fighting a power against which you may make no real headway. A shallow, brush-lined gully; the lea of a bank, or small clump of trees; these and other seemingly slight protections sometimes mean life instead of death. The experienced woodsman never leaves camp without matches in his pocket; and in winter he carries a few pieces of dry birch bark in the bosom of his hunting shirt, as he knows how vitally necessary it is on occasions to be able to kindle a blaze at very short notice.

A tent should never be pitched loosely, as no matter how fine the evening the weather ere morning may be tempestuous in the extreme, and the unpleasantness of having a tent come down about one's ears in the dark must be experienced to be realized. Also, never pitch a tent with the doorway toward the northwest in winter, because that is the quarter from which comes the cold.

In summer, from June until mid-August, the mosquito, the black fly and the midge or sand fly, make life a burden in the north. The best remedy for the mosquito and black fly is a mixture of tar and olive oil, of the consistency of cream, rubbed on all exposed parts of the person. A dark green veil will also keep the insect pests out of the eyes, mouth and ears, and in winter is better than snow goggles to avert blindness. But, unfortunately, it interferes with the enjoyment of the pipe, and hence is not in much favor with woodsmen.

To make good bread it is not necessary to take either yeast cakes or mixing pan into the wilderness An old hand thinks himself rich with a few pounds of flour in his sack, and soon has a batch of bread baking that would turn many a housewife green with envy. He proceeds in this fashion: A visit to the nearest hardwood ridge shows him a green parasitic lichen growing on the bark of the maples (lungwort). Some of this he gathers, and steeps it over night in warm water near the embers. In the morning he mixes his flour into a paste with this decoction, using the bag as a pan. The dough is next covered with a cloth and set in a warm corner to rise; a few hours later it is re-kneaded and baked. The result should be delicious bread. Some of the leaven, or raised dough, may be kept, and will suffice for the next batch of bread, and so on ad infinitum.

Making bed takes longer in camp than in the city, but the result is just as satisfactory. Nothing more comforting than a couch of fir boughs has been devised by man. Choosing a level spot the woodsman cuts several armfuls of the feathery tips of the fir balsam. These he places in layers like shingles on a roof, beginning at the foot and laying the butt of each bough toward the head. If sufficiently deep, say a couple of feet or so, such a bed will be soft and elastic for a night or two, when it will require re-laying. Fragrant it always is, with the delicious aroma of the fir balsam.

The white man stretches himself instinctively feet to the fire; the Indian just as instinctively reclines with his side to it—and his way is the most philosophical.

Strange as it may seem, the greatest danger the wanderer runs is on his return to civilization. Land surveyors, engineers, and others whose work calls them into camp for months at a stretch, dread their first night in a feather bed. They find by experience that they are lucky if they escape with nothing more serious than a heavy cold. Hot, stuffy air, and poor ventilation cause the trouble. Leaving the window wide open will almost always prevent these evil consequences, and allow the constitution to become once more tolerant of a lack of oxygen. In the wilderness, notwithstanding, wet, cold, and exposure, such ills as consumption, pneumonia, bronchitis, etc., are unheard of.

Boat building and net making are two arts that the prospector will do well to master. A few weeks passed in a building yard, and a half dozen lessons from an old fisherman will teach him all that he requires of these simple but extremely useful accomplishments.

The best food for sustaining life in the north is pemmican. It was once made out of buffalo meat, but now the flesh of the moose, or caribou, or of the deer, is substituted. The meat is cut in thin flakes and air-fried; then a mixture is made of one-third dried meat, one-third pure hunch fat, and one-third service berries (A canadensis). These are rammed by main force into a bag of green hide, and pounded until as solid as a rock. Such a solid mass of food will keep for years in a cool climate.

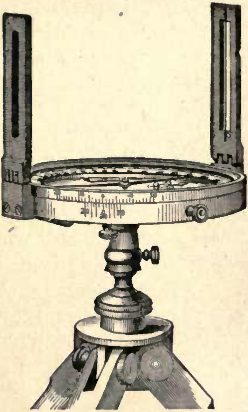
Perhaps the reader may be inclined to exclaim: "Why so much about the North; why not more about the East, South or West?" My reply to such would be: Because the great finds of the future will surely be made in the North. Dr. G. W. Dawson, the best authority on the subject, has said there are 1,000,000 square miles of virgin territory in Canada to-day, and no doubt a very large proportion of it contains mineral deposits. This 1,000,000 square miles he divides into sixteen separate areas, some half as large as Ireland, others half that of Europe, and in none of them has the footfall of a white man yet been echoed.

CHAPTER VII.

SURVEYING.

A man, to make a success of prospecting, must have what is known as "a good eye for a country." Given that faculty he will readily pick up the little knowledge of surveying that is sometimes almost indispensable. A tape measure, and a prismatic or surveying compass, are all that he is likely to require in laying off to his own satisfaction the extent of his claim, or any similar simple operation. The surveying compass has two fixed sights, and a Jacob staff mounting, into which a wooden support is inserted. The north end of the compass is always pointed ahead, while the needle, which of course indicates the magnetic north, gives the bearing of the line run toward that north. Now, magnetic north is not by any means the same thing as true north, in fact in very few localities on the earth's surface are they the same, and then never for long. In the extreme east of the United States the needle points some twenty degrees to the west of true north, and in Alaska it points thirty-five degrees to the eastward of it. There is therefore one meridian somewhere in the central valley where the true north corresponds with the magnetic north, but as the magnetic pole is always shifting this never remains true of the same meridian for long.

When there is no local magnetism from iron ores, or rocks containing magnetite, the needle is fairly reliable, though never perfectly accurate, but when such attraction exists the compass is unsatisfactory. Such areas of attraction, however, are usually limited, and by squinting back, taking what is known as a "back sight," a local attraction may be detected, and in that



SURVEYING COMPASS.

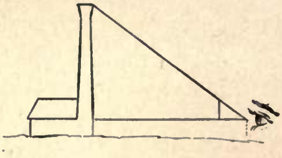
case ranging by rods must be resorted to until the compass needle once more seeks its true position. To range by rods the course of the line having been determined by retracing the route followed to the last reliable mark, a stake is driven in at that point, and the surveyor standing some little distance behind it on the correct line directs an assistant to place another rod in such a position that the first hides it from view. It will then be on a prolongation of the line, and this operation being continued the surveyor will, in due time, find himself beyond the reach of the local attraction that deflected his needle and can resume compass work.

A chain is 66 feet long. Oftentimes in mountainous or brush-covered countries a half chain of 33 feet, made of light wire links, is preferred. Two men do the chaining, which could of course be done by means of an ordinary tape measure in an emergency, the leader carrying ten pins of iron or wood, and the rear man taking one up as each chain is measured off. When all are used, ten chains ($\frac{1}{8}$ mile) have been covered. The men exchange pins and the tally man, usually the hind chainman, calls out "Tally one," and cuts a notch in a stick. Careful chaining is the essence of good surveying. The chain must always be kept horizontal, or else an allowance made for the inclination at which it was held when the measurement was taken, otherwise the results will be misleading, for all surveyors' measurements of areas are theoretically on a flat surface.

To ascertain the height of a tree, tower, etc., fold a square of paper across, and glancing along the hypothenuse (longest side) of the right angle so found, ascertain at what point your line of sight just catches the top of the object. Then its height is the same distance as the distance from where you stand to its foot, or the length of a plumb line falling from its summit, together with the height of your eye above the ground, added.

Another method is to measure the shadow of the object on a level surface, next measure your own. Then

As your shadow is to your height so is the shadow of the object to its height.

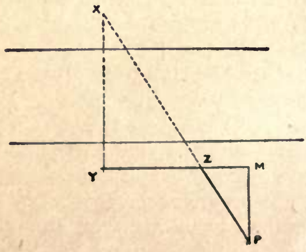


The area of a square is equal to the square of one of its sides.

The area of a triangle is equal to the base multiplied by half the height.

The areas of figures containing more than three sides may always be found by resolving such figures into a series of right angled triangles.

Very frequently the surveyor is called upon to measure an inaccessible line. There are many ways of solving such a problem, but one of the simplest is as follows:



Supposing the required distance is that from bank to bank of a river (Y-X). Then lay off the base line Y-M, driving stakes at each end; make M-P at right angles to Y-M. Sight from P to X, and drive in a stake at Z. Then:

$$ZM : MP :: ZY : YX.$$

While these simple surveying problems are easily solved, the prospector should never forget that mine surveying requires skill, experience and accuracy. He will do well always to call in the service of a mining engineer should his "prospect" ever become a full-fledged mine, as little errors of direction are particularly costly mistakes when they occur underground.

Should you wish to lay off a certain acreage as a square, proceed as follows:

As there are ten square chains to one acre, multiply the content in acres by 10 to reduce to square chains. Then find the square root of this number of square chains, and that will be the length of a side of the square required. For instance:

To lay off 25 acres as a square:

25 times 10 equals 250 square chains.

Whose square root is 15.81.

Ans. The plot must be 15 chains 81 links square.

Seventy average paces is almost exactly equal to the side of a square acre.

If you know the content and length of one of the sides of a rectangular figure it is easy to lay it off. Thus:

Given a claim 10 chains long, how wide must it be to cover 5 acres?

5 times 10 equals 50 square chains.

10 divided by 50 equals 5.

Ans. 5 chains wide.

CHAPTER VIII.

FLOATING A COMPANY.

Should the prospector discover mineral that increases in amount as the mine is opened, and shows that it is likely to prove a profitable deposit, he will have little difficulty in selling out to some wealthy syndicate. But if his mine is likely to become a big producer he should try rather to organize a company, of which he should be a shareholder—the controlling one if possible—as then the output of the mine will probably make him a rich man. It is rare that a prospector selling outright obtains anything but a fraction of the value of a good mine. Nor is it reasonable to suppose he should. When he sells, the profits of the buyers are all in the future, and may never materialize. They take all risk, and consequently insist upon a bargain.

The more money a prospector can invest in the development of a good mine the better price he is likely to get when he sells. Business men dearly like to see great masses of ore in the shafts and cuts, and are always more willing to pay a handsome price when they know something distinctly promising about the purchase.

Let the prospector, therefore, lay open his prospect as thoroughly as he can with the means at his disposal, and if he has faith—as he should have—in the mine he is selling, let him take a good big block of stock in part payment.

He must see to it, too, that sufficient working capital is provided, as there are very few mines that pay expenses from the start. Sometimes, when the shareholders are very timid, and but little money has been paid into the treasury in the first instance, they become restive after a call or two and refuse to honor further demands. This has been the ruin of many a promising venture.

Supposing, however, that this mistake has been avoided, and that sufficient funds are in the treasury to meet all likely, legitimate drains upon it, the question of officers remains a weighty one. The board of directors should be level-headed, shrewd men, with common-sense, business ideas; the secretary should understand his work; and the mining engineer placed in charge of the mine should be one whose professional knowledge is equal to the demands of the position. The secretary must have such a knowledge of the proper price of labor, and material, as to detect any extravagance on the part of the manager.

At least one member of the board of directors should understand mining. Good salaries paid to the mining engineer or manager, and to the secretary, will be money well spent, provided they are competent. Cheap men have no business in such responsible positions, where the handling and wise expenditure of large sums of money necessitate brains and special training.

As to the mine manager, he should be a miner, surveyor, metallurgist, assayer, bookkeeper and half-dozen other things rolled into one, and that one an honest man. Very low grade ore would probably pay in the hands of such a paragon of perfection—but he must be sought for long and diligently, and even then he may not be found.

New processes are to be shunned until they have proved their worth and ceased to be new. No sooner is a mine floated than all sorts of knaves and fools appear on the scene, with new and wonderful appliances for saving 99.9 per cent of all the value in the ore. Be rude to them. Drive them away with sticks and stones if necessary, but as you value your salvation do not hearken to them. Let some one else do the experimenting; when you know a process is good, the time will have come to spend money on it. There are at the present moment thousands of tons of costly machinery rusting in lonely Rocky Mountain canyons that were in their day "novelties," warranted to save all the values in the ore, while the unfortunate shareholders, whose misspent money freighted these things to their final resting place, are now, perchance, "touching" the belated Chicago or New York pedestrians for a nickel.

The only real guide to the economic value of an ore is the treatment of a large bulk of it in the mill.

Plenty of ore should be kept blocked out ahead of the workings. The more ore in sight the better for the future of the mine.

Lastly, remember that thieving sometimes takes place on rather a large scale, and be on the watch to detect it.

But there is a bright side to mining as well as a dark, and those fortunate men who paid 3, 5 or 8 cents for the stock of a mine that now sells for $7 can see it quite plainly; and there are many such. Mining is not a gamble as some would have the world believe, but a legitimate occupation, demanding great nerve and skill, and sometimes great patience, but not infrequently rewarding the possessors of these admirable attributes by wealth almost inexhaustible.

CHAPTER IX.

MEDICAL HINTS.

Miners as a rule are a healthy, hardy lot of men, but nevertheless they are occasionally taken ill, and there is very seldom a doctor near at hand. Moreover, by the very nature of their work they are particularly liable to accidents.

The so-called miner's consumption is caused by want of fresh air. The miner passes most of his life in places where there is a great deficiency of oxygen. Deep down in the mine the air is usually very bad, being full of smoke and damp, and the hut in which he sleeps is too often overcrowded, while the places in which he seeks his amusement, should he live in a mining camp, are usually little better. The remedy for this state of affairs is to get all the fresh air possible, then consumption is not to be feared.

Should poison have been swallowed, an emetic ought to be given as quickly as possible. Mustard, or salt and warm water, are tolerably efficacious, but a dose of 60 grains of ipecac is more effectual. While the emetic is acting, the patient should drink freely of warm water or warm milk.

In case of apparent drowning the body should be stripped down to the waist, rapidly dried, placed on a flat surface with the head and shoulders raised a little, and hot bricks applied to the feet. Breathing should be imitated by raising the arms above the head and turning the body on its side; turn the body back on the face and press the arms down to the side. Do this about sixteen times a minute, and keep it up half an hour if necessary.

In case of a wound which bleeds freely, a distinction must be made between blood issuing from a vein and blood issuing from an artery. In the first instance, it will be nearly black, or at least very dark; in the second, it will be bright red and spurt forth. When from a vein, bleeding must be controlled by pressure below the wound, that is, farther away from the heart, while in the case of an artery, which is always more dangerous, immediate pressure must be made above the wound on the line of the artery between the wound and the heart. A pebble rolled up in a handkerchief and tied around the limb, with the stone directly above the artery, and tightened by twisting a stick in it, is a good rough-and-ready means to stop bleeding. Sometimes a pad should be placed between the handkerchief and the artery.

Anything that excludes the air, such as wheat flour, or olive oil, or boiled linseed, or grated raw potato, is good to spread over a burn. If any considerable surface is burned the patient is in great danger, but small burns are rarely fatal, although they may be very painful. The best application of all is linseed oil and lime water.

Scurvy is a disease that is very much to be dreaded whenever fresh meat and vegetables are scarce. It is now thought to be a condition of acid-poisoning, and the remedy is alkaline salts, such as carbonate of soda or carbonate of potash. Lime juice is also an anti-scorbutic. In cold weather a diet of almost exclusively fresh fat meat will keep off scurvy.

Pneumonia is usually most fatal in crowded camps, where the men do not get a sufficient amount of pure, fresh air.

CHAPTER X.

DYNAMITE.

Dynamite should be stored in a magazine which must be dry, cool, and well ventilated. Bricks are best, but when built of wood, the frame should be covered inside and out with boards allowing the air to have free circulation between the walls, so that the inner wall may not be heated by the sun.

Do not store your caps with your dynamite.

If powder was well made, it is as good a dozen years afterwards as it was on the day it came from the mill.

Most accidents occur in thawing dynamite. Dynamite freezes between 40 and 45 degrees Far., that is, 10 degrees above the freezing point of water, and although it does not explode, if heated slowly, until 320 degrees Far. is reached, yet the quick application of dry heat may explode it at 120 degrees Far. This makes it so dangerous, for a stick of powder hot enough to explode under certain conditions may be held in the hand with little inconvenience. Powder should be thawed by placing it in a water-tight vessel and the vessel set in hot water. It should never be placed on or under a stove, or in an oven, or on a boiler wall to thaw out, as is so often done by the unthinking. Frozen dynamite is especially liable to explode from heat quickly applied. Nevertheless, reckless men will continue to blow themselves to pieces by foolhardy carelessness.

Frozen powder is unfit for use. It will burn or smoulder, and some of it may be left in the drill hole to explode when it is not wanted to.

CHAPTER XI.

ATOMIC WEIGHTS.

The atomic weight of a mineral is the proportion in which its elements are united, i. e., they represent the weights of the different atoms in the minerals. Hydrogen, being lightest, is made the unit.

Supposing it becomes desirable to find the proportional weights of the elements of any substance with a known chemical formula. Multiply the atomic weight of each element by the number of atoms of such element, and add these products together; this will give the weight of all. The proportion of each is arrived at by a simple calculation.

For instance: How much metallic silver is there in 100 pounds of Argentite, or silver glance, whose composition is Ag_2S?

Then

Ag equals 108 times 2, — 216.
S equals 32 times 1, — 32.

So that in every 248 pounds of the glance there are 216 pounds of metallic silver, and by proportion we find its percentage is 87.1.

The following tables give the symbols, atomic weights and specific gravities of certain abundant elements. Rare elements are omitted:

	Symbol.	At. Wt.	Sp. Gr.
Aluminum	Al	27.5	2.56
Antimony	Sb	122.0	6.70
Arsenic	As	75	5.70
Barium	Ba	137	4.00
Bismuth	Bi	210	9.7
Calcium	Ca	40	1.58
Carbon	C	12	3.50
Chromium	Cr	52.5	6.81
Cobalt	Co	58.8	7.70
Copper	Cu	63.5	8.96
Gold (Aurum)	Au	196.77	19.30
Hydrogen	H	1.0	0.069
Iodine	I	127.0	4.94
Iron (Ferrum)	Fe	56.0	7.79
Lead (Plumbum)	Pb	207.0	11.44
Manganese	Mn	55.0	8.1
Mercury (Hydrargyrum)	Hg	200	13.59
Nickel	Ni	58.8	8.60
Nitrogen	N	14.0	0.972
Oxygen	O	16.0	1.105
Phosphorus	P	31.0	1.83
Platinum	Pt	197.4	21.53
Potassium (Kalium)	K	39.0	0.865
Selenium	Se	79.5	4.78
Silicon	Si	28.0	2.49
Silver (Argentum)	Ag	108.0	10.05
Sodium (Natrium)	Na	23.0	0.972
Sulphur	S	32.0	2.05
Tellurium	Te	129.0	6.02
Tin (Stannum)	Sn	118.0	7.28
Zinc	Zn	65.0	7.14

CHAPTER XII.

ODDS AND ENDS.

MINER'S INCH.

A miner's inch of water varies in different States, and is, therefore, not a fixed quantity. In some States it means the quantity of water that will flow through an orifice one inch square on the bottom or side of a box under a pressure of four inches. Under these conditions a miner's inch will discharge 2259 cubic feet, or 17,648 gallons every twenty-four hours, which is at the rate of 12 gallons a minute. Fifty of these miner's inches are equal to a cubic foot of water discharged every second. One cubic foot of water a second would be sufficient to supply the wants of seven thousand city dwellers.

In calculating the amount of water required by a stamp mill it is usual to allow 72 gallons for every stamp, 120 gallons for every pan, 75 gallons for every settler, 120 gallons for every Fruevanner, 30 gallons for a concentrator, 350 gallons for a jig, and 7½ gallons for every horse-power of a boiler each hour. If the water after passing through the mill is impounded and used over again, the loss will be about 25 per cent.

LUMBER IN A LOG.

To Find: Multiply the diameter in inches at the small end by one-half the number of inches, and again multiply this product by the length of the log in feet; this product divided by 12 will give the number of feet of one-inch boards the log will make.

HORSE-POWER OF BOILERS.

For horizontal, tubular and flue boilers, divide the number of feet of heating surface by 15; this will give the horse-power. A cord of pine wood weighing 2,000 pounds is about equal to 1,000 pounds of soft coal for steam purposes. Each foot of grate should burn 20 pounds of soft coal, or 40 of wood, per hour, with a natural draught.

HORSE-POWER OF AN ENGINE.

Multiply the area of the cylinder in square inches by the average effective pressure in pounds to the square inch, deducting three pounds per square inch for friction. Multiply this remainder by the speed of the piston in feet per minute, and divide by 33,000. The quotient will be the true horse-power.

HORSE-POWER OF PELTON WHEEL.

The Pelton wheel is in high favor with California miners. When the head of water is known in feet, multiply by 0.0024147 and the product is the horse-power that one miner's inch of water will give.

ASSAYING.

The muffle furnaces of the Morgan Crucible Company of Battersea are favorably known. The most useful size is that taking a "D" Muffle, $8\frac{1}{2}$ inches by 5 inches by $3\frac{1}{4}$ inches.

A CHEAP "TESTING" OUTFIT.

Sometimes the pioneer is forced to attempt a good many investigations with very simple apparatus. Should he possess the following, he can achieve much: A spirit lamp, candle, blow-pipe, magnet, a bottle of hydrochloric acid, quart glass jar, three test tubes with corks, two feet of glass tubing (hard glass), copper wire, two square inches of tin plate, forceps and test paper. Such an outfit could certainly be bought for $1.

WEIGHT OF EARTH, SAND, GRAVEL, ETC.

A ton of shingle averages 23 cubic feet.
A ton of pit sand averages 22 cubic feet.
A ton of earth averages 21 cubic feet.
A ton of river sand averages 19 cubic feet.
A ton of coarse gravel averages 19 cubic feet.
A ton of clay averages 18 cubic feet.
A ton of marl averages 18 cubic feet.
A ton of chalk averages 14 cubic feet.

WEIGHTS OF ORES AND ROCKS.

Quartz, 162 pounds a cubic foot; silver glance, 455 pounds; ruby silver, 362; brittle silver, 386; horn silver, 345; antimony glance, 287; cinnabar, 549; copper pyrites, 262; gray copper, 280; galena, 461; zinc blende, 249; iron pyrites, 312; limestone, 174; clay, 162.

CALIFORNIA PUMP.

A very useful pump, in regions where transportation is a problem, is the California pump. It is a rough chain-pump. A box 10 inches by 3 inches, inside measurement, and 10 feet to 30 feet in length, according to requirements, forms a tube reaching from the water to be removed to the level at which it is to be discharged. In this an endless band of stout canvas or leather works, passing under a roller at the lower end, which is immersed in the water. At the higher end the belt passes around a drum worked by water, horse, or manual power. On the belt are wooden or metal projections that fit the box, forcing the water upward as the drum revolves.

HYDRAULIC DATA.

The prospector, and more especially the miner, will do well to commit the following figures to memory:

An Imperial gallon of water weighs 10 pounds.
Gallons multiplied by .1606 equals cubic feet.
Cubic feet multiplied by 6.288 equals gallons.
Gallons multiplied by 277.46 equals cubic inches.
Cubic inches multiplied by 0.003604 equals gallons.
Cubic feet multiplied by 62.8 equals pounds.
Pounds multiplied by .0166 equals cubic feet.
Gallons multiplied by 0.004464 equals tons.
Tons multiplied by 224 equals gallons.
Tons multiplied by 35.97 equals cubic feet.

A head of 10 feet gives a pressure of about 4 1-3 pounds to the square inch. Let H represent the head of water in feet, and P the pressure to the square inch. Then:

H equals P times 2.311.
P equals H times .4326.

A FIRE LUTE.

To make a fire-proof joint between the lid and body of a retort, or crucible, use the following as a lute:

Quartz sand	8 parts.
Clay (pure as possible)	2 parts.
Horse dung	1 part.

Mix and temper like mortar.

CONTENTS OF A VEIN.

To find the number of cubic feet per fathom of matter in a vein, multiply its thickness in inches by 3. Great care is requisite in estimating the ore in a vein or the amount of mineral in sight. Very clever men often make grave mistakes in such calculations.

A MAKE-SHIFT FLUX.

Rough smelting may be done with powdered white glass, though either borax or carbonate of soda is better. As soon as the gold is melted and the flux fluid and still, remove the bulk of the flux with an iron spoon, and pour the metal into a clay mould. Crush the flux for gold.

SAVING BLAST SAMPLES.

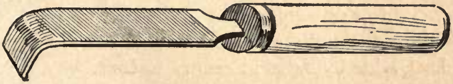
Place a quantity of spruce boughs over a hole before firing the shot, and very few stones will fly.

A SIMPLE RETORT.

Squeeze the quicksilver amalgam containing gold through a chamois skin or piece of cotton until it is as dry as you can get it. Then take a large potato, cut off one end and hollow out a piece of it large enough to receive the amalgam. Heat a shovel or a piece of sheet iron red hot, hold the potato up and press the shovel to it, covering the amalgam. As soon as the potato sticks fast to the shovel, turn it over so that the potato is on the top and place it over the fire and keep it red hot until the retorting is finished. As soon as it cools, loosen the potato with a knife, and the gold will be underneath and the quicksilver in the potato. The quicksilver may be recovered by bruising the potato to pulp in a cup with water.

CLEANING AMALGAMATED PLATES.

A very simple plan for getting the gold off an amalgamated copper plate is as follows: Take out the surface dirt for the depth of nine inches over an area a little larger than the plate to be scaled; place six bricks around the excavation as supports for the plate.



Make a brick fire, and let it burn down to red hot embers. Lay the plate on three iron bars resting on the bricks, and cover the face with strips of old blanket soaked in a strong solution of borax. Keep the blankets wet with the solution, and when the amalgam is white, remove the plate and scrape.

CALCULATING WEIGHT OF ORE.

Measure the cubic contents of the mass; multiply this by the weight of one cubic foot of the mineral.

For small masses, where no scales are at hand, fill a bucket with water, and stand it in an empty barrel. Fill the bucket brimful; introduce the rock, or ore, and measure the water it displaces. Find the number of cubic inches in the overflow by reference to the following table:

1 gallon equals 231 cubic inches.
1 quart equals 57.75 cubic inches.
1 pint equals 28.87 cubic inches.
1 gill equals 7.21 cubic inches.

Multiply the total so found by the specific gravity of the ore, and the result will be the answer sought.

Supposing the bottom of the bin to be wedge-shaped, measure half the height from the bottom to the top and multiply the number of feet by the width and length, both in feet. This will give number of cubic feet in the bin. Multiply the number of cubic feet by the weight of one cubic foot of the ore, and the result will show the number of pounds of ore the bin will hold. Divide by 2,000 to reduce to tons.

MINING REGULATIONS.

The mining regulations of every country differ, and the prospector must learn by heart the provisions of the one he works under. A claim notice written with a hard pencil or surveyor's marking lead on a soft pine board will last for years.

WEIGHTS AND MEASURES.

Troy Weight.

24 grains	1 pennyweight.
20 pwts.	1 ounce.
12 ounces	1 pound.

Long Measure.

12 inches	1 foot.
3 feet	1 yard.
2 yards	1 fathom.
16½ feet	1 rod.
4 rods	1 chain.
10 chains	1 furlong.
8 furlongs	1 mile.

Square Measure.

9 sq. feet	1 sq. yard.
30¼ sq. yds.	1 sq. rod.
40 sq. rods	1 sq. rood.
4 sq. roods	1 sq. acre.
640 sq. acres	1 sq. mile.

An acre is 209 feet square.

Land Measure.

7.92 inches	1 link.
25 links	1 rod.
4 rods	1 chain.
80 chains	1 mile.

Avoirdupois Weight.

16 drams	1 ounce.
16 ounces	1 pound.
25 pounds	1 quarter.
4 quarters	1 cwt.
20 cwt. (2,000 pounds)	1 ton.

Apothecary's Weight.

20 grains	1 scruple.
3 scruples	1 dram.
8 drams	1 ounce.
12 ounces	1 pound.

GLOSSARY.

Adamantine—Having diamond luster.

Adit—A horizontal tunnel from the surface draining a mine.

Alluvium—Deposit by streams.

Amalgamation—Combining mercury with another metal.

Analysis—A chemical search whereby the nature (qualitative) and amount (quantitative) of the components of a substance are found out.

Aqua regia—A mixture of 3 parts hydrochloric acid with 1 part strong nitric acid.

Arenaceous—Sandy.

Argentiferous—Silver-bearing.

Argillaceous—Clay-bearing.

Arrastra—A rotary and primitive mill.

Assay—A test.

Assay-ton—29.166 2-3 grammes.

Auriferous—Gold-bearing.

Bar—Obstruction in the bed of a river.

Bar-diggings—Claims in the shallows of streams.

Base Metals—Those not classed as precious.

Batea—Mexican gold-washing dish.

Battery—A set of stamps for crushing.

Bed—A seam or deposit.

Bed-rock—Solid stratum below porous material.

Bench—Old river bed; also called a terrace.

Booming—The sudden discharge of accumulated water.

Bort—Black diamond.

Calcite—Carbonate of lime.

Canon—Pronounced canyon; a gorge.

Carat—About 4 grains Troy.

Cement—Compacted gravel.

Color—A speck of gold.

Country Rock—The rock enclosing a vein.

Cradle—A mining apparatus; also called a rocker.

Cupriferous—Copper-bearing.

Decrepitate—Crackling when hot.

Development—Work done in opening a mine.

Dip—The inclination of a vein at right angles to its length.

Dolly—A primitive stamp-mill.

Drift—A horizontal gallery in a mine; or the rubbish left by the last ice age.

Drifting—Driving a tunnel.

Dump—A heap of vein stuff, etc.

Exploitation—The actual mining following exploration.

Fathom—Six feet.

Fault—A break in a vein or bed.

Float-gold—Fine grains that do not sink in the water.

Float—Veinstone or ore by which a vein is traced.

Flume—Wooden troughs carrying water.

Flux—Material added to help fusion.

Foliated—In thin layers.

Gangue—Veinstone.

Gouge—A selvage of clay between vein and country rock.

Grade—The inclination of a ditch, etc.

Grating—Perforated iron sheet, or bars with spaces.

Gravel—Broken down, rounded rock fragments.

Ground Sluice—A gutter in which gold is washed.

Iridescent—Showing the hues of the rainbow.

Litharge—Proto oxide of lead.

Long Tom—A machine for saving alluvial gold.

Marl—Clay containing lime.

Miner's Inch—An arbitrary measure of water regulated by local custom.

Mundic—Iron pyrites.

Open Cut—A surface working.

Outcrop—That part of a vein showing on the surface.

Oxidation—A chemical union with oxygen.

Oxide—Combination of a metal with oxygen.

Panning—Washing gravel, or crushed rock, in a gold-miner's pan to detect gold, etc.

Peroxide—The oxide of any substance that is richest in oxygen.

Placer—A deposit of valuable metal in gravel.

Plat—A map from an original survey.

Plumbago—Graphite or black lead.

Precipitate—Matter separated from a solution.

Pulp—Pulverized ore mixed with water.

Quarry—An open working.

Quartz—Silica.

Quartzose—Containing a large proportion of quartz.

Reduce—To turn ore into metal by taking away oxygen.

Riffle—A groove or strip to catch gold and mercury in a sluice.

Roasting—Heating in contact with air.

Shaft—A pit giving access to a vein or working.

Stratum—Bed or layer.

Striated—Marked with parallel workings.

Strip—To remove overlying material from a vein.

Sulphate—A salt containing sulphuric acid.

Sulphide—A combination of sulphur and a metal.

Sulphurets—When the miner employs this term he usually means pyrites.

Tailings—The refuse matter after ore has been crushed.

Throw—The movements of vein caused by a fault; it may be up or down.

Translucent—If light passes through a mineral, it is translucent; if you can see the details of an object through it, it is transparent.

Underlie—The same thing as dip.

Unstratified—Without stratification or bedding.

Wash Dirt—Auriferous gravel or clay.

Whim—A machine for hoisting by a revolving drum.

Winze—An interior shaft connecting the levels.

Zinc—White oxide of zinc.