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Prospector's and Miner's Manual

A Practical Reference Book for the Use of Prospectors,
Miners, Investors and Mining Men; with a
Description of the Principal Mining
Districts in Each State.

By

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Preface

There is a strong and growing demand among prospectors and miners for reliable and useful information that will assist in the search for new discoveries. The time worn maxims found in books thus far published on prospecting are considered by the prospectors as only the A. B. C. of the subject. Many prospectors know much more about the practical side of prospecting than is to be found in most books on the subject. The demand is for reliable rules for prospecting based upon experience, and for information regarding the productiveness and the distinctive features of the various known mineral producing localities.

To meet this demand rules are given whenever possible. When the rules have exceptions, these are also noted. The distinctive geological features characterizing the various mineralized districts of the West are described in every instance possible, inculcating the idea that each mineral is generally associated with certain geological formations and conditions.

Metamorphism receives more attention than in other books on prospecting, and it is hoped that the information given on this subject will prove useful, not only to the prospector, but to the miner and mine superintendent as well.

Maps of mineral localities are intended to serve a two-fold purpose—to show where the present producing mineral districts are situated, and to suggest to the prospector where he should search for new discoveries. Mineralized areas are usually elongated zones, and their direction and extent will be suggested by making a close study of these maps. Prospecting along the borders of known mineralized zones will usually be attended with success.

It is hoped that those who know of mineral localities not mentioned will write to the author in order that future editions, if any, may be made more useful.

Those who discover errors will confer a favor by informing the author.

O. H. PACKER, E. M.

San Francisco, California, May 1, 1912.

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CHAPTER I.

PROSPECTING.

1. No other calling is as profitable as that of intelligent prospecting; no other calling more fascinating or healthful, and no other more honorable or praisworthy. The reward of the prospector is not dependent upon either rain or sunshine, hard times or good. Pure gold always sells for $20.67 an ounce and the demand is unlimited. The demand for other minerals is, in almost every case, greater than the supply. We are forced to admit the profitableness of prospecting if we only observe the fact that the most prosperous countries are those that contain numerous productive mines. Of course, agriculture has almost an equal bearing upon prosperity.

2. There is, however, one peculiarity about prospecting; the profits may be nothing, or they may be thousands, or even millions of dollars, depending upon the intelligence, industry and luck of the prospector. But this uncertainty and the hope of great success lends a halo of fascination about the calling not possessed by any other business activity. Now there are those who look upon success in prospecting as a mere matter of luck. This is a great mistake, especially at the present day. Luck is, no doubt, a factor, and a large one with those who are ignorant of the important sciences of geology, mineralogy and the arts of blowpipe analysis and assaying. But the well informed man is not dependent upon luck alone. Knowledge is the key with which he expects to unlock earth's greatest storehouse. With him success is almost certain, and that, too, in a reasonable time, for minerals are everywhere. He may not find the particular minerals most desired, but being well informed he may recognize some other mineral of value.

3. At this point a word of advice is in order. Having discovered, developed and sold a good prospect, do not, like many unfortunately have done, proceed to "blow in" your money. A large book could be filled with stories of prospectors who have separated themselves from their money in a remarkably short time.

4. Furthermore, do not underestimate the value of knowledge. The old statement that "no expert geologist ever discovered a mine" is not true. Not many experts do discover mines, for the reason that they are so well paid for examining those that have been discovered that they seldom prospect. In cases where geologists have been em-

ployed to prospect, their employers have been well satisfied with the results. The Colorado Fuel and Iron Company employed a geologist for years for the express purpose of searching for coal, and with great success. The Utah Fuel Company did the same thing, and Mr. E. T. Dumble, formerly State Geologist of Texas, made such a success as a coal prospector for the Southern Pacific Company that this corporation now keeps a large force of geologists in the field continually. A number of large mining companies employ geologists, either continually or for short periods. The writer was employed one year by a large lumber company to prospect its land after the timber had been removed, and before selling the land for agricultural purposes. Certain corporations have secured large areas of what is now known to be some of the best oil lands in California. The geologists who selected these lands for these corporations certainly did not see through one thousand feet of earth, yet they knew oil land from worthless desert. As a rule, the prospector who scorns geology and thinks it all depends upon luck alone, grows gray headed before he meets with success; while the young prospector who has eagerly absorbed all knowledge within reach, strikes it rich the first or second season out.

5. A prospector is naturally hopeful and industrious, and is skilled in the use of mining and prospecting tools. He is accustomed to roughing it, and has a rugged constitution. If to this equipment he will add a proper amount of scientific knowledge he will be even better fitted for prospecting than the average geologist, who, often times, lacks endurance and lacks the greatest of all incentives for hard work, undaunted hope.

PRELIMINARY INFORMATION.

Use and Care of Mining Tools.

6. The young man who expects to follow prospecting must become skilled in the use and care of prospector's tools. If he is a miner he will likely be familiar with all manner of mining and prospecting tools, for most prospectors have mined more or less. If he is not accustomed to miners' tools he should work for a time in a mine, and also act as blacksmith's helper.

7. For prospecting, a light, strong hand-pick will be required. Those of good steel with an iron braced handle are excellent. It should be kept sharp and properly tempered. If too hard, the point may break off, or a glancing blow may cause a speck of steel to fly into the eye. For most purposes the temper should be the same as for drill steel for the same rock. Striking hammers will also be

required. Heavy striking hammers are not necessary, in fact, swift, well directed blows with a medium sized hammer will be much more effective. More depends upon the way the drill is turned than is commonly supposed. The cutting edge of the bit should be pressed firmly against the bottom of the hole when the blow is given. A small amount of loose material between the bit and the bottom of the hole will cushion the blow. Use water freely, and clean out the hole often. A light drill with an upset, heavy, cutting end will not take up the force of the blow as will a heavy piece of drill steel. Striking hammers should be used for nothing else, and drill heads should be ground free from burrs.

8. In sharpening drills do not draw out the steel any more than absolutely necessary. Strike almost an "upset" blow. This will cause the grain of the steel to run across the bit, making a better lasting and wearing tool. Heat the drills as seldom as possible, and never raise them to a welding heat. A plunge temper is best, the degree of hardness being regulated by the heat of the drill when plunged into the water. Pulling a bit in and out of the water is apt to check it. If drills are tempered by standing them on end in a tub of shallow water, agitate the water so that the hard steel tip will gradually shade off into the soft steel above.

9. Shoeing hammers and shoeing outfit will be necessary if pack animals are taken along. All heavy material may be left at a central camp.

Mining Methods.

10. The method of exploiting or working a mine is a great factor in the economy of mining. Often a poorly planned and improperly executed method of attack or procedure results in failure, when a different plan would have succeeded. For example, in most mines pumping from the bottom level could be avoided, and a consequent saving made if the water were not permitted to run down the shaft and winzes. Many mines, commonly supposed to be receiving an influx of water from every level, have actually reached a depth below the water zone, and the lower levels would be dry if water were not permitted to percolate from above. By constructing a small pit, and placing a pump on each level near the shaft, piping the water across all winzes and also across or around the main shaft, using waterproof cement or concrete for setting these pipes, nearly all the seepage water can be confined to the levels producing it. There are many other cases where improved methods would result in a material saving.

11. In planning the development work for a metal or coal mine two methods suggest themselves at once. First, initial expense

for a large hoisting plant may be avoided by beginning at the surface, taking out all, or nearly all, ore as depth is gained. This works well for a short time, but when considerable depth has been reached the fissure will begin to close, or the walls will cave, and no amount of timber will save the situation. Rains will flood the workings and the deeper we go the greater will be the expense of mining. This plan is, therefore, impractical except for quarries. Second, the ideal way would be to sink a double or four compartment shaft to the very lowest depth that the mine is expected to be worked, running drifts every one hundred feet. Then overhead stope from the lowest level. then from next to the lowest, leaving all waste ore in the level below, which is robbed of much of the timber. By this plan there will be no necessity for making changes in the hoisting plant, as all the conditions are known, and the expense of mining will be less and less as stoping progresses. Another advantage is, that the owner knows exactly how much ore is in the mine, everything being blocked out. But, unfortunately, this plan is absolutely out of the question, for no mine owner would care to incur the necessary expense for the plant and development work required before any dividends had been declared. Our only recourse, then, is the "happy mean." That is, sink the working shaft as deep as a reasonable expenditure will permit, considering local conditions, such as the usual depth of mines in the vicinity and the zone of secondary enrichment, and then run drifts and prepare for overhead stoping, beginning at the bottom level. As soon as the mine is paying dividends the main shafts can be sunk deeper, and levels run as desired. This, really, is the proper way to develop a mine. Of course the prospector should begin differently. For example, in the case of a vein dipping 50 to 70 degrees, the prospector should invariably sink an inclined shaft on the vein, even rising and falling as the dip may change, till he has demonstrated that he has a mine [978, 979]. Then he can enlist capital on terms favorable to himself for the purpose of sinking a vertical, two-compartment shaft at a considerable distance from the outcrop to intersect the vein at depth, as a vertical shaft can be kept in order more easily, and hoisting can be done much more rapidly than with an incline. The well-to-do prospector can exploit his mine by the use of a core drill. This can be purchased as low as $250, but the diamonds for cutting cost a small fortune, and may be broken or lost. There are several core drills using chilled steel fragments that will work well and cost about the same as a diamond core drill without the diamonds. The cost of drilling is about $1 per foot in either case.

12. The timbers for a one-compartment shaft are shown in Fig. 1. This is the proper sized shaft for a prospect. These timbers may be square, as shown at A, B, C and D, or the horizontal

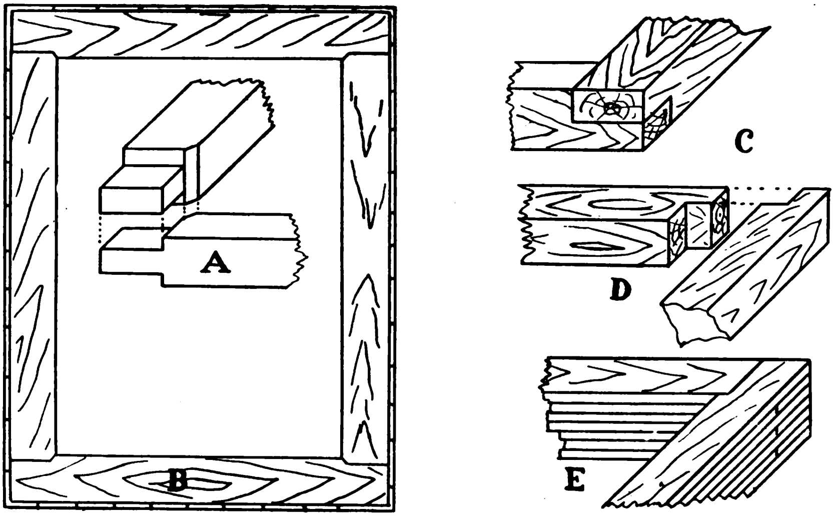


Fig. 1. Methods of Framing Timbers for a One-Compartment Shaft.

A. Bevel Hitch. C. Box Shoulder.
D. Halved Joint. E. Plank Boxed Joint.

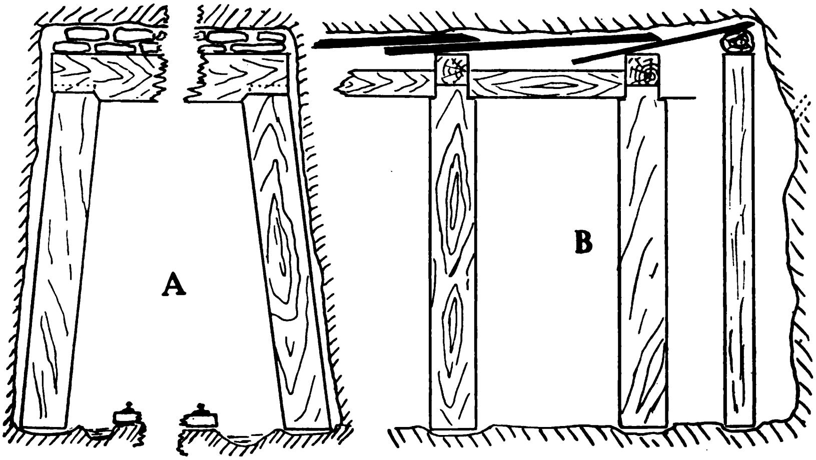


Fig. 2. Timbers for a Tunnel.

A. End View. B. Side View.

width may exceed the height where great strength is required, or plank may be used, as shown at E. Close cribbing, built something like a log cabin, as shown, should be used in a shaft from the surface down to solid ground, then open cribbing should be continued for 5 to 15 feet to the point where regular sets begin. The practice of using regular sets at the surface with boards behind to hold the ground is to be severely condemned, as these boards soon decay and the shaft caves in. Similarly, in beginning a tunnel the timbering should be continued far enough underground to insure permanency. Many a prospector has taken a likely buyer to see his prospect, only to find the shaft or tunnel caved at the mouth just beyond the timbering, making the workings inaccessible. In most cases observed by the writer two or three additional sets would have saved the tunnel or shaft. Peeled timbers last longer than unpeeled. At this point it is well to emphasize the value of creosoting mine timbers to prevent decay. As a rule the average life of untreated mine timber is three years. Treated timbers will last on an average thirteen years. Creosote may be applied with a brush, or by immersion in the open, or in the closed pressure tank. With a brush the cost is about two cents per cubic foot of timber treated. By the open tank method the cost is eleven cents per cubic foot, but the tank treatment is the cheaper nevertheless, owing to superior results obtained. Properly done, the open tank method is as follows: The timbers are heated to a temperature of 212 to 220 degrees F., in creosote to expel the sap, and then allowed to cool to absorb the creosote. The pressure method is expensive, but very effective, a vacuum being created to expel the moisture, and then the creosote or zinc chloride forced to the very heart of the wood by pressure.

13. A set of timbers properly cut and set for a tunnel is shown in Fig. 2. A station set for an inclined vein is illustrated in Fig. 3. In such a case the drift is turned into the hanging in order to dump the ore into the car. Methods of timbering prospect drifts in inclined veins are shown in Fig. 4. Various methods of placing stulls are shown in Fig. 5. D and E are good, F is likely to get out of position. A stull, in any case, should not be exactly perpendicular to the walls, but the free end should be slightly higher than the other in order that it may be kept in place by the weight of the rock upon it. The details of square sets for stopes are shown in Fig. 6. When the greatest pressure comes from the top the posts are framed with the tennons "y" long enough to meet each other. When the side pressure is greatest the tennons "x" are made long enough to meet. This feature is well shown at A.

14. In many cases where ore shoots are kept full of ore the gate is often difficult to open and close. By making a bend in the

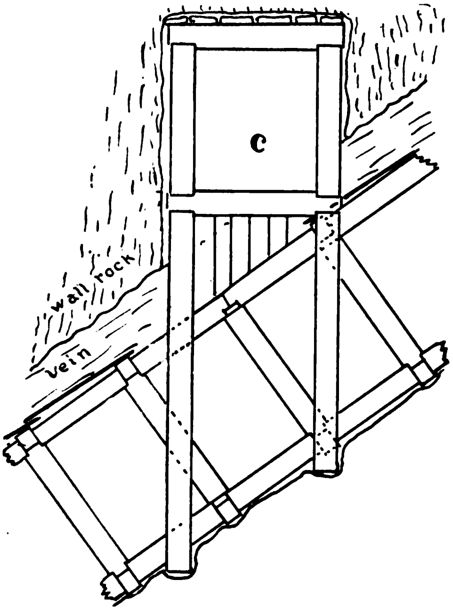


Fig. 3. Timbers for a Station for an Inclined Vein.

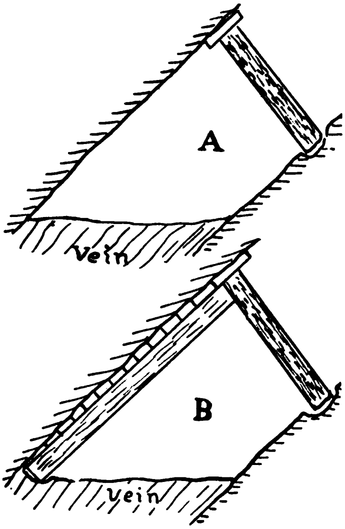


Fig. 4. Methods of Timbering a Prospect Drift.

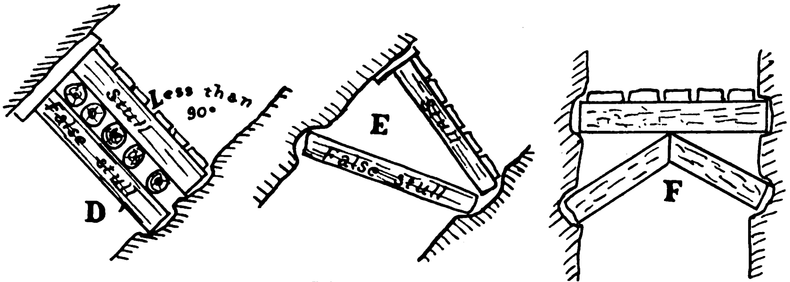


Fig. 5. Stulls.

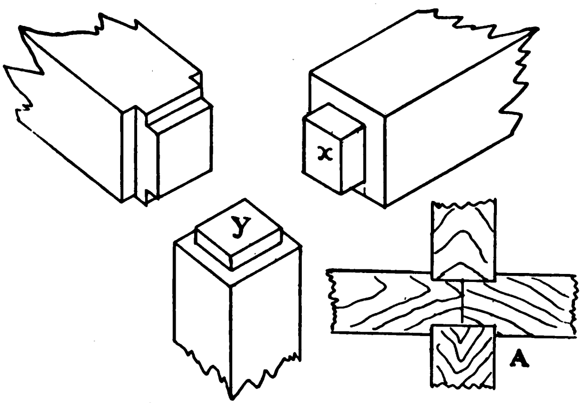


Fig. 6. Details of a Square Set.

shoot, this difficulty can be avoided. This plan is better than making the entire shoot on an incline, for the reason that an inclined shoot may choke up at any point and tempt a workman to get into the shoot to start the lodged ore, with possibly fatal results. If made as described a crowbar can be used, as the only place the ore can choke is near the shoot gate.

15. The proper ventilation of prospect shafts and tunnels should not be neglected. Not only is the health of the prospector affected by poor air, but his ability to work is seriously impaired. A shaft from 100 to 200 feet deep, or a tunnel twice that length, can be ventilated by means of a large canvas sail supported by a spar and a mast, and turned to face the wind as may be required. Guy ropes should be used to keep it in position. The lower part of the canvas sail should be funnel-shaped and secured to a hoop, which, in turn, is temporarily attached to the ventilation pipe.

16. Suction centrifugal fans similar to those used by the blacksmith but reverse in action, are much more efficient than commonly supposed for ventilation purposes. They may be operated by hand with satisfactory results for tunnels 500 feet or less in length. The advantage of the suction fan over a blower is that the men may return to work almost immediately after a blast, provided the air is started at once after blasting, as the suction draws the foul air out through the pipe instead of its being forced the entire length of the tunnel, as would be the case with a blower. Evidently, the removal of only a few cubic yards of air from the face will be all that is necessary. There are many places where a small wood stove, arranged in a suitable ventilation drum, connected with the ventilation pipe, will keep up a flow of air to the face of a distant cross-cut or drift.

Power.

17. MAN-POWER.—The mean effective force of a workman is one-seventh of an indicated horse-power, or one-fifth that of the average horse.

18. HORSE-POWER.—The term "horse-power" is used to measure the rate of work. It is equivalent to raising 33,000 pounds one foot high in one minute, and is called the "indicated horse-power." It is greater than a horse can endure, except for six or eight hours at a time. Compared with steam or other engines that can be used continuously, a horse will, in a year, perform only about one-fourth as much work as a one-horse-power engine. Unless otherwise specified a horse-power is understood to be an indicated horse-power. To calculate horse-power use the following formula in which $P =$ weight raised in pounds, $F =$ height in feet, and $M =$ time in minutes.

$$\text{Horse-power} = \frac{P \times F}{33000 \times M}$$

The actual horse-power, working eight hours, of a
Horse = 2/3 of an indicated horse-power.
Ox = 1/2 of an indicated horse-power.
Mule = 1/3 of an indicated horse-power.
Donkey = 1/6 of an indicated horse-power.
Man = 1/7 of an indicated horse-power.

For further information see sections 1090 to 1096, inclusive.

Water-power is thoroughly discussed in sections 1135 to 1144, inclusive.

19. Coal.—One pound of coal should evaporate 12.2 pounds of water into steam. (Theoretically 15.28 pounds). This is with a first class boiler under most favorable conditions. It is an efficiency of 80 per cent.

20. Wood.—About two and a quarter pounds of dry wood is equivalent to one pound of soft coal. Weight alone considered, all woods are about equal in heating power.

21. Water Required.—A boiler requires seven and a half gallons per horse-power per hour. Each stamp requires 8 to 10 cubic feet, or 60 to 80 gallons per hour. Each amalgamation pan requires 100 to 140 gallons per hour. Each settler requires 60 to 100 gallons per hour. Each Frue or other belt concentrator requires 200 to 300 gallons per hour. The average amount of water required per ton of ore treated in a gold mill is 700 gallons for all purposes. For measuring water see sections 1122 to 1134.

22. Horse-power for Hoisting.

Wgt. of ore, car, cage and rope.	Speed in feet per minutes. (Efficiency 80%.)										
	25	50	100	150	200	250	300	350	400	450	500
1000	7/8	1	3	5½	7½	9	11	13	14½	16¼	18
1200	1	2¼	4¼	6½	8¾	11	13	15	17½	19½	22
1500	1½	2¾	5½	8¼	11	14	16½	17	22	24½	27¼
1800	1¾	3¼	6½	9¾	13	16¼	19½	22¾	26	29¼	32½
2000	1⅞	3¾	7½	11	14½	18	22	26	29	32½	36
2200	2	4	8	12	16	20	24	28	32	36	40
2500	2¼	4½	9	13½	18	22½	27	31½	36	40½	45
2800	2½	5	10	15	20	25	30	35	40	45	50
3000	2⅛	5¾	11½	17¼	23	28¾	34½	40¼	46	51¾	57½
3200	3	6	12	18	24	30	36	42	48	54	60
3500	3¼	6¼	12½	18¾	25	31¼	37½	43¾	50	56¼	62½
3800	3½	7	14	21	28	35	42	49	56	63	70
4000	3¾	7¼	14½	21¾	29	36¼	43½	50¾	58	65¼	72½

23. HORSE-POWER FOR MILLS.

(Efficiency, 80 per cent.)

7 x 9 Blake Crusher	4 to 6 horse-power.
8 x 12 Blake Crusher	5 to 7 horse-power.
9 x 15 Blake Crusher	8 to 10 horse-power.
6 x 6 Dodge Crusher	3 to 5 horse-power.
7 x 8 Dodge Crusher	5 to 7 horse-power.
8 x 12 Dodge Crusher	7 to 10 horse-power.
Each 850-lb. stamp, dropping 6 ins., 100 times per min.	1.60 horse-power.
Each 1000-lb. stamp, dropping 6 ins., 100 times per min.	1.90 horse-power.
Each Frue or other rubber belt concentrator—	.50 horse-power.
Each ore feeder, belt driven	0.25 horse-power.
Each amalgamation pan in a silver mill—	5 to 10 horse-power.
Each settler in a silver mill	2.50 horse-power.

24. HORSE-POWER FOR AIR.

To find the horse-power required for ventilation fans multiply the cubic feet of air required per minute by the pressure in pounds per square inch, and this product by .0144.

$$V \times P \times .0144 = H.\ P.$$

Methods of Ore Treatment.

25. The prospector should know something of the methods of ore treatment, otherwise he might locate a claim and expend much money and valuable time upon it only to learn later that the ore cannot be profitably worked. The cost of power, freight, fuel, labor, water, etc., must be considered in every case, and the mineral composition of the ore correctly determined.

26. The following brief and general outline of methods of ore treatment will enable the prospector to form some idea of the cost of treating his ore.

Ore.—Free gold in a quartz gangue. Fairly rich.

Treatment.—Crush with stamps. Amalgamate on plates. Each stamp will crush about four tons each 24 hours.

Ore.—Free gold in a quartz or mixed gangue. Low values, fine gold.

Treatment.—Crush with stamp and cyanide the entire battery product by percolation. If the ore slimes badly, grind in a tube mill and cyanide by agitation. Use a gravity, vacuum, or pressure filter. Each stamp will crush about four tons each 24 hours. For fine crushing the output will be less.

Ore.—Free gold and iron pyrites in a quartz, or mixed gangue. Both coarse and fine gold.

Treatment.—Crush with stamps, amalgamate on plates and then concentrate. Ship the concentrates to a smelter, or treat them with chlorin gas after roasting. In some cases the concentrates may be cyanided without roasting. In other cases the tailings may be run through a canvas plant with profit. Each stamp will crush from two to three tons per stamp each 24 hours.

Ore.—No free gold. Iron pyrites containing gold.

Treatment.—Crush with stamps and cyanide by percolation or by sliming. Or, use concentration only and treat the concentrates by the chlorin gas method. Each stamp will crush one to two tons per stamp each 24 hours. Use a high drop and low discharge.

Ore.—Free silver, or silver chlorid.

Treatment.—Crush with stamps and amalgamate by pan amalgamation. Each stamp will crush two to four tons per 24 hours.

Ore.—Free silver with silver chlorid and silver sulfid.

Treatment.—Crush with stamps. Grind in a pan with blue vitrol and salt, and then treat by pan amalgamation. If the ore is rich enough it may be roasted with salt and then treated by pan amalgamation. Capacity of stamps as above. Or use the cyanide process.

Ore.—Silver sulfid only.

Treatment.—Crush with stamps and treat by lixiviation with sodium hyposulfite. Or, roast with salt and then crush and treat by pan amalgamation. Capacity of mill, about two tons per stamp, depending upon the required fineness of the product. The cyanide process is now extensively used for such ores.

Ore.—Galena. (Galena usually contains silver.)

Treatment.—Crush coarse with a rock crusher and rolls (no stamps). Size with screens and concentrate in jigs. The tailings from the jigs are usually crushed, sized and again concentrated. A final concentration is often made with buddles (round tables), or vanners. The concentrates are smelted and the silver, which is now in the pig lead, is separated by cupellation. There is no established basis for duty of rock crushers or rolls.

Ore.—Native copper, any kind of gangue.

Treatment.—Crush with stamps and concentrate with jigs or bumping tables. Smelt into copper bars. The capacity of the mill depends upon the required fineness of the product.

Ore.—Copper sulfid ores. (Chalcocite, bornite, etc.)

Treatment.—Crush with stamps or rolls and then concentrate with jigs or (and) vanners. Ship the concentrates to a smelter. Capacity four to six tons per stamp, depending upon the required fineness of the product.

Ore.—Copper carbonate. (Malachite, green; or azurite, blue.)

Treatment.—The ore may be hand sorted and shipped to a smelter if rich enough to bear this expense. Or, it may be crushed with rolls or stamps and treated with water containing a small amount of sulfuric acid, running the solution through sluice boxes containing old scrap iron, wrought iron, scrap tin, etc. The iron will precipitate the copper, which may be washed off at regular intervals and melted into bullion.

Ore.—Iron ores, such as hematite, limonite, magnetite and siderite.

Treatment.—Ship to an iron smelter. Iron ores cannot be successfully worked without cheap fuel. For this reason many good iron deposits in the western part of the United States can not be worked at the present time. Electric smelting or cheaper coal may remedy this disadvantage in the near future.

Ore.—Rare elements.

Treatment.—Hand sorting and shipment to market. Most of the ores of the rare elements must be treated by special processes which necessitate their shipment to New York or San Francisco.

27. A GOLD MILL.—Stamp mills are almost universally used for gold and silver ores and in some rare cases for other ores. A gold mill may be briefly described as follows: The building is usually of wood, but steel frames are slowly coming into use. Large rock crushers are employed to reduce the ore to a size suitable for the stamps which follow. The stamps may be arranged in batteries of two, three or five. Single stamps are also used. Two-stamp batteries are usually single discharge, and single-stamp batteries are usually triple discharge. The cams will be made so as to produce a low or high drop, depending upon the ore. The baser the ore the higher the drop required. Copper plates may be used inside the mortar box at either the back, ends, or on the chock block, or at all three places, depending upon the nature of the gold in the ore.

28. Amalgamation plates follow the stamps in a mill working a free, or nearly free, gold ore. These plates are either plain copper or silver plated. The latter is not always best, some ores being most successfully worked upon plain copper plates.

29. As a rule, free gold ores require a low drop and a low discharge. Base ores require a high drop and a high discharge. Thus a free gold ore might possibly be worked to best advantage with a 7-inch drop and a 3 to 4-inch discharge, while a very base ore might require a 14-inch drop and a 7 or 8-inch discharge. Success often depends upon the selection of a properly designed stamp battery.

30. Concentrators usually follow the plates when there is a sufficient amount of base mineral present to warrant their use.

Here again good judgment and experience is required in making a selection, for the styles of concentrators upon the market are almost innumerable. Concentrators may be described as fine or coarse, with gradations from one extreme to the other. Machines for coarse concentration make long vigorous strokes, while those for fine materials make short gentle strokes. An extreme style of a coarse concentrator is the jig, the bumping table following as a close second. An extreme style of a fine concentrator is the hydraulic slime separator (motionless), the Frue vanner being a close second.

31. The average cost of a free gold stamp mill in the United States, complete and ready to run, is from $500 to $1,000 per stamp, depending upon local conditions and the size of the mill. This cost is made up of the following items: Mining machinery, including grizzley, rock breaker, ore bin and gates, ore feeder, stamp battery complete, mortars, shafting, belts, pulleys, boiler and engine, etc. Weight complete, about 8,000 pounds per stamp.. 77.0 per cent.

Lumber	9.0 per cent.
Labor, carpenters, etc	9.0 per cent.
Labor, machinists, etc	2.3 per cent.
Shingles	1.3 per cent.
Hardware	1.0 per cent.
Windows, etc.	.4 per cent.
Total	100.0 per cent.

32. A SILVER MILL.—Although a silver mill often contains machinery that appears to be like that used in a gold mill, the fact is that the rock crusher is usually the only piece of machinery that could be used indiscriminately with success in either case. The mortars for a gold mill are, or should be, of a different design from those used in a silver mill, the latter being without inside amalgamation plates. Instead of amalgamation plates the silver mill contains amalgamation pans.

33. Generally the machinery in a silver mill consists of a rock crusher followed by the stamps, working either dry or wet. The stamps are followed by amalgamation pans when the ore is free milling, or nearly so. The pans are followed by settlers. Concentrators follow if there is sufficient base mineral of value in the ore to warrant their use.

34. When the ore is base the expensive process of roasting, or either the lixiviation or cyanide process must be employed. Roasting furnaces sometimes follow the rock crusher, or the dry-crushing-stamps, but more often the pulp from the stamps is settled, dried and roasted, salt being usually mixed with it. The object of the salt is to convert the sulfid of silver and the other

sulfids to chlorids, as silver sulfid will not amalgamate. When only a small amount of silver sulfid is present, roasting is dispensed with and the pulp from the battery is ground in a grinding pan with salt and "blue stone" to convert the silver sulfid into a chlorid. If the sulfids are abundant roasting must be resorted to.

35. Some silver sulfid ores are simply crushed, stamped, and then leached with "hyposulfite" (sodium thiosulfate), and the dissolved silver precipitated with sodium sulfid. This is a cheap process, but requires an experienced chemist to manage it.

36. Before a silver mill is built, extensive and unavoidably expensive trial tests should be made. Mine owners will find large testing plants in all of the large western cities for this purpose. Ores of all kinds are tested in these plants.

37. The "Boss Continuous Process" is a money saving method for treating free silver ores. In ordinary cases the pulp is ground in the pans and then the mercury added, and after further agitation the pulp is run into the settlers and a fresh charge is run into the pans. In the "Boss Continuous Process" the pulp runs continuously through the entire set of grinding pans, amalgamation pans, and settlers. This continuous circulation is brought about by a slight modification in the design of the pans and settlers.

38. A silver mill costs about $1,000 to $1,500 per stamp, complete and ready to run.

39. THE CYANIDE METHOD.—A great many low grade gold and silver ores, and base silver ores of all grades, are successfully worked by the use of potassium cyanide solutions to dissolve the gold and silver from the rock. In many cases mill tailings are profitably treated by this method.

40. A cyanide plant consists essentially of a crushing outfit, solution tanks, zinc boxes, vacuum or other style of filter, and suitable pumping machinery. The crushing is usually done with rock crushers and rolls, stamps not always being necessary. The degree of fineness to which an ore must be reduced is a matter to be determined by actual trial. Tests should be made on as large a scale as possible, especially those by percolation. Some ore may be successfully treated when crushed no finer than three mesh, while other ores must be reduced to slimes. The crushing machinery to be considered before making a final selection follows: Rock breakers, rolls, stamps, Huntington mills, Chilian mills, ball mills, and tube mills. Tube mills are generally used for sliming ores, but they may be used for any kind of grinding, being very efficient for this purpose.

41. Many ores require roasting before cyaniding. Some ores must be given a "dead roast" and others a slight roast. Tests alone will determine the point.

42. A few years ago slimes were greatly dreaded and every effort made to prevent sliming, because the slime required days to completely settle, and the solution could not be run through the zinc boxes till it became clear. Now ores are purposely slimed, stamps and tube mills being used for this purpose, and the slime run into a quick-filter tank, and the clear filtrate run through the zinc boxes. These filters are of various designs, some requiring a vacuum pump, while others work by gravity. The filtering is done by means of cocoa matting secured between two canvas sheets. A whole tank full of cyanide solution passes through this filter as clear as fresh water in a few hours. Continuous filter devices are coming into use at present. The gold-cyanide solutions are run through zinc shavings to precipitate the gold as usual. Zinc boxes exclusively were formerly used for this purpose, but zinc buckets, or similar individual receptacles, are now in favor.

43. A Lead Mill.—A silver-lead mill consists of crushers and coarse concentrating machinery such as jigs and bumping tables. Almost always a system of crushing rolls, alternating with jig concentrators and sizing screens, is used, the fine material from the last jig being then concentrated upon vanners or buddles, or both. The concentrates are sent to a smelter for reduction. If the pig lead contains silver, as it almost invariably does, the latter is separated from the lead by cupellation or by the zinc process, litharge being produced by the cupellation. No general estimate of the cost of a lead concentrating plant can be made, as the machinery required varies greatly.

44. Smelting.—In any case where smelting is contemplated the question of fluxes and fuel is all important and must be given due consideration.

45. Very few ores are self-fluxing. In nearly all cases two or more different ores must be mixed in order to make a charge that may be smelted economically. Different mixtures require different amounts of fuel to effect a separation of metal from the slag, and the mixtures are made with a view to reduce the fuel consumption.

46. Base gangues, as limestone alone, can not be melted in any furnace at any heat. Pure quartz alone can not be melted in any ordinary furnace, but pulverized lime and quartz, if mixed in the proper proportions, will melt at a temperature easily attained in any furnace. The underlying principle is that base and acid ores assist each other in melting. It appears that certain elements have what may be termed likes and dislikes, and these likes and dislikes, or chemical affinities, as the chemist would call them, must be taken into consideration. Consequently, before making plans, send your ore to a chemist, or better, to some metallurgical works, to be tested, in order that you may know the cost of treatment.

47. There are two principal methods of smelting for the precious metals—lead smelting and copper smelting. [Bismuth smelting and a few other unimportant kinds might be mentioned.]

48. The object of smelting is to separate the valuable metals from the worthless gangue. The precious metals can not be separated from their gangue if smelted in the absence of lead, copper or other base metal, for the reason that gold and silver will, under such circumstances, go into the slag. Some base metal, such as mentioned, must be present to dissolve the precious metals and hold them securely. If not already present, either lead or copper ore is always mixed with gold or silver ores before smelting.

49. Smelting is accomplished in either blast or reverboratory furnaces. The blast furnace is a vertical shaft with a crucible at the bottom. The ore, fuel and fluxes are charged into the shaft alternately and a forced draft or blast of air is used to intensify the heat. In iron blast furnaces hot air is usually used. All blast furnaces are water jacketed. Reverboratory furnaces are made of brick as a rule, and are sometimes water jacketed. While only coke, coal or charcoal may be used in a blast furnace, coke, coal, charcoal, wood or crude oil may be used in a reverboratory furnace, the heat passing through the ore in a blast furnace and over it in a reverboratory.

50. The product of a lead furnace is lead bullion, from which the precious metals may be separated by cupellation, the lead being converted into litharge, as previously mentioned, and marketed as such. By another process the gold-silver-lead bullion is treated by first roasting in a small reverboratory to oxidize it and drive off the arsenic, sulfur, etc. It is then run into desilverizing kettles, where zinc is added. The zinc takes all the gold and silver from the lead. and as the molten mass slowly cools, the zinc crystalizes out first. together with the gold and silver (and a small amount of lead) and is skimmed off with suitable ladles, to be treated later by the distillation of the zinc and the cupellation of the lead. Gold and silver being obtained together. are separated from each other later by an acid or electric method.

51. The product of a copper furnace is copper matte, which consists of approximately 50 per cent. copper, 20 per cent. sulfur, and 30 per cent. of other sulfids, such as iron, etc.

52. If no precious metals are present, copper matte is first "converted" or "bessemerized" by heating it till molten and then air is forced through it to oxidize or burn out the sulfur, iron and other impurities. The copper is still further refined, either in reverboratory refining furnaces or by electrolysis. When copper matte contains precious metals it must be "converted" as before, and then

refined by electrolysis, a process which leaves the precious metals at one electric pole and the copper at the other. By another process it is dissolved in sulfuric acid, and then lead sheets are hung in the solution till the copper sulfate (blue stone) crystalizes upon them. The residue, a mud or slime in the bottom of the vat, contains the gold and silver, which are separated from each other later by chemical means.

53. No smelting operations should be undertaken without the advice and employment of a competent metallurgist. It is marvelous how much the ordinary mining man does not know about smelting.

54. ROASTING.—Many ores are roasted as a preparation for further treatment. Sulfides containing gold are roasted before they are subjected to chlorin gas, and often before cyaniding. Silver sulfid ores are often roasted; usually with salt, before amalgamation.

55. There are three kinds of roasting: Oxidizing roasting, where the metals are converted into oxids; chloridizing roasting, where the metals, or some of them, are converted into chlorids, and sulfate roasting, where the metals in the ores and mattes are converted into soluble sulfates as a preparation for extraction by leaching with water.

56. Roasting may be accomplished by hand-stirred, reverboratory furnaces; mechanically-stirred reverboratory furnaces, or in revolving-roasting furnaces.

57. A CONCENTRATION PLANT.—Any base ore may be treated in a concentration plant and the concentrated minerals shipped to a smelter, provided it is rich enough to warrant the expense. If the metal sought can be more cheaply obtained by some other process concentration should not be resorted to.

58. The machinery to be used in a concentration plant depends upon the nature of the ore. The principles involved are three: First, mineral particles of high specific gravity will settle in water more quickly than those of the same size of low specific gravity; second, the rates of settling of particles of different sizes are inversely proportional to the square of the diameter of the particles. That is, a particle of twice the diameter of another but of the same specific gravity, will take four times as long to settle; third, if particles be first separated into sizes, the precipitation by gravity in water, of the heavy from the light material, will be more quickly and more perfectly done. It is understood that slimes do not settle in accordance with the above rules.

59. The sizing may be done by means of horizontal or revolving screens, or by hydraulic sizers.

60. Concentration is effected by means of jigs, bumping tables,

buddles (round tables), traveling rubber belts (vanners), centrifugal classifiers, canvas or blanket tables, etc.

61. Not only the kind of ore, but also its character, determines the particular class of machinery which will most cheaply and perfectly concentrate it.

62. Mills and Plants in General.—In times past the manufacturers of mining and milling machinery freely advised purchasers regarding the class of machinery most suitable for specific purposes, even going so far as to furnish the plans for entire plants. Conditions have now materially changed. The arts of mining, milling, concentrating and cyaniding, have advanced so rapidly, mining engineers have become so expert in their specialties, and the mine owners so universally convinced that it pays them to employ skilled engineers of their own selection to design their plants, that this old custom is rapidly dying out. At present most mining machinery firms refuse to give technical advice regarding the adaptability of their machines to certain ores, neither will they guarantee the capacity of their machines except in a very general way. The correct way to ascertain the most suitable machinery for a mine, or to determine the most economical method of treatment, is to employ a competent mining engineer or metallurgist, or to send trial lots of ore to testing works.

Knowledge of Panning.

63. Skill in this art must be acquired by practice under the personal instruction of an experienced miner. It is a good plan to practice with a mixture of sand and brass filings. Also practice concentrating with the horn spoon. It is advisable, when learning, to work the tailings over to ascertain how much has been lost. About 100 miner's pans heaping full, or 150 level full will make a ton of gravel. The smooth, enameled pans are not good. Use a plain iron pan or one made of aluminum.

How to Make a Rocker.

64. It is a good plan to learn to use the rocker before going into the prospecting business. A rocker is shown in Fig. 7. It should be made with great care. Every miner has his own ideas regarding the design of a rocker, but the one shown in the illustration is fairly representative. The removable box, *A*, is about 18 inches square and has a sheet iron bottom with quarter-inch to half-inch holes punched through it. The dashboard, *C*, is often dispensed with. Its use is to deliver the material to the upper edge of the

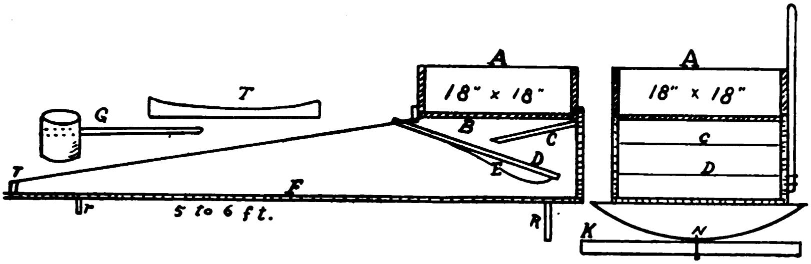


Fig. 7. Details of a Rocker.

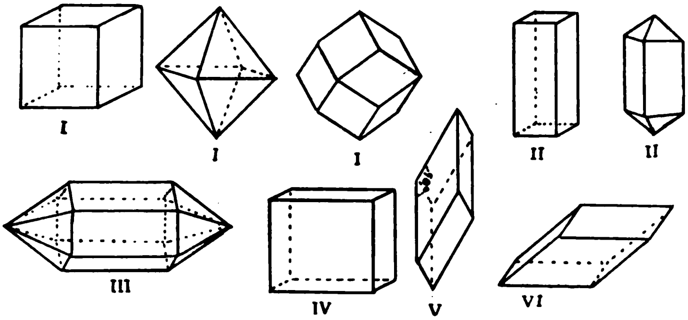


Fig. 8. The Six Systems of Crystems of Crystallization.

I.	Isometric.	IV.	Orthorhombic.
II.	Tetragonal.	V.	Monoclinic.
III.	Hexagonal.	VI.	Triclinic.

canvas apron *E,* which is tacked to the removable frame *D.* The bottom, *F,* of the rocker should be made of one perfectly smooth pine or redwood board 18 inches wide and 5 or 6 feet long, perfectly free from knots. Strips should be screwed (not nailed) across the bottom to prevent even the slightest warping. The tailgate *T* should be made one-half to one inch high. The rocker piece *R* is made larger than the rocker piece *r,* or if both are made the same size the rocker is placed upon an inclined foundation. These rocker pieces are shod with strips of strap iron, and a large hole is made in the center of each one for a long nail, *N,* which is driven up through the foundation board *K.* This nail is to keep the rocker from moving about when it is being worked.

65. When operated, the gravel is shoveled into the hopper *A*, and a stream of water turned upon it, or the water is dipped with the dipper *G*, vigorously rocking all the time by means of the handle. The fine material falls upon *C* and is delivered to the upper part of the apron *E*, which catches the greater part of the gold. The material is now washed down the bed of the rocker, the lighter part being washed over the tailgate *T*, and the concentrates caught upon the rocker bed. With a small hand scoop the concentrates are then transferred from the lower end to immediately beneath the canvas and water again turned on, rocking as before. This concentration operation is repeated several times and the remaining concentrates panned very carefully. The contents of the canvas apron is also panned. The coarse gravel in the hopper is thrown out and the operations repeated.

CHAPTER II.

MINERALOGY.

66. The science of mineralogy usually embraces the subject of crystallography, physical properties of minerals, descriptive mineralogy, chemistry and blowpipe analysis. Only an outline of these subjects can be given in this volume. Blowpipe analysis will be treated in Chapter 4.

Crystallography.

67. Minerals are either massive, crystalline, or individual crystals. Massive minerals have no definite form, and when thin sections are examined under the microscope they show no definite molecular arrangement. Crystalline minerals have no definite form, but do show a systematic molecular structure under the microscope, and in many cases this crystalline structure is plainly evident to the unaided eye. A piece of marble or galena when broken will show the little cleavage faces which are evidences of crystalline structure. A crystal has definite form and will also show a definite arrangement of the molecules under the microscope.

68. There are six principal crystal forms: Isometric, Tetragonal, Hexagonal, Orthorhombic, Monoclinic, and Triclinic. These six systems embrace every known mineral.

69. *Isometric.* Three equal axes at right angles to each other.

70. *Tetragonal.* Three axes at right angles to each other, two of them equal in length and the third longer or shorter.

71. *Hexagonal.* Four axes; three equal axes in one plane at angles of 60 degrees, and a vertical axis at right angles to this plane and longer or shorter than the others.

72. *Orthorhombic.* Three axes at right angles to each other, but all of different lengths.

73. *Monoclinic.* Three axes of unequal length and having one of their intersections oblique, the two other intersections being at 90 degrees.

74. *Triclinic.* Three unequal axes, all intersections oblique.

Physical Properties.

75. The physical properties of minerals depend upon cleavage, fracture, hardness, flexibility, elasticity, specific gravity, color, luster, transparency, optical properties, taste, odor and streak.

76. *Cleavage.* The tendency to split or break in certain directions.

77. *Fracture.* The kind of surface exposed by breaking in a direction other than a cleavage plane.

78. *Hardness.* The resistance to scratching. The scale of hardness is as follows:

1. Talc.
2. Gypsum.
3. Calcite.
4. Fluorite.
5. Apatite.
6. Orthoclase.
7. Quartz.
8. Topaz.
9. Sapphire.
10. Diamond.

79. *Flexibility.* Property of bending and remaining bent.

80. *Elastic.* That which will bend and return to its original position.

81. *Specific Gravity.* The weight compared with the weight of an equal bulk of water.

82. *Color.* The color in ordinary daylight.

83. *Luster.* The appearance of the surface of a mineral. Metallic luster is like that of gold, copper, silver, etc.—always opaque. Adamantine luster is bright like a diamond. Vitrious luster is like that of a fresh break in glass. Resinous luster is like resin. Pearly luster is like that of the pearl. A silky luster is like silk.

84. *Transparency.* The property of being clear like glass. A sub-transparent mineral will transmit a small amount of light. An opaque mineral will transmit no light.

85. *Optical Properties.* These are observed by the use of a microscope having a polariscope attachment. They include refraction, reflection and polarization of light.

86. *Taste.* A few minerals have taste.

87. *Odor.* Minerals have garlic, horse-radish, sulfurous, bituminous, fetid and argillaceous odors.

88. *Streak.* The color of the powdered mineral.

Descriptive Mineralogy.

89. A considerable knowledge of minerals is absolutely necessary. Many valuable deposits of uncommon minerals are passed over every day by the miner and prospector because of ignorance of the identity and worth of these minerals. Life is too short to learn how to identify them all by actual field experience or to personally collect a complete set of mineral specimens. The most practical and satisfactory plan is to buy a collection of mineral specimens from a firm dealing in minerals. To be most useful a set of specimens for study should include all the common metallic minerals that occur plentifully enough to warrant mining, together with a few associated metallic minerals. The most useful nonmetallic minerals, the common rock forming minerals, and the common rocks should be included to make the set more beneficial. Neither the miner nor the prospector will be likely to pick up all the varieties of even the most common metallic minerals. This makes it necessary for him to purchase a complete set from some firm dealing in minerals. A large set is unnecessary except for the mining engineer. The specimens which the writer has found most useful, both to himself and to his students, are enumerated below in Lists Nos. 1, 2, 3 and 4. Specimens marked with a star (*) may be omitted as less important. For the purposes of the prospector specimens should be from three-fourths to one and one-quarter inches square.

MINERAL LIST NO. 1.

90. *Metaliferous Minerals.*

1. Native sulphur. S.
2. Stibnite. Antimony sulfid. Sb 71.8 %, S 28.2 %.
3. Graphite. Plumbago. Black lead. C.
4. Auriferous quartz. Gold in quartz.
5. Ruby silver. Pyrargyrite, dark red, Ag. 59.8%; Proustite, light red. Ag 65.5 %.
6. Cinnabar. Hg 86.2 %.
7. Chalcopyrite. Copper pyrites. Copper-iron sulfid. Cu 34.5%.
8. Cuprite. Red copper ore. Cu 88.8%.
9. Malachite. Cu 57%.
10. Azurite. Cu 55%.
11. Galena. Pb. 86%.
12. Cerussite. White lead ore. Pb. 77%.

13. Sphalerite. Blende. Zinc blende. Zn 67%.
14. Zincite. Red zinc oxid. Zn 89%.
15. Willemite. Zinc silicate. Zn 58.5%.
16. Calamine. Hydrous zinc silicate. Zn 54%.
17. Cassiterite Tin oxide. Sn 79%.
18. Pyrite. Iron Pyrites. Fe 46.7%.
19. Pyrrhotite. Nickeliferous iron pyrites.
20. Hematite. Iron oxide. Fe 70%.
21. Magnetite. Magnetic iron ore. Fe 72%.
22. Limonite. Hydrous iron oxide. Fe 60%.
23. Siderite. Spathic iron. Iron carbonate. Fe 48.2%.
24. Pyrolusite. Manganese dioxide. Mn 63%.
25. Corundum. Aluminum oxide.
26. Cryolite. Aluminum sodium fluoride.
27. Wavellite. Hydrous aluminum phosphate.
28. Fluorite. Fluor spar. Calcium fluoride.
29. Gypsum. Hydrous calcium sulfate.
30. Apatite. Calcium phosphate.
31. Calcite. Spar. Calcium carbonate.
32. Dolomite. Calcium-magnesium carbonate.
33. Barite. Heavy spar.
34. Celestite. Strontium sulfate.
35. Rock crystal. Quartz.
36. Amethyst. Colored quartz.
37. Milky quartz. Common white quartz.
38. Chalcedony. Quartz with a waxy luster.
39. Moss agate. A variety of quartz.
40. Jasper. Red quartz.
41. Pyroxene. A silicate.
42. Rhodonite. Manganese spar.
43. Amphibole. Hornblende.
44. Garnet. A silicate.
45. Mica. A silicate.
46. Scapolite. A silicate.
47. Orthoclase feldspar.
48. Cyanite. Aluminum silicate.
49. Talc. Hydrous magnesian silicate
50. Serpentine. Magnesian silicate.

91. The meaning of the word mineral is not well understood by the average prospector, for he usually restricts the word to the metaliferous minerals, whereas, all substances except those of vegetable or animal origin are mineral. A mineral has definite chemical composition, and usually definite crystalline form, specific gravity, hardness and luster. Example: Quartz, calcite, garnet, galena, diamond, mica, gold, etc. A rock is composed of either one mineral or a mixture of two or more minerals. Examples: Granite, a mixture of the minerals quartz, feldspar and mica; sandstone, a mixture of grains of broken minerals and rocks; limestone, a mixture of the minerals quartz and calcite. Minerals are either individual crystals or they are crystalline masses. The mineral quartz, a common example, often occurs as a crystal, and when so formed it is a six-sided prism terminated by a six-sided pyramid. Crystalline, massive quartz is very common, being the gangue mineral in most veins. The mineral galena, when it occurs as a crystal, is usually a cube; garnet, a dodecahedron; feldspar, a rhombohedron. Why does the same mineral substance sometimes occur as a crystal and at other times only crystalline? The explanation is that when the act of crystallization takes place unhindered, as in a cavity, a crystal forms; otherwise a crystalline mass results. Amorphous (uncrystalline) minerals are very uncommon. The opal is an example. Minerals are formed either by deposition from a water solution of the mineral substance, or within a mass of cooling lava. In order to observe crystal formation evaporate a solution of salt and water to dryness and observe the salt crystals under a magnifying glass. To observe magmatic crystallization melt some antimony or babbit metal and allow it to cool slowly. When a crust has formed puncture it and quickly pour out the remaining metal. Now examine the crystals lining the cavity. Had the metal been allowed to cool completely a crystalline mass would have been the result. In some rocks the different minerals are sufficiently large and perfect to be distinguished with the unaided eye. In other cases a microscope must be uesd. In the latter case the rock is said to be microcrystalline.

92. There is a phase of mineral life, so to speak, with which most prospectors are quite unfamiliar—metamorphism, or the alteration of minerals after they are first formed. Minerals seldom remain in their primary condition, one or more elements being later removed or replaced by others. This is a most important subject and will be more fully treated in sections 163 to 182, inclusive.

The following table of rock forming minerals, although it is primarily a reference list, deserves careful study. Observe that the minerals are grouped and described. For example: It shows that there are seven varieties of feldspar, two of which are of the monoclinic system of crystallization, and the others triclinic.

MINERAL LIST NO. 2.

93. *Rock-Forming Minerals.*

1	Quartz,	variety	crystal.		
2	"	"	amethyst crystal.		
3	"	"	agate.		
4	"	"	flint.		
5	"	"	jasper.		
6	"	"	fire opal.		
7	"	"	wood opal.		
8	Feldspar,		orthoclase	Monoclinic.	Cleavage angle over 90°
9*	"	"	sanidine		
10*	"	"	microline	Triclinic.	" " below 90°
11	"	"	albite	Plagioclases.	Triclinic. Cleavage angle below 90°
12*	"	"	anorthite		
13	"	"	oligoclase		
14	"	"	labradorite ...		
15	Pyroxene,	"	diopside	Monoclinic....	Prismatic angle 87° to 93°. Crystals stout or granular. Contain more lime than amphibole. Associated with basic rocks.
16	"	"	augite	"	
17	"	"	diallage	"	
18	"	"	enstatite	Orthorhombic..	
19*	"	"	hypersthene ..	"	
20*	Amphibole,	"	anthrophyllite..	Orthorhombic..	Prismatic angle 56° to 124°. Crystals long. More Magnesium and alkalies than Pyroxenes. Associated with acid rocks.
21	"	"	tremolite	Monoclinic....	
22	"	"	actinolite	"	
23	"	"	asbestos	"	
24	"	"	hornblende ...	"	
25	Mica,	"	muscovite	Potash mica.	Flexible scales.
26	"	"	lepidolite	Lithia mica.	" "
27	"	"	biotite	Magnesia-iron mica.	" "
28	"	"	phlogopite	Magnesia mica.	" "
29*	"	"	lepidomelane ..	Iron-magnesia mica.	" "
30	Chlorite,	"	clinochlore	Magnesia-iron chlorite.	Usually greenish.
31*	"	"	prochlorite	" " "	inflexible scales.
32	Epidote,	"	zoisite	Calcium-aluminum epidote.	
33	"	proper	....	Calcium-iron-aluminum epidote.	
34	Leucite-nephelene-sodalite,	variety	leucite..	Potassium aluminum silicate.	
35*	" " "	"	nepheline..	Pot. alum. sodium "	
36*	" " "	"	sodalite..	Sodium aluminum "	
37	" " "	"	olivine (chrysolite, peridot).		
38	Serpentine,	variety	true serpentine..	Hydrous magnesian silicate.	
39	"	"	talc..............	" " "	
40	"	"	pyrophyllite......	" " "	
41	"	"	chrysotile........	" " " (asbestos).	
42	Garnet,	"	grossularite......	Cinnamon garnet.	
43	"	"	andradite........	Common garnet.	
44*	"	"	almandite........	Oriental garnet.	
45*	"	"	pyrope...........	Bohemian garnet.	
46	Zircon.	Zirconium silicate.			
47	Apatite.	Calcium phosphate with a little chlorine.			
48	Corundum.	Variety	sapphire.		
49	"	"	emery.		
50	Vesuvianite.	Calcium aluminum silicate.			

51	Topaz.	Aluminum silicate with a little fluorine.
52	Andalusite.	" " " " "
53	Cyanite	" " " " "
54	Tourmaline (black).	Aluminum silicate with iron, boron, etc.
55	" (red)	" " " lithium.
56	Staurolite.	Iron-aluminum-magnesium silicate.
57	Monazite.	Phosphate of Ce, La, Di and Th.
58	Magnetite.	Magnetic oxide of iron.
59	Chromite.	Iron chromate.
60	Calcite.	Calcium carbonate.
61	Barite.	Barium sulfate (heavy spar.)

LIST NO. 3.

94. *Rocks.*

1 Granite.
2 Syenite.
3 Limestone.
4 Dolomite.
5 Sandstone.
6 Slate.
7 Mica schist.
8 Trachyte.
9 Obsidian.
10 Diorite.
11 Andesite.
12 Gabbro.
13 Diabase.
14 Dolerite, basalt.
15 Pumice.
16 Porphyry.
17 Coal, anthracite.
18 Coal, bituminous.
19 Coal, lignite.
20 Asphaltum.
21 Phosphate rock.

MINERAL LIST NO. 4.

95. *Rare and Uncommon Minerals.*

	Tantalum.	
1	Columbite.	Iron-niobium-tantalum oxide.
2	Tantalite.	Iron-tantalum oxide.
	Thorium.	
3	Monazite.	Thorium and cerium phosphate. (See list No. 2)
	Titanium.	
4	Ilmenite, (menaccanite).	Titanic iron oxide.
5	Rutile.	Titanium dioxide.
6	Titanite.	Calcium-titanium oxide.
	Tungsten.	
7	Wolframite.	Iron-manganese tungstate.
8	Hubernite.	Manganese tungstate.
9	Scheelite.	Calcium tungstate.
	Molybdenum.	
10	Molybdenite.	Molybdenum sulfid.
11	Uraninite (pitchblend).	Uranium, radium, thorium, zirconium, lanthanum, and yttrium with the gasses helium and argon in small amounts.
12	Torbernite.	Hydrous phosphate of uranium and copper. Contains some radium.
13	Carnotite.	Essentially uranium potassium vanadate with small amounts of calcium, barium and radium.
	Boron.	
14	Boracite.	Magnesium chloroborate.
15	Colemanite.	Hydrous calcium borate.
16	Borax.	Hydrous sodium borate.

CHEMISTRY.

96. As previously explained, a knowledge of this science is extremely beneficial. Perhaps no other science is of more service to man, and its value is not confined to mineralogy alone, but is felt in every branch of human endeavor. It will especially assist the miner, prospector and mining engineer in comprehending the literature of today concerning vein formation, secondary enrichment, oxidation, cyanidation, etc. Unfortunately, space permits only a few brief principles to be given, some of the most elementary of which are as follows:

97. All substances, animal, vegetable or mineral, are composed of molecules. Molecules are too small to be seen, even with a microscope. All molecules are made of atoms.

98. An elementary substance is composed of atoms of one kind only. For example: Gold is made of atoms of gold only. Iron is made of atoms of iron, etc.

99. A compound substance is composed of molecules having atoms of two or more different kinds. For example: Galena is made of lead and sulfur atoms, and has the formula PbS. Quartz (SiO_2) is made of one atom of silicon (Si) and two atoms of oxygen (O). Magnetite iron ore (Fe_3O_4) molecules are made of three atoms of iron (Fe, for ferrum), and four of oxygen.

100. Chemists throughout the world have agreed that the atoms of the various elements shall, for convenience, be represented by the initial letters of their respective latin names. Thus: $H =$ hydrogen. $O =$ oxygen. $Na =$ natrum, sodium. $Cu =$ cuprum, copper, etc. A list of these symbols will be found in Section 1149.

101. Chemists use what might be termed a chemical shorthand to represent molecules, in which the atoms are represented by the symbolic letters above referred to, with a subscript to denote the number of atoms in the molecule. Thus: $H_2O =$ water, containing two atoms of hydrogen and one of oxygen. The molecule of the mineral calamine has the formula $(ZnOH)_2SiO_3$, which means that it contains two groups of zinc hydrate, each group having one atom each of zinc, oxygen and hydrogen, which groups are combined with one atom of silicon and three of oxygen.

102. All acids contain hydrogen.

103. When the hydrogen in any acid is replaced by a metal a chemical salt is formed.

104. The acids containing no oxygen are called the haloid acids. When a metal takes the place of the hydrogen in a haloid acid a salt is formed, the name of which ends in "id." [Formerly written "ide."]

Haloid acids.	Haloid salts.
HCl, hydrochloric acid.	KCl, potassium chloride.
HBr, hydrobromic acid.	$NaBr$, sodium bromid.
HI, hydriodic acid.	BiI_3, bismuth iodid.
H_2S, hydrosulfuric acid.	CaS, calcium sulfid.

105. The names of acids containing oxygen, and also their salts, have an ending in accordance with the number of atoms of oxygen in the respective molecules, the number of oxygen atoms being dependent upon the valence [see glossary] of the "naming elements" [see glossary]. "Ic" acids make "ate" salts, and "ous" acids make "ite" salts, when a metal replaces the hydrogen of these acids.

Acids.	Salt.
$HC_2H_3O_2$, acetic acid.	$Fe_2(C_2H_3O_2)$, ferric acetate
H_2CO_3, carbonic acid.	K_2CO_3, potassium carbonate.
HNO_2, nitrous acid.	$AgNO_2$, silver nitrite.
HNO_3, nitric acid.	$Pb(NO_3)_2$, lead nitrate.
H_2SO_3, sulfurous acid.	Ag_2SO_3, silver sulfite.
H_2SO_4, sulfuric acid.	Ag_2SO_4, silver sulfate.

106. The elements potassium, sodium and the group ammonium (NH_3) are called the alkali metals, the group NH_3 acting as one individual element.

107. The elements magnesium, barium, calcium and strontium are alkaline earth metals.

108. Metalic elements, in addition to replacing the hydrogen in acids to form salts, will also under certain conditions, replace one atom of hydrogen in water to form a "hydrate." [Sometimes called "hydroxid."]

Water. Hydrate.
$H_2O = Ba(OH)_2$, barium hydrate.
$H_2O = Fe(OH)_2$, ferrous hydrate.
$H_2O = Fe_2(OH)_6$, ferric hydrate.
$H_2O = NaOH$, sodium hydrate.
$H_2O = KOH$, potassium hydrate.
$H_2O = NH_4OH$, ammonium hydrate (Hartshorn).

109. When there is an exchange of atoms between two or more molecules the changes are expressed by an equation. In an equation there must be the same number of atoms of each kind on each side of the equality sign. Space will not permit an explanation of the method of balancing an equation. A few examples only will be given.

Equations.

$$CaCo_3+2HCl=CaCl_2+CO_2+H_2O.$$

110. The above equation means that one molecule of calcite reacts with two molecules of hydrochloric acid, making one molecule each of calcium chlorid, carbon dioxid and water. Try the experiment of dissolving pulverized marble in hydrochloric acid, observing the gas, CO_2, escape.

$$Zn + H_2SO_4 = ZnSO_4 + H_2$$

That is, zinc is dissolved by sulfuric acid forming zinc sulfate and free hydrogen gas.

$$3Ag + 4HNO_3 = 3AgNO_3 + NO + 2H_2O$$

111. When nitric acid dissolves silver, four molecules of the acid unite with three atoms of silver, forming three molecules of silver nitrate, one of nitric oxid gas, and two of water. Observe that according to the rule [109] there are, on each side of the equality sign, three atoms of silver, four atoms of hydrogen, four atoms of nitrogen and twelve atoms of oxygen.

112. Atoms have weight. Although we can not actually weigh them, we have determined their relative weight. For example: oxygen atoms are 16 times heavier than hydrogen atoms. Therefore, by means of a table of atomic weights [1149] we can compute the percentage composition of any pure mineral. Thus, chalcocite has the formula Cu_2S. One atom of copper weighs 63 microcriths and the two weigh 126. The atom of sulfur weighs 32 microcriths, making the total weight of the molecule 158 microcriths. Now, $126 \div 158 = 79.8\%$ copper in strictly pure chalcocite. If there is any rock or other mineral present, the specimen must be analyzed by a chemist to determine the percentages.

113. The trading or exchanging of elements between molecules previously referred to [92, 110, 111] is an important and common occurrence in the secondary enrichment [173 to 177] of ore bodies. For example, in the belt of weathering silver may be dissolved by water containing ferric sulfate, silver sulfate being one of the products; thus:

$$H_2O + 2Ag + Fe_2(SO_4)_3 = Ag_2SO_4 + 2FeSO_4 + H_2O.$$

114. The silver sulfate is dissolved by descending meteoric water (rain water) and carried down to a point in the vein where it meets some strong sulfid, as FeS_2, where it is precipitated as silver sulfid, argentite. The oxidation of iron pyrites as a preliminary to the above is also a common example of the transferrence of atoms from one molecule to another. Space does not permit of a more thorough explanation of this interesting and practical phase of chemistry, upon which a large book could be written without exhausting the subject.

CHAPTER III.

GEOLOGY.

General Divisions.

115. *Physiography.*—A study of the outline and topography of the surface features of the earth.

116. *Stratigraphy.*—A study of the chronological order of rock formation, and the relations of the rock-strata to each other.

117. *Dynamical geology.*—A study of the forces of nature that have produced geological changes. That branch of geology relating to mountain making, erosion, mineral growth and alteration.

118. *Petrology.*—That branch of geology relating to the origin, mode of occurrence, mineral composition, and structure of rocks.

119. *Historical geology.*—A delineation of the order and manner in which the earth's features were formed, and an investigation of the development of vegetable and animal life.

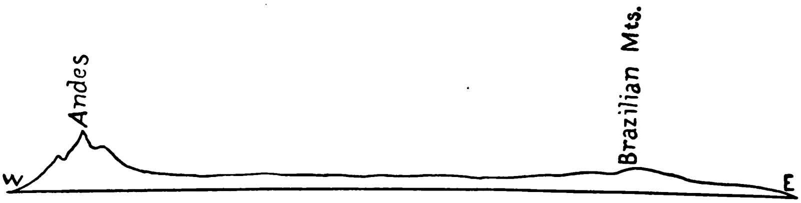
120. *Economic geology.*—That branch which discusses the occurrence of the useful minerals for the purpose of facilitating their discovery and extraction.

121. PHYSIOGRAPHY.—The earth's form is that of a nearly perfect oblate spheroid—that is, a sphere flattened at the poles. The crust, or lithosphere, has a density of 2.75. The interior, or centrosphere, has a density of 10.8, and is, therefore, more rigid than steel, which has a density of 7.7. The density of the earth as a whole is 5.48. The weight of the earth is 6,550,000,000,000,000,000,000 tons, and the pressure at the center due to gravity is 43,000,000 pounds per square inch.

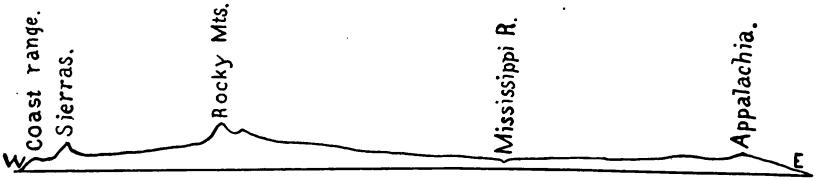
122. The continents and oceans are irregular in outline and topography. The mountain ranges usually border the continents, and valleys and plains are in the central portions.

123. The chief physographic features of the continents are shown in Fig. 9.

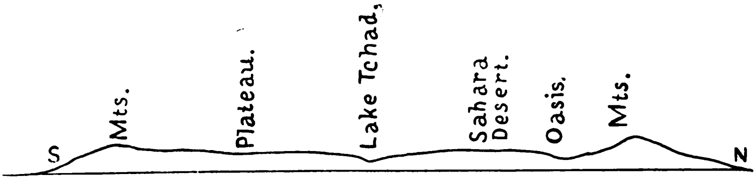
124. STRATIGRAPHY.—The earth was formerly a highly heated molten mass. As it cooled, the surface became solidified. Erosion and chemical agencies disintegrated a part of this early crust, forming sediments which settled in a more or less stratified form in the early shallow oceans. With successive epocs the composition, position and rate of formation of these strata varied, vegetable and animal life appearing in due course of time. The various forms



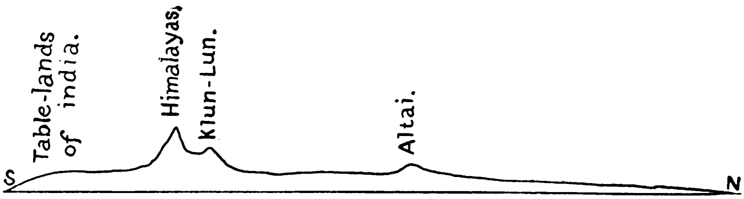
East and West Cross-Section of South America.



East and West Cross-Section of North America.



North and South Cross-Section of Africa.



North and South Cross-Section of Asia.

Fig. 9. Cross-Sections of the Continents.

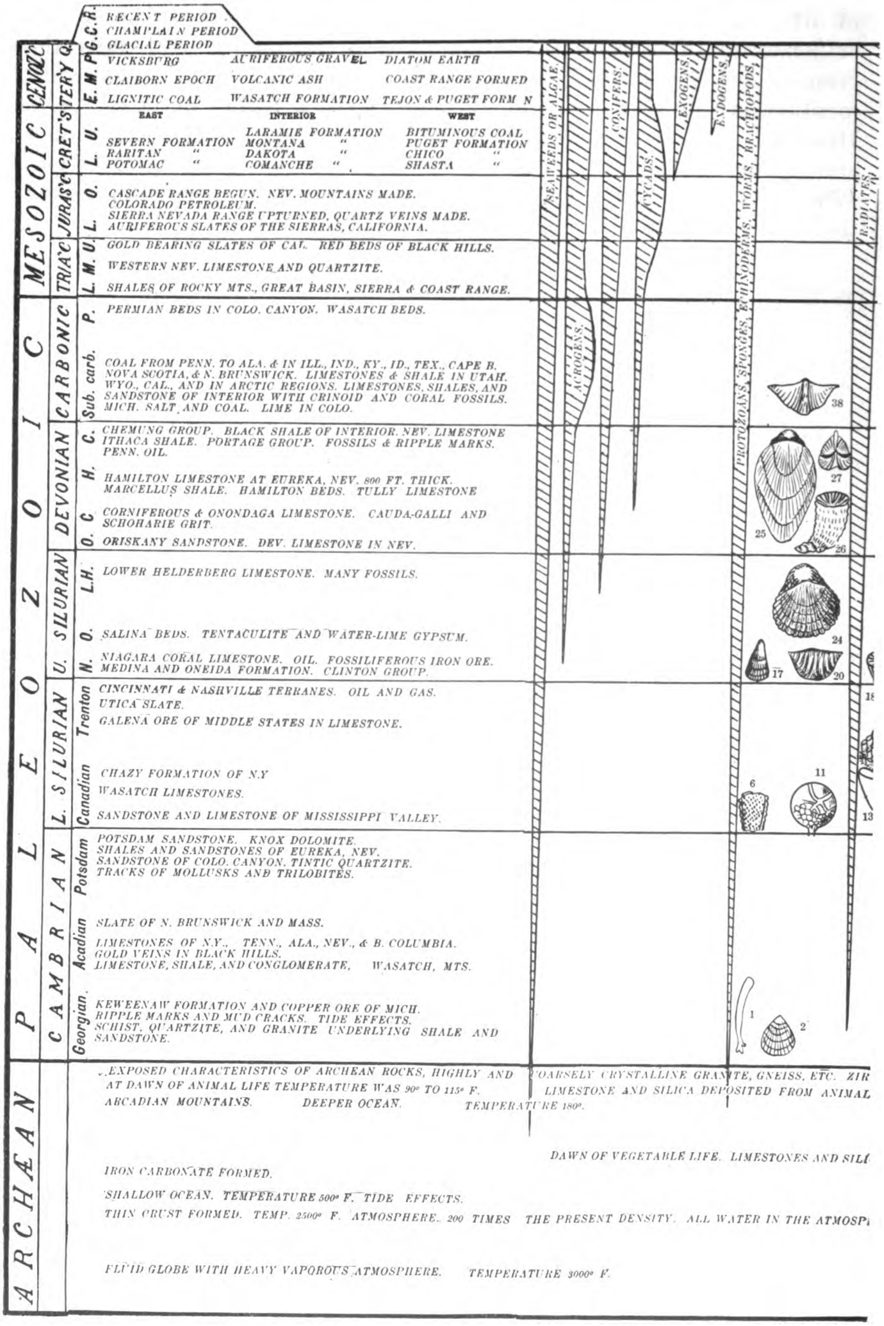
of life, as they developed into more highly organized types, left evidences of their existence, either as casts or fossils. Naturally the remains of the earliest forms would be found in the older sedimentary strata, and those of the more recent forms in later rocks. However, these strata have been, in many cases, so faulted, folded and upturned that it is difficult to determine their original position. When this is the case the fossils found aid materially in determining the original position.

125. The order in which the original strata were formed is as follows, according to James D. Dana:

Geologic Time.

Time.	*Age.*	*Period.*	
Cenozoio	Quarternary	Recent	
		Champlain	
		Glacial	
	Tertiary	Pliocene	Neocene
		Miocene	
		Eocene	
Mesozoic	Cretaceous	Upper	
		Lower	
	Jurassic		
	Triassic		
Paleozoic	Carboniferous	Permian	
		Coal Measures	
		Subcarboniferous	
	Devonian	Chemung	
		Hamilton	
		Corniferous	
		Oriskany	
	Upper Silurian	Lower Helderberg	
		Onondaga	
		Niagara	
	Lower Silurian	Trenton	
		Canadian	
	Cambrian	Potsdam	
		Acadian	
		Georgian	
Archean			

126. Archean rocks were the first formed on the earth. They consist of coarse, highly crystalline, igneous and metamorphic rocks. Paleozoic rocks were next formed, and contain many limestones, ending with the coal formations. Mesozoic and Cenozoic rocks fol-



RECENT PERIOD
CHAMPLAIN PERIOD
GLACIAL PERIOD

VICKSBURG — AURIFEROUS GRAVEL — DIATOM EARTH
CLAIBORN EPOCH — VOLCANIC ASH — COAST RANGE FORMED
LIGNITIC COAL — WASATCH FORMATION — TEJON & PUGET FORM N

EAST	INTERIOR	WEST
	LARAMIE FORMATION	BITUMINOUS COAL
SEVERN FORMATION	MONTANA "	PUGET FORMATION
RARITAN "	DAKOTA "	CHICO "
POTOMAC "	COMANCHE "	SHASTA "

CASCADE RANGE BEGUN. NEV. MOUNTAINS MADE.
COLORADO PETROLEUM.
SIERRA NEVADA RANGE UPTURNED, QUARTZ VEINS MADE.
AURIFEROUS SLATES OF THE SIERRAS, CALIFORNIA.

GOLD BEARING SLATES OF CAL. RED BEDS OF BLACK HILLS.
WESTERN NEV. LIMESTONE AND QUARTZITE.
SHALES OF ROCKY MTS., GREAT BASIN, SIERRA & COAST RANGE.

PERMIAN BEDS IN COLO. CANYON. WASATCH BEDS.

COAL FROM PENN. TO ALA. & IN ILL., IND., KY., ID., TEX., CAPE B. NOVA SCOTIA, & N. BRUNSWICK. LIMESTONES & SHALE IN UTAH. WYO., CAL., AND IN ARCTIC REGIONS. LIMESTONES, SHALES, AND SANDSTONE OF INTERIOR WITH CRINOID AND CORAL FOSSILS. MICH. SALT AND COAL. LIME IN COLO.

CHEMUNG GROUP. BLACK SHALE OF INTERIOR. NEV. LIMESTONE ITHACA SHALE. PORTAGE GROUP. FOSSILS & RIPPLE MARKS. PENN. OIL.

HAMILTON LIMESTONE AT EUREKA, NEV. 800 FT. THICK. MARCELLUS SHALE. HAMILTON BEDS. TULLY LIMESTONE

CORNIFEROUS & ONONDAGA LIMESTONE. CAUDA-GALLI AND SCHOHARIE GRIT.

ORISKANY SANDSTONE. DEV. LIMESTONE IN NEV.

LOWER HELDERBERG LIMESTONE. MANY FOSSILS.

SALINA BEDS. TENTACULITE AND WATER-LIME GYPSUM.

NIAGARA CORAL LIMESTONE. OIL. FOSSILIFEROUS IRON ORE. MEDINA AND ONEIDA FORMATION. CLINTON GROUP.

CINCINNATI & NASHVILLE TERRANES. OIL AND GAS.
UTICA SLATE.
GALENA ORE OF MIDDLE STATES IN LIMESTONE.

CHAZY FORMATION OF N.Y
WASATCH LIMESTONES.
SANDSTONE AND LIMESTONE OF MISSISSIPPI VALLEY.

POTSDAM SANDSTONE. KNOX DOLOMITE. SHALES AND SANDSTONES OF EUREKA, NEV. SANDSTONE OF COLO. CANYON. TINTIC QUARTZITE. TRACKS OF MOLLUSKS AND TRILOBITES.

SLATE OF N. BRUNSWICK AND MASS.

LIMESTONES OF N.Y., TENN., ALA., NEV., & B. COLUMBIA. GOLD VEINS IN BLACK HILLS. LIMESTONE, SHALE, AND CONGLOMERATE, WASATCH, MTS.

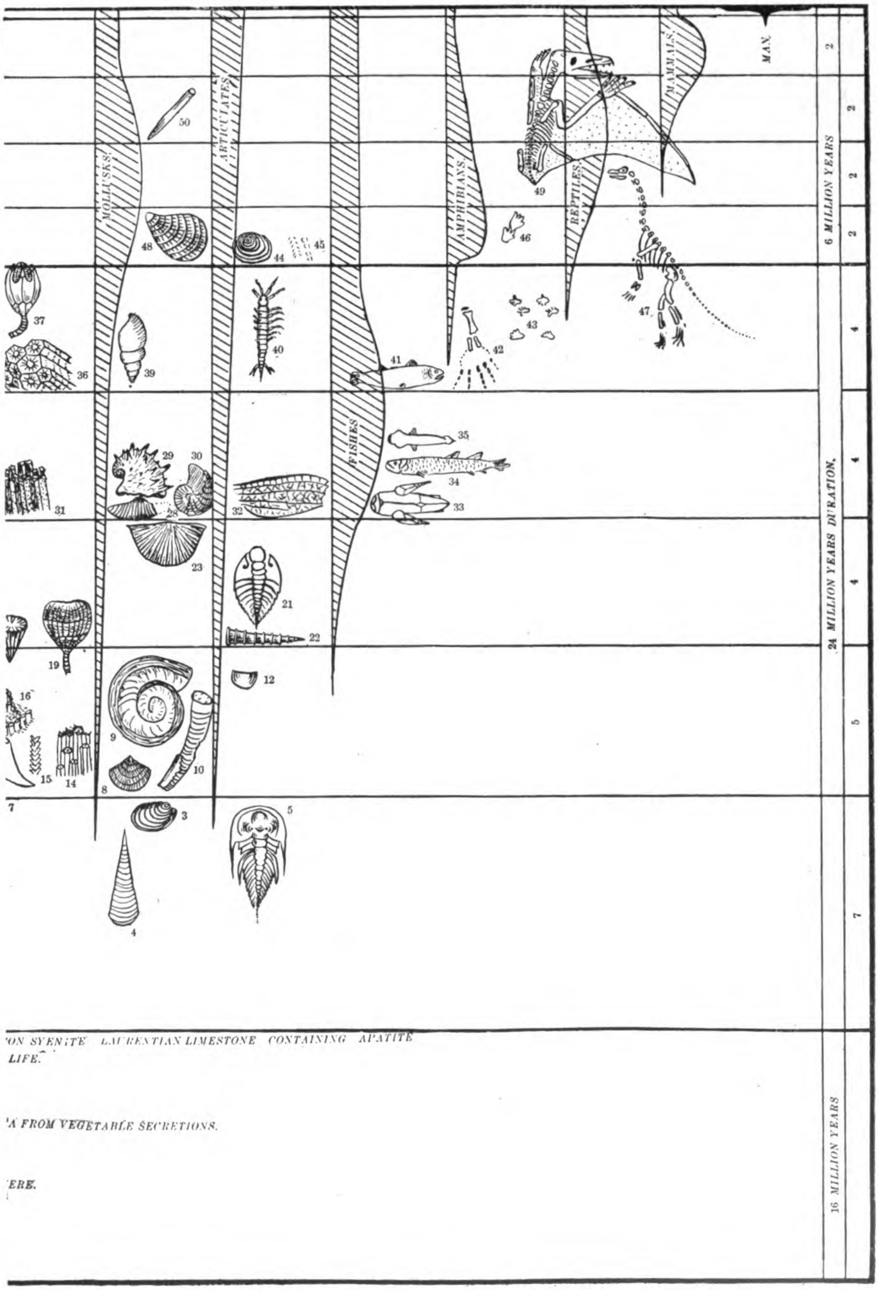
KEWEENAW FORMATION AND COPPER ORE OF MICH. RIPPLE MARKS AND MUD CRACKS. TIDE EFFECTS. SCHIST, QUARTZITE, AND GRANITE UNDERLYING SHALE AND SANDSTONE.

EXPOSED CHARACTERISTICS OF ARCHEAN ROCKS, HIGHLY AND COARSELY CRYSTALLINE GRANITE, GNEISS, ETC. ZIR
AT DAWN OF ANIMAL LIFE TEMPERATURE WAS 90° TO 115° F. LIMESTONE AND SILICA DEPOSITED FROM ANIMAL
ARCADIAN MOUNTAINS. DEEPER OCEAN. TEMPERATURE 180°.

DAWN OF VEGETABLE LIFE. LIMESTONES AND SIL
IRON CARBONATE FORMED.
SHALLOW OCEAN. TEMPERATURE 500° F. TIDE EFFECTS.
THIN CRUST FORMED. TEMP. 2500° F. ATMOSPHERE 200 TIMES THE PRESENT DENSITY. ALL WATER IN THE ATMOSP

FLUID GLOBE WITH HEAVY VAPOROUS ATMOSPHERE. TEMPERATURE 3000° F.

Fig. 10. Geological Chart Showing the Comparative Duration



of the Ages, and the Evolution of Vegetable and Animal Life.

lowed, composed chiefly of sedimentary and metamorphic formations. Surface soil, sand, gravel, etc., belong to the Recent Period of the Quarternary Age. Regarding position, the earliest rocks naturally lie deepest, but later disturbances have often exposed them to view.

127. In order to show the relative duration of the various geologic ages, and also the development of vegetable and animal life, the chart, Fig. 10, has been devised by the author.

128. Although 48,000,000 years has been assumed in this chart as the age of the earth since the first crust was formed, the author does not contend that this estimate is any more trustworthy than others. Some authorities estimate the earth's age as low as 10,000 years, and others as high as 300,000,000 years. The reader can take his choice. The *relative* duration of the "Times" and "Ages" as given, however, can be accepted as accurate. The development of life, both vegetable and animal, is shown by shaded areas. Fossils of the forms of life specified are found in the rocks of the ages through which these shaded areas pass. For example, fossil mammals (animals that suckle their young) are found in the Carbonic, Triassic, Jurassic, Cretaceous, Tertiary and Quarternary Ages, having made their first appearance in the Carbonic Age.

129. DYNAMICAL GEOLOGY.—Heat, together with the pressure caused by the force of gravity, constitute internal forces, the resultants of which have uplifted mountain ranges, faulted, folded and cracked rock strata, influenced vein formation, and in many other ways affected the surface features of the earth. These may be called constructive effects. The antagonistic or destructive forces of wind, rain, frost and change in temperature, are constantly tearing down the mountains and filling up the bays and lakes, while chemical forces, acting in conjunction with circulating waters, are dissolving, precipitating and altering minerals in a marvelous way within the crust of the earth.

130. PETROLOGY.—A detailed discussion of rock formation would be out of place in a small volume. This much should be said, however: Rocks are composed of a single mineral, or an aggregation of a number of minerals. For example, sandstone rock is chiefly composed of grains of the mineral quartz. Granite is composed of three minerals; quartz, feldspar, and mica. Rocks vary in structure: Crystalline rocks contain minerals that are wholly or partially crystallized. When the crystals are too small to be seen except with a glass they are said to be microcrystalline. Rocks are fibrous when they contain fibers, as asbestos; lamellar when containing laminae, as mica; reticulated when the fibers cross like a net work. As to origin, a rock may result from the cooling of a lava, the product being called an igneous rock; or from the solidifying of

pulverized rock material under pressure, with or without the aid of a cementing material. Sandstone, shale, and marble are examples. These are called sedimentary rocks.

131. Historical Geology.—The history of the earth can be ascertained with considerable reliability by studying its crust and also, by analogy, by observing the stars, nebulae, planets, etc.

132. It is now generally believed that the earth was at one time a molten mass surrounded by an atmosphere containing many gasses not now present. As the earth cooled by the radiation of its heat into space, a solid crust was formed. Many of the atmospheric gasses chemically combined with other substances making additional rock. For example, carbon dioxid gas, once forming a large proportion of the atmosphere, was largely absorbed by raindrops and later chemically combined with lime to form common limestone. This limestone has been, in part, dissolved by streams, taken up by all manner of sea and land life for bone material, and later deposited in beds and compressed into secondary limestone. A large proportion of the early igneous rock has been eroded and disintegrated, and the product carried down stream and deposited in bays, or along the ocean beach, forming sedimentary, stratified rocks. [185]. Later, as explained under dynamical geology, these strata have later become stratified, folded, faulted, etc., in which condition we now find them.

133. Many forms of vegetable and animal life became imbedded in the sands of these old-time ocean beaches, and are now found as fossils. By means of these fossils geologists who have made a study of the subject, can tell the geological age to which any particular rock stratum belongs, and can form a reasonably reliable idea of conditions which existed at the time the rocks were made that now enclose the fossils.

134. Economic Geology.—The most usual modes of occurrence of the useful minerals will be described under the headings of the respective minerals, to which the reader is referred, and only a brief generalization will be given here.

135. The following is a classification of mineral deposits based upon origin:

1. Eruptive.
    a. Disseminated.
    b. Massive.
2. Chemical.
    a. Sublimation.
    b. Precipitated.
    c. Replacement.
    d. Concentration.

136. Classified according to form of deposit we have the following:

1. Placers.
    - a. Benches and river bars.
    - b. Ancient river channels.
    - c. Glacial moraines.
2. Deposits other than placers.
    - a. True veins. (In pre-existing openings).
        1. Contact vein.
        2. Gash vein.
        3. Fissure vein.
    - b. Ore channels.
        1. Joint fillings.
        2. Trunk channel fillings.
    - c. Concretionary.
        1. Concretions.
    - d. Sedimentary.
        1. Bedded deposits.
        2. Bog ores.
    - e. Sublimations.
        1. Chimneys.
        2. Irregular.
    - f. Segregations.
        1. Magmatic.
        2. In sedimentary rocks.
        3. Metamorphic.

137. It should be observed that many ores originally deposited by a certain process in a certain form, have since been dissolved, transported, and reprecipitated over and over again, possibly in a different form and manner each time. It is, therefore, impossible to give the complete history of an ore in many instances. However. the information available at present concerning ore deposits is quite useful.

138. *Gold.*—Gold is widely distributed, being mined in certain restricted regions. It is found chiefly in placers and in quartz veins. It is also found in veins of quartz and calcite, and in veins of quartz and fluorite: in the latter case it is often associated with tellurium. It is found in fissure and contact veins, rarely in replacement veins. Gold bearing fissure veins are most frequently formed in sedimentary and metamorphic rock. Gold is commonly associated with iron pyrites. It is also frequently found with copper, antimony, arsenic, and cobalt minerals. All native gold contains at least a trace of silver. It is seldom combined with other elements.

139. *Silver.*—Silver minerals [877] are more widely distributed than gold. They are rarely [416] found in placers, most silver minerals being either soft, brittle, or soluble. They occur in fissure, contact and replacement veins. Often found in veins of quartz and calcite, also in quartz alone. A common mode of occurrence is in association with galena, sphalerite, or pyrites, or any two or all three of these minerals. Also found associated with copper, especially in quartz-calcite-barite veins. [286.]

140. *Lead.*—Lead minerals [788] are found in fissure, contact, and replacement veins. Galena occurs in quartz veins, and in quartz-calcite-barite veins. Highly argentiferous galena is often found with sphalerite, pyrites, arsenopyrite, or calcopyrite. [286.] Lead carbonate is often associated with quartz, calcite, siderite, rhodochrosite and dolomite.

141. *Copper.*—Copper is found in fissure veins in igneous rocks, but chiefly in contact and replacement deposits. When found in quartz veins there are usually several copper minerals associated with each other and with pyrites; as, calcocite, bornite, enargite, tetrahedrite, and pyrites. [286.] It is almost invariably the case that the percentage of iron increases and that of copper decreases with depth, especially below the zone of secondary. enrichment. The contact and replacement deposits are usually connected in a genetic way (by way of origin) with igneous rock, such as dikes and intrusions.

142. *Iron ores.*—Hematite occurs in bedded deposits in the rocks of every age except the most recent. The specular variety is chiefly confined to metamorphic rocks [190.] Magnetite occurs in highly crystalline and metamorphic rocks, either in beds or as replacements and segregations. Most western iron deposits are irregular replacements in limestone or igneous rock. Limonite is formed in bedded deposits.

143. In estimating the economic value of a mineral several things should be taken into consideration: First, the market price; second, the cost of production, preparation for market, and the cost of transportation; third, the probable future value of the mineral. In many cases the refining, concentrating, or other purifying process, used in one branch of mining or milling, may be adopted with profit to another. Power cost is usually a big item in all mining operations, and an expense reduction along this line may oftentimes mean success instead of failure. In many instances the erection of a water power plant would reduce the cost of mining and milling of gold ores to from one-half to one-fourth the present cost. Lack of capital is usually the reason why such improvements are not made, but in some cases it is lack of knowledge.

144. *Economic Products of the Ages.*

Archean.

Marble of organic origin.
Iron ores.
Graphite.
Apatite.

Lower Silurian.

Lead in Wisconsin, Illinois and Iowa.
Petroleum in Ohio and Indiana.
Marbel in Vermont, Massachusetts, New York and Tennessee.

Upper Silurian.

Salt in New York and Canada.
Gypsum.
Hydraulic cement in New York.

Devonian.

Oil in Pennsylvania and Arkansas.
Phosphates in Tennessee and Arkansas.
Hydraulic lime at Louisville, Kentucky.

Lower Carboniferous.

Salt in Michigan.
Marble in Tennessee and Arkansas.
Coal in the Eastern States.

Upper Carboniferous.

Coal in the Eastern States.
Iron ores.
Fire clay with coal beds.

Permian.

Gypsum in Kansas.

Triassic.

Gypsum in Kansas.
Coal in Virginia.
Brownstone.
Potomac marble.

Jurassic.

Gold veins in the Pacific States in slates, etc.

Cretaceous.

Chalk in Arkansas and Texas.
Gypsum in Iowa.
Coal in Puget Sound, Colorado, Wyoming, Montana and New Mexico.
Auriferous conglomerate in California.

Cenozoic.

Placer gravels in California.
Diatomaceous earth in California and Richmond, Virginia.
Phosphates in Florida and South Carolina.
Lignite in Arkansas, Texas, Mississippi, California and Alaska.
Bog iron ores.
Petroleum in California.

Geological Concentrates.

145. Some ore deposits are due to vaporous eminations from igneous rock; others are due to the action of circulating waters in the earth's crust; and others to the combined effects of vapors and waters. Circulating waters have produced practically all of our workable ore deposits, though the water solutions probably obtained their mineral matter from the igneous rocks in the majority of cases. The genesis of ore deposits is a subject for the consideration of our wisest geologists, who are able to employ thoroughly scientific methods of investigation, and the prospector, miner, and mining engineer must look to these men of wide experience for information on this subject.

146. Veins were not made by melted rock forcing its way up from lower depths. Quartz veins were never melted. Dikes, however, are cooled molten rock. The quartz and other minerals in veins are believed to have been precipitated from solutions. Just what the solutions were is not definitely known, though in many cases we are reasonably certain. Water is the most common solvent.

147. The dark color of basic rocks is due to the presence of base metals, especially iron and magnesia.

148. The erosion of mountain streams has, during the past ages, worn, or cut out, canyons and gulches in the mountains to great depths, and at the same time many veins have been worn away and the gold which was in them has been left in placer deposits, some of which are far removed from the veins that produced the gold.

149. Basic rocks are usually dark colored.

150. Acid rocks are usually light colored.

151. Coal can not be found in igneous rocks.

152. Metallic minerals are found in veins in all varieties of rock.

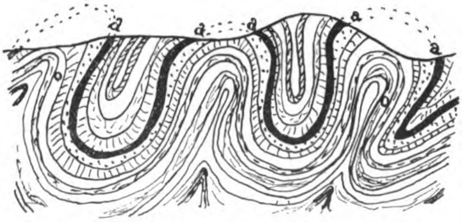


Fig. 11. Contorted Sedimentary Strata.

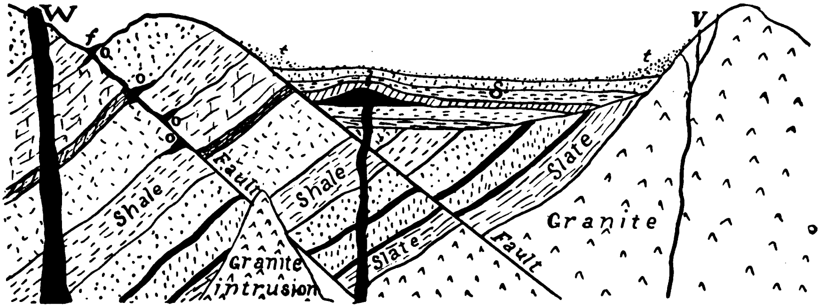


Fig. 12. Ideal Section Illustrating Geological Terms.

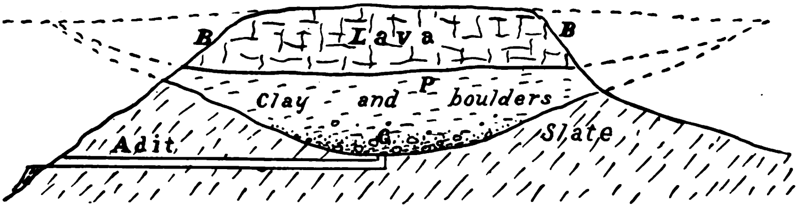


Fig. 13. Lava Capping of Ancient Gold Bearing River Channel.
Table Mountain, California.

153. Many minerals occur in deposits other than veins; as, in beds, placers, segregations, replacements and impregnations.

154. The contact between sedimentary and igneous rocks is favorable for ore deposition. A contact vein may be at quite a distance from the actual contact, however, because the effect of the igneous rock may extend to quite a distance—nearly a mile in some instances, but usually less than 100 feet.

155. Sedimentary strata are often folded and, at times, the fold is so great as to produce an overthrow as at O, Fig. 11. In this case a portion of the strata has been worn away, leaving the edges of the strata exposed, and thus making it difficult in the field to ascertain just how the original strata lay. In such a case a geologist will usually make a topographical survey, noting the thickness, strike and dip of each stratum. A drawing is then made in accordance with the survey in which the strata composed of the same kind of rock are connected, either above the surface by dotted lines, or below by full lines, as the dips and topography may suggest. In the illustration the exposed edges of the stratum a a a a are all of the same kind of rock and are, therefore, connected. The remaining strata are fitted in in a similar manner.

156. In Fig. 12 a fault is shown at *f,* a fan or fingered fissure vein at *v,* and a fissure vein at *w,* a laccolith at *d,* talus at *t,* and unconformable, sedimentary strata at *s.* Ore deposits often occur along or across a line of fault, as at *o.*

157. Ancient river channels, often gold bearing, are some times found beneath old lava overflows, especially in the Sierra Nevada Mountains in California. Such a channel is shown in Fig. 13. A layer of sand, clay, or mud, usually occurs beneath the lava and upon the bed rock, as at *p.* A recent (geologically modern) river is shown at the left, and an adit taps the bed rock at *G.*

158. The earth's crust is from six to seven miles thick, beneath which intensely hot, molten material exists under great pressure. The term crust as here used means solid mineral matter such as is ordinarily called rock. At the surface, rocks are brittle and may be cracked, either by human agencies, as with hammers or dynamite; or by natural forces, as earthquakes and other crustial movements. Passing from the surface toward the center of the earth the rocks become less and less brittle till a depth is reached where cracks can no longer exist, owing to the great pressure. Still lower the material is plastic like molten lava, yet perfectly solid owing to pressure.

159. For purposes of study the crust is divided into zones: The zone of *Katamorphism,* which is subdivided into two belts;

the belt of *weathering,* and the belt of *cementation:* and the zone of *anamorphism,* not subdivided. [See glossary.]

160. The belt of *weathering* extends from the surface to the lowest level of ground-water. In this belt minerals are hydrated, oxidized, carbonated, or dissolved, depending upon local conditions, hydration being the most common reaction, and oxidation next. A hydrated mineral is one containing water of crystallization. [See glossary]. The quantity of hydrated minerals in this belt is exceedingly great. A few examples with the percentage of water follows: Borax, 47.2% water; Boric acid, 43.6% water; Gibbsite, 34.6% water; Brucite, 31% water; Bauxite, 26.1% water; Gypsum, 20.9% water; and the Zeolites with 8 to 28% water. There are many others. Among the oxides we find the oxid of every metal except gold. Among the carbonates we have lead, copper, zinc, iron, calcium and barium carbonates. Solution is the most characteristic reaction of this belt.

161. The belt of *cementation* begins at the water level and extends down to the beginning of rock flowage, or to a depth of six or seven miles. It is much thicker than the belt of weathering. Hydration is the most common reaction, and precipitation, or the act of making solid compact rock, is the most common occurrence. Water is present but not circulating water produced by rain or snow as in the belt of weathering.

162. The zone of *anamorphism* begins at a depth of about six or seven miles and extends to unknown depths. In this zone there are no rock openings or cracks, and minerals are of a very complex composition, the formation of silicates being the most important reaction. Deoxidation and dehydration also take place.

Metamorphism.

163. As here used the word metamorphism denotes any change that may occur in the texture or composition of a rock or mineral. Rocks are slowly and constantly changing in texture and mineral composition. Heat, pressure, chemical affinity and the slow circulation of water cause these alterations. The primary, or first cause of metamorphism, is chemical affinity, or the natural tendency of the elements to combine as minerals. The particular minerals formed will depend upon the degree of heat and pressure, and the elements present. When there is a change in the degree of heat, pressure, or water circulation, a corresponding change in the mineral composition or the rock takes place. Such changes are called metamorphism. [190]. The alterations may occur in the rock without the addition of any outside material, as by pressure

alone, or other material may be added. Metamorphism may occur—

1. Without a chemical change:
    - a. By molecular re-arrangement.
    - b. By re-crystallization.
2. With a chemical change:
    - a. By addition or subtraction of elements.
    - b. Without addition or subtraction of elements.
    - c. By substitution of elements.

164. Metamorphism may be attended with the absorption or evolution of heat. It may cause either expansion or contraction, or neither one, according to circumstances.

165. The important alterations are as follows:

Oxidation, adding oxygen.
Deoxidation, subtracting oxygen.
Hydration, adding water.
Dehydration, subtracting water.
Carbonation, adding carbon dioxid, CO_2.
Decarbonation, subtracting carbon dioxid.
Silication, adding silica.
Desilication, subtracting silica.
Sulfidation, adding sulfur.
Desulfidation, subtracting sulfur.

166. When a mineral is altered by metamorphism its specific gravity, size, color, and hardness may change, and any one or all of these changes may occur in any particular case, depending upon the circumstances. Like conditions always produce like results.

167. If a mineral in a certain dike, stratum or region undergoes metamorphism, forming a product of greater volume than that of the original mineral, a general expansion will take place, causing pressure in every direction. This produces what is commonly called swelling ground. If a shrinkage occurs, the rock may crack or drop to a lower level. Either of these changes in volume may be the cause of slow rock flowage, or sudden movement severe enough in some cases to produce earthquakes, depending upon circumstances.

168. Metamorphic changes usually cause an absorption or liberation of heat. If the reaction is that of a combination, as

most surface and zone-of-weathering reactions are, heat will be liberated. If the reactions are dissociations, especially at high temperatures and under great pressure, absorption of heat occurs. One can now understand how metamorphism and the circulation of underground waters play their respective parts in carrying heat from the interior of the earth to the surface. Generally, the heat liberated by near-surface metamorphism has a tendency to hasten and assist chemical reactions. If space permitted, many cases exemplifying the above statements could be given. One will be given: When hematite alters to limonite by chemically uniting with water, there is an increase of 60.72% in volume and heat is set free. (The volume of the water before the combination is not considered). It may seem strange, but rocks will absorb and chemically combine with water or gasses needed by the minerals in the rock, apparently against the expansive force of the enlarging minerals.

169. It should be observed that most of the alterations of minerals may be reversed under reverse circumstances. For example, a mineral may be oxidized by an oxidizing agent, and later the oxidized product may be reduced (deoxidized) by the action of sulfids or other reducing agents.

170. TABLE OF METAMORPHISM.*

Original Mineral.	*Alteration product or products. The alteration product will vary under varying conditions.*	*A = Addition.* *S = Subtraction.* *O = Oxidation.* *Do = Deoxidation.* *H = Hydration.* *Dh = Dehydration.* *C = Carbonation.* *Dc = Decarbona.* *Si = Silication.* *Dsi = Desilication.* *S = Sulfidation.* *Ds = Desulfidation.* *Sub = Substitution.*	*Increase or decrease in volume over the original volume. Per cent.*
Feldspars			
Albite	Epistilbite-zeolite	H & C	+37.50
	Kaolin and quartz	H, C & Dsi	— 4.89
	Gibbsite and quartz	H, C & Dsi	+ 1.58
Orthoclase	Kaolin and quartz	H, C & Dsi	—12.57
	Kaolin (quartz dissolved)	H, C & Dsi	—54.44
	Muscovite and quartz	H, C & Dsi	—15.58
Microcline	(Same as orthoclase.)		
Anorthoclase	Kaolin and quartz	H, C & Dsi	— 9.56

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*Taken from a Treatise on Metamorphism, by Van Hise, and rearranged.

Micas			
Muscovite with $MgCO_3$	Vermiculite	H & A	
	Serpentine	H & Do	+16.50
	Talc	H & Do	—25.23
	Talc and gibbsite	H & Do	+41.69
	Serpentine and gibbsite	H & Do	+88.44
	Parogonite	Sub	— 2.67
Biotite	Hydrobiotite	H & C	+ 3.8
	Chlorite	H & C	+22.92
	Epidote	H & C	
Phlogopite	Hydro-phlogopite	H & C	+26.89
	Chlorite-penninite	H & C	+41.02
Orthorhombic pyroxenes			
Enstatite	Talc	H & C	+ 9.93
Bronzite or Hypersthene.	Bastite	H & Dsi	+22.77
Monoclinic pyroxenes			
Diopside	Talc	H, C & Dsi	—30.13
	Serpentine, quartz and calcite.	H, C & Dsi	+56.32
Augite	Hornblende	Sub	+ 4.30
Orthorhombic amphibole			
Anthophyllite	Talc and hematite	H & O	+11.41
Monoclinic amphiboles			
Tremolite	Talc (clacite dissolved)	H & C	— .83
	Talc and calcite	H & C	+25.61
	Talc (other products dissolved.)	H, C, O & Dsi	—36.51
Actinolite	Talc, calcite, hermatite and quartz.	H, C, O & Dsi	+20.83
Hornblende	Augite	Sub	— 4.13
Hornblende + quartz, etc.	Biotite, calcite, etc	H, C & Si	+41.13
Garnet group—	Chlorite, talc or serpentine.	H or H & C	
Chrysotile—			
Olivine	Serpentine(Fe dissolved.)	H & O	+29.96
	Serpentine, magnetite and quartz.	H, O & Dsi	+12.20
Olivine	Cromite		
Serpentine-talc—			
Serpentine (seldom altered) Talc (not altered).	Magnesite, brucite and quartz.	C	+13.02
Metallic minerals, etc.-			
Gypsum	Calcite	C, Dh, Ds	—50.29
Limonite	Siderite	C, Do & Dh	+22.27
Aragonite	Calcite	Molecular	+ 8.35
Marcasite	Pyrite		— 2.98
Calcite	Dolomite	Subs	—12.00
Limestone, impure calcareous schists	Garnet-rock		

171. There are several metamorphic changes in rocks which deserve special mention; as:

The alteration of feldspars to clay and kaolin.
" " " limestone to marble.
" " " sandstone to quartzite.
" " " limestone to dolomite.
" " " sediments to shale or slate.

These alterations are of common occurrence and can be detected by any miner or prospector.

172. When an igneous extrusion or intrusion cools quickly a glassy product, as obsidian, is formed. The same molten material might have made granite if cooled slowly, as obsidian and some varieties of granite have the same chemical composition. Rocks may or may not differ in chemical composition: In either case their texture is largely a matter of the rate of cooling. That is, two rocks, entirely different in appearance and texture, may have the same chemical composition. A dike may be quite homogenous in mineral composition at the sides where the cooling was rapid, yet it may be crystalline and contain distinct crystals near the center where the slow rate of cooling has permitted the elements to come together in accordance with their chemical likes and dislikes, so to speak, although the chemical composition of the central and outer portions of the dike may be the same. [67]. Sometimes elements move through rock to great distances, chiefly with the aid of water, for the purpose of forming a mineral. It is now believed that even deep-seated, heated rock contains more or less moisture. But it is not necessary to rely solely upon water as a transporter of the mineral forming elements; many substances are transported in the form of a vapor or gas.

173. SECONDARY ENRICHMENT.—This is a metamorphic process in which minerals are taken from one or more portions of a vein and accumulated in a section of comparatively smaller volume. When veins were first formed the metallic minerals were much more uniformly distributed than they now are. Circulating waters have transported the minerals from place to place, each removal usually resulting in a concentration. In some cases these waters moved upward, and in others the waters moved horizontally from the wall rock to the vein; but in a majority of cases meteoric water (rain water) dissolved the minerals from the upper portions of the veins and carried them down to the zone of sulfids where they were precipitated. The continuation of this work has produced what is termed "secondary enrichment."

The alterations relating to metallic minerals may be briefly summarized as follows: [See 165].

174. *Copper.*

Calcocite alters to metallic copper by desulfidation.
Metallic copper alters to cuprite by oxidation.
Cuprite alters to tenorite by oxidation.
Tenorite alters to malachite by carbonation and hydration.
Malacite alters to azurite by further carbonation.

The reverse of these alterations takes place when solutions containing copper descend to the zone of sulfids, where the copper is precipitated, thus causing a secondary enrichment of the ore body. [748].

175. *Gold.*

No known alterations can be given. However, gold must have been in solution some time previous to its deposition in quartz veins. Often the ores in the zone of oxidation are very rich in gold, while in the zone of sulfids below they are low grade*

This condition must have been caused by solution and downward concentration. Possibly the gold was disolved in ferric chlorid, cupric chlorid, sodic carbonate, or alkaline sulfid solutions.

176. *Silver.*

Silver sulfid alters to metallic silver by oxidation.
Silver sulfid alters to silver sulfate by oxidation.
Silver sulfid with salt alters to silver chlorid and sodium sulfate by desulfidation and chloridation.

The sulfantimonite and sulfantimonate, sulfarsenites and sulfarsenates are similarly altered:

177. In general—
Silver chlorid + base sulfid = base chlorid + silver sulfid.

This reaction takes place when downward percolating waters carry silver solutions into the sulfid zone where the silver is precipitated, thus causing a secondary enrichment.

178. *Lead.*

Galena alters to cerussite by carbonation.
Galena alters to anglesite by oxidation.
Cerussite and anglesite often encrust galena as a proof of the above alterations.

Reverse reactions may occur with descending solutions.

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*Lindgren, 17th Rpt. U. S. Geol. Survey.

179. *Zinc.*

Sphalerite alters to zinc sulfate by oxidation.
Zinc sulfate alters to zinc silicate by silication.
Zinc sulfate alters to zinc carbonate by carbonation.
The carbonation is often effected by the limestone wall rock.
The reverse reactions may occur under reverse conditions.

180 *Iron.*

Pyrite alters to hematite by oxidation and desulfidation.
Pyrite alters to magnetite by oxidation and desulfidation.
Hematite alters to limonite by hydration.
Hematite alters to siderite by carbonation.
Hematite alters to pyrite by sulfidation.
Pyrrhotite alters to pyrite by sulfidation.
Pyrrhotite alters to magnetite by oxidation and desulfidation.

181. Circulating ground waters from the surface to what is called the ''water line'' are oxidizing and desulfurizing. At and below the so-called ''water line'' the water circulates very slowly and contains very little free oxygen. For this reason deep waters tend to keep minerals in the sulfid or base form.

182. The evidences of weathering are often seen by crushing a mineral and examining it under a magnifying glass. The interior will differ from the outer walls, the center being usually more solid and of a darker color than the outside. Evidences of metamorphism are most easily detected by comparing samples of a formation taken several feet apart. That portion of a dike or formation adjacent to or near a later igneous formation will differ in texture and possibly in mineral composition from those portions of the formation more distantly situated. This is because metamorphism has been promoted by the heat of the late intrusion and was most intense nearest the intruded rock.

Knowledge of Rocks.

183. Only a limited knowledge of rock classification is necessary for the precious metal prospector, for the reason that such information will be of but slight assistance. Owing to the fact that the influence of wall rock upon vein formation is not very well understood it follows that the naming of the wall rock has but little known bearing upon the value of a vein. [379]. If one is prospecting for the rare minerals, such as rutile, cassiterite, tantalite, monazite, molybdenite, etc., a knowledge of rocks will be quite useful, however.

184. Rocks are often difficult to classify, especially when two or more kinds blend into each other almost imperceptibly. Many of the igneous rocks will usually be too difficult to determine. Only when typical in texture and composition can they be distinguished by the prospector. In such cases he should be able to identify the following rocks with the aid of a pocketknife and magnifying lens:

Sedimentary rocks.	Sandstone. Limestone. Conglomerate
Sedimentary, metamorphic rocks.	Quartzsite Marble Slate
Igneous rocks.	Granite Diorite Basalt Gabbro Porphyry Rhyolite Obsidian Trachyte

185. Sedimentary rocks are those that were precipitated from the waters of streams, lakes, or oceans; hence they are usually stratified, that is, laid in layers. These layers have since, in many cases, been wonderfully folded, warped, and contorted by the unequal pressures exerted in the earth's crust. [See Fig. 11].

186. Sedimentary rocks are usually found overlying igneous rocks, but in cases where comparatively recent lavas have flown from volcanoes or fissures, the reverse condition exists, still, in any case, igneous rock will be found beneath all sedimentary rocks at some depth.

187. Sandstone.—A sedimentary rock of a granular texture made of grains of sand cemented together. It results from the action of water or glaciers. Light colored.

188. Limestone.—A sedimentary rock having a compact, granular texture. Color white, gray, brown or (rarely) bluish. Composed of lime, sand and clay, the lime being derived from marine shells. Dolomite is a variety containing magnesia in place of part of the lime. Limestone effervesces in nitric, hydrochloric or sulfuric acid. Pure dolomite must be heated with the acid in a test tube before it will effervesce.

189. Conglomerate.—A sedimentary rock composed of a mixture of stones cemented together. When the stones are quite

rounded it is called a pudding stone; when composed of angular fragments it is called a breccia.

190. Metamorphic rocks are generally sedimentary rocks that have been changed in texture by pressure, moisture and heat, [163] the heat having been supplied by igneous dikes or intrusions. Igneous rocks are sometimes metamorphosed by later intrusions. When a sedimentary rock is intensely metamorphosed the original minerals are altered to other kinds and the stratification almost entirely obliterated, making it difficult to distinguish from igneous rock. It is only by the use of the petrographic microscope under the hands of a skilled mineralogist and petrographer that highly metamorphosed sedimentary rock can be distinguished from igneous rock. [67].

191. Quartzite.—Metamorphosed sandstone. A strong Coddington lense should show the granular texture. When it becomes difficult to distinguish from true quartz one must examine the rock in place, taking note of the formation on either side. Quartzite will have sedimentary rock on one or both sides of it as a rule.

192. Marble.—Metamorphosed limestone. Effervesces with any acid, even with vinegar.

193. Slate.—This is really dried, compressed, metamorphosed silt or mud. Texture granular. Laminated or (usually) cleavable into thin plates. When the mud or silt has been simply dried and compressed but not metamorphosed it is called shale. Shale breaks up into small scales or flakes.

194. Igneous rocks.—Those that have been formed by cooling from a molten condition. They are almost invariably highly crystalline, and the individual grains, or crystals, are usually angular—not rounded as they are in sedimentary rocks. The central part of an igneous dike or ejection will be more coarsely crystalline than the borders, because the slow rate of cooling at the center favors crystallization.

195. Granite.—An igneous rock of a decided granular structure, and consisting of quartz, mica, and orthoclase feldspar. Either one of these minerals may be present in large or small amounts, or even absent, though in typical granite all three are present. The feldspar is usually most abundant and the most perfectly crystallized, the mica following next, and the quartz last. The feldspar is whitish to pinkish in color, the mica is usually brown or black, but sometimes light colored.

196. There are many varieties of granite, some of which have other feldspars replacing a part of the orthoclase. Hornblende often replaces mica, especially in the variety called syenite.

197. Pegmatite, aplite, greisen, etc., are varieties of granite.

198. a. Pegmatite is an exceedingly coarse-grained granite, the crystals being very large with little or no fine-grained groundmass.

199. b. Aplite is a fine-grained granite with little mica.

200. c. Greisen is a granite with little or no feldspar and having a coarse texture. The gangue of tin ore is usually Greisen.

201. Diorite.—An igneous (generally intrusive) rock having a compact, granular texture, but usually finer grained than granite. Color olive-green to almost black. Composed chiefly of soda-lime feldspar (plagioclase) and hornblende, with usually a little mica or pyroxene. [93]. Quartz is usually absent or scarce. The hornblende is usually black-green (hence the rock is often called green-stone), and in long crystals. In the brown and blackish varieties of this rock the hornblende is usually in short, stout crystals. The feldspar is usually the oligoclase variety, in tabular crystals. Tabular crystals of other plagioclase feldspars may predominate, however. When other minerals are present in marked amount a qualifying adjective is placed before the word diorite, as quartz-diorite, pyroxene-diorite, etc. Andesite is a variety found plentifully in the Andes Mountains.

202. Basalt.—This igneous (usually extrusive rock may be most easily understood by subdividing it into three varieties; namely, dolorite, which is coarse-grained; anamesite, which is medium fine-grained; and basalt proper, which is very fine-grained. These different varieties are produced by variations in the rate of cooling of certain basic rock. The basalts are usually dark colored. Dolorite consists chiefly of plagioclase feldspar and the augite variety of pyroxene. The former is light to gray, and the latter brown, red or green. Anamesite has the same composition, but the crystals cannot be distinguished without a lens. Olivene is sometimes present in amounts sufficient to be distinguished without a lens. Basalt proper is microcrystalline [91] to homogeneous in texture. [See glossary]. Color grayish to brown, or blue-black. It usually occurs in columnar form, as at Giants Causeway, Ireland, and at Devils Post Pile, California, and at several places along Table Mountain, in California. All three varieties usually contain pores or vessicles, especially basalt proper. Sometimes these cavities are large enough to contain a man standing, and they are usually lined with a vitreous crust. Infiltration often fills these cavities with lime or some other mineral (as zeolite), forming amygdaloids.

203. Gabbro.—This igneous (usually intrusive) rock may also be subdivided into varieties. Classified according to mineral composition these would be as follows:

Gabbro (true), in which plagioclase feldspar predominates.
Peridotites, in which olivine predominates.
Pyroxenites, in which pyroxene predominates.

204. a. Typical gabbro is an equidimensional, coarse-grained, granular mixture of plagioclase [93] and diallage pyroxene with some magnetite, titanite, apatite or olivine (or all of these) present. The olivine often alters to sepentine. Color greenish to very dark or black. Diabase is a fine-grained variety. Norite and melaphyre are almost glassy varieties.

205. b. Peridotite is free from feldspar and contains much olivine with some pyroxene and (or) hornblende.

206. c. Pyroxenite is free from plagioclase or olivine with pyroxene predominating. Texture granular.

207. Porphyry.—Properly, this word should not be used as the name of a rock, but adjectively; as, porphyritic granite, etc. If it is used as a noun it should be restricted to rocks containing a feldspathic groundmass, or base, with comparatively large crystals of orthoclase feldspar scattered through it. In a general sense it is often used for any rock consisting of a fine groundmass in which there are crystals (phenocrysts) of any kind that are sufficiently large and perfect to be distinguished with the unaided eye.

208. a. Typical quartz porphyry has a groundmass of fine hornstone, feldstone, or claystone with well defined crystals of feldspar, quartz and, sometimes, mica scattered through it.

209. b. Porphyritic granite is a rock consisting of a groundmass in which the feldspar crystals are especially large and well defined.

210. c. There is a porphyritic condition of nearly every igneous rock known; as, porphyritic diorite, porphyritic diabase, etc.

211. Rhyolite.—An acid [glossary], extrusive, igneous rock which has a compact (sometimes drusy) groundmass, with crystalline grains of sanidine and quartz scattered through it. Mica is often present in visible grains—also magnetite. Occurs in sheets and beds. Color yellowish, ash-gray, redish or greenish. It has a shiny, almost vitreous luster.

212. Obsidian.—Volcanic glass. The color varies from brown to red. Looks like melted, colored glass.

213. Trachyte.—A rough, sandpaper-feeling, fine-grained groundmass with a few crystals of glass or sanidine of visible size. Usually the grains are sufficiently well defined to call the rock porphyritic.

214. It will be observed that many igneous rocks are made up of a fine-grained or vitreous groundmass, with crystalline grains of a larger size scattered throughout. By taking this fact into consideration rock study will be rendered less difficult. The crystalline grains scattered through the groundmass are important in determining the name of an igneous rock, and should be carefully observed. Experts in geology often have slides made for microscopical examination before naming an igneous rock.

215. Rocks are distinguished from each other chiefly by their mineral constituents; therefore, unless we can identify the common rock forming minerals we can never hope to name rocks. The miner reads in the preceding pages of certain rocks containing olivine, pyroxene, hornblende, orthoclase, or sanidine as characteristic minerals, but if he cannot identify these minerals he can not, as a consequence, identify the rocks containing them. In order to learn the chief characteristics of the rock forming minerals he should buy specimens of the nearly pure minerals and familiarize himself with the hardness, luster, and crystalline form, etc., of each one. [93].

216. Geologic formation of certain districts.—If you desire to learn something about the geologic formation of any particular district address

The Director,
U. S. Geological Survey,
Washington, D. C.

and briefly ask for a ''List of publications of the Geological Survey.'' From the list of geological folios select the one you wish and order by number, enclosing 25 cents for each copy.

CHAPTER IV.

TESTING THE SAMPLES.

Blowpipe Tests.

217. Many minerals may be very conveniently tested with a blowpipe.* This useful instrument is shown in Figs. 14 and 15. With it almost any mineral may be determined by the use of suitable fluxes, but it cannot be used in the field. To use it properly requires a great amount of skill and knowledge, however. The following articles and fluxes will be required, though others may be added to the list as suggested by reading the detailed tests.

218. Blowpipe Outfit.

Blowpipe. (Figs. 14 and 15.)
Charcoal. (Compressed sticks are the best).
Sodium bicarbonate.
Pulverized borax glass (pure).
Microcosmic salt.
Platinum wire, 6 inches long.
Alcohol lamp.
Wood alcohol (poison).
Gypsum tablet (make it out of plaster Paris).
Acid dropping bottles. (Fig. 16).
Sulfuric acid (called oil of vitrol).
Nitric acid (called aqua fortis).
Hydrochloric acid (called muriatic acid).
Porcelain mortar and pestle (small size).
Test tubes.
Closed tubes, ignition glass.
Litmus paper.
Tumeric paper.
Funnel.
Filter paper.

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*One of the best books on blowpipe analysis is Brush Penfield's Determinative Mineralogy and Blowpipe Analysis. Price $4.50.

Fig. 14. Plain Blowpipe.

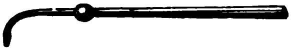

Fig. 15. Bulb Blowpipe.

Fig. 16. Acid Dropping Bottle.

Fig. 17. Platinum Tipped Pincers.

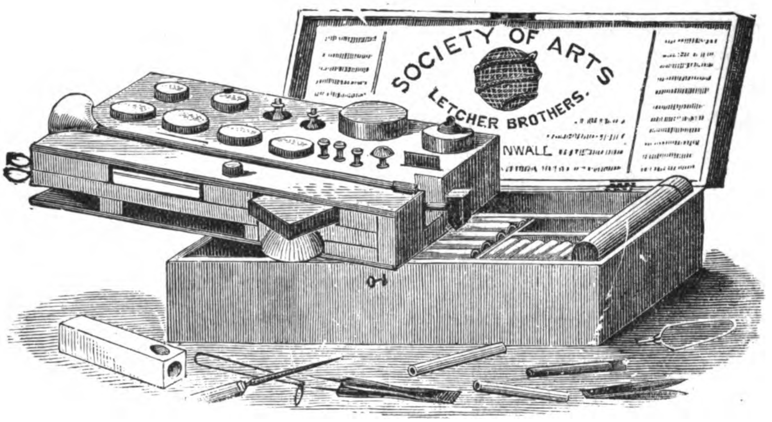

Fig. 18. Complete Blowpipe Set.

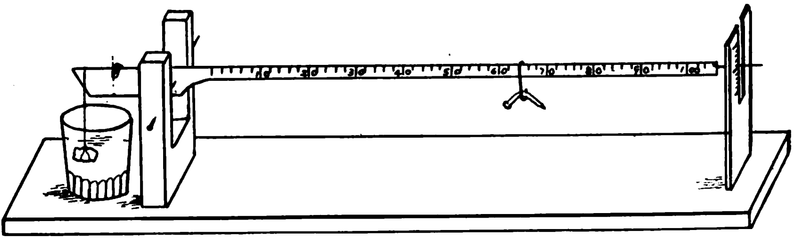

Fig. 19. Home-Made Specific Gravity Balance.

A large box in which to pack the above.

Diamond mortar. The diamond mortar is made of hard steel and is not easily broken, but a trace of iron will be obtained after grinding a sample in it. The writer prefers the small porcelain mortar. Besides, the former costs $4.00 and the latter only 25 cents.

219. Seal all acid bottles with parafin for transportation. When reagents are subject to rough treatment in transportation use parafin and then surround the stopper and bottle-mouth with plaster of Paris to keep the stopper from being loosened. Remove the rubber nipple from the acid dropping bottle and close the opening with a small rubber cork and then parafin and use the plaster of Paris, as otherwise the acid might destroy the nipple during transportation.

220. It must be understood that blowpipe tests do not give the percentage of a metal or element in a sample, and do not in any way take the place of the assay furnace, except that by experience one may judge the comparative richness of ores.

221. The following instructions for the use of the blowpipe will be found adequate for the prospector. If more knowledge is desired consult a text book on Blowpipe Analysis.

222. FLAME TESTS.—These are made by placing the pulverized mineral upon charcoal and blowing a flame upon it, observing the flame color. Oxidation is produced at the end of the flame, and reduction at the end of the inner cone of the flame. Many minerals give the flame test best after they have been moistened with hydrochloric acid. Use the dropping bottle so as not to get the slightest trace of the mineral in the acid bottle. Never touch a mineral with the cork of any reagent bottle, as this is almost certain to contaminate the entire bottle of acid.

223. BEAD TESTS.—These are made by heating the looped platinum wire red hot and then plunging it into the flux and again heating with the blowpipe. Borax, soda, and microcosmic salt beads are used. In making the last, use a very low heat or the bead will drop off.

224. *Borax bead.* Fuses to a clear, colorless glass.

225. *Soda bead.* Fuses to a milk-white glass.

226. *Microcosmic bead.* Fuses to a clear, colorless glass.

227. After the bead has been made it is touched to a few particles of mineral while still hot and then heated again, and the color of the bead observed. After the test clean the wire by fusing borax on it repeatedly until no color remains. [237].

228. CLOSED TUBE TESTS.—These are made by placing a small

amount of powdered mineral in the ignition tube and intensely heating. Fumes and sublimates are observed.

229. Charcoal Tests.—These are made by placing a portion of the pulverized mineral upon the charcoal and intensely heating. The fumes, sublimates upon the charcoal, and the fused mass are observed. Some minerals are, of course, infusible alone. These are mixed with the proper flux and heated again. Very few tests can be made without fluxes. To prevent the powdered ore and flux from blowing away, first moisten them with water to make a paste.

230. Chemical Tests.—These are made by pulverizing the mineral and treating with acids in a test tube. The solution is filtered to separate the residue of rock and then the reagents added as indicated in the following pages under "Chemical Test."

231. Specific Gravity Test.—By making this test the possible minerals may be narrowed down to only a few, thus saving time by the elimination.

232. A specific gravity balance may be easily constructed of inexpensive material. The dimensions need not be of any exact proportions. The length of the beam, and the size of the weight are immaterial, and the distance between the divisions on the beam is also immaterial, except that the divisions must all be the same distance apart. The beam end that supports the mineral should be comparatively short, say two inches long, and the other end light and long, say 20 inches. The same weights must be used to weigh the specimen both in and out of the water, but different weights may be used with different specimens. Nails may be used for weights. A hair, or fine silk thread, may be used to support the mineral. Specimens for testing should be quite pure to give reliable results. A home-made specific gravity balance is shown in Fig. 19.

233. $$\text{Specific gravity} = \frac{\text{Weight in air}}{(\text{weight in air})-(\text{weight in water})}$$

234. That is, the specific gravity equals the weight in air divided by the difference between the weight in air and in water.

235. To find the weight of gold in a piece of specimen quartz when no other minerals are present see section 1106.

Hints.

236. Do not heat lead, antimony, tin or bismuth minerals in the platinum wire or on the platinum foil, because these will fuse with the platinum.

237. A bead may be removed from the platinum loop by giving it a sharp jerk while the bead is hot.

238. Considerable judgment must be used in following these instructions, as they are very brief.

239. Platinum tipped forceps [Fig. 17] are useful for holding mineral fragments, especially if acid is to be used on the pieces. These forceps cost $2.50. A piece of platinum foil, costing $1.00, may be used instead. Hold the foil in a pair of iron pincers.

240. Litmus paper can be used in chemical tests to tell when a solution is acid or alkaline. Acid turns litmus paper red, and alkali turns it blue.

Abbreviations used.

B. p. = Before the blowpipe.
R. f. = Reducing flame.
O. f. = Oxidizing flame.
Pp. = Precipitate.
Soda. = Sodium bicarbonate.

Chemical symbols.

HCl,	Hydrochloric acid.
HNO_3,	Nitric acid.
H_2SO_4,	Sulfuric acid.
NH_4OH,	Ammonium hydroxid.
$(NH_4)_2CO_3$,	Ammonium carbonate.

TABLE OF REACTIONS WITH THE BLOWPIPE.

Aluminum.

241. Chemical test.—Pulverize. Mix with equal parts of sodium bicarbonate and potassium carbonate. Fuse in a platinum wire loop or in a porcelain crucible. Dissolve the melt in dilute HCl and add a drop of HNO_3, boiling if necessary. Filter. To the filtrate add NH_4OH. Result: The pp. will contain iron, aluminum and chronium. Filter. Treat the pp. repeatedly with a hot solution of potassium hydrate. This dissolves the aluminum only. Filter. Barely acidulate the filtrate with HCl, testing with litmus paper, and then add ammonium carbonate solution. Result: A white pp. for aluminum.

Antimony.

242. Charcoal test.—Pulverize. Heat on charcoal in the o. f. Result: It fuses readily and yields dense white fumes, especially if the flame be played upon the assay intermittently.

Arsenic.

243. Charcoal test.—All the common arsenic bearing minerals may be tested by heating alone on charcoal. Result: A garlic-like odor.

Bismuth.

244. Charcoal test.—Pulverize. Mix with four parts of a mixture of sulfur and potassium iodid. Heat on charcoal with a small o. f. Result: A yellow coating on the charcoal fringed with bright red.

Borax.

245. Special test.—Treat the pulverized mineral in a porcelain dish with hot, strong H_2SO_4. Cool. Add alcohol and ignite. Result: A green flame indicates boron.

Calcium.

246. Charcoal test.—Calcium in calcite, marble, dolomite, or limestone, may be detected by intensely heating a fragment in the forceps or on charcoal. Result: It will glow as brightly as the sun.

247. Flame test.—Moisten with HCl and heat in the flame and view through the cobalt-blue glass. A yellow-red color indicates calcium.

Carbonates of any element.

248. Special test.—Pulverize. Place in a test tube. Add any mineral acid and heat. Result: Effervescence.

Chronium.

249. Special test.—Fuse the pulverized mineral in a platinum loop or on platinum foil with equal parts of sodium bicarbonate, potassium carbonate and nitre. The fused mass will be yellowish-green if chronium is present. For further proof dissolve the melt in water and filter. Acidify with acetic acid (use litmus paper), and add a little lead acetate. Result: A yellow pp. of lead chromate.

Coal.

250. Special test.—Pulverize a sample and dry it at a very low heat. Cool. Weigh and heat in a platinum crucible or porcelain capsule over a bunsen burner or gas stove flame. After all the carbonaeceous matter has been consumed, cool and weigh. The ash should not exceed 10% in anthracite or 20% in bituminous coal. [736].

Cobalt.

251. Bead test.—Pulverize. Fuse in a borax bead. Result: A blue bead much like the copper bead.

Copper.

252. Flame test.—Pulverize. Roast if the sample is a sulfid. Place on charcoal and add a drop of HCl. Apply the o. f. Result: An intensely blue flame tinged with green.

253. Bead test.—Pulverize. Roast if a sulfid. Fuse in a borax bead. Result: A deep blue for copper, and light blue for cobalt.

254. Charcoal test.—Pulverize. Roast if a sulfid. Fuse on charcoal with a mixture of sodium bicarbonate and borax glass. This test is best suited for carbonates and oxids. Result: Beads of metallic copper.

255. Chemical test.—Pulverize. Roast if necessary, and dissolve in $HCl + HNO_3$. Dilute slightly and filter if necessary. Divide into two portions. To one portion cautiously add NH_4OH. Result: A blue color after the precipitated iron settles. In the other portion insert a polished iron wire. Result: A coating of metallic copper on the wire.

Gold.

256. There is no good test for gold except the regular fire assay. As a rule, if no gold can be found by the use of Way's Pocket Smelter the ore is too low grade to work. The following test is, perhaps, as good as any: Pulverize about two ounces of ore and roast if any sulfids are present. Place in a glass or porcelain dish. Add several crystals of iodin and enough grain alcohol to cover it. Let it stand half an hour. Moisten a strip of filter paper in the solution, dry and ignite it. Result: A purple colored ash for gold.

257. The writer prefers the following method: Pulverize. Roast if any sulfid minerals are present and place a weighed sample of four to six Assay Tons in a 10 or 12 ounce bottle with a globule of mercury the size of a pea and fill the bottle half full of water. Shake the bottle vigorously for at least 20 minutes. Carefully horn the pulp over a pan so as to catch any mercury that may be washed over. Horn the tailings over again. Place the recovered globule of mercury in a test tube and add dilute HNO_3. Warm till the mercury is all dissolved. There is no danger from salivation. The gold will remain undissolved, and may be washed and weighed. It will be sufficiently accurate for the prospector's purposes to consider each ounce as one ton, in which case each milligram of

gold will represent one ounce of gold to the ton of ore, if one ounce of sample has been taken for the test. If more than one ounce is taken divide by the number of ounces.

Iron.

258. Charcoal test.—Pulverize. Roast if a sulfid, then heat on charcoal in the reducing flame. Cool. Result: It becomes magnetic.

259. Bead test.—To detect small amounts of iron pulverize and roast if necessary. Then fuse in the borax bead. Result: Yellow to red-brown in the reducing flame when hot; colorless to yellow when cold.

260. Chemical test.—To detect very small amounts of iron, as in the silicate minerals, pulverize, roast, fuse with borax glass on charcoal or in a closed tube. Pulverize again. Dissolve in a mixture of HCl and HNO_3. Cautiously add NH_4OH till alkaline. Result: A red-brown pp. indicates iron. (A blue solution indicates copper). For this test do not pulverize the mineral with anything made of iron; use rock against rock, or use the porcelain mortar.

Lead.

261. Charcoal test.—Pulverize. Fuse on charcoal with pulverized charcoal and sodium bicarbonate. Result: A bead of metallic lead. Collect the beads and heat them on charcoal in the o. f. Result: A sulfur-yellow color on the charcoal indicates lead.

Lithium.

262. Flame test.—Heat in the forceps with the blowpipe flame, looking through a cobalt-blue glass at the same time. Result: A deep crimson color.

Magnesium.

263. Special test.—Minerals containing magnesium are practically infusible alone. Pulverize, and fuse on charcoal, or in a capsule, with sodium bicarbonate and potassium carbonate. Dissolve the melt in dilute HCl. Add NH_4OH till alkaline. (Use litmus paper). Filter if there is a pp. Add $(NH_4)_2CO_3$. Result: A white pp. of calcium, barium and strontium. Filter. To the filtrate add sodium hydrogen phosphate. Result: A white pp. for magnesium.

Manganese.

264. Bead test.—Pulverize and fuse in the o. f. in a borax bead, using only a small amount of the mineral. Result: A deep amethyst color.

265. The microcosmic salt bead gives the same result.

266. Pulverize and fuse in the soda bead in the o. f. Result: Green when hot and blue-green when cold.

Mercury.

267. Closed tube test.—Mix the pulverized mineral with four parts of sodium bicarbonate and heat in the closed ignition tube. Small globules of mercury will collect on the sides of the cold part of the tube. Use a magnifying lens if necessary.

Nickel.

268. Chemical test.—Pulverize. Dissolve in HNO_3. The solution is greenish if nickel is present. Filter. Add NH_4OH. Result: Pale blue colored solution.

Platinum.

269. There is no blowpipe test for platinum. Concentrate the sand supposed to contain platinum by panning and fuse the material which looks like platinum on charcoal with metallic lead and a very little borax. Hammer the lead bead (which now contains the platinum) into a thin sheet and dissolve it in a mixture of two parts water and one part HNO_3. Result: A residue containing gold, platinum, irridum, osmium, etc. Dissolve in $HNO_3 + HCl$. Result: A yellowish color suggests platinum. Evaporate to a small bulk and add HCl and evaporate down again. Dilute and filter. Add cautiously NH_4OH. Result: A yellow pp. containing platinum. The gold will be in the filtrate.

Potassium.

270. Flame test.—Any volatile substance containing potassium gives a deep violet color to the blowpipe flame, observed only through a cobalt-blue glass if sodium is present. Sodium gives a yellow flame.

Silver.

271. There is no good blowpipe test for silver in small amounts.

272. Charcoal test.—If silver is present in large amounts pulverize and roast on charcoal in the o. f. Result: A red-brown coating on the charcoal at a little distance from the assay.

273. Chemical test.—Pulverize. Fuse on charcoal with a mixture of soda and pulverized charcoal in the r. f. Pulverize and collect the beads by horning. If the beads are too small to be recognized dissolve them (with part of the fused mass if necessary) in dilute HNO_3. Boil and filter. To the cold filtrate add a few drops of HCl. Result: A white curdy pp. of silver and (or) lead.

Boiling will redissolve the lead pp. but not the silver. Filter hot. The pp. of silver chlorid on the filter paper will turn purple in the sunlight and will dissolve in NH_4OH. The filtrate may be tested for iron or copper by adding NH_4OH.

Sulfids or sulfates of any metal.

274. Special test.—Pulverize. Heat on charcoal with soda. Use the flame of an alcohol lamp, as city gas contains sulfur. Remove the melt and pulverize. Place on a polished silver coin and moisten with a drop of water. Result: A brown stain on the coin for sulfur.

Strontium.

275. Flame test.—Strontium yields a reddish flame viewed through the cobalt-blue glass. Compare with the crimson of lithium and yellow-red of calcium.

Tin.

276. Charcoal test.—Mix one part of pulverized ore with two parts of soda and one part of pulverized charcoal. Fuse on charcoal in the r. f. Result: A coating of white oxid of tin may result and globules of metallic tin will be formed. Collect the globules (use horn spoon) and dissolve them in dilute HNO_3. Result: Globules are changed to a white pp.

Tungsten.

277. Chemical test.—Pulverize. Dissolve in HCl. An insoluble canary-yellow tungstic oxid results. Add a little metallic tin and boil. Result: A blue solution which turns brown in time. [894, 895].

Water.

278. Many minerals contain water of crystallization. [160].

279. Closed tube test.—Heat the pulverized and thoroughly dried sample in a closed tube. The tube should first be heated and then cooled to dry it. Result: Globules of water will condense on the cool part of the tube. To dry the sample hold it over a flame on a piece of paper. This will heat it neither too much nor too little.

Zinc.

280. This metal is difficult to detect with a blowpipe. Chemical tests are also rather difficult for the inexperienced chemist.

281. Special test.—Make a mixture of soda and pulverized ore. Fuse in the platinum wire loop while held against the charcoal, using the r. f. Result: Canary-yellow coating on the charcoal when hot and white when cold.

282. *Minerals with hardness equal to or greater than quartz.*

Barite	7	Andalusite	7.5
Cyanite	7	Beryl	7.5
Tourmaline	7 to 7.5	Spinel	8.
Garnet	6.5 to 7.5	Topaz	8.
Iolite	7 to 7.5	Crysoberyl	8.5
Staurolite	7 to 7.5	Corundum	9.
Zircon	7.5	Diamond	10.

283. *Scale of hardness.*

1 Talc	3 Calcite	5 Apatite	7 Quartz	9 Corundum
2 Gypsum	4 Fluorite	6 Orthoclase	8 Topaz	10 Diamond

For the grouping of the metals according to the reagents that will precipitate them see section 1147. For solvents see section 1148. Atomic weights of the elements are given in section 1149.

284. *Minerals as soft or softer than gypsum.*

(Gypsum 2.)

Graphite, molybdenite, argentite, talc, pyrophyllite, orpiment, cerargyrite, cinnabar and sulfur.

285. *Examples of luster.*

Metallic.—Iron pyrites, galena and most sulfids. Opaque minerals.

Submetallic.—Ilmenite, columbite, tantalite, wolframite and a few others.

Adamantine.—Diamond, corundum, cassiterite, zircon, rutile, cerussite, anglesite, cerargyrite, cuprite, sphalerite (sometimes).

Resinous or waxy.—Sphalerite, elaeolite.

Vitreous.—Quartz, garnet, beryl.

Silky.—Satin spar, asbestos.

Pearly.—Foliated talc, cleavage faces of stilbite or feldspar.

286. TABLE OF MINERAL ASSOCIATION.

Two minerals	*Three minerals.*	*Four or more minerals.*
Galena Zinc blende	Galena, silver bearing Zinc blende Pyrite	Galena, silver bearing Zinc blende Pyrite Siderite Calcite Rhodochrosite

Tables of Mineral Association.

Pyrite Chalcopyrite or silver with Chalcopyrite	Pyrite Chalcopyrite Quartz or Chalcopyrite Sphalerite Silver minerals	Pyrite Chalcopyrite Quartz Galena Zinc blende Siderite Calcite Silver
Gold-bearing quartz Pyrite	Gold Pyrite Galena	Gold Pyrite Galena Zinc blende Siderite Calcite
Cobalt Nickel	Cobalt and nickel Pyrite	Cobalt and nickel Pyrite Galena Zinc blende Siderite Calcite
Tin Wolfram	Tin Wolfram Quartz	Tin Wolfram Quartz Mica Tourmaline Topaz
Gold Tellurium	Gold Tellurium Tetrahedrite	Gold Tellurium Tetrahedrite Quartz Siderite Calcite
Cinnabar Tetrahedrite	Cinnabar Tetrahedrite Pyrite	Cinnabar Tetrahedrite Pyrite Quartz Siderite (rarely) Calcite
Magnetite Chlorite	Magnetite Chlorite With metasomatic minerals, as in granite, slate, etc.	Magnetite Chlorite Garnet Pyroxene Hornblende Pyrite

Assaying.

287. As a rule it is not advisable for the prospector to do his own assaying, especially if he is not well skilled in the art. If he will make the simple tests described in this book he will not need many assays. However, as some may desire to do their own assaying brief directions will be given.

288. Assaying is smelting on a small scale, but with this difference: In smelting, a mixture of base and acid ores is used for fluxing, while in assaying chemical fluxes are used. Otherwise the fundamental principles are the same for each art.

289. From a fluxing standpoint minerals may be divided into two general classes: Base and acid. A base mineral contains an excess of base metal. An acid mineral contains an excess of silica (quartz). From a reduction standpoint minerals may be divided into two general divisions: Oxidizing and reducing. An oxidizing mineral contains an excess of oxygen that can be liberated. A reducing mineral is one that will rob other minerals or fluxes of oxygen. A classification of minerals and fluxes follows:

Base Minerals.

Lime (calcite).
Heavy spar (barites).
Iron minerals.
Manganese minerals.

Acid Minerals.

Quartz (Silica).
Silicates, such as feldspar, porphyry, granite, etc.

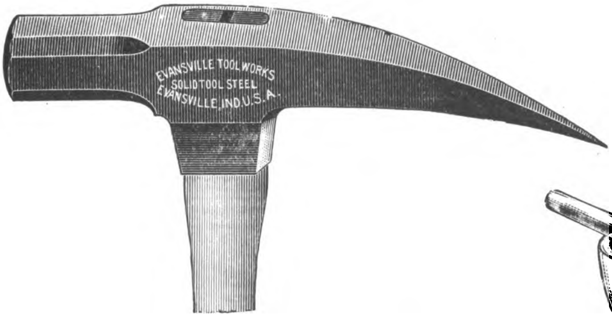

Fig. 20. Prospector's Single Hand Pick

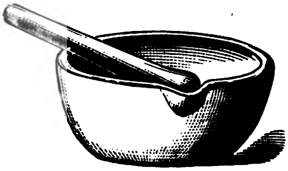

Fig. 21.
Wedgewood Mortar

Base Fluxes.	*Acid Fluxes.*
Litharge.	Borax.
Nitre.	Silica.
Sodium carbonate.	Glass.
Sodium bicarbonate.	

Oxidizing Minerals.	*Reducing Minerals.*
Hematite (iron oxid).	Sulfides of iron, copper, etc.
Limonite (hydrous iron oxid).	Antimonial sulfids.
Pyrolusite (manganese oxid).	Zinc sulfid.
Tenorite (red copper oxid).	Arsenical sulfids.
Melaconite (black copper oxid).	

290. PRINCIPLES INVOLVED.—According to one of nature's inevitable laws, either base or acid ores melt with difficulty alone, but when mixed in suitable proportions the mixture will melt readily at a moderate heat. For example, lime alone cannot be melted at any heat yet devised by man, and quartz alone melts only under a high heat; but lime and quartz, mixed in suitable proportions, will melt under the ordinary heat of the assay furnace. The only explanation of this is that base (metallic) elements have a natural tendency to chemically combine with acid elements, and that the product of the combination will become fluid at a lower temperature than will either element alone.

291. In fluxing, the operator of a smelter will mix base and acid ores in suitable proportions to make a fusible slag. The assayer, to produce a fusible slag, will mix base chemical fluxes with acid ores, and acid chemical fluxes with base ores, because each ore must be assayed separately. Assaying is, therefore, only an expensive method of smelting.

292. According to another inevitable law of nature, metallic oxids have a tendency to combine with non-metallic (acid) fluxes and minerals, the combination taking place at the ordinary temperature of the assay furnace. The mineralogist takes advantage of this law in blowpipe analysis. He heats a metallic mineral in the oxidizing flame till it is converted into an oxid. Then, by heating a small particle of this oxid in a borax or other suitable bead, a characteristically colored bead is produced. This enables him to determine the name of the mineral. The assayer also takes advantage of this law. The metals not wanted in the lead button are oxidized by using oxidizing fluxes so that they will chemically

combine with the acid fluxes, forming a slag. The metals which are desired in the lead button, as gold and silver, are not oxidized and they, for this reason, can not go into the slag but must settle to the bottom as a part of the lead button. Fortunately gold, silver and lead do not oxidize very readily, while most other metals do, so that it is an easy matter to get a gold-silver-lead button and to carry iron, copper, manganese, etc., into the slag

293. The smelter operator uses oxygen of the air in the form of a blast as an oxidizing agent, and charcoal or coke as a reducing agent. The assayer uses nitre, litharge, etc., as oxidizing agents, and charcoal, argol, etc., as reducers.

294. To illustrate fluxing, let the student heat iron rust with a comparatively large amount of borax or powdered quartz sand in a platinum wire loop. A greenish-black slag will be obtained. To illustrate oxidizing, heat borax, nitre and metallic lead together on a gypsum tablet or other suitable material. All the lead will be in the slag if enough nitre has been used. Even gold may be carried into the slag by using an excessive amount of nitre. To illustrate reduction, heat borax, powdered charcoal and litharge together on a piece of charcoal. A metallic lead button will be formed.

295. In assaying we must not forget that some ores are, of themselves, either oxidizing or reducing. In such cases the amount and kind of fluxes added will be regulated accordingly.

296. Lead is particularly useful to both the assayer and the smelter. In the heated charge it seizes the gold and silver and retains them. Copper is also used for the same purpose by the smelter. Lead may also be oxidized or reduced without much difficulty by adding the proper reagents, so that the size of the lead button can be easily regulated. Adding nitre oxidizes lead and permits it to go into the slag, producing a smaller button. Adding charcoal reduces lead oxid (litharge) to metallic lead and, therefore, increases the size of the lead button.

297. PROPERTIES OF FLUXES AND MINERALS.—In order that the student may experiment intelligently, the various fluxes and minerals are classified below according to their several properties. Some assayers who have had several years' experience may find these tables helpful, although they are designed chiefly for the beginner.

298. TABLE OF PROPERTIES OF FLUXES AND MINERALS IN THE FURNACE.

Slight action is indicated by x
Moderate action is indicated by xx.
Strong action is indicated by xxx.
Intense action is indicated by xxxx.

FLUXES.	*Oxidizing.*	*Reducing.*	*Acid.*	*Base.*	*Desulfurizing.*
Borax glass			xx		
Silicates			xxx		
Silica			xxxx		
Pot. cyanid.........		xxx		x	xxx
Litharge	xxxx			xxxx	xxx
Nitre	xxxx			x	xxxx
Soda bicarbonate ...	x			x	xx
Pot. carbonate	x			x	xx
Argol		x			
Flour		xx			
Starch		xxx			
Sugar		xxx			
Charcoal		xxxx			
Iron nails					xxxx
MINERALS.					
Quartz			xxxx		
Silicates			xxx		
Limestone				xxxx	
Zinc blende		xx			
Iron pyrites		xx		xx	
Arsenopyrites		xx		x	
Magnetite	xx			xxx	
Limonite	x			xx	
Copper pyrites or bornite		xx		x	
Cuprite	x			x	
Chalcocite		xx		x	
Menaconite (tenorite)	x			x	
Azurite or malachite.	x			x	
Antimonite		xx		x	

299. Lime is a strong base, but as it requires a high heat to make a fusible slag its use is not advisable for fluxing purposes. Litharge is generally used.

300. There are two classes of desulfurizers: true desulfizers and oxidizers. The former is represented by iron nails, potassium carbonate, sodium bicarbonate and potassium cyanide. These form FeS, K_2S, Na_2S and K_2S respectively. The latter is represented by all oxidizing agents. These form SO_2.

301. Crucible Assay.—A common practice is to keep on hand a standard flux mixture made up in large quantities. When making up a charge for crucible assay a measured portion of this mixture is added to the weighted ore and then borax, nitre, or charcoal are added as the case may require. After mixing, the charge is covered with salt and heated to quiet fusion in the furnace. The charge is then poured into a warm iron mould and when cold the lead button is hammered to free it from slag and placed in a hot cupel in the muffle furnace. Here the lead is oxidized by the air, leaving the gold and silver bead alone as a tiny sphere on the cupel. The bead is weighed and, after fusing additional silver with it, it is treated with weak HNO_3 to dissolve the silver. Then by dextrous manipulation the (black) gold is transferred to a capsule, dried *very* slowly over a flame and finally heated to redness. The gold now assumes its natural yellow color, and when cold may be weighed. Subtract the weight of the gold from the bead's original weight to obtain the weight of the silver. Use assay ton weights for weighing the ore when mixing the charge, and milligram weights for weighing the final gold bead. Some assayers call the gold bead a "button," and others apply the same term to the lead button. This often leads to confusion.

302. One assay ton (A. T.) contains 29166. milligrams, and an avoirdupois ton of ore contains 29166. troy ounces. Therefore, each milligram of gold or silver obtained by the assay represents one ounce of gold or silver in the ore if one A. T. of pulp be taken for assay. If more than one A. T. be taken divide by the number of tons taken.

303. *Standard flux mixtures.*

No. 1.		No. 2.	
Soda bicarbonate	1 part.	Soda bicarbonate	1 part.
Litharge	1 to 2 parts.	Litharge	5 parts.
Borax glass or silica ...	1 part.	Borax glass or silica....	1 part.

No. 3.	
Soda bicarbonate	3 parts.
Litharge	2 parts.
Potassium carbonate....	1 part.
Borax glass or silica....	2 parts.

304. These mixtures may be measured, but as they are of different specific gravities, a different scoop must be used with each one.

305. For quartz ores with no base minerals take—

No. 1,	3 A. T. (by measure.)
Ore,	1 A. T. (by weight.)
Charcoal (for neutral ore use 8/10 gram.)	
Salt cover.	

306. For sulfid ores take—

No. 2,	7 A. T.
Ore,	1 A. T.
Nitre as required.	
Salt cover.	

307. For silicates or other minerals difficult to decompose, or for sulfids take—

No. 3,	4 A. T.
Ore,	1 A. T.
Nitre, or charcoal, as required.	
Salt cover.	

308. With free gold and silver ores 7/10 to 8/10 of a gram of charcoal will produce a 15 gram lead button.

309. One gram of nitre will oxidize four grams of lead. Therefore, if your lead button weighs eight grams too much, for example, assay the ore over again and use 8 ÷ 4 = 2 grams of nitre.

310. Only gold and silver ores can be satisfactorily estimated by the fire assay. Lead and copper are most conveniently estimated by titration—a chemical method. All other metals are estimated by chemical methods, the fire assay not being suitable. Many assayers are also chemists and can analyze ordinary minerals.

311. Scrofication Process.—Rich silver ores free from sulfids are assayed in the muffle by the scorification method.

312. Charge.—The charge for scorification is as follows:

Ore,	1/10 to 1/5 A. T.
Granulated Lead,	1½ A. T.
Borax Glass,	250 Milligrams.

If copper or a small amount of sulfids is present use a larger amount of lead.

313. There are few assay furnaces small enough for the prospector to include in his outfit. Perhaps the best plan is to pack only the muffle. The crucible assays may be made in a blacksmith forge, and then the muffle may be fixed over the forge fire by the use of bricks or clay, for the cupellations. A good combination crucible and muffle furnace set up for operation is shown in Fig 22. It operates with gasoline. A sectional view of the furnace is shown in Fig. 23.

314. An outfit suitable for a prospector's permanent camp may consist of a combination furnace, Fig. 22; a hand rock crusher, Fig. 24; a pulp balance, Fig. 25; a bead and nugget balance, Fig. 26, or a scale for measuring the size of beads; and a burette. A portable bead balance is shown in Fig. 27. This is much more sensitive than the one shown in Fig. 26, which will not weigh a small bead.

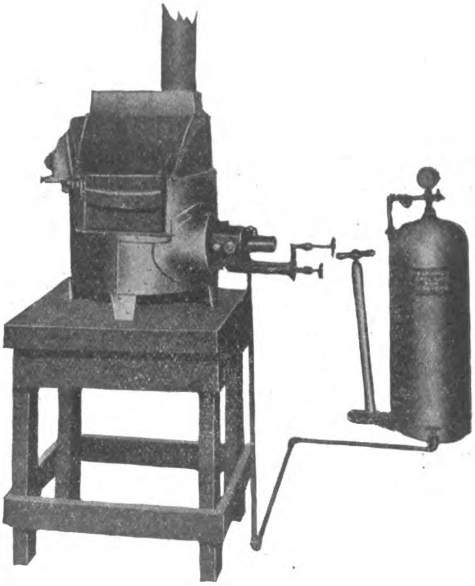

Fig. 22. Complete Combination Assay Outfit.

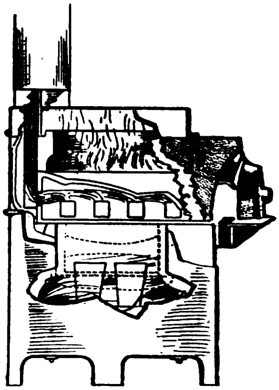

Fig. 23. Sectional View of Combination Furnace.

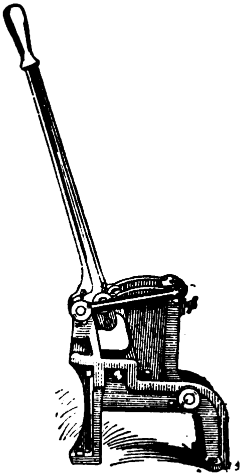

Fig. 24. Prospector's Hand Rock Crusher.

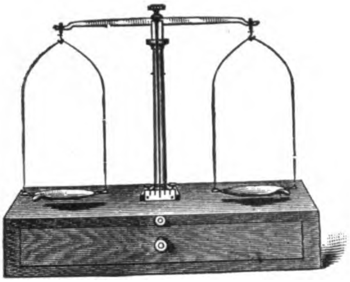

Fig. 25. Pulp Balance.

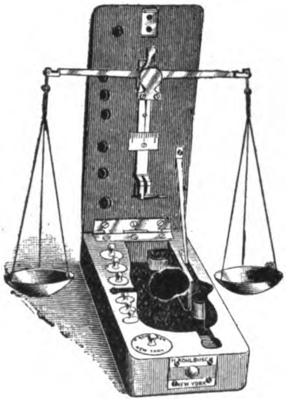

Fig. 26. Prospector's Bead and Nugget Balance.

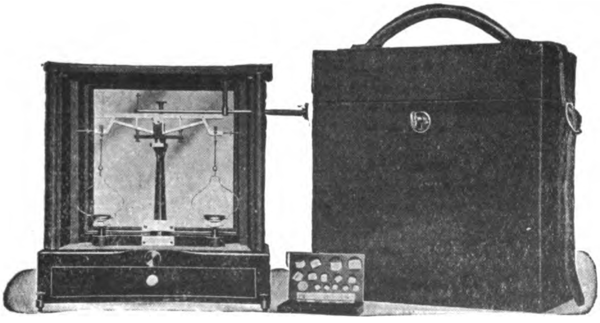

Fig. 27. Portable Assay Balance. High Quality.

315. WET GOLD ASSAY.—The following is a description of a chemical process for the assay of gold: Make up a solution of 100 parts of water to two parts of resublimed iodin and four parts of potassium iodid. This solution is a rapid solvent for gold. Next weigh out one assay ton of pulp, transfer to a porcelain mortar, add 50 c. c. of the solution, and grind for 10 minutes. Let stand for one hour to insure the solution of all the gold in the ore. Should the solution turn clear in the meantime it shows that there is an excess of reducing agent present in the ore, and more iodin and potassium iodid must be added until the brown color of the solution becomes permanent. Next filter and wash off the iodine solution from the pulp, add to the filtrate three grams of mercury, and shake vigorously in a glass stoppered bottle until the solution clears. The gold will then be all precipitated from the solution and amalgamated with the mercury. Transfer the mercury to a porcelain evaporating dish, wash with pure water and add 10 c. c. of dilute HNO_3 and warm gently until vigorous action commences. The mercury will collect in one globule and finally dissolve completely, leaving the gold in a compact bead. Pour off the mercury nitrate and wash the gold bead with distilled water if available; if not use rainwater, or ordinary water slightly acidulated with nitric acid. Finally dry over a lamp, or better over an alcohol lamp or Bunsen burner.

316. The weight of the bead can then be determined on a balance or by any other suitable means. A very convenient way is to compare the bead with a set of standard beads of known weight.

CHAPTER V.

OUTFITTING.

Outfit.

317. The outfit will necessarily vary, depending upon the locality to be prospected. The outfit required for Alaska would, naturally, be different from that required for Mexico or Peru. The lists of articles below are intended to serve as a guide, and especially to prevent the prospector from forgetting any necessary items.

318. If a number of individuals are going on a trip together, and especially if the outfit is large, a tent will be useful. Otherwise sleeping-bags will be sufficient. The writer prefers a sleeping-bag, even when using a tent, because it is so light and convenient. Prospectors and miners generally sleep in blankets. This is well enough when in a permanent camp, but for a prospecting trip there is nothing equal to the sleeping-bag. A ready made sleeping-bag can be bought for $10.00. A waterproof cover costs $3.75, weight of bag and cover eight pounds.

319. A more convenient sleeping-bag can be made as follows: Buy two *wool-filled* comforters covered with cheese cloth on both sides. Make a tick for each one out of light, strong, drab sateen. The ticks are necessary to keep the comforters clean, as the latter cannot be washed. Fold the covered comforters lengthwise and sew up the bottom end and the greater part of the side. Place one comforter inside of the other. Now make a cover of waterproof silk to fit. It should be slightly longer than the comforters. In cold weather sleep inside of both comforters. In warm weather sleep on top of one and inside of the other. The waterproof cover should be used in either case. Bear this in mind: The warmth is due to air spaces in the comforter and not to the weight of the material. The same weight of wool that is used in a sleeping-bag, if made into a tightly woven cloth, as serge, would be extremely cold to sleep in. Fleece lined garments are warm because of the

air spaces in the fleecing. The cost of the sleeping-bag just described is as follows:

Two wool-filled comforters......	3 lb. ea. at $3.50	=	$7.00	$3.50
Ten yards sateen at 15 to 35c....	½ lb. ea.	=	1.50 to	$3.50
Waterproof cover, 5 yards at 75c..	1 ½ lbs.	=	3.75	
Weight......................	8½ lbs.	Cost	$12.25	

320. These sleeping-bags are much warmer than one would suppose, and are comfortable in the snow in the highest mountains. They are used by Arctic explorers and by all outing clubs.

Clothing, etc.

Sleeping-bag..........................	8 lbs.
Sweater..............................	1 lb. 8 oz.
2 Blankets (if sleeping-bag is omitted)...	16 lbs.
Pajamas or nightgown..................	1 lb.
2 suits underclothing..................	3 lbs.
1 pair boots..........................	4 lbs.
6 pairs socks.........................	½ lb.
6 handkerchiefs.......................	⅛ lb.
2 over-shirts	1 lb. 4 oz.
Towels...............................	1 lb.
Knapsack and shoulderstrap harness......	1 lb. 8 oz.
Dunnage bag..........................	2 lbs.
Felt hat	¼ lb.

Useful and necessary articles.

Purse
Knife
Matches
Waterproofed match-box
Pipe and tobacco
Compass
Watch
Almanac
R. R. time tables
Water canteen
Smoked glasses or goggles
Stationery
Postage stamp book
Pencils
Location blanks
Candles
Maps
Note books
Book on prospecting
2 magnifying lenses [675]
Blowpipe outfit
A field testing outfit
Gun and ammunition
Mosquito netting
Camera
If pack animals are taken carry a shoeing outfit and extra shoes
Fuse
Caps
Dynamite

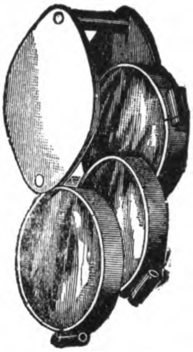

Fig. 32. Combination Magnifiers—Ore

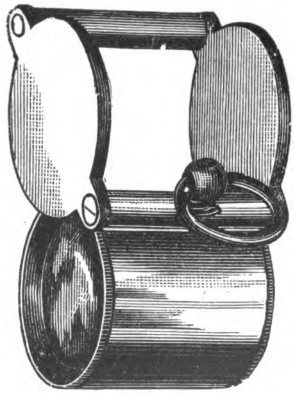

Fig. 31. Coddington Lens.

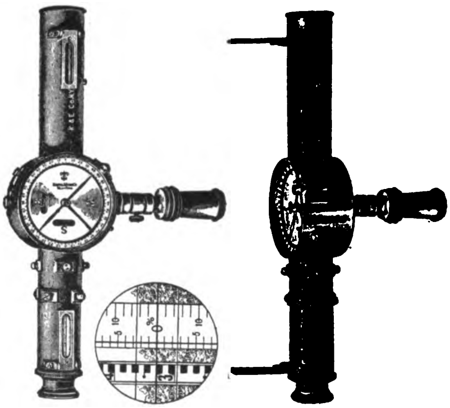

Fig. 29. Stadia Hand Transit.

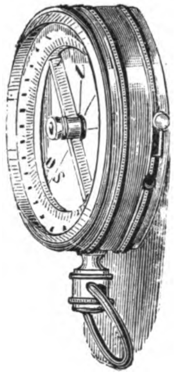

Fig. 30. Pocket Compass.

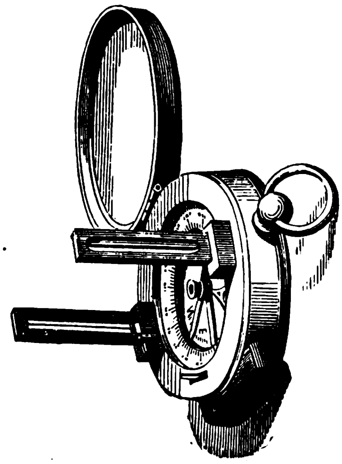

Fig. 28. Pocket Surveying Instrument.

Tools.

- Drills
- Horn spoon
- Pole pick
- Smith hammer
- Magnet
- Hammers
- Miner's pan
- Large pick
- Shovel
- Mortar

Cooking outfit.

- Combination aluminum cooking pans, pans fitting together like a pie cut in three or four pieces.
- Tin mush dishes
- Tin dishpan
- Large spoons
- Bread pans.
- Portable stove
- Frying pan.
- Knives, forks, spoons
- Tin plates
- Tin cups, nested
- Coffee pot, spout not soldered
- Tea pot, spout not soldered
- Can opener
- Butcher knife
- Salt and pepper shakers

321. *Rations for one man for two months.*

(In pounds.)

	LIGHT		HEAVY	
Meats, etc.—	Summer.	Winter.	Summer.	Winter.
Salt pork	..	10	..	10
Bacon	12	12	10	10
Ham	5	5	5	5
Corned beef	4	4	4	4
Concentrated soups	2½	2½	1½	1½
Canned consomme	..	..	2	2
Fresh eggs (4 doz.)	..	..	5	5
Butter	..	..	6	6
Cheese	1	1	1	1
Lard	3	3	3	3
Evaporated milk (or powdered milk) (6 cans)	2½	2½	2½	2½
	30	40	40	50
Bread, etc.—				
Flour	25	25	25	25
Corn meal	3	10	3	10
Buckwheat flour	..	3	..	3
Rolled oats	3	3	3	3
Rice	3	3	3	3
Macaroni	1	1	1	1
Baking powder	1	1	1	1
Baking soda	1	1	1	1
	37	47	37	47

	LIGHT		HEAVY	
Vegetables—	Summer.	Winter.	Summer.	Winter.
Potatoes	..	..	30	30
Potatoes, evaporated	4	4	..	..
Onions, fresh	4	6	4	6
Beans	4	6	4	6
Split peas	4	4	4	4
Tomatoes, canned	..	..	5½	5½
Sweet corn, canned	..	..	2½	2½
	16	20	49½	53½
Beverages—				
Coffee	3	3	3	3
Tea	½	½	½	½
Chocolate	½	½	½	½
	4	4	4	4
Sugar, etc.—				
Sugar	5	5	5	5
Maple syrup	..	...	3	3
Jam	...	..	5	5
	5	5	13	13
Fruits, etc.—				
Evaporated apples, peaches, prunes etc.	2	4	2	2
Raisins	1	1	1	1
Canned fruit	..	..	10	10
	3	5	13	13
Miscellaneous—				
Vinegar	..	1	..	..
Salt (extra if to be used for hides)	2	2	2	2
Pepper (extra if flies bother meat) ounces	1	1	1	1
Olive oil (bottles)	..	..	1	1
One package each				
Mustard	..	..	..	..
Sage	..	..	..	..
Parsley				
Nutmeg	..	..	..	..
Ginger	..	..	..	..
Brandy	..	..	..	..
	2½	2½	5	5

322. It is advisable for at least two individuals to prospect together so that if one is taken sick or meets with an accident the other can go for help. Besides, one may cook and test samples while the other is out in the field. When two or more are prospecting together it is advisable to take a larger outfit. A tent would be very convenient in such a case, especially if prospecting at a distance from your supply center.

323. Canned fruit, though palatable and healthful, is heavy and bulky. Dried fruit is lighter and more convenient. See that canned meats are marked "inspected," as provided by the Pure Food Law, and bear recent date. Canned fruit and meat is healthful and safe if the tins have not been dented in transportation. Canned butter is convenient and keeps well while sealed. Chocolate is very strengthening, try it. Extracts and spices may be omitted in most cases.

324. The amount and kind of material required for an outfit depends upon the distance from a center of supply. If one is prospecting near civilization very little is needed, the drills, hammers, shovels, powder, caps, etc., being left at the supply center till wanted. If you are going far from other camps purchase a good, complete outfit. Make your camp in a favorable locality and leave all your outfit there except the portable outfit for daily use.

325. *Rations for animals.*

	Oats.	Corn.	Hay.
Heavy horse	12 lbs.	15 lbs.	18 lbs.
Light horse	10 lbs.	12 lbs.	14 lbs.
Mule	8 lbs.	8 lbs.	12 lbs.

326. *Medicines.*

The following may be found useful in camp:

Absorbent cotton, 1 pkg.
Surgeon's adhesive, antiseptic, sticking plaster (not court plaster), 1 roll.
Hydrogen peroxide, 6 oz. bottle.
Prepared bandages (buy of a druggist), several rolls.
Corosive sublimate gauze, 1 pkg. (Poison).
Calomel tablets, 1/5 grain each, 1 doz.
Carbolic acid, 1/4 lb. (Poison).
Grain alcohol, 6 oz. (Not wood alcohol).
Potassium permanganate crystals, 1 oz. (Poison).

Ammonium hydroxide (hartshorne), 1 lb. bottle.
Salts, 1 lb. pkg.
Cascarets, 1 box.
Mustard, 1 lb.
Virgin castile soap, 1 cake. (Or good castile soap).
Olive oil, ½ pint.
Camphor gum, ¼ oz.
Camphor solution, 4 oz.
Boric acid, ¼ oz.
Lunar caustic, 1 stick.
Colera remedy.
Quinine, best quality, capsules.
Sweet spirits of nitre, 6 oz.

CHAPTER VI.

THE UNEXPECTED.

Getting Lost.

327. No one expects to get lost. For this reason the articles most seriously needed in case one should get lost are too frequently left at camp. When prospecting, especially in a new country, always carry with you a pocket compass so marked that you cannot become confused in regard to the end of the needle that points north. With a piece of quartz write on the back "Black end points north." Always carry food and water. Most persons, as soon as they realize that they are lost, become confused. As a matter of fact getting lost is really not such a serious matter if you can "keep your head." When a man realizes that he is lost he is apt to become suddenly excited—it might be said he becomes insane. He is apt to rush about this way and that, apparently in an endeavor to go several directions at the same time. As a result he loses his bearings entirely. If you could look into the face of a lost man you would realize how utterly unfit he is for reasoning or for cool calculation. Men have been lost for a day in a 40 acre patch of timber. A man with his full reasoning faculties would find his way out in less than an hour. Lost men have stared blankly at old trees and fences that they had seen many times before, without recognizing them. A school-mate of the writer at one time became lost in a woods and came out of it at a clearing where he had a rear view of his father's barn and other buildings, but he did not recognize them. This point, the loss of reason, is emphasized because it is really the important point. It has been said that if a lost man does not "lose his head" at first he will at least become practically insane within twenty-four hours. This is not necessarily true, for anyone can calm himself if he will exert his will power. However, a man lost a few days and suffering for thirst will undoubtedly become in a measure insane in spite of anything he may do. In such cases men have been known to ford streams and not know enough to drink the water.

328. It will first be in order to tell how people become lost; second, how to prevent getting lost and, finally, what to do when lost. Many become lost by getting on the wrong side of a main

divide or ridge. A double bend in a river will often deceive the best of us. Ninety-nine per cent of those who get lost do so by becoming too much absorbed in the object of the pursuit. The only reason why an Indian or a professional guide seldom gets lost—and they get lost at times—is that they observe the surroundings as they travel. Therefore, observe as you travel and make a mental picture of the surroundings. Lightly blaze trees and bend over the brush along your trail. Some people make a regular topographic map of the country as they travel, noting objects of importance, especially in a new locality. Keep your eye on the sun and also keep the time of day in mind. It is surprising how far one can go and return with certainty by simply taking due and deliberate note of things. The map plan is good. If you get lost sit down at once and think it over. Don't stir out of your tracks one foot till you have thoroughly and calmly canvassed the situation. You know a few things as a basis for your plans. For example, so many minutes ago you knew where you were. The distance could not be far. In your mind retrace your steps. Make a sketch of this on a piece of paper. Mark the spot where you are in some way: blaze a tree on four sides, or cut brush, or set up a flag pole, or build a monument of rocks, or in some other way fix the spot so you will recognize this, the one and only spot you know is a certain distance from camp. Then start out by deliberately selecting the point to be reached. This will prevent traveling in a circle. Do not lose the starting point where you first realized you were lost. You may wish to return there to wait for others to find you. The writer has twice been lost and has also searched for others who were lost and can speak from experience. If there are others who will search for you the safest and surest way is to remain at the spot where you first realized you were lost, or on the nearest ridge. Build a fire so that the smoke may attract others. Even if you stay out all night it will not be serious. In most cases lost individuals lose their reason before they become exhausted. Endeavor to prevent this from happening in your case. Fight against the dethronement of reason, your most serious peril.

329. If there is no possibility of others searching for you and you are in a thinly populated region, travel down a main ridge, or down a stream, for sooner or later you will, by this means, reach civilization. If in a desert, select some favorable appearing canyon and stick to that course. You may find water and possibly a rancher's home at the foot of the canyon.

330. In a timbered country the moss is thickest on the north side of the trees. In a desert the brush bends in the direction of the prevailing winds. There is no excuse for a miner or prospector

traveling without a compass, and he should not be obliged to observe moss covered trees or the like. Neither should he travel without a canteen in a dry region. No matter how unnecessary it may appear take the canteen along. You will be thankful for it some day when least expected.

Accidents.

331. BLEEDING.—Bleeding from an artery is in jets. It should be stopped by pressure on the artery on the side of the wound next the heart by using a strong cord with a knot in it. A handkerchief may be placed next the flesh to make the cord less painful. Place an object about the size of a base ball in the arm pit and press against it if the wound is in the arm. This retards the circulation in the arm. A knotted handkerchief may be used instead of a cord, or two persons may take turns pressing against the artery. Send for a surgeon as the artery must eventually be tied. Do not leave a tight cord around a limb longer than one-half hour. Bleeding from a vein is a constant flow. It should be stopped, if possible, by washing the wound with cold water, and by gentle pressing on the side of the wound farthest from the heart.

332. WOUNDS.—Before dressing any wound wash the hands with virgin castile soap, or pure castile soap, and water that has been recently boiled, and wash every article that touches the wound in boiled water. A small wound is dressed by washing it free from dirt by the use of boiled water that has been allowed to cool to blood heat or cooler, and then by covering it with absorbent cotton and bandaging with bandages that have been boiled. Do not wrap bandages tight enough to retard the blood circulation. For small wounds, or wounds in places where bandages can not well be applied, use a small tuft of absorbent cotton and long narrow (¼″) strips of surgeon's adhesive sticking plaster. Do not use court plaster if avoidable, as it is not nearly as good as surgeon's sticking plaster. Large wounds may be treated the same as small ones except that stitching may be necessary. This should be done by a surgeon. Wounds caused by powder from a fire-arm should be scrubbed out with a (boiled) tooth-brush to remove the powder. Remove all flesh that shows the powder stains, cutting if necessary. A few drops of carbolic acid may be added to the water for washing the wounds (teaspoonful to one quart of water).

333. SPRAINS.—Hold or bathe the sprained part in as hot water as can be withstood, then bandage snugly and give the part absolute rest. If the sprain is severe place the patient in bed for a few days.

334. BROKEN BONES.—Remove the clothing without jerking or twisting the broken part. Pull the broken limb and try to put

it in its natural position. Continually bathe the limb at the break with cold water to keep down inflammation. Send for the surgeon at once. If more than an hour elapses before the surgeon arrives begin the use of hot water instead. If the patient suffers much pain keep up a slight pull on the limb till the surgeon arrives.

335. BURNS AND SCALDS.—For slight burns without blisters or broken skin apply a solution of baking soda and when dry cover with the white of an egg. For severe burns cover the parts with either olive, sweet or linseed oil, being careful not to break any of the blisters. If the patient is cold and appears confused give him whiskey in water and put hot water bottles to the feet. Keep patient in a warm room. Keep fresh air in the room, however. For very severe burns cover the parts with bandages, saturated with any of the above mentioned oils and keep the patient in a very warm, well ventilated room. A good plan is to place the patient in a highly heated tent (made of sheets and blankets, if necessary) with his head out for air. Blisters should not be allowed to burst. Puncture them with a clean needle through the unblistered skin.

336. DROWNING.—First, wipe out the patient's mouth and throat with a handkerchief and give him several smart slaps on the back, holding his head up by means of one arm around the waist at the same time. If this does not restore breathing proceed as follows: Second, separate the jaws with a piece of cork or wood and, with the patient's face downward and with a roll of clothing or other material beneath his stomach press your weight over the small of the back to expel the water. Third, to produce breathing, place the patient on his chest and direct an assistant to hold the patient's tongue out of his mouth, if necessary. If no assistant is at hand try to wedge the tongue between the teeth and the piece of wood used to keep his mouth open, or place a common rubber band over the tongue and chin, if one is at hand, or tie with a handkerchief if necessary. The tongue will usually take care of itself if the patient's face is kept downward.

337. It is advisable to place something under the forehead to keep his mouth out of the dirt. Standing astride of the body, draw the patient's arms up alongside of his head and then quickly bring them alongside of his body, pressing in and down on the short ribs, still retaining your hold on the arms near the elbows. The first or upward movement of the arms tends to cause inspiration and the second or downward movement expiration. If breathing does not begin within about four minutes try to expel more water, and again wipe out his mouth and throat. Resume the respiration movement. If possible, send some one for hot water and cloths. Have the assistant wring the cloths out of hot water and

place them around the patient's neck. When a patient drowns the muscles of the neck contract. It is now believed that many have died from drowning who could have been saved by the hot applications to the neck which cause the muscles to relax. Never waste time carrying the patient to more comfortable quarters till respiration has begun. Then take him to a warm room, replace the wet clothing for warm dry blankets, and put him in bed. Stimulants may be given in small doses, increasing the doses as needed. Congestion of the lungs may follow at any time within two days. In cases of congestion of the lungs place a mustard plaster on the chest and send for a doctor. If the breathing becomes difficult before the doctor arrives again resort to artificial respiration.

338. SOMETHING IN THE EYE.—Remove it with the moistened end of a lead pencil point. You can touch the eyeball with this without causing the patient to jerk away. Slivers of steel may be removed with a magnet if not too deeply imbedded. Try barber's tweezers or the assayer's bead tweezers. Do not use a needle. A surgeon, or better, an oculist, should attend to any case where foreign bodies are firmly lodged in the eyeball. To prevent inflammation, drop into the eye a few drops of a 2% solution of boric acid every few hours.

339. FROZEN EARS, FINGERS, ETC.—Remain in a cool room till the pain begins again and ceases. Apply cold water to the frozen parts. A warm room or warm water will not only cause severe pain but may also cause gangrene to set in. If a person is almost frozen to death begin by employing artificial respiration as in cases of drowning, and wrap the patient in dry blankets. Place warm bricks, rocks, or hot water bottles around the body, and care for the ears, fingers and feet as directed above.

340. RUPTURE.—Keep the patient on his back till the doctor arrives. Double up the knees and gently press the parts back into the abdomen.

341. BITES OF DOGS OR CAT.—If you have no cracks on the lips suck the wound and spit out the fluid. Wash the wound with a 30% solution of carbolic acid, or apply lunar caustic. If it is suspected that the animal is mad (hydrophobia) do not kill it, but keep it in a safe place, and if alive at the end of a week it was not mad. This may save possible worry on the part of the patient.

342. STING OF CENTIPEDE OR SCORPION.—Bathe the wound with weak ammonia or a 2% solution of carbolic acid. Usually not fatal except with children. Saleratus may be used.

343. **Bite of Tarantula or Spider.**—Pour moderately strong ammonia on the bite. If the patient becomes weak give him strong coffee. Saleratus may be used if no ammonia is at hand.

344. Rattlesnake bite.—First, tie a strong cord or strong rubber tubing around the limb two or three inches from the wound and between the wound and the heart. Draw it tight enough to be slightly painful. Second, cut open the wound, cutting lengthwise, not across the limb, and have some one suck the wound if his lips are free from cracks. Third, rub into the opened wound powdered potassium permanganate in large amounts. If skilled in the use of a hypodermic syringe inject half a syringe full of a one to two per cent solution (1 grain to 1 teaspoonful of pure water, distilled water is best) of potassium permanganate into the wound and inject the remaining half beneath the skin just above the wound. Make two or three injections beneath the skin near the wound. If these injections are given a few minutes after the bite a cure is absolutely certain, as potassium permanganate is the best remedy known. In your outfit keep the potassium permanganate tablets or powder and the distilled water in separate vials, dissolving the powder or tablets just before use. It is a good plan to have the potassium permanganate powdered extremely fine so it will dissolve immediately. Remove the ligature within half an hour or the limb may die or gangrene set in. Give whiskey if the pulse is weak. Large amounts of whiskey are not necessary and may be harmful. Its purpose is to stimulate the heart action until the system can effect a cure. It does not cure the snake bite. Ammonia can be applied to the wound if no potassium permanganate is at hand.

345. **Sting of Insects.**—Apply ammonia, or a saturated solution of saleratus or baking powder, the first being the most efficient.

346. **Poison Oak or Ivy.**—Moisten the affected parts with grain alcohol, both as a preventative and as a cure, and to stop the itching pain.

347. Another cure is to use a solution of one or two parts of carbolic acid and one part of baking soda (sodium sulfite is better) in 50 to 70 parts of water.

348. Another excellent cure is to apply a solution (any strength) of menthol to the affected parts. In any case take a dose of salts or cascarets—the former is severe and the latter mild. Many bathe the parts with a solution of sugar of lead. The use of this deadly poison may result in lead poisoning (by absorption) and its use should be discouraged.

349. SUN STROKE.—Only a few cases have been known on the Pacific Coast. Take the patient to a shady place and bathe the head with cold water. Ice water is best. Apply mustard plaster to the spine.

350. SHOCK.—After severe injury a patient often suffers or dies from what is called shock. Symptoms: The patient becomes cold and almost pulseless and the skin clammy. Breathing is often slow. Treatment: Apply to the feet and body many hot bricks or rocks wrapped in cloths. Cover the patient up well and do not give any alcoholic drinks.

351. BAD AIR.—Suffocation often results from entering a shaft or drift containing foul air. Treatment: Remove the patient to the fresh air. Apply ammonia to the nostrils and immediately begin artificial respiration as in cases of drowning. Apply to the body hot bricks or rocks wrapped in cloths.

352. DYNAMITE POWDER SMOKE.—Treatment is the same as for bad air.

353. ELECTRIC SHOCK.—To free the victim from contact with the live wire seize only the clothing, as the coat tails, or you may also receive a shock. First, hold the patient's head down for two minutes. Second, apply a mustard plaster to the chest and wrap the patient in a blanket wrung out of hot water, leaving the arms out for the respiration movement. Inject whiskey, 30 drops if possible. Third, begin artificial respiration as in cases of drowning. After a time replace the blanket with hot bricks or rocks wrapped in cloths. Keep the patient well covered up.

354. BOILS.—Lance and inject hydrogen peroxide. Wash the flesh around the boil with grain alcohol to prevent other boils appearing.

355. BURNS BY ACIDS.—Apply soda or other alkali, then wash off the alkali and apply oil. If no alkali is at hand wash off the acid with much water and then apply the oil.

356. BURNS OF ALKALI.—Ammonia, lime or potash burns should be neutralized with weak acid. Vinegar is good, but any acid diluted with water will answer.

357. MALARIAL FEVERS.—Quinine is the best remedy known. Take the best grade to be had (in capsules). Quinine pills and tablets are often almost worthless. It should be given about two hours before the chills set in. Take 30 grains the first day, in three doses of five, ten and fifteen grains, and three grains a day thereafter. Keep the bowels loose, especially at first.

Antidotes for Poisons.

358. Where the directions call for something to produce vomiting and an antidote is also specified, it is understood that the antidote is to be given after the vomiting has been produced. An antidote is a substance that will chemically combine with the poison taken and produce a harmless product. For example, in cases of lead acetate poisoning the weak sulfuric acid antidote produces lead sulfate and acetic acid (vinegar)—both practically harmless.

Poison.	*Antidote and directions.*
Aconite. Belladona Bryony Camphor Conium Cicuta Croton oil Digitalis Dulcamara Gamboge Hemlock water Laudanum Lobelia Morphine Nuxvomica Opium Paregoric Sanguinaria Savin oil Strychnine Tobacco	For these vegetable poisons give an emetic of mustard in water. Give frequent drinks of warm water. Tickle the throat with a feather or with the finger to cause vomiting. Keep the patient awake till the doctor arrives. Give strong coffee after the vomiting has ceased.
Arnica	Drink vinegar.
Prussic acid Bitter almond oil. Laurel water	Drink at once a teaspoonful of ammonia (hartshorn) in a cup of water. Do not delay a second.
Ammonia Potash Soda	Take vinegar or lemon juice, followed by castor, olive, sweet or linseed oil. Cream or condensed milk will answer as a substitute. Do not try to cause vomiting.
Iodine, tincture of	Take starch or flour beaten in water, after giving a mustard emetic to cause vomiting.
Saltpeter (Nitre) Soda saltpeter	Give, at once, a mustard emetic. Drink plenty of warm water, followed by olive oil or cream.

Poison.	*Antidote and directions.*
Lunar caustic (silver nitrate)	Take two teaspoonfuls of table salt in a cup of water.
Corosive sublimate (bug poison) White precipitate Red precipitate Vermilion	Beat the whites of six eggs in a quart of cold water. Give a cupful every two minutes. A substitute is soapsuds with a little flour thickening. Do not try to cause vomiting.
Arsenic (rat poison) Cobalt (fly powder) Kings yellow Scheeles green	Use stomach pump at once. The next best thing is to give a mustard emetic. After the vomiting give large amounts of calcined magnesia. The antidote is hydrated peroxid of iron which can be made by a chemist only. Wash the rust from iron nails and give to the patient. It is harmless.
Lead acetate (sugar of lead) White lead	Give a mustard emetic and then Epsom or Glauber salts. The antidote is dilute sulfuric acid. (1 of acid to 10 of water. Pour the acid in the water—not water into the acid when mixing).
Antimony, wine of Tartar emetic	Give ground nutgall or ground oak bark followed by a teaspoonful of paregoric.
Pearl ash Lye Salts of tartar	Drink freely of vinegar or weak acid followed by drinks of flaxseed tea.
Sulfuric acid (oil of vitrol) Nitric acid (aqua fortis) Hydrochloric acid (muriatic acid) Oxalic acid	Give flaxseed tea and much water as soon as possible. The antidote is calcined magnesia. Chalk, lime or soapsuds are substitutes for the magnesia.
Phosphorous (rat poison)	Give calcined magnesia, then flaxseed tea.
Verdigris Blue vitrol	The antidote is cooking soda or white of eggs after giving frequent drinks of milk.
Stings of insects	Apply ammonia or moist cooking soda.
Illuminating gas Charcoal fumes Bad air in a mine	Fresh air and artificial respiration.

Poison.	*Antidote and directions.*
Potassium cyanide fumes Prussic acid gas	If taken in large amounts death is almost as instantaneous as if shot with a pistol. Antidote: Cause the patient to inhale ammonia and then give internally from one to three teaspoonfuls of hydrogen peroxide in water. Act without delay. Employ artificial respiration and apply cold water to the back.
Potassium cyanide	First, cause the patient to vomit by running the finger down the throat, and then treat as directed under prussic acid gas. If taken in large doses death is almost instantaneous. Keep ammonia (hartshorn) and hydrogen peroxide on hand where potassium cyanide is used.
Ptomaine poisoning (caused by eating spoiled meat or vegetables. Often caused by eating canned food that has been allowed to stand in the tin after opening)	Symptoms: Sudden vomiting and diarrhoea appear a few hours after eating the spoiled food. Often colic, headache or cramps of the muscles occur. Sometimes there are eruptions on the skin. Treatment: Give the patient warm water and then cause vomiting. Give more warm water and induce vomiting again. Repeat this method of washing out the stomach three times or more. Of course, a stomach pump could be used if one was at hand. Next, give a one-fifth grain tablet of calomel every 15 minutes till 10 doses have been given. The patient may vomit it up—give another tablet if the vomiting occurs immediately after giving one. If vomiting continues longer than desired, inject warm soapsuds into the rectum. Next, give teaspoonful doses of brandy or whiskey every 30 minutes. Keep the patient warm.

CHAPTER VII.

EVIDENCES OF A GOOD MINERAL DISTRICT,
OR
RULES FOR PROSPECTORS.

359. Strong dynamic action, indicated or suggested by rugged mountains, numerous faults or fissures and cross-fissures, and the presence of igneous intrusions or extrusions, especially if these have caused extensive metamorphism within the adjoining rocks, are all very favorable. [681]. The southern part of Nevada, where mazes of faults and cross-faults are found, is a good exemplification of the foregoing statement. [526, 532, 533, and Fig. 46]. The presence of any of the minerals commonly associated [286] with the precious metals is favorable: iron, [698, 699] copper and lead minerals are good indications for gold and silver, and the strike of such mineralized seams or veins should be followed, examining the surface all the way and for a considerable distance beyond the mineralized streak.

360. The presence of hot or sulfur springs [805] is favorable for cinnabar, especially in the Pacific Coast ranges. The springs are usually in the foothills below the cinnabar deposits.

361. Crystalline igneous rocks are favorable for the precious metals. The regions most favorable for any particular mineral. especially the economic minerals, are those containing the rock and minerals that usually alter [170] to the mineral sought. One or more of the above mentioned favorable conditions will be found to exist in almost any noted mining camp.

362. It will pay, not only the prospector, but the miner, superintendent, and the mine investor, to study the relations existing between the ore-vein and any faults or dikes that may be in the vicinity. No relation may be discovered by surface indications, but careful assays and chemical tests of underground vein rock and wall rock may reveal facts that will facilitate the search for ore. It appears to be a more and more settled fact that there is a genetic relationship between ore bodies and igneous rock. The subject is, to say the least, worthy of careful and thorough investigation, not only by geologists, but by all who have an opportunity to observe.

363. Dikes are indicative of a good mineral district. If the dike was formed just before the vein, the effect is especially beneficial, as at Douglas Island, Alaska, and at Cripple Creek, Colorado. It may be noted that dikes seldom occur singly. Large dikes, characterized by their coarse crystallization owing to the long time in cooling, are more effective than small dikes. The size of a dike can not always be judged by the exposed rock because later sedimentary or igneous rock may have covered a part of it. A rule has been developed by A. J. Queneau* for determining the distance from any point in a dike to either wall, the calculations being based upon the size of the crystals. The author does not vouch for the correctness of this theory, however. It is mentioned in order that those interested may be inspired to further investigation.

364. Pegmatite [197] seems to shade off between a dike and a vein, so that when a pegmatite dike is found it will be advisable to search for a vein along the borders of the pegmatite.

365. Most of the rare minerals are found in igneous rocks. They do not occur in veins, however, but in scattered grains or crystals.

366. A quartz vein is usually more easily fractured by crustal movements than the country rock, and for this reason it furnishes a natural water channel. The water encountered in running a crosscut in country rock is, therefore, a good indication of a vein near at hand. [701]. All underground water channels are not connected with veins, but water channels, if any veins are in the vicinity, will be in the veins or connected with them.

367. Evidences of metamorphism are especially favorable because the heat, moisture, and pressure required to produce the metamorphism are the agencies that are most effective in the transportation and deposition of valuable minerals. To detect metamorphism search for altered minerals. [170]. Do not forget that large dikes almost invariably produce more or less metamorphism. This is because the dike furnishes the heat, pressure and, according to some authorities, the moisture necessary for mineralization.

368. If the water issuing from a prospect shaft or drift contains much iron (test chemically) it is more favorable for gold than if it is pure. If the water contains copper it has probably passed through copper ore. Other mineral deposits are sometimes indicated by this means. At Steamboat Springs, Nevada; Sulfur Bank, California; and Boulder Hot Springs, Montana, minerals are in solution in the water and minerals are in the act of forming at the present time.

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*See School of Mines Quarterly, 1891.

369. Ore shoots in a vein outcropping on a ridge, hill, or table land are generally richer than the ore shoots on the same vein but outcropping in depressions or gulches, and the steeper the gulches the more pronounced will the difference in richness become. Examples of this condition are numerous on the Mother Lode, California.

370. Gulches are often the result of erosion along a plane of disturbance, such as a fault or a sharp synclinal bend in the strata. In such cases the veins crossing such a gulch or ravine will usually be low in value beneath the gulch. There are many examples in California and Arizona illustrating the truth of this theory, though there are exceptions.

371. Some of the apparent exceptions are not valid, however. For example, the plane of disturbance may not be vertical, but may have a dip. Therefore, the ore shoots on one side of the ravine may continue beneath the gulch, but the ore shoots on the other side of the ravine will terminate in approximately the plane of disturbance, and before reaching a point beneath the ravine. In other words, the ore shoots will terminate along the line of intersection of the plane of the vein with the plane of disturbance.

372. Similarly, when a fault occurs after a vein has been formed and its ore shoots made, the ore shoots will, of course, be shifted in an amount equal to and in the direction of the movement. In order to find the vein and the ore shoots beyond a fault it will be necessary to determine the dip of the vein and also the dip of the fault plane. This having been done an engineer can, by the principles of descriptive geometry, determine the pitch of the line of intersection between these two planes. Then, after ascertaining the amount and direction of the rock movement along the fault the position of the ore body on the unexplored side of the fault can be determined. The great difficulty in all such cases is to determine the amount of movement and its direction. Where the expenditure is justifiable the method pursued by the writer is to run a drift along the fault, keeping the fault in the center of the drift, using care to blast on the sides only, so as to secure the rock on both sides of the fault in large unshattered pieces. The rock is then removed to the surface, taking care not to lose track of the relative positions of the pieces. These should be washed perfectly clean and arranged in the same relative position occupied under ground. Now, by careful inspection of the fractured surfaces and the rock texture, under a glass or by means of microscopic slides of sample scales, the character of movement may be determined. Evidently this class of work is too difficult for the prospector. Nevertheless, this method of searching for ore is prospecting, in a sense, and deserves dis-

cussion in a book of this kind. Careful surveys of all the underground workings and a careful tabulation of the descriptions of rock samples taken from various localities will be of material aid in determining the amount and direction of the movement where faults occur.

373. Strong outcrops, especially those occurring on high and nearly level ground, indicate a deep vein and good pay ore.

374. Long, well defined outcrops are usually indications of a deep vein. Waldemar Lindgren, of the U. S. Geological Survey, is authority for this statement.

375. Ore shoots are usually greater in their vertical than in their horizontal extent. Therefore, if we know the horizontal length of an ore shoot we can generally depend upon its extending to a depth greater than its known horizontal measurement.

376. Veins usually become richer with depth till the zone of secondary enrichment has been passed, then the value of the ore will almost invariably decrease. Sometimes, as at Butte, Montana, another zone of secondary enrichment is encountered. More than one zone of secondary enrichment is unusual but not rare. To make the ironclad statement that veins grow either richer or poorer with depth is unwise, considering our present knowledge. General rules only can be given and the exceptions noted.

377. The presence of a "gouge" is positive evidence that there has been movement along the fissure since the vein was formed. A positive relation between the presence of the "gouge" and the richness of the ore has not been well established. As a gouge is impervious to water it will undoubtedly prevent the horizontal circulation of water to and from the country rock, and to some extent retard the ore formation, especially where the gouge was formed before the deposition ceased. Checking the horizontal flow of water would affect only those ores formed by this method of water circulation.

378. A gouge is usually absent from shallow veins and present with deep ones.

379. Any change in wall rock structure, either in depth or horizontally will usually result in a change in the value of the ore. [183]. That is, a rich ore may terminate, or a low grade ore may become richer with a change in the wall rock formation. [700]. Usually, on entering greenstone, gold ores drop in value and the vein pinches or entirely disappears.

380. Deep water in a mine suggests that the vein will continue to greater depth. Do not be deceived by water that has percolated from the upper levels.

381. Ore shoots often have the same upper contour as the surface; that is, they follow along approximately at the same distance from the surface, measuring perpendicularly (not vertically) from the surface. By rights, the measurement should be from the original surface at the time the vein was made, but this is not usually known. This peculiarity of ore shoots often causes disappointment to those who are searching for ore by means of a lower level.

382. Ore deposits other than in veins are often found in synclines, as shown in Fig 33, or in anticlines, as shown in Fig 34. The latter is an illustration of the New Chum Consolidated Mine, Bendigo, Australia. [See sections 369, 370 and 371, regarding ore shoots beneath ravines.] Ore is often found in a fault vein, or a shear vein [see glossary], as in the Enterprise Mine, Colorado, shown in Fig. 35.

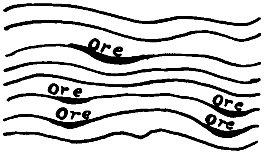

Fig. 33. Ore in Synclines.

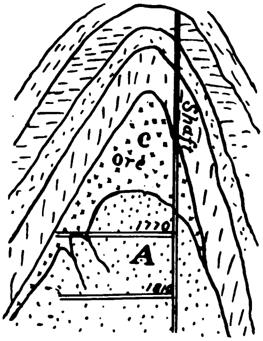

Fig. 34. Ore in Anticlines.

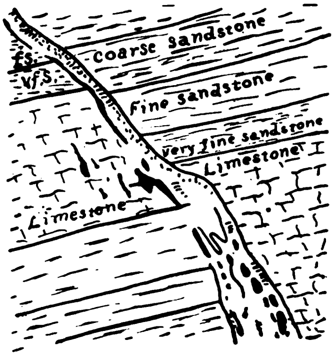

Fig. 35. Ore in a Fault-Vein or Shear Zone.

383. Ore is often found along joint planes in sedimentary rock as shown in Fig. 36. Here the ore follows the irregular jointing of a limestone, Tintic district, Utah. Rocks that are readily soluble in water, as limestone, are often replaced by mineral deposits. This replacement is most likely to occur along or across some fault or fissure in the limestone. Copper ores often occur by replacement in limestone near igneous rock. [Figs. 37 to 40, inclusive].

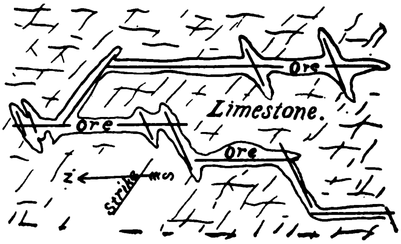

Fig. 36. Ore in Joint Planes.

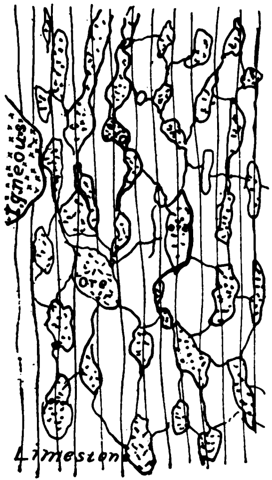

Fig. 37. Replacement Deposit. Eureka, Tintic District, Utah.

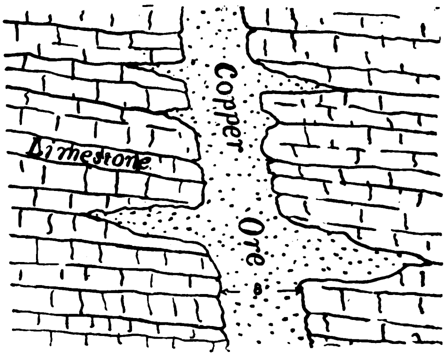

Fig. 38. Replacement Deposits.

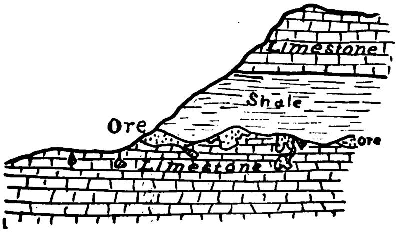

Fig. 39. Ore in Limestone at the Contact. Bremen Mine, Silver City, N. M.

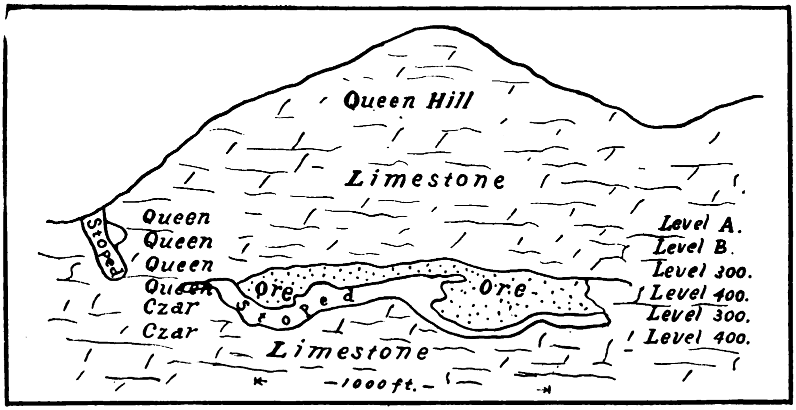

Fig. 40. Copper Queen Mine, Arizona.

384. Extrusive [glossary] rocks are favorable for vein formation, and intrusive rocks are still more favorable [609]. Laccoliths, being intrusions of great volume, are especially influential in vein formation, and in filling the veins with valuable minerals. The Ortiz laccolith [Fig. 41] is an example, there being working mines in its vicinity.

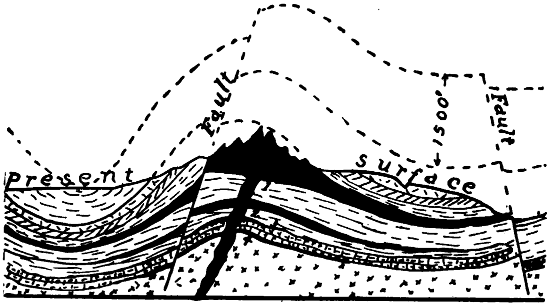

Fig. 41. The Orlitz Laccolith, New Mexico.

385. Dark, basic igneous rocks are favorable for the formation of many ores—we may say, favorable for the formation of all ores except tin, tungsten, and molybdenum ores, which are usually found in light colored, acid, igneous rocks.

386. When a rapidly flowing mountain stream enters a comparatively flat area, this flat area is favorable for placer ground.

387. The inside of a river bend is favorable for placers. [Fig. 42].

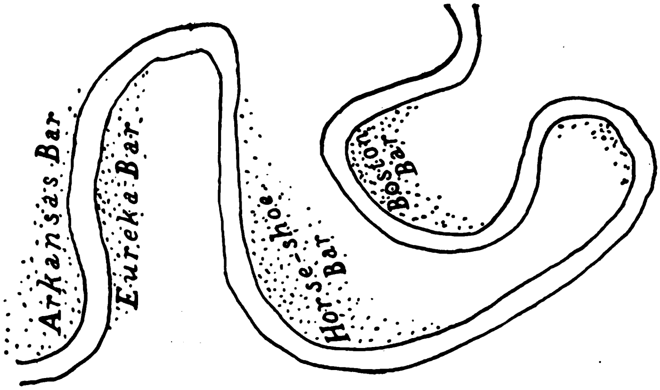

Fig. 42. Placer Bars.

388. Placers are more likely to be found below veins in a slate formation than in granite. This is because slate decomposes more readily than granite. The great placers of California are striking examples of this rule.

389. Swiftly flowing streams will, naturally, carry gold farther down stream than sluggish streams. For this reason placers may be expected near a region of known quartz veins where the streams flow slowly, and more distant therefrom when the streams flow rapidly.

CHAPTER VIII.

SELECTING A DISTRICT IN WHICH TO PROSPECT.

390. This is always a serious question and must be answered by each individual prospector for himself. Too much thought can not be given to the subject. Having decided where to go, first, read all the mining journals available and send to "The Director," U. S. Geological Survey, Washington, D. C., for folios, bulletins, etc., pertaining to the districts in which you intend to prospect. Also send for bulletins upon the metals and minerals which interest you. It is impossible to overestimate the value of these bulletins—and many of them are sent free of charge. They will give, not only an exhaustive discussion of the origin and formation of mineral deposits, but will also list the localities where these minerals are found, and describe the geologic formations in which they occur. Second, copy or make a scrap book of all maps that are of interest, such as geologic and geographic maps of mineral districts. These may prove valuable some future day. Third, keep a note book in which to make a memorandum of all pointers gained by conversing with old prospectors. Show your set of mineral specimens to your fellow prospectors, and ask them to tell you which specimens resemble minerals they have seen during their travels. By so doing a mutual benefit may result. Fourth, before starting out in any particular locality it will be advisable to go to the County Seat or Land Office and copy the necessary maps to show you the sections that are public land. Usually the local Land Office will make you a plat showing all public land at the rate of $1.00 for each township. This map may be less expensive than visiting the Land Office. Very often it is of considerable assistance to write to the U. S. Surveyor General of your state for a copy of such segregation plats as show the patented claims in the mineral district in which you are interested. These plats, if they can be obtained, may be expensive, but they will repay the outlay by showing you where the mineral belts or zones are situated and the directions in which they extend. If you can visit the Surveyor General's office personally you will be permitted to make a copy of any plats you desire. These plats will be very valuable as they show the exact situation of all patented claims, thus enabling you to find claim corners.

Mineral Districts of the United States.

391. The day of haphazard prospecting is a thing of the past, and victory belongs to the well-posted man. Prospectors and miners should make a study of characteristic mineral deposits, especially those situated in that part of the world in which they intend to prospect, because conditions which have produced ores in one district will, most probably, produce ores in other districts under similar conditions.

392. For the benefit of prospectors, miners, and others who may desire information of this character, brief descriptions of some of our most important districts and deposits will be given in the following pages. In order to simplify these descriptions, and at the same time make them more comprehensive, each state will be divided into regions and these regions will be subdivided into mineral districts.

393. As there is but little public land [934] and very little prospecting outside of the Pacific and Rocky Mountain States the mineral deposits in the Eastern States will not be discussed in detail. No doubt prospecting could be made possible in those states, especially if prospectors could secure from the property owners permits to prospect, with long time options to purchase. Such options would, in the end, result in a mutual benefit to both owner and prospector, to say nothing of the great indirect benefit to the community at large.

394. In the maps (original) of the Western States, drawn to show the location of the various mineral districts, the following signs are used:

LEGEND:

□	GOLD.
⧅	GOLD AND SILVER.
◺	SILVER.
△	LEAD.
◺	SILVER AND LEAD.
○	COPPER.
⦶	COPPER AND GOLD.
⊘	COPPER AND SILVER.
▲	MERCURY.
P	PLATINUM.
F	IRON.
Z	ZINC.
T	TIN.
C▨	COAL AREAS.
▒	PROBABLE COAL.
●	PETROLEUM.
⊕	PROBABLE PETROLEUM.
⊖	GAS.
■	BLACK SAND.
✢	MONAZITE.
+	MAGNESTE.
×	MANGANESE.
◣	CHROMITE.
⌓	GYPSUM.
⊙	CITIES.
▧	MINERALIZED AREA.

395. **Alabama.**—Nearly all the mineral productions of this state come from the northern and central parts. Vast amounts of coal, iron and limestone are produced, the limestone being used as a flux. In the production of iron this state ranks fourth or fifth. Bauxite is very abundant in several localities. [706]. Clay, marble and cement are also important productions. Gold mining began long before the war, and has continued to the present day. But the amount of gold produced is not large, amounting to only $26.272 in 1907, and $41,200 in 1908.

396. According to the State Geologist for Alabama, the value of the undeveloped phosphate [755, 756] beds in the central and southern parts of the State exceed even the value of the total coal area of the State. The Mineral Resources of the United States for 1907, however, state that the production is small* at the present time.

397. **Alaska.**—This territory has produced a vast amount of mineral wealth, but it should be observed that Alaska has an area equal to about one-fifth that of the entire United States, or as large as Washington, Oregon, Idaho, California, Nevada and Utah combined.

398. The Territory is not divided into counties. The districts recognized are as follows: Southeast Alaska, Copper River Basin, Cook Inlet Region, Yukon Basin, and Seward Peninsula. The self-explanatory term, Pacific Coast Belt, is often used. It includes Southeastern Alaska and Prince William Sound.

399. The principal districts in the Pacific Coast Belt are Ketchikan, Juneau and Sitka.

400. In the Copper River Basin considerable prospecting for copper is being done in the copper bearing areas north and south of Wrangle Mountain.

401. In the Cook Inlet Region there is still considerable prospecting going on. Quartz gold in bench deposits is being sought with favorable indications.

402. The Yukon Basin contains many important districts. They are the Fairbanks, Rampart, Circle, Fortymile, Koyukuk, Chandlar and Innoko districts. Fairbanks produces more than all the others combined.

403. In the Seward Peninsula the most important districts are Nome, Council, Kaugarok and Fairhaven. Of these Nome is the most important. Mining declined slightly in 1908.

404. Prospecting in Alaska is attended with many hardships and much expense, even at the present day. Trails have been built

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*Mineral Resources of the United States, 1907, page 651

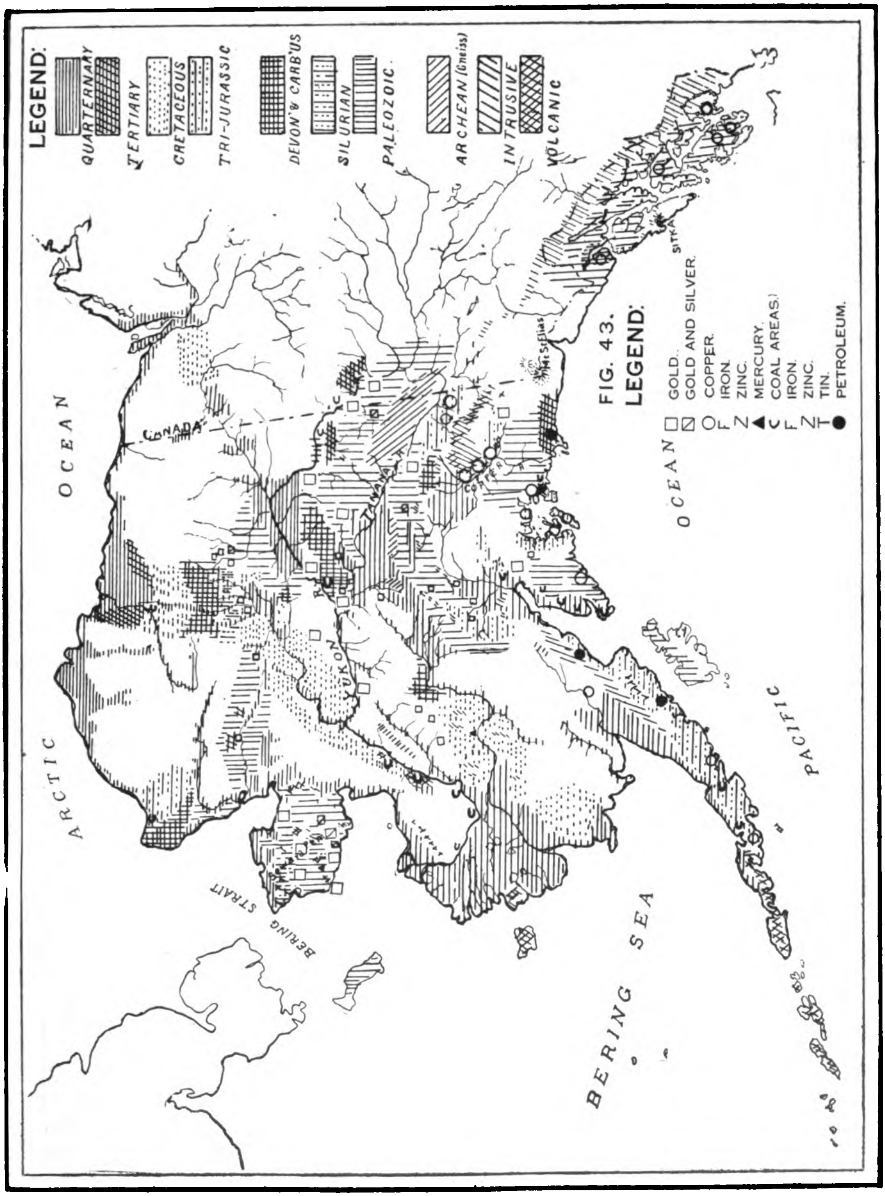

FIG. 43.

ALASKA.

and permanent camps and villages established in all the important parts of the territory. Yet traveling is difficult, especially during the winter, when travel is almost suspended.

405. Before going to Alaska it is absolutely necessary to consult those who have been there and thus obtain practical hints and suggestions. It would take a large book to print all the necessary information about Alaska, and for this reason no attempt will be made to give details.

406. There are many rich strikes to be made in this Territory, not only in gold, silver and copper, but in other metals and minerals as, tin, coal, graphite, gypsum, marble, mineral water, lead, zinc, copper, tungsten, cinnabar, oil, etc.

407. The coal areas of Alaska are very large and numerous. Owing to the great value of these deposits Congress will likely pass special laws regulating the acquirement of these lands. For the present much coal land has been reserved from entry till suitable legislation can be enacted. [955].

408. Tungsten is found near Nome, also graphite. Cinnabar is found on the Kuskoquim river, and also east of Nome.

409. Tin is reported at Diomede Islands in Behring Strait; Brooks Mountain, 11 miles north of Lost River; on the north side of Don River; at Ear Mountain, 50 miles north of Teller; at Hot Springs, 70 miles northeast of Port Clarence; at Asses Ears, near the headwaters of Pinnel River south of Kotzebue Sound; and other localities. All of these being in the Seward Peninsula would indicate that the region is favorable for tin prospectors.

410. **Arizona.**—It will be observed that the chief mineral districts of Arizona lie in a northwest-southeast zone running through approximately the center of the territory. All the important copper deposits, and many of the gold and silver veins, are closely associated with igneous rocks and occur in regions of numerous faults. The silver and gold zone is considerably wider than the copper zone, and these metals occur in a greater variety of rocks.

411. Copper.—In the Bisbee district, the largest in the Territory, the ore occurs in sheet-like masses in limestone, mostly within 1000 feet of a northeast-southwest fault, and closely related to a porphyritic granite intrusion. [209] from which the copper was undoubtedly derived. A vertical section of the Copper Queen mine is shown in Fig. 44. This is one of the largest copper mines in the southwest.

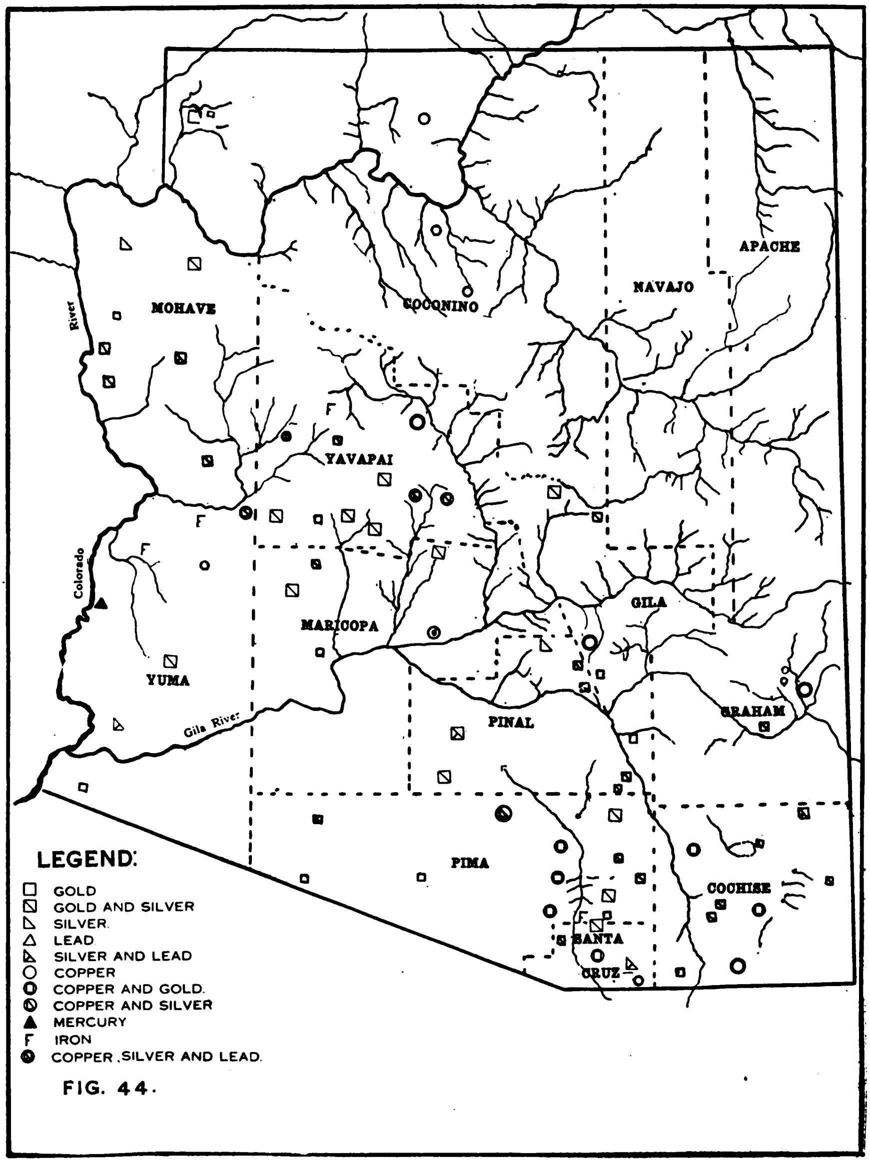

FIG. 44.

ARIZONA.

412. At Morency, near Clifton, there are large bodies of disseminated copper sulfid in altered porphyry (porphyritic granite). The conditions are such that this ore can be mined and worked at a very low cost. Oxidized copper minerals occur in limestone near the faults or dike walls. The workings are not deep—400 to 500 feet. Secondary enrichment [173] has been an important factor in forming these ore bodies.

413. At Globe, the district ranking third in importance as a copper producer, the ore occurs in sheet-like masses in limestone, and is closely related to nearby igneous rocks, and to a large fault.

414. At Jerome, the center of the district ranking fourth in importance, the copper occurs as a sulfid in wide, columnar masses in a shear zone [see glossary] in diorite. The copper ores of this district contain higher values in silver and gold than either of the preceeding districts.

415. Copper also occurs in notable amounts in the Silver Bell Mountains, near Tucson; in the Bradshaw Mountains, south of Prescott; and in the Kaibob Plateau, 125 miles north of Flagstaff.

416. Gold and silver.—There are few important gold mines in Arizona, though it ranks seventh in the production of this metal. Many good gold discoveries have recently (1911) been made in Mojave County. Silver is abundant, chiefly occurring associated with copper ores, and when thus found its amount varies with the percentage of copper in the ore. Placer silver is found in a few localities.

417. There are several important districts producing both gold and silver. The occurrences being as follows: In Apache County, in limestone associated with copper; in Yavapai County, in veins in granite and metamorphic rocks, especially in the copper districts; in Mojave County, the ores being base; in Pinal County, the veins being in both sedimentary and igneous rocks; in Cochise County, in rich veins associated with dikes in several cases. Tombstone is the center of a very important silver district.

418. Lead.—Considerable lead is produced from silver-bearing galena [788] veins—chiefly from Cochise, Mojave, Santa Cruz, Yavapai, and eastern Pima counties.

419. Zinc.—This metal is derived chiefly from Yavapai, Santa Cruz, and Mojave counties, named in the order of their importance.

420. **Arkansas.**—Zinc, galena, gold, copper, manganese, nickel, limonite iron ore, phosphate, bauxite, salt, and anthracite coal are the chief mineral productions.

421. Among the economic minerals the State produces is th

world-famous "Ouachita" oil stone for tool sharpening; also grindstones, millstones, granite, slate, marble, asphalt, graphite, chalk, and a bitumen known as grahamite.

422. **California.**—This State is well covered with mines and mineral deposits, but many of these are as yet either undiscovered or undeveloped. Many prospectors consider California a poor field because it is one of the oldest mining States in the west. This is a mistake, for new mines are being discovered every day. Supply centers are not far distant from the prospector at any time, which means that his necessities may be often replenished, instead of packing a large load.

423. The Mother Lode.—This lode is the most important mineral region in the State, or possibly in the United States, production considered. It is not a single, continuous vein, but more properly, a series of veins. It is the most wonderful lode in the world. There are a few places along its course where neither vein nor mineral is found, and at some places the vein is without valuable minerals. Nevertheless, it is practically a continuous chain of veins across three counties. In some localities the vein becomes a zone or belt of stringers. In such cases it is called a "stringer vein."

424. The Mother Lode as a whole has produced about $200,000,000 up to the present time, 1911. Ross E. Brown gives the total production up to 1898 as $100,000,000. This is a very conservative estimate, however. At present the lode is producing about $4,000,000 annually. During the last 62 years California has produced about half the gold yield of the entire United States, Alaska included, and contains a greater number of gold mines than any other State. About 45% of the present yield comes from the placer mines, and 85% of the placer gold is produced by dredging.

425. The veins of the Mother Lode, so far as known, all dip to the northeast, generally at a flatter angle than the enclosing slate. The strike is generally the same as the slate. The veins are thrust faults, that is, faults, the hanging walls of which moved up as compared with the foot wall. Later, the hanging has moved down again in most cases, forming slickens.

426. The Sierra Nevada Mountains are composed of two principal groups of rocks;* 1. An ancient complex of steeply dipping schistose rocks, invaded by igneous masses of granite; 2. Overlying the complex is a group of younger rocks resting upon the complex non-comformably, and composed of auriferous gravel and Neocene [125] lavas such as rhyolite, andesite, etc.

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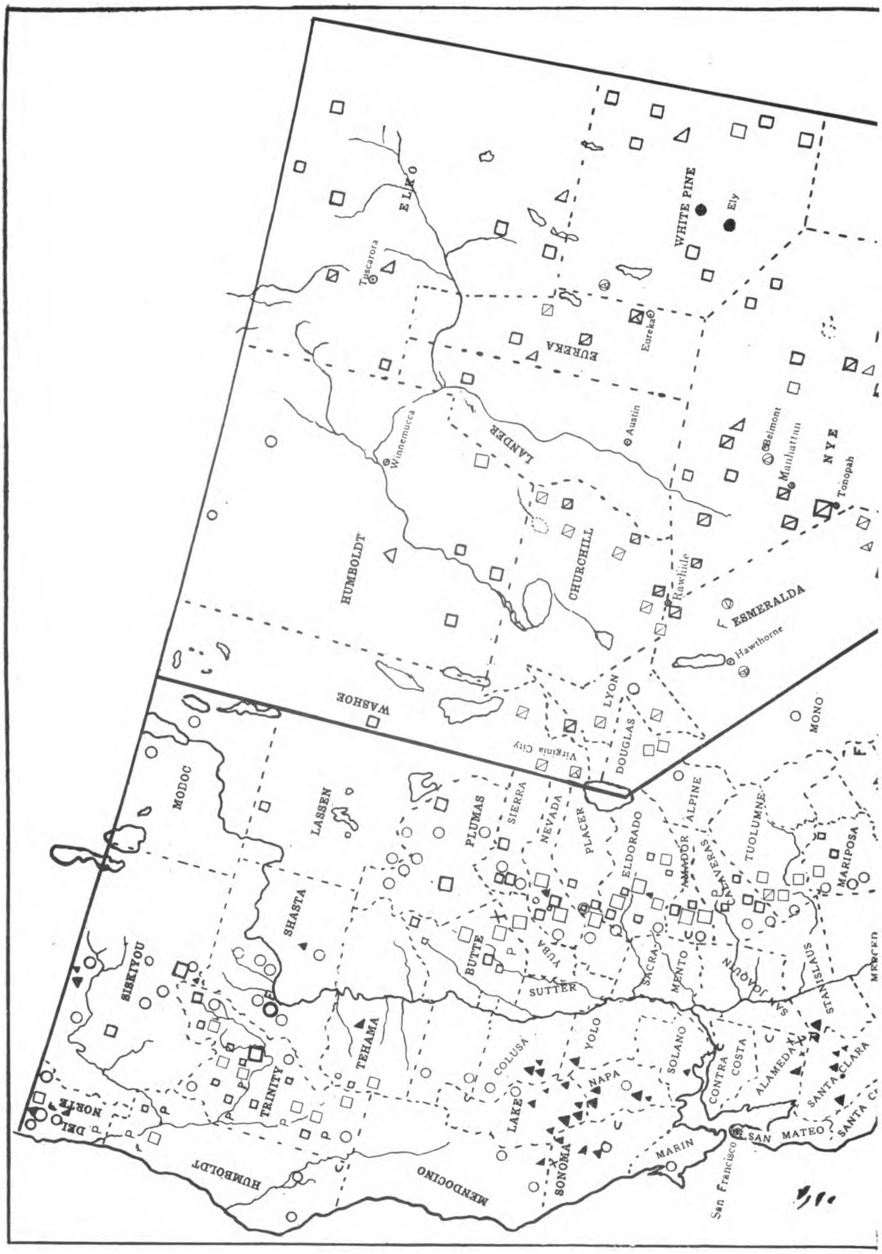
*Geological folio No. 63. Price 50c.


ELKO
Tuscarora
WHITE PINE
Ely
EUREKA
Eureka
Austin
LANDER
Winnemucca
Belmont
Manhattan
NYE
Tonopah
HUMBOLDT
CHURCHILL
Rawhide
ESMERALDA
Hawthorne
WASHOE
LYON
DOUGLAS
Virginia City
MONO
MODOC
LASSEN
PLUMAS
SIERRA
NEVADA
PLACER
ELDORADO
ALPINE
AMADOR
CALAVERAS
TUOLUMNE
MARIPOSA
SHASTA
SISKIYOU
BUTTE
YUBA
SUTTER
SACRAMENTO
SAN JOAQUIN
STANISLAUS
MERCED
TEHAMA
TRINITY
DEL NORTE
COLUSA
YOLO
SOLANO
CONTRA COSTA
ALAMEDA
SANTA CLARA
LAKE
NAPA
SONOMA
MARIN
San Francisco
SAN MATEO
HUMBOLDT
MENDOCINO

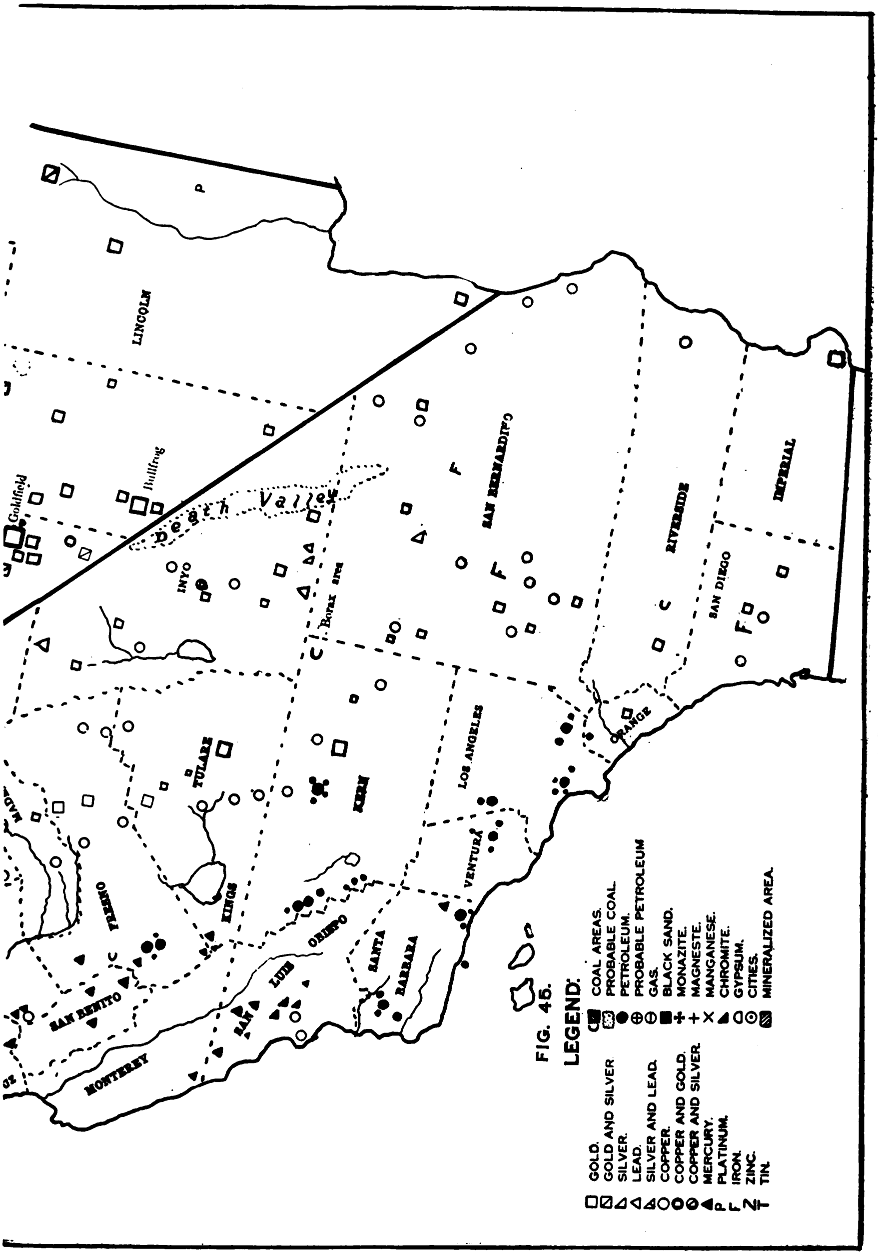


FIG. 45.

CALIFORNIA AND NEVADA.

The ancient complex is described as follows:

427. a. Calaveras formation. Comprising conglomerates, slates, sandstones, limestones, cherts, quartzites, mica-schists, etc. The eastern limit of this formation is an eruptive contact. Fossils found in the limestone show the formation to be of the Carboniferous Age. This formation lies chiefly to the east of the Mother Lode. The light colored dikes occur on the eastern edge of the belt. The Calaveras formation is non-conformable with the Mariposa formation.

428. b. Mariposa formation. Comprising cleavable and homogenous clay slates with small amounts of sandstone and conglomerates, mainly Jurassic. This formation is a narrow zone, almost continuous with the Mother Lode, which it follows quite closely.

429. c. Igneous rocks. Along the Mother Lode these rocks are quite altered; as, typical schistose amphibolite (gray slate of the miners) which is distinguished from the sedimentary slate by the greenish tint of the former; meta-andesite or volcanic tuffs and breccias of a greenish color, outcropping like grave stones; granodiorite, lying in the high Sierras; quartz-diorite, found at Big Oak Flat and Parrot Ferry; meta-diorite, called granite by the miner, and serpentine which has resulted from the alteration of basic rock, found in elongated dikes.

430. The overlying group may be described as follows: It consists of Cretaceous, Eocene, Neocene and Pleistocene sediments, together with volcanic rocks of the same period. The material is mostly gravel and lava streams. Phyolite occurs as ashes and tuffs. Andesite lava is also found in beds and streams.

431. The Mother Lode veins in the Mariposa, dark, clay-slate or Calaveras slaty schists are generally "stringer leads" with slight outcrops. The largest stringers are often banded as a result of re-openings and re-fillings. Slate often remains with the quartz in such cases.

432. Mother Lode veins in the amphibolite schist are similar to the above, but the country rock is much altered and filled with pyrite. Tellurides are often present.

433. Mother Lode veins in serpentine are seldom paying, but some serpentine contact-veins are rich, as the Crown Point and Maryland, at Grass Valley. They have large outcrops and are often 200 feet or more in width.

434. Contact veins are also common on the Mother Lode.

435. The Mother Lode counties are Eldorado, Amador, Calaveras, Tuolumne and part of Mariposa. The lode is about 75 miles long.

436. The rank of the gold producing counties in California is as follows: Butte, Nevada, Amador, Yuba, Calaveras, Kern, Tuolumne, Shasta, Sacramento, Trinity, Sierra, Placer, Mariposa, Siskiyou and Mono.

437. California is not gaining in the annual production of gold of late.

438. Quicksilver ore, cinnabar, is found in plentiful amounts in the Coast Range Mountains, being found in every county in the State bordering on the Pacific, and in nearly all the counties in the second tier. It is also found in very small amounts in some of the Mother Lode gold mines. In nearly all cases it occurs near serpentine, and hot springs are common in the vicinity.

439. Copper is found in nearly every county in the State, but not in paying quantities in every instance. The value of the copper production of the State is now second only to that of gold and petroleum. The chief copper districts are: the Shasta County, the Western Foothills of the Sierra Nevadas, and the Southeast Desert regions, named in the order of their importance.

440. Lead. Inyo County produced $139,147 worth in 1907, but none in 1906. Small amounts are mined elsewhere, the annual production for the State ranging from 500 to 800 tons.

441. Very little zinc is found in California. Inyo County produces a small amount.

442. Manganese bearing minerals are found in a few localities, the most important of which is at the junction of Alameda, San Joaquin, Stanislaus, and Santa Clara Counties. Jasper associated with any mineral that resembles pyrolusite should be carefully tested as jasper in this range is favorable for it.

443. Chromite is more widely distributed than manganese, and is found in several localities along the Coast Range. It is a valuable ore and should be prospected for. Search for it in localities abounding in serpentine.

444. Iron is found in isolated places, notably in Del Norte, Shasta, San Diego, San Bernardino, Madera and Placer Counties.

445. Petroleum has become one of the most valuable mineral productions of the State. The production in 1909 aggregated 54,4333,000 barrels, valued at $30,675,267. The Coalinga and Kern County districts are rapidly gaining in activity. The Santa Maria district, which forms a part of the larger Santa Barbara region, has the largest export trade, being situated near the coast. The value of California's petroleum output exceeds that of any other mineral product. Petroleum occurs most plentifully in the Los Angeles and Santa Barbara districts, and along the western border

of the great Central Valley of the State. Some good prospects exist in Humboldt County, and in Alameda County. Prospect for it along the borders of the Central Valley, especially along the western borders.

446. Borax. Immense deposits of this mineral occur in the desert regions in the southeastern part of the State. Search for it in the arid regions, and in the Frazier Mountains.

447. Molybdenite. This mineral is found in granite formations in small amounts in many places, notably near Corona, Riverside County.

448. Platinum is found near Cherokee, Butte County; Crescent City, Del Norte County; Hay Fork, Trinity County; and in the Black Sands of the Klamath River and its branches.

449. Silver. The silver is chiefly a by-product in the treatment of gold and copper ores; [52] and its value is less than one-twentieth of that of the gold. Shasta County leads in the yield of silver.

450. Magnesite deposits are numerous in this State, but only seven are productive. These are in Tulare, Fresno, Riverside, Santa Clara, and Napa Counties. Sonoma, Alameda, Stanislaus, and a few other counties contain non-producing mines. In 1909 the State produced 9,465 tons valued at $37,860. Owing to an increase in the use of this mineral its production is increasing.

451. **Colorado.**—This State may be divided into two natural divisions: the Great Plains region, comprising the eastern part of the State, and the Rocky Mountain region, comprising the western two thirds of the State. The Great Plains region consists chiefly of Quarternary [125] and Cretaceous rocks. The foothills are mostly upturned Jura-Triassic and Cretaceous formations. All these stratified rocks rest upon the crystalline, igneous rocks of the Archean Age. The Rocky Mountains, which cross the center of the State from north to south, are composed chiefly of granite with local exposures of more recent extrusive and exposed intrusive rocks. The San Juan sub-region in the southwest consists chiefly of successive outflows of igneous rocks; as diorite, andesite, diabase, basalt, etc. The veins in these rocks often carry galena, pyrargyrite, tetrahedrite and native silver.

452. As shown in Fig. 46 the most important metaliferous mineral districts lie in a rather well defined zone in the center of the State, and the coal bearing formations lie along the flanks of the mountains on either side. This State produced $13,586,988 worth of coal in 1908, outranking all other States west of the Mississippi. It is second in the production of zinc.

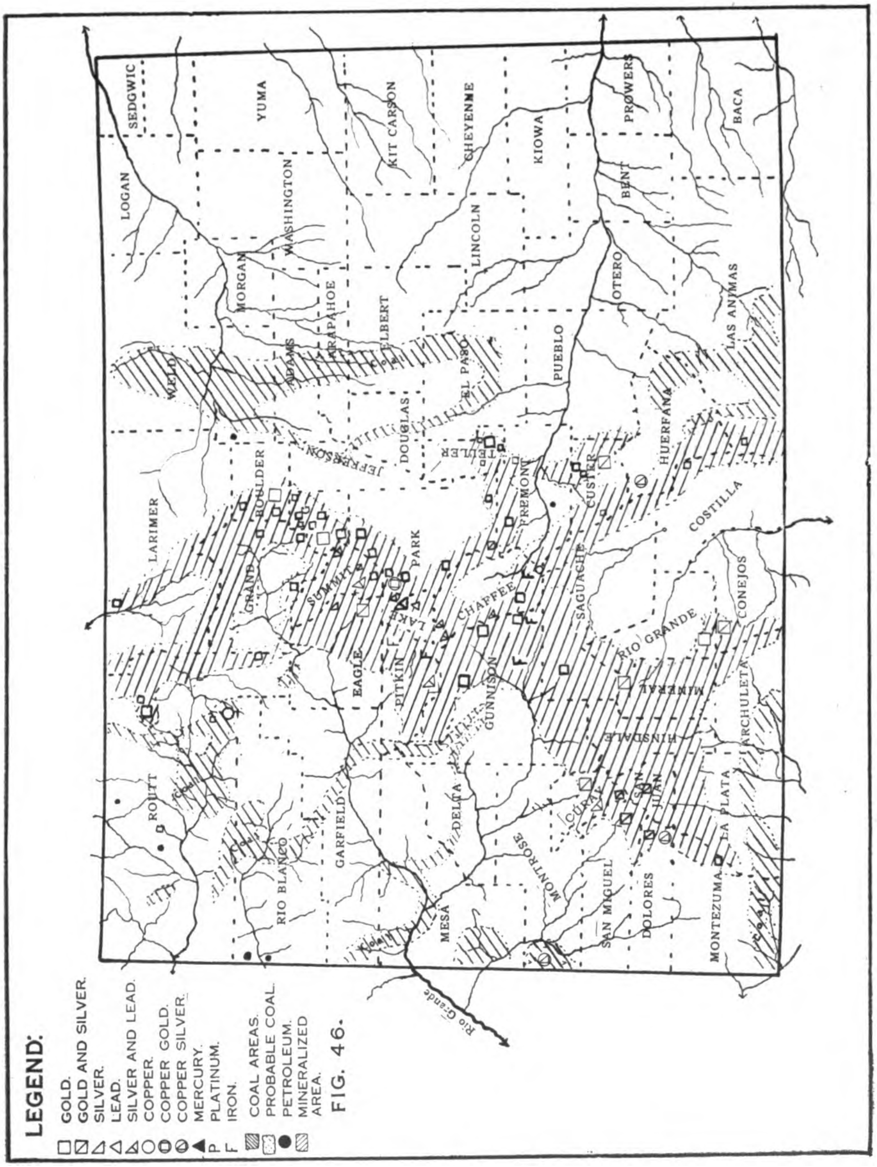


FIG. 46.

COLORADO.

A more detailed description of the State will be given by counties.

453. Archuleta County.—The Conejos Mountains are mostly igneous and the rest of the County is cretaceous sedimentary, the metal mines being in the mountains in the eastern part of the County, while coal and oil are found in the southern part.

454. Boulder County.—The principal rocks are granite, gneiss and schist. Eruptive dikes are numerous in the mountainous parts. The veins are seldom continuous, and often divide into branches and stringers. All the veins carry both gold and silver. Galena is often present. The principal districts are Grand Island, Sugar Loaf, Magnolia, Gold Hill, Central, and Ward. As a rule the ores are base and refractory.

455. Chaffee County.—Prospectors have slighted this county in the past—possibly with justice, the metaliferous mineral veins having been found only along the borders of the county. Placer ground is found in the central part. La Platte, Hope, and Red Mountain districts have received attention.

456. Clear Creek County.—The principal formations are granite, gneiss, and mica schists, cut by numerous eruptive dikes. The veins, which appear to be closely associated with the dikes, are usually fissures, but they sometimes appear to be only an altered condition of the country rock. The Silver Plume and the Idaho Springs districts are important.

457. Conejos County.—Mining is confined principally to the mountains of the western border. The veins are usually large and carry gold. Platoro is the chief mining center.

458. Costella County.—The formation is mostly recent metamorphic, but little mining is done.

459. Custer County.—The leading districts are Hardscrabble, Silver Cliff, West Cliff, Rosita, and Querida.

460. Gilpin County.—This small county has been a large producer. The formation is chiefly granite, which has been much disturbed, and many dikes occur. The veins are chiefly fissures carrying gold and silver.

461. Gunnison County.—This is a good mineral county. Granite predominates in the mountains along the eastern border; and Paleozoic rocks, broken by a series of igneous dikes, cover the balance of the County. South of Gunnison there is a so-called gold belt. In the Elk Mountain district many fissure veins are found. There are many iron and manganese deposits in the county, an important one being situated 25 miles south of Gunnison, and another one the same distance to the northeast. Mangetic iron ore is found in the southwestern part of the county.

462. Grand County.—Not very well mineralized, especially in the central part.

463. Huerfano County.—There are good gold mines in the west and good coal mines in the east.

464. Jefferson County.—There are a few placer mines in the west, and a fair quality of coal is found in the east. Fire clay is found near the coal fields in the Dakota formation.

465. Lake County.—Better known as the Leadville district. The mineral output of the county has run up into the millions, the greater portion of which has been gold and silver. The geologic formation of the Leadville district is very interesting. The ore is silver-bearing lead carbonate, passing into sulfids with depth, deposited in limestone which has been much faulted.

466. Larimer County.—No great amount of mining has been done in this county, though good mineral ground is to be found in the Medicine Bow and Park ranges.

467. Mineral County.—Creede is the center of a very important silver mining district.

468. Routt County.—Hahns Peak district in the Park range, near the eastern boundary line, contains good placer mines and some excellent gold quartz veins. Carnotite is mined in this county.

469. San Juan County.—This county is covered by what has been termed the San Juan formation, which consists of early schists, granites and gneisses, overlaid with Paleozoic stratified rocks in some places, and the whole then covered with later lavas which have been eroded in spots, exposing the earlier rocks. Silverton is the center of an important silver mining industry. Copper is also found in paying quantities.

470. San Miguel County.—The eastern part of this county contains Telluride, an important gold mining camp. The veins are in early schists and slate. Barren (bull) quartz seams are common and should be avoided.

471. Summit County.—A good mining county. The placer mines on Blue River have produced millions. Dredging is carried on now. Gold lode-mining is also followed.

472. Teller County.—This county contains the famous Cripple Creek district and has been fairly well prospected. The prevailing rocks are granite, gneiss and schist, through which later eruptive rocks have reached the surface. An eruptive phonolite characterizes the district. The district has produced over $130,000,000 in gold and 700,000 ounces of silver. Cryolite (aluminum ore) has been found in this county.

473. **Connecticut.**—The mineral productions of this State are not important. Building stone, lime, mineral water, gravel, and precious stones are produced. Named in the order of importance.

474. **Delaware.**—Granite, kaolin, glass sand, feldspar, marl, and bog iron ore are produced.

475. **Florida.**—Phosphate rock mining is an important industry in this State, the annual production exceeding that of any other like area in the world.

476. Fullers earth and kaolin are also produced.

477. **Georgia.**—The northern part of Georgia produces coal, iron, aluminum, manganese, slate, hydraulic cement, and gold.

478. Granite and marble are produced in the central part of the State.

479. The largest bauxite deposits [809] are in Bartow and Floyd Counties. Corundum [932] is found in paying quantities in Rabum, Towns, Union, Habersham, Carroll and Heard Counties.

480. Iron pyrites, copper, graphite, asbestos, mica, barite, limestone, marl, and phosphate rock are also found. Moonstones, amethysts, and a few diamonds have been found.

481. **Hawaiian Islands.**—These Islands are practically non-mineral. In 1908 $81,219 worth of granite, and $11,000 worth of sand were marketed. In 1909 $558,889 worth of salt was produced. Lime, limestone, and sulfur are also produced in small amounts.

482. **Idaho.**—This State may be divided into six natural divisions: the Great Plains region of the extreme southwest, extending into Nevada and Wyoming; the Snake River region, covered in part by recent basaltic lava; the Granite region, which lies north of the Snake River and west of the center of the State; the Panhandle region in the extreme north; the Bitter Root Mountain region, and the Pocatello region in the extreme southeast.

483. The Great Plains region is practically non-mineral.

484. In the Snake River region there are a number of good mineral districts, among which are the Delaware and Silver City districts of Owyhee County. Along the Snake River there is considerable placer ground suitable for dredging, especially in Lincoln County. In many cases in the past larger dredges have been built than the ground warranted. This in many cases was due to failure to properly prospect the ground with a churn drill, and in other cases due to extremely fine gold.

485. The Granite region extends south to within a short distance from Snake River and north to and including the Sawtooth

Mountains. In it are several noted mining districts, the most important of which is that of Boise. Seven Devils and Heath districts are promising.

486. The Panhandle region consists of Archean, Algonkian and Paleozoic rocks with many igneous intrusions of granite and basalt. The Coeur d'Alene series of rocks consist of blue-gray slate, flaggy fine-grained sandstone, and shales interbedded with quartzite; calcareous shales, sandstones with ripple marks, sun cracks, etc. Above the Coeur d'Alene series there is, in some cases, a great thickness of argillaceous shales overlain with calcareous argillite, as at Cabinet Mountains. There are many faults, but the mineral deposits are usually with the small faults rather than with the large ones. Geologically, the Arrow Lake, Lardeau and Revelstoke mineral districts in British Columbia really form a part of the Panhandle region of this State.

487. Kootenai County contains much rich placer ground.

488. The Coeur d'Alene silver-lead mines in Shoshone County are the principal mines of this region.

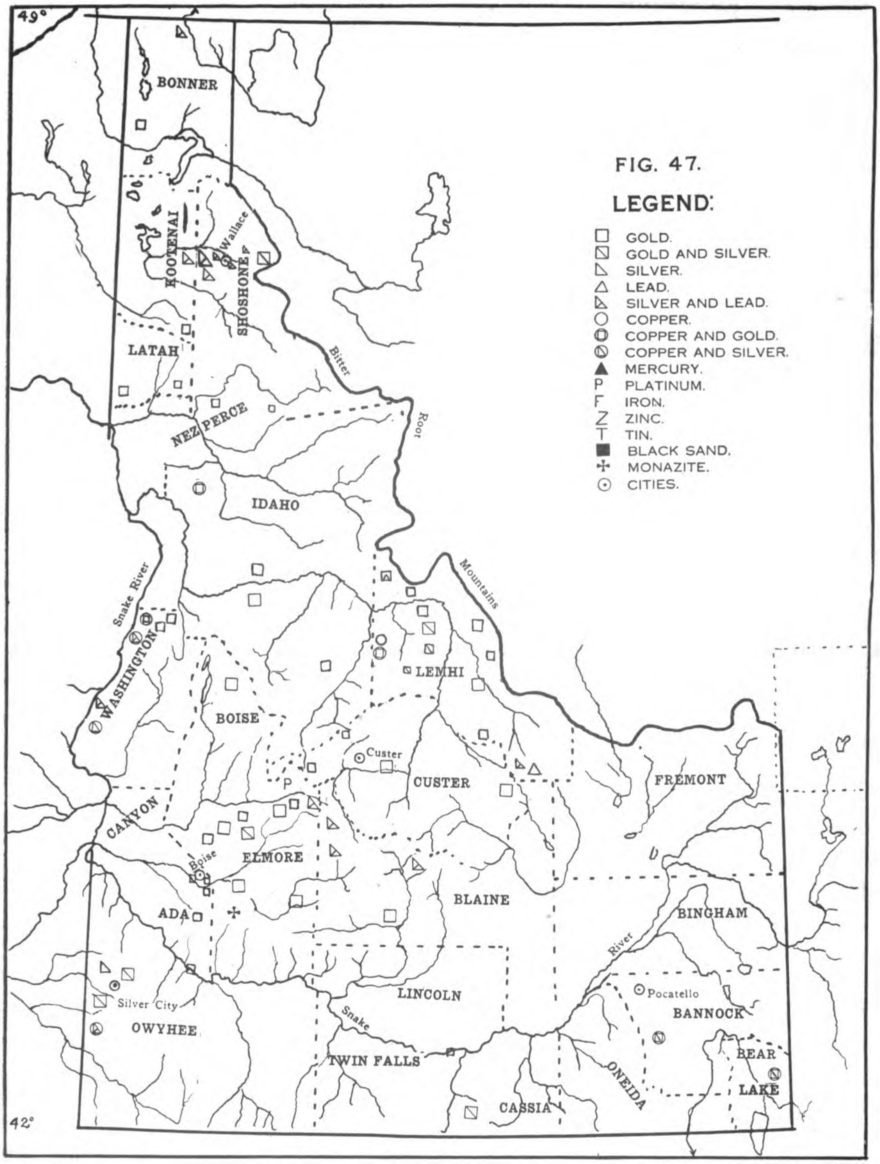
489. The St. Joe River Basin district lies immediately south of the Coeur d'Alene and forms a part of the Panhandle region. It contains many indications of silver-lead, copper and gold ores, but neither prospecting nor mining has been diligently prosecuted. The rocks containing silver-lead are mostly the same as in the Coeur d'Alenes.

490. The Panhandle region is an excellent one for the prospector as it contains much good unprospected ground. The long winters are a drawback, of course. The writer is personally familiar with the region, and believes it is destined to become one of the greatest mineral producers in the Northwest.

491. The Bitter Root Mountain region is very important. It includes a portion of Montana.

492. In Lemhi County there is considerable placer ground, some of which has been prospected and much that has not. The Yellow Jacket district in the southwest, and the Gilmore district in the south, are important mining centers. The former is a gold camp and the latter is silver-lead producing. The gold ores of this county are usually base. The county is well watered but transportation facilities are meager.

493. Idaho County is varied in its mineral character and contains many important mineral districts, among which are the famous Thunder Mountain gold mining districts, and the lesser important Marshal, and Lake Districts. Newsom is a placer district of some importance.


49°
BONNER
FIG. 47.
LEGEND:
□ GOLD.
⊠ GOLD AND SILVER.
◺ SILVER.
△ LEAD.
◭ SILVER AND LEAD.
○ COPPER.
⊕ COPPER AND GOLD.
⊘ COPPER AND SILVER.
▲ MERCURY.
P PLATINUM.
F IRON.
Z ZINC.
T TIN.
■ BLACK SAND.
✢ MONAZITE.
⊙ CITIES.
KOOTENAI
Wallace
SHOSHONE
LATAH
Bitter
Root
Mountains
NEZ PERCE
IDAHO
Snake River
WASHINGTON
LEMHI
BOISE
Custer
CUSTER
P
FREMONT
CANYON
Boise
ELMORE
BLAINE
ADA
BINGHAM
River
Pocatello
BANNOCK
Silver City
OWYHEE
LINCOLN
Snake
TWIN FALLS
ONEIDA
BEAR
LAKE
CASSIA
42°

IDAHO.

494. Custer County contains many rich gold and silver mines and has considerable excellent unprospected ground open to location. The writer has examined many important prospects in this county and in the adjoining Thunder Mountain district.

495. Blaine County contains rich mercury deposits in the Hailey district.

496. In the Pocatello region there are a number of gold, copper, lead and silver mines, especially around Pocatello.

497. Bear Lake County has many copper prospects of promise, but of late years phosphate rock mining has become a very profitable industry, crowding out metal mining to some extent.

498. **Illinois.**—Illinois produces a large amount of coal and considerable quantities of lead, zinc, petroleum, fluorite, building stone, clay, and glass sand (used for glass making).

499. **Indiana.**—Petroleum, natural gas, and coal are the chief mineral products, coal being in the lead with petroleum following. Building stone, clay, glass sand and cement are also produced.

500. **Iowa.**—With the exception of Colorado this State is the leader in coal production west of the Mississippi, the coal area covering over one-third of the State. Limestone, gypsum, clay and mineral waters are important productions.

501. **Kansas.**—Coal, zinc, lead, natural gas, petroleum, cement, gypsum and building stone are produced.

502. **Kentucky.**—Coal is the chief mineral production. Iron, building stone, limestone, fluor spar, salt, mineral water and natural gas are also produced in paying quantities.

503. **Louisiana.**—Rock salt, sulfur, petroleum, marl, and small amounts of iron and coal are the only minerals produced.

504. **Maine.**—Granite is the chief mineral product, large amounts being used within the State or shipped to other States. In many cases the granite is found near the ocean and convenient for loading on ships. Slate is found in the central part of the State. Feldspar and silica are mined for pottery making. Tourmaline and beryl are found in paying quantities. Iron, copper, zinc, arsenic, manganese, tin, silver, gold, antimony, pyrites and mica are mined on a limited scale.

505. **Maryland.**—Iron ore is the chief mineral production. Limestone, clay, kaolin, marble, granite, coal and building stone are also important productions.

506. **Massachusetts.**—The mineral products of this State are building stone, clay, lime, mineral water, sand, gravel and glass sand. [937].

507. **Michigan.**—The chief mineral product of this State is iron, copper being next in production. Both of these metals are mined in the northern peninsula. Small amounts of silver and gold are mined in the northern peninsula.

508. Salt, gypsum, cement, building stone, sandstone, limestone, grindstones, peat and coal are produced in the southern peninsula. With the exception of the coal these are all produced in large quantities.

509. **Minnesota.**—This State excels all the others in the production of iron ore, yielding 54.63% of the total in the United States in 1909. Plagioclase feldspar, limestone, granite, mineral water and sandstone are also produced.

510. **Mississippi.**—Clay is the principal mineral product, but marl, phosphates, hydraulic lime, gypsum and coal are produced in limited quantities.

511. **Missouri.**—This State produces large quantities of zinc, coal, iron, lead, nickel and clay. Building stone, marl and limestone are also produced. It produces more zinc than any other State.

512. **Montana.**—This State may be divided into two general divisions: The eastern Great Plains region, and the western Mountain region. There is a general rise from the plains to the Great Divide, broken here and there by isolated groups of mountains.

513. In the mountain region Paleozoic [125] rocks are important and extensive—contrast with Colorado where they are feebly developed. In the Butte copper district, dark granite prevails, and forms the core of the mountains extending from Butte to Helena. The veins occur chiefly in this dark granite. Dikes of lighter granite called aplite [197] intersect the dark granite, and dikes of later "Modoc" porphyry cut both of these granites. There is a rhyolite found that is more recent than the veins.

514. This State is a leader in the production of copper and silver, producing more of these metals than any other State. The greater part of the copper comes from the Butte district, but

there are, undoubtedly, other good copper mines to be found to the north along the rocky mountains as suggested by the prospector's map. While it is advisable for Montana prospectors to search diligently in formations similar to those prevailing at Butte, it must be remembered that there are other formations that are favorable for copper.

515. Madison County contains many gold mines. At Virginia City the quartz veins are usually in schists. In the northern part of the county the veins are in granite. At Rochester the gold is associated with galena. Tellurides have been found in the Tobacco Root Mountains.

516. In Jefferson County the formation is similar to that of Butte. Many varieties of ore are found, however. In some mines arsenopyrite and galena occur. At Elkhorn silver sulfid occurs in a replacement vein in limestone near a slate contact.

517. In Silver Bow County considerable silver is produced in addition to copper. The silver veins occur in both the dark and light colored granite, manganese minerals being associated with the silver. The manganese oxidizes and stains the outcrop very black.

518. In Broadwater County the veins are usually in granite.

519. In the southwestern part of Granite County silver and gold occur, chiefly in granite near the contact with metamorphosed sedimentary rocks, as at the Granite Mountain mine.

520. There are gold and silver bearing veins in the Little Rocky Mountains of Chateau County, associated with igneous intrusions of porphyritic syenite.

521. Free gold and tellurides with associated fluorite are found in Furgus County in contact veins [154] between igneous and sedimentary (limestone) rocks, as at Lewiston and Maiden in the Snowy Mountains.

522. There are excellent showings of coal in Carbon County aside from the working coal mines.

523. The investor should not overlook this county for there are many excellent opportunities.

524. In general, the best localities for the Montana prospector are in the Rocky Mountains, especially within a radius of 100 miles of Butte and Helena. The territory between the Rockies and the Bitter Root Mountains is above the average in promise.

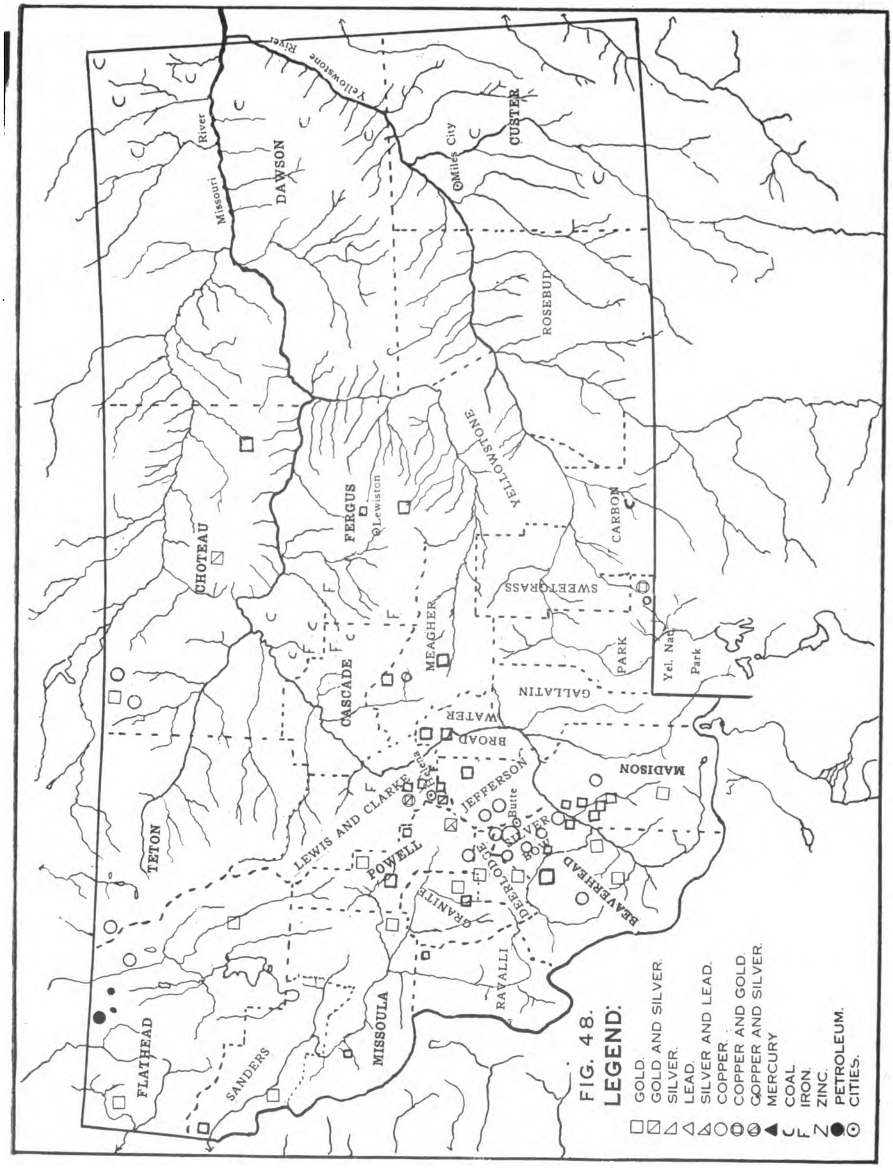


FIG. 48.

MONTANA.

525. **Nebraska.**—An agricultural State. Coal prospects have been found.

526. **Nevada.**—This State has become very prominent of late as a mineral producer. Judging by present indications it is destined to become one of the most important and continuously producing States in the Union. This prediction is based partly upon the present mineral production, but chiefly upon the many evidences of widespread and intense geologic disturbances. Faults, dikes, intrusions and great lava overflows are numerous, especially in the southern part of the State, which appears to be the most favorable for gold, which is found in widely scattered districts. Some of the most important of these are Goldfield, Bullfrog, Tonopah, Manhattan and Rawhide.

527. In the past silver has been the most important mineral production of the State, but the value of the gold product is now about three times that of the silver. The Comstock Lode, in the Virginia City district, has produced many millions in silver, and efforts are periodically made to again open up the camp. Many other localities, as Austin, Silver Peak, and Eureka have been large producers. Many new silver camps are being developed in recent years.

528. In many of the southern Nevada mining camps the veins carry extremely rich ore but, judging from the present developments, they are often cut off, or the values decrease rapidly with depth.*

Mine operators do not practice economy at present but employ methods of extravagance.

529. The mineral deposits discovered in recent years may be classified as follows:

530. (a) Veins in pegmatite [197] dikes in granite, as at Oak Springs, carrying gold and silver; (b) in zones of breciation in granite with large quartz veins carrying gold, pyrites, silver bearing galena and chalcopyrite; (c) in Paleozoic sedimentary rock, chiefly limestone, as at Lida, Bear Mountain, Oriental, Wash, Chloride Cliff, Montezuma, Oak Springs, and Southern Klondike, carrying gold and silver with chalcopyrite, galena and pyrite as associated gangue minerals; (d) in veins in silicified Tertiary monzonite [see glossary] carrying gold with pyrites, as at Kawich and Gold Center; (e) in veins in Rhyolite rock, carrying gold and silver with iron pyrites, chalcopyrite, and stephanite as primary minerals, and horn silver, malachite, azurite, limonite and hematite as secondary minerals, as at Silver Bow, Eden, Cactus Spring, Willows

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*Bulletin 303, U. S. Geological Survey, page 38.

Camp, Stonewall Mountains and Wellington. At South Klondike the gold vein is along a rhyolite-limestone contact. At Happy Hooligan the gold vein is along a basalt-limestone contact.

531. Prospectors in Southern Nevada will find ledges in limestone near igneous intrusions and extrusions, especially porphyry, very favorable for gold. In the extreme southwest quartzite, schists and limestone are favorable country rocks. Sometimes the quartz outcrops contain much oxidized iron pyrites with low gold values, the values increasing below this "gossan" of iron. Old rhyolite flows are also favorable.

532. In Goldfield the ores are mostly in siliceous veins in dacite with craggy outcrops. Cross-fissures are numerous, and the veins are not continuous in strike or dip for any great distance. There is a tendency for values to decrease with depth, especially below the 300 foot level.*

533. In the Bullfrog district faults are very numerous. Rhyolite prevails. Basaltic and pegmatite dikes are common. The veins are mostly mineralized faults in rhyolite. Many of the veins are stringer veins.

534. Tonopah.—This is a silver-gold camp, producing about three times as much silver as gold, values considered.

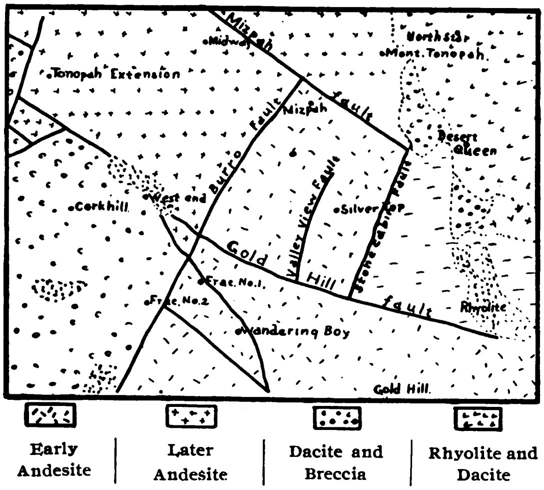

Fig. 49. Geological Surface Map of the Producing Area of Tonopah, Nevada.

Below is a review of the districts by counties.

535. Churchill County.—The important districts are Fairview, Wonder, Stillwater, and White Plains. The eastern part of the county is the most favorable for the prospector.

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*Bulletin No. 202, U. S. Geological Surrvey, page 38.

536. Douglas County.—There are a number of good prospects being opened up near Gardnerville; as, the Longfellow, Orpheus, Big Frank, and a number of others in the Pinenut Mountains.

537. Elko County.—The districts are Aura, Edgemont, Tuscarora, Spruce Mountain, Railroad, Tocoma, and Gold Circle.

538. Esmeralda County.—Goldfield is the most important district. The others are Aurora, Buena Vista, Hawthorne, Buckley, Lida, Hornsilver, Luning, Candalaria, Mina, Pine Grove, Silver Peak, and Thorp. There are many other favorable localities.

539. Eureka County.—Eureka, Cortez, and Palisade are old camps.

540. Humboldt County.—The favorable districts are Fitting, Golconda, Humboldt House, Mills City, Chaffey, Unionville, Seven Troughs, Winnemucca, Rosebud, Ashdown, Paradise Valley, Rebel Creek, Goldbanks, and Kennedy. Judging from personal observation there are good opportunities in the northern part of the county as well as in the southern part where these districts are situated.

541. Lander County.—Austin, Bullion, Battle Mountain, Copper Basin, Gweenah, and Skookum, are the leading districts. Austin is an old camp.

542. Lincoln County.—There are many good districts in this county; Bunkerville, Caliente, Crescent, Delemar, Eldorado Canyon, Fay, Gold Butte, Lyons, Patterson, Pioche, Searchlight, and Yellow Pine are the most favorable.

543. Lyon County.—This small county contains the Dayton, Silver City, Ramsey, and Mason districts. Yerrington, in the Mason district, is a promising copper camp. Many are prospecting for oil in the valley between Yerrington and the Pinenut Range.

544. Nye County.—The western half of this county is well mineralized and contains very rich mines. The chief districts are Bellehelen, Berlin, Bullfrog, Cactus Range, Cloverdale, Goldyke, Hannapah, Ione, Johnnie, Lodi, Manhattan, Millet, Round Mountain, and Tonopah.

545. Ormsby County.—No mining operations of importance are in progress at present.

546. Story County.—This is the seat of the once famous camp of the Comstock lode. At present Gold Hill and Silver Hill produce considerable bullion. Not a favorable county for the prospector who lacks means.

547. Washoe County.—Jumbo, Olinghouse, Reno, and Leadville, are the leading camps. Not especially favorable.

548. White Pine County.—Black Horse, Cherry Creek, Granite, Duck Creek, Ely, Hamilton, Osceola, and Ward are good districts. Ely is a copper district of much importance.

549. This is an excellent State in which to prospect, many very valuable prospects being found from time to time. Every time a new strike is made a rush takes place for the locality. The prospector will have little difficulty in selling a good prospect in this State.

550. **New Hampshire.**—Carroll, Coos and Grafton Counties contain a number of old mines, very few of which are producing at present. The ores are sulfids of copper, lead, zinc and iron. This State produced $115 in silver from lead in 1907. Clay, mica, mineral water and building stone are produced in commercial quantities.

551. **New Jersey.**—Zinc, iron, graphite, arsenical and nickeliferous pyrites, clay and glauconite are the chief mineral products.

552. Copper has been mined but the ore is too low grade to pay at the present time.

553. **New Mexico.**—This State has not been a great metal producer; but it has produced a large quantity of coal.

554. From a geologic standpoint the State may be divided into four sections: the northwest plateau region; the Desert Range region, which lies south of the latter; the Central Mountain belt; and the Great Plains region, which lies in the eastern part of the State.

555. The Great Plains and Northwest Plateau regions contain localized deposits of iron and copper ores in sedimentary rocks.

556. The Central Mountain belt and the Desert Range regions contain many valuable deposits, notably silver and gold.

557. In Rio Arriba County stringer veins carrying gold and copper are found in schists. Often chalcopyrite, pyrite and sphalerite are present in these veins. In Colfax County there are contact-metamorphic veins carrying gold and copper. The contacts are between porphyritic granite or syenite and cretaceous shales and sandstones.

558. In Santa Fe County similar contact veins contain zinc blend and argentiferous galena. The veins are in the igneous rock as a rule; but sometimes cross the actual contact into the sedimentary, cretaceous rock.

559. In Otero County laccolithic [Fig. 41] porphyry has produced contact deposits carrying gold. Placers abound.

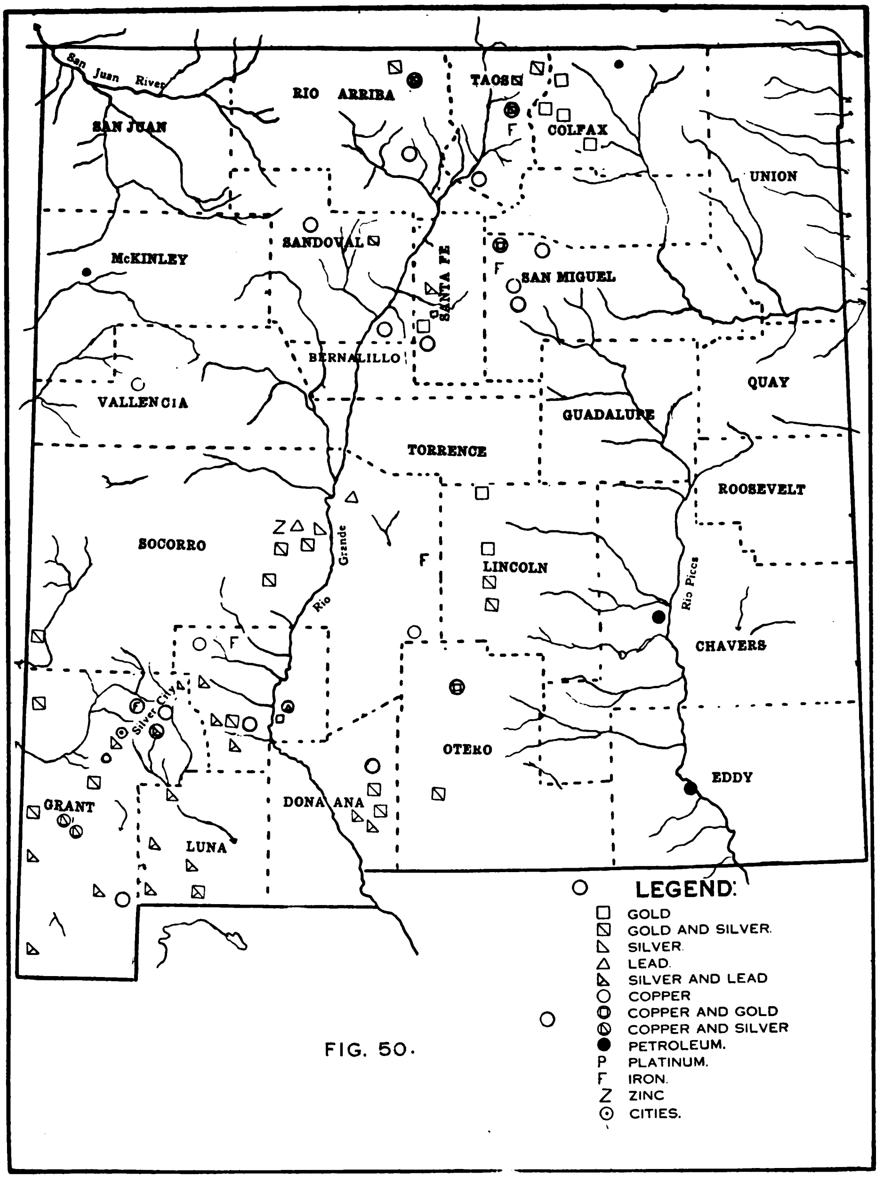


FIG. 50.

NEW MEXICO

560. In Donna Ana County a laccolithic granite has intruded into limestone and produced deposits of lead and zinc in the limestone, and gold and silver ores in the granite.

561. In Grant County porphyry has intruded into limestone producing contact metamorphic veins which carry good values in copper. Near Pinos Altos these veins carry silver, copper, lead and zinc.

562. Nearly all the copper, lead and zinc produced in this State comes from contact-metamorphic deposits. This fact is well worth noting by both prospector and mine operator. An apparently contradictory occurrence is that of the valuable silver ores of Grant County which occur in replacement deposits in limestone near intrusions or extrusions. These ores are produced by contact effects [154], however.

563. The fissure veins which do occur are usually found in later igneous rock, as at Red River in Taos County where fluorite occurs associated with the gold and silver ores; at Bland in Cochita County where the veins are gold bearing, and in Sierra and southwestern Socorro Counties where the veins have produced millions of dollars in gold, silver and lead. In the last mentioned locality the gangue is quartz and calcite in brecciated fissure veins, and the wall rock is rhyolite in many cases.

564. Copper is found in the eastern Great Plains region in "red beds" of sedimentary rock. There is every liklihood of very valuable copper mines being found in this region.

565. **New York.**—Salt, iron, sandstone, limestone, fire clay, marble, granite and slate are the chief mineral products.

566. The salt output has, of late, exceeded that of Michigan.

567. **North Carolina.**—Corundum, kaolin, stone, mica, copper, talc, monazite, zircon, mineral water and coal are the most important mineral products.

568. Silver, lead, zinc, graphite and manganese are also found in paying quantities. The corundum product exceeds that of any other region in the world. Diamonds, emeralds, rubies, garnets, amethysts, opals, agates and hiddenites are also found, sometimes in paying quantities.

569. Gold is found in 29 counties but the production is not great. The total yield to date is a little over $30,000,000.

570. **North Dakota.**—Lignite coal is the only important mineral production of this State. It covers the western part of the State.

571. The lignite coal area covers western North Dakota, eastern Montana and the adjacent part of Wyoming and contains about 100,000 square miles.

572. **Ohio.**—This State produces a large amount of coal annually, and the coal fields are far from being exhausted. Extremely good fire clay is found between the coal strata. The value of the clay product exceeds that of any other State. Iron and sandstone are also produced. Ohio is one of the leading petroleum producing States and its production of natural gas is also large.

573. **Oklahoma.**—This State led in the production of petroleum, but California has outranked it for several years past.

574. The most valuable mineral productions are petroleum, bitumen called grahamite, coal, clay, natural gas, zinc, lead, sand and gravel, mineral water, salt and gypsum. The deposits of the last named being the largest yet developed in the United States.

575. **Oregon.**—This State has not been as thoroughly prospected as it should be. There are many favorable districts which have been only superficially prospected and many parts have never been prospected at all. At present there are very few really good mines in the State.

576. Gold and silver.—This State produces annually from one to two million in gold and silver. The most important mining region is in the Blue Mountains, eastern Oregon, the ores being found chiefly in veins in basaltic lava. It is embraced within Baker, Union, Wallowa, Grant and Malheur Counties.

577. The next important region is in the southwestern part of the State and embraces Curry, Josephine, Jackson, and Southeastern Douglass Counties, and a portion of the narrow Cascade Mountain belt. The mineral districts within these regions are well shown in Fig. 51.

578. Copper.—The most important district is near Waldo, in the southwestern part of the State.

579. Gold.—The important districts are Imanaha, Iron Dike, North Powder, and Quartzburg in eastern Oregon; Dodson, Butte, Upper and South Umpqua in Douglass County, and the Waldo district in Josephine and Curry Counties in western Oregon. In the southwest region the ore is in masses in altered schists, and in the Blue Mountain region the ores are in basaltic lavas.

580. Placers.—Placer gold occurs in the area of the older rocks as a rule; to be specific, in the rocks preceding the Jurriasic in the Blue Mountain region, and in the rocks preceding the Tertiary in

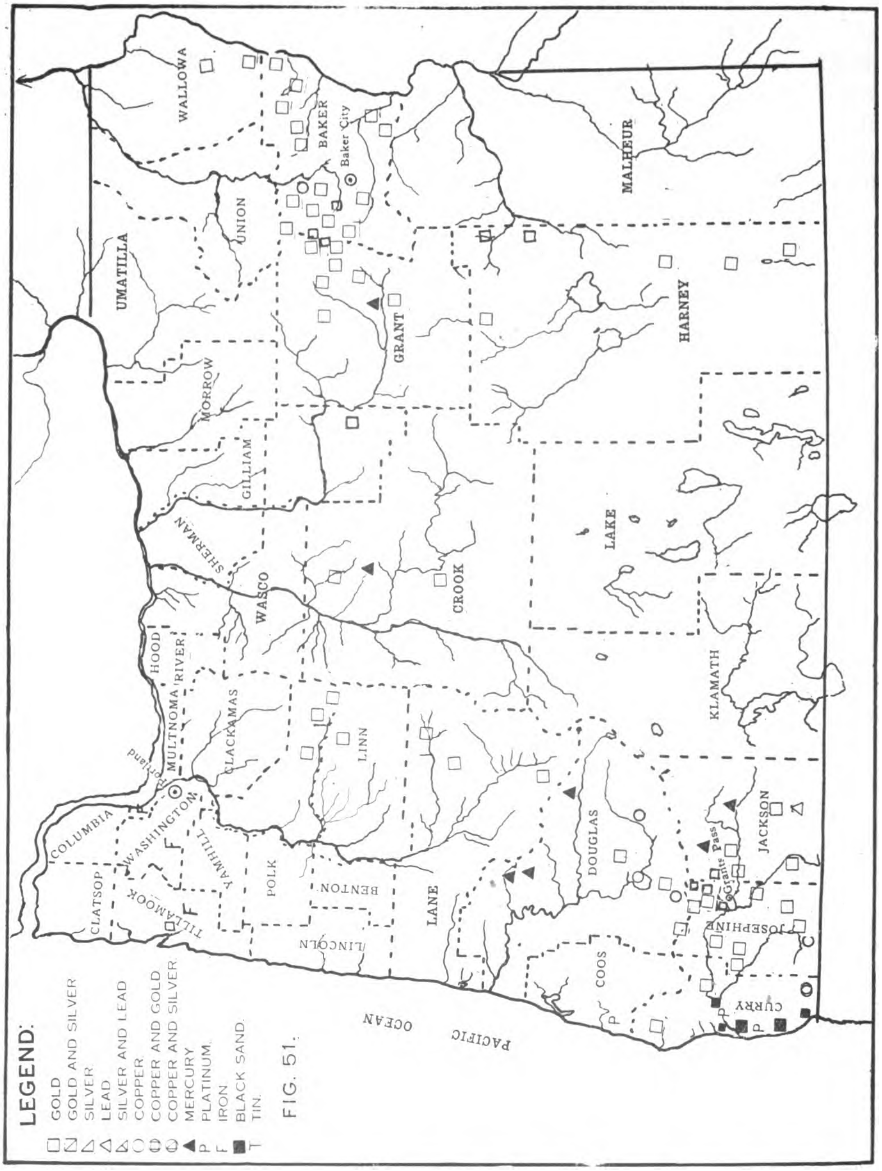


FIG. 51.

OREGON.

the southwestern region. Later rocks do not appear to carry much gold.

581. Black sand.—Black sand is found in paying quantities in several localities along the coast from California to Cape Perpetua. Tests made anywhere along this portion of the coast line will show gold and platinum in greater or less amounts. In cases miners make $2.00 a day with a rocker, working at low tide only. The mouth of Rogue River was worked at a profit in the early 60's but other localities are more profitable now.

582. Cinnabar.—Prospects have been found in several places, as in Sumpter, Granite, Susan, and Yamhill districts, but there is not much liklihood that many paying mines will be found.

583. Platinum.—This valuable metal is obtained from the black sand and placer gravels of California and Oregon. The black sand is found in Coos, Curry, Jackson, Josephine, Baker, Union and Wheeler Counties, Oregon. In most cases it is associated with osmium and iridium.

584. Iron, cobalt (Grant County), coal, infusorial earth, gypsum, lime, molybdenite (Baker County), nickel, ozokerite, and several rare gems are also found in this State.

585. Petroleum.—Oil is being prospected for by boring near Ontario and also at Yale, both in eastern Oregon.

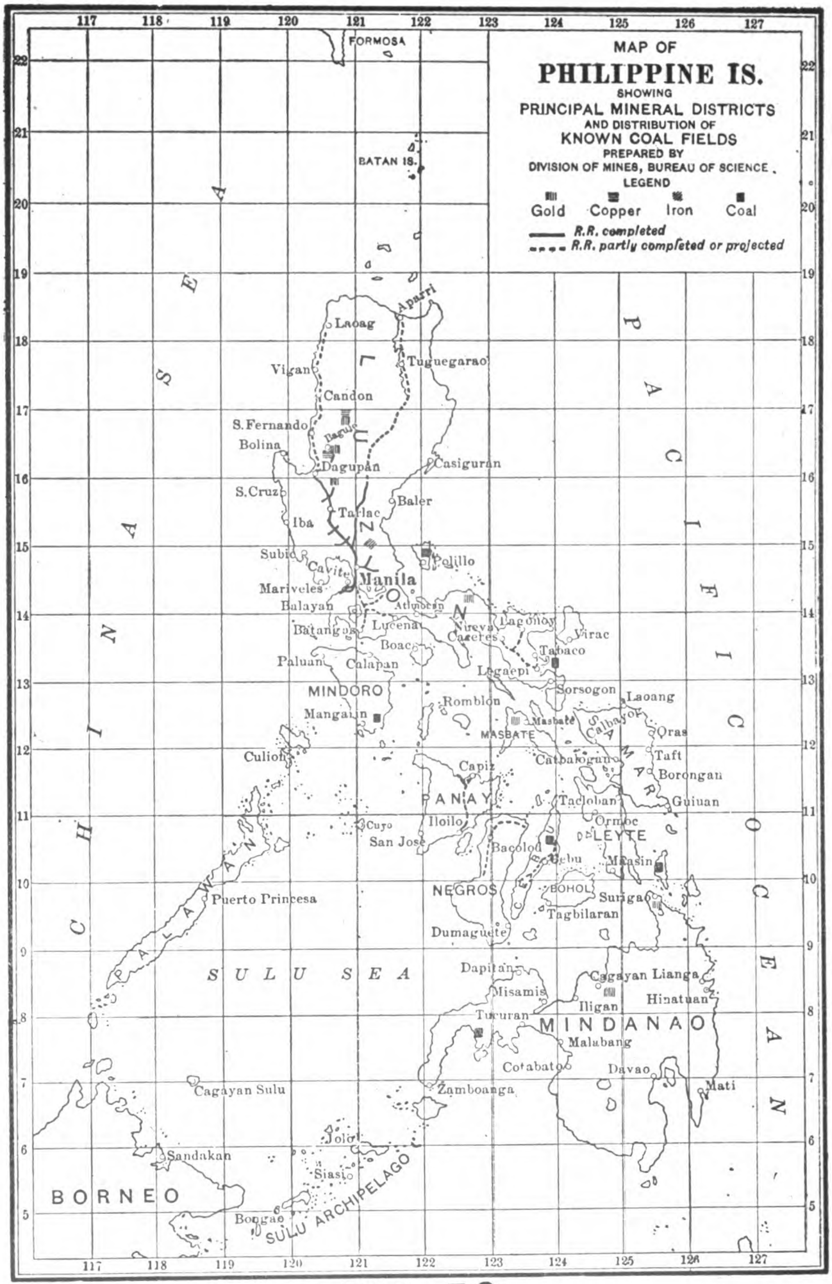
586. **Pennsylvania.**—This State produces over one-half of the coal mined in the United States.

587. Petroleum is also produced in large quantities. Iron mining is a great industry, coal for its reduction being close at hand. Nickel, zinc, and glass sand are produced.

588. **Philippine Islands.**—Mining has been carried on here for centuries, but the production has never been large.

589. Lately considerable prospecting has been done and very favorable prospects found. ·Placer mining has been in the lead but lode mining is increasing.

590. In 1907 the Islands produced $79,775 in gold and $55.00 in silver. In 1908 the production was $284,500 in gold, and $700.00 in silver—a notable gain. At present the most favorable localities for gold are in Luzon, Masbate, and Mindanao Islands. The chief producing provinces are Benguet, Lepanto, and Bontoc in northern Luzon, and Ambos Camarines in the southeast; Surigao in Mindanao Island; and Sorsogon, which includes the Island of Masbate and a part of Luzon. Considerable placer gold is mined in Sarsogon. Copper is worked on a small scale in northern Lepanto.


MAP OF
PHILIPPINE IS.
SHOWING
PRINCIPAL MINERAL DISTRICTS
AND DISTRIBUTION OF
KNOWN COAL FIELDS
PREPARED BY
DIVISION OF MINES, BUREAU OF SCIENCE.
LEGEND
Gold
Copper
Iron
Coal
R.R. completed
R.R. partly completed or projected
117
118
119
120
121
122
123
124
125
126
127
22
21
20
19
18
17
16
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14
13
12
11
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9
8
7
6
5
FORMOSA
BATAN IS.
CHINA SEA
PACIFIC OCEAN
LUZON
Aparri
Laoag
Tuguegarao
Vigan
Candon
S.Fernando
Baguio
Bolina
Dagupan
Casiguran
S.Cruz
Baler
Tarlac
Iba
Subic
Polillo
Cavite
Manila
Mariveles
Balayan
Atimonan
Batangas
Lucena
Nueva Caceres
Lagonoy
Virac
Boac
Tabaco
Paluan
Calapan
Legaspi
MINDORO
Sorsogon
Laoang
Mangarin
Romblon
Masbate
MASBATE
Calbayog
Oras
SAMAR
Culion
Catbalogan
Taft
Capiz
Borongan
PANAY
Tacloban
Guiuan
Cuyo
Iloilo
Ormoc
LEYTE
San Jose
Bacolod
Cebu
Maasin
CEBU
PALAWAN
BOHOL
Puerto Princesa
NEGROS
Surigao
Tagbilaran
Dumaguete
SULU SEA
Dapitan
Cagayan
Liang[a]
Misamis
Iligan
Hinatuan
Tucuran
MINDANAO
Malabang
Cotabato
Davao
Mati
Cagayan Sulu
Zamboanga
Jolo
Sandakan
Siasi
BORNEO
Bongao
SULU ARCHIPELAGO

FIG. 52.

591. Coal is found in the Islands of Cebu, Batan and Polillo. Most of it is best suited for gas production, the percentage of volatile hydrocarbons being high.

592. **Porto Rico.**—The only precious mineral product reported is gold, of which $1,200 worth was produced in 1907, and $600.00 worth in 1909. In 1909 $26,810 worth of salt was produced.

593. **Rhode Island.**—Iron, granite and coal in small amounts.

594. **South Carolina.**—Phosphate rock, glauconite, marl and gold are produced in paying quantities. About 60 gold mines have been opened up in the State, one of which, the old Dorn mine has produced $1,100,000.

595. Galena, copper, bismuth, magentic iron, limestone, feldspar, manganese, asbestos, spinel ruby, tourmaline, corundum, zircon, mica, monazite sand, and tin are all found in the State.

596. **South Dakota.**—The chief mineral district of this State is the Black Hills, in the southwestern part. It consists of a central north and south axis of granite upon which are laid successive strata of sedimentary rock. Gold, silver, lead and tin are produced.

597. Nearly all the above values come from Lawrence (99.9%), Custer and Pennington Counties.

598. **Tennessee.**—This State produced in 1908 over $7,118,494 worth of coal, $561,789 worth of coke, $876,007 worth of iron ore, $529,735 worth of copper and $790,233 worth of marble.

599. This State ranks thirteenth in coal, sixth in copper, second in phosphate, fourth in marble, seventeenth in clay and twentieth in pottery production.

600. **Texas.**—This State is not a great mineral producer.

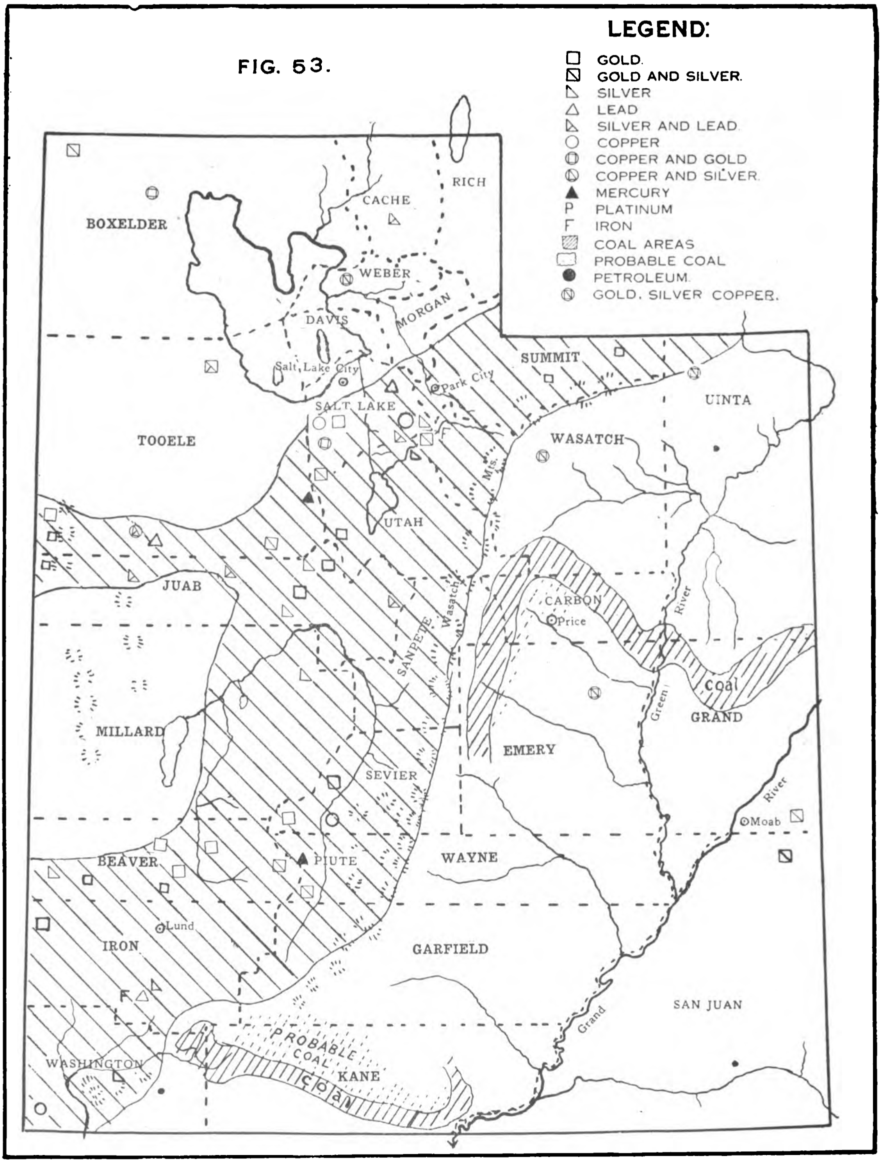
601. Petroleum.—Texas has produced considerable petroleum during recent years, the greatest yield being from Beaumont, Jefferson County.

602. Tin.—Narrow quartz veins carrying cassiterite have been found recently near El Paso. The veins occur along the sets of joints in granite.

603. Mercury.—This metal has been found in paying quantities in the western part of the State, chiefly in Brewster County.

Gypsum.—This mineral is mined in considerable quantities.

FIG. 53.


LEGEND:
□ GOLD.
▨ GOLD AND SILVER.
SILVER
△ LEAD
SILVER AND LEAD.
○ COPPER
COPPER AND GOLD
COPPER AND SILVER.
▲ MERCURY
P PLATINUM
F IRON
▨ COAL AREAS
PROBABLE COAL
● PETROLEUM.
GOLD, SILVER COPPER.
BOXELDER
CACHE
RICH
WEBER
MORGAN
DAVIS
Salt Lake City
SUMMIT
Park City
UINTA
TOOELE
SALT LAKE
WASATCH
Mts.
UTAH
JUAB
CARBON
Price
River
Wasatch
SANPETE
Green
Coal
GRAND
MILLARD
EMERY
SEVIER
River
Moab
BEAVER
PIUTE
WAYNE
Lund
IRON
GARFIELD
F
Grand
SAN JUAN
PROBABLE COAL
WASHINGTON
Coal
KANE

UTAH.

604. **Utah.**—This State may be divided into two divisions: the Plateau region, embracing the eastern and northern portions; and the Desert region, embracing practically the entire northwest half, the Wasatch Mountains being the dividing line between the two divisions. The chief metallic mineral resources of the State are obtained from a mineral belt or zone approximately 100 miles wide, situated on the west side of the Wasatch Range.

605. Gold and silver.—These metals are derived chiefly from a few camps east and south of Salt Lake; as, Park City, Bingham, Mercur, and Tintic. Large amounts of silver-lead ore are produced by the Park City district. This State is fifth in the production of gold and silver. It is one of the most promising fields in the West and the wise prospector will make no delay in getting into it.

606. Coal.—This State has exceedingly promising coal fields of which but little has been published. The present fields are in Rock Cliffs, Wasatch, Weber River, and Southern districts.

607. The State produced over $400,000 in coal in 1907, being twenty-second in rank.

608. Copper.—The chief copper districts are Bingham, Park City, Tintic, Frisco, and Alta. Less important are Little Cottonwood, Ophir, and Tutsagubet.

609. According to J. M. Boutwell, the copper ores of Bingham are the result of contact metamorphism brought about by monzonite intrusions through quartzites and limestones. The most marked mineralization is in the monzonite that has been most extensively fractured, the fractures permitting the access of the mineral solutions. This information should be of value to prospectors and operators as well.

610. At Park City the copper ore occurs in fissure veins and replacement deposits in limestone closely associated with porphyry intrusions. [384].

611. Utah produced about $64,000,000 worth of copper in 1907, chiefly from Bingham and Park City, Tintic, and Frisco districts.

612. Antimony.—Antimony ore is mined in the southeastern part of the State.

613. Lead.—Large amounts of lead are produced from argentiferous galena.

614. Scattered beds of pumice stone are in the northwest.

615. Mercury is produced at Mercur.

616. Valuable phosphates have been found, recent discoveries

indicating that this State is a favorable field for phosphate prospectors. [955].

617. Ozokerite.—This is a mineral wax or parafin occurring in veins in shales and sandstones 120 miles south of Salt Lake.

618. **Vermont.**—The slate product of this State is second to that of Pennsylvania only, and the marble output exceeds that of all other States combined. Granite is an important product.

619. Limestone, soapstone, talc, manganese, asbestos, mica, ocher, kaolin, and copper are also produced.

620. **Virginia.**—Coal and iron are important products. The salt and manganese production is fairly large. Mica and amphibole asbestos are productions.

621. Gold, lead, copper, zinc, barytes, granite, sandstone, marble and slate are produced on a small scale.

622. **Washington.**—The mineral wealth of this State is produced in the mountain regions, chiefly in the northern half of the State.

623. Gold.—This State is not a great gold producer, yielding only $253,700 in gold in 1908. The greater part of this came from Stevens and Snohomish Counties, the former yielding about one-third of the State's product. Whatcom and Kittitas Counties produce $21,860 in placer gold the same year. Placer prospecting may well be confined to these counties.

624. Silver.—Only 88,823 ounces were produced in 1908, mostly from Okanogan and Stevens Counties.

625. Copper.—This State ranks seventeenth in the production of copper. Most of the metal comes from eastern Washington, but prospects are numerous in the Lake Chelan region and in the Cascades near the station of Index. The Copper King Mine, Stevens County, is in shistose rock near granite. The Belcher Mine is in east-and-west fissures in diorite underlain by diorite and porphyritic syenite.* In Snohomish County the ores are in granite and are very siliceous, requiring base ores for fluxing.

626. Coal.—This State produces a large amount of coal, ranging from lignite to bitumous coking coal, with a small amount of anthracite and natural coke.

627. Five principal fields may be mentioned: North Puget Sound, South Puget Sound, Puget Sound Basin, Roslyn, and the southwestern field of Lewis and Cowlitz Counties. The coking coals are found in the North and South Puget Sound fields. The lignite comes from Newcastle and Renton, in the South Puget Sound field.

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*See Mining World. January 9, 1904.

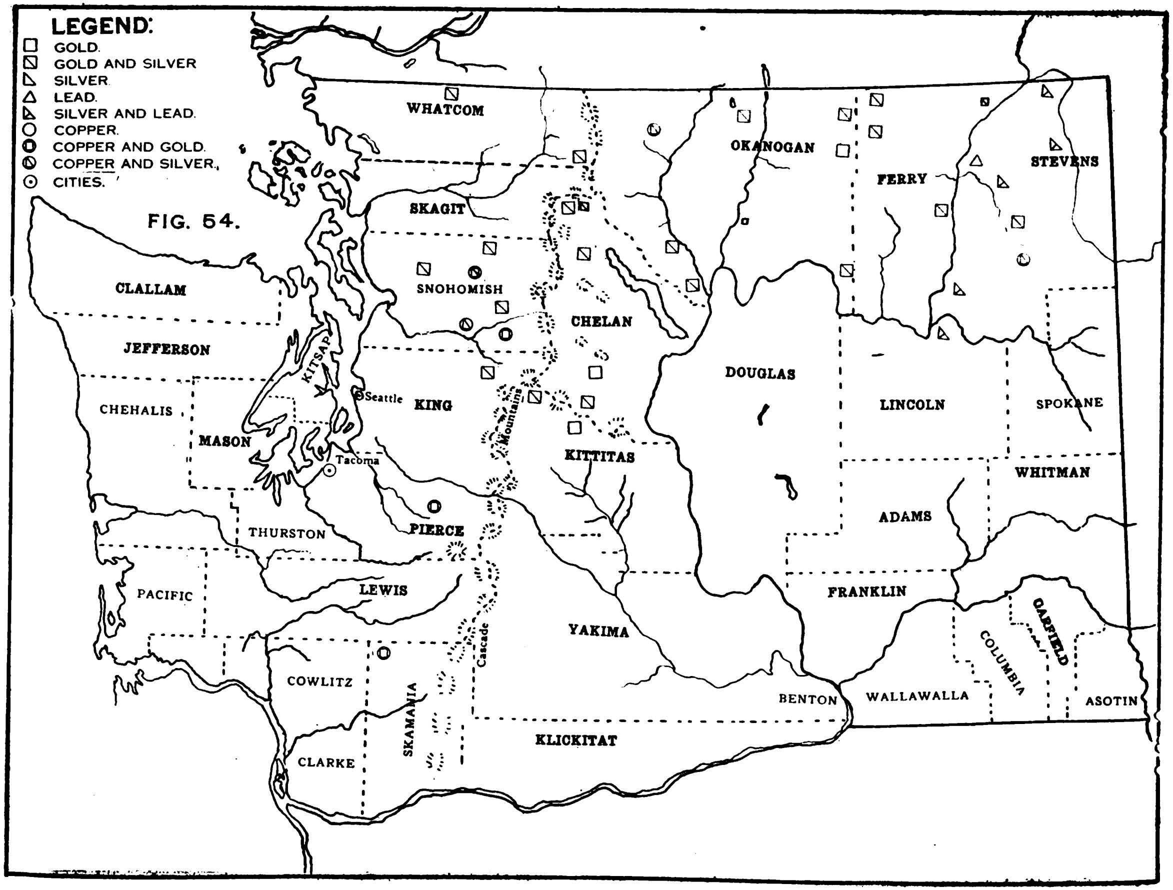

FIG. 54.

WASHINGTON.

628. As a rule the Washington coal occurs in seams interbedded with light colored sandstones and shales, the former predominating. The shale is bluish to gray in color when fresh, weathering to buff. Usually the strata are nearly flat but occasionally they are folded and faulted. The total thickness of the coal formation in the Puget Sound district is about 10,000 feet according to Bailey Willis. The commercial coal is now found in the lowest 3,000 feet of this series of rocks. The rocks are Eocene, according to Professor F. H. Knowlton. The coal region was a shallow sea or wide lagoon at the time the sediments were laid down.

629. The great value of coal near the Pacific Coast is at once appreciable, and prospectors in or near Washington should not overlook it. A crude test for coal may be made by weighing a sample and heating slowly at first, then to a red heat, in a covered seamless iron cup. Weigh the ash that remains. The ash should not exceed 20% of the weight of the coal. High grade coal will have less than 10% ash. [736 and 740].

630. Tin.—This metal is mined a few miles south of Spokane. The discovery was kept a secret as long as possible. It might be well to prospect in this vicinity at once.

631. Lead.—Lead is produced, the State ranking fourteenth.

632. Tungsten.—Tungsten has been found in Stevens County.

633. Monazite.—This mineral has been found in sand and gravel. It contains a number of rare elements. The black sand on the sea coast contains magnetite, limonite, chromite, garnet, zircon, gold and platinum.

634. Antimony.—Antimony is mined in Okanogan County.

635. Iron.—There are many places in this State where iron is found; as, Skagit, King, Kittitas, Stevens, and Mason Counties. Bog ore is found in Whatcom, Clattan, Spokane, Whitman, Thurston, and Jefferson Counties. Thus far no iron is manufactured from these ores.

635. The following minerals are produced in commercial quantities in addition to the above mentioned: Arsenic, brick and tile, cement, clay, coal tar, coke, gas, granite, lime, limestone, marble, mineral water, pottery, sand, gravel, sand-lime, brick and sandstone.

637. **West Virginia.**—Coal is the most important mineral product. Petroleum and natural gas, salt, and gypsum are produced in large quantities.

638. **Wisconsin.**—Iron, lead, zinc, copper, limestone and clay are all produced in large amounts.

639. **Wyoming.**—This State offers many inducements to the prospector. There is a large amount of public land open to location,

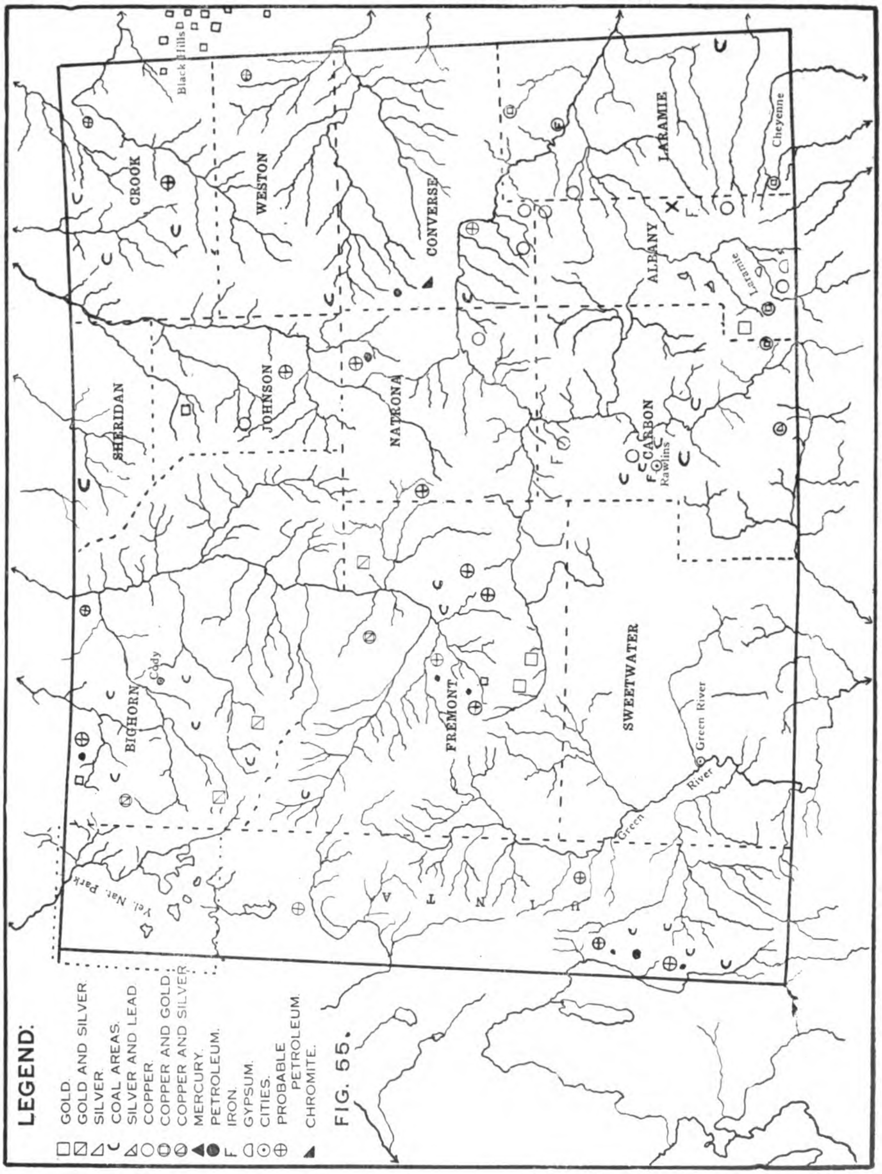

FIG. 55.

WYOMING.

and there are large areas of unprospected ground. There are prospects and mines in every part of the State indicating general mineralization. The mountainous regions contain metallic minerals, and the lowlands coal, oil, and gypsum. Iron mining has great future possibilities. The State may be divided into five natural divisions: The Great Plains region in the southeast; the Rocky Mountain region, extending north and south through the central part of the State; the Colorado Plateau in the southwest; the Volcanic regions in the northwest; and the Black Hills region in the northeast.

640. Gold and silver.—These metals are found in Carbon and Albany Counties; in the Atlantic City district, Freemont County; and also in the Black Hills region, the greater part of which lies in South Dakota. There are also many favorable spots along the Big Horn and Laramie ranges.

641. Coal.—Coal mines are worked in every county in the State except one, the greatest production being from Sweetwater, Uinta and Sheridan Counties. Other coal fields of the State may be as great as these but lack of railroad transportation facilities retards their development.

642. Iron.—There are several promising fields in the State and the presence of coal suitable for making coke will undoubtedly result in the early upbuilding of a great iron industry. The largest deposits are of red hematite but only the Hartville, Rawlins and Seminole districts have been thus far developed. The Hartville district, Laramie County, produces excellent ore of Bessimer grade. Magnetite is plentiful in the Laramie Mountains. Hematite ores are found in Creek, Uinte, Johnson, Freemont, Big Horn, Albany and Sheridan Counties.

643. The prospector should not forget that iron and other economic ores are often as valuable as gold and silver ores, especially if well situated and in sufficient quantity.

644. Copper.—This State produced 106,000,000 pounds of copper in 1908 as against 2,500,000 pounds in 1895. The greatest part of this came from the Encampment district, Sierra Madre Mountains, in the southern part of Carbon County. The above mentioned mountain range is an excellent district in which to prospect for either gold or copper.

645. Oil.—There appears to be an oil zone running northeast-southwest through the center of the State. The wells in the central part of the State are numerous, many of which are flowing wells and have been capped because of lack of transportation facilities.

The wells in Southwestern Uinta promise to become famous. Oil prospectors should not neglect this State.

646. Natural Gas.—There are many natural gas wells and prospects in the State, many of which are situated near the oil fields. A gas well at Gray Bull, Big Horn County, indicated a pressure of 600 pounds per square inch, and when ignited made a flame 50 feet high.* Many gas wells are temporarily capped.

647. Gypsum.—Several grades of this mineral are mined and manufactured; as, land plaster, cement plaster, and plaster Paris. It is claimed that the deposit near Red Buttes, Albany County, could supply the world with plaster Paris.

648. Bismuth.—Ore of rare purity is found at Jelm Mountain.

649. Sulfur.—Found in paying quantities near Cody, northwest Wyoming.

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*Report of the State Geologist of Wyoming, also M. R. of U. S., 1907, p. 344.

CHAPTER IX

PROSPECTING FOR VEINS OR LODES.

Claims.

650. The prospector is apt to load up with claims till he is location poor. It is better to locate one good claim than a dozen poor ones. Of course, no one can tell for a certainty whether a discovery will make a mine or not, but it is useless to locate every discovery that looks promising with the sole idea that it will be "good enough to sell." It is difficult enough to sell a good claim, to say nothing of a poor one. Let your rule be this: If a prospect is not good enough to develop do not locate it. A prospect will not develop itself, so there is nothing gained by making a location unless you are able and willing to develop it.

Dont's.

651. Do not use your imagination—use your judgment instead.

652. Do not conclude that a series of veins in one general direction is necessarily one continuous vein.

653. Do not expect every vein to grow richer with depth—many veins do and many do not.

654. Do not become unduly elated over a wide vein, because such veins are seldom mineralized from wall to wall. All things considered, they should contain a rich pay streak to be desirable. A wide vein with a rich pay streak, especially if the pay streak contains several kinds of minerals, is likely to prove valuable; but if it is all low grade ore it is not a poor man's prospect.

Searching for the Vein.

655. Begin in the gulches or ravines and pan for colors, gradually working up stream. When you have found colors, continue up stream as long as colors can be obtained, then pan the mountain slopes on both sides of the gulch. The gold will be spread out upon the mountain side like a fan. That is, the little particles of gold will be found scattered over the mountain slope below the vein, spreading wider and wider till the gulch is reached. This explains why one should pan back and forth horizontally as he ascends the hill after leaving the gulch. If you are looking for other minerals than gold and silver the same rule will apply. Of course, minerals of low specific gravity, and those that decompose readily, cannot be prospected for by panning.

656. When outcrops [669] can be seen on the mountain sides, owing to their prominence or color, they should be examined before taking the time to pan up the gulches. Do not overlook the promi-

nent outcrops because you think others have prospected them. The fact may be that others have overlooked them for the very reason that tempts you to pass them by. Or, it may be that those before you did not prospect the ledge thoroughly.

657. Often you will be able to get colors on the site of old cabins or camping places, because former prospectors have cleaned their gold dust or panned there. Be not deceived.

658. In examining previously prospected or well traveled districts the method of panning up the gulches is most satisfactory, especially if the surface is covered with soil or vegetation. New mines in old camps are often found by this thorough and laborious process.

659. Observe that a sudden change in the vegetation indicates a fault or a vein. This change in the size or kind of vegetation is most easily detected at a distance, as from an adjacent ridge. A slight change in rock formation is also oftentimes most easily detected at a distance. The writer recalls several instances where no change in the formation could be discerned by walking over the ground, but by viewing the mountainsides in question from neighboring ridges sharp lines of change in vegetation and formation were distinctly noticeable. Later explorations in some instances demonstrated the presence of a vein along the line of change in formation. No outcrop was visible because the vein-rock was practically as hard as the adjacent wall rock.

660. Following the vein.—Migration.

When you find what appears to be a vein endeavor to follow it. On level ground this will be a comparatively easy matter, but if the vein crosses ravines and ridges, and has a dip, it may be quite difficult. The chief difficulty is caused by the outcrop becoming obscured in the ravines by the accumulation of soil and the destructive effects of landslides, snowslides, etc. Oftentimes the outcrop on an adjoining ridge, considered by the prospector to be the continuation of a known valuable vein, may be an entirely separate and parallel vein. The error is due to a lack of knowledge of the true strike and dip of the vein concerned. Keep in mind the fact that on sloping ground the outcrop does not have the same course as the strike except with vertical veins. Dip always causes the outcrop to bend or migrate, as it is called, on sloping ground. That is to say, an outcrop will migrate to the—

Left with a right dip when ascending.
Right with a left dip when ascending.
Right with a right dip when descending.
Left with a left dip when descending.

661. In other words, the migration and dip are opposite in kind when ascending a hill, and alike when descending. This is an easy expression to commit to memory. A little reasoning, however, should make the subject clear after having once given it a little study. The subject may be best understood by building immitation mountains out of sand, with long strips of paper representing veins running from one mountain to another, and at various dips. After the strips have been placed in position tear out the paper in the valleys between the mountains and observe how the directions of the various outcrops differ from the strikes.

662. Suppose the outcrop of a vein on level ground strikes north and south and dips to the east at an angle of 43°. If this outcrop be followed north to the foot of a hill directly in front and 400 feet high, how far to the left should we look for the outcrop at the top of the hill?

663. Solution: The answer is most easily obtained by the use of the table below [668]. For 100 feet change in elevation with a dip of 43° the migration is 107 feet. For an elevation of 400 feet the migration will be four times 107 feet, or 428 feet.

664. If a vein has a strike of, say N. 40° E. across a level ridge, and dips at an angle of 46 degrees, how far will the outcrop migrate for each 100 feet of drop in elevation on descending the hill, walking along the course of the strike, that is, walking N. 40° E.?

665. Solution: By the Migration Table [668] the answer is found to be 97 feet (exact migration is 96.56 ft.) Therefore, if the prospector levels down the hill with a hand level or a surveying instrument to a point on the line of strike 100 feet lower in elevation, he should then measure S. 50° E. 97 feet to search for the outcrop. If the ground at the point 97 feet out should happen to be, say 10 feet higher in elevation, or only 90 feet lower than the starting point, subtract one-tenth of 97 feet, or 9.7 feet, from 97 feet to find the corrected distance out. This will be 87.3 feet in this case. If the ground had been 10 feet lower the 9.7 feet would have to be added.

666. In many cases it is difficult to find the true strike as a basis for further calculations and measurements, owing to there being little or no visible horizontal outcrop. Sometimes the strike can be ascertained only by a traverse survey from a point on one side of a ridge, over the top and down the other side, to a point at the same level as the starting point. The calculated course of

the line joining the beginning and ending of this survey will then be the true strike. A surveyor will be required to make the survey and calculations.

667. Any three points on a vein, not in the same straight line, will determine the strike and dip of a vein. The accurate solution of this problem, however, requires a knowledge of descriptive geometry. There is, however, a simple method, devised by the author and based upon descriptive geometry, that will give fairly accurate results. It is as follows: Make a traverse survey of as long a stretch of outcrop as possible, and ascertain the elevations of each station on the line of survey. Draw the courses and distances to scale on a planed board. Consider the lowest point on the survey to be the surface of the board. Drive a small nail in the board to its head at this point. Drive a nail in the board at each of the remaining stations, leaving the height of each nail equal to the elevation of the respective stations of the survey, using the same scale for measuring the heights of the nails as that used for the scale of the drawing. A piece of window-glass or cardboard can now be so placed as to touch each nail head. Draw a pencil line on the board along the edge of the glass, or cardboard, as the case may be. This line will be the strike of the vein, the course of which can be ascertained by a protractor. The only advantage in using more than three points is that the additional points may enable you to strike an average that will be more nearly accurate than the result given by three points only. In making the survey endeavor to select three such points as will most nearly form an equilateral (equal sided) triangle. That is, there should be a great difference in the elevation between the points, if possible. When the three points are nearly in a straight line the result by this method is not very reliable. Wooden pins may be used instead of nails to good advantage. Try the following example as an experiment: A to B is S. 82° 15′ E., 375 feet. B to C is S. 43° 30′ E., 480 feet. A datum, B is 400 feet above datum, and C is 100 feet above datum. Find the strike and dip. On a planed board, using a scale of, say 100 feet to the inch, draw course AB S. 82° 15′ E., 3.75 inches long, and BC S. 43° 30′ E., 4.8 inches long. At A drive a small headed nail to the head. At B drive a nail or insert a wooden peg 4 inches high, and at C drive a nail 1 inch high. Now lay a piece of glass against the nail heads and draw a pencil line along the edge of the glass to represent the strike. It will be S. 57° 30′ E. if the work has been correctly done. By repeatedly cutting and fitting a piece of cardboard vertically in the angle between the glass and the board the dip angle can be measured. In this example it is 69°. The dip may be ascertained directly by applying

a clinometer to the glass. Dip is always measured from the horizontal and not from the vertical. A dip of 10° is nearly flat. A dip of 80° is nearly vertical. A dip of 90° is vertical.

668. MIGRATION TABLE.

Dip of vein	*Horizontal migration of outcrop.*	*Dip of vein.*	*Horizontal migration of outcrop.*
5°	1143	57°	65
10°	537	58°	62
15°	373	59°	60
20°	275	60°	58
22°	247	61°	55
24°	225	62°	53
26°	205	63°	50
28°	188	64°	49
30°	173	65°	47
32°	160	66°	45
33°	153	67°	42
34°	148	68°	40
35°	143	69°	38
36°	137	70°	36
37°	133	71°	34
38°	127	72°	32
39°	123	73°	31
40°	119	74°	29
41°	115	75°	27
42°	111	76°	25
43°	107	77°	23
44°	103	78°	21
45°	100	79°	19
46°	97	80°	18
47°	93	81°	15.8
48°	90	82°	14
49°	87	83°	12.2
50°	84	84°	10.5
51°	81	85°	8.7
52°	78	86°	6.9
53°	75	87°	5.2
54°	73	88°	3.5
55°	70	89°	1.7
56°	67	90°	0.0

Outcrops.

669. The subject of outcrops deserves special attention, most mines having been discovered through their existence. There are a few mines, however, that have been discovered while running a cross-cut tunnel or a railroad tunnel, the vein being what is called a "blind lead." Ore has also been discovered by core drilling. Owing to the high cost of other methods, searching for outcrops will continue to be the favorite plan with prospectors. To be able to judge as to the value of a vein at depth by studying the outcrop is the desire of every prospector, miner, and mine owner. Let us see if we cannot improve ourselves by classifying and studying the knowledge thus far acquired by others. First of all, we must take into consideration the character of the country rock over which we are prospecting. If it is hard and durable, as quartzite, granite, diorite, and most igneous rocks, we should not expect to find outcrops, for the country rock will not wear away more rapidly than the vein. On the other hand, we may in such cases, expect to find depressions produced by the wearing away of easily weathered veins. A step-like appearance is often produced on a mountain side by the weathering of soft material. When studying metamorphism we learned that many minerals are oxidized to more soluble forms near the surface. [181]. When this takes place the mineral dissolves and is carried away. Water percolates into the cavities previously occupied by the minerals, freezing bursts the rock, and rains carry the fragments down the hill. We will speak of the destiny of the valuable minerals set free from such a vein a little later. Iron pyrites oxidizes to a somewhat soluble oxid of iron, [180] a small amount of acid being formed at the same time from the sulfur. The result is a solution and weakening of the vein. Therefore, a strong iron stain, or accumulations of limonite, although these are found in a depression, may be as favorable as a high outcrop. In passing, let us not forget that all our hills and mountains were once much higher than they now are, and that a large part of most veins has been worn away. Pinnacled and sawtoothed ridges are the result of this weathering. If the country rock is soft, as limestone, serpentine, or other easily weathered rock, we may expect to find high outcrops, both of veins and dikes. However, do not lose sight of the fact that even quartz veins, when they contain much pyrites, or other easily oxidized mineral, are likewise subject to weathering. The iron stain, or other oxidized mineral is the key to the situation, as gold is usually associated with iron pyrites. Highly silicious veins, as pure quartz, will never wear away as rapidly as the country rock, but in granite or other igneous rock the quartz outcrop may not be much higher than the adjacent rock.

Examples of highly silicious veins are the Mother Lode, California; Hope Ledge, Philipsburg, Montana; Mineral Hill Vein, Eureka County, Nevada; Original Bullfrog Vein, Bullfrog, Nevada.

670. Dealing with the subject in a general way we may say that the presence of oxidized minerals at the surface in considerable quantity in a vein indicates that higher grade ore is below. If the minerals in the vein at or near the surface show but little oxidation it is likely that no secondary enrichment has taken place. These two statements apply to gold, silver, copper, and lead. The records of actual mining show that where there is oxidation, either at the surface or lower down in the vein, an enrichment of the vein will be found in the lower part of the zone of oxidation, or just below.*

671. *Gold bearing veins.*—Gold is one of the most insoluble metals, yet it must have been in solution at one time. [175]. Slight as the solubility may be, some concentration is produced by downward percolation and subsequent precipitation. Gold is as easily precipitated as it is difficult to dissolve. For this reason it is nearly always found as metallic gold. So far as observations have gone at the present time, ferric sulfate and chlorid, especially in the presence of manganese dioxid (pyrolusite), are the most likely natural solvents of gold. The effect is increased by pressure. Therefore, the presence of iron oxid (rusty iron), copper carbonate (copper stain), or the like, especially with a manganese stain, may be safely considered as a strong indication of an enriched ore body at or just above the zone of sulfids. Philipsburg, Montana; Comstock, Nevada; Tonopah and Bullfrog, Nevada; and the Black Mine, Custer, Idaho, are examples. Another important significant coincidence has been observed: When secondary enrichments are found in a vein, placer ground is practically absent below the vein, showing that the gold has been carried down in the vein. Where the gold is coarse, and but little or no secondary enrichment has taken place, placers are commonly found below. Placers of the Sierra's are examples. There are some exceptions due to easily explained causes. For example, placer ground may be produced by some unknown or distant gold vein, or by glacial action.

672. *Silver bearing veins.*—Silver minerals are much more soluble than gold and, therefore, secondary enrichments of silver veins are quite common. [874]. Silver sulfid (argentite, etc.) is oxidized to silver sulfate in the zone of oxidation and, as this mineral is somewhat soluble (one-half grain in one quart of water), it is carried down in the vein till it meets an excess of iron pyrites or other sulfid, where it is precipitated. In the presence of salt, silver

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*T. A. Rickard. Trans. A. I. M. E. Vol. XXI.

sulfid alters to silver chlorid (cerargyrite). This accounts for the presence of this latter mineral being so common in the arid regions. Cerargyrite usually occurs in the upper part of the vein. Shale is held by many to be the cause of the presence of metallic silver, the carbonaceous matter in the shale having precipitated the silver.* If the country rock is shale containing silver mineral bearing veins, metallic silver may be expected lower down if oxidation and secondary enrichment has taken place. Native silver is also quite common in silver mineral bearing veins containing large amounts of spongy iron oxid. In such cases the outcrop will not be prominent for reasons previously explained. If it is true that silver minerals are generally more soluble than gold, as has just been stated, we would naturally expect to find the outcrop of silver veins low in silver, due to leaching, and the lower depths enriched. This has been found to be the case quite generally. In most workable silver mines the pay ore begins at from 75 to 200 feet from the surface and continues down to the sulfid zone at or below "permanent water level." Therefore, when silver ore found in a highly oxidized outcrop assays low, it should not be considered discouraging.

673. *Copper bearing veins.*—Copper is not always found in veins, as gold and silver usually are, but occurs quite often in deposits of irregular form. These irregular deposits often assume the appearance of veins, especially in the eyes of the prospector. Prominent copper outcrops are not common, a light stain or low grade ore without an outcrop being the usual sign of a deposit. [751]. Copper deposits in the early igneous rocks, as in Michigan, and in highly metamorphosed igneous and sedimentary rocks, are usually but little leached, the metal being found at the surface outcrop. In many cases of this kind the copper sulfid is found at the surface. In the later (Mesozoic and Tertiary) deposits, associated with granite, monozite, etc., and often containing garnet zones, there are both strong durable outcrops and also soft, easily weathered outcrops. When the garnet zone is exposed the outcrop is likely to be prominent. Example: Clifton-Morency, New Mexico. Replacements in limestone often show no prominent outcrop. A most important class of copper deposits is that of disseminated copper ore in porphyry. Porphyry dikes often extrude through, or intrude into limestone, inducing contact metamorphism. Garnet zones with copper are usual in such cases, but the richest ore is most likely to be found in the porphyry and not with the garnet-rock. These porphyry dikes are likely to be prominent, being more durable than the limestone. Examples: Bingham, Utah; Clifton, Arizona; and Ely, Nevada. The outcrop, in nearly all of these porphyry associated

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*Spur, Economic Geology, Vol. IV, page 301.

deposits is much leached, making it necessary to run prospect tunnels or to use a core drill in prospecting. In fact, core drilling is an excellent method of prospecting for copper in any case, but it is too expensive for the average prospector.

674. In the desert region a sudden change in the vegetation often denotes the presence of a vein, dike or fault. Either of these formations may act as a retaining wall or dam, holding back the water and supplying it to the vegetation along the line of the vein, dike, or fault.

Testing in the Field.

675. When you find a good appearing spot in an outcropping vein take a sample with your prospecting pick. Examine the pieces carefully with both the low and high power magnifying glasses and, if found worthy, pulverize them for panning. There is a great advantage in carrying two magnifying glasses. One of them should consist of two or more lenses and the other should be a Coddington. [320]. A Coddington of small diameter will magnify more highly than one of large diameter, but the lens of large diameter will give a larger field of view. This rule holds good for any kind of magnifying lens. In using any lens hold it near the eye and *focus by moving the rock* to or from the lens—*not* by moving the lens. If the lens is held about one-half inch from the eye the best results will be obtained.

676. Some prospectors carry two canteens of water when prospecting in places where water for panning is at a great distance from the field of operations. The small canteen is filled with drinking water, and an extra large one with water for panning. In such a case two small miner's pans or one pan and a horn spoon are needed. To use the outfit proceed as follows: Pulverize the ore upon a large, smooth rock, or in a small hand mortar and transfer it to the horn spoon. Concentrate by horning into the pan, saving the water to be returned to the canteen after it has been allowed to settle. This plan requires but little water and works admirably in arid regions. Where water is close at hand it is advisable to take the samples to the water. The chief objection to collecting a lot of samples to be panned at the close of the day is that, in many cases, the prospector either fails to take as many samples as he should, or he forgets where some of his samples came from. There is nothing like being thorough, and thoroughness in prospecting is most satisfactorily obtained by testing in the field. As a rule the extra canteen of water and outfit will not weigh as much as your samples.

677. Samples may be panned or horned in the field in the manner described above when the ore is "free," that is, contains the mineral in a metallic state. In many cases the metal is locked up in some base mineral, such as iron pyrites or copper pyrites, and can not be detected by panning unless the sample has been roasted. Prospectors usually roast such samples over the camp fire or a blacksmith's forge. This necessitates packing the samples to the camp every night—a tiresome task in many cases. Besides, it spoils our plan for testing in the field. Samples may be very conveniently tested in the field by the use of some of the "field smelting" materials sold by dealers in Assayer's Supplies. These are advertised in the leading mining journals of the West.

678. When your field tests indicate a good vein take a large sample for more careful testing in camp at the close of the day. Be thorough, be careful, be painstaking, and remember that eternal vigilance is the price of success.

679. When you have found a vein in a place where there is a large amount of surface soil, a hill-side plough and a team of horses will uncover more places along the course of the vein than a dozen men in the same time. There are many cases where a large portion of the vein is not exposed at the surface, but is covered with soil to a considerable depth. In these cases a plough is very serviceable. Of course this plan can not be used in rocky ground, or in regions remote from ranches where such outfits are kept.

680. The prospector should keep his hand pick with him on every trip, using it almost continually to knock off fresh pieces of rock regardless of the favorable or unfavorable external appearance. The least speck of "rusty iron" calls for the use of the magnifying lens. If the piece looks favorable crush and horn it, or test with the field testing outfit. Keep up a sharp lookout for iron stained rock. Veins or ridges on "hogbacks" are generally more favorable than veins in gulches or valleys. [369]. Try to keep in your mind the strike of the outcrops, good or bad, in the vicinity, because a system of parallel veins is an indication of some value. Generally, it would indicate that the several parallel veins were produced by the same dynamic forces, and that valuable minerals were deposited in some of them.

681. It has been previously stated [359] that a region showing evidences of strong geologic disturbance is favorable for vein formation, and that faults are signs of such intense disturbance. It is also stated that in a district where faults are known to be common, the persistence of the vein and ore body is uncertain. It follows, therefore, that the presence of faults is both a blessing and a

curse. Some of the exceedingly rich gold and silver districts of Nevada are noted for the prevalence of faults, yet veins in these districts are eagerly sought by mining men. Nearly every noted mining district in the West is characterized by some one or many of the indications of strong geologic disturbance, such as faults and folds, etc. In general, it may be said that evidences of strong geologic disturbance speaks well for any mineral district as a whole, but obliges us to make a low estimate of the probable ore, especially if these evidences be faults. There are other indications of strong geologic force, as persistent mountain ranges, igneous injections and ejections, metamorphic rocks, hot springs, sulfur springs, etc. These evidences suggest deep, strong, well mineralized veins, and when present with dikes, form a combination that is unexcelled. A shear zone, that is a zone of crushed, bent and broken rock, is an evidence of strong pressure and crustal movement. Such zones often become mineralized, and they generally have a well defined form resembling a vein. A shear zone often becomes a fault because of the movement on one side. In applying the hints to prospectors as given in the preceding paragraphs it is necessary to make a distinction between precious metal prospecting, and prospecting for some other metal or mineral, especially if details are considered. The above general instructions, however, will apply to metal prospecting generally, zinc and lead in the plains of the central States excepted. Panning is of no service when searching for soluble minerals. For minerals lighter than their gangue save the tailings and discard the concentrates.

CHAPTER X.

PROSPECTING FOR PLACERS.

682. Placer ground is usually in low flats, or in benches along the mountain slopes, being the product of either recent or ancient rivers, or glaciers. The gold found in placers was originally derived from quartz veins. When quartz veins wear away by the action of the elements, the gold set free is carried down stream and deposited in some river bar or bank. In the course of time the river cuts deeper into the bed rock, leaving the river bar, or a part of it,

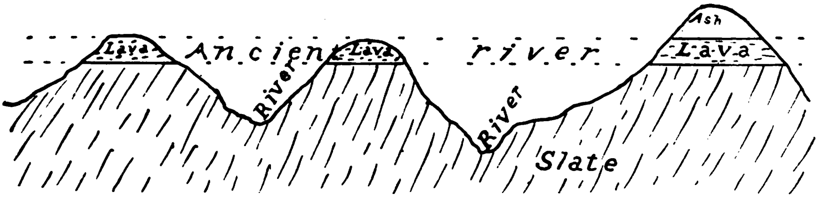

Fig. 56. Ancient River Channel Intersected by Modern Rivers.

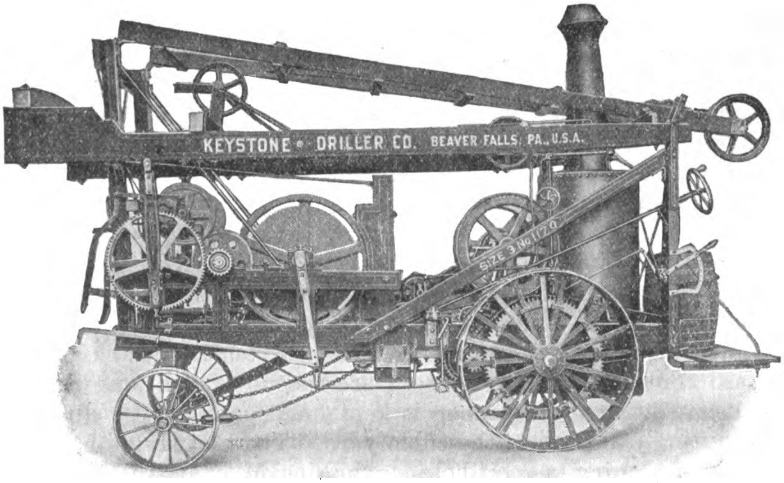

Fig. 57. Keystone Prospecting Drill.

high and dry on the mountain side. In some cases the river channels have been covered with later flows of lava, thus covering the valuable ground from view. Many examples of this kind occur on the western slope of the Sierra Nevada Mountains, and are known as ancient river channels.

Searching for a Placer.

683. In prospecting for placers other than ancient, buried river channels, it is necessary to pan the ground along the banks of ravines, gullies, and the like, searching for colors. Placer gold can be distinguished from float, vein gold by the smooth, worn appearance of the former contrasted with the sharp, angular and slightly worn grains of the latter. The more worn the grains appear the greater the distance they have traveled. The origin of the gold in any particular placer can sometimes be ascertained by carefully determining the proportion of silver in it, especially when the fineness of the gold from the veins in the vicinity is known.

Testing the Ground.

684. Having found a likely piece of ground pan the surface for gold. Also dig pits as deep as possible with a shovel and test for colors. The pits should be dug to bed rock if possible. When colors are found, the ground on each side of the gulch should then be tested. This will usually require shafts or test holes to be sunk to bed rock. This is no easy task, especially where there is much water to be taken care of, as is usually the case. Where the ground is not deep and the water not too plentiful, post-hole augurs with extended shanks may be used with success. The prospector is not often able to buy a rig for drilling and casing test holes, as is often done by mining engineers when testing placer ground for a purchaser, or for working purposes; but an outfit for shallow ground can be made by a carpenter and a blacksmith which will not be very expensive and would prove quite profitable for the prospector in many cases. It may consist of a tripod made of three 4x4-inch or 4x6-inch timbers, together with a geared windlass for raising the casing after the hole has been drilled. A weight is employed to drive down the casing, and a bit similar to a post-hole augur is used for boring the hole. Extension shanks or bars are used for these holes. If rocks are encountered a long drill rod must be used. A good panner is kept busy panning the dirt taken out, counting 150 pans to the cubic yard. The best style of augur is made by fastening a post-hole augur .inside of a short piece of casing. small enough to slip up and down inside of the casing used to case the hole. Of course, "running" ground, or ground con-

taining many large boulders, can not be worked with this hand outfit. Even a full sized churn drill will have difficulty in such ground. Hand prospecting outfits are on sale with which holes can be drilled to a depth of 50 to 150 feet.

Calculating Value in Placer Ground.

685. The casing ordinarily used with a power percussion-drill in testing placer ground is 5⅞ in. inside and 6½ in. outside and is called 6-in. casing. The outside diameter of the drive-shoe is 7½ in. The actual amount of the ground delivered to the panner depends chiefly upon two things: the nature of the ground and the method of drilling. To some extent the form and condition of the shoe affect results. For these reasons engineers have not adopted a uniform "pipe factor." Laying all arguments aside, the proper "pipe factor" to use is the one that will give results in accordance with tests made by sinking a shaft by hand. In a large majority of cases, judging by past experience, it may be assumed that 100 ft. of hole with a 7½-in. shoe will represent 1 cu. yd. of ground. Upon this basis I have constructed a chart (Fig. 58) to facilitate valuation calculations.

686. The method of panning and drilling deserves attention in this connection. I do not approve of the method of counting the "colors" obtained by the panner. Neither do I approve of the method of panning a portion of the ground delivered by the pump. I always run through a rocker all the material obtained from a hole and then pan the concentrate, using mercury when the colors are small. The samples are kept in small numbered vials. The mercury is dissolved with nitric acid and the resulting gold weighed in milligrams. If the colors are large the sample is inquartated with silver and parted with nitric acid. In either case pure gold is obtained. If the fineness of the gold is not considered, gross error is likely to result [691]. By weighing the pure gold, all chance of error is eliminated. If these precautions are taken, and the depth of hole kept at the proper point with reference to the bottom of the shoe, the use of my chart will give values concordant with results obtained by hand shaft sinking.

687. To obtain the value of the ground in cents per cubic yard by ordinary methods, the pure gold being weighed in milligrams, a lengthy calculation is necessary. To avoid this calculation I have devised the chart referred to. In using the chart, begin with the weight of the pure gold in milligrams. Follow the horizontal line to the right to its intersection with the diagonal line representing the length of hole from which the gold was obtained. Follow down

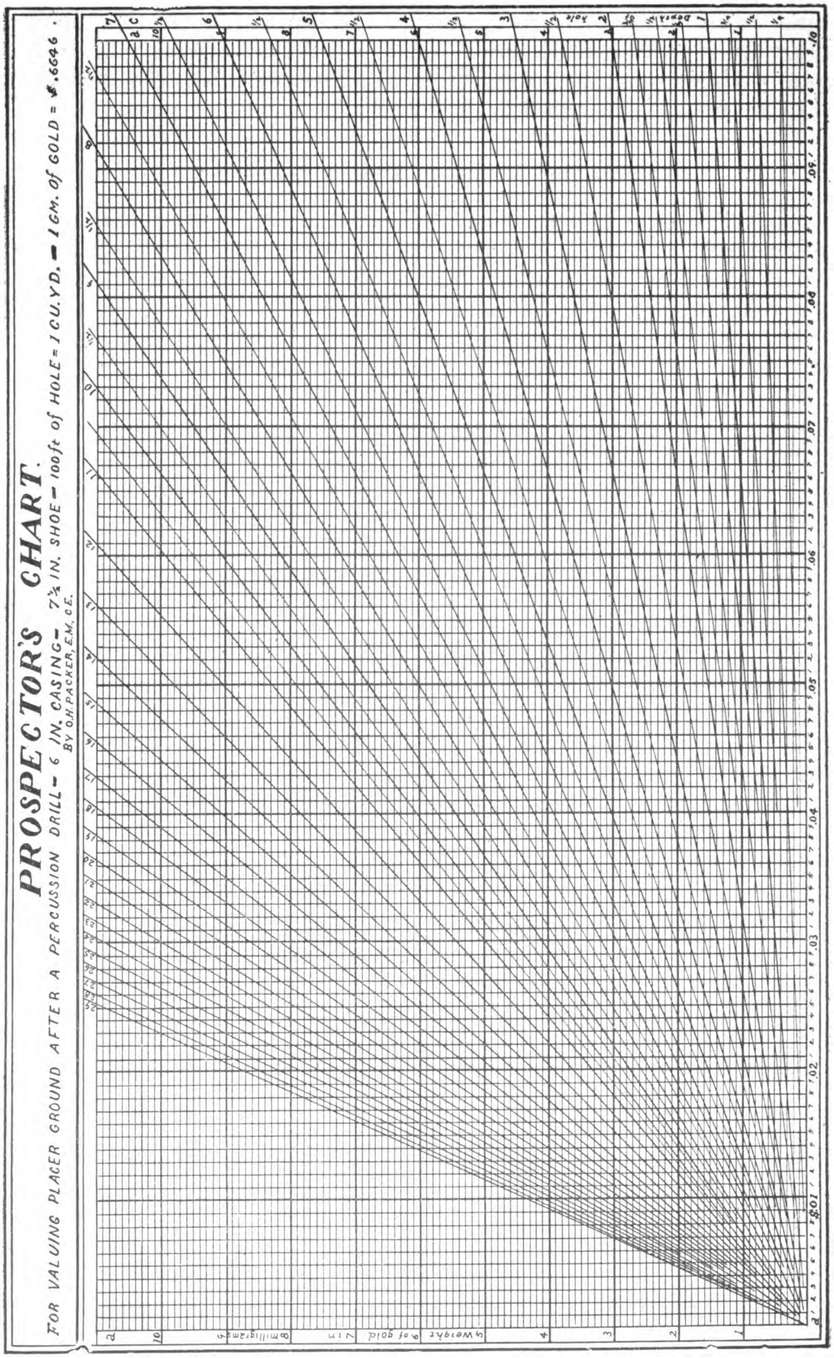

Fig. 58. Chart for Calculating the Value of Placer Ground.

the vertical line to the bottom where the value of the ground in decimals of a dollar will be found. Following are a few examples:

Example 1. What is the value of dredging ground per cubic yard when 5.4 mg. of 20-carat gold is obtained from a 4-ft. hole?

Solution by ordinary method: 5.4 mg. × $^{20}/_{24}$ = 4.5 mg. of pure gold. 4.5 × 0.0006646 = $0.00299 value of the gold, from 4 ft. of hole = $^{4}/_{100}$ cu. yd. 0.00299 × 25 = $0.0747 per cubic yard.

Solution by the chart: Begin at 4.5 mg. (mg. of pure gold) in the left-hand column. Follow the horizontal line to the right to its intersection with the 4-ft. diagonal line. Drop to the bottom of the chart (at z) where the result $0.0747 per cu. yd. is found. If the weight of pure gold had been 45 mg. instead of 4.5 mg. the result is multiplied by 10, giving $0.747 per cubic yard.

Example 2. What is the value of dredging ground per cubic yard where 22 mg. of pure gold is obtained from 17 ft. of hole?

Solution: In this case the intersection is in the closely crowded lines. Take some multiple of 22, as 4× 22 = 88. Follow the 88 line to intersection with the 17-ft. diagonal, and drop to the bottom, where 0.0344 will be found. Now divide by 4 and multiply by 10. The result is $0.086 per cu. yd. In many such cases the length of hole can be *divided* and the result *divided* by the same number.

Example 3. What is the value of the bedrock stratum of dredging ground 2½ ft. thick (last 2½ ft. of drill-hole) where 108 mg. of gold is obtained, 22 carats fine?

Solution: 108 × $^{22}/_{24}$ = 99 mg. of pure gold. As the 9.9 mg. line does not cross the 2½-ft. diagonal, take 4 × 2.5 = 10. From the 10-ft. diagonal drop to the bottom at 0.0658, which multiplied by 10 for 99 mg. and by 4 for 2½-ft. hole, yields $2.632 per cubic yard.

If it is desired to compute values mathematically, the chart may be used to check the computations.

Ancient River Channels.

688. In prospecting for ancient, buried, river channels the side hills must be prospected. Pan along the tops of benches or humps, especially where several benches are observed to be of nearly the same elevation. When a change in vegetation is observed along a nearly horizontal line on a mountain side it often indicates the dividing line between the lava capping and the channel. When a good prospect has been found a drift must be run into the hill to tap "bed rock"; but at first the prospector should follow the gold till he has proven that a channel exists. Later he may run a drift lower down the hill to tap the lowest part of the channel. Sometimes this requires a long drift. In some cases the location of an ancient channel can be judged by observing the elevation

of the known channels in the neighborhood. [Fig. 59]. This method may be deceptive sometimes, however, where later earth-crust movements have changed the levels of the various sections of the channel. In the number of cases in California the channel appears to be running up hill. This is because some of the ridges through which the channel runs have been either elevated or depressed since the present ravines were made.

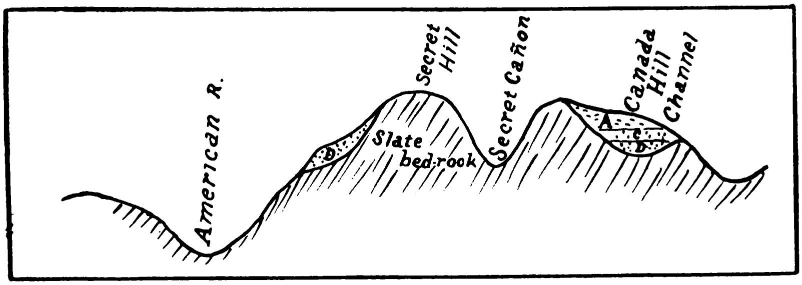

Fig. 59. Side-Hill Placer Ground.
A. Volcanic Lava Cap. C. Quartz and Gravel.
D. Rich Gravel.

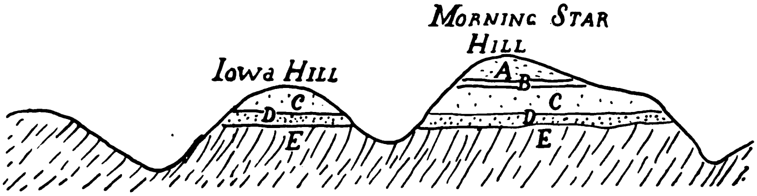

Fig. 60. Lava-Capped River Channel.
A. Lava Cap. C. Quartz and Gravel.
B. Clay. D. Rich Gravel.
E. Bed Rock.

689. A miner's pan [63] is one of the most useful implements for the placer miner, but if much work is to be done—that is, if a piece of ground is to be tested, a rocker [64] or long tom is required. In working a placer, a sluice box [1006 to 1008] will be required, the size and kind depending upon local conditions.

Value and Purity of Gold.

690. The method of expressing fineness in carats is used by jewelers, but mining men and the mints express it as parts of pure gold in 1000 parts of alloy. A jeweler might speak of a bar of

gold, or a ring, as being 18 carats fine; that is, 18/24 or 3/4 gold. The U. S. Mint would call the same bar of gold 750 fine; that is 750/1000 gold. Gold bars or nuggets 21 carats fine are 21/24 gold. Gold 12 carats fine is 12/24 or one-half gold. A solid gold watch case is usually 18 carats fine, or only three-fourths gold, the remainder being silver and copper added to give the case hardness and durability. Gold plating is pure gold on a base of composition metal. [1103-4-5].

691. TABLE OF GOLD VALUES.

11000	fine	= 24	carats	fine,	worth	$20.67	per	troy	ounce.
958.3	"	= 23	"	"	"	$19.81	"	"	"
916.6	"	= 22	"	"	"	$18.94	"	"	"
875.0	"	= 21	"	"	"	$18.08	"	"	"
833.3	"	= 20	"	"	"	$17.22	"	"	"
750.0	"	= 18	"	"	"	$15.50	"	"	"
708.3	"	= 17	"	"	"	$14.62	"	"	"
666.6	"	= 16	"	"	"	$13.78	"	"	"
625.0	"	= 15	"	"	"	$12.91	"	"	"
583.3	"	= 14	"	"	"	$12.05	"	"	"
541.6	"	= 13	"	"	"	$11.19	"	"	"
500.0	"	= 12	"	"	"	$10.33	"	"	"
458.3	"	= 11	"	"	"	$9.47	"	"	"
416.6	"	= 10	"	"	"	$8.61	"	"	"

692. One ounce of pure gold is worth $20.67183 + and one dollar's worth of gold weighs 23.22 grains. One cubic foot of gold is worth $362,963. One cubic inch of gold is worth $210.04, and one pennyweight of gold is worth $1.033 +.

CHAPTER XI.

PROSPECTING FOR POCKETS.

693. A small amount of unusually rich ore, especially if isolated from the main ore body, is commonly called a pocket. Although rich bunches in veins are sometimes called pockets, the word more properly applies to small accumulations of mineral in gash veins, seams, cavities, stringers, and the like, near the surface, and not forming a part of any well defined vein. The origin of these pockets varies with the locality. In some cases they are purely concentrations produced by ancient or modern streams. Such pockets are found in the cracks and seams in the rocks along river canyons. Properly speaking these are not pockets, but crevices. Rich pockets are often the result of secondary enrichment and, as such, are found in veins and gash seams. Pockets are often found in regions of many intersecting gash veins, and in such cases the pocket is usually found at the intersections [695] as shown in Fig. 61.

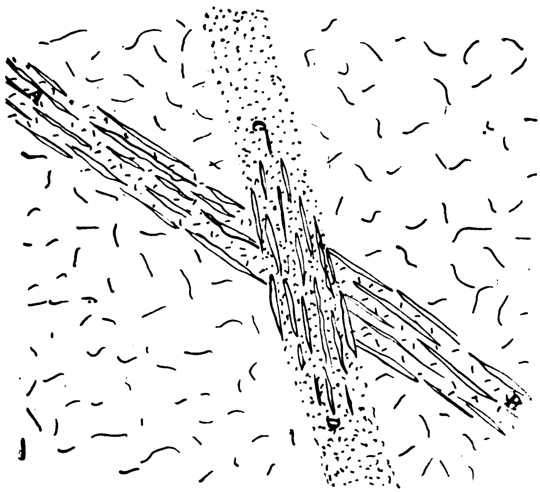

Fig. 61. Pay Ore at the Intersection of Two Veins.

694. In many localities these small seams or stringers would not prove profitable to a mining company; but prospectors, working

either alone or as "partners," often find them a source of wealth. The skill and ingenuity of the pocket miner is remarkable. He may have many fanciful theories but nevertheless he finds the pocket—and "nothing succeeds like success."

695. Positive indications of a pocket can not be given for several reasons. There are pockets in zinc, lead, silver, and gold mining districts, and the indications are different in each case. Even when only one metal is considered the conditions vary in each district, so that what would be found reliable indications in one locality might fail in another. Only one general rule can be given: That is, districts known to be "pockety" are most favorable—one way of saying that "gold is where you find it." Speaking more specifically, and considering gold, silver, and copper alone, districts are favorable where "feeders" are common. The crossing of two veins, originally formed at the same time, often contain a pocket. If the cross-vein was made a long time after the first vein there may be no pocket. [693].

696. The presence of galena in a gold bearing quartz vein usually indicates a pocket of gold ore. The galena may or may not be most plentiful near the pocket, the chief point being that galena is more often found in a pockety vein than in a vein of uniform values.

697. Feeders or stringers are often most numerous on one side of the vein, sometimes the hanging-wall and at others the foot-wall side. When this is the case, and the stringers follow the pitch of the ore shoot, pockets are likely to be found in the stringers, or in the vein near the junction with the stringers.

698. When beginning a shaft or open cut in a pockety district search for small seams of rusty iron and follow the rusty seams to their termination. Sometimes pockets may be thus traced a distance of 10 or 15 feet.

699. When a vein or small seam of quartz is crossed by a seam of oxidized iron pyrites (rusty iron) search for a pocket by following the line of intersection between the two seams.

700. When a vein cuts through two kinds of wall rock, one more soluble than the other (that is replacable by metasomatism [glossary], a pocket or ore body is likely to occur in the vein just as it enters into the more soluble wall rock. [366, 379].

701. Often, especially in the case of replacement deposits, when the water circulation in the vein has been restricted, or cut off entirely, a pocket is likely at the line of restriction. The restriction may be due to a narrowing of the vein as it passes into a stratum of hard wall rock.

702. When fissure veins contain zinc or lead the indications of pockets of these metals will be the same as for gold, with the exception of the indications given in sections 698 and 699, but when these metals are found in deposit similar to those of the Central States, that is, not in veins, entirely different rules apply. As the genesis of these latter deposits has not been satisfactorily determined, rules for pocket hunters in the Central States cannot be given.

703. It is certain, however, that both lead and zinc ore-bodies, as well as pockets of these metals, are most plentiful along fracture-seams in the limestone as shown in Fig. 36. These fractures are usually followed by the miners instead of running straight drifts as in gold and silver mining. Of course, the main passage ways are made straight.

704. In general it might be said that anything suggesting secondary enrichment [glossary] indicates pockets, for these are likely to be formed in the zone of secondary enrichment. In such cases the occurrence of the associated minerals [286] would indicate that a pocket, or at least a body of high grade ore, is close at hand. A large pocket in a mine is called a bonanza.

CHAPTER XII.

PROSPECTING FOR THE COMMON ECONOMIC MINERALS AND ROCKS.

705. There are many valuable mineral deposits other than gold and silver. The prospector should inform himself regarding them and keep them constantly in mind. Although heretofore you may have searched for the precious metals only, you should now change your plan, because the rapid development of the country is making minerals valuable that were worthless a short time ago. You have only to look about you to see many men who have made comfortable fortunes out of oil, lime, coal, salt or some other common mineral or material. Money made out of a gypsum mine is just as useful as if made out of a gold mine.

706. ALUMINUM.—This metal is found in abundance in Georgia, Alabama and Arkansas, and in other localities. Its chief ore is bauxite. In all cases where this ore has been found east of the Mississippi River it is associated with the Cambro-Ordovician (early) rocks. [125]. These are chiefly limestones and shales. The deposits are, apparently, related to the extended Appalachian compression fault, and to the ocean water-level at the time the deposits were formed. This latter statement is corroborated by the fact that nearly all Alabama-Georgia bauxite occurs between the 900 and 950 foot contours. This fact should be taken into consideration in prospecting for bauxite in southeastern United States. The ore always occurs in nodules, and these are nearly always surrounded by clay. The color is whitish to ocher-yellow, brown, and red. Sp. g., 2.55.

707. The fact that the ore is often a residual, alteration product of dolomite limestone may serve as a hint to western bauxite prospectors. The Arkansas deposit of Saline and Pulaski Counties, however, are associated with intruded syenite of Paleozoic Age.* [125].

708. For a description of the deposits along the upper Gila River 40 miles northwest of Silver City, New Mexico, see the Trans. Am. Inst. Min. Eng. XXIV, p. 571. These deposits are too distant from the railroad to be of value at present.

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*See American Geologist, VII, 1891.

709. As the patents relating to the manufacture of aluminum expired in 1909 the industry will soon spread to the West. Nearly all the American product is now manufactured at Niagara Falls from Alabama-Georgia and Arkansas bauxite, with the aid of a small amount of cryolite from Greenland. While the Alabama-Georgia district formerly lead in production, the Arkansas district is now far in the lead. Tennessee produces a small amount. About 130,000 tons of ore were produced in the United States in 1909, valued at $5.00 a ton at the mine. Workable ore must run from 40% to 70% in Al_2O_3.

710. ASBESTOS.—There are two varieties [93] of this mineral: One, a true asbestos, is a variety of hornblende, Sp. g. 3+, color greenish, no water or crystallization: the other, chrysotile, is a variety of serpentine. Sp. g. 2.2. Color greenish. Water 12% to 14%. The true asbestos is found associated with hornblende in metamorphic rocks. The serpentine asbestos is more valuable because its fibers are stronger, though both are non-conductors of heat and resist acid. The long fibered (2 to 5 ins.), serpentine asbestos is very valuable, being worth from $100 to $350 a ton. ($1500 a ton stripped from all rock.) The hornblende variety is worth about $20.00 a ton. Most of the asbestos of commerce is of the hornblende variety.

711. Both varieties occur in small seams in metamorphic rocks. The fibers of serpentine asbestos usually run across the seam, but the hornblende variety is found with the fiber running either across or with the seam—also in bunches. The best varieties are of very fine fiber and appear green in the solid form, but white as soon as the fibers are separated from each other.

712. Both varieties occur in California in the Coast Range, in the Appalachian Mountains, in Arizona, Wyoming and Texas, the chief supply coming from Georgia and Vermont. Asbestos for paint is produced at Dallas, Texas. Serpentine asbestos is plentiful near Casper, Wyoming, and east of Grand Canyon, Wyoming. Also reported in the Philippines, but none is mined. There is a strong demand for serpentine asbestos suitable for spinning, the chief present supply coming from Canada.

713. ANTIMONY.—This metal is found native and also in the mineral stibnite. These minerals both resemble galena when occurring in small grains. Stibnite usually occurs in long slender crystals. Its chief use is for type metal. The ore is mined in large quantities at Mill City, Humboldt County, Nevada, and a small amount comes from near Butte, Idaho, though the larger portion consumed comes from foreign countries. Native antimony

is found in Kern and Riverside Counties, California; and other prospects are known in Washington, Utah and Oregon.

714. ARSENIC.—There are two important arsenic minerals: realgar and orpiment. These often occur together and associated with silver and lead minerals. The former is red to orange-red. Streak the same. It usually occurs as an incrustation. The latter is lemon-yellow and occurs massive. Luster pearly. Both varieties yield a strong garlic-like odor when heated before the blowpipe. Arsenic is produced in only a few places in the United States, and some of this is a by-product in the reduction of gold ores.

715. ASPHALTUM.—A natural, semi-solid, bitumen found most notably in the Island of Trinidad and in Sicily. It is also found in lesser amounts in several places in the United States, as in California; Texas; Pike County, Colorado; Kentucky; Bighorn Basin, Wyoming; Salt Lake Basin, Utah; Southwestern Indiana; Arkansas, etc. A variety called ozokerite occurs at Thistle, Utah. There are many other varieties found in the West. California produced $968,400 worth in 1907, most of which came from Los Angeles, Kern and San Bernardino Counties.

716. Asphaltum does not yield the strong odor that is so marked in petroleum, but when burned it yields a tar-like odor.

717. When prospecting for it observe all dark colored sandstones or other dark porous rocks. Heat the specimens found and observe the odor or any oil that may be brought out by the heat. Try to ignite the rock. Rocks containing coal will often yield an oil upon heating, but the odor of asphaltum will be lacking. Asphaltum is very valuable. Search for it in sedimentary strata of dark sandstones.

718. There are many varieties of asphalt and bitumen; as, bituminous rock, brea, oil asphalt, gilsonite, grahamite, elaterite, tabbyite, and ozokerite. The last is the rarest and most valuable of these hydrocarbons.

719. BARYTES.—Called barium sulfate or heavy spar. This mineral is produced in considerable quantities in Missouri, Kentucky, North Carolina, Virginia, Tennessee and Utah. It should be free from iron and calcite. It may be concentrated to advantage, being of high specific gravity. The crude ore is worth about $4.00 a ton. After treatment with H_2SO_4 it is worth $18.00 a ton if suitable for paint manufacture.

720. It occurs in bedded veins, and in pockets in limestone as a rule. It is frequently found as a gangue of the metaliferous minerals in veins, and galena is often found scattered through it. It may be detected by its high specific gravity (4.5) and its light color. It is insoluble in acids and difficultly fusible, yielding a

faint yellowish-green flame when heated alone on charcoal or in the forceps. H. 2.5 — 3. Luster vitreous.

721. Borates.—This is a general term for borax, ulixita, colomanite, and boracite. Borates are found on the borders of large, flat, arid desert regions, as in the southwestern part of the United States. They are associated with salt, soda, and gypsum, and usually occur in beds, though there is a borax vein in California produced, most likely, by hot springs like the Tuscany deposits.

722. Borates are light colored—usually white. They may be detected by their sweetish, alkaline taste when fairly pure. (Arsenical waters also taste sweet. Do not drink such sweet waters.) To detect impure varieties, boil a small amount of the sample in a porcelain dish with H_2SO_4, and when cool add alcohol and ignite with a match. A green flame indicates boron. Borax deposits are very valuable.

723. Borax deposits are found in California, Nevada, Arizona and Chila. The principal source is from two localities: Death Valley, Inyo County, and Long Station, Los Angeles County, California. About one-third of the product is used for household purposes.

724. Black Sand.—The term black sand as here used is intended to include the sands of magnetite, gold, ilmenite, garnet, zircon, hematite, chromite, platinum, iridium, olivine, iron silicate, pyrites, monazite, copper, cinnabar, cassiterite, corundum, columbite, tentalite, palladium and quartz, as these minerals are all represented in the West Pacific Coast black sand.

725. Platinum has been found in black sand in over 120 localities in the United States, the most profitable fields being in Coos, Jackson, Curry, and Josephine Counties, Oregon; and Humboldt, Del Norte, Siskiyou and Trinity Counties, in California.

726. Titanium is often found in the magnetite sands which are found plentifully along the California and Oregon coasts. The titanium often amounts to from 5% to 10% of the weight of the magnetite and could be worked in an electric furnace, producing valuable titanic iron.

727. Gold is found in considerable quantity in nearly all black sand, but no profitable method of extraction has been found up to the present time. Concentration with a magnetic separator has been tried with only partial success. In most cases the gold is not in the magnetic iron, but in the other minerals of which the sand is composed, or it occurs as fine, free gold. This fact accounts for the failure of magnetic separators in many cases. Tests should be made to find just what condition the gold is in, and which minerals contain it.

728. CHROMITE.—This mineral is found in metamorphic sedimentary rocks, and quite generally associated with serpentine and olivine rocks. It is found in the eastern States from Maine to Georgia, and in California on the Pacific slope. More than half the product comes from Wyoming, and most of the remainder from California. [See maps, Figs. 45 and 55].

729. It occurs in lenses as segregated deposits scattered through the metamorphic rock and in placers—never in veins. The mineral looks a little like iron ore, but it has a peculiar luster, which, once seen, will never be forgotten. There are usually small, white grains scattered through the ore, which serve as a means of detection. and a slight apple-green stain may be found on the outcrop. H. 5.5 Sp. g. 4.5. Streak brown.

730. It is a valuable ore, being used in the manufacture of chrome steel. Search for it in the neighborhood of metamorphic rock where serpentine abounds.

731. CLAY.—There is almost an unlimited quantity of clay to be found in any foothill or valley locality. The chief points to be considered are demand and transportation. Brick clay is very common and is not valuable unless it is found near a large city or where some large smelter or other building is to be built, as in many cases it pays to make common brick "on the spot" rather than ship them from a distance. A "pug mill" and common hand moulding-forms are used in such cases. High grade clays, that is, clays containing much kaolin, are found near the foothills of mountains that contain feldspar, clay being derived chiefly from the decomposition of feldspatic rock [170, 171], such as granite. Clays may be tested as follows: Make little test samples by moulding between the thumbs and two forefingers. Dry very slowly and thoroughly without artificial heat, and then heat in an assayer's muffle furnace. In some cases baking should be continued 24 hours. With good samples the edges will not fuse unless the heat is carried too high. The heat should not be as high as in assaying.

732. There are two varieties of potters' clay: kaolin, containing a small amount of sand which must be washed out, and ball-clay which contains more kaolin and is not usually washed.

733. Fire clays are often found associated with coal formations. They are tested at a higher heat than ordinary clay and should contain but little alkali mineral.

734. Clay working machinery is very expensive and the details of operation can not be given here. It may be worth noting, however, that a study of old Egyptian brick, made with straw, has resulted in the discovery that the liquid obtained by boiling straw or other tannin producing substance, mixed with clay, will generally

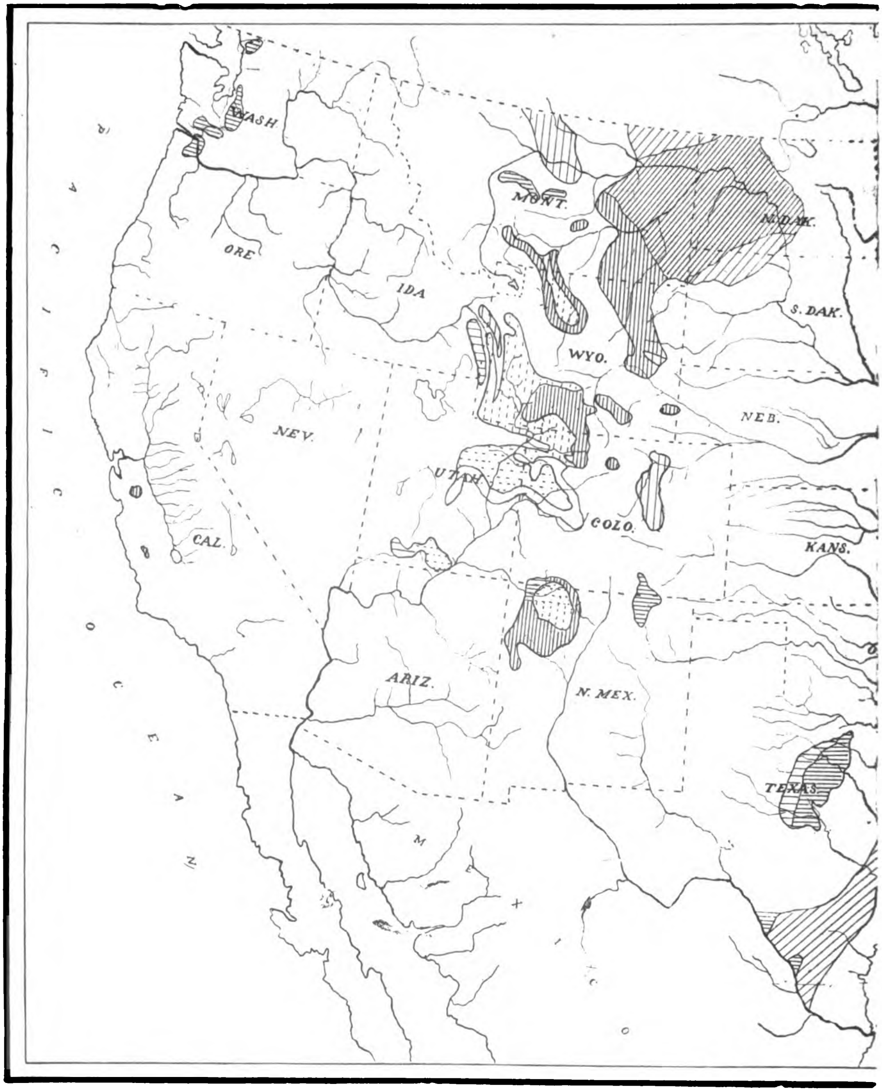
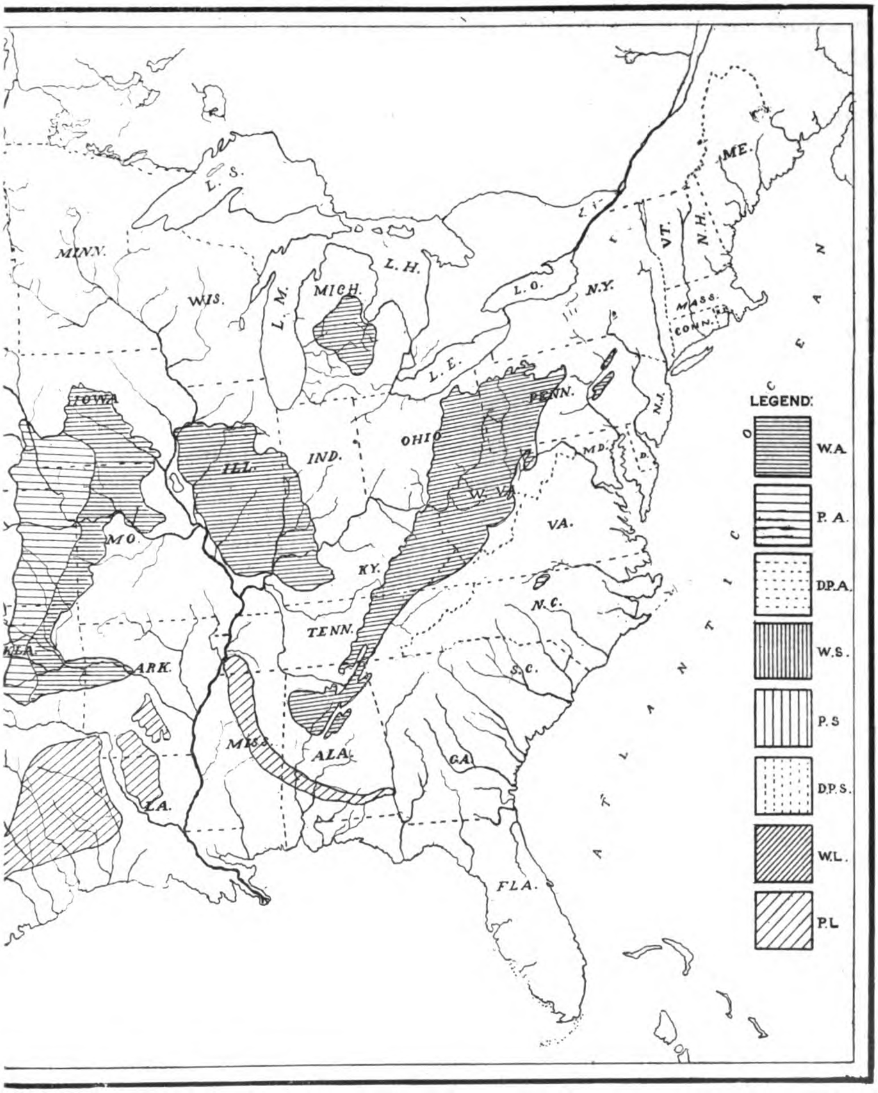


Fig. 62. Coal Areas

W. S.	Workable Semibituminous Coal.
D. P. A.	Deep Probable Anthracite and Bituminous Coal.
P. A.	Probable Anthracite and Bituminous Coal.
W. A.	Workable Anthracite and Bituminous Coal.



of the United States.

P. S.	Probable Semibituminous Coal.
D. P. S.	Deep Probable Semibituminous Coal.
W. L.	Workable Lignite.
P. L.	Probable Lignite.

improve it, cracking and shrinking being in a large measure prevented.

735. COAL.—This valuable mineral is widely distributed throughout the United States, the varieties mined varying from high grade peat to anthracite.

736. The following table will give an idea of the relative composition of these varieties, but no sharp line of distinction can be drawn as coal from one locality may be quite different from the same variety produced in another:

Representative American lignite and coal–	*Water.*	*Volatile hydro-carbon.*	*Fixed carbon.*	*Fuel ratio.*	*Ash.*	*Sulfur.*
Lignite	12	44	40	1.03	5	0-1
Bituminous	3	32	59	1.72	4	1
Semi-bituminous	1	16	73	4.8	7	1
Semi-anthracite	1	8	85	11.	5	1
Anthracite	2	4	85	45.	6	0-1

737. Lignite is brown to black, though the powder is always brown. It often contains stems that look like wood. Usually light, some kinds floating on water. It burns with a smoky flame, contains a large amount of moisture, crumbles easily, and often slacks to mud in the rain, or to a powder in the open air on long exposure.

738. Bituminous or soft coal is black. Its powder is also black. The luster is resinous to dull, and its specific gravity from 1.25 to 1.4. Coking, smokeless, gas, and cannel coal are varieties. Bituminous coal free from sulfur is used for forging.

739. Anthracite or hard coal is black, as is also its powder. It does not soil the fingers. It ignites with difficulty, but yields a great heat, producing little or no smoke. Its specific gravity is from 1.3 to 1.75.

740. A first-class fuel coal should contain not to exceed 6% to 7% ash, and a good gas coal should contain less than 7% sulfur. Coal containing as high as 20% ash is sold in the regular market, however.

741. In prospecting for coal search for dark colored sedimentary strata. Even light brown, sandy rocks are suggestive of coal if in a region known to be coal bearing. It is highly advisable to visit near-by coal fields to ascertain what kind of rocks lie above and below the coal seams in order that you may know the favorable formations. Each coal area has its own peculiarities, which, once learned, makes success in prospecting more certain.

742. Fig. 62 shows the coal areas of the United States as delineated by the United States Geological Survey. It will be ob-

served that vast fields of soft coal exist between the Rockies and the Mississippi. Most of the coal lying along the eastern flank of the Rocky Mountains is in Cretaceous rocks. The Pacific Coast coals are chiefly Teritary. Appalachian coals are Carboniferous.

743. Although Montana contains the largest known coal area of the States west of the Mississippi, Colorado has the greatest yield, Iowa, Kansas and Wyoming follow, each of the last three named producing about the same amount.

744. COPPER.—The genesis of copper ores and the conditions under which they occur are better understood at the present time than that of any other ore. As a rule copper deposits are closely associated with igneous rocks—either extrusive or intrusive [glossary]. In some cases the deposit is in or adjacent to an igneous dike, and in others at some distance, but connected in a genetic way.

745. When the copper has not been derived directly from igneous dikes it may have been indirectly. This is often the case with many other minerals besides those of copper.

746. Another observed fact is that copper deposits, and often deposits of other metals, are found in localities that have been greatly faulted. The ore is not always associated with the largest individual fault in the district, but the genetic relationship appears to exist between the ore and either the first or some subsequent system of faults.

747. Porphyry, limestone and granite are favorable enclosing rocks, and the prospector should examine thoroughly the contacts [154] between any two of these three rocks.

748. The condition and alteration of copper minerals at various depths [174] is, at present, a subject fairly well understood. This is partly because the step-by-step changes in copper ores are more readily traced than in the ores of any other metal. These alterations are chiefly produced by circulating waters, especially the downward moving meteoric waters (rain water). Such waters are always oxidizing, and if they pass through limestone they become carbonating. The original, or first formed copper minerals in a vein or copper deposit are chalcopyrite, and higher up, bornite and chalcocite. Below the chalcopyrite we may find iron pyrites carrying a low percentage of copper. The effect of downward moving surface water is to constantly change these minerals and continually lower the zone of each respective kind of mineral. The order of the progression is as follows: Chalcopyrite, bornite, and chalcocite are oxidized to metallic copper. The metallic copper is then oxidized to cuprite. Cuprite is then oxidized to tenorite, and the tenorite is finally hydrated (combined with water) and also

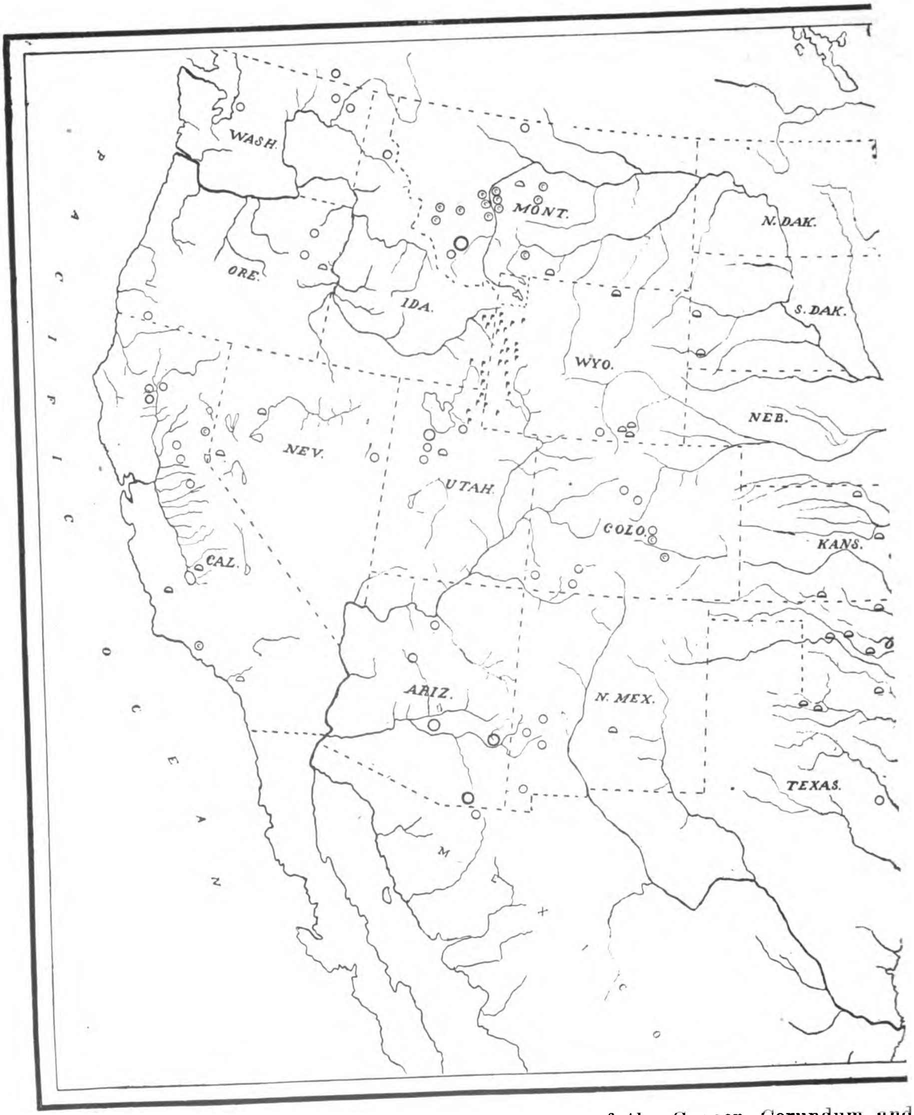
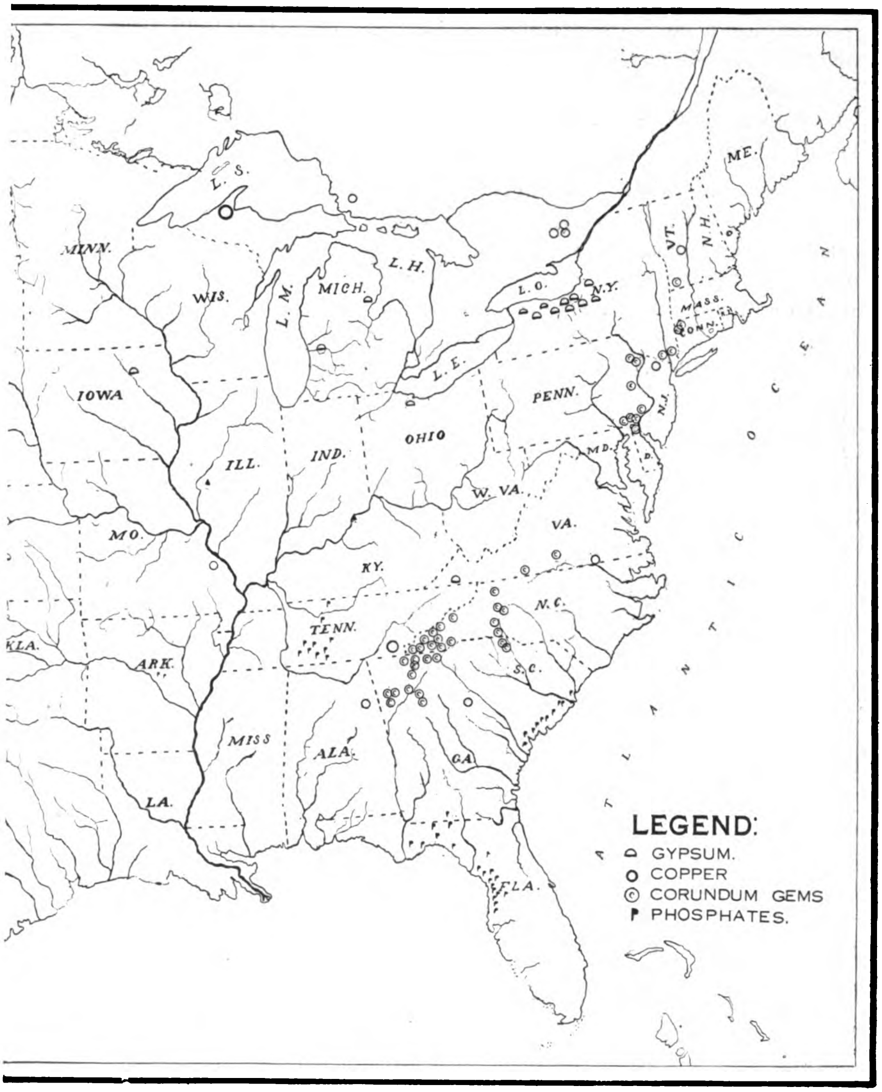


Fig. 63. Map of the Copper, Corundum and



Phosphate Deposits of the United States.

carbonated, forming either azurite (5.2% water and 25% CO_2) or malachite (8.2% water and 19% CO_2). Often all these minerals are found forming an endless chain from the carbonates at the top to the chalcopyrite at the bottom of the deposits, but they are not all present in every copper mine by any means. Isolated bunches or pockets have been found formed of practically concentric layers of the minerals above named, the carbonates being on the outside and chalcopyrite or chalcocite at the center, the various forms being the result of metamorphism.

749. Sometimes these minerals are mixed with each other to some extent, but generally each one is found most plentifully in its respective zone. Fractures, faults or porous underground water channels, are often the cause of an apparent reversal of the order of metamorphism, a second zone of oxidized ores being found below the zone of sulfid. By the due observation of these metamorphic alterations the prospector and miner may form a more reliable idea of the depth and value of his prospect or mine. If the ore is a carbonate, sulfids may be expected below in the zone of secondary enrichment. If considerable depth is reached before the carbonates give way to oxids and sulfids the deposit is likely deep and, therefore, more valuable than it would be if only a shallow zone of carbonates existed. As the sulfids of copper are the original minerals, no copper deposit should be considered persistent till a zone of sulfids has been found. In any case the dryness of the climate affects metamorphism materially. In dry climates soluble carbonates will be more plentiful on and near the surface than in a wet region. This should be taken into consideration.

750. Copper ores are found in five regions: Appalachian, Michigan, Arizona, Montana, and the Pacific Coast. Of these the first may be neglected as it produces practically no copper at present. In 1909 Montana produced 28.81% of the total yield of the United States, Arizona 26.63%, and Michigan 20.77%. Isolated districts are scattered all over the west, the most notable of which are in Utah and California. Alaska copper comes from the Ketchikan district and the Copper River basin. [Fig. 43.]

751. In prospecting for copper examine every rock that has a green stain. Observe that nickel silicate looks much like malachite and would likely be more valuable than copper ore of the same percentage composition. For this reason it is best to test all discoveries in the field. The field test is made as follows: Place a few drops of nitric acid (better to use nitric and hydrochloric mixed) upon the pulverized mineral and then transfer a few drops of this solution to a shaving of dry wood, and light with a match. A blue flame tinged with green denotes copper.

752. A favorite field test with the author is as follows: Take with you a bottle of NH_4OH and one of $HNO_3 + HCl$. In a cigar holder carry a small test tube and an ink dropper. To use, crush the mineral supposed to be copper and treat with the acid mixture in the test tube. Then add the ammonia and wait for the precipitated iron to settle. A blue color indicates copper. Instead of adding ammonia a knife blade or bright iron wire may be held in the solution. If copper is present a copper coating results. [255, 268].

753. *Copper minerals.*

Mineral.	*Formula.*	*Color.*	*Streak.*	*H.*	*Sp. g.*	
Copper	Cu	Copper-red	Shining	2.5	8.8—8.9	100% cu.
Chalcocite	Cu_2S	Gray-black	Gray-black	2.5	5.5	79% cu.
Chalcopyrite	$CuFeS_2$	Brass-yellow	Gr'n'sh blk	3.5	4.2	34% cu.
Chrysocolla	$CuSiO_3 2H_2O$	Blue-green	White	2.4	2. —2.3	36% cu.
Cuprite	Cu_2O	Red	Red-brown	3.5	2. —6.	88% cu.
Malachite	$CuCO_3,Cu(OH)_2$	Green	Greenish	3.5	3.7	57% cu.
Azurite	$2CuCO_3,Cu(OH)_2$	Blue	Blueish	3.5	3.5	55% cu.
Bornite	Cu_3FeS_3	Variegated	Gray-black	3.	4.5—5.	61% cu.

754. *Production of copper by States.*

Copper was produced in 1909 in 21 States and territories. The contribution of each State for the year is as follows:

Production of copper in the United States, 1909, *by States, in pounds.*

State—	1909.
Alaska	4,057,142
Arizona	291,110,298
California	53,568,708
Colorado	11,485,631
Idaho	7,096,132
Michigan	227,005,923
Montana	314,858,291
New Mexico	5,031,136
Nevada	53,849,281
Oregon	245,403
South Dakota	41,988
Utah	101,241,114
Washington	120,611
Wyoming	433,672
Eastern States	1,083,033
Southern States	19,563,625
Middle States	2,159,636
Total	1,092,951,624

Blister copper production of principal districts in 1909, *in pounds.*

District or region—	State—	Rank.
Butte	Montana	1
Lake Superior	Michigan	2
Bisbee	Arizona	3
Bingham	Utah	4
Morenci-Metcalf	Arizona	5
Ely	Nevada	6
Shasta County	California	7
Jerome	Arizona	8
Globe	do	9
Tennessee	Tennessee	10
Silver Bell	Arizona	11
Coeur d'Alene	Idaho	12
Tintic	Utah	13
Calaveras County	California	14
Leadville	Colorado	15
Lucin	Utah	16
San Juan-Ouray	Colorado	17
Santa Rita	New Mexico	18
Southeastern Alaska	Alaska	19

755. FERTILIZERS.—The best fertilizers are the phosphates, and the best phosphate is the mineral called apatite, which occurs in early eruptive and metamorphic rocks. It is not common, and when found it should be thoroughly investigated. Very little apatite fertilizer is upon the market. It is mined in large amounts in Canada. Pure apatite is easily detected by either its physical or chemical properties. [758]. Any rock containing a considerable amount of phosphorous may be tested by fusing the pulverized sample with soda on charcoal and dissolving in HNO_3. To a strong solution of ammonium molybdate add a few drops of the filtered nitrate solution of the mineral. A yellow precipitate is a test for the presence of phosphorous. Guano is an excellent fertilizer found on the islands near Peru, and in lesser amounts on the islands in Great Salt Lake, Utah. Fertilizers may be classified as follows:

Mineral Phosphate	Phospherite	Chlor-apatite Fluor-apatite
	Apatites	
Rock Phosphate	Amorphous nodular phosphate Phosphatic limestone Bone beds	
Guano	Soluble Insoluble	

756. Rock phosphate is common, occurring abundantly in Florida, Tennessee, South Carolina, North Carolina, Alabama, Wyoming, Utah, and Idaho, named in the order of production. [Fig. 63]. In the last three States the deposits overlie quartzites and sandstones which serve to aid in their discovery. The phosphate deposits of these three States cover the largest area of known prosphate beds in the world. The irrigation and reclamation of arid lands in the West will make a market for large amounts of this material in the near future.

757. Rock phosphate and apatite are sometimes treated with sulfuric acid before marketing in order to make the material more useful to vegetation. Western rock should contain at least 32% of phosphoric acid to repay shipment to the coast-city markets.

758. Apatite has a hardness of 4.5. Sp. g. 3.5. Luster vitreous. Color green to brown. Occurs in columnar and hexagonal crystals, often granitelike rock.

759. Rock phosphates are much like limestone in appearance. Sometimes they are quite dark colored.

760. **FLUORITE.**—This mineral is found in fissure and contact [154] quartz veins throughout the West. It occurs as cubes and octahedrons, and combinations of these forms. The color varies from green to brown, blue or colorless. The hardness is 4. The market for this mineral is increasing owing to its introduction into the reduction of refractory ores. It is mined in Harden County, Illinois; Colorado, Kentucky, Arizona, and near Deming, New Mexico.

761. **GRANITE.**—A building stone of unusual strength and durability. The best varieties are fine textured and contain but little mica. The variety called syenite is quite valuable. To be salable this rock must be free from cleavage planes, blotches, and patches of basic minerals. It must also be near cheap transportation facilities. A good granite quarry near a large city is as good as a gold mine.

762. **GRAPHITE.**—This mineral is valuable as a lubricant and in the manufacture of lead pencils. It is found associated with early metamorphic rocks, especially limestones. It can be detected by its greasy feel and by marking on paper. It is distinguished from molebdenite by the latter cleaving up in folia. Graphite is always granular. It slightly resembles galena in some cases. H. 1—2. Sp. g. 2.

763. Its market value varies from $5.00 to $30.00 per ton. It is found in large amounts in New York, and in lesser amounts in Alaska, Colorado, Georgia, Nevada, Wisconsin and California.

Also found in Japan, Australia, New Zealand, Guatamala, Germany and Greenland. The production of artificial graphite exceeds that of the natural product.

764. GYPSUM.—This mineral is a hydrous calcium sulfate. It is usually a white or pinkish, amorphous granular rock of sedimentary origin. H. 1. Sp. g. 2.3. Luster pearly. Contains 20% water. It usually occurs on the border of some ancient ocean, being a marine precipitate. It is used as a fertilizer, and as such is called land plaster. [See map, Fig. 63].

765. When pure gypsum is calcined by heating (called boiling) in large kettles to drive off the greater part of the water of crystallization, the product is called plaster of Paris.

766. Gypsum is found in large quantities in Michigan, New York, Oklahoma, Texas, Iowa, Ohio, Virginia, Alaska, Colorado, Montana, New Mexico, South Dakota, Utah, Kansas, California, Nevada, Oregon, Wyoming, and in small amounts in most of the other western States, named in order of production. In Utah it is found in sand dunes near Filmore.

767. IRON ORE.—Iron ores are easy to find when they are exposed because the oxidation and solution of the iron will have discolored the adjoining rocks. The rocks bordering the streams flowing from iron deposits will often have a brownish-yellow coating. These streams may be traced up the gulches to the deposit. Iron is a very common element, being a constituent of many rocks, but only oxid of iron and the uncommon carbonate are mined for ore. Terrestrial metallic iron has never been found, except in Greenland, in small amounts, where it is supposed to have been produced by the burning of a near-by coal deposit. Of course, meteoric iron is metallic. No iron mineral can contain more than 72.4% of iron.

768. Many iron ores that appear to the eye to be high grade may be in fact worthless. In some cases a small percentage of some objectionable element will make it valueless, and in other cases the percentage of iron will not be high enough. Ores to be salable must contain from 30% to 60% iron—that is, they must be nearly pure mineral in any case. Limonite is salable if it contains from 40% to 50% iron. Hematite should contain from 50% to 65% iron. Pure magnetite contains 72.4% iron.

769. The presence of a very small amount of sulfur will ruin the richest iron ore for iron making. Iron pyrites (iron and sulfur) is valuable for the manufacture of sulfuric acid, but not as an iron ore. A very small amount of phosphorous will ruin an iron ore. Bessimer iron ores should not contain phosphorous to a greater amount than 1/1000 of the iron content. Cheap fuel is one

of the essentials for iron manufacture. In the West coal is worth more for fuel than for iron smelting. However, this condition is rapidly passing away with the opening up of our western coal fields.

770. The electric smelter may make our many iron deposits valuable in the near future.

771. One of the latest and best methods of prospecting for iron on a large scale is by means of magnetic surveys made by a surveyor provided with a transit having a solar attachment for taking the sun, so that the magnetic variation can be ascertained and platted upon a map.

772. All iron ores become magnetic when highly heated and allowed to cool. To make this test use a blowpipe and a small magnet. If not rich enough to give this test do not locate it.

773. *Iron minerals.*

Mineral.	*Color.*	*Streak.*	*H.*	*Sp.g.*	*When pure.*
Hematite	Red-black	Red-brown	5.5	4.5	70% iron.
Limonite	Brown	Yellow-brown	5.5	3.5	60% "
Magnetite	Iron-black	Black	5.5	5.	72% "
Pyrites	Yellow	Yellowish-black	6.	5.	46% "
Siderite	Gray to brown	White	3.5	3.5	48% "

774. The iron of commerce is usually obtained from the oxid ores. The carbonate siderite has furnished a small amount, however. The principal ores are hematite, magnetite, and limonite.

775. Hematite is a widely distributed ore. It occurs in crystalline and stratified rock of all ages. From New York to Alabama it occurs in silurian rocks. In Michigan and Wisconsin it is found in quartzite and schists of the Archean Age.

776. Siderite, the carbonate, occurs in stratified slates and sandstones, usually as replacement deposits.

777. Limonite, or bog ore, is found in marshes or bogs, both ancient and modern, and is often of comparatively recent age. It is often found as an alteration product of iron oxid in wet gold and silver mines, but in such cases it is not plentiful enough to be worked as an ore. It is also found in the older slates and limestones, especially those earlier than the Tertiary. In Texas it is found in Tertiary rocks. From Vermont to Alabama it occurs in a limestone belt of the Mesozoic Age. In Oregon, near Portland, it occurs in hollows in a basaltic overflow covered by a later flow.

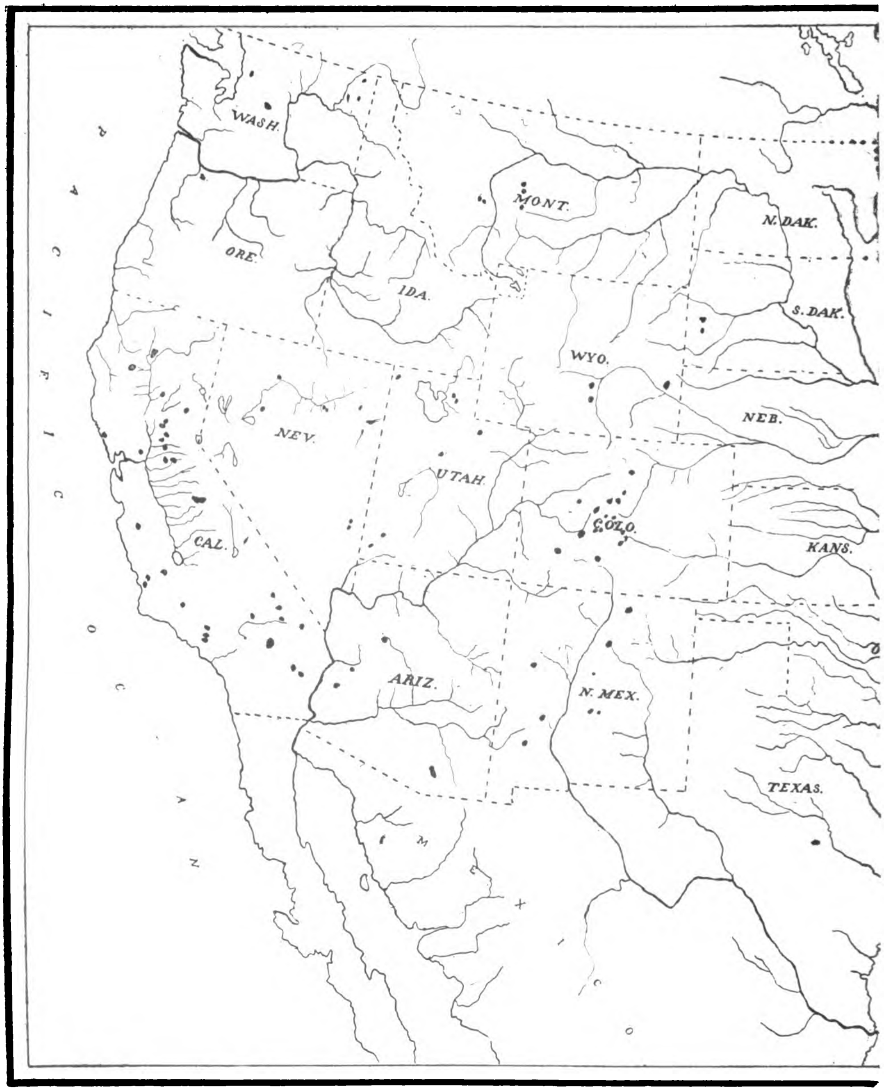
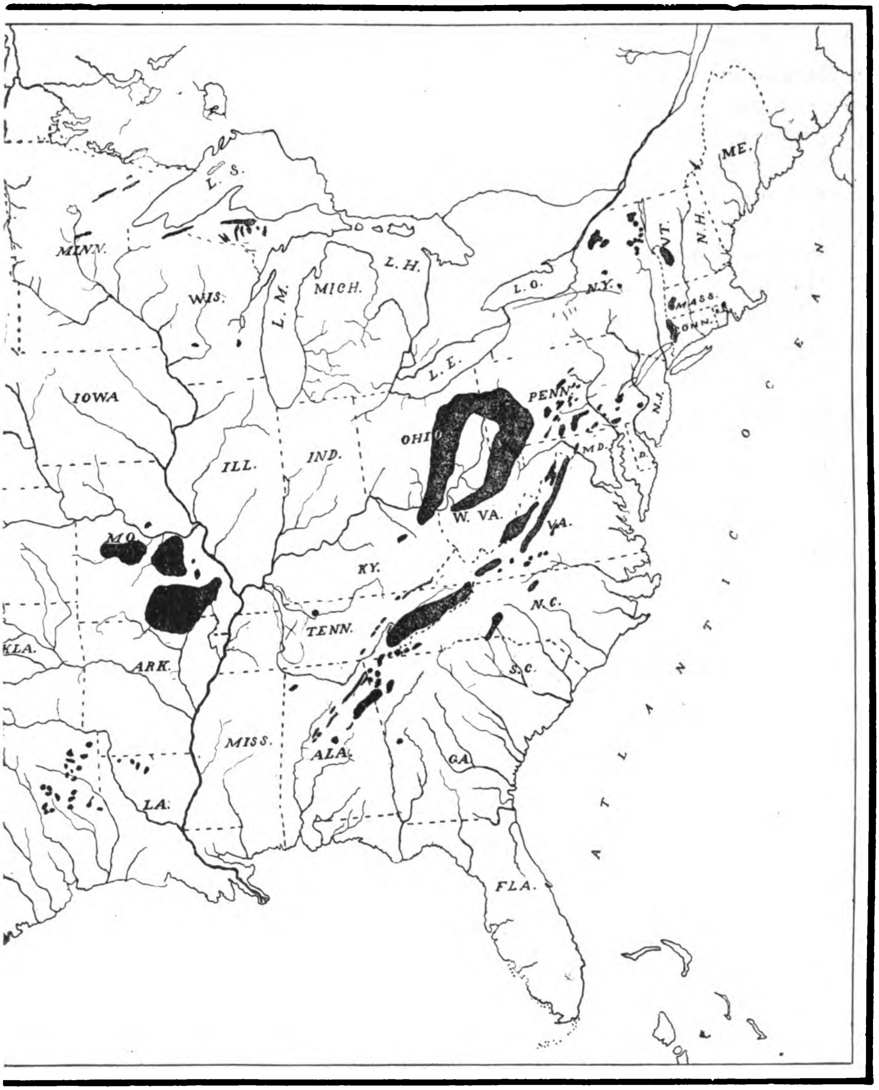


Fig. 64. Map of the Iron Producing



Areas of the United States.

778. *Rank of iron ore producing States in* 1909, *with value of product and percentage of each.*

Rank.	State.	Amount.	Percentage of total value.
1	Minnesota	$60,253,314	54.63
2	Michigan	32,282,622	29.27
3	Alabama	4,996,455	4.53
4	New York	3,072,323	2.79
5	Wisconsin	2,727,406	2.47
6	Virginia	1,693,188	1.54
7	New Jersey	1,607,003	1.46
8	Montana, Nevada, New Mexico, Utah, Washington, and Wyoming	955,775	.87
9	Tennessee	907,282	.82
10	Pennsylvania	792,672	.72
11	Georgia	332,478	.30
12	Missouri	210,853	.19
13	Kentucky, Maryland, and West Virginia.	157,073	.14
14	Connecticut and Massachusetts	141,274	.13
15	North Carolina	107,013	.10
16	Ohio	28,547	.02
17	Colorado	16,000	.01
18	Texas	9,318	.01
	Total	$110,290,596	100.00

779. In California the principal iron deposits are as follows:

Pit River, Shasta County.
Gold Valley, Sierra County.
Minaret, Madera County.
Eagle Mountain, Riverside County.
Iron Mountain, San Bernardino County.
Cave Canyon, San Bernardino County.
Providence Mountain, San Bernardino County.

The less important deposits are:

Patamocas, Tehama County.
Indian Springs, Nevada County.
Dietert, Calaveras County.
Mount Raymond, Madera County.
Perfumo Canyon, San Luis Obispo County.
Owl Hole, San Bernardino County.
Kingston Range, San Bernardino County.
Garlic Spring, San Bernardino County.
Iron Age, San Bernardino County.

780. **Iron Pyrites.**—In many localities this mineral is mined for the sulfur content, sulfuric acid being made from it.

For this purpose the ore should be practically pure iron pyrites. The price varies from $3.00 to $6.00 a ton, depending upon the locality and the local demand for the acid.

781. **Lead.**—Galena is the most important lead producing mineral, but considerable metal is produced from cerussite. Galena is always crystalline and brittle, easily breaking up into cubical grains. Color bluish-gray. H. 2.5. Sp. g. 7.2. Often found crystallized in cubes and octahedrons, or in combinations The Missouri-Kansas district leads in the production of lead, Idaho, Utah, Colorado and Montana following in the order named.

782. Associated with silver and gold ores in particular, and often with marcasite, sphalerite, chalcopyrite and arsenopyrite. Zinc and lead minerals are common associates. [286].

783. In the Appalachians galena occurs in metamorphic rocks, but not in paying quantities.

784. In Missouri, Kansas, Wisconsin and Illinois, lead and zinc are found in paying quantities in shallow deposits in sedimentary rocks, usually limestone. It commonly occurs along fractures in the limestone and between the strata. [See Fig. 36]. In the West lead is found in fissure veins with the precious metals and also with copper minerals. [286]. It sometimes occurs alone in quartz veins. The galena from the western United States is usually quite high in silver, while the galena from the Mississippi Valley is low in silver.

785. Cerussite, the carbonate of lead, is white to gray in color. Luster admantine is pearly. H. 3 to 3½. Sp. g. 6.4 Cleavage prismatic. Found in large quantities in Leadville, Colorado; also at the Flux Mine, Pima County, and at Red Cloud Mine, Yuma County, Arizona. All lead minerals may be detected by their high specific gravity or the blowpipe, a lead button being easily obtained on charcoal.

786. Search for ores near limestone, especially in localities where zinc and copper ores are found.

787. Lead ores are usually smelted free by all smelters when they are reasonably high grade.

788. *Lead minerals.*

Rare minerals are marked with a star.

Mineral.	*Formula.*	*Color.*	*Streak.*	*Sp. G.*	
Galena	PbS	Lead-Grey	As Color	2.5—2.7	86.8% Pb
Cerussite	$PbCO_3$	White, grayish		3. —3.5	77.4% Pb
Anglesite*	$PbSO_4$	White	Uncolored	2.7—3.	67. % Pb
Pyromorphite*	$3(Pb_3P_2O_8)$ $PbCl_2$	Green Yellow Brown	Yellowish	2.3—4	75. % Pb
Wulfenite*	$PbMoO_4$	Orange Yellow Red	White	2.7—3.	56.4% Pb

789. LIMESTONE.—This is a poor building material, because it will weather away quite rapidly. It is chiefly calcite in composition, with a small amount of silica. It is valuable for the production of lime and cement, being most valuable when found near clay and cheap transportation. The United States produced over $12,640,000 worth in 1907. Pennsylvania, Ohio, Maine and Missouri lead in production.

790. LITHOGRAPHIC STONE.—This is a compact, very fine grained, homogenous limestone. Found in Texas, Virginia, Indiana, Arkansas, and also in several Western States in inferior quality. The texture of the rock should be slightly porous and there should be no flaws or spots in it. Good rock in large pieces is worth about 40 cents a pound, but the price is decreasing owing to the fact that metallic aluminum is being used in its place.

791. MAGNESITE.—This mineral is usually found massive and in veins in rocks such as talcose slate, dolomite and metamorphosed magnesian rocks. Often adjoining serpentine. Found in notable quantities in Greece and California, the deposits in the latter place being the largest in the world. It is a snow-white, porcelain-like rock of very fine texture. It can generally be identified by its resemblance to unglazed porcelain. H. 3.5 to 4. Sp. g. 2 to 3. If heated in a closed tube with moist blue litmus paper the latter will turn red.

792. This mineral is very valuable for making fire-brick and fire-proofing material, also for making artificial stone, floor tiling and in paper manufacture. A valuable by-product is carbon dioxid (CO_2) gas. This gas is given off when the magnesite is heated, the gas being compressed in iron cylinders and sold for charging so-called soda water. Three tons of crude magnesite make one ton of calcined material valued at $20.00 per ton. It is most valuable when found near water or cheap transportation.

793. It is found in Massachusetts, Maryland, Pennsylvania, and California. In California it occurs in about 100 localities, the most important being in Tulare, Napa, Sonoma, Riverside, Alameda. Stanislaus, and Santa Clara Counties. It sells for $2.35 to $9.00 per ton at the mine.

794. MANGANESE.—Manganese dioxid, or pyrolusite, is quite valuable, being used in the manufacture of high grade steel, and for the production of chlorin gas from salt. Manganese mining has not been extensive for several years past. The price ranges from $5.00 to $15.00 per ton.

795. The mineral resembles iron ore in appearance and also by being slightly soluble in water and producing a stain upon adjacent rocks. It has a bluish-black color when pure, however. which aids in distinguishing it from iron ore. Psilomelane is a black to a greenish-black variety with a little water of crystallization. All manganese ores may be detected by the blowpipe with the borax bead.

796. Manganese dioxid ores are sedimentary deposits, generally speaking, though some deposits might be called residual, that is, they are the remains from the decomposition of crystalline, igneous rocks.

797. Manganese dioxid does not occur in veins but in irregular masses or beds, the largest found thus far containing about 25,000 tons. Never found crystallized.

798. Rhodochrosite, the carbonate of magnesium, is a pinkish-white crystalline mineral often found associated with silver, lead and copper ores—especially with silver. [286]. It often alters to a black mineral resembling wad. The presence of this latter mineral indicates that leaching has been extensive in the locality where it is found.

799. The principal localities where manganese is found are as follows:

Grand County, Utah, 10 miles south of Little Grand.
Juab County, Utah.
Iron County, Utah (with iron).
Custer County, South Dakota.
Leadville, Colorado.
Golconda. Nevada.
Lincoln County, Nevada.
Eureka County, Nevada.
Meadow Valley, Plumas County, California.
Placer County, California.
Calaveras County, California.
Near Livermore, California.

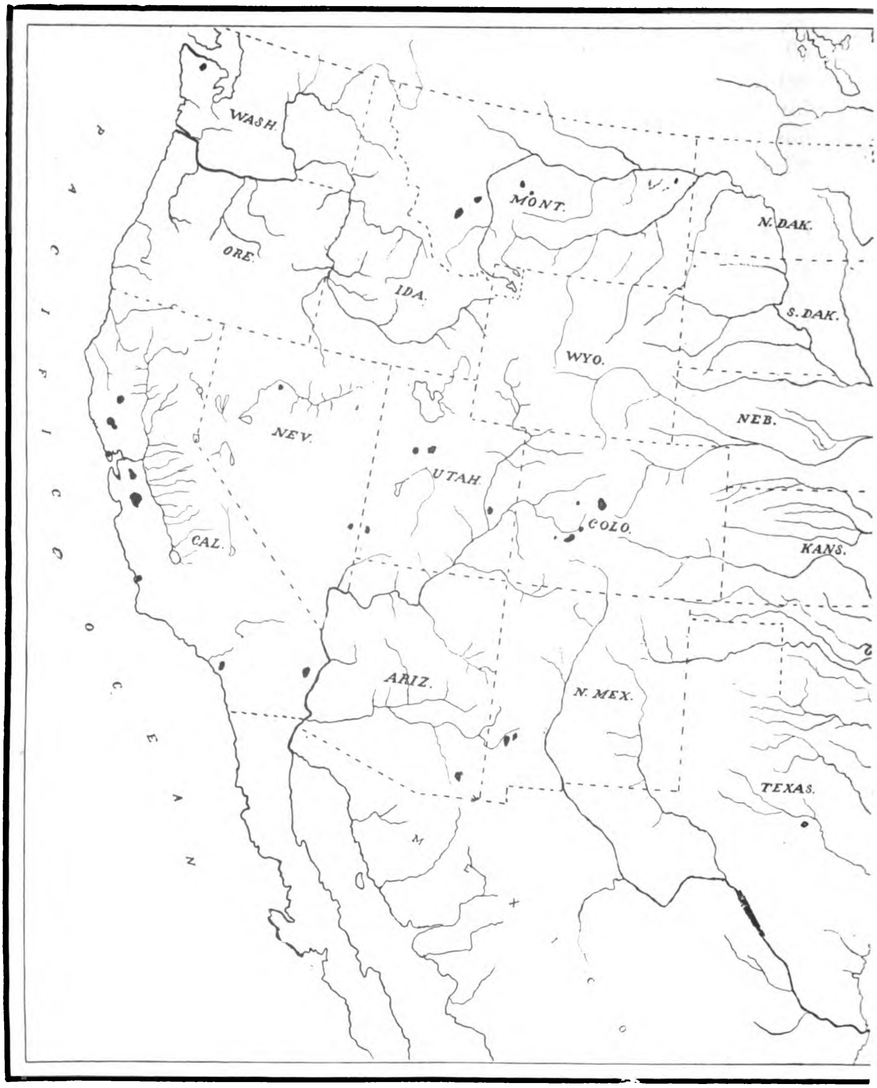
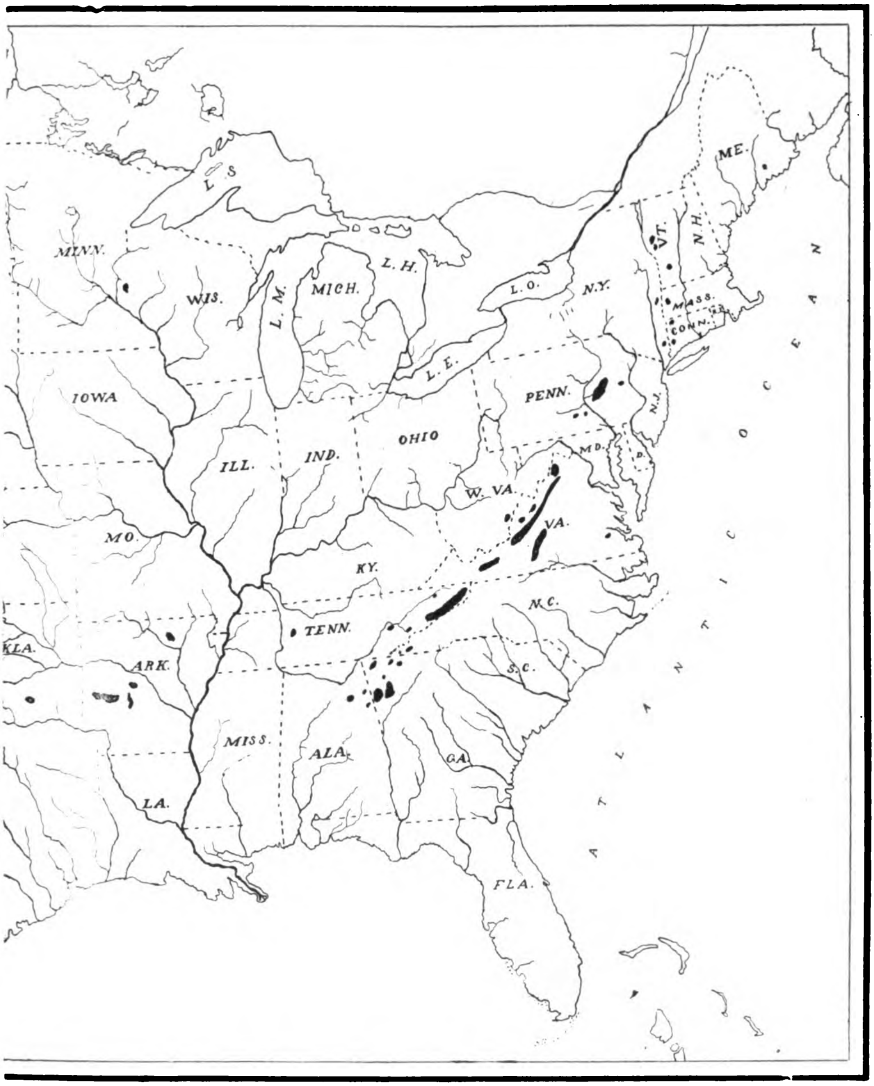


Fig. 65. Map of the Manganese



Areas of the United States.

Small deposits are found at or near the following places:

Butte, Montana (with silver).
Meagher County, Montana (with silver).
Gunnison County, Colorado (with iron).
Sierra County, New Mexico (with silver and iron).
Kingston, New Mexico (with silver and iron).
Tombstone, Arizona.

800. MARBLE.—This is metamorphosed limestone. It is much used for interior decoration and for tombstones. To be valuable it must be free from cracks, flaws and discolorations. The texture must be fine, not coarse. That is, it must be finely crystalline.

801. Onyx is a beautiful variety obtained in California and Mexico.

802. There are immense deposits of marble at several places in the West, but exorbitant freight rates prevent many of them from being worked at a profit. It is identified by its hardness (3), and its effervescing with any mineral acid.

803. The marble output for 1909 was valued at $6,548,905, and was from Vermont, Georgia, Tennessee, Colorado, New York, Massachusetts, Alabama, Pennsylvania, California, Alaska, and New Mexico, named in the order of value of product.

804. MERCURY.—With the exception of the very rare mineral tiemanite, which has been found in paying quantities near Marysville, Utah, the only mineral mined for mercury is cinnabar. The localities where the latter is found are limited, compared with the wide distribution of gold, silver and copper ores, being confined to a chain of deposits extending along the western coast of North and South America, from Alaska to Chili. The rocks in which these deposits occur are, for the most part, sedimentary, being made up of granite detritus. Owing to metamorphism these sedimentary rocks are quite crystalline, in some cases making it difficult for the inexperienced geologist to distinguish them from igneous rocks.

805. Cinnabar occurs in shale, sandstone, slate, serpentine, conglomerate and volcanic rock, both acidic and basic. Color red. Streak Scarlet. H., 2; Sp. g. 8 to 9. Contains 86% mercury. It seems to have a slight preference for sandstone, especially in California. Serpentine often occurs near the deposits and sulfur springs are not uncommon. Cinnabar never occurs as a replacement deposit. It is invariably deposited in pre-existing cavities and in porous rocks, sedimentary or igneous.

806. Mercury is, in all probability, originally derived from the underlying igneous rock, having been brought up in solution in hot, alkaline, or sulfureted waters and precipitated in the cool surface

rocks. In some cases it is thought to be the result of vaporous emanations of mercury coming in contact with sulfureted waters.

807. In America nearly all the cinnabar deposits are found near the coast of the Pacific Ocean. A few prospects have been found in Nevada, Utah, Idaho and Texas, and a still fewer number of working mines. Mexico contains a number of prospects but no good paying mines.

808. Most of the deposits in California were formed since the Miocene Period of the Tertiary Age [125]. For this reason it is advisable to prospect for cinnabar in the recent rocks rather than the old formations. California localities are shown in Fig. 45.

809. In Nevada the prospects are in Eldorado and American Canyons; in the Antelope Range, Humboldt County; and in Ione, Belmont and Bullfrog districts, Nye County. In several cases the prospects are very encouraging. The deposits visited by the writer in Nye County were especially promising.

810. In Arizona the prospects are in Yuma County. In Texas they are in the Terlingula district. In Utah they are near Murcur. In Oregon there are prospects at Pineville, Crook County; near Drew, Douglass County; and near Black Butte, Lane County.

811. *Mercury minerals.*

Rare minerals are marked with a star. Mixtures are marked "a."

Mineral.	*Formula.*	*Color.*	*Streak.*	*H.*	*Sp. g.*	
Cinnabar	HgS	Deep red	Adamantine	2. —2.5	8. —8.2	86 % Hg.
Native mercury	Hg	Tin-white	Metallic	1.5— .5	11. —7.2	
Horn mercury*	Hg Cl	White, yellow	As color	1. —1.5	6.4—7.	84.9% Hg.
Amalgam* a	Hg Ag	Silver-white	As color	3. —3.5	13—14	14 to 74% Hg.
Tiemannite*	HgTe	Steel-gray	Metallic	2.5	8.2—8.3	71.7% Hg.
Metacinnabarite*	HgS	Black	As color	3.	7.8— .3	86.2% Hg.
Onofrite*	Hg(SSe)	Dark gray	As color	2.5	7.9—8	82.8% Hg.
Coloradoite*	HgTe	Iron black		3.	8.6	61.5% Hg.
Livingstonite*	HgSb S	Lead-gray	Red	2.	4.8	24 % Hg.

812. **NITER.**—(Nitre, saltpeter). Niter occurs in many places, notably Spain, Egypt, Persia, and India. In the United States it occurs in small amounts in the caves in Kentucky, Tennessee and elsewhere along the Mississippi Valley. Also found northeast of Salton, Riverside County, California. Chemically it is potassium nitrate. H. 2. Sp. g. 2.1. Color snow-white. Occurs in acicular crystals. It is effervescent. Soluble in water.

813. Soda niter, or Chili niter, is sodium nitrate. It occurs in great quantities in Chili and neighboring parts of Peru and Bolivia. It occurs in Humboldt County, Nevada, and San Bernardino County, California. It is white to brown and lemon-yellow. Transparent. H. 1.5. Sp. g. 2.2. Soluble in water.

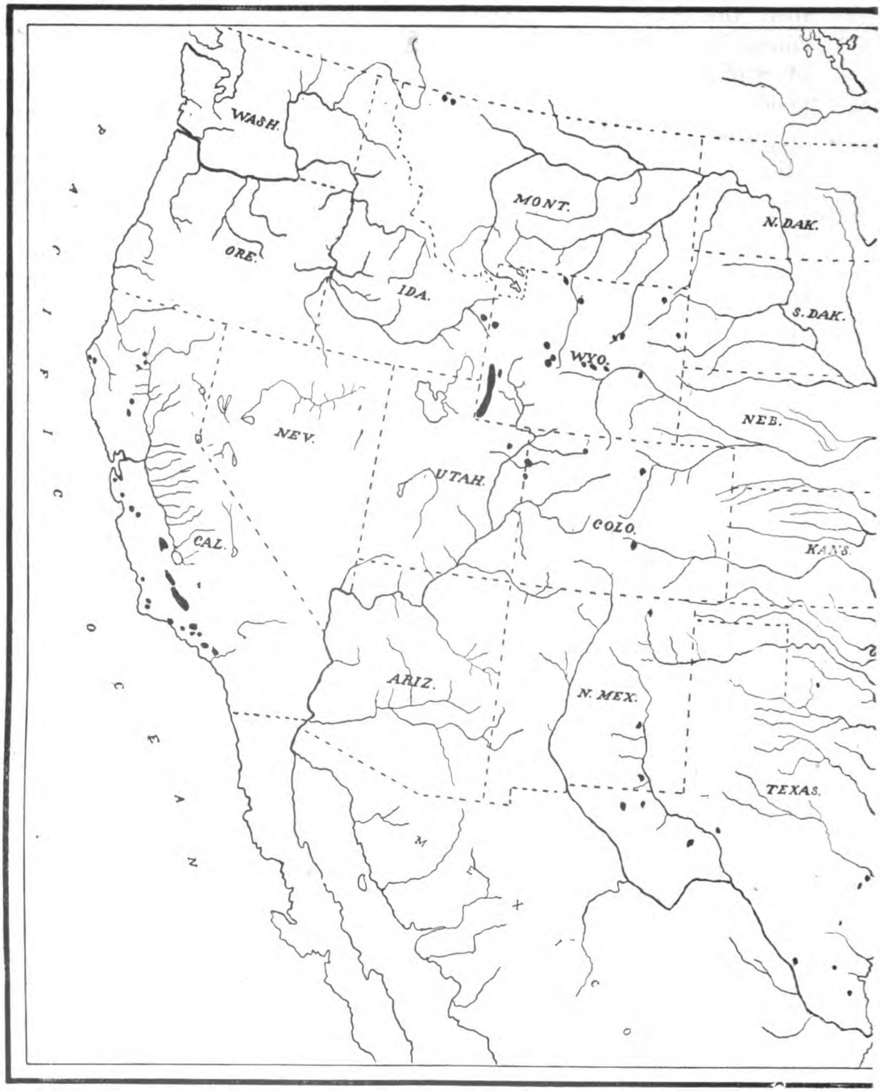


Fig. 66. Map of the Oil Producing

Areas of the United States.

814. In the process of manufacturing potassium nitrate, which is more valuable than soda niter, the soda niter is boiled with potassium chlorid. This forms potassium nitrate and sodium chlorid. The sodium chlorid (common table salt) crystallizes out when the solution cools and is skimmed out with perforated ladles. Although potassium nitrate is more valuable than the soda niter it follows that the latter is nevertheless quite valuable if found near potassium chlorid.

815. Both of these niters deflagrate (snap and fly in pieces) when heated. When heated in the blowpipe flame and viewed through cobalt-blue glass the potash niter yields a deep violet color. The soda niter gives an intense yellow color to the flame.

816. The nitrogen minerals are as follows: Soda niter; potash niter; nitro barite; nitro calcite; nitro magnesite; gerhardite; darapskite and nitro-glauberite.

817. Petroleum.—This mineral is a hydrocarbon of disputed origin. It occurs in the Silurian and Devonian sedimentary rocks in the eastern States; in the Laramie series of the Cretaceous rocks in Colorado; and in the Tertiary shales in California and Texas. Eastern petroleum has a parafin base (parafin residue from distillation) and western petroleum has an asphalt base. The latter petroleum is sold chiefly for fuel purposes without any treatment, but it is also refined, several products being formed. The eastern petroleum is usually refined and numerous products marketed.

818. In prospecting for petroleum it will often be observed that an odor of petroleum is a certain indication of a seepage. In many cases, however, the seepage is so slight that there is no odor, but there will be a thin scum of oil on stagnant water in the vicinity of the seepage. There is a vegetable oil that has very much the same appearance as the mineral oil, but the former film will leave a ragged trace when the surface of the water is disturbed with a stick while the latter oil will leave no trace, but will immediately close up again. Very often the presence of oil may be detected by placing some of the pulverized oil rock in a dish of water. If oil is present a thin film of oil will be seen on the water.

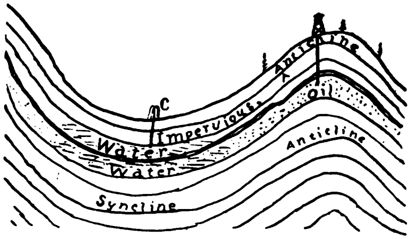


Fig. 67. Typical Oil-Bearing Formation.

819. The place to drill for oil is not at the seepage, but at a distance therefrom, depending upon the position of the strata beneath the surface. The oil is usually in anticlinal folds above the water level in a porous stratum, often sandstone, limestone or shale, with a non-porus stratum above it in each case.

820. It is often found in the rocks which were once along the shores of an ancient inland sea, or nearly enclosed bay. Fossil shells are common in the neighborhood, especially shells resembling common oyster shells. These are usually very thick. In most cases the original shells are found instead of fossils or casts.

PHOSPHATES.—(See fertilizers).

821. PRECIOUS STONES.—While it is not advisable to make a business of searching for precious stones in the United States, it will be well to keep up a constant lookout for them. The amount and value of precious stones produced in the United States is increasing from year to year, and it will not be long before some noted discovery will be made along this line. While the American prospector is very alert he has never taken much interest in precious stones.

822. *Diamonds* have been found in the United States in California, Arkansas, Kentucky, North Carolina, and possibly in Montana. They are found in volcanic pipes or chimneys of blue earth and in placers.

823. The luster of the uncut diamond is adamantine with a greasy or slightly pearly look. If one has seen an uncut diamond he will have slight difficulty in distinguishing the natural crystals from other similar minerals. It crystallizes in the isometric system [69], usually occurring in octahedrons (eight sides) with the edges beveled and the faces slightly bulged out instead of flat. Quartz occurs in long six-sided prisms, and topaz in long four-sided prisms, so there should be little trouble in distinguishing one from the other. However, quartz crystals sometimes occur practically round, and when so found they would slightly resemble diamonds, were it not for the fact that they are six-sided and not octahedral. Its hardness exceeds that of any other mineral, although it is very brittle. Its color varies from colorless to black. Good black diamonds are worth almost as much as the ordinary clear stones, as the demand for them for diamond drills is very strong.

824. *Turquoise.*—This mineral occurs massive in rocks associated with trachyte. It is of a peculiar blue color, and occurs in irregular masses in the igneous rock.

825. Artificial turquoise so closely imitates the genuine that the price of the latter is not high. There is a strong demand for turquoise in the matrix.

826. *Tourmaline.*—Tourmaline crystals of the gem variety are found in paying quantities in Arizona, New Mexico, Nevada, and California. The crystals are green, rose-pink or blue. Black crystals are not valuable, but it should be noted that thin sections of crystals that appear nearly black are really often quite transparent, and therefore valuable for use in polariscope manufacture. Tourmaline crystals are three-sided, the sides being slightly convex and having longitudinal striae (fine grooves).

827. *Garnets.*—These are beautiful red minerals, usually of dodecahedral form. The hardness is about the same as quartz. They are found abundantly in mica schist, hornblende schist, gneiss, and rarely in granite and ganular limestone. Many are found in ant-hills in the Navajo Indian reservation where they have been collected by the ants. They are found plentifully in Alaska and Washington.

828. *Corundum gems.*—These gems are extremely hard, being next to diamonds. They are usually found in six-sided prisms and the impure varieties are barrel shape, that is, bulged at the center. The Corundum gems are all of practically the same composition, infinitessimally small amounts of natural coloring matter giving rise to the different names. Formula, Al_2O_3. Sp. g. 4. H. 8 to 9.

829. *Sapphire* is known under several different names depending upon the color; if red it is called Oriental ruby; yellow, Oriental topaz; green, Oriental emerald; violet, Oriental amethyst; hair brown, adamantine spar; radiated interior, asteriated sapphire. All the above gems are corundum from a mineralogical standpoint, the composition being Al_2O_3 as above stated. Ordinary amethyst is simply quartz having an amethyst color.

830. Sapphires have been found in New Jersey, New York, Pennsylvania, Connecticut, Alabama, Georgia, and most notably in North Carolina and South Carolina; near Los Angeles, California; Helena, Montana; Santa Fe, New Mexico; in Arizona and Colorado. In prospecting for any of the corundum gems above mentioned the presence of the minerals commonly associated with them are important indications. The associated minerals are: margarite, an alteration product of corundum; and chlorite with peridotite rocks. Descriptions of these minerals can be found in any Mineralogy. Search for the gems near the contact between peridotite and gneiss. Owing to the fairly high specific gravity of these gems panning is the most practical method of conducting the field work. If waterworn the crystallization faces will be partially destroyed, but the extreme hardness (8 to 9) serve as a means of positive identification. Fig. 63 shows localities.

831. Pumice.—This is a vesicular, acid, volcanic rock, used

chiefly as an abrasive. It occurs massive in large beds as fragmental rocks, and in beds in a powdered form.

832. The chief supply comes from Nebraska, South Dakota, California, Wyoming and Oklahoma. It has been suggested as a suitable facing for stone office buildings, being light.

833. QUARTZ SAND.—This material is used in the manufacture of common glass. For this purpose the sand should be free from iron, or other metal. Large quantities are mined in Illinois and elsewhere in the United States. It is worth about $7.00 per ton, delivered at the glass works.

834. SALT.—This mineral is of marine origin. It is found in beds in New York, Michigan, Ohio, Kansas, California, Louisiana, Texas, Utah, West Virginia, Vermont, and in lesser amounts in many other States. It is most easily detected by its taste. To be valuable it must be near railway transportation. Salt is also obtained in large quantities by the evaporation of Ocean and Great Salt Lake waters. Its average value in 1909 was $4.50 per ton.

835. SANDSTONE.—Sandstone may be classified into five varieties, depending upon the material which cements the grains of sand together: first, cemented with silica; second, cemented with lime; third, cemented with iron; fourth, cemented with alumina; fifth, mixtures. The first variety is the most durable and the strongest. The second variety ranks next, etc. Sandstone is a sedimentary rock.

836. SLATE.—Slate is a metamorphosed sedimentary rock composed of the finely pulverized particles of other rocks. As might be expected, it varies in color and composition. It is found among the rocks of all geological ages, except the Archean. [125]. The most valuable varieties cleave readily and joint planes occur in the slate bed making it less expensive to quarry. In 1907 Pennsylvania produced $3,800,000 worth; Vermont $1,477,000 worth, and Main $236,000 worth. California and Utah are the only western States that mine this material.

837. SULFUR.—Native sulfur is found widely distributed throughout the western part of the United States, associated with late igneous rocks, especially volcanic lavas. It is easily detected by its sulfurous odor when burned. If pure it burns with a blue flame.

838. The market for native sulfur is decreasing owing to the use of iron pyrites in the manufacture of sulfuric acid. Native sulfur is found in Louisiana, Wyoming, California, Nevada, Philippine Islands, and Alaska. Also in Japan and Iceland.

839. TALC.—Talc is a soft, greasy-feeling, metamorphic rock, It is common among other metamorphic rocks, especially those con-

taining olivine. Of unusual occurrence in the pure state. To be valuable it must be near cheap transportation. Used for making drying, anti-irritating toilet powders, etc.

840. *Soapstone* has a similar composition but occurs as a solid rock. It is used for fire bricks, hearths, etc. Ground to powder it makes an excellent acid-proof paint. It has a greasy feel and will react for magnesia, as will talc, when tested chemically.

841. Do not confuse it with chlorite rocks which are also soft and greasy-feeling. Talc or soapstone sells for $1.35 per ton, rough; for $19.00 per ton sawed into slabs; for $8.00 per ton ground, and for $27.50 per ton for fine material suitable for manufactured articles, as pencils and gas burner tips. The fibrous variety used in paper making, paint, plaster, etc., sells for about $10.00 per ton. Produced notably in New York, Virginia, and North Carolina.

842. ZINC.—This metal is produced chiefly from sphalerite, the sulfid of zinc; but the silicates, willemite and calamine; and the carbonate, smithsonite, supply considerable ore. The red oxid zincite, was formerly mined extensively in New Jersey.

843. When present in small amounts in gold and silver ores all zinc minerals are objectionable and the smelters often charge extra in such cases. Many of our western ores contain zinc but in only a comparatively few cases is the metal present in quantities sufficient to pay for extraction. Arizona and New Mexico produce considerable zinc.

844. Sphalerite, or zinc blende, when in fine grains, looks much like galena, but may be distinguished from the latter by yielding a red-brown streak when scratched with a knife. [281].

845. The silicates and carbonates may be easily mistaken for quartz crystals as these zinc materials are usually clear and transparent, or nearly so. Sometimes they are milk-white and in such cases may be mistaken for cerussite. [785].

846. As the specific gravity of sphalerite is about 4 (quartz is 2.5) it may be concentrated by panning. Small brownish black grains may be found in the float sands near the outcrops of veins containing this mineral. Often found associated with galena and copper minerals. [286].

CHAPTER XIII.

PROSPECTING FOR RARE ELEMENTS AND MINERALS.

847. Remarkable progress in many of the trades, arts and sciences has produced a strong demand for a number of rare elements, making it profitable for the prospector to be on the lookout for the minerals containing them. No one can learn to identify the common minerals by studying mineralogy without the aid of specimens, much less the rare minerals. Therefore, it is imperative that a set of sample specimens be purchased. This advice is doubly valuable because the rare minerals are usually difficult to test, either with the blowpipe or chemically. Comparison is often the sole guide. If doubtful regarding the identity of a specimen send a sample to your State University for analysis. The University will charge you nothing for naming the specimen, but it will not give you the percentage composition or value. The University of California is well fitted for this kind of work.

848. Many of the rare elements are found in minerals which occur in granite and other highly crystalline rocks [183, 67]; therefore, it is advisable to carefully examine all such rocks as you travel from place to place. This will cost you but a small part of your time and may result in a valuable find.

849. **Bismuth.**—Bismuth is not a very rare element, yet it is by no means common. It is most abundant in Bolivia, Germany, Australia, Mexico and the United States. Bolivia is the most important producer; the other countries are named in the order of their importance.

850. The native element and the sulfid are the most abundant, the carbonate following. The native element is grayish-black with a slightly bluish tint when freshly broken. The grouping of the crystals often resembles a terraced city in miniature—a distinctive characteristic. It is brittle and, when heated on charcoal with potassium iodid, yields a bright red sublimate on the charcoal. The sulfid gives the same charcoal test and it also gives the sulfur reaction. [244, 274]. It is found associated with silver and gold in Sinaloa, Mexico. [648].

851. No production was reported in the United States in 1907, but 8,334 pounds were produced in 1906, valued at $12,500, and a still larger amount was produced in 1909. The chief market for bismuth ore is in Germany.

852. **Cadmium.**—This metal is obtained chiefly as a by-product

in zinc and lead distillation, the zinc ores of the central States furnishing the greatest amount at the present time. Cadmium sulfid, greenockite, is plentiful enough to be mined as an ore. Colorado produces a small amount of cadmium as a by-product in lead smelting.

853. Gold.—This precious metal occurs native or disseminated through the sulfids of the base metals; as in pyrite, chalcoyrite, galena, etc. The only positively known natural chemical combinations of gold with other elements are: gold tellurid, electrum, and bismuth-gold. There are several of the gold tellurids: petzite, gold-silver tellurid; sylvanite, gold-silver tellurid; krennerite, gold-silver tellurid; and nagyagite, sulfo-lead tellurid. Some of these tellurids may be only mixtures, however. [856].

854. The almost universal association of gold with quartz is as yet as unexplained as it is noteworthy. The association of gold with pyrite is also very common. [286]. Pyrite is often free from gold, but gold is seldom found without pyrite.

855. Gold is a yellow, malleable metal. There are several minerals that resemble it, notably yellowish mica, called fool's gold: and pyrites. Native gold never glitters. It has a dull yellowish appearance, no matter which way the light strikes it. Fool's gold and pyrites glisten when held in certain positions with respect to the light. Therefore, to distinguish gold from the minerals that resemble it, hold the specimen in the light and look at the particles in question through a strong magnifying lens, turning on your heel at the same time, and if it glistens it is not gold. If the particle is large enough, hold the rock firmly in a vice, or by other means, and prod it with a fine pointed knife blade. If the particle is gold it will be found malleable.

For more particulars regarding this metal consult section 671 and also chapter 7.

856. *Gold minerals.*

Rare minerals are marked with a star. Mixtures are marked "a".

Mineral.	*Formula.*	*Color.*	*Streak.*	*H.*	*Sp. g.*	*Av.*
Gold	Au	Yellow, light yel.	Yellow	2.5—3.	15.6—19	100%
Electrum*	Au,Ag	Pale yellow			12. —15	64%
Bismuth-gold*	Au_2Bi_2	Pinkish silver-white				65%
Gold-amalgam*	$Au + Hg$	Gray		2.5—3.	8.7— 9	25%
Pitzite*	$(AgAu)_2Te$	Steel or iron-gray		1.5—2.	7.9—8	24.5%
Sylvanite	$(AgAu)Te_2$	Steel-gray, lighter	As color	1. —1.5	6.8—7	
Krennerite a	$AuTe_2$	Silver-white, brass				
Nagyagite	$Au_2Pb_{14}Sb_3Te_7S_{17}$	Blackish lead-gray	As color	8.7		20%
Kalgoorlite*	$HgAu_2Ag_6Te_6$	Iron black				
Coolgardite*	$(AuHgAg)_2Te_3$	Iron—to yellow-gray				
Von Dresdite*	$AuAgPbBiTeS$	(a)				
Goldsmithite*	Au_2AgTe_6	Silver-white	Grayish	2.	82	31%

857. Rank of the gold producing States, 1909.

Colorado, California, Alaska, Nevada, South akota, Utah, Montana, Arizona, Idaho, Oregon, Washington, New Mexico, Philippine Islands, Georgia.

858. IRIDIUM AND OSMIUM.—These metals are usually found alloyed in a mineral called iridosmine. This mineral is commonly found in flattened, malleable, white to gray scales which resemble nickel. The specific gravity is high—19 to 20. It is found in the beach and river sands of Northern California. Platinum is often present in the alloy.

859. IRIDIUM is worth about $1.00 per gram. ($30.00 an ounce.) Osmium is worth about $2.00 per gram.

Iridosmine is used for gold ten points.

860. LITHIUM.—The metal lithium is not of practical use, but lithium carbonate is used for storage batteries, fireworks, and medicinal purposes. Lithium bromid is used in photography. The most valuable lithium bearing minerals are, amblygonite, a fluo-phosphate of alumina and lithium; lepidolite, a variety of mica of a delicate lilac color; and petalite. Nearly all the lithium compounds prepared in the United States in 1909 were made from the amblygonite ores of South Dakota. By the flame test [262] lithium minerals give a red flame. Lithium carbonate sells for about 50 cents a pound. Lepidolite occurs in granite and is often associated with muscovite mica.

861. MOLYBDENUM.—This element is obtained from Molybdenite, a steel-gray to bluish-gray mineral, which occurs in flexible but not elastic scales. It looks much like galena but may be distinguished from it by scaling up with a knife. H. 1. Sp. g. 4.5. It has a greasy feel and will mark on paper like graphite, which it also resembles. Galena breaks up into little cubes, seen under the lens; graphite is granular, and molybdenite will split up into thin scales. These forms are best distinguished under a strong glass.

862. Molybdenum is used in steel manufacture, in making a chemical reagent which is especially valuable in the analysis of phosphorous, [755] and in making some varieties of smokeless powder.

When sorted to 98% purity it is worth $400.00 a ton. There is not a large demand for it, however.

863. It occurs in granite, gneiss, and in zircon-bearing syenite. Also found in granular limestone.

864. The localities are: Maine, Connecticut, Vermont, New Hampshire, New York, Pennsylvania, Nevada, Washington, Arizona,

Corona, California, New Mexico, and Texas. It occurs in the regions of early crystalline rocks in the West generally.

MONAZITE.—See Thorium.

865. PLATINUM.—This metal occurs native in placers. It is not *positively* known to have been found in place in any kind of rock except gneissoid granite, and there is only one occurrence of this: At Santa Rosa, in Antioquia, Columbia. Reported found in sperrylite, at Rambler, Wyoming; at Sudberry, Canada; at Grand Encampment, Wyoming; in corellite near Bunkerville, Nevada; and in peridotite dikes, Clark County, Nevada. Platinum is found in placers in the Ural Mountains, Russia, and in the river sands of northern California. It is also found in less amounts in Oregon, Alaska, North Carolina and in the Philippines.

866. Thus far no great success has attended the efforts of those who have tried to work the California sands. There is no doubt that these sands could be profitably worked if some one would expend the necessary capital to find the correct method of mining and working. The platinum is not evenly distributed through the river sands, and for that reason much time and labor has been spent uselessly working low grade material. The sandbars and river bands should be tested in some cheap, effective way before working them. An outfit like that used in testing placer ground, but built on a smaller scale is suggested. The soil testing outfit used in the irrigation districts might prove very effective. The color of native platinum is a steel gray with a very slight bluish tint. It looks a little like metallic zinc. It is very heavy, the specific gravity being from 14 to 19, according to purity. At present (1912) it is more valuable than gold, being worth about $47.00 an ounce.

867. RADIUM.—This interesting and marvelous element was discovered by Curie and his wife in France, in 1899. The element and its salts will emit light and heat almost indefinitely. The light will pass through nearly all substances, but it passes through some with greater facility than others. This property enables photographs, or, more properly, shadowgraphs, of the internal structure of many objects to be made; as, the human hand, minerals, small animals, etc.

868. The emitted light may be seen in a dark room and it will permanently change the color of sapphire gems.* The strange behavior of this element caused quite an excitement in the scientific world when it was first discovered.

869. Radium has an atomic weight of 225—the highest atomic weight known. It is bivalent. It is found in all minerals containing uranium, uraninite, a variety of pitchblende, being the

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*Mineral Resources of the United States, 1907, p. 839.

usual source. The radium samples in use are all salts of radium—the radium chlorid being commonly used. Radium chlorid looks like quinine.

870. Prospectors should save all dark, pitch-like minerals resembling uraninite (pitchblende [908]), or other uranium bearing minerals, and test them by placing them upon the rubber slide of a loaded photographic plate holder, as radium effects a photographic plate. After two weeks time develop the plate. The minerals containing radium will produce dark spots on the negative, (light on prints). If the light spot is produced with only a few days exposure the mineral may be valuable. Test the specimens for uranium as well. Magnetite, hematite and obsidian all look a little like pitchblende.

871. SELENIUM.—This element occurs native in some lavas, and as sulfur selenid in native sulfur. It is often found in iron pyrites and chalcopyrite.

872. It has the peculiar property of being a better conductor of electricity in the light than when in the dark. This makes it valuable for special electrical apparatus, such as self-lighting and self-extinguishing light-buoys off rocky and dangerous coasts. It is also used in the construction of an appliance for signalling without wires, called the selenium cell, and in appliances for recording automatically the duration of sunshine and cloud.

873. It is chiefly obtained as a by-product where seleniferous iron pyrites is used to make sulfuric acid. The selenium collects in the flues leading from the burners.

874. SILVER.—This metal occurs both native and combined with other elements, as chlorine and sulfur. In the formation of silver ores it may be assumed that the sulfid was the first silver mineral deposited in veins. [775]. It is oxidized in the zone of weathering of silver sulfate* and native silver. Silver sulfate, being soluble is readily taken into solution and carried down deeper till it comes in contact with base metal sulfids which precipitate the silver as a sulfid again; or chlorids, as salt, may cause the formation of silver chlorid. Either reaction will result in a secondary enrichment of the ore body at the level where the precipitation takes place. Chalcocite reacts readily with descending silver solutions and for this reason silver and copper minerals are often associated [286]. The reaction of base-metal sulfids with descending solutions cause, with depth, the formation of silver-lead, silver-copper, silver-zinc, or even silver-iron minerals. Therefore, the presence of these double salts indicate a zone of enrichment. In many cases this en-

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*A Treatise on Metamorphism, Van Hise, pp. 1099 and 1167.

richment is local, that is, occurring in segregated bunches or ore lenses. Silver is also precipitated from solution by bromids, forming silver bromid, or by chlorids and bromids combined forming chlorobromid of silver.

875. It is evident from the foregoing that the chlorids and bromids will be found most plentifully in the zone of weathering, especially near the surface, and that native silver, the sulfid, and arsenical and antimonial silver minerals, will be found lower down. It will also follow that, as a rule, the presence of silver chlorid or bromid will suggest the existence of an enriched ore body below.

876. The presence in a prospect of minerals commonly associated with silver, as copper, lead and zinc, is very favorable.

877. *Silver minerals.*

Rare minerals are marked with a star. Mixtures are marked "a".

Mineral	*Formula*	*Color*	*Streak*	*H.*	*Sp. G.*	
Silver	Ag	Silver-white	As color	2.5—3.	10—11	100 % Ag.
Cerargyrite	$AgCl$	Pearl gray, brown		1. —1.5	5.5	75.3% "
Embolite*	$Ag(ClBr)$	Pea-green, yellowish		1. —1.5	5.3—5.4	63—65 % "
Bromyrite*	$AgBr$	Amber-yel. to green		2. —3.	5.8—6.	57.4% "
Iodyrite*	AgI	Sulfur-yellow	Yellow	1.	6.8—5.6	46 % "
Iodobromite*	$(AgClBr)_2AgI$	Sulfur-yellow		1.	5.7	60 % "
Pyrargyrite	Ag_3SbS_3	Gray-black, black	Purple-red	2.5	5.7—5.8	59.9% "
Proustite	Ag_3SbS_3	Scarlet-vermilion	As color	2. —2.5	5.5—5.6	65.4% "
Argentite	Ag_2S	Lead-gray	Shining	2. —2.5	7.2—7.6	37.1% "
Pyrostilpenite*	Ag_3SbS_3	Hyacinth-red		2.	4.2	59.9% "
Rittingerite*a	Ag Se As	Steel-gray				
Hessite*	Ag_2Te		Metallic	2.5—3.	8.3—8.4	63.3% "
Petzite*						42 % "
Sylvanite*						13.4% "
Matildite*	$AgBiS_2$	Gray	Light gray	1.	6.9	28.4% "

878. TANTALUM.—This element is chiefly obtained from the mineral tantalite, niobium and several other uncommon elements usually being present.

879. The best tantalite now comes from the Black Hills, South Dakota, and sells for from $250.00 to $500.00 per ton. It is also found in Colorado, North Carolina, Alabama, Connecticut, and Massachusetts. Found in Finland, Sweden, Australia and France. The demand is slight, but increasing, being used for incandescent lamp filaments.

880. The color of tantalite is cinnamon brown to black. H. 6 to 6.5. Sp. g. 7 to 8. It occurs in crystals and also uncrystalline. Found in granite in slightly rounded grains. As its specific gravity is high it may be easily concentrated. It may be obtained by sluicing as for gold.

881. It is insoluble in any acid or combination, except hydrofluoric acid, in which it dissolves slowly when heated.

882. THORIUM.—The oxid of thorium is used to make incondescent gas light mantles. The oxids of other rare elements, as lanthanum, ceriun, etc., are used for the same purpose. Thorium oxid is produced from *monazite, thorite* and *thoranite.*

883. Monazite is quite widespread in the United States, being found in commercial quantities in North and South Carolina, Georgia and Idaho, and less plentifully in gravel and sand in California, Colorado, Indiana, Montana, Nevada, New Mexico, Oregon, South Dakota, Texas, Utah, Washington and Wyoming. Idaho is a very promising field. It is also found in Brazil, South Australia, and Ceylon.

884. Monazite varies from opaque to subtransparent. The specific gravity is 4.9 to 5.3. Brittle. H. 5 to 5.5. Color, dull yellow, reddish brown and blendings of these colors.

885. It occurs in regions of crystalline rocks, particularly granite, and in placers.

886. It is worked by sluicing as for gold. The concentrates are further concentrated on vanners or other concentrators, and the product, which contains several minerals, is, as a rule, treated in a magnetic concentrator. The monazite thus obtained will be about 90% pure and will contain about 5% thorium.

887. Sand concentrated to 90% monazite sells for 12 cents per pound. The market is strong and the price likely to rise. Test: a pale blue-green flame is an indication of thorium phosphate if the original mineral is moistened with H_2SO_4, then heated on charcoal.

888. TIN.—Tin is produced from the oxide cassiterite, a black to brown mineral with hardness 6 to 7. S. p. 6.8 to 7.1. Luster adamantine. Somewhat brittle. Nearly transparent when extremely pure. When worn, as in gravel beds, the color is a dull-black to brown. Streak white. It is infusible before the blowpipe. [276]. On charcoal, when pulverized and mixed with soda and powdered charcoal, it may, with difficulty, be reduced to metallic tin. Tourmaline and rutile are often mistaken for tin ore. Tourmaline has a specific gravity of 3, and rutile 4. Tin also slightly resembles magnetite crystals.

889. Tin is found in paying quantities in the western part of Seward Peninsula, Alaska.* Also near Spokane, Washington; Black Hills, South Dakota; Franklin Mountains, north of El Paso,

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*Bulletin No. 229, United States Geological Survey.

Texas; San Diego, Riverside, and San Bernardino Counties, California; and in the Carolinas.

890. Tin ore is usually found in coarse-grained granite. In the Black Hills it is found in a granite called greisen. [200].

891. Search for it in greisen, coarse-grained granites, and in streams that cut through granite. It is very frequently associated with wolframite. [286].

892. *Titanium.*—This element is obtained from titanic iron and the mineral rutile. The titanic iron is called ilmenite or menacconite. It is found as distorted cubes, usually in parallelopipedons (cigar-box shape). Also in thin plates and lamina. Rutile is found in granite, gneiss, mica schist, and syenite. It is almost as hard as quartz, the hardness being 6 to 6.5. The specific gravity is 4. The luster is high (adamantine) and the usual color from brown to red. It is found in all colors, however. Usually imbedded crystals. Mined in Nelson County, Virginia. There is little demand for it at present.

893. Test. Fuse the powdered mineral with soda bicarbonate and dissolve the mass with HCl. Add metallic tin filings and boil. A delicate violet blue color indicates titanium.

894. TUNGSTEN (Wolfram).—This element is derived from *wolframite, hubernite* and *scheelite.*

895. To detect tungsten in any of its minerals, fuse the powdered mineral with a little soda [277]. Dissolve in boiling water and filter. Barely acidulate (use litmus paper) with HCl. A canary yellow powder will precipitate. Add metallic tin filings (zinc filings will do) and boil. The powder and solution will turn blue; the color of the solution will change to lilac, wine, and then to brown. Woframite usually becomes magnetic after heating.

896. Tungsten minerals are associated with tin ores. Often found in replacement veins in dolomite and in refractory, silicious gold ores. Seldom found except in granite.

897. *Wolframite* is a tunstate of iron and manganese and looks much like tin ore. It also slightly resembles tourmaline in some cases. The chemical formula is $(FeMn)WO_4$. Color, black to brown. Luster, resinous to adamantine. Sp. g. 7.

898. Found in Randsburg, California; Boulder, Ouray and San Juan Counties, Colorado; Pennington County, South Dakota; Connecticut; Maryland; Missouri; North Carolina; South of Austin, Nevada; Lincoln County, Nebraska; Falls County, Texas; Stevens County, Washington; near Encampment, Wyoming; and in Cochise and Pima Counties, Arizona.

899. *Hubernite* is a variety of the above with little or no iron. Its composition is indicated by the formula $MnWO_4$. Sp. g. 7; H. 4.5.

900. *Scheelite* is a calcium tungstate, the formula being $CaWO_4$. The color of scheelite is cream white. It may be detected by its high Sp. g. 6. Its hardness is 5.

901. Scheelite has been found in San Bernardino County, California; Missoula County, Montana; Stevens County, Washington; near Murray, Idaho; Humboldt County, Nevada; Mohave County, Arizona; and Baker County, Oregon.

902. Tungsten ores are worth from $500.00 to $550,00 per ton.

For additional information see United States Geological Survey Bulletin No. 340, and Mineral Resources of United States for 1908, Vol. 1, p. 721.

903. URANIUM.—This element is found in several minerals; as *pitchblende,* called uraninanite, and *carnotite.*

904. *Pitchblende* is usually a massive, velvety-black, pitch-like mineral found in granite and also associated with some silver, lead, and copper ores.

905. It is found in Connecticut; Mitchel County, North Carolina; South Carolina; Llano County, Texas; near Central City, Gilpin County, Colorado; Black Hills, South Dakota; and in some parts of Utah. It is recognized by its unusual weight. Sp. g. 9.

906. A 10% ore sells at $1.25 per pound of uranium oxid present, or for $250.00 per ton of ore. An ore containing 30% of the oxid sells for $960.00 per ton of ore. Ores should be concentrated before shipping to New York, the chief market.

907. *Carnotite* is a uranium mineral found in but a few places, notably in Colorado, where it is found disseminated through sandstone in thin, horizontal streaks. It contains nearly a dozen other elements and varies in appearance.

908. Uranium may be detected in either of the above minerals by fusing in a micorcosmic salt bead in the oxidizing flame. A green bead, which is yellowish-green on cooling, is the test for uranium. As radium is present in all uranium minerals they will affect a photographic plate if placed near the plate for a period of from one to two weeks. [869, 870.]

909. For further information consult United States Geological Survey Bulletins No. 315 and 340.

910. VANADIUM.—Vanadium is used to make a valuable alloy with steel, to produce a golden enamel on pottery, and also in calico printing.

911. It is produced chiefly from roscoelite, found in Montrose County, Colorado; and less plentifully at Granite Creek, Eldorado County, California; in Arizona, 23 miles south of Casa Grande; and in Montana, 27 miles northwest of Dillon. Found in some Pennsylvania and Nova Scotia coal. Ore containing 2% vanadium sold for $6.00 a ton at the mines (Colorado) in 1907.

912. Test. In the oxidizing flame vanadium imparts a yellow color to the borax bead when hot; green when cold. In the salt of phosphorous bead the oxidizing flame yields an amber color, and the reducing flame yields a dirty green when hot, fine green when cold.

913. ZIRCONIUM.—This element is found chiefly in the mineral zircon, $ZrSiO_4$. Zircon is brown to red in color, streak uncolored. Sp. g. 4 to 4.5. H. 7. Luster adamantine. In square prisms terminated by pyramids.

914. Zircon occurs in crystalline rocks and in granular limestone, also found in placer mines.

915. Localities: New York; New Jersey; Maryland; Pikes Peak, Colorado; abundantly in Henderson County, North Carolina; in California gravel mines; and recently it has been found in Oklahoma near Cache.

916. Zircon is sometimes found as a gem. There are other minerals that contain zirconium, but not in quantities sufficient to pay for extraction. Most of the present supply of zirconium comes from Henderson, North Carolina.

917. It is very valuable, being used in the manufacture of incandescent gas mantles.

918. Test. Zirconium tests are not very satisfactory. A small fragment when heated intensely before the blowpipe glows brilliantly as does calcite. These two minerals do not resemble each other in appearance, however. Its specific gravity, hardness and luster serve best as a means of identification.

CHAPTER XIV.

LOCATING A CLAIM.

Requirements of the United States Statutes.

919. When there are no State laws or district regulations upon the subject, the manner of locating, staking out and recording lode and placed claims is a simple matter. District regulations are often complicated and confusing. If prospecting within the jurisdiction of a mining district familiarize yourself wth the regulations before making a location. State laws are often merely a repetition of the United States Statutes.

920. The form and position of a lode location should depend upon local conditions, such as dip, pitch of ore body, strike, position of adjoining claims, etc. Unfortunately, the locator does not give these matters proper consideration, and costly litigation is often the result in later years, or valuable rights are lost through ignorance or carelessness.

921. The entire requirements of the United States Statutes relative to lode and placer locations may be summarized as follows:

922. First, the locator must be a citizen of the United States or one who has declared his intentions to become such.

923. Second, lode claims shall not exceed 1500 feet in length or 300 feet on either side of the center of the vein or lode at the surface.

924. Third, the end lines of a lode claim must be parallel in order to carry dip rights (extralateral rights).

925. Fourth, placer claims must conform to legal subdivisions when upon surveyed land, except when clearly a "gulch claim," and when upon unsurveyed land they must conform as nearly as practicable to the subdivisions extended.

926. Fifth, a 10 acre tract is the smallest legal subdivision that can be located as a placer. It must be square in form.

927. A 20 acre tract is the maximum size in a single placer location by one individual. Eight or more individuals may locate a 160 acre placer as the maximum size of a single location. There is no limit to the number of locations that one individual or a group of individuals may locate.

928. One hundred dollars worth of work must be done upon each placer or lode location every year, commencing with the year following the year of location.

929. Sixth, both lode and placer locations must be distinctly marked upon the ground so that their boundaries may be readily traced. Boundaries of placer claims upon surveyed public land need not be marked by the locator—the public land survey enables the boundaries to be readily traced. (It is advisable to mark the corners, however.)

930. Seventh, recorded location notices (lode or placer) shall contain the name or names of the locators, date of location, and such a description of the claim by reference to some natural object or permanent monument as will identify the claim.

931. The description of a placer by legal subdivisions is equivalent to describing it by "reference to a permanent monument."

932. Eighth, a vein in place must be discovered within the limits of a lode claim in order to make the location valid.

933. Ninth, mineral, other than veins of quartz or other rock in place, must be discovered within the limits of a placer claim in order to make the location valid.

934. Lode and placer claims may be located upon public land anywhere in the United States, Alaska, and the Philippines [942] included, and forest reserves do not affect this right; but mineral reserves do. However, it must be kept distinctly in mind that each and every requirement above given must be complied with in order to make a valid (legal) location. For example, a tract properly monumented but without a discovery of valuable mineral, would not constitute a valid claim; but if a prospector discovers mineral, as by drilling a hole and striking oil, he may then make a valid location, even in a forest reserve. Many California oil wells have been thus located. If a second party discovers mineral before you do upon the land you are prospecting, he will certainly have the legal right

ITEMS REQUIRED IN RECORDED LOCATION NOTICES.

		Alas.	Ariz.	Ark.	Cal.	Colo.	Ida.	Mont.	Nev.	N. Mex.	N. Dak.	Ore.	P. I. ††	S. D.	Utah	Wash.	Wyo.
U. S. STATUTES. Lodes or Placers	Name or names of locators	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	Date of location	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	Description of the claim with reference to a natural object	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	Name or names of locators		L		L	PL	PL	PL*	PL	L	L	L		L	L	L	L
	Date of location		L		L	PL	PL	PL	PL		L	L		L	L	L	L
STATE LAWS Lode Claims	Description of the claim with reference to a natural object, as river or mountain		L		L		L	L	L	L		L			L	L	L
	Name of claim		L		L	PL	PL	PL	PL		L	L		L	L	*** L	L
	Width of claim					**											
	Width of claim each side of the center of the vein				L		L	PL	PL		L	L		L	L		L
	Distance from discovery point to each end of the claim		L		L	L	PL	PL	PL		L	L		L	L	L	L
	General course of the vein		L		L	L	L	PL	PL		L	L		L	L	L	L
	Name of the Mineral District, County and State																
	Dimensions of discovery cut or shaft							L	L								
	Description of corner post markings								L								
	Declaration of intent to locate.									L							
	Length of claim		L														

LAW CHART No. 1.

to make the first valid location regardless of the expense you may have incurred in prospecting.

935. National Parks and National Monuments are not classed as public land. The latter are natural curiosities or historical spots set apart by the President under the right given him by Congress. For example, the Devil's Postpile National Monument, recently established by the President in Inyo County, California, embracing an area of 8,000 square chains, is the most wonderful natural exhibition of basaltic columns known, the Giant's Causeway excepted.

Statutory Requirements of the Various States.

937. Law Chart or table No. 1 shows the statutory requirements of each of the mining states relating to the subject matter required in the location notice.

In the chart—

L=Required in the location notice to be recorded.

P=Required in a preliminary notice to be posted but not necessarily recorded.

938. *In Montana the preliminary location notice posted at the time of making the location need not be recorded, but a location notice called a "Declaratory statement" must be filed for record with the County Clerk within 90 days after the date of location. This Declaratory statement is equivalent to a location notice.

939. **In Colorado the law requires that in Gilpin, Clear Creek, Boulder, and Summit Counties no claim shall exceed 75 feet on either side of the center of the vein; in all other counties 150 feet. In all other states claims may be 300 feet on either side of the center of the vein, no district regulations standing to the contrary.

940. ***In Washington, according to the state statutes, the posted notice must contain the name of the claim, but the recorded notice need not—evidently an oversight in wording the statute. The United States Statutes require the name of the claim in the recorded notice.

941. †Federal mining laws are in force in Alaska, Arizona, Arkansas, California, Colorado, Florida, Idaho, Illinois, Indiana, Iowa, Louisiana, Mississippi, Montana, Nebraska, Nevada, New Mexico, North Dakota, Ohio, Oklahoma, Oregon, South Dakota, Utah, Washington, Wyoming and the Philippines [942]. But

these laws are practically inoperative in Illinois, Indiana, Iowa, Ohio, Florida and Louisiana, owing to there being little or no public land in these states, or because there are no known mineral deposits of value in them.

942. ††In the Philippine Islands lode claims must be 300 meters square or less. Two location posts are required, one at each end of the lode, and on each post shall be written the name of the claim, name of the locators, and the date of the location. On post No. 1 shall be marked "initial post," the compass bearing of post No. 2, and the number of meters to the right and to the left of the lode line. Claims must be recorded with the Provincial Secretary, the record containing a description of the two posts. A discovery post must be placed at the point of discovery marked "Discovery Post" and on the back of the notice a sketch of the claim shall be made. A sketch of the claim must be made on the back of the notice for record. No extralateral rights are allowed (i. e. no dip rights.) Only one claim may be located on one vein by one locator or association of individuals, directly or indirectly. Placer claims shall conform as nearly as practicable to the system of public land surveys.

943. A person having discovered mineral upon public land may make a lode or placer location in the name of another party by signing the name of the absent party to the notice. The absent party may disavow the act, however. A power of attorney is not necessary in order to make locations in the name of another party, but highly desirable.

944. In naming a location use only the words desired to form the name of the claim. The words "quartz claim" and "quartz gold mining claim," etc., are unnecessary, and in a sense, improper. Only two kinds of locations are recognized by law—"lode" and "placer." Location blanks are on sale in some states improperly headed "Quartz claim" instead of "Lode claim." Bear in mind the fact that many lode claims do not have quartz veins upon them. The lode may be porphyry containing copper, or sandstone containing cinnabar, for example. It is the practice of the United States Land Office to use the characteristic part of the name as named by the locator, followed by the word "lode" or "placer" as required. For example, a lode claim called "The Excelsior Gold Quartz mining claim" will be patented as "The Excelsior Lode." Why not call it The Excelsior Lode in the location notice?

	Alas.	Ariz.	Ark.	Cal.	Colo.	Ida.	Mont.	Nev.	N. M.	N. D.	Ore.	P. I.	S. D.	Utah	Wash.	Wyo.
Time allowed after discovery to stake out the claim		90d			3m	10d	30d	20d			30d		60d		90d	60d
Time allowed after discovery to do discovery work, and the kind of work required		90d S or t =○= *			60d S or t =○=	60d S or t =○=	60d S or t =○= *	90d S or t =○= *	90d S or t =○=	60d *	60d S or t =○=		60d S or t =○=		90d S or t =○=	60d S or t =○=
Time allowed after discovery to record the location notice		90d		30d	3m	90d ***	60d	90d **	30d	60d	60d		60d	30d	90d	60d
Number of monuments required and where placed		6 c&e			6 c&e	4 c ‡	4 c ‡	6 c&s	4 c	8 c, s &e	6 c&e		8 c, s &e		4 c	4 c&s
Time allowed in which to record assessment work (proof of labor)	90d y †	3m y	Dec. 31	30d y	6m y	60d y	20d w	60d w	60d y					30d w	30d w	60d w
Corner posts must be marked with— 1. No. of cor. or its direction from point of discovery 2. Name of claim 3. Marked so as to identify the corner						1 2		3	3							
Time allowed in which to record placer claim location notices		60d		30d	30d	30d	20d	90d						30d		90d
Time allowed in which to do the placer location work						15d										

LAW CHART No. 2

Statutory Requirements of the Various States.

946. Law chart No. 2 will show the statutory requirements of the various states relative to perfecting the location of mining claims and recording location notices.

In the chart—

d=days.
m=months.
f=shaft
t=tunnel (adit)
=○= a cut equivalent to a shaft or adit 10 feet into the earth.
c=corner posts.
p=side center posts.
e=end center posts.
y=assessment work must be recorded within the time specified after the end of the year in which the work was done.
w=assessment work must be recorded within the time specified after the work has been completed.

947. *In Arizona, Montana, Nevada and North Dakota the discovery work must be continued till a vein has been exposed.

948. **In Nevada the location notice must be recorded with the County Recorder and also with the District Recorder, if there be one.

949. ***Idaho requires a preliminary notice to be posted when the location is made and a regular notice posted and the monuments set within 10 days. The regular notice must be recorded within 90 days after location.

950. In Alaska the Proof of Labor must be recorded, such proof to contain the name of the claim, where situated, number of days work done and its character, date when improvements were made, for whom made, amount paid for improvements and by whom.

951. When there is a bend in the location each angle in the boundary must be marked.

952. In California, where a locator has his claim surveyed by a U. S. Mineral Surveyor, or a licensed land surveyor, and his claim connected with a corner of the public land survey, and has the fields notes of this survey attached to and filed for record with his location notice, together with the Surveyor's certificate. such a report is prima facia evidence of the facts therein. The survey and the recording thereof may be done at any time after making the location, or after recording the notice. That is, in order to dispossess a locator the contestor must prove the location invalid. If this survey be not made and a contest arises, it will be incumbent

upon the first locator to prove that his location was properly made and is valid. In other words, the survey throws the burden of proof upon the contestant.

Special Minerals, How Located.

953. By special acts of Congress petroleum, salt and building stone must be located under the requirements of the placer mining laws.

954. Borax, onyx, gypsum, talc, graphite, phosphate rock, chalk, marl, mica, asbestos, fluorspar, sulfur, mineral paint, etc., should be located under the requirements of the placer mining laws, unless in place, when they should be located as lodes. To be in place the rock or mineral must constitute a vein or lode with permanent or fixed wall rock on both sides thereof. The term in place has been variously interpreted, however.

955. Until a few years ago coal lands could be purchased in tracts conforming with the legal subdivisions, 160 acres being the maximum size of a claim for one individual, at $20.00 an acre if within 15 miles of a railroad, otherwise at $10.00 an acre. At present the coal lands are appraised by the U. S. Geological Survey. The purchase must be completed within 60 days after the date of possession. Only surveyed, public land can be purchased, but preferential rights may be initiated upon unsurveyed land. Coal lands, not being subject to location, may be withdrawn from sale. A large amount of probable and known coal land is at present withdrawn from sale in the United States and in Alaska. Phosphate lands are at present being located by prospectors both as lode and as placer claims. This is owing to a dispute as to whether the phosphate beds are in place or are placers. Congress will, doubtless, pass suitable laws regulating the disposal of these lands. Such laws cannot affect previous locators, however. Many areas of phosphate land are now withdrawn from location.

956. It is particularly unfortunate that the Federal laws do not require the locator to mark the corner posts of his claim so that they may be identified. To this end it is very desirable that each post be marked with—

First, the initial letters of the words comprising the name of the claim.

Second, the number of the post.

Third, the distance each way to the next boundary posts.

957. Locators should either write the location notice with India ink, or place it in an inverted tin can at the point of discovery. Lead pencil writing will last longer than common ink, as

the latter fades in the sunlight and is easily obliterated by rain storms. Where timber is scarce stone monuments may be used for corner markings. Even large mounds of earth would suffice in certain cases.

958. It is not necessary that a location notice be worded in any particular way, provided that the various requirements of the National and State laws and the local rules and regulations be complied with.

959. Blank location notices are on sale in every western mining State, but being gotten up by printing houses in most cases, they are often either improperly worded or do not strictly comply with the law. For example, some of the blanks on sale in California are headed "Notice of location of quartz claims." The heading should be—

NOTICE OF LOCATION.
Lode Claim.

The placer location blank should be headed as follows—

NOTICE OF LOCATION.
Placer Claim.

960. If a lode intersects a placer claim the lode must be located as a lode claim, otherwise the lode is subject to location by other parties.

961. In order that every legal point be covered, specimen notices of location are given below. These forms are so worded that they comply with the United States Statutes, and *with the laws of each Western State.* The fact that they contain descriptions not required by your State is immaterial, as the additional information does not in any way invalidate your location. There is no necessity for stating "dips and spurs, etc.," as the United States Statutes give you these under a lode location where the end lines are parallel. If the lines are not parallel you have no dip right even if you claim it. It is safe to say that a large proportion of the locations made from year to year do not comply with the laws and could be proven invalid.

962. Witnesses to a location notice are not absolutely necessary but very desirable, especially in States where you can not protect yourself by an official survey and record, as you can in California.

NOTICE OF LOCATION.

PLACER CLAIM.

963. *Notice is hereby given to all whom it may concern:*—That ..(1)..citizen.. of the United States over the age of 21 years,

have (has) this day and date under the laws of the United States and the State of ....(2)....located the following described placer claim:

.... (3) ....

situated in ....(4)..mining district, County of....(5)....and State of ....(6).... The name of this claim is....(7).... placer. This notice is posted at the discovery cut—shaft.

Located this......(8)....day of....(9)...., 19....

Witnesses:

........(12)........ ....(10)........
Locator(s)
........(12)........ Per ....(11)........
Agent for the locator.

Explanation:

1 Name or names of locator (s).
2 State.
3 Description of claim by legal subdivisions, or by metes and bounds if it is a "gulch claim." In the latter case refer to some natural object. See section 930.
4 Name of mining district.
5 County.
6 State.
7 Name of claim.
8 Day of month.
9 Name of month.
10 Signature of locator if present. See sections 930, 936.
11 Signature of agent if locator is absent.
12 Signature of witnesses.

NOTICE OF LOCATION.

Lode Claim.

964. *Notice is hereby given to all whom it may concern:*—That ..(1)..citizen.. of the United States over the age of 21 years, having discovered a vein or lode in place bearing..(2)..ha (3) this day and date under the laws of the United States and the State of ..(4)..located, and ..(5)..hereby declare..(6)..intent to locate and hold..(7)..linear feet on this vein or lode, with..(8)..feet of width on the..(9)..side of the vein or lode and..(8)..feet of width on the..(9)..side of the vein or lode,, situated in..(10).. mining district, County of..(11).., State of..(12).., and known as the..(13)..lode, the vein extending..(8)..feet in a..(9).. direction and..(8)..feet in a..(9)..from this notice of location at the discovery..(14)..., said..(14)..being..(8)..feet..(15).., and ..(8)..feet deep, said claim being more particularly described as

follows, to-wit: Beginning at Cor. No. 1, a..(16)..post marked "..(17)..Cor. No. 1," whence..(18)..bears..(19).., ..(8).. feet distance, thence..(19).., ..(8).. feet to Cor. No. 2, a..(16).. post marked "..(17)..Cor., No. 2," thence..(19).., ..(8)..feet to Cor. No. 3, a..(16)..post marked "..(17)..Cor. No. 3," thence ..(19).., ..(8).. feet to cor. No. 4, a ..(16).. post marked "..(17)..Cor. No. 4," thence..(19).., ..(8)..feet to Cor. No. 5, a..(16)..post marked "..(17)..Cor. No. 5," thence..(19).., ..(8)..feet to Cor. No. 6, a..(16)..post marked "..(17)..Cor. No. 6," thence..(19).., ..(8)..feet to Cor. No. 1, the place of beginning.

Located this..(20)..day of..(21).., 19...

Witnesses:

.........(24)........ ....(22)........
Locator(s)

.... *Per*....................
Agent for the locator.

Explanation:

1 Name or names of locator(s).
2 Name of mineral.
3 "s" or "ve."
4 Name of State.
5 "do" or "does."
6 "his" or "their."
7 Total length of lode.
8 Feet.
9 Easterly, southerly, etc.
10 Name of mining district.
11 Name of County.
12 Name of State.
13 Name of claim. [See 936].
14 "cut" or "shaft."
15 "wide" or "square."
16 Kind of post.
17 Name of claim.
18 Some natural object, as a mountain peak, a noted bluff, or the like. Or a Cor. of the public survey. See 930.
19 Course in degrees and minutes if known, if not, write "southerly," "easterly," etc.
20 Day of month.
21 Name of month.
22 Signature of locator if present.
23 Signature of agent when locator is absent.
24 Signature of witnesses.

In States requiring only four location posts the remainder of the notice may be left blank or crossed out.

As side center post may not be at a corner the word "post" should be substituted for "Cor." as the case requires.

Boundaries.

965. Staking out a claim is a very important matter. A great deal of advice has been printed in books and mining journals on this subject, some of which illustrates the old saying that "fools wade in where angels fear to tread." In many cases misleading advice has been given and in other cases absolutely erroneous statements have been made. Realizing this fact, and also the fact that many important points have not yet been decided by the courts, and that several States have rendered decisions diametrically opposed, only a few well established points will be considered here. In case of doubt consult a mining attorney.

966. If a locator is uncertain as to the exact course of an outcrop it is advisable to cover the ground in question by making two locations, one or both of which may be amended and remonumented later. Of course, each location must have a discovery of mineral. Your amended location notice should describe the location as amended, and the following paragraph, or a part thereof as the case requires, should be added to it.

> *"This is an amended location of the....................lode, and is made for the purpose of making the location more nearly conform to the apex of the vein or lode, for correcting any errors or defects in the former said location, and for the purpose of more particularly describing the same, and is made without revocation of any rights acquired under the former location."*

967. In staking out a claim observe the following:

1. The end lines must be parallel.
2. A discovery of mineral must be made before a location becomes valid.
3. The discovery should be on or near the lode line and must be in the vein or lode.
4. The notice of discovery should be posted at the discovery.
5. The discovery and notice must be within the boundaries of the claim.

6. The claim must not be over 300 feet wide on either side of the vein, measuring perpendicularly from the lode line. Slight bends and turns are not to be considered. The lode line should be a close approximation to the general course or trend of the outcrop. If a vein does not come to the surface the entire length of the claim, the points vertically above the apex are considered the lode line. [See decisions of California State Supreme Court.]

7. If the outcrop changes its course materially make an angle in the location.

968. Fig. 68 illustrates a simple case. Four corner posts are all that are required in most States. [For exceptions see section 945]. As the pitch of the ore shoots is practically at right angles to the strike the claim is right-angled.

969. In Fig. 69 the pitch of the ore shoot is, as is usually the case, oblique to the strike. In order that the locator may not only follow the vein on its dip, but also follow the ore shoot on its pitch, the location should be as shown. If the pitch of the ore shoot is not known at the time of making the location, an amended location may be made at any future time, provided dip rights acquired by other locators do not interfere.

970. In Fig. 70 two claims overlap. No. 1 is the first locator, No. 2 is the second, and No. 3 the third. The question is, does No. 2 own the dip right on his vein beneath the shaded portion. One State Supreme Court has decided in the affirmative and another in the negative. The United States Supreme Court has not yet passed upon the point.

971. The customary practice of making group locations as shown in Fig. 71, all right-angled and all contiguous, is not only disadvantageous but suggests the improbable. For does not such a group imply that the veins are all parallel to each other and exactly 600 feet apart? Strange that nature should place veins so as to thus exactly fit our statutory dimensions! The locations should have been so made that they would cover the apexes of the several veins, otherwise dip rights will be lost. The well known object of making a solid block of locations as in Fig. 71 is to secure all the ground and keep out other locators. This can be done as effectively another and a better way. Locate so as to secure dip rights, as shown in Fig. 72, survey for U. S. patent, and then apply for the remainder of the land in the quarter section by purchase with scrip. If scrip is too expensive, or is practically impossible to purchase, make overlapping locations as shown in Fig. 71 so as to cover the vacant strips. Of course annual assessment work must be performed upon these "protection claims," as they are called. By following

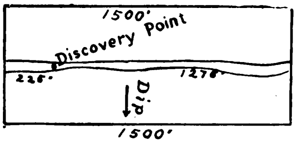


Fig. 68. A Rectangular Claim.

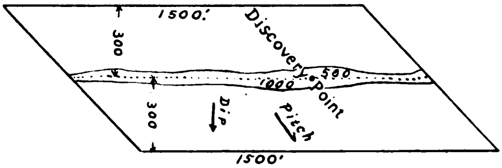


Fig. 69. A Claim with a Pitching Ore Shoot.

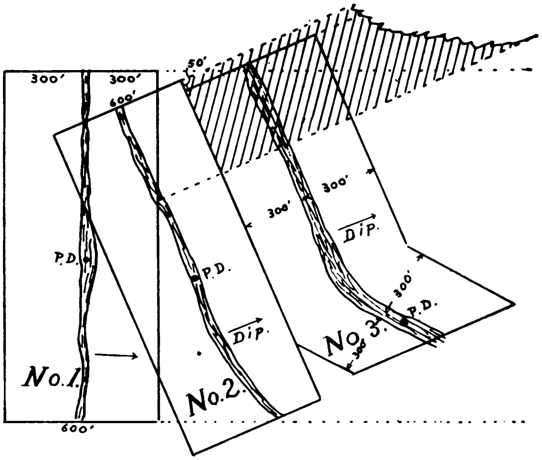


Fig. 70. An Unsettled Case.

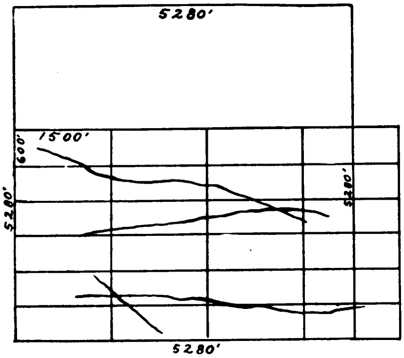


Fig. 71. Banked Locations. Dip Rights Jeopardized.

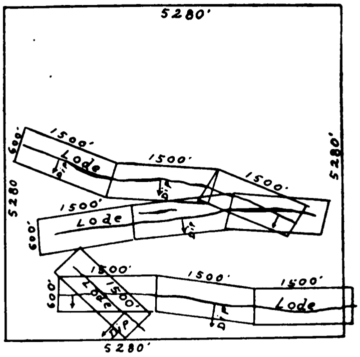


Fig. 72. Outcrops Properly Located to Secure Dip Rights.

this plan the claims upon the veins can be patented and dip rights secured for all time to come. If located as shown in Fig. 71 trouble over dip rights might arise at any time—even years after the locations have been made. Furthermore, if patent is applied for where claims are banked solid similar to those shown in Fig. 71, it will be impossible to secure a patent unless positive testimony is furnished to the effect that lodes do actually exist on each location as shown, and that the discovery points and the vein centers of the locations are within three hundred feet of the side lines of the respective claims. [See 923 and 1034].

972. In any case it is very desirable to have your claims examined, surveyed, and amended if necessary, under direction of a mining engineer who has a practical knowledge of geology. Although this may appear expensive, time may demonstrate the wisdom of it.

973. A mill site of five acres or less may be located on nonmineral ground in conjunction with a lode claim. It need not be adjoining to the lode claim.

CHAPTER XV.

ASSESSMENT WORK.

974. Each year, commencing with the calendar year following the year of location, one hundred dollars worth of work must be performed for each lode or placer claim, or the claim becomes subject to location by others. It is not necessary to perform the work within the boundaries of the claim; it may be done upon any one of the group of contiguous locations held in common, provided the work actually benefits each claim in the group for which the work is intended to apply.

975. The fact that the owner pays one hundred dollars for having the work done and has the usual "Proof of Labor" filed for record does not prevent some one from locating (jumping) the claim and holding it if he can prove that one hundred dollars worth of work was not performed. For example, he might prove that the workmen did not do a customary (full) days work, or that the work done did not benefit the claim in question. The courts are usually liberal towards the first locator if he has shown good faith and good intentions, however.

976. Have the assessment work done where it will be most beneficial to the claim—not necessarily in the easiest place. It is not the amount or volume of work that counts; it is the actual value of the work as measured by the physical efforts and expenditure necessary to do it. A large hole might deceive a "tenderfoot" but not a miner or prospector of experience, or a Court of Justice.

CHAPTER XVI.

DEVELOPING A CLAIM.

977. After the prospector has made a promising discovery and has properly staked out a lode claim and recorded the location notice, he should develop the claim, for by no other means can he hope to sell it except under uncommon circumstances.

Lode Claim.

978. The first thing to do is to select the best surface showing as the place to sink a shaft or begin an adit. This will not, necessarily, be the "point of discovery." Follow the mineral no matter in what direction it extends. Do not plan to make a shaft for hoisting ore to supply a large mill, because later developments may show that the working shaft should be at another place. [Figs. 73 and 74]. Let happen what may, stick to your ore till you have proven that you have a mine. It will be time enough then to plan for a working shaft or tunnel.

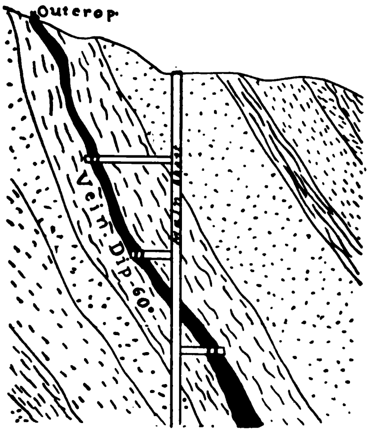


Fig. 73. Working Shaft Cutting the Vein at Depth. End View.

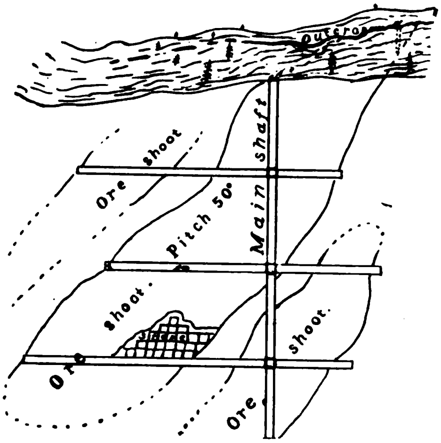


Fig. 74. Working Shaft Cutting the Vein at Depth. Side View.

979. *Cross-cut adit.*—By all means do not begin by starting a cross-cut adit in wall rock (country rock) that will require as many thousands of dollars as you possess hundreds. And even if you have the thousands necessary to run the cross-cut do not do so until you have sunk or drifted upon the vein sufficiently to prove that you have a mine worthy of the larger expenditure. Before beginning the cross-cut consider the case carefully. The arguments in favor of the cross-cut adit are: First, it will tap the vein at a great depth (if the vein extends to that depth); second, all trouble with water is avoided; third, hoisting ore and workmen is avoided; fourth, danger when blasting is lessened; fifth, work can be done at a lower cost per foot; sixth, there is practically no limit to the length of adit that may run without a power plant.

980. The arguments in favor of the work being done upon the vein are: First, every foot you sink or drift increases the value of your mine; second, if your money runs out you have something to show for it; third, you will find it comparatively easy to borrow money for continuing the work in exchange for a part interest; fourth, it will enable you to decide upon the advisability of running a cross-cut adit to cut the vein at a greater depth; fifth, it enables you to calculate the length of adit necessary to cut the vein, because it gives you the dip and strike; sixth, it enables you to make a fairly accurate estimate of the value of the mine; seventh, your mine is in a salable condition.

981. The proper way for a prospector to develop his mine is, therefore, to follow the ore as far as possible with the means at hand. When you have exhausted all your means or encountered too much water you can, if you have exposed good ore, secure help to continue the work with machinery. This you could not do if you had run a cross-cut and found yourself short of money before cutting the vein at depth.

982. Remember that the capitalist requires a showing before he will invest—he seldom buys on faith or imagination.

983. There are many ingenious ways for the prospector to dodge the difficulties. He may use a geared whim to enable him to hoist a large load at the expense of time. A canvas sail, connected to a canvas pipe or tube, will ventilate the shaft to quite a depth. [15, 16]. A hand pump will deliver a good stream of water and often proves less expensive than boiling it out. A one-horse whim will do wonders.

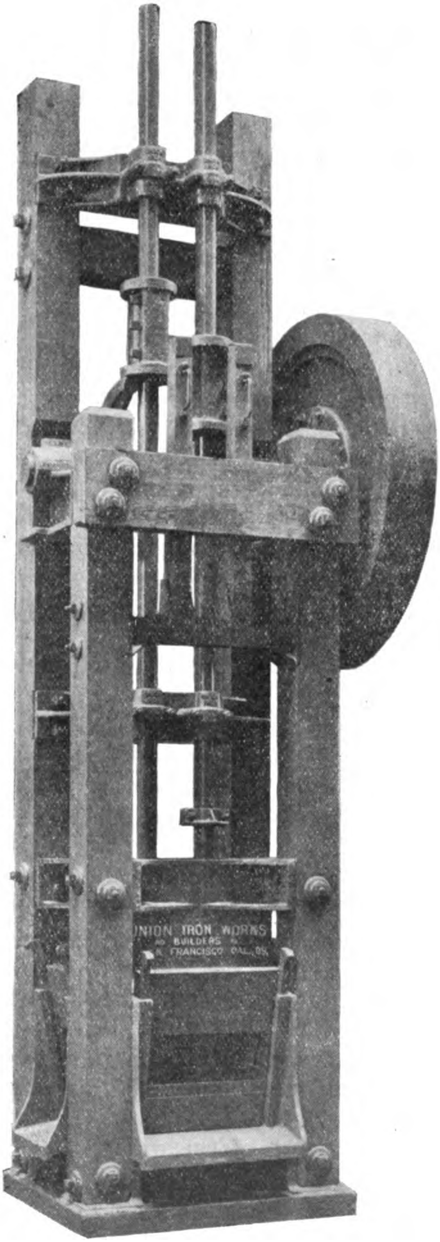


Fig. 75. Two-Stamp Battery Suitable for a Prospect.

Placer Claim.

984. If the claim is a placer the locator should either sink or drift, as the nature of the ground may suggest, so as to expose good gravel. If possible, the first work should be done in the most likely spots if the inflow of water does not prevent. Having sufficiently developed the ground to show the limits of the pay gravel, begin a drift at a depth low enough to drain the entire area, if this can be done.

985. In many cases water will be required to work the claim. The water question is one of the first to be settled after you have proven that pay dirt exists. [1006]. A small stream may supply all the water necessary for prospecting purposes, but it will not furnish sufficient water for working purposes. Therefore, the prospector must find a stream sufficiently large and at a suitable height to meet his requirements and then file a water right. In due time he must make a ditch or flume for diverting the water for a useful purpose in order to hold his right.

As there is a strong demand for definite information on flume, ditch and mine-sluice construction full directions will be given.

Construction of Flumes and Ditches.

986. The cost of either a flume or ditch may be reduced to a minimum by the observance of the laws governing the flow of water. The application of these laws to a particular case is not an easy matter, however, owing to certain difficulties peculiar to the subject. The following brief explanation of the necessary calculations will show how a majority of these obstacles may be obviated in a great measure.

987. *Flow of water in open channels.*—The amount and velocity of water flowing in an open channel is modified by four factors: the slope or grade, the kind of bottom and sides, the size of the channel, and its form. The velocity of the water increases with the grade, the smoothness of the sides and bottom, and the size of the channel. For a given "wet area," or cross-section, the maximum volume will flow through a channel when its width is approximately twice the depth of the water. That is, with a given amount of lumber for a flume, the maximum volume of water will be transported if the flume width is made twice the depth of the water.

988. Hydraulic engineers, endeavoring to find a formula that will give a theoretical flow equal to the actual flow under all conditions, discovered that a simple coefficient of friction can not be used because the frictional resistance to the flow is modified, not by only one, but by four elements: the slope or grade, the material of

which the flume or ditch is made, its size, and form. The simplest formula thus far devised is one in which a variable coefficient, c, is used. Its value is calculated by the use of a secondary formula (Kutter's) in which another variable coefficient, n, is used. The value of n depends upon the kind of walls and bottom in the flume or ditch and must be ascertained by actual trial. These trial tests have been made by many independent, competent observers, yet the flume builder will find it advisable to take such measurements as will enable him to determine independent values for n for his own use in the future when building other ditches in similar ground. Such results would be valuable to others, if published. In the following formulas let,

R=hydraulic radius in feet= $\frac{\text{wet perimeter}}{\text{wet area}} = \frac{r}{A}$

S=slope ratio= $\frac{\text{fall}}{\text{length}} = \frac{H}{L}$

V=velocity in feet per second.

Q=cubic feet of water flowing per second.

A=area of cross-section in square feet=wet area.

p=wet perimeter in feet.

I=miner's inches.

w=safe load.

n=.009 for planed lumber.

.012 for rough lumber.

.010 for cement or iron pipe.

.013 for brickwork.

.017 for rubble or straight open cut through rock. Smooth walls.

.020 for smooth regular earth with many bends or rough open cuts in rock.

.025 to .035 for irregular natural streams.

989. To calculate the value of c for a particular case use Kutter's formula as given below, selecting the most suitable value for n, conditions considered.

Formula 1.

$$c=\frac{41.6+\frac{.00281}{S}+\frac{1.811}{n}}{1.+\frac{n\left(41.6+\frac{.00281}{S}\right)}{\sqrt{R}}}$$

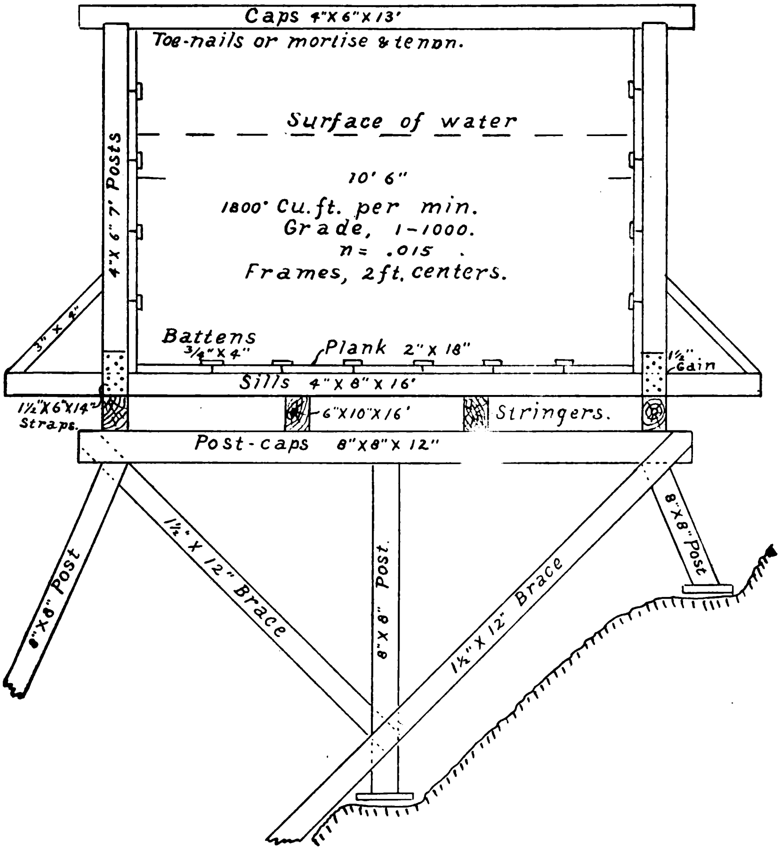


Fig. 76. Details of Flume Construction.

Having found the value of c, compute the theoretical velocity of water in feet per second by the following formula:

Formula 2. $V = c\sqrt{RS}$.

990. To find Q, the cubic feet of water flowing per second, multiply the wet area in square feet by the value of V as found by Formula 2. That is—

Formula 3. $Q = AV$.

991. To find I, the miner's inches, divide the cubic feet per second by 1.5

Formula 4. $$I = \frac{Q}{1.5} = \frac{AV}{1.5}$$

992. The four above formulas are all that are necessary for calculating the capacity of any flume or ditch. In practice, a sur-

vey of the ditch line is made and the character of the ground noted. Having ascertained the amount of water flowing at the head of the ditch line (by weir measurement, or otherwise), the size, or wet area, of the ditch is assumed and then by formulas 1, 2 and 3 we can ascertain the correctness of the assumed size.

993. Water is most accurately measured by means of a weir dam, using the following formula:

Formula 5. $Q=3.33\ (L-.2H)\sqrt{H^3}$ in which,
Q=cubic feet of water flowing per second.
L=length of weir in feet.
H=head in feet.

994. The grade of the ditch is important. To insure a good flow and at the same time not cause excessive erosion, use a ¼% grade (=12.2 feet per mile). In rock the grade may be anything desired. With a steep grade the size of the ditch may be diminished.

995. *Flumes.*—When absolutely necessary, flumes instead of ditches are used to carry water. Small V flumes or box flumes are easily made, 1x4 inch material being used for frames, 1x12 inch boards for boxes, and 2x4 inch scantlings for trestles. When the span is considerable 1½ or 2-inch plank may be used for the sides. If a flume is very high, requiring several sets of diagonal braces, these braces must be well nailed and sufficiently strong to prevent the posts from bending. As a precaution, try Formula No. 7, using twice the distance between braces for the value of l. If this gives a safe load no harm will result if a brace board becomes detached or broken. Side bracing should be used also.

996. The safe load for the posts in the supporting trestle may be calculated by multiplying the area of the cross-section of the post in square inches by 1100 (for Douglas fir, factor of safety, 4) when the length of a post, measured from one brace to another, does not exceed 12 times the least diameter. Formula 6. $L=A\times 1100.$

Otherwise, calculate the value of C, for use instead of 1100, by means of—

Formula 7. $C=1100-\dfrac{10\,l}{d}$ in which,

l=length of post in inches (between braces).
d=least diameter of post in inches.

Example. Find the safe load on the end of a vertical 4 x 6 inch scantling, 10 feet between the braces.

Solution. The length being greater than 12 times the least diameter, find C by Formula 7.

$$C=1100-\frac{10\ l}{d}=1100-\frac{10\times120}{4}=800.\ \text{pounds.}$$

The area of the cross section is $4\times6=24$ square inches. $24\times800.=$ 19,200 pounds.

997. Small flumes having a wet area of four square feet or less may be made of 1x12 inch boards, ½x3 inch battens, 3x4 inch frames, 6x6 inch bent posts, and 4x6 inch stringers. The braces may be boards instead of the usual fitted brace. These boards serve as straps at the same time, holding the frames together.

998. For large flumes the size of the bent-posts and girders should always be calculated. The cubic feet of water per second, the grade, and length of box must be given as a basis for the calculations. The size of flume must be found by "cut and try" using formulas 1, 2, and 3. The load on each post is found by dividing the weight of timber and water per bent by the number of supporting posts.

999. The uniformly distributed safe load on a trestle girder for a flume is—

Formula 8. $W=\frac{2\ C\ b\ h^2}{L}$ in which,

W=the safe load in pounds.
b=breadth of girder in inches.
h=height of girder in inches.
L=length of girder in feet.
C=100 for Douglas fir (Oregon pine), factor of safety 2.5.
If timber is badly checked in drying use a smaller number for C.

Example. What is the safe uniform load on a 4x6 inch girder 16 feet long between the supports?

Solution. $W=\frac{2\ C\ b\ h^2}{L}=\frac{2\times100\times4\times6^2}{16}=1800\ \text{lbs.}$

Example. What sized girder should be used to support a uniform load of 7,200 pounds, the girder being 20 feet long between the supports?

Solution. As the height and breadth are both unknown we must assume one and calculate the other. If the result gives a badly proportioned girder, or if the breadth is more than the height, assume a new value. In this example we will assume the height to be 10 inches. Then, transposing Formula 8:

$$\frac{WL}{2Ch} = b, = \frac{4000 \times 20}{2 \times 100 \times 10} = 4 \text{ inches.}$$

Therefore, the girder should be a 4x10.

1000. To find the weight of water in a flume between bents, multiply the wet area by the distance between bents, and the product by 62.5.

1001. To find the weight of the number per box, multiply the weight of one board foot by the number of board feet in the box, rating the weight as follows:

One board foot of white pine weighs 2 pounds.
One board foot of Douglas fir weighs 3 pounds.
One board foot of Northern pine weighs 3 pounds.

1002. For very large flumes make the boxes of 2x12 inch plank, 12 to 16 feet long. The battens should be ⅝ to ¾ by 4 inches, and nailed every three inches. For short turns use short lumber, of course.

The frames should be 4x4 or 4x6 inch lumber.
The sills should be 4x6 or 4x8 inch lumber.
The caps should be 4x6 or 6x6 inch lumber.
The bents should be 6x6, 6x8 or 8x8 inch lumber.
The side braces should be 3x4 or 4x4 inch lumber.

1003. Braces should be set at an angle of 45 degrees, and should rest in notched seats—not simply nailed to the sill and post. The girders and bent posts should be calculated by formulas 7 and 8. A properly designed flume is shown in Fig. 76. Some of the details may be modified by an experienced flume builder, but the inexperienced should follow directions as given. The straps as shown are intended to prevent the post from rising out of its seat. To prevent rotting at the joints place a piece of plain, thin sheet iron between the parts. The oxidation of the iron prevents the wood from decay. The bent-posts should have a batter of one to four, or one to six. Intermediate, vertical posts may be placed between bents to avoid using excessively large girders. Set all posts on firm foundations. If the ground is soft use a broad foundation plank or planks.

1004. A word regarding the factor of safety. In building bridges and similar structures where life or limb is endangered, the factor of safety should be higher than in other cases. An increase in strength does not always mean a more enduring structure. A falling tree will crush a flume having a factor of safety 4 as readily as if it were only 2. The factor of safety may be modified to suit other conditions, however. If a small flume is to be built for use where a break and the consequent interruption of the stream would not be serious, a low factor may be used. If a large flume is contemplated for use where an interruption in the water flow would be more serious, a high factor may be used profitably. In Formula 7, for buildings or bridges, make C=750, giving a safety factor of 6. In Formula 8, for similar cases, make C=90, giving a safety factor of 3.

1005. The above figures are all based upon commercially dry (12% moisture) timber. Late investigations of the U. S. Government indicate that calculations should be based upon green timber, for the reason that large timbers check so badly in drying that they are but slightly stronger than green timber. Dividing the above given factors of safety by .6 gives the factor for green timber. For water power see section 1175.

The Mine-Sluice.

1006. A Mine-sluice is a continuous series of troughs of "boxes" used by prospectors and miners for working placer ground on a larger scale than would be possible with a rocker or "long tom." Placer gold can be saved at less expense by this means than by any other method. Preferably hydraulic giants are used to deliver gravel to the sluice-way when a large gravel bed is to be worked, but in many parts of California hydraulicing is now prohibited by law. The use of sluices, supported by any other method, however, is not restricted. Two ordinary giants will require a sluice four feet wide. One giant will require a 2½ to 3 foot sluice. When giants are not permissible or available the sluice may be filled by hand shovelling.

1007. In constructing a sluice for working gravel an undercurrent and spillway should be placed at every advantageous point along the line to eliminate the large boulders, as the strong current required to move the large rocks will carry fine gold the entire length of the sluice and into the tailings. At each spillway the velocity of the water should be decreased. A spillway is simply a grating of suitable timber or iron rods, through which the water, fine gravel and gold passes, turning the boulders out of the sluice in a pile at one side of the line. At the head of the sluice the water should be deepest and the current swift. At each spillway the current should be decreased, either by lessening the grade, or by increasing the width of the sluice. The water should be about 4 to 6 inches deep at all times, except above the first spillway, where it may be deeper.

1008. The sluice is made in sections, called boxes. Each box should be about 12 feet long and have a fall or grade of from 3 to

12 inches per box. A fall of 6 to 10 inches is best. If the fall is 3 inches or less per box the sluice will fill with black sand. A grade of 12 inches per box will carry away most of the gold. Use good lumber and brace every part well. Make the sections so that they will fit together neatly. The splice boards for joining boxes should be well nailed to the lower box and only tacked to the upper box to facilitate removal from place to place. Allow for swelling, as the bottom must be perfectly flat. Use frames, or blocks on end, for the riffles. In many cases side-boards, or false sides, are used to protect the box from wear.

The Use and Care of Dynamite.

1009. Dynamite freezes at a temperature between 45° and 50° Fahr., or 13° to 18° above the freezing point of water. This fact makes it necessary to take extra precautions to prevent its chilling or freezing long before the weather has become severely cold.

1010. Chilled or frozen dynamite is unsafe to handle, as the breaking of a stick in this condition may cause it to explode. It is dangerous to use because it can seldom be detonated with a blasting cap, thus causing a "missed hole," which is always a source of danger.

1011. When dynamite has been frozen it is necessary to thaw it before using. For this purpose many and various devices have been invented—some good and some positively dangerous. An excellent plan for a mine requiring large amounts of powder is to construct a building, or better, a drawer cabinet, the heat being produced by a steam heater supplied with steam from the mine power plant. In either case the heater should be covered so that it will be impossible for the miners to place the sticks of powder in contact with the heater. Sawdust should be placed in the bottom of the drawers, and replaced with fresh material regularly. The use of a cabinet instead of a building will discourage the habit of priming sticks near the stock supply, as many miners do because the thawing room is warm. Caps should be kept in a dry box just inside the tunnel or at the collar of the shaft. A bottle of sulfuric acid or calcium chlorid may be kept in the box to keep the air perfectly dry. Of course, the cabinet is built with thick walls to retain the heat.

1012. Do not thaw dynamite in front of or near any fire, in an oven, over a steam boiler, on a hot shovel, in hot water, over a stove, in direct contact with any steam pipe, or in the same place where caps are kept. The prospector, however, can not make use of a steam heater. He must devise some other plan. Most thawing devices that make use of a lighted candle are very dangerous.

If a candle must be used place it on an old pie tin in a warming box, so made that it will be impossible to place any powder above the candle. The tin dish will prevent the box from taking fire in case the candle should burn out. The sticks may be placed on side shelves with the candle in the center. Sawdust or fine shavings should cover the bottom of each shelf to absorb any nitro-glycerine that might ooze out of the powder. The sawdust should be replaced with fresh material quite often.

1013. An excellent thawing oven, absolutely safe and quite convenient, may be built on the principal of the so-called ''fireless cooking oven.'' In using this oven the food is heated as hot as possible on an ordinary stove and then placed in the fireless oven, from which the heat imparted by the stove can not escape. As a result the food remains hot till cooked. In order to apply the same principle to a dynamite thawing box, proceed as follows: Select a nail keg or pickle keg and a tin pail that will just set in the keg without much free space. Select a large apple box or barrel and place a layer of straw, bran or sawdust about two inches thick over the bottom. Then set the keg in the center of the box or barrel and fill in around it with the same material that was used for the bottom. Make a cushion to fit the top of the barrel and stuff it with the same material. To use the outfit, heat a pail of water on the stove and set it in the keg. Suspend the basket, box or sack of dynamite above the hot water, and close the oven. In a short time the powder will be thawed by the heat of the water. Water will absorb and give out more heat units than any other substance of like bulk, hence it is well adapted for supplying heat to the oven. Sawdust or some other good absorbent should be placed in the bottom of the basket or tray containing the powder. Thawing kettles [Fig. 77] on the market, though intended for use alone, are excellent for use in the fireless heater just described. The thawing kettle alone will thaw the dynamite, but the water soon cools and the powder is liable to chill or freeze again if left in a

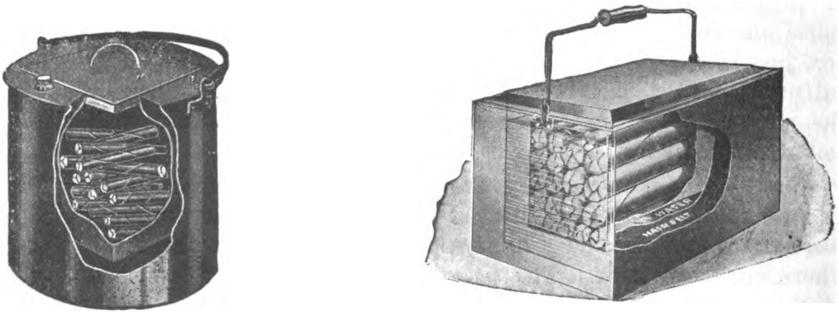


Fig. 77. Dynamite Thawing Kettles.

cold place. The fireless heater will keep the dynamite soft for over 24 hours. The success of the heater depends on the material used for the packing. Try the plan before condemning it.

1014. *The use of caps.*—Blasting caps are sold of varying strengths: XXXX, XXXXX, and XXXXXX. Some cap manufacturers use other terms for designating the different grades instead of the X, and different kinds of material are used for the explosive. For these reasons comparisons between different makes can not be made without trial.

1015. Repeated experiments and continued use have demonstrated that a great loss in the effectiveness of dynamite will result if weak or damp caps are used. The loss of force is not the only evil; the gasses set free when the weak cap is used will be much more poisonous than with a strong one.

1016. In the perfect detonation of dynamite the gases produced are CO_2, N, and O. In the incomplete explosion the gases are, in part, CO_2, N, CO, NO_2, H, and C_2H_4. The CO and the NO_2 are both poisonous. The CO is colorless and hence invisible. The NO_2 is of a reddish-brown color and might be noticed in the daylight, but not in a mine.

1017. It should be explained that the force of dynamite is not produced by the amount of gas evolved, but by the extremely high heat which expands the gas to a great bulk. When the powder is detonated by a strong cap there is a greater amount of heat produced than with a weak cap, because the chemical reactions taking place are different. Still less heat is generated when dynamite is burned, as it may be sometimes without exploding. The evidence of the great heat produced by the detonation of dynamite is well shown in "springing" holes. Any man who has worked on railroad cuts will tell you that it is not safe to reload a hole that has been sprung till several hours afterward, because the rock at the bottom of the hole is so hot that it will explode the powder during reloading. In ordinary blasting the heat is expended in expanding the gasses instead of heating the rock, because the rock gives way, thus allowing the gasses to expand.

1018. The particular grade of cap to use with a certain powder can not be given, as there are local conditions that influence the results. For example, a certain dynamite may detonate perfectly with a XXX cap in a warm climate when a XXXXX or a XXXXXX cap may be necessary with the same powder in a cold climate. The particular cap to use must be determined by actual trial in each case. However, as caps are comparatively inexpensive it is advisable to use a high grade at all times.

1019. There are other things to be considered besides the strength of the cap, such as the method of priming, loading, etc. Holes should be so loaded that there will be no air spaces left. That is, the sticks should be slit up one side and tamped till they fill the entire hole, and they should come in close contact with each other.

1020. *Priming.*—In priming, place the cap in the dynamite to a depth nearly equal to the length of the cap, but never any deeper. If the hole is wet place grease around the cap and tie it in the stick with a strong string, or plunge it in a quickly drying asphaltum paint made for the purpose. If caps are damp or dirty the fuse may fail to explode it, and sparks from the fuse may then cause an incomplete explosion of the dynamite, or simply set it on fire. [1017].

1021. *Misfires.*—Misfires are caused in a variety of ways, but seldom by faulty cap manufacture. The most common causes are damp caps, dirt in the caps, damp fuse, water getting into the cap after loading, grease or oil on the fuse having penetrated to the powder, crimping with a narrow crimper, loss of powder from the end of the fuse, partially severed fuse, punctured fuse, etc. Perhaps the greatest number of misfires is caused by damp caps or fuse, or both.

1022. It is well known that table salt will absorb moisture from the air. Many other chemical salts do the same thing, and the explosive material in blasting caps is one of them. Caps will be rendered unreliable by leaving the box open 24 hours in a damp place. The black powder in a fuse is also hygroscopic—that is, it absorbs moisture readily from the air. Therefore, caps and fuse should always be kept in a dry place above ground. All primers should be made up above ground and taken into the mine as needed. Any surplus should be immediately taken out of the mine and stored in a dry place.

1023. *Blasting.*—A skillful miner will break down more rock with a given amount of powder and labor than an unskilled workman. The difference in results is chiefly due to the depth, direction and location of the drill holes, and the quality and manipulation of the caps and powder, other things being equal.

1024. It is a falacy to take it for granted that a stick of dynamite will produce the same results regardless of the method of causing the detonation. (The term "detonation" applies when every particle of a charge goes off at the same instant, as with dynamite, and the term "explode" applies when an appreciable amount of time is required for one grain of powder to communicate its force to the neighboring grain, as in the explosion of black powder.) It has been proven by numberless experiments that a stick of dynamite may, by proper detonation, be made to produce much better results than can be obtained by improper detonation. To demonstrate that the effectiveness of a blast depends largely upon the effectiveness of the cap, perform the following experiment: Load two holes in the same kind of rock, firing one with a strong cap and the other with a weak one. By repeated experiments it will be found that the stronger cap will produce the better results. A more convincing experiment is as follows: Hang a row of dynamite sticks on a line in the open air about 25 to 30 inches apart and fire the end one with a weak cap, noting the results. Then hang up another similar line of sticks, and fire the end stick with a strong cap. It will be observed that the strong cap will detonate the greater number of sticks. In any case a number of sticks will be blown to pieces, but not exploded.

1025. In any case of blasting in a mine the cap should be strong enough to produce what is called a complete detonation with the production of NO and CO_2. Whenever the powder smoke causes unusual headaches there has been an imperfect explosion in some hole.

1026. To obtain complete detonation and at the same time prevent misfires, take all the known precautions and never be careless. Proper crimping and suitable grease will prevent water from entering the cap after loading. In very wet holes wrap one half of the cap and three or four inches of the fuse with electrician's water-proof tape instead of using grease. [1020]. Candle grease is good, however, as it will not soak through the fuse and spoil the powder.

CHAPTER XVII.

SECURING A UNITED STATES PATENT.

1027. When the owner of a lode or placer claim has made $500.00 worth of improvements upon or for, the benefit of his location he may apply for a U. S. Patent. (A patent is a conveyance of the paramount title from the U. S. Government to the individual.) The fact that five years assessment work has been performed will not necessarily suffice, for the reason that many State laws specify that certain acts constitute assessment work which the U. S. Land Office can not accept as mine improvements. Before a patent can be obtained for a location there must be $500.00 worth of improvements for the benefit of that particular claim. The improvements need not, necessarily, be actually upon the claim, but they must benefit it. A claim may be patented as soon as $500.00 worth of work has been performed upon it. If a locator has this amount of work done upon it within one month or less after location, the claim is patentable. Here, as in the case of assessment work, the amount of money spent does not necessarily determine the value of the improvements. This is determined by the U. S. Mineral Surveyor, who is instructed as to what improvements he can include.

Mine Improvements, Lode Claims.

1028. Mine improvements which are accepted at the present time (1912) are: First, a tunnel running toward any vein apexing within the claim—it need not necessarily be upon the claim but it should be upon ground owned by the claimant; second, a shaft upon any vein within the claim, or a shaft which, if continued, would intercept a vein apexing within the claim—it should be upon the ground owned by the claimant; third, a shaft which may be connected with any vein apexing within the claim by means of a drift or cross-cut; fourth, any building used for strictly mining (not milling) purposes, such as a building for storing mining tools, powder, etc., though buildings are seldom accepted as improvements unless the claimant shows conclusively that they aid actual mining operations in his particular case; fifth, an ore hoisting plant; sixth, a permanent mine pumping plant used in keeping out water so that mining may be continued, (not for simply pumping out a flooded mine for examination or other purposes).

Improvements, Mill Sites..

1029. Mills, reduction works, boarding houses, bunk houses, etc., are not now considered mine improvements, though they are proper improvements for a mill site.

1030. Brush cutting, surveying, etc., will not be accepted as mine improvements.

1031. Trails and wagon roads will not be accepted as mine improvements unless it be shown that they materially aid mining operations, and even then only such portions of the trail or road will be accepted as lies within the boundaries of the claim.

Mine Improvements, Placer Claims.

1032. Placer mine improvements may consist of water ditches, flumes, pipe lines, etc., hydraulic nozzles and general placer mining outfits, adits, shafts and cross-cuts run to cut the gravel, and general, actual improvements.

1033. Having the required amount of improvements upon the claim the procedure for procuring a patent is as follows: First, apply to the U. S. Surveyor General for the State in which the claim is situated for a survey by a United States Mineral Surveyor; second, post the official plat on the claim and advertise 60 days; third, apply for patent. It will be necessary to employ an attorney familiar with this branch of legal work, who will attend to all the minor details; for this reason particulars will not be given here.

1034. It is highly advisable for those who own valuable unpatented mining claims to patent them as soon as the required amount of improvements have been made, because the conservation idea is spreading so rapidly that there is a probability of legislation which will prevent the patenting of mining claims under any circumstances. One fact is certain: the requirements for patenting are becoming more rigid every year. A word to the wise is sufficient.

CHAPTER XVIII.

HOW TO SELL A PROSPECT OR A MINE.

1035. It is seldom that a prospector, unaided by others, is able to develop his prospect into a paying mine, because he has rarely sufficient capital to do the necessary work or to purchase and construct the necessary buildings and equip them with suitable machinery. Instead of selling his prospect the owner may, if the ore values permit, mill his ore in a custom mill, provided one is at hand, or he may ship the ore to a smelter. In either case if the mine contains milling ore, a mill on the ground would effect a greater saving. Therefore, it follows that a prospect or small mine is worth more to a man of means who will be able to make all necessary expenditures, than to a man without capital. There are, at times, many good and sufficient reasons why a prospector may desire to sell a good prospect. It does not follow, by any means, that a prospect or mine is worthless simply because the owner desires to sell.

When to Sell.

1036. When the prospect has been sufficiently developed to demonstrate that it will, in time, make a paying mine it is a salable property. In such a case a prospector may or may not have the necessary means to continue operations: his object in selling may be that he desires to realize a profit on his holdings and invest this profit in some new discovery, he being better qualified and better able to prospect than to operate a mine.

Under the following conditions it is usually advisable to sell:

1037. When the cost of exploration and exploitation exceeds the amount of the returns from the sale of ore or bullion, the owner being without means to make needed improvements which would be calculated to increase profits.

When you find it necessary to "rob" or "strip" the mine to meet running expenses.

When more expensive pumping machinery is required than you are able to purchase.

When a depth is reached that demands a larger hoisting plant than you are able to furnish.

When a mill is required and you are not financially able to build it.

Estimating the Value of a Prospect.

1038. The value of a slightly developed prospect is entirely problematical, and the purchase of such a property is a hazard or a gamble, as no rule for estimating its value can be given. As development work progresses the elements of uncertainty give way to those of certainty, either favorable or unfavorable. When the property has been well developed, and valuable ore bodies blocked out ready for stoping, the value of the mine can be determined almost as accurately as that of a tract of real estate or a store full of merchandise; for the ore blocked out becomes, in a sense, "goods on the shelf."

Estimating the Value of a Well Developed Mine.

1039. The valuing of a developed mine is largely a matter of figures, together with a greater or less amount of geology. The value of any mine should be based upon the combined value of the ore blocked out and the estimated ore ahead of the present workings, called probable ore, taken in conjunction with the profit per ton that can be realized from the ore. The assay value of the ore is simply one of the items used in making the computations, the profits per ton being the important point.

1040. By making proper surveys, assays and mathematical calculations the value of the ore blocked out is ascertained. The ore that may be safely depended upon ahead of the present workings may be determined with a core drill or conservatively estimated by carefully observing all geologic conditions affecting the case. If the district is known to be badly faulted the ore ahead may be declared nil. If, on the other hand, the conditions strongly indicate a continuation of the ore, a considerable amount may be assumed to exist ahead.

1041. The profit per ton is obtained by subtracting the sum of the estimated items of expense in producing bullion, from the average milling value of the ore per ton.

1042. These results and estimates are most accurately obtained by a competent mining engineer, but the prospector or miner may arrive at results which will answer his purposes. These results he may most easily obtain by the use of the chart, Fig. 80, devised by the author. The following directions for mine valuation are intended for the prospector and not for the mining engineer. The latter will usually employ means and methods of his own, such as will be best suited to the case in hand, and calculated to produce more reliable results than could be obtained by a prospector or miner.

1043. SAMPLING.—Samples should be taken at every 5, 10 or 20 feet along the drift or ore shoot, taking care to obtain as much rock from the hard parts of the vein as from the soft places. Take the sample from the roof of the drift across the entire vein or pay streak, noting the width sampled in a note book. Assay the samples separately in order to ascertain where the ore shoots are, and to determine their pitch.

1044. MAKING THE CALCULATIONS OF ORE IN SIGHT.—Make a drawing of the developments, drawing to a suitable scale. To find the average value of the ore on a level or drift multiply each assay value by the width of vein represented in each respective sample. Add these products together and divide by the sum of the widths sampled.

1045. It is not uncommon for those estimating the value of ore in a vein to make errors by using improper methods of calculation. The most common error is that of adding a number of assays together and dividing by the number of assays to find the average assay value. A moment's reflection will make it clear that this is incorrect. A small amount of rich ore, mined and mixed with a large amount of low grade ore, will not make a mixture assaying an amount equal to half the sum of the two assays. To illustrate: Suppose a two-inch seam of a 26-inch vein assays $20.00 per ton, and that the remainder of the vein, two feet in width, assays $2.00 per ton. The average value of the entire vein at that point is not ($20+$2)÷2=$11. The true value is found thus:

Assay value.		Width of vein sampled.		Product.
$20	×	2	=	$40.00
$2	×	24	=	$48.00
		26		)88.00($3.38

The average value per ton of the entire vein 26 inches wide is $3.38.

1046. Fig 78 represents vein widths and assay values of the respective widths on one level of a mine. In this figure the dis-

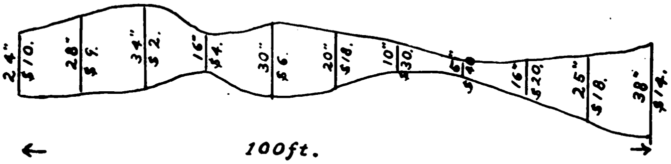


Fig. 78. Drawing to Represent the Vein Widths Sampled.

tances between samples is not drawn to the same scale as the vein widths. It is supposed that samples are taken 10 feet apart.

Assay value.		Width of the vein sampled.		Product.
$10	×	24	=	240
9	×	28	=	252
2	×	34	=	68
4	×	16	=	64
6	×	30	=	180
18	×	20	=	360
30	×	10	=	300
40	×	5	=	200
20	×	16	=	320
18	×	25	=	450
14	×	38	=	532
		246		)2966($12.05 average value.

1047. Having thus found the average value of the ore exposed on each level in the mine, and also that of the surface outcrop, proceed to compute the value of the ore between levels, taking the levels two at a time, as explained and illustrated below:—

1048. To find the average value of the ore body between any two levels proceed as follows:

(a) Find the average assay value of each level as explained and illustrated above. [1044 to 1046].

(b) Find the average of the two areas sampled on the two levels under consideration by adding the two areas together and dividing by two.

(c) Find the tons of ore between the two levels by multiplying the average area (b) by the vertical distance between levels and dividing by the cubic feet of ore in a ton. For quartz this is 13. It is not necessary that one area be directly above the other. Use the vertical distance between levels, disregarding the pitch of the ore shoot.

(d) Find the average value of the ore per ton between levels thus: Multiply the area sampled on each level by its respective average assay value, add the products and divide by the sum of the two areas.

(e) To find the total value of the ore between levels multiply the average value per ton (d) by the number of tons (c).

1049. The above rules give only approximate results. If exact results are desired the prismordal formula [1120] must be used in calculating the volume of the ore body. Computing volumes by this formula is rather difficult for the inexperienced.

1050. Example. On the fifth level of a mine the ore shoot averages 6 feet in width and is 347 feet long, and the average assay value computed as in the above example [1046] is $9.00 per ton. On the sixth level the ore shoot averages 8 feet in width, is 460 feet long and assays $12.30 per ton, average value. The vertical distance between levels is 100 feet and 13 cubic feet of ore make a ton. What is the value of the ore between the fifth and sixth level?

Solution: Average assay value, fifth level, $9.00 (a)
Average assay value, sixth level, 12.30 (a)

Area sampled on fifth $6 \times 347 = 2082$
Area sampled on sixth $8 \times 460 = 3680$

2)5762(2881 (b)

$$\frac{2881 \times 100}{13} \div 13 = 22161 \text{ tons (c)}$$

$\$9.00 \times 2082 = 18738$
$\$12.30 \times 3680 = 45264$

5762)64002($11.107 (d)

$\$11.107 \times 22161 = \$246,142.22$ total value, (e).

Let us take another example.

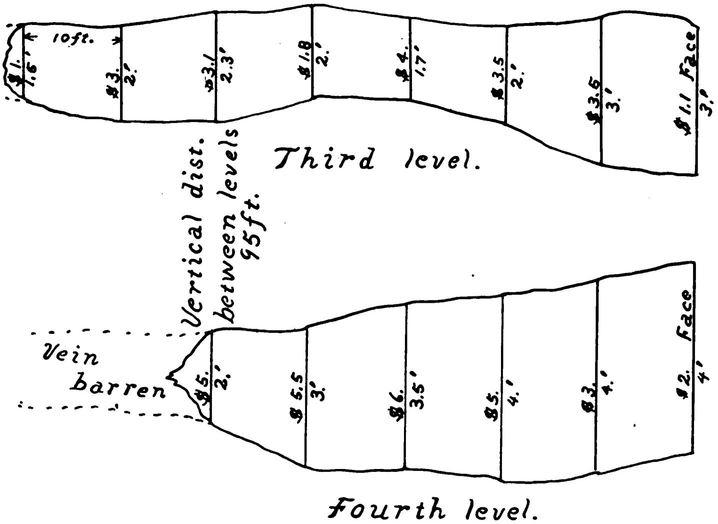


Fig. 79. Drawing to Represent the Vein Widths Sampled on the Third and Fourth Levels.

1051. Example. The width sampled, the distance between samples, and the assay values of the samples from the third and fourth levels of a mine are shown in Fig. 79. If the vertical distance between levels is 95 feet, 15 feet to remain to support the track on the third level, and 13 cubic feet be allowed per ton, what is the value of the ore between levels?

Third Level.

Assay value.	Width.	Product.
$1. ×	1.5 =	1.50
3. ×	2. =	6.00
3.1 ×	2.3 =	7.13
1.8 ×	2. =	3.60
4. ×	1.7 =	6.80
3.5 ×	2. =	7.00
3. ×	3. =	9.00
1.1 ×	3. =	3.30
	17.50	)44.30($2.53 (a)

Fourth Level.

Assay value.	Width.	Product.
5. ×	2. =	10.0
5.5 ×	3. =	16.5
6. ×	3.5 =	21.
5. ×	4. =	20.
3. ×	4.4 =	12.6
2. ×	4. =	8.0
	20.5	)87.5(4.26 (a)

Average width, third level, 17.50 ÷ 8 = 2.18, length 70 feet.
Average width, fourth level, 20.5 ÷ 6 = 3.41, length 50 feet.
2.18 × 70 = 152.6 square ft., third level.
3.41 × 50 = 170.5 square ft., fourth level.

2)323.1(161.55 (b)
161.55 × 80 ÷ 13 × 99.41 tons (c)
2.53 × 152.6 = 386.07
4.26 × 170.5 = 726.33

323.1) 1112.40($3.44 (d)
3.44 × 91.41 = $311.97 (d) value of ore between levels.

In this particular case the error produced by adding the assay values together and dividing by the number of assays to find the average assay value is not great, $2.56 being obtained for the third level and $4.41 for the fourth level by this improper method. If there had been a greater variation in the richness of the ore the error would have been greater. The only correct way is to solve as in the above example.

To make clearer the method of calculating values a few special rules will be given.

1052. To find the volume of a rectangular solid: Multiply the length, breadth, and height together. Volume=l×b×h.

1053. To find the volume of any frustrum of a rectangular prism: Multiply half the sum of the areas of the two parallel sides by the perpendicular distance between the two parallel sides. This rule can be used to find the volume of an ore bin.

$$\text{Volume} = \frac{A + a}{2} \times h.$$

1054. To find the volume of any cone (right or oblique): Multiply the area of the base by the height measured perpendicularly to the base, and divide by three.

$$\text{Volume} = \frac{Bh}{3}$$

1055. To find the approximate volume of an ore dump on a mountainside:

Let L = the length of the dump in feet, measured on the slope of the mountainside along one side of the dump.

d = the horizontal width of the dump in feet.

h = the height of the dump in feet, measured perpendicularly to the mountainside and not vertically. Then,—

$L \times d \times h \times .2618 =$ volume in cubic feet.

If the answer is required in tons use the following:

$L \times d \times h \times .13 =$ tons of ore.

1056. The seller is apt to imagine that in his mine there are immense undeveloped ore bodies of high value, and the buyer endeavors to purchase on the basis of the ore blocked out, or as near that as possible. A compromise is the only solution of the difficulty.

1057. The theoretical value of any mine is the present worth of its annual net income, calculated for the life of the mine, due allowance being made for interest (profit) on the investment.

1058. The net income of a mine is usually determined by a competent mining engineer who takes into consideration mining and milling costs, insurance, taxes, assays, mill capacity, etc., and makes an allowance for a depreciation fund (8% to 10%) in his calculations. The present worth of the annual dividends may be calculated by anyone familiar with arithmetic. In order to avoid the time and labor involved in making such calculations, they being very long, the author has devised a "Present Worth Chart," Fig. 80.

1059. The reader is cautioned not to imagine that this chart in any way lessens or dispenses with the necessity for skill, knowledge and experience in mine valuation. It simply saves the labor of calculating the present worth of an annuity. However, the Chart is useful for many purposes, such as determining the most economical mill for a mine, and for quickly making rough estimates of the value of a mine, or of any other enterprise of limited life which produces an annual income.

1060. CALCULATING THE VALUE OF A MINE AS AN INVESTMENT.—For our present purpose, the ore blocked out, added to the amount of probable ore agreed upon by the buyer and seller as existing ahead of the workings, we will designate as *ore reserve.* After the ore reserve has been agreed upon, the profit per ton that can be derived from mining and milling the ore must be determined and agreed upon.

1061. PRESENT WORTH CHART.—When this has been done the present worth, or present value, can be either calculated, or ascertained directly by means of my Present Worth Chart, Fig. 80, which is based upon the following assumptions:

First, money worth 10% per annum, compound interest.

Second, capacity of a stamp mill, 1000 tons per stamp per annum.

Third, profit per ton of ore milled, $1.00.

Fourth, when the profit per ton is greater or less than $1.00 per ton, the results obtained from the Chart are to be multiplied or divided accordingly.

1062. Present worth is the present value of a sum due at a future date. Thus, the present worth of $212, due one year from today, is $212 ÷ 1.10 = $192.72, calculated at 10% simple interest. If due two years from today the present worth at the same rate is $212 ÷ 1.20 = $176.66, and at 10% compound interest for two years the present worth is ($212 ÷ 1.10) ÷ 1.10 = $175.20. The present worth of an annuity of $109.60 at 10% compound interest for two years is also $175.20, as can be ascertained by using the formula given at the end of this paragraph. An annuity is a certain sum payable each year for a specified number of years. For example, if a mine returns a net profit of $1000 a year for five years, it is called a five year annuity of $1000. The present worth of this annuity is the sum of the present worths of—

$1000 due 5 years from date,
“ “ 4 “ “ “
“ “ 3 “ “ “
“ “ 2 “ “ “
“ “ 1 “ “ “ If money is worth 10% compound
interest this is $3790.97. It is commonly held that an investor in a mine is entitled to 10% compound interest. Compound interest is used because the income from the mine is not immediate, but is deferred several years—in some cases 50 years or longer. As a matter of fact savings banks pay compound interest, and life insurance rates are based on compound interest. Those who desire to calculate

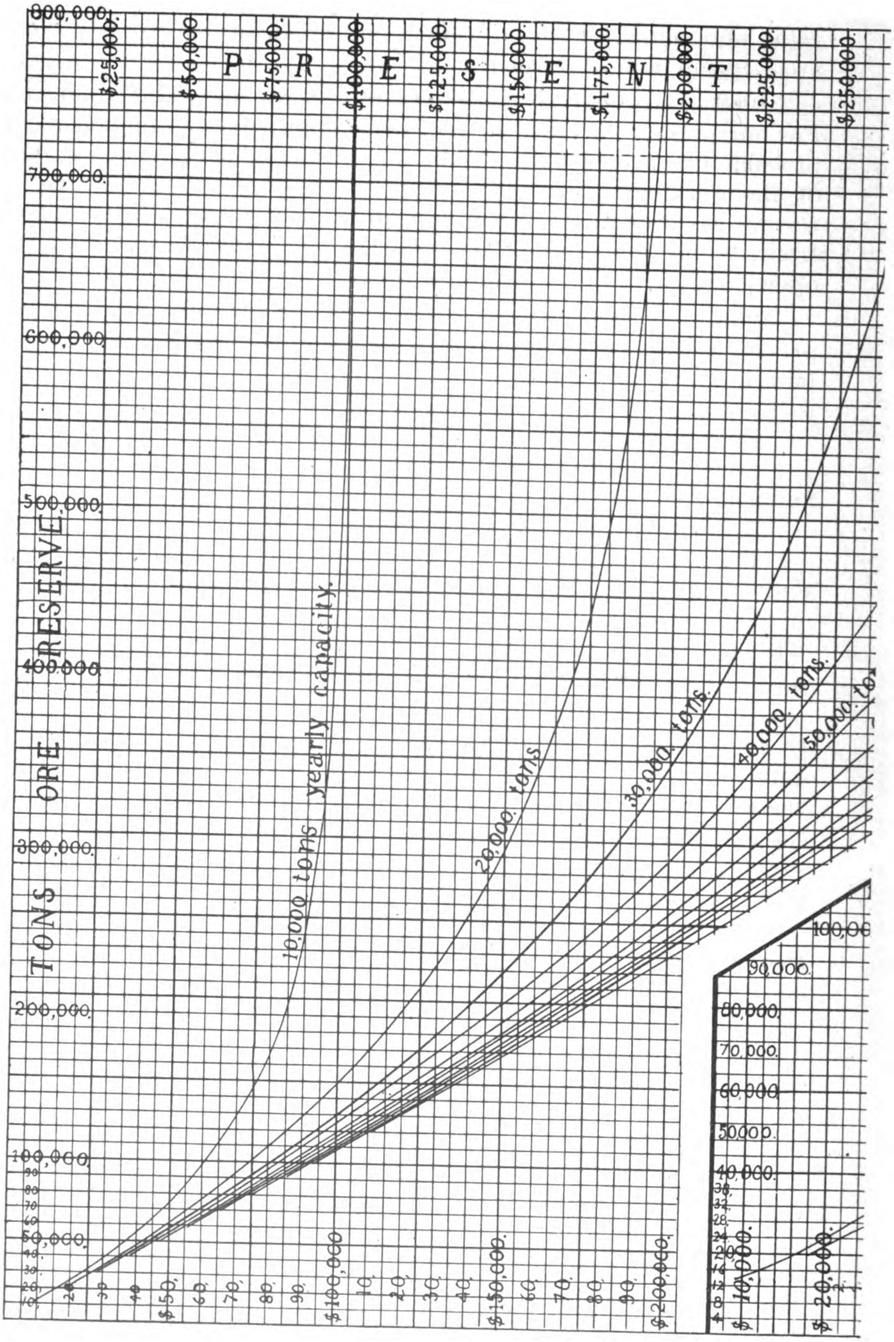
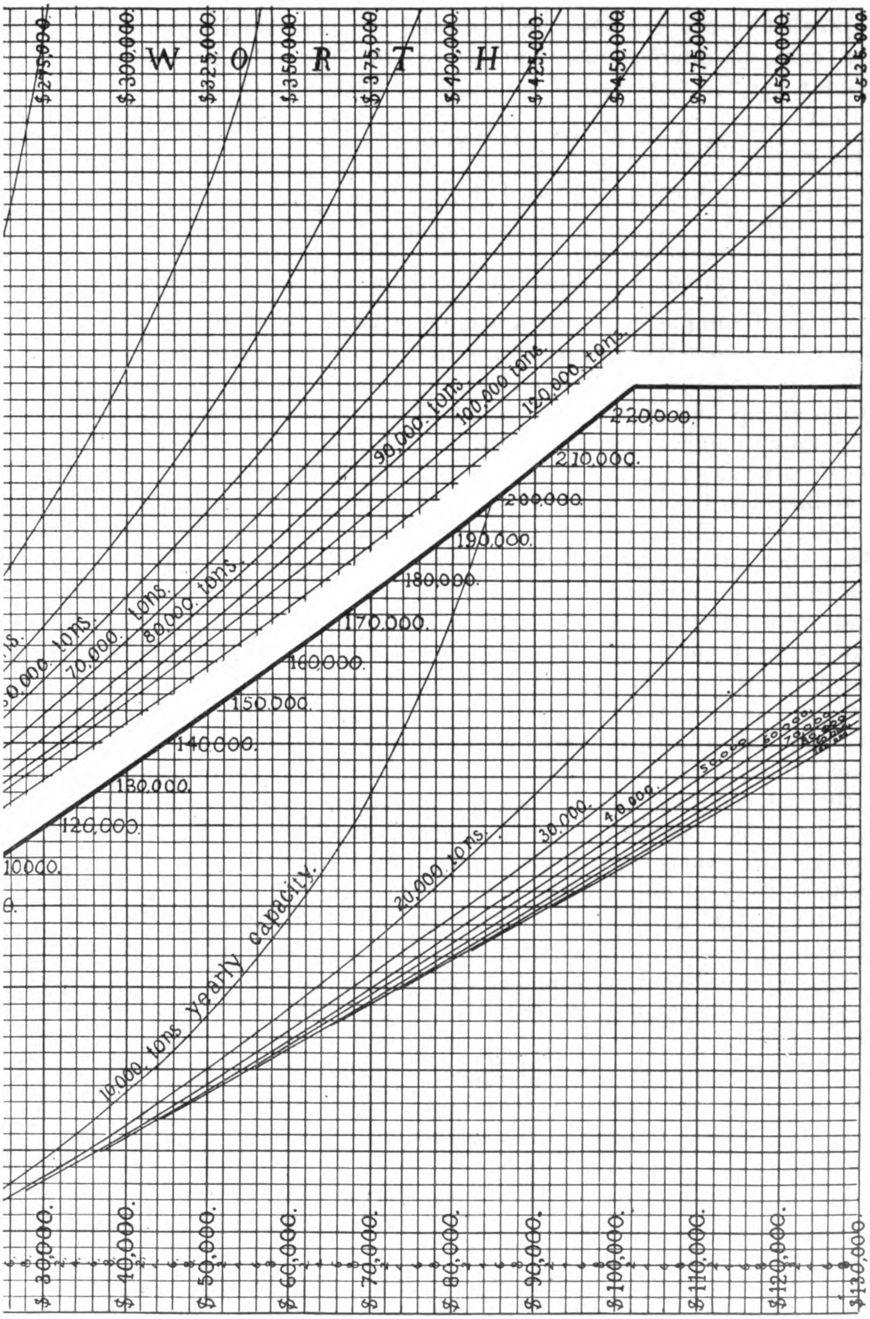


Fig. 80. Present


W O R T H
$275,000
$300,000
$325,000
$350,000
$375,000
$400,000
$425,000
$450,000
$475,000
$500,000
$525,000
ns.
0,000 tons
70,000 tons.
80,000 tons.
90,000 tons.
100,000 tons.
120,000 tons.
220,000.
210,000.
200,000.
190,000.
180,000.
170,000.
160,000.
150,000.
140,000.
130,000.
120,000.
10000.
0.
10,000 tons yearly capacity.
20,000 tons.
30,000.
40,000.
50,000.
60,000.
70,000.
80,000.
90,000.
100,000.
$30,000.
$40,000.
$50,000.
$60,000.
$70,000.
$80,000.
$90,000.
$100,000.
$110,000.
$120,000.
$130,000.

Worth Chart.

the present worth for cases not covered by the table, or at some other rate of interest, may do so by the use of the following formula:

$$\frac{(1+r)^n-1}{r(1+r)^n} \times A = P.\ W.$$ In which,—

r=rate of interest expressed decimally.
A=annuity.
P. W.=present worth.

A few examples will illustrate the scope and value of the chart.

1063. Example 1. A certain mine contains 380,000 tons of ore blocked out, and the buyer and seller agree that 20,000 tons of similar ore probably exists ahead of the present workings. The ore may be mined and milled at a profit of $1.50 per ton in a twenty-stamp mill having a yearly capacity of 20,000 tons. What is the present value of the mine?

Solution: Upon the chart, Fig. 80, in the column of "Tons ore reserve," select 400,000 and follow the horizontal line to the right to the intersection with the curved line marked "20,000 tons." Then follow up or down the vertical line where the present worth is found to be $170,000. As the profit will be $1.50 per ton the present worth of the mine in this case will be $170,000 × 1.50 = $255,000. This means that when the last of the 400,000 tons of ore has been mined and milled, the buyer will have had his investment for the mine and mill returned, together with 10% compound interest on his investment. He will also have the mill, which could be sold at a greatly reduced price, or in case he has discovered more ore than could be safely assumed at the time of purchase, could be kept running. In other words, the interest on a twenty-year annuity of $30,000 will amount to the same sum at maturity as the single item of $255,000 at interest for twenty years. (The twenty-stamp mill is assumed to handle 20,000 tons annually at a net profit of $1.50 a ton for twenty years, the life of the mine). Clearly then, reversing the operations, the present worth of the $30,000 annuity is $255,000.

1064. Example 2. Ore blocked out, 112,000 tons. Ore ahead (probable ore), estimated, 40,000 tons. Profit per ton in thirty-stamp mill, $0.50. Cost of thirty-stamp mill, $25,000. What is the present worth of the mine?

Solution: Select 152,000 tons "ore reserve" at the left. Follow to the right to the curved line marked "30,000." At the bottom find $114,000. (Use the chart in the lower right hand corner, Fig. 80). Divide by 2 (profits 50 cents per ton). The result is $57,000. Subtracting $25,000, the cost of the mill, leaves $32,000 as the selling price of the mine.

1065. Example 3. Ore blocked out, 600,000 tons. Probable ore 100,000 tons. Cost of forty-stamp mill $30,000. Estimated that a forty-stamp mill will handle 25,000 tons per year. Profit per ton, estimated, $2.00.

Solution: Select 700,000 on the left, follow to the right to half way between 20,000 to 30,000 capacity curves. Follow the vertical line to the top where the present worth is found to be $230,000. Multiply by 2. The product is $460,000. Subtracting $30,000, the cost of the mill, leaves $430,000 as the present value of the mine.

1066. It will be observed that if a mill be selected which is too small for the mine under consideration, the present worth, or selling price will be lower than if a suitable mill be built, owing to the comparatively high cost for milling in a small mill. If the mill selected is too large, the present worth will also be lower than for a proper mill. This is because the cost of the mill must be returned to the purchaser in the form of profit, and whatever decreases the net profits will decrease the present worth. Therefore, if data is at hand so that a reliable estimate of the cost of mining and milling can be made, the chart can be used for determining the size of the mill most suitable for any mine under consideration with considerable reliability. This use of the chart can be most easily understood by an example.

1067. Suppose we have a mine with an 80,000 ton ore reserve. Let the net profit be assumed at $0.75 per ton with a ten-stamp mill costing $10,000. This gives us ($53,000 × ¾) — $10,000 = $29,750. as the price of the mine. Now, try a forty-stamp mill, assuming a net profit of $1.00 per ton. This will give us $70,000 — $40,000 = $30,000 as the price to pay the seller in order that the buyer may have the cost of both mill and mine returned to him by the time the ore is exhausted. Now try a twenty-stamp mill, and assume that the calculated net profit is $0.90 per ton. The chart gives $63,500, and ($63,500 × .90) — $20,000 = $37,150. Evidently, the ten-stamp mill is too small, the present worth being only $29,750, owing to the low profit per ton. The forty-stamp mill increases the profit per ton to $1.00, but as the cost of the mill (also the purchase price of the mine) and 10% compound interest on the investment must be returned to the purchaser by the time the 80,000 tons of ore has been milled, the present worth is reduced to nearly $30,000. The twenty-stamp mill yields the highest present worth, owing to the fact that it is large enough to bring the profit per ton up to $0.90, but not so expensive that the interest on the cost of it will eat up the profits. Therefore, the proper selling price is $37,150 and a twenty-stamp mill most suitable, for the mill which will produce the highest present worth is the most profitable in any case. This latter statement should be self-evident—it can be mathematically demonstrated to any one doubting it, however. The most suitable mill for any other mine may be determined by the use of the chart in a manner similar to the above. There are, of course, many rich mines and prospects in favored districts, as in parts of Nevada, which will sell for exceedingly high sums—many times larger than would be obtained were the sale based solely upon the ore blocked out. This is no argument against the use of the chart, which may be used to advantage in any case, the value of the "probable ore" being taken into consideration.

1068. Owner's Report on a Mine or Prospect.—The examination and report may be made by a mining engineer, or by the owner. In either case the following points should be covered in the report. Any other information considered useful should be added.

Report.

1 Name of owner.
2 Address.
3 Name of mine.
4 Placer or lode claim.
5 Situated near ...., in Sec...., T...., R....
6 Draw a map of the entire immediate mining district, showing all mining locations and operating mines. Draw to scale.
7 Draw a map of your claims to a large scale.
8 Which claims are patented?
9 Which claims are surveyed for patent?
10 Are there are conflicts with claims of other parties?
11 Was the assessment work done last year?
12 Is your title undisputed?
13 Is your mine a shaft, cross-cut tunnel, or drift tunnel proposition?
14 What development has been made? Draw map of developments. Mark the width of vein and assay value at each place sampled.
15 How much water is available for household, mine, or power purposes?
16 How much water is in the mine?
17 Cost of fuel? Cost of timber?
18 Cost of common labor of all kinds required.
19 Distance to the nearest railroad station.
20 Condition of the road from the mine to the station.
21 How many tons of ore exposed on three sides? Exposed on two sides? Exposed on one side?
22 How much probable ore do you believe can be safely depended upon? Here compute the value of the mine, using the Present Worth Chart, Fig. 80.

CHAPTER XIX.

USEFUL INFORMATION.

Tables of Weights and Measures.

1069. *Troy Weight.*

24 grains	1 pennyweight.
20 pennyweights	1 ounce, 480 grains.
12 ounces	1 pound, 5760 grains.

1070. *Avoirdupoise Weight.*

16 drams	1 ounce, 437½ grains.
16 ounces	1 pound, 7000 grains.
2000 pounds	1 ton.

1071. *Liquid Measure.*

4 gills	1 pint.
2 pints	1 quart.
4 quarts	1 gallon, 231 cu. ins.

1072. *Dry Measure.*

4 pecks	1 bushel, 2150.42 cu. ins.
8 quarts	1 peck.
2 pints	1 quart.

1073. *Linear Measure.*

12 inches	1 foot.
3 feet	1 yard.
5½ yards	1 rod.
320 rods	1 mile.
3 miles	1 league.
6080.27 feet (in U. S.)	1 nautical mile. 1 geographical mile. 1 knot (at sea).
120 fathoms	1 cable's length, 720 feet.

1074. *Time.*

60 seconds	1 minute.
60 minutes	1 hour.
24 hours	1 day.
7 days	1 week.
52 weeks	1 year.

1075. *Longitude and Time.*

15° of longitude	1 hour.
1° of longitude	4 minutes.
1′ of longitude	4 seconds.
1″ of longitude	.066 seconds.

1076. *Land Surveyor's or Land Measure.*

144 sq. inches	1 square foot.
9 sq. feet	1 square yard.
30¼ sq. yards	
160 sq. rods, 43560 sq. ft.	1 square rod.
10 sq. chains	1 acre.

1077. *Cubic Measure.*

1728 cu. ins.	1 cu. foot.
27 cu. ft.	1 cu. yard.

Metric solid and liquid measure.

1000 cu. millimeters	1 cu. centimeter. 1 gram of distilled water.
1000 cu. centimeters	1 liter 1 cu. decimeter. 1.05671 quarts.

1078. *Metric Weights.*

10 milligrams	**1 centigram**
10 centigrams	**1 decigram**
10 decigrams	**1 gram. 15.432 grains.**
10 grams	**1 dekagram. (decagram.)**
10 decagrams	**1 hectogram.**
10 hectograms	**1 kilogram. 2.2046 pounds Av.**
10 kilograms	**1 myriogram.**
10 myriograms	**1 quintal.**
10 quintals	**1 ton, 2204.6 pounds Av.**

1079. *Lumber Measure.*

Size in inches.	Length in feet.									
	12	14	16	18	20	22	24	26	28	30
2x3	6	7	8	9	10	11	12	13	14	15
2x4	8	9	11	12	13	15	16	17	19	20
2x6	12	14	16	18	20	22	24	26	28	30
2x8	16	19	21	24	27	29	32	35	37	40
2x10	20	23	27	30	33	37	40	43	47	50
2x12	24	28	32	36	40	44	48	52	56	60
2x14	28	33	37	42	47	51	56	61	65	70
2x16	32	37	43	48	53	59	64	69	75	80
3x4	12	14	16	18	20	22	24	26	28	30
3x6	18	21	24	27	30	33	36	39	42	45
3x8	24	28	32	36	40	44	48	52	56	60
3x10	30	35	40	45	50	55	60	65	70	75
3x12	36	42	48	54	60	66	72	78	84	90
3x14	42	49	56	63	70	77	84	91	98	105
3x16	48	56	64	72	80	88	86	104	112	120
4x4	16	19	21	24	27	29	32	35	37	40
4x6	24	28	32	36	40	44	48	52	56	60
4x8	32	37	43	48	53	59	64	69	75	80
4x10	40	47	53	60	67	73	80	87	93	100
4x12	48	56	64	72	80	88	96	104	112	120
6x6	36	42	48	54	60	66	72	78	84	90
6x8	48	56	64	72	80	88	96	104	112	120
6x10	60	70	80	90	100	110	120	130	140	150
6x12	72	84	86	108	120	132	144	156	168	180
8x8	64	75	85	96	107	117	128	139	149	160
8x10	80	93	107	120	133	147	160	173	187	200
8x12	96	112	128	144	160	176	192	208	224	240
10x10	100	117	133	150	167	183	200	217	233	250
10x12	120	140	160	180	200	220	240	260	280	300
12x12	144	168	192	216	240	264	288	312	336	360
12x14	168	196	224	252	280	308	336	364	392	420
14x14	196	229	261	294	327	359	392	425	457	490

1080. *Equivalents.*

1 (troy) grain = .064798 grams
1 gram = 15.43235 grains
1 gram of gold = $0.6646
1 (troy) pennyweight of gold = $1.0335
1 (avoir.) ounce of gold = $18.8415
1 Assay ton = 29.166 grams = 450.099 grains
1 Assay ton = 29166.66 milligrams
1 (avoir.) ton = 29166.66 troy ounces = 2000 pounds

1081. *Special Multiplication Tables.*

Explanation. If it is desired to find the number of square feet in 279 acres proceed as follows:

9×43560, by the table = 392040
7×43560, by the table = 304920
3×43560, by the table = 87120

Total = 11153240 sq. ft.

If it is desired to find the number of gallons in 729864 cu. ins. we proceed as follows:

729864 (3159
By table 231 × 3 = 693
368
By table 231 × 1 = 231
1376
By table 231 × 5 = 1155
2214
By table 231 × 9 = 2079
135 remainder.

27 table.
Cubic yards to cubic feet.
27 cu. ft. = 1 cu. yd.

27 × 1 = 27
27 × 2 = 54
27 × 3 = 81
27 × 4 = 108
27 × 5 = 135
27 × 6 = 162
27 × 7 = 189
27 × 8 = 216
27 × 9 = 243
Log.27 = 1.4313638

Tons of quartz to cu. yds.
13 cu. ft. of quartz = 1 ton.

13 × 1 = 13
13 × 2 = 26
13 × 3 = 39
13 × 4 = 52
13 × 5 = 65
13 × 6 = 78
13 × 7 = 91
13 × 8 = 104
13 × 9 = 117

66 table.
Chains to feet.
66 feet = 1 chain.

66 × 1 = 66
66 × 2 = 132
66 × 3 = 198
66 × 4 = 264
66 × 5 = 330
66 × 6 = 396
66 × 7 = 462
66 × 8 = 528
66 × 9 = 594
Log.66 = 1.8195439

Miles to feet.
5280 ft. = 1 mile.

5280 × 1 = 5280
5280 × 2 = 10560
5280 × 3 = 15840
5280 × 4 = 21120
5280 × 5 = 26400
5280 × 6 = 31680
5280 × 7 = 36960
5280 × 8 = 42240
5280 × 9 = 47520
Log. 5280 = 3.7226339

Acres to square feet.
43560 sq. ft. = 1 acre.

43560 × 1 = 43560
43560 × 2 = 87120
43560 × 3 = 130680
43560 × 4 = 174240
43560 × 5 = 217800
43560 × 6 = 261360
43560 × 7 = 304920
43560 × 8 = 348480
43560 × 9 = 392040
Log.43560 = 4.16460863

20.67 table.
Ounces gold to dollars.
Value of 1 troy oz. = $20.67.

20.67 × 1 = 20.671
20.67 × 2 = 41.343
20.67 × 3 = 62.015
20.67 × 4 = 82.687
20.67 × 5 = 103.359
20.67 × 6 = 124.030
20.67 × 7 = 144.702
20.67 × 8 = 165.374
20.67 × 9 = 186.046
Log.20.6718 = 1.3153784

7.48 table.

Cubic feet to gallons.
748 gallons = 1 cu. ft.

7.48 × 1 = 7.48
7.48 × 2 = 14.96
7.48 × 3 = 22.44
7.48 × 4 = 29.92
7.48 × 5 = 37.40
7.48 × 6 = 44.88
7.48 × 7 = 52.36
7.48 × 8 = 59.84
7.48 × 9 = 67.32
Log.748 = .8739317

231 table.

Gallons to cubic inches.
231 cu. ins. = 1 gallon.

231 × 1 = 231
231 × 2 = 462
231 × 3 = 693
231 × 4 = 924
231 × 5 = 1155
231 × 6 = 1386
231 × 7 = 1617
231 × 8 = 1848
231 × 9 = 2079
Log.231 = 2.363120

7.48 division table.

Gallons to cu. ft.
7.480519 gallons = 1 cu. ft.

1 × 7.48 = .133681
2 × 7.48 = .267361
3 × 7.48 = .401042
4 × 7.48 = .534722
5 × 7.48 = .668403
6 × 7.48 = .802083
7 × 7.48 = .935764
8 × 7.48 = 1.069444
9 × 7.48 = 1.203125

3.1416 table. 3.1416 table.

Diameter of circle to circumference.
Diameter X 3.1416 = circumference.

3.1416 × 1 = 3.1416
3.1416 × 2 = 6.2832
3.1416 × 3 = 9.4248
3.1416 × 4 = 12.5664
3.1416 × 5 = 15.7080
3.1416 × 6 = 18.8496
3.1416 × 7 = 21.9912
3.1416 × 8 = 25.1328
3.1416 × 9 = 28.2744
Log.3.14159 = 1.7581226

.7853982 table.

Diameter of circle to area.
Diameter X .7854 = area of circle.
Diam. X .7854 X 4 = area of sphere.

.7854 × 1 = .7854
.7854 × 2 = 1.57079
.7854 × 3 = 2.35619
.7854 × 4 = 3.14159
.7854 × 5 = 3.92699
.7854 × 6 = 4.71238
.7854 × 7 = 5.49778
.7854 × 8 = 6.28318
.7854 × 9 = 7.06858
Log .7853982 = 9.8950899

4.1888 table.

Radius of sphere to volume.
Cube of radius X 4.1888 = volume.

4.1888 × 1 = 4.1888
4.1888 × 2 = 8.3776
4.1888 × 3 = 12.5664
4.1888 × 4 = 16.7552
4.1888 × 5 = 20.9440
4.1888 × 6 = 25.1328
4.1888 × 7 = 29.3216
4.1888 × 8 = 33.5104
4.1888 × 9 = 37.6992
Log.4.1888 = .6228896

1082. *Cubic feet to the ton.*

4.2 cu. ft. of solid galena	1 ton.
5.6 cu. ft. of solid chalcocite	1 ton.
6 cu. ft. of solid iron pyrites	1 ton.
13 cu. ft. of. solid quartz	1 ton.
14 cu. ft. of loose, broken quartz	1 ton.
18 cu. ft. of loose, clay	1 ton.
19 cu. ft. of loose, gravel	1 ton.
21 cu. ft. of loose, soil	1 ton.
22 cu. ft. of loose, sand	1 ton.
23 cu. ft. of loose, quartz rock	1 ton.
20 cu. ft. of settled, broken quartz	1 ton.

1083. *Wheelbarrow loads.*

3 to 4 cu. ft. of rock	1 wheelbarrow load.
9 to 10 wheelbarrow loads	1 hour's work for one man.

1084. *Ore car loads.*

¾ ton of broken quartz	1 ore car of average size.

1085. *Shaft vs. tunnel.*

1 ft. of shaft (wet) costs as much as 2 to 3 ft. of tunnel.
1 ft. of shaft (dry) costs as much as 1½ to 2 ft. of tunnel.

1086. *Cu. yds. solid vs. cu. yds. broken.*

1 cu. yd. of solid rock 1.8 cu. yds. of rock broken by blasting.
1 cu. yd. of solid rock 1.6 cu. yds. of packed broken rock.

1087. **Code of Mine Signals.**

Code of signals adopted by Colorado and Wyoming.

1 bell —Hoist.
1 bell —Stop (if in motion).
2 bells—Lower.
3 bells—Men on, run slowly (followed by one or two bells after men are on).
7 bells—Accident, hoist or lower by verbal orders only.
3-2-1 bells—Ready to shoot. After signal 3-2-1, the engineer shall raise the bucket or cage 2 feet and lower again to show that all is in working order, and he shall remain at his post until the final order is given. Miners should then signal 3 bells, spit the fuses, get on the cage or bucket and signal 1 bell to hoist

1-1 bells..........	1st level.
1-2 bells..........	2nd "
1-3 bells..........	3rd "
1-4 bells..........	4th "
1-5 bells..........	5th "
2-1 bells..........	6th "
2-2 bells..........	7th "
2-3 bells..........	8th "
2-4 bells..........	9th "
2-5 bells..........	10th "
4-1 bells..........	11th "
4-2 bells..........	12th "
4-3 bells..........	13th "
4-4 bells..........	14th "
4-5 bells..........	15th "
5-1 bells..........	16th "
5-2 bells..........	17th "
5-3 bells..........	18th "
5-4 bells..........	19th "
5-5 bells..........	20th "

Other signals may be added to suit special cases.

1088. *Code of Mine Signals Adopted by California.*

1 bell —hoist.
1 bell —stop, if in motion.
2 bells—to lower bucket or cage.
3 bells—man to be hoisted; run slowly.
4 bells—start pump if not running, or stop it if running.
1-3 bells—start or stop air compressor.
5 bells—send down tools.
6 bells—send down timbers.
7 bells—accident, run by verbal orders only.
1-4 bells—foreman wanted.
2-1-1 bells—done hoisting till called.
2-1-2 bells—done hoisting for the day.
2-2-2 bells—change buckets from ore to water, or vice versa.
3-2-1 bells—ready to shoot in shaft.

Signal to stop at a level is given by ringing the number of the level immediately before giving the signal to hoist or lower, making a double pause after the level number, thus:

4-3-1 bells—means stop at fourth level, man on, hoist.
2-1-4 bells—means stop at the second level with foreman.
6-5 bells—means stop at the sixth level with tools.

Rule 1. The interval (-) should take the same time as for the stroke of the bell, no more.

Rule 2. Never get on or off the cage while it is in motion.

Rule. 3. After signal "ready to shoot in shaft" the engineer must raise the bucket or cage two feet and lower it again, remaining at his post till 1 bell is given to hoist. Miners then signal 3 bells, spit the fuse, get in the bucket, and then signal 1 bell to be hoisted.

1089. **Loading Ore Cars.**

One man can load an ordinary ore car by shovelling in 15 minutes under favorable circumstances. Local conditions may be such as to require twice as long. The condition of the floor, the fineness of the rock, and its weight are all elements that must be considered. It is common practice to use a flooring of loose boards at all drift faces, but strips of sheet iron are much better. As ore cars are often loaded, moved and emptied by the same man, the following tables have been calculated to facilitate the estimation of work:

Trips per day.—This table gives the number of trips per day one carman can make in a mining tunnel, using the ordinary ore car (¾ ton), and loading his own car. One minute is allowed for dumping the car and 15 minutes for loading. The carman is supposed to travel at the rate of 2½ miles per hour. (200 feet per minute.)

Distance from dump to face.	*Hours worked in one day.*		
	8	9	10
feet.	*trips.*	*trips.*	*trips.*
100	28	32	35
200	27	30	33
300	26	28	31
400	24	27	30
500	23	26	28.5
600	22	25	27
700	21	23	26
800	20	22.5	25
900	19	21.7	24
1000	18	20.8	23
1500	15	17	20
2000	13	16	16.6
2500	10	13	14

When a car, or a train or ore cars, is hauled by man, animal, or other power, the number of trips per day may be calculated by the use of either of the following formulas:

$$\frac{\text{Minutes in one day's work.}}{\left(\begin{array}{l}\text{minutes to load,}\\ \text{empty, switch, etc.}\end{array}\right) + \dfrac{\text{Length of round trip in feet}}{\text{Speed in feet per minute.}}} = \text{Trips per day.}$$

$$\frac{\text{Hours in one day's work.}}{\left(\begin{array}{l}\text{Hours to load,}\\ \text{empty, switch, etc.}\end{array}\right) + \dfrac{\text{Length of round trip in miles}}{\text{Speed in miles per hour.}}} = \text{Trips per day.}$$

The following table gives the number of trips per day one carman can make in a mining tunnel, using an ordinary ore car (¾ ton), the cars being filled ready for him as he returns with the empty car. Four minutes time is allowed for dumping and switching cars. The carman is supposed to travel at a speed of 2½ miles per hour.

Distance from dump to face.	*Hours worked in one day.*				
	8	9	10	11	12
feet.	*trips.*	*trips.*	*trips.*	*trips.*	*trips.*
100	96	108	120	132	144
200	80	90	100	110	120
300	70	77	85	94	102
400	60	67	75	82	90
500	53	60	66	73	80
600	48	54	60	66	72
700	43	49	54	60	65
800	40	45	50	55	60
900	37	41	46	51	55
1000	34	38	42	47	51
2000	14	21	24	27	29

Example: How many trips a day can be made with an ore car, working eight hours (480 minutes) per day, round trip .2 miles (1056 feet), speed 2½ miles per hour (220 feet per minute), time loading, etc., 15 minutes?

Solution:

$$\frac{480}{15+\frac{5280\times .2}{220}} = \frac{480}{15+4.8} = \frac{480}{19.8} = 24.24 \text{ trips.}$$

Solution by rule under 772, b.

$$\frac{8}{\frac{1}{4}+\frac{.2}{2.5}} = \frac{8}{\frac{1}{4}+\frac{2}{25}} = \frac{800}{33} = 24.24 \text{ trips.}$$

1090. **Horse Power.**

One horse power is the amount of energy required to lift 550 pounds one foot high in one second, or 33000 pounds in one minute. [See Sec. 18].

$$\text{Horse Power} = \frac{\text{Pounds} \times \text{feet}}{550 \times \text{seconds}} = \frac{\text{Pounds} \times \text{feet}}{33{,}000 \times \text{minutes.}}$$

Example: An engine of what horse power will be required to raise 2,000 pounds at the rate of 1,000 feet per minute? (No allowance being made for friction).

Solution:

$$\text{Horse Power} = \frac{\text{Pounds} \times \text{feet}}{33{,}000 \times \text{minutes}} = \frac{2000 \times 1000}{33{,}000 \times 1} = \textbf{6.6 H. P.}$$

1091. *Horse-Power transmitted by belts.*

Single leather belt.—Multiply width in inches by velocity in feet per minute and divide by 1,000.

1092. *Horse-Power transmitted by shafting.*

Main line shafts should have a higher factor of safety than counter shafts. In all cases bearings should be close enough to prevent the deflection exceeding 1/100 inch per foot of length.

$H.P. = d^3 R \div 125$, for main line shaft, turned iron.
$H.P. = d^3 R \div 90$, for counter shaft.
$H.P. = d^3 R \div 75$, for main shaft, steel

d = diameter in inches.
R = revolutions of shaft per minute.

1093. *Horse-Power of belts.*

1203. Horse-power transmitted per inch of width of rubber belt for each 600 feet of speed per minute.

4 ply	5 ply	6 ply	7 ply	8 ply
1.0	1.2	1.4	1.6	1.8

Example: What horse-power may be transmitted by a 6-inch 5-ply rubber belt traveling 3,000 feet per minute?

$$\frac{3000 \times 1.2 \times 6}{600} = 36.\ \text{H. P.}$$

1094. *Actual horse-power of a boiler.*

The unit adopted by the American Society of Mechanical Engineers is the capacity to evaporate 30 pounds of water per hour from a temperature of 100 F., into steam at 70 pounds gauge pressure, or 34¼ pounds of water per hour from a feedwater temperature of 212 F., into steam at atmospheric pressure. A rough rule is:

No. of tubes × length in feet × dia. of tubes in inches × 50 = H. P.

1095. *Horse-power of steam engine.*

For single-cylinder (Corliss or shaft-governor, high speed engine type), square the diameter of the cylinder and divide by 2. This is only approximate.

1096. *Horse-Power of a Waterfall.*

To find the horse-power of a waterfall,—

Let H. P. = Available horse-power.
H = Height of fall in feet.
Q = Quantity of water in cubic feet per minute.
e = Efficiency of the water wheel or power plant.
Then $H.P. = .0019HQe$.

Example: What is the available horse-power of 600 cubic feet of water per minute at a height of 20 feet above the water wheel, the plant having an efficiency of 80%?

Solution: $.0019 \times 20 \times 600 \times 80\% = 18.24$ H. P.
A pipe line usually has an efficiency of 95%.
Electric generators usually have an efficiency of 96%.
Water wheel usually has an efficiency of 80%.
Transformer usually has an efficiency of 98%.
Nozzles, etc., usually has an efficiency of 98%.
Average efficiency of the water power electric plant, 67% to 70%.

1097. **Miner's Inch.**

Miner's inch = 1½ cubic feet per minute.
Cubic feet per minute divided by 1½ = miner's inches.

1098. **Forces.**

Levers.

Let P = power.
W = weight.
Lp = length of power arm.
Lw = length of weight arm. Then,—

$$P : W :: Lw : Lp, \text{ or } P \times Lp = W \times Lw.$$

1099. *Wheel and Axle.*

Let R = radius of the power or lever.
r = radius of the axle supporting the weight or load.
P = pounds of force used to turn the power arm.
W = weight raised by the axle. Then,—
r : R :: P : W

1100. *Block and Tackle.*

Let L = load in pounds.
s = number of supporting ropes.
P = power in pounds. Then,—

$$P = \frac{L}{s} \text{ or } Ps = L.$$

1101. *Force of Wind.*

Wind blowing one mile an hour produces .004 pounds per square foot, and the force or pressure increases with the square of the velocity. 10 miles an hour = .4 pounds per square foot. 100 miles per hour = 40 pounds per square foot.

1102. *Strength of rope or chains.*

Let W = safe load in tons of 2,000 pounds.
D = diameter of rope in inches = dia. of iron from which chain is made.
W = ½ D for common hemp rope.
W = 8/3 D for iron wire rope.
W = 14/3 D for steel wire rope.
W = 6 D for closed link chain.

Example: What is the safe load for a steel wire cable ⅞ inch in diameter?

Solution:

$$W = 14/3\ D = 14/3\ X\ (7/8)^2 = 14/3\ X\ 49/64 = 689/192 = 3.5 \text{ tons.}$$

Value of Bullion.

[See 690-1-2.]

1103. To ascertain the fineness of bullion, gold nuggets, etc., take about one gram of fine drillings or shavings and fuse with an equal amount of silver with a blowpipe. Hammer flat and heat to a dull red to anneal. Dissolve in dilute (half water) nitric acid, wash with distilled water, or rain water. Carefully collect the residue (black) in a porcelain capsule and very slowly heat it to dryness. Then heat red hot when the gold will assume its natural yellow color. This is pure gold. Considerable skill is required to do this work. It is advisable to employ an assayer.

Let W = weight of the filings.
G = weight of pure gold obtained.
Then,—

$$\frac{G\ X\ 1000}{W} = \text{Fineness.}$$

1104. The gold testing points used by jewelers will give fairly accurate results, the maximum error being less than 86 cents per ounce. They may be used by any one. As these points give the purity in carets instead of fineness it will be necessary to use the table under section 695. To use the points make three marks on the stone sold for the purpose, one with the nugget and the others with the points between which you think the purity will come. Dissolve the alloy of all three marks with a drop of nitric acid and observe the brightness of the remaining mark, and judge of the fineness in carats.

1105. To find the value of nuggets of placer gold any of the following formulas may be used when the purity is known:

Ounces × $20.67 × carats divided by 24 = value.
Pennyweights × $1.033 × carats divided by 24 = value.
Ounces × $20.67 × fineness divided by 1,000 = value.
Pennyweights × $1.033 × fineness divided by 1,000 = value.
Use the 20.67 table under 1081 when multiplying by 20.67.

Example: A solid gold watch case weighs 26 pennyweights and is 18 carats fine. What is the gold worth as bullion?

Solution: $1.033 × 26 × 18 divided by 24 = $20.14.

Value of gold in a specimen.

1106. To determine the weight and value of the pure gold in a quartz specimen without injuring the specimen estimate the fineness of the gold and use the following formula:

$$\frac{(X-Y)\,W}{X-1} = \text{Weight of gold in the specimen.}$$

Let,

$$X = \frac{\text{Sp. g. of gold in the specimen.}}{\text{Sp. g. of quartz.}}$$

$$Y = \frac{\text{Sp. g. of gold in the specimen.}}{\text{Sp. g. of the specimen.}}$$

W = weight of specimen.
G = weight of pure gold in the specimen.
19.33 = Sp. g. of pure gold.
17.85 = Sp. g. of gold 900 fine.
16.55 = Sp. g. of gold 800 fine.
15.44 = Sp. g. of gold 700 fine.

Example: Sp. g. of gold in a specimen is 17. The Sp. g. of quartz is 2.6. Weight of specimen is 115.355 oz. Sp. g. of the specimen is 2.985 [232].

$$\frac{\left(\frac{17}{2.6}-\frac{17}{2.985}\right)115.355}{\frac{17}{2.6}-1} = \frac{(6.539-5.695)\;115.355}{5.539} = 17.577 \text{ oz. gold}$$

1107. The above rule may be used for finding the weight of one of two minerals in a rock, or for finding the proportions of two metals in an alloy. The specific gravity of gold as found in nature is lower than pure gold, being from 15 to 19. As a rule it is near 18. Ascertain the fineness by the use of the jeweler's points before applying the formula. In any case let X = the larger and Y = the smaller of the two quantities.

Example: Silver in calcite.
Sp. g. Ag. = 9. (See a mineralogy.)
Sp. g. CaCO = 2.7
Sp. g. of specimen = 8.
Weight of specimen = 84. oz. Then, —

$$\frac{(x-y)\,w}{x-y} = \frac{\left(\frac{9}{2.7}-\frac{9}{8}\right)84}{\frac{9}{2.7}-1} = \frac{(3.333-1.125)\;84}{3.333-1} = \frac{2.208\times 84}{2.333} = 79 \text{ oz}$$

Carpentry.

1108. *To find the number of shingles for a roof.*—Multiply the square feet of surface in the roof by 8 if the ends of the shingles are exposed 4½ inches to the weather. If exposed 5 inches multiply by 7.2. There are 250 shingles to a bundle.

1109. *To find the length of a rafter.*—For quarter pitch multiply the width of the building, outside to outside, by 56 and point off two places for decimals. For third pitch multiply by 60 and point off two decimal places. For half pitch multiply by 71 and point off two decimal places.

1110. *Shakes.*—1,000 shakes, 6" x 36", laid 16" to the weather, will cover 650 sq. ft. of surface; add for doubling top and bottom courses one extra shake for each ft. in the length of the roof.

1111. *Corrugated Galvanized Roofing.*—Size of sheets 26 inches by from 6 to 10 ft. flat steel, made corrugated with corrugations about 1" in depth and 5" between centers of corrugations, laying 24" wide, with from 3" to 6" lap, according to pitch of roof, weigh about one-third more than flat sheets of same area.

For roofing, No. 24 is more generally used, while No. 26 is used for siding. Tack with wire nails on ends only and lap one corrugation on sides and from one to two inches on ends. The nail heads are sometimes soldered to assure absolute impermeability. The usual method, however, is to place lead washers under the heads.

1112. *Lumber.*—When computing the amount of material required to cover a specified area, add to the area:

For 1"x6" tongue and groove, 20%.
" 1"x4" " " 25%
" 1"x4" " " kiln dried, 30%.
" rustic, 25%.

1113. *Nails.*—For 1,000 shingles allow 4 lbs. of 4d nails or 3½ lbs. of 3d nails.

For 1,000 lath allow 6 lbs. 3d fine nails.
" 1,000 ft. of clapboarding allow 18 lbs. of 6d box nails.
" 1,000 ft. of board siding allow 20 lbs. 8d or 25 lbs. 10d common nails.
" 10 ft. of partition studding allow 1 lb. of 10d common nails.
" 1,000 ft. of 1"x3" flooring allow 45 lbs. 10d common nails.
" 1,000 ft. of 1"x2" flooring allow 65 lbs. 10d common nails.
" 1,000 ft. of pine finish allow 30 lbs. of 8d wire nails.

1114. *Brick.*—A 4½" wall requires 7 brick per sq. ft. of surface.
9" " " 14 " " " "
13" " " 20 " " " "
18" " " 26½ " " " "
21" " " 33 " " " "
27" " " 39½ " " " "

The weight of brickwork is 112 pounds per cu. ft.

Laid brick will crush at 500 lbs. per sq. in. or at 72,000 lbs. per sq. ft.

Fire brick weighs 150 lbs. per cu. ft.

Cement concrete weighs 140 lbs. per cu. ft.

A bricklayer should average 1,500 bricks in 8 hours, and 2,000 to 2,400 when starting wall before staging or ladder is used. Staging is used above 4 ft.

Brick at $10.00 and labor at $7.50 per 1,000 should be considered good work.

CONCRETE.

1115. *Formula No.* 1.—For retaining walls and machinery foundations.
60 cu. ft. of rock that will pass a 3-inch mesh screen.
20 cu. ft. of clean, sharp, coarse sand.
10 cu. ft. of Portland cement.

1116. *Formula No.* 2.—For concrete mortar blocks for stamp batteries.
52 cu. ft. of rock.
32 cu. ft. of sand.
16 cu. ft. of cement.

If broken rock is not available, clean creek gravel of the same size may be substituted, but in no case use clay, loam or very fine sand.

Mix all together dry. When required for use, mix small quantities with sufficient water to make a thick mortar, use immediately and tamp with a tamping bar.

Concrete will set sufficiently in 24 hours to sustain a load, and in from three to four days in medium dry weather machinery may be run on the foundations.

Electricity.

1117. *Resistance and weight of copper wires.*

Gauge No.	*Resistance of 1000 ft. Ohms.*	*Pounds per 1000 ft.*	*Safe current Underwriters' Rule. Amperes.*
0000	.001	639.33	312
000	.063	507.01	262
00	.080	402.09	220
0	.101	319.04	185
1	.127	252.88	156
2	.160	200.54	131
3	.202	159.03	110
4	.254	126.12	92
5	.321	100.01	77
6	.401	79.32	65
7	.509	62.90	..
8	.643	49.88	46
9	.811	39.56	..
10	1.023	31.37	32
11	1.289	24.88	..
12	1.626	19.72	23
13	2.048	15.65	..
14	2.585	12.41	16
15	3.177	9.84	..
16	4.582	7.81	8
17	5.183	6.19	..
18	6.536	4.91	5
19	8.477	3.78	..
20	10.394	3.09	The above is for weatherproof insulated wire.
21	13,106	2.45	
22	16.525	1.94	
23	20.824	1.54	
24	26.284	1.22	
25	33.135	.97	
26	41.789	.77	
27	52.687	.61	
28	66.445	.48	
29	83.752	.38	
30	105.641	.30	
31	133.191	.24	
32	168.110	.19	
33	211.820	.15	
34	267.165	.12	
35	336.85	.10	
36	424.65	.08	
37	535.33	.06	
38	675.22	.05	
39	851.78	.04	
40	1074.11	.03	

The OHM is the unit of resistance. R.
The VOLT is the unit of force or difference of pressure. E.
The AMPERE is the unit of rate of flow. I.
The COULOMB is the unit of quantity. Q.
The WATT is the unit of power. P.
The JOULE is the unit of work or energy. W.
The FARAD is the unit of capacity. C.
The HENRY is the unit of induction. L.
Time in seconds t.

1118. The relations between these units may be expressed as follows:

1 Ampere=1 Coulomb per second.
1000 Volt-ampere hours=2,654,200 foot-pounds.
1 Horse-power=746 watts.

Example: How large a wire must be used to transmit a current of 500 volts at a current strength of 10 amperes, the line being 5000 feet long?

Solution: $1 = E/R$. Transposing, $R = E/I$. Substituting, $R = 500/10 = 50$ ohms. A resistance of 50 ohms in 5000 feet of wire is a resistance of 10 ohms per 1000 feet of wire. From the table we find that No. 20 wire is the nearest size.

Example: How many horse-power is represented by the above current?

Solution: $P = IE = 10 \times 500 = 5000$ Watts.
1 H. P. = 746 Watts, therefore 5000 Watts = $5000 \div 746 = 6.7$ H. P.

Note.—If a larger wire be used the resistance will be less and a greater horse-power can be transmitted.

Kennelly's formula for calculating the temperature of a wire due to an electric current is as follows:

T = temperature of wire; t = temperature of air, Fahr.; d = diameter of wire in mills.

Mensuration.

1119. *Plane Surfaces.*—Area of a square equals the square of one edge.

Area of a rectangle equals the product of the length by the breadth.

Area of a rhombus or rhomboic equals the product of the base by the altitude.

Area of a trapezoid equals the product of the altitude by one-half the sum of the two parallel sides.

Area of any triangle equals the product of the base by one-half the vertical altitude.

Let h = hypothenuse, a = altitude and b = base of any right-angled triangle. Then,

$$h = \sqrt{(a^2 + b^2)}$$
$$a = \sqrt{(h^2 - b^2)}$$
$$b = \sqrt{(h^2 - a^2)}$$
$$\text{Area} = \frac{a \times b}{2}$$

When the three sides only of any triangle are given, let s = one-half the sum of the three sides. Then,

$$\text{Area} = s \sqrt{s\,(s-a)\ (s-b)\ (s-c)}$$

Area of an ellipse equals .78544 × the major axis M × the minor axis m.

1120. *Solids.*—Volume of a cube equals the cube of one edge.

Volume of a parallelopipedon (rectangular solid) equals the product of length, breadth and thickness.

Volume of a cylinder equals the product of the length by the area of one end.

Volume of any pyramid or cone equals the product of one-third the vertical height by the area of the base.

Area of any right pyramid or cone equals the product of, the perimeter of the base by one-half the slant height.

Prismoidal formula: This must be used when the exact volume of a prismoid is desired. The form of the two parallel ends is immaterial and need not be alike. One end might be round, for example, and the other square.

$$\text{Vol.} = L \times \frac{A+4m+a}{6}$$

in which A = area of the larger end, a = the area of the smaller end and m = the area of a cross-section midway between the two ends, and L = the length of the prismoid. The mid-section is not half the sum of the two areas, except when the two end areas are similarly formed. The mid-way section m is always equal to the square root of the product of the two end areas. The formula could be written thus:

$$\text{Vol.} = L \times \frac{A+\sqrt{(Aa)}+a}{3}$$

1121. *Circles and Spheres.*—The diameter of a circle multiplied by 3.1416 gives the circumference.

To find the area of a circle multiply the square of the diameter by .7854, or multiply half the diameter by half the circumference, or multiply the square of the radius by 3.1416.

To find the side of the largest square which may be inscribed in a circle multiply the diameter of the circle by .7071.

To find the area of a sphere multiply the square of the diameter by 3.1416, or, multiply the square of the radius by 12.5664, or, take 4 times the area of a circle of the same diameter.

To find the volume of a sphere multiply the cube of the diameter by .5236 or, multiply 1/6 the diameter by the area of the surface or, multiply 1/3 the radius by the surface.

Water-Flow Measurements.

1122. *Miner's Inch.*—The miner's inch is a term of California origin, but it is in general use throughout the West. In practice its value varies in different localities, owing to the fact that all water companies do not use identical methods of measurement. In California the legal miner's inch is equivalent to a flow of 1½ cubic feet of water per minute. Therefore, when the flow in cubic feet is known, dividing by 1½ will give the miner's inches.

1123. There is a direct method of measuring the flow of miner's inches, but it is not strictly accurate, as will be later explained. The measurement is made by means of the miner's inch box as shown in Fig. 81. This consists of a box with an adjustable strip for regulating the inches of flow. For small amounts of water the opening should be 2 inches high, except that when the area of the opening is less than four square inches, when the height should be one inch. If large quantities of water are to be measured the height should be increased. In any case the width of opening should be about three times the height. The partition in which the opening is made should be 1¼ inches thick. If thicker or thinner the delivery will be less than the following rules call for.

1124. There are several reasons why the miner's inch box will not give an accurate measurement of water. The contraction of the stream, friction, velocity of approach, and the effect of head all follow different laws and make it impossible to compute the allowance to be made for the combined effect of these conditions. Actual experiment must be made in each case. Contraction is the diminution of the size of stream as it leaves an opening. Friction is produced by the sides of the opening, a slight rounding of the corners materially increasing the flow. The height of water surface above the center of the opening should be measured several feet back of the opening to make the effect of the velocity of approach as low as possible. An increase in head increases the flow in proportion to the square root of the height of head. As a result of these conditions, the flow of water through a circular opening of say four square inches in area, a rectangular opening of one inch high and four inches wide, and a rectangular opening one inch wide and four inches high will be different in each case, although the area of opening and head are the same in each case.

1125. The nearest approach to an accurate method of calculating the flow of water through rectangular orifices in partitions not over one and one-fourth inch thick, for all practical purposes so far as the miner or prospector is concerned, is by the use of the following formula:

$M = 200A\sqrt{H}$, for feet; and $M = .4\ a\sqrt{h}$, for inches, in which,—
M = miner's inches = 1.5 cubic feet per minute.
A = area of opening in square feet.
a = area of opening in square inches.
H = head in feet (water surface above center of opening).
h = head in inches.
(The coefficient used in the formulas above is .6224).

1126. If the partition in which the orifice is made is thick, bevel it on the down stream side to one and one-fourth inch.

Example: With an opening 9 inches wide, 6 inches high, the center of which is 36 inches below the surface of the water, what is the flow in miner's inches?

Solution:

Area is 54 square inches = .375 sq. ft.
The height, 36 inches = 3 feet. Then,

$$\begin{aligned} M &= 200\ A\sqrt{H} \\ &= 200 \times .375 \times \sqrt{3} \\ &= 200 \times .375 \times 1.7321 \\ &= 129.9 \text{ miner's inches.} \end{aligned}$$

The same example using inches.

$$\begin{aligned} M &= .4\ a\ \sqrt{h} \\ &= .4 \times 54 \times \sqrt{36} \\ &= .4 \times 54 \times 6 \\ &= 129.6 \text{ miner's inches.} \end{aligned}$$

Example No. 2: How many miner's inches will flow through an opening 2 inches wide by 6 inches long, the center of the opening being 8 inches below the surface of the water?

Solution: Area is $2 \times 6 \div 144 = .0833$ sq. ft. The head is $8 \div 12 = .6666$ ft. Then,

$$\begin{aligned} M &= 200\ A\sqrt{H} \\ &= 200 \times .0833 \times \sqrt{.6666} \\ &= 200 \times .0833 \times .816 \\ &= 13.60 \text{ miner's inches.} \end{aligned}$$

The same example using inches.

$$\begin{aligned} M &= .4\ a\ \sqrt{h} \\ &= .4 \times 12 \times \sqrt{8} \\ &= .4 \times 12 \times 2.828 \\ &= 13.57 \text{ miner's inches.} \end{aligned}$$

1127. When greater accuracy is required it is necessary to use the table of coefficients, §1128, and the following formula:

$M = 321.2\ Ac\sqrt{H}$, for feet, and $M = .644\ ac\sqrt{h}$, for inches.

Example: Same as No. 2 above. From table of coefficients we find $c = .63$. Then,

$$\begin{aligned} M &= 321.2\ Ac\sqrt{H} \\ &= 321.2 \times .0833 \times .63 \times \sqrt{.6666} \\ &= 321.2 \times .0833 \times .63 \times .816 \\ &= 13.75 \text{ miner's inches.} \end{aligned}$$

Same example using inches.

$$\begin{aligned} M &= .644\ ac\sqrt{h} \\ &= .644 \times 12 \times .63 \times \sqrt{8} \\ &= .644 \times 12 \times .63 \times 2.828 \\ &= 13.76 \text{ miner's inches.} \end{aligned}$$

1128. *Table of Coefficients for c.*

(*Derived from Poncelet and Lesbros.*)

Head in feet. h	*Height of opening in decimals of a foot, and also in inches.*					
	.656 7.8″	.5 6.″	.328 4.″	.2 2.4″	.164 2.″	.098 1.″
.033					.607	.630
.066	.572	.584	.596	.606	.615	.634
.098	.578	.589	.600	.610	.620	.638
.131	.582	.592	.603	.613	.623	.640
.164	.585	.595	.605	.615	.625	.640
.197	.587	.597	.607	.617	.62[illegible]	.640
.23	.588	.598	.609	.619	.628	.639
.26	.589	.600	.610	.620	.629	.638
.295	.591	.600	.610	.620	.629	.637
.328	.592	.601	.611	.621	.630	.637
.394	.593	.602	.612	.621	.630	.636
.46	.595	.604	.613	.622	.630	.635
.52	.596	.605	.614	.623	.631	.634
.59	.597	.606	.615	.623	.630	.634
.656	.598	.607	.615	.623	.630	.633
.98	.600	.608	.616	.624	.629	.632
1.31	.602	.609	.617	.623	.628	.631
1.64	.603	.610	.617	.623	.628	.630
1.97	.604	.610	.617	.622	.627	.630
2.29	.604	.610	.616	.622	.627	.629
2.62	.605	.610	.616	.621	.627	.629
2.95	.605	.610	.615	.621	.626	.628
3.28	.605	.610	.615	.621	.626	.628
3.60	.604	.609	.614	.620	.625	.627
3.94	.604	.609	.614	.619	.624	.626
4.26	.603	.608	.613	.617	.622	.624
4.60	.603	.607	.612	.617	.621	.622
4.92	.602	.606	.611	.616	.620	.620
5.20	.602	.606	.611	.615	.618	.618
5.57	.602	.605	.610	.614	.617	.616
5.90	.601	.605	.609	.612	.615	.615
6.23	.601	.604	.608	.611	.614	.613
6.50	.601	.604	.607	.611	.613	.612
9.80	.601	.602	.603	.604	.606	.608

1129. To reduce square inches to square feet divide by 144, using the 144 multiplication table to assist in the division. To multiply by 321.2 use the 321.2 multiplication table:

—144's—	—321.2's—
144 × 1 = 144	321.2 × 1 = 321.2
144 × 2 = 288	321.2 × 2 = 642.4
144 × 3 = 432	321.2 × 3 = 963.6
144 × 4 = 576	321.2 × 4 = 1284.8
144 × 5 = 720	321.2 × 5 = 1606.0
144 × 6 = 864	321.2 × 6 = 1927.2
144 × 7 = 1008	321.2 × 7 = 2248.4
144 × 8 = 1157	321.2 × 8 = 2569.6
144 × 9 = 1296	321.2 × 9 = 2894.8

1130. There is a much more accurate method of measuring water than directly by use of the miner's inch box. This is by means of a weir. The one objection to the weir is that it requires considerable space in order that the water will not approach the weir with great velocity. Another serious objection is that the amount of water delivered varies greatly with a slight change in the head. Of course, variations in head affect the flow of water through the miner's inch box, but not to the same extent as with a weir.

1131. Weir tables as published are only approximately correct for the reason that the end contractions should be allowed for in each individual case. This error is slight, however. By the use of the following formula strictly accurate results will be obtained, as the subtraction of two-tenths of the head makes due allowance for this end contraction.

$Q = 3.33\,(L - .2H)\,\sqrt{H^3}$ for feet, and
$Q = .00676\,(l - .2h)\,\sqrt{h^3}$ for inches, in which,
L = length of weir in feet
l = " " " " inches
H = head in feet
h = " " inches.
Q = cubic feet of water per second (not minutes).

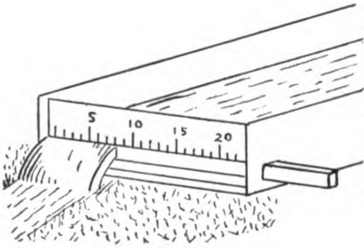


Fig. 81. Miner's Inch Box.

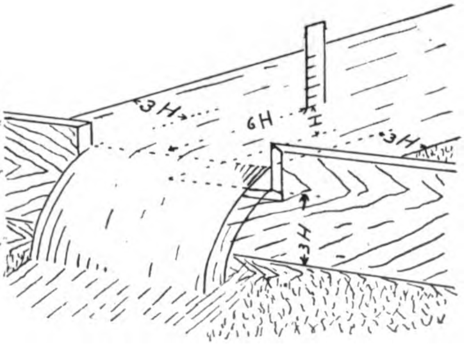


Fig. 82. A Weir Dam for Water Measurement.

1132. To measure water by means of a weir be careful to make a water-tight dam. Drive a stake up stream a distance equal to at least six times the height of the water over the crest of the weir. Mark the water level on this stake just as the first drop runs over the crest of the weir. Mark again when the water is flowing at its full capacity. The distance between marks is the head, or H. Either formula can be used and the cubic feet per second can be obtained as a result which, when multiplied by 40 will give the miner's inches. The cubic feet per minute divided by 1.5 also gives miner's inches. This is the only exact way to ascertain the flow of water in miner's inches.

1133. In constructing a weir for actual measurement, the height of the crest above the bottom of the dam must be at least three times H, and the width of the stream each side of the weir must also be at least three times H. Fig. 82 illustrates these specifications.

1134. The reason why weir tables do not give accurate results is because the varying elements ".2h" can not be taken into account in a table, as it varies with each individual case. Use the formula when accuracy is desired.

Example 1: How many cubic feet of water per second will flow over a weir 3 feet long and 1.5 deep?

$$\begin{aligned} \text{Solution: } Q &= 3.33\ (L - .2H)\ \sqrt{H^3} \\ Q &= 3.33\ (3 - .2 \times 1.5)\ \sqrt{3.375} \\ Q &= 3.333 \times 2.7 \times 1.83 \\ Q &= 16.47 \text{ cu. ft. per second.} \\ 60 \times Q &= 988.2 \text{ cu. ft. per minute.} \end{aligned}$$

(The weir table gives 1099.44 cu. ft. or 111.2 cu. ft. too much.)

Note. To obtain cubic feet per minute direct let V equal cubic feet per minute. Then,

$$V = 200\ (L - .2H)\ \sqrt{H^3}$$

Example 2: How many cubic feet of water per second and how many miner's inches will flow over a weir 9 inches (.75 foot) long by 3 inches (.25 foot) high?

$$\begin{aligned} \text{Solution: } Q &= 3.33\ (L - .2H)\ \sqrt{H^3} \\ Q &= 3.33\ (.75 - .2 \times .25)\ \sqrt{.25^3} \\ Q &= 3.33 \times .7 \times \sqrt{.015625} \\ Q &= 3.33 \times .7 \times .125 \\ Q &= .2913 \text{ cu. ft. per second} \\ Q &\Rightarrow .2913 \times 60 = 17.4 \text{ cu. ft. per minute} \\ Q &= 17.4 \div 1.5 = 11.6 \text{ miner's inches.} \end{aligned}$$

For the horse-power of water falling from a known height, see 1096.

1135. *Water Power.*—In nearly every case arising in practice the data upon which calculations are based are as follows: First, the quantity of water, either in cubic feet per second or per minute, or in miner's inches; second, the available fall; third, the necessary length of pipe. The information usually desired is: The available horse-power; the diameter of the pipe, its thickness, weight, safe pressure, and cost.

1136. Formulas for the calculation of these items may be used, but in the majority of cases the application of these requires greater technical knowledge than the average miner or prospector possesses. Therefore, it is deemed best to insert suitable tables.

1137. The procedure is as follows: Measure the flow of water by means of a weir and calculate the amount in cubic feet per minute by the formula [§1134]. The fall and length of pipe is ascertained by a surveyor. The size of pipe is found from table, §1139, calculated by the author. The horsepower is found by formula H. P. = .0019HQe [§1096]. The cost and weight data is taken from table, §1140.

1138. In explanation it may be stated that pipe lines built for power purposes discharge through a nozzle or through a turbine wheel. If the lower end were left open to the full size of the pipe the velocity of the water in the pipe line would be greater in every case than that given in the table, §1139, but no power would be obtained. By using a turbine, or a nozzle and a tangential wheel the velocity of the water and the friction in the pipe line is reduced and power is obtained. A nozzle and a tangential wheel is used for high pressure (fall) and small amounts of water. A turbine wheel is used for low pressure and large amounts of water.

TABLE.

1139. *Loss of head by friction in pipes.*—This table gives the loss by friction for each 100 feet in length when discharging the given quantity of water per minute. Calculated for riveted steel pipe. For smooth iron pipe multiply the loss of head by .7, and for wood pipe multiply the loss of head by .5. Diameter of pipe is given at the head of columns.

Vel.	2		3		4		5	
in ft. per sec.	*Cu. ft. per min.*	*Loss head in ft.*	*Cu. ft. per min.*	*Loss head in ft.*	*Cu. ft per min.*	*Loss head in. ft.*	*Cu. ft. per min.*	*Loss head in ft.*
2.	2.62	1.20	5.89	.80	10.47	.60	16.36	.48
2.5	3.27	1.78	7.36	1.18	13.09	.89	20.45	.76
3.	3.92	2.45	8.84	1.63	15.71	1.23	24.54	.98
3.5	4.58	3.23	10.31	2.15	18.33	1.61	28.63	1.29
4.	5.24	4.10	11.78	2.73	20.94	2.05	32.72	1.64
4.5	5.89	5.08	13.25	3.38	23.56	2.54	36.82	2.03
5.	6.55	6.15	14.73	4.10	26.18	3.08	49.91	2.46
5.5	7.20	7.33	16.20	4.88	28.80	3.66	45.00	2.93
6.	7.85	8.60	17.67	5.73	31.42	4.30	49.10	3.44
6.5	8.51	9.98	19.14	6.64	34.03	4.99	53.18	3.99
7.	9.16	12.45	20.62	7.63	36.65	5.73	57.27	4.59

	6		7		8		9	
2.	23.6	.40	32.1	.34	41.9	.30	53.0	.27
2.5	29.5	.59	40.1	.50	52.4	.44	66.3	.39
3.	35.3	.81	48.1	.70	62.8	.61	79.5	.54
3.5	41.2	1.07	56.1	.92	73.3	.81	92.8	.72
4.	47.1	1.36	64.1	1.16	83.8	1.03	106.0	.91
4.5	53.0	1.69	72.2	1.44	94.2	1.27	119.3	1.23
5.	58.9	2.04	80.2	1.75	104.7	1.54	132.5	1.37
5.5	64.8	2.43	88.2	2.08	115.2	1.83	145.8	1.63
6.	70.6	2.86	96.2	2.44	125.7	2.15	159.0	1.91
6.5	76.6	3.31	104.2	2.83	136.1	2.49	172.3	2.21
7.	82.5	3.81	112.2	3.26	146.6	2.86	185.6	2.52

	10		11		12		13	
2.	65.4	.24	79.2	.22	94.2	.20	110.6	.185
2.5	81.8	.36	99.0	.32	117.8	.30	138.3	.273
3.	98.2	.49	118.8	.45	141.4	.41	165.9	.377
3.5	114.5	.65	138.6	.59	164.9	.54	193.6	.496
4.	130.9	.82	158.4	.75	188.5	.68	221.2	.631
4.5	147.3	1.02	178.2	.92	212.1	.84	248.9	.781
5.	163.6	1.23	198.0	1.12	235.6	1.03	276.5	.946
5.5	180.0	1.47	217.8	1.33	259.2	1.22	304.2	1.127
6.	196.3	1.72	237.6	1.56	282.7	1.43	331.8	1.323
6.5	212.7	1.99	257.4	1.81	306.3	1.60	359.5	1.534
7.	229.1	2.28	277.2	2.07	329.9	1.91	387.1	1.750

	14		16		18		20	
2.	128.3	.171	167.0	.150	212.0	.133	262.	.120
2.5	160.4	.253	209.4	.222	265.	.197	327.	.178
3.	192.4	.349	251.0	.306	318.	.272	393.	.245
3.5	224.5	.461	293.2	.403	371.	.358	458.	.323
4.	256.6	.585	355.0	.513	424.	.456	524.	.410
4.5	288.6	.751	377.0	.634	477.	.563	589.	.508
5.	320.7	.878	419.0	.769	530.	.683	654.	.615
5.5	352.8	1.046	460.8	.916	583.	.813	720.	.733
6.	384.8	1.228	502.0	1.075	636.	.954	785.	.860
6.5	416.9	1.424	544.5	1.247	689.	1.107	851.	.998
7.	449.0	1.520	586.0	1.430	742.	1.271	916.	1.145

	22		24		26		28	
2.	316.	.109	377.	.099	442.	.092	513.	.086
2.5	396.	.161	471.	.147	553.	.136	641.	.127
3.	475.	.222	565.	.204	663.	.188	770.	.175
3.5	555.	.293	660.	.268	774.	.248	898.	.230
4.	633.	.372	754.	.341	885.	.315	1026.	.293
4.5	713.	.461	848.	.422	995.	.390	1155.	.362
5.	792.	.558	942.	.512	1106.	.472	1283.	.439
5.5	871.	.719	1037.	.609	1217.	.563	1411.	.523
6.	950.	.781	1131.	.716	1327.	.660	1539.	.614
6.5	1030.	.906	1225.	.830	1438.	.766	1668.	.712
7.	1109.	1.041	1319.	.953	1548.	.879	1796.	.817

	30		32		34		36	
2.	589.	.079	670.	.075	757.	.071	848.	.067
2.5	736.	.118	838.	.111	946.	.105	1060.	.098
3.	833.	.163	1005.	.153	1135.	.144	1272.	.136
3.5	1031.	.215	1172.	.201	1324.	.190	1484.	.179
4.	1178.	.273	1344.	.256	1513.	.241	1696.	.227
4.5	1325.	.338	1508.	.317	1702.	.298	1908.	.281
5.	1472.	.410	1676.	.384	1892.	.362	2121.	.341
5.5	1620.	.488	1841.	.457	2081.	.431	2333.	.406
6.	1767.	.573	2011.	.537	2270.	.506	2545.	.476
6.5	1914.	.664	2178.	.623	2459.	.587	2757.	.553
7.	2061.	.762	2346.	.715	2648.	.673	2969.	.643

1140. TABLE OF RIVETED HYDRAULIC PIPE.

Showing price and weight with safe head for various sizes of double riveted pipe. (Revised.)

Diameter of Pipe in Inches.	Thickness of Material U. S. Standard Gage.	Equivalent Thickness in Inches.	Head in Feet Pipe Will Safely Stand.	Weight per Lineal Foot in Pounds.	Price per Foot.
3	18	.05	810	2.25	$0.20
4	18	.05	607	3.00	.25
4	16	.062	760	3.75	.35
5	18	.05	485	3.75	.30
5	16	.062	605	4.50	.45
5	14	.078	757	5.75	.50
6	18	.05	405	4.25	.44
6	16	.062	505	5.25	.50
6	14	.078	630	6.50	.56
7	18	.05	346	4.75	.50
7	16	.062	433	6.00	.56
7	14	.078	540	7.50	.63
8	16	.062	378	7.00	.65
8	14	.078	472	8.75	.75
8	12	.109	660	12.00	.94
9	16	.062	336	7.50	.69
9	14	.078	420	9.25	.88
9	12	.109	587	12.75	1.06
10	16	.062	307	8.25	.72
10	14	.078	378	10.25	.82
10	12	.109	530	14.25	1.00
10	11	.125	607	16.25	1.25
10	10	.14	680	18.25	1.50
11	16	.062	275	9.00	.75
11	14	.078	344	11.00	.94
11	12	.109	480	15.25	1.25
11	11	.125	553	17.50	1.44
11	10	.14	617	19.50	1.62
12	16	.062	252	10.00	.82
12	14	.078	316	12.25	1.00
12	12	.109	442	17.00	1.38
12	11	.125	506	19.50	1.50
12	10	.14	567	21.75	1.69
13	16	.062	233	10.50	.90
13	14	.078	291	13.00	1.12
13	12	.109	407	18.00	1.50
13	11	.125	467	20.50	1.65
13	10	.14	522	23.00	1.80
14	16	.062	216	11.25	.98
14	14	.078	271	14.00	1.17
14	12	.109	378	19.50	1.57
14	11	.125	433	22.25	1.72
14	10	.14	485	25.00	1.95
16	16	.062	190	13.00	1.05
16	14	.078	237	16.00	1.20
16	12	.109	332	22.25	1.70
16	11	.125	379	24.50	1.85
16	10	.14	425	28.50	2.00
18	16	.062	168	14.75	1.20
18	14	.078	210	18.50	1.40
18	12	.109	295	25.25	$ 1.90
18	11	.125	337	29.00	2.10
18	10	.14	378	32.50	2.40
18	8	.171	460	40.00	3.00
20	16	.062	151	16.00	1.26
20	14	.078	189	19.75	1.54
20	12	.109	265	27.50	2.10
20	11	.125	304	31.50	2.25
20	10	.14	340	35.00	2.50
20	8	.171	415	45.50	3.40
22	16	.062	138	17.75	1.40
22	14	.078	172	22.00	1.70
22	12	.109	240	30.50	2.25
22	11	.125	276	34.50	2.40
22	10	.14	309	39.00	2.80
22	8	.171	376	50.00	3.75
24	14	.078	158	23.75	1.80
24	12	.109	220	32.00	2.35
24	11	.125	253	37.50	2.70
24	10	.14	283	42.00	2.95
24	8	.171	346	50.00	3.50
24	6	.20	405	59.00	4.30
26	14	.078	145	25.50	2.00
26	12	.109	203	35.50	2.59
26	11	.125	233	39.50	2.87
26	10	.14	261	44.25	3.10
26	8	.171	319	54.00	3.85
26	6	.20	373	64.00	4.75
28	14	.078	135	27.25	2.12
28	12	.109	188	38.00	2.75
28	11	.125	216	42.25	3.00
28	10	.14	242	47.50	3.20
28	8	.171	295	58.00	4.15
28	6	.20	346	69.00	5.00
30	12	.109	176	39.50	2.90
30	11	.125	202	45.00	3.15
30	10	.14	226	50.50	3.50
30	8	.171	276	61.75	4.30
30	6	.20	323	73.00	5.25
30	1/4	.25	404	90.00	6.50
36	11	.125	168	54.00	3.80
36	10	.14	189	60.50	4.30
36	3/16	.187	252	81.00	5.75
36	1/4	.25	337	109.00	7.60
36	5/16	.312	420	135.00	9.50

1141. PELTON TANGENTIAL WATER WHEEL TABLE.

12-in. wheel, $ 40, weight 150 lbs., pulley 6 in. diameter × 4-in. face
15-in. wheel, $ 60, weight 175 lbs., pulley 7½ in. diameter × 5-in. face
18-in. wheel, $100, weight 300 lbs., pulley 9 in. diameter × 6-in. face
24-in. wheel, $150, weight 450 lbs., pulley 12 in. diameter × 8-in. face
30-in. wheel, $180, weight 650 lbs., pulley 15 in. diameter × 10-in. face
36-in. wheel, $200, weight 800 lbs., pulley 20 in. diameter × 10-in. face

NOTE.—These prices are high to cover market fluctuations in raw material, and are only intended for approximate purposes. Net prices on application to any dealer in pipe. The discount is about 40%. This also applies to §1140.

1142. *Nozzle sizes.*—To ascertain the proper size of nozzle for a given head and quantity of water use the following:

$$d = \sqrt{\left(\frac{\text{cu. ft. per min.}}{2.62\sqrt{H}}\right)}$$

in which H = effective head in feet, and d diameter of hydraulic nozzle in inches. Nozzles for tangential wheels are of special design, and the value of d as found by the above formula will apply to the actual diameter of the stream of water issuing from the nozzle, and not to the diameter of the nozzle itself. Manufacturers usually designate the various sizes, however, by a number approximating the diameter of the issuing stream at the maximum efficiency. The above formula expressed in words as follows: Divide the cubic feet of water per minute by 2.62 times the square root of the head, and extract the square root of the quotient. This gives the diameter of the nozzle in inches.

1143. Example: A ditch carries 160 cu. ft. of water per minute as determined by a weir measurement [1131]. The total vertical height of fall or head, is 325 feet. Length of pipe owing to slope, 500 ft. What is the effective horse-power delivered by a Pelton water wheel? What size of pipe should be used? What is the weight and cost of the pipe? Is the pipe safe for the pressure?

Solution: Try a 9 inch pipe. From the table, §1139, under 9 inch pipe find 159 cu. ft. per min., this being the number nearest to 160. Opposite 159 we find 1.91 ft. loss in head per 100 feet of length. Then $1.91 \times 500 = 9.55$, total loss. Subtracting, $325 - 9.55 = 315.45$ effective head. By the formula in §1096 the effective horse-power delivered by the water wheel is, $HP = .0019HQe$, in which H = head; Q = cu. ft. per min; and e 80%

$$.0019 \times 315.45 \times 160 \times .80 = 76.7 \text{ horse-power.}$$

From the table, §1140, the gauge of the 9 inch pipe is #16 U. S. S., the safe head is 336 ft., the weight of the line is $7.5 \times 500 = 3{,}750$ pounds, and the cost will be $500 \times .69 = \$345$, less the discount of about 40%, or $207.

1144. Now let us try 11 inch pipe. By the table, §1139, we find 158.4 cu. ft. the nearest to 160., and .75 ft. is the proportionate loss by interpolating. $500 \times .75 = 3.8$ ft. loss of head for the line. $325 - 3.8 = 321.2$ ft. effective head.

$$HP = .0019HQe \quad [1096]$$
$$= .0019 \times 321.2 \times 160 \times .80 = 79 \text{ effective horse-power.}$$

This is a gain of two and one-third horse-power by using the larger pipe. The cost of the 11 inch pipe is $500 \times .94 \times 60\% = \$282$, or $75 more than the 9 inch pipe. The yearly interest on $75 at 10% is $7.50, and water power companies usually sell one "horse-power-year" for $65 for continuous service. It will, therefore, pay well to use the larger pipe. If economy is necessary use thin pipe at the upper end of the line.

Before buying a power plant it is advisable to employ a hydraulic engineer. The information given here is calculated to enable the reader to judge of the practicability of putting in a plant and employing an engineer.

1145. *Water pressure.*—A column of water 1 inch square and 1 foot high weighs .432 pounds. Therefore, to find the pressure per square inch in pipes or tanks multiply the height in feet by .432. For estimates, call the pressure per square inch one-half the height in feet.

1146. *Water pressure against a dam.*—Multiply the area of the dam in contact with the water, expressed in square feet, by one-half the greatest depth of the water in feet, and this product by 62.5. The distance the dam water extends up stream, that is, the back water, has no bearing on the case. The weight of the dam, should exceed the pressure against it.

1147. **Grouping of the Metals.**

Precipitated by adding hydrochloric acid.

Group 1.
Lead.
Silver.
Mercury, (ous).

Precipitated by adding hydrogen sulfid gas to the filtrate from the first group.

Group 2.
Arsenic.
Antimony.
Bismuth.
Cadimum.
Copper.
Mercury.

After boiling to expel hydrogen sulfid, precipitated by adding ammonium chlorid and ammonium hydrate to the filtrate from the second group.

Group 3, part 1.
Aluminum.
Chronium.
Iron.

Precipitated by adding ammonium sulfid to the filtrate from the first half of this group.

Group 3, part 2.
Manganese.
Cobalt.
Nickel.
Zinc.

Precipitated by adding ammonium carbonate and hydrate to the filtrate from the second half of the third group.

Group 4.
Barium
Strontium
Calcium.

1148. **Solvents of Metals.**

Gold.
Aqua Regia
Potassium cyanide
Sodium cyanide
Chlorine water
Bromine water

Lead.
Nitric acid (dilute)

Mercury.
Nitric acid

Iron.
Aqua Regia
Nitric acid
Hydrochloric
Sulfuric acid (weak)

Silver.
Nitric acid
Sulfuric acid
Potassium cyanide
Sodium cyanide

Copper.
Nitric acid
Sulfuric acid
Aqua regia

Tin.
Nitric
Hydrochloric (hot)
Sulfuric acid
Aqua regia

Zinc.
Hydrochloric acid
Sulfuric acid
Nitric acid
Aqua regia

Metals within the earth's crust, being under pressure, are soluble in many other reagents [671]. The above reagents are those that may be used in the chemical laboratory.

1149. The Chemical Elements, Their Atomic Weight and Valence.

Element	Symbol	Atomic weight. H = 1	Element	Symbol	Atomic weight. H = 1
Aluminum	Al	26.9	Neodymium	Nd	142.5
Antimony	Sb	119.3	Neon	Ne	19.9
Argon	A	39.6	Nickel	Ni	58.3
Arsenic	As	74.4	Nitrogen	N	13.93
Barium	Ba	136.4	Osmium	Os	189.6
Bismuth	Bi	206.9	Oxygen	O	15.88
Boron	B	10.9	Paladium	Pd	105.7
Bromine	Br	79.36	Phosphorus	P	30.77
Cadmium	Cd	111.6	Platinum	Pt	193.3
Caesium	Cs	131.9	Potassium	K	38.85
Calcium	Ca	39.7	Praseodymium	Pr	139.4
Carbon	C	11.9	Radium	Ra	225.
Cerium	Ce	139.2	Rhodium	Rh	102.2
Chlorine	Cl	35.18	Rhubidium	Rb	84.9
Chromium	Cr	51.7	Ruthenium	Ru	100.9
Cobalt	Co	58.55	Samarium	Sm	149.2
Columbium	Cb	93.3	Scandium	Sc	43.8
Copper	Cu	63.1	Selenium	Se	78.6
Erbium	Er	164.8	Silicon	Si	28.2
Flurine	F	18.9	Silver	Sg	107.11
Gadolinium	Gd	154.8	Sodium	Na	22.88
Gablium	Ga	69.5	Strontium	Sr	86.94
Germanium	Ge	72.0	Sulfur	S	31.82
Glucinium	Gl	9.03	Tantalum	Ta	181.6
Gold	Au	195.7	Tellurium	Te	126.6
Helium	He	4.0	Terbium	Tb	158.8
Hydrogen	H	3.	Thallium	Tl	202.6
Indium	In	114.1	Thorium	Th	230.8
Iodine	I	126.01	Thulium	Tm	169.7
Iridium	Ir	191.5	Tin	Sn	118.1
Iron	Fe	55.5	Titanium	Ti	47.7
Krypton	Kr	81.2	Tungsten*	W	182.6
Lanthanum	La	137.9	Uranium	U	236.7
Lead	Pb	205.35	Vanadium	V	50.8
Lithium	Li	6.98	Xenon	X.	127
Magnesium	Mg	24.18	Ytterbium**	Yb	171.7
Manganese	Mn	54.6	Yttrium	Yt	88.3
Mercury	Hg	198.5	Zinc	Zn	64.9
Molybdenum	Mo	95.3	Zirconium	Zr	89.9

*Wolframium is another name for Tungsten.

**The International Congress has recently decided that Ytterbium is a mixture of two elements, neoytterbium and lutecium, the atomic weight of the former being 172 and the latter 174.

1150. Market Value of Metals and Minerals.

The prices of metals and minerals fluctuate, depending upon the supply and demand. The prices vary also with the locality, depending upon local conditions, such as cost of transportation, local demand, etc. The principal markets for the rare minerals are San Francisco and New York.

1154. A point which must be considered is that the price per unit varies with the purity of the material. And the most profitable degree of purity must be determined by trial or careful estimation. For example, a mineral 90% pure may sell for $1.00 a pound, and the same mineral 95% pure may sell for $1.25 a pound—amounting to 25c for the additional 1/20 of a pound. But it may cost 40c to raise the purity from 90% to 95%. Much depends upon the quality, quantity, and condition of the original ore, and also the method employed to concentrate it. For this reason some of the quotations may be unavoidably misleading. The only safe way is to investigate all the conditions affecting the case.

1155. Buyers desire ores having a high percentage of purity. But many low grade ores may be profitably concentrated. For this reason the percentage of purity required by the buyer, and percentage of purity of the ore that may be profitably worked, are both given in many instances below.

Current Prices, 1912.

Metals and Value.	**Marketable and Workable Purity, Etc.**
	Metals.
Aluminum, 18-19c lb.	50% Al_2O_3 ore is marketable.
Antimony, 8c lb.	40% to 50% ore is marketable.
Bismuth, $1.75 lb.	5% Bi is workable ore. Chief market is in Europe.
Copper, 14-17c lb.	2% to 5% Cu is workable ore. 15% to 20% is marketable.
Cadmium, $1.75 lb.	
Gold, $20.67 oz.	$1 to $5 a ton is workable under favorable circumstances.
Iron, No. 1 pig, $10-15 ton.	35% to 60% ore is marketable.
Steel, $22-23 ton.	
Ferro-mangan, $36 ton.	
Iridium, $1 gm.	
Lead, 4-5c lb.	2% is workable, 10% marketable.
Nickel, 40-50c lb.	2% to 5% is workable.
Osmium, 50c gm.	
Platinum, $47 oz.	
Quicksilver, 61c lb.	¾% to 3% is workable.
Silver, 52c oz.	$5 a ton is workable.
Tin, 40c lb.	25% to 30% is workable.
Zinc, $47 ton	for 60% Zn ore. 25% ore is workable.
	Economic ores and minerals.
Abrasives—	
Corundum, 7-10c lb.	
Diatom. earth, $26-30 ton.	$10 is Pacific Coast price.
Garnet earth, $25-35 ton.	
Pumice, $.016-.20 lb.	
Quartz sand, $3 ton.	
Asbestos, $10-200 ton,	According to length of fiber.
Asphaltum, $10-80 ton.	
Barytes, $7-20 ton.	Highest price on the Pacific Coast.
Bauxite, $3-4 ton.	50% Al_2O_3 is salable.
Bitumen, 3-4c lb.	
Borax, 4-5c lb.	
Chalk, $2 ton.	
Chrome iron, $14-16 ton.	Market dull.
Clay, China, $7-10 ton.	At N. Y.
Clay, fire, $2.50-5 ton.	
Cryolite, 6-7c lb.	
Diamond "bort," $2-15 carat.	
Diamond "carbon," $75-100 carat.	
Feldspar, ground, $10-15 ton.	
Fluorspar, lump, $8-10 ton.	

Fullers earth, $17 ton.	At N. Y.
Graphite, 1-4c lb.	Higher for best quality.
Gypsum, $4-7 ton.	Price varies greatly.
Iridosmine, $20 oz.	
Iron ore, hematite, $3-4 ton.	35% to 60% is salable.
Iron ore, limonite, $2-4 ton.	35% is salable.
Limestone, $1.5-3 ton.	
Magnesite, $7.5-10 ton.	At N. Y. or S. F.
Manganese ore, $12-25 ton.	For crude. 80% to 85% MnO marketable.
Mica, sheets, $.15-1.50 lb.	Price varies according to size of the sheets.
Mica, ground, 4-6c lb.	
Mica, ground, 4-6c lb.	
Monazite sand, 12c lb.	For 90% sand. 5% thorium oxid is salable.
Molybdenite, $500-600 ton.	For 95%.
Phosphate rock, $6-8 ton.	For 77% phosphoric acid. 32% salable.
Iron pyrites, $3 ton.	
Rutile, $100 ton.	For 90% rutile.
Salt, $1.50 bbl.	of 280 lbs.
Saltpeter, 4-5c lb.	For crude.
Sulfur, $20-25 ton.	
Talc, ground, $20 to $50 ton.	
Tungsten ore, $520-550 ton.	For 60% WO.
Uranium oxid, $2.20-2.25 lb.	For 10% U_3O_8.
Vanadium ore, $200-250 ton.	For 15% vanadium oxid.

Conditions must be ideal in order that gold ores may be profitably worked for less than $1.00 a ton. In a few cases this has been done.

GLOSSARY.

Acid.—Hydrogen combined with a non-metallic element to form a compound that will unite with metals or bases to form a salt. An acid turns blue litmus paper red.

Acid Rock.—One composed chiefly of quartz. This definition applies to rock to be assayed or smelted.

Acid ore.—One which gives an acid reaction owing to the presence of decomposed iron pyrites, forming free sulfurous acid. This definition applies to ores to be treated by the cyanide process and not to smelting ores.

Acidify.—To add enough acid to make the solution slightly acid in reaction.

Adamantine.—Having diamond luster.

Adit.—A horizontal, or nearly horizontal passage-way in a mountain begun at the surface.

Amygdaloids.—Small nodules formed in cavities in igneous rocks.

Amorphous.—Not having a crystalline form.

Analysis.—Ascertaining the composition of a substance by means of chemical solutions, or the blowpipe.

Anamorphism.—A term applied by Van Hise to the zone of the earth's crust below the zone of katamorphism, and in which pressure excludes the probability of any large openings or of porosity. It begins at about seven miles below the surface, and may also be defined as the zone where rock flowage begins.

Anticline.—A fold in a rock stratum with the convex side up. Opposite of syncline.

Apex.—The outcrop of a ledge or stratum, or the edge of a blind vein nearest the surface.

Arrastre.—Apparatus for grinding ore by means of a stone dragged around a circular enclosure.

Assay.—To test gold, silver or lead ores by fire.

Assay ton.—A weight of 29166-2/3 grams.

Atom.—The smallest particle of matter entering into chemical combination. See molecule.

Auriferous.—Containing gold.

Bar.—A sand bank in a stream.

Base minerals.—Minerals that contain iron, calcium, aluminum or any other metal, gold, platinum, silver and mercury excepted.

Base metal.—See Base Mineral.

Basic rock.—One composed chiefly of base minerals.

Batholith.—Also called batholite—a mass of intrusive rock (usually granite) which has melted its way up into overlying sedimentary strata.

Battery.—A set of stamps for crushing ore.

Bedded vein.—A vein or ore body enclosed between two strata, usually approximately horizontal.

Bed-rock.—Solid rock beneath gravel or alluvial.

Black jack.—Zinc sulfid. Zinc blende.

Blick.—The flash of an assayer's gold or silver bead just as the last trace of lead leaves it.

Blind lode.—A vein that does not outcrop.

Blow-out.—A term improperly used for a large outcrop over a narrow vein.

Blue vitrol.—Blue stone. Copper sulfate.

Blue lead.—Bluish-white gravel found in one of the noted gravel channels of California.

Bonanza.—A rich ore body.

Bonds.—The combining power of an element. For example, hydrogen has one bond and oxygen two, therefore they combine thus: H-O-H. Valence expresses the same thing.

Bort.—An opaque diamond.

Breast.—The working face of a drift or level.

Breccia.—Conglomerate of sharp, angular fragments.

Buddle.—A round table. A revolving circular table for concentrating ore.

Button.—The lead obtained from a crucible assay. The gold bead obtained from the lead button is often also called a button.

Cage.—Frame or platform used in a vertical shaft.

Calcine.—To roast.

Calcareous.—Containing lime.

Calcite.—Carbonate of lime.

Cap-rock.—Barren covering over an ore body.

Carat.—A one-twenty-fourth part.

Carat.—A weight used in weighing diamonds. The international carat is 1.368 grains.

Carbonaceous.—Containing carbon.

Cast.—Material that has filled a cavity formerly occupied by some other substance, and having the form of the original substance.

Cementation.—A word applied by Van Hise to the zone in the earth's crust just below the belt or level of weathering. The belt in which oxidation, carbonation and hydration are the chief reactions. The belt of mineral growth.

Centrosphere.—The interior of the earth, or that part below the rock-crust. The density of the crust is from 2.75 to 3 times that of water, and the density of the earth as a whole 5.5 times that of water. Therefore, the centrosphere is more rigid than steel, though it is hot enough to expand to a vapor if the pressure be removed. The pressure in pounds per square inch below the earth's surface, is as follows: 1 mile, 6,000 lbs.; 2 miles, 12,000 lbs.; 100 miles, 679,500 lbs.; center of the earth, 43,960,000 lbs.

Chlorid.—A metal combined with chlorin, as salt.

Chloridize.—To treat with a chlorid; as, to treat with salt.

Chlorinate.—To treat with chlorin gas.

Claim.—A lode or placer location.

Clay-slate.—A slate that originally consisted chiefly or in part of clay.

Cleavage.—Property of splitting easily.

Color.—A particle of gold obtained by panning.

Concretion.—A nodule.

Contact.—A vein formed between two different kinds of rock, or produced by reason of the contact, and in such cases not always occurring at the contact, but near it.

Cross-cut.—An underground passage-way across a vein or formation at nearly a right angle to the stratification. It may be entirely under ground, or it may start from the surface.

Crystal.—A mineral having a definite form due to the laws of crystallization.

Crystallization.—The act of forming a solid, definite crystal, either from a solution or from a molten mass.

Cyanide.—Potassium cyanide is usually intended. Any salt of cyanogen is really a cyanide.

Debris.—(Pronounced de-bree.) Fragments.

Denude.—To take off the top part.

Deoxidize.—To remove oxygen.

Desilver.—To remove silver.

Desulfurize.—To remove sulfur.

Detonate.—To explode instantly.

Dike.—A vein of igneous rock.

Dip.—The angle of inclination of a vein, fault, dike, etc., measured from the horizontal. A dip of 90° is vertical.

Disintegrate.—To crumble or decay.

Discovery.—The hole or place where the first mineral is found.

Disseminated.—Scattered through.

Distillation.—Heating to vaporization and condensing the vapors later in suitable cooling apparatus.

Ditch.—Artificial water course.

Divining-rod.—A rod, usually witch hazel, used by superstitious persons to locate water, metal, and oil.

Dodecahedron.—A solid having twelve equal, regular faces.

Drift.—A horizontal passage-way along the course of a vein.

Dry ore.—Ore not containing lead.

Dyke.—See dike.

Dynamic geology.—The branch that treats of the heat, water, air and chemical effects upon rocks.

Effervesce.—To dissolve with the formation of bubbles filled with CO_2 gas upon treatment with an acid.

Element.—Original, indivisible substances; as, gold, hydrogen.

Epi-.—A prefix signifying that a rock, though it may have a different mineral composition than originally, has the same chemical composition as the rock to which the prefix is attached; as, epidiorite. That is, having the chemical composition of diorite, but not its mineral composition.

Erosion.—Wearing away.

Exploitation.—Productive working of a mine.

Exploration.—Seeking minerals.

Extrusion.—Igneous rock forced up to the surface.

Face.—The breast of a drift.

Fathom.—Six feet.

Fault.—A break and relative movement of rock strata, or of a vein. A dislocation. A normal fault is a downthrow of the overlying portion. A reverse fault or overlap is an upthrow of the overlying portion of rock. A strike fault is one in which the rock movement is parallel with the strike. A dip fault is where the rock has moved in the direction of the dip, up or down, and may be either a normal or reverse fault.

Fceder.—A small stringer or vein adjoining the main vein.

Ferruginous.—Containing iron.

Filtrate.—That which passes through a filter paper, as a solution.

Flux.—Material used to aid other material in smelting by making a more fusible mixture.

Fissure vein.—A vein filling a crack or fissure in the earth's crust. It may be of any size or depth, but usually of great depth. A fissure vein has two distinct walls.

Fossil.—Animal or vegetable substance that has been preserved in a rock in its original form. It may be composed of the original substance, or partly replaced by other material; as, lime, silica, iron, etc. Fossil shells are quite common in sedimentary rock.

Foot-wall.—The rock on the underside of a vein.

Free-milling.—That which may be amalgamated. Not requiring roasting or other preliminary treatment.

Frozen vein.—A vein with no distinct wall on one or both sides.

Gangue.—The mineral associated with and containing the ore.

Gash-vein.—A vein of shallow depth.

Geode.—A rock cavity studded with crystals.

Geosyncline.—The combination of an upward and a downward fold in a stratum of rock.

Geyser.—An intermittent boiling spring.

Gossan.—Iron oxid at the outcrop.

Gouge.—Selvage. A layer of crushed or altered material between the vein and the wall rock.

Gravel mine.—A placer mine.

Green vitrol.—Iron sulfate.

Gulch claim.—A location in a steep canycn, such that it would be impractical to locate by legal subdivisions.

Hade.—The underlay. Angle of inclination of a fault plane measured from the vertical. The use of this word should be discouraged, as it is an opposing term and leads to confusion. See dip.

Heading.—Portion of the vein above a drift. Also an interior level.

Heave.—Displacement of the fractured parts of a vein or stratum vertically or horizontally.

Homogeneous.—Composed of only one substance.

Horse.—Barren wall rock enclosed in a vein.

Hydrochloric acid.—Muriatic acid. HCl.

Hydrous.—Containing chemically combined water.

Incline.—A shaft not vertical.

Infusible.—That which can not be melted.

In place.—In solid rock.

Intersection.—Meeting of two lines. Meeting of two planes. The intersection of two planes is a line.

Intrusion.—Igneous rock that has been forced up through a fissure but not reaching the surface, though the fissure may or may not (usually not) reach the surface. Later erosion may expose the intruded rock. See extrusion.

Iridescence.—Showing rainbow colors.

Jumping.—The act of taking up a location that is claimed by another. That is, seizing a claim upon the assumption that the assessment or location work has not been legally done by the former locator. Locating a claim that is indisputably abandoned should not be called jumping.

Katamorphism.—A term applied by Van Hise to the zone above the zone of rock flowage. It contains the belt of weathering and cementation. The zone in which complex minerals are changed to simple ones.

Laccolith.—An intrusion that has not reached the surface, but has spread out between two strata, raising the upper stratum and thus forming a mountain-shaped mass of lava.

Lava.—Rock formed by the cooling of melted rock.

Leach.—To dissolve and wash out minerals from an ore by means of water or chemical solution.

Leaching.—See lixiviation.

Lead.—The course of an ancient gravel channel.

Ledge.—A vein of ore. That part of a vein which projects above the surrounding surface rock.

Lenticular.—Lens-like.

Level.—A drift in a mine.

Lime.—Calcined (burned) limestone. CaO.

Limestone.—Chiefly calcite, with a little sand and other impurities.

Litharge.—Monoxide of lead. PbO.

Lithosphere.—The earth's crust of rock. It gradually merges into the centrosphere, (which see). It is 5 to 10 miles deep, the depth varying with the locality. Its density varies from 2.75 to 3 times that of water.

Lixiviation.—Dissolving and separating minerals from the insoluble material by means of water or chemical solutions.

Lode.—A vein of ore.

Lodestone.—Oxid of iron that has become a natural magnet. That is, having polarity like a compass needle.

Long Tom.—A long rocker for washing out gold.

Magmatic segregation.—The formation of minerals by crystallization within a rock, especially in the act of cooling.

Matrix.—Rock containing a gem or crystal.

Matte.—A mixture of a metal and sulfur as a result of fusion in a furnace.

Meta-.—A prefix signifying between or with. Therefore, it is used to denote that a change has taken place between two rock forms, or from one to the other.

Metamorphic.—Changed in texture.

Metamorphism.—The act of making changes in the texture or composition of minerals or rocks.

Metasomatism.—The act of replacing one rock or mineral by another, the replacement being made atom for atom; that is, by chemical substitution.

Mine.—An excavation containing valuable minerals. Not a quarry.

Microcrystalline.—Crystals visible only through a microscope.

Microcrith.—An imaginary weight used in calculating the proportionate weight of the elements in a substance. Thus, an atom of hydrogen weighs one microcrith. An atom of oxygen weighs 16 microcriths. An atom of iron weighs 56 microcriths, etc. The actual weight of a microcrith is unknown.

Mineral.—A chemical combination of two or more elements forming a crystal or crystalline mass of approximately definite composition, hardness, luster, density and color. (See Rock.) A mineral may or may not contain a metal. Some minerals are composed of only one element; as, gold, copper, or silver. Some minerals are formed of two or more elements; as granite, calcite, etc.

Mineral acid.—Any acid except the organic acids. That is, the acids which do not contain carbon.

Mineralized.—Containing minerals, usually understood to be metalliferous minerals.

Miner's inch.—One and one-half cubic feet of water flowing per minute.

Molecule.—A combination of atoms forming the smallest particles of physical matter. It is impossible to divide or break up molecules by physical force. Only by chemical (or electrical) action can this be done. Ice, water and steam are all made of water molecules. By chemical or electrical means a molecule of water may be broken up into two atoms of hydrogen and one of oxygen.

Monzonite.—A variety of norite gabbro. A granular rock containing alkali and soda-lime feldspar in almost equal amount.

Mundic.—Iron pyrites. (Cornwall term.)

Naming element.—The substance from which a substance is named. The characteristic element in a substance. The naming element of sulfuric acid is sulfur.

Native.—Occurring in nature.

Niter.—Potassium nitrate.

Nitric acid.—Aqua fortis.

Noble metals.—Gold, platinum, silver and mercury.

Nugget.—A lump of metal.

Octahedron.—A solid of eight similar sides.

Organic.—Composed of vegetable or animal substance or the products of animal or vegetable life.

Open cut.—A surface working.

Outcrop.—That part of a vein appearing at the surface.

Oxid.—A compound composed of oxygen and any other element.

Oxidize.—The act of combining oxygen with an element. It also means the act of increasing an atom's power to unite with other elements. To increase the valence.

Parallelogram.—A surface having its opposite edges parallel.

Pay streak.—That part of a vein which is rich enough to repay mining.

Percolate.—To soak through, or filter through a porous material.

Persistent.—A persistent vein is one that shows evidences of having great depth. Improperly called permanent.

Petrified.—Substituted by stone, molecule for molecule. (See cast.) Petrified does not mean turned to stone. As the original material has been replaced by stone, atom at a time, the texture of the petrifaction becomes similar to that of the original substance, giving the impression that it has turned into stone. Lime and quartz are the most common minerals that replace vegetable and animal substances in the formation of petrifactions.

Pinch.—To become less thick, said of a vein.

Placer.—A gravel mine.

Plumbago.—Graphite.

Pocket.—A small rich ore body.

Precipitate (Noun).—A solid formed by adding one solution to another. Upon filtering, the precipitate remains upon the filter paper, the filtrate passing through.

Prism.—A solid having its ends of the same area and form, the sides being parallelograms.

Raise.—A shaft made from one mine level to the one above, usually for ventilation or to serve as an ore shoot.

Reduce.—To take away oxygen or lower the valence.

Refractory.—Not free milling. More properly, an ore that is difficult to smelt.

Replacement.—Taking the place of another mineral.

Riffle.—A framework used in the bottom of sluice boxes to collect gold.

Rim-rock.—Rock bordering an ancient channel.

Rock.—A mass of one mineral, or a mixture of two or more minerals in indefinite proportions. Compare mineral.

Rocker.—An implement resembling a child's cradle or rocker, for use in saving gold and heavy minerals.

Rusty gold.—Free gold that appears to be coated so that it will not amalgamate.

Sal ammoniac.—Ammonium chlorid.

Salvage.—Gouge.

Schist.—Crystalline rock having parallel scales.

Secondary enrichment.—Made richer by additions to the first deposit.

Segregation vein.—Formed by natural concentration from the adjacent rocks.

Sericite.—A variety of hydromica resulting from decomposition.

Shaft.—A vertical or inclined passage-way excavated in the earth's crust.

Shear zone.—A zone of crushed and metamorphosed rock along a fault plane.

Shoot.—The ore body within a vein.

Silicate.—A base metal combined with silica.

Slime.—Ore crushed so fine that it settles slowly in water.

Solfatara.—Areas of dying volcanic action, characterized by the escape of steam, gases and sublimates.

Specific gravity.—The weight of a mineral or other substance compared with the weight of an equal volume of water.

Stockwork.—An ore deposit of a form workable in floors or stories.

Stope.—That part of a vein where the ore has been removed. Also the act of mining ore in a stope.

Strata.—Two or more layers.

Stratum.—Singular for the word strata.

Streak.—The color of the mark made by a mineral on unglazed porcelain or other substance, used in testing minerals.

Striated.—Marked with parallel grooves or striae.

Strike.—The horizontal direction of a vein or stratum.

Stull.—A timber braced across a working from side to side.

Sulfate.—A compound of sulfur and oxygen in the ratio of one of the former to four of the latter, together with a base. The formula is $R''SO_4$, in which R'' represents any bivalent metal; as $CuSO_4$, copper sulfate.

Sulfid.—A compound of sulfur with any other one element. A sulfuret (Obsolete).

Sulfuric acid.—Oil of vitrol, H_2SO_4.

Syncline.—A bend in a stratum having the concave side up. A tough like form.

Tailings.—The lighter and less valuable portions of an ore.

Thermal.—Hot; as, Thermal springs.

Trap rock.—A dark, igneous rock.

Transit.—A surveying instrument.

Tufa.—Calcareous deposits from water.

Tuff.—Volcanic fragments or ashes.

Tunnel.—An underground passage-way entirely through a hill or mountain. Properly speaking, an adit should not be called a tunnel, but as the word tunnel is used in this sense in both State and United States Statutes, is in common use in the United States, and therefore, fixed in the language, it is not absolutely incorrect.

Underlay.—The same as Hade. Usually measured horizontally and expressed in terms per foot of depth, or in degrees from the vertical. See Hade and dip.

Unstratified.—Not in layers.

Unwater.—To take the water from a mine.

Upraise.—A term wrongly used for raise.

Valence.—The combining power of an element.

Vein.—*Lode. Ledge.*—In Australia and South Africa the word Reef is used for a vein. The material filling a fissure or the like in the earth's crust is properly called a vein or lode. That part which outcrops is properly called a ledge or outcrop.

Verdigris.—Oxy-acetate of copper. A green coating often found on copper utensils.

Vinegar.—Weak acetic acid produced by the complete fermentation of the sugar in vegetable juices.

Vitreous.—Glassy.

Volatile.—That which may be easily vaporized.

Walls.—The adjacent rock that encloses a vein. Do not use the term country rock to designate the rock adjacent to a vein. Wall rock is a better expression. The wall rock is in contact with the vein or the gouge. The country rock may extend miles in either direction from the vein. The hanging wall is the upper wall, and foot wall the lower.

Water of crystallization.—The elements of water (hydrogen and oxygen) chemically combined with other elements in a mineral, but not in such a way as to form water. With the application of heat these two elements will separate from the others and unite with each other, forming sensible water. Perfectly dry gypsum contains 20% of crystallization of water.

Whim.—A vertical drum or cylinder revolved by horse-power or steam.

Wing dam.—A dam built part way across a stream to deflect the water into a flume or ditch.

Winze.—A shaft sunk from one level to another in a mine.

Zinc white.—Zinc sulfate. Zinc vitrol. White vitrol.