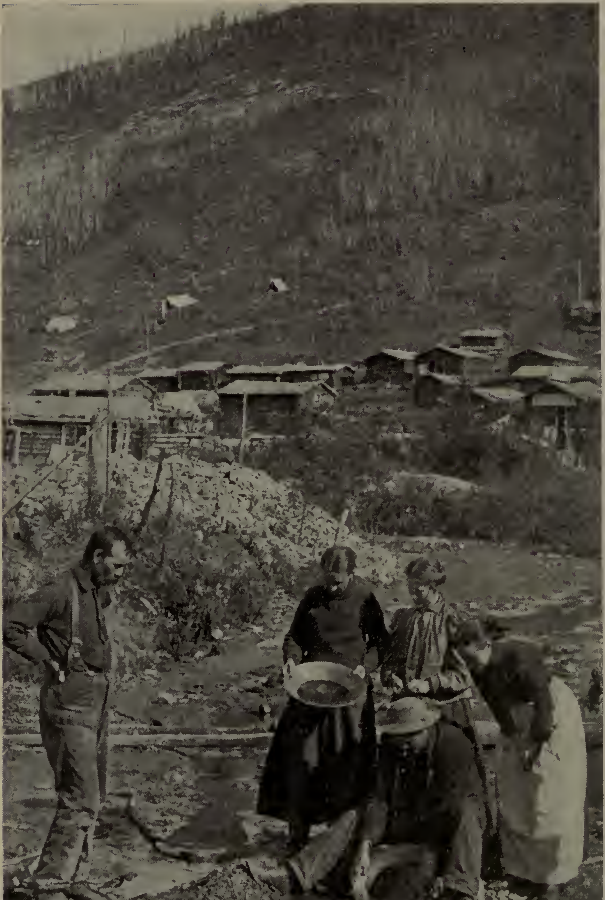
THE STORY OF GOLD



"Panning" at the junction of Eldorado and Bonanza Creeks.

THE STORY OF GOLD

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H. W. NICHOLS

WITH THE SINCERE THANKS OF

THE AUTHOR

PREFACE

This book is an attempt to present the development of the modern gold mining industry, with especial reference to the connection between its development and the ebb and flow of business prosperity.

The connection between the gold supply and prosperity is now thoroughly understood. Without a supply of gold, increasing at a rate corresponding to the volume of business transactions, prices must decline, and the scale of business operations must be curtailed.

On the other hand, if the gold mines furnish an adequate supply of reserve money, which serves as a foundation for the immense edifice of credit and token money, prices tend upward, and prosperity endures and increases.

Starting from this generally accepted view of the connection between gold and prosperity, the "Story of Gold," after a brief non-technical description of the nature and manner of occurrence of gold in nature and the methods of its extraction, goes on to explain the enormous increase in gold production in recent years, by reference to three controlling influences: (1) the advance in the value of gold from 1873 to 1897; (2) the new discoveries of gold ores; (3) the revolutionary improvements in the machinery and methods of gold mining and metallurgy. From this account of the history of gold production, material is drawn which serves as a basis for a forecast of the future of gold production. The conclusion is reached that, in spite of many and serious obstacles, the world's output of gold will go on increasing for many years, and at a rate, absolutely at least, as rapid as during the past quarter century. No marked depreciation of the value of gold is, however, to be anticipated from this increased production, because of the certainty that the industrial development of the world will continue to absorb all the supply of money which the gold mines can reasonably be expected to furnish.

I have dedicated this work to Mr. H. W.

Nichols, now and for many years Curator of the Department of Economic Geology of the Field Columbian Museum, as a public acknowledgment of his generous and valuable aid extended in the early and later stages of this book. I am also indebted to Professor J. Laurence Laughlin of the University of Chicago, and to Professor Joseph French Johnson of New York University, for helpful suggestions and criticisms. For my material I have utilized a series of magazine articles published by me some years ago in the *Journal of Political Economy* and the *Annals of the American Academy of Political and Social Science.* I have also made large use of the *Engineering and Mining Journal,* the *Transactions of the American Institute of Mining Engineers* and the volumes of the *Mineral Industry.*

EDWARD SHERWOOD MEADE.

PHILADELPHIA,
September 7, 1908.

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THE STORY OF GOLD

CHAPTER I

INTRODUCTORY

We live in an age of specialization. The workman feeds steel bars into a machine, or polishes gun barrels, or varnishes carriage bodies. The great factory unites the labors of hundreds and thousands of workmen into a continuous series whose outcome is a locomotive, or a steamship, or a watch, or a needle. Even cities and states are specialized; Pittsburgh to iron and steel manufacture; Kansas City to meat production, Fall River to the textile trade. Throughout every class and grade of labor, the specialization of employment, the concentration of productive energy on single objects, is the universal rule.

The reason for the organization of industry along lines of specialization is because in no other way can the highest efficiency be attained. Men, cities and nations, by devoting their energies to specific pursuits, by developing their capacities along particular lines, acquire extraordinary skill, capacity and facility in performing these operations, cheapen the cost of production and enlarge the output of industry and the sum of human comforts and luxuries.

Because of the division of labor, the common laborer of to-day is better fed and more comfortably housed and clothed than was Queen Elizabeth. A man does best that which he does habitually, so with a city or a state. The division of labor makes the performance of every industrial act a matter of habit, achieved without conscious attention, rapidly and with the accuracy of machinery. "Doffers" in the cotton mill, "splitters" in the abattoir, wrappers in the department store, are familiar illustrations of the wonderful skill and accuracy with which manual operations, oft repeated, are finally performed. By force of long habit, by attending to a few movements and manipulations, the man becomes a machine, and society gets the benefit of his superior efficiency in a larger volume and lower cost of the goods which he produces.

In order that production may be carried on by the division of labor, in order that one man may devote his entire time to grinding razors, and another to spraying fruit trees, there must be some institution whereby every member of society, from the bank president to the hod carrier, may exchange the results of his labor for those products of other producers which the needs of his daily life require. To satisfy the wants of every family the resources of the whole world must be utilized; the material for their shoes comes from South America, their coffee from Brazil, their tea from Japan, their bread from Minnesota, their meat from Texas, the materials for their clothing from Alabama and Australia. From every corner of the world are collected into the homes of common laborers, men earning as little as four hundred dollars a year, the products of every producing country, upon which, in extracting the materials, transporting and fashioning the finished product and distributing them to the consumer, thousands of other men, each performing his single task, have been employed. How is this feat accomplished? How is it possible for a shoe vamper in Haverhill, Massachusetts, to draw upon the labor of the tea grower of Japan and the sheep herder of New South Wales? How can millions of workers, scattered over the face of the globe, each one laboring at his single task, bring within the reach of everyone, the necessities, comforts and luxuries of modern existence?

This achievement is accomplished by two agencies: transportation,—the railroad and the steamship,—and money. It is with the material of money that this book is concerned. Money can be briefly defined as the medium of exchange; it is that article which is so universally desired by everyone, that, in order to obtain it, either for its use to him, or because he can pass it on in exchange for something else, he will give for this article his labor or his property, even in some cases his honor and reputation. By the use of money, the division of labor, which I have briefly described, is made possible. Every worker labors at his allotted task, consisting of a few operations which contribute to the production of a plow or a wagon. For this labor he receives money and for the money, in turn, he receives from other producers, through the retail stores, whatever he wishes for the satisfaction of his wants. The institution of exchange through money, the medium of exchange, is as simple as it is wonderful. Money has made modern industrial civilization possible. Without a medium of exchange, without this connecting link between every man's labors and every man's desires, we should quickly sink back into the laborious poverty of early times where men were Jacks of all trades and masters of none.

No better evidence of the importance of money to our industrial welfare could be desired than the experience of the United States in 1907 and 1908. Because the banks ceased, within a few days, to pay out money to their depositors, and also to furnish funds to borrowers, the country was suddenly plunged from prosperity into depression, and the output of manufacturing industry was reduced one-third from its former volume. Modern industry is so organized that it will not run without the aid of some medium of exchange, and when this ceases to be provided business must suddenly come to a stop.

Money—whatever it may have been in times past, beads, iron, cattle, salt—is now gold. The civilized world now uses gold, directly or indirectly, as its medium of exchange. This gold, in the form of coins, may pass from hand to hand, exchanging goods, and paying for services, or, in various forms, coin, bars or even dust, it may lie in the vaults of banks or public treasuries while its representatives, promises to pay gold on demand, such as the greenbacks, issued by the government, or promissory notes, issued by national banks, or checks and drafts issued by people who have money on deposit with the banks, circulate through the channels of trade, doing the work of gold and multiplying many times its efficiency.

The amount and distribution of this gold, its existing stock and its annual production, is of great importance to the prosperity of everyone. If gold is plentiful and the supply of money and credit abundant and increasing, prices, which are the amounts of gold for which coal, iron, wheat, copper and a thousand other articles can be exchanged in the markets, are high and increasing. Business men, under these circumstances, make large profits by selling at higher prices than those at which they buy, and workmen, because of these large profits, earn high wages at constant employment. In other words, when the supply of gold is abundant, men will give more gold for what they want, prices will rise, and prosperity, as we have seen, by which we mean the so-called "making" of money, is the result. Whatever a man has to sell, labor, wheat, cotton, newspapers, he can sell in time of prosperity, because the people who wish these things have plenty of gold or its equivalent with which to buy them. On the other hand, when the gold supply is decreasing and money is therefore scarce, sellers find trouble in disposing of their wares, prices fall, profits are reduced, mills are closed and labor is thrown out of employment; in short, depression and hard times are bound to succeed to prosperity and good times.

We see now why the study of gold is of importance: first, because gold makes money possible, and money makes possible the organization of industrial society along lines of that division of labor which is necessary to high efficiency and large production; and second, because upon the supply of gold and the effect of the gold supply upon wages and prices, depends the prosperity of every part of the world. Gold is also used for ornament and industrial uses, about half the annual output going into jewelry and the arts, but this use is of little consequence to man's welfare. The savage values gold for its ornamental uses, as much or more than the civilized man. Its glitter, its lustrous beauty, its lasting radiance, which no exposure can destroy, appeal quite as strongly to the Hindoo peasant as to the wife of the New York broker. This use of gold is, however, superfluous, unnecessary, even childish. Its important service is its use as money. Deep under the ground, behind the gratings of bank and treasury vaults, passing from hand to hand in the process of exchanges, the permanent foundation of the business activities of mankind, it is in this capacity that gold is of greatest significance to human welfare.

In the succeeding pages we are to inquire first, how gold occurs in nature; second, we are to study the history of gold production especially during the last sixty years, a period which witnessed the development of the modern gold producing industry, and third, we are to forecast, as far as possible, the future production of the metal.

CHAPTER II

THE OCCURRENCE OF GOLD IN NATURE

Aside from its scarcity, which goes far to make it desirable, gold presents a combination of useful and beautiful qualities of which it is difficult to find a counterpart.

"To a rich and brilliant yellow, a yellow which can only be adequately described as golden, it unites extreme malleability and a very high specific gravity, exceeded only by that of platinum and a few of the rarer and almost unknown metals." Gold is remarkable for its freedom from corrosive solutions, being quite unaffected and untarnished after exposure for any length of time to light, or moisture, or heat, and also being insoluble in all the simple acids. Strong nitric acid will rapidly attack any counterfeit metal but will not touch gold, or at most, will frequently dissolve any copper or silver alloyed with it. In almost all respects gold is perfectly suited for coinage when quite pure. Indeed it is almost as weak as tin, but, when combined with one-tenth or one-twelfth part of copper, becomes sufficiently hard to resist wear and tear. Its melting point is remarkably high, yet there is no perceptible oxidization or volatilization of the metal at the highest temperature which can be produced in the furnace.[1] Gold, because of its chemical inactivity, is called a noble metal and it is used extensively in great quantities for the chemical combination of the metal with other substances.

The occurrence of gold throughout nature is either in a pure state or in the form of an alloy, that is a mixture of gold with other substances in much the same way that sugar is mixed with water. This mixture possesses a character which neither of the substances composing it has, as for example in the illustration used, the water becomes sweet when the sugar becomes dissolved. If the sugar and water were frozen it would still be a mixture. A metal alloy, therefore, is a mixture of materials wherein the mixture is solidified.

Comparatively speaking, gold is a common metal and occurs widely throughout nature. Not only is it contained like all minerals in ordinary clay or rock which may be encountered

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[1] Jevons, "Money and the Mechanism of Exchange."

anywhere, but it is found in minute quantities in sea water, and large amounts of money have, from time to time, been contributed in fruitless attempts to extract it from the latter source. In workable quantities, it occurs in almost every part of the world. There are few mountainous regions which do not, to a careful investigation, reveal the existence of gold veins. Europe, at one time, produced large amounts of gold from the mines of Hungary and Spain. Gold is found in every country of Asia, especially in Southern Siberia and Northern China, and is generally distributed throughout Africa and Northern South America. Australia is rich in the precious metal, especially in the Southwestern portion. In Mexico and Central America gold is abundant, and the deposits extend northward through the Cordilleras, being found throughout the western part of the United States and extending as far north as Alaska.

Because gold is so widely distributed, we must not, however, assume that it is a plentiful metal. From the beginning of recorded time, the amount of gold produced up to the present day has been less than 20,000 tons. When we contrast this with the enormous production in the United States of 300,000,000 tons of coal, 30,000,000 tons of iron ore and 625,000 tons of copper, we can get some idea of the extreme rarity of the "King" of metals. In value, however, though not in weight, its production compares very favorably with that of other metals. In 1905, for example, the United States produced $87,-948,237 in gold, $120,000,000 of copper, $367,-862,000 of iron and $19,993,000 of lead. The total amount of gold produced throughout the world in this year was $379,635,413. There were four important producers: the United States with $87,948,237, the Transvaal with $101,225,558, Australia with $85,970,779, and Russia with $22,197,155. In addition to these principal producers, we have Canada and Mexico with about $14,500,000 each, British India with $12,000,000 and Brazil, Columbia, British and Dutch Guiana, Hungary, Germany and Rhodesia in South Africa, China and Japan with $2,000,000 or over.

Gold occurs in two general forms of deposit: veins and placers, or, describing these formations with reference to their relation to each other, primary and secondary formations. Like all other metals gold occurs in fine particles throughout the earth, but, as already observed, in quantities too minute to be profitably extracted. In order that gold should be mined, it must be collected in sufficient quantities to repay the work of the miner in separating it from the surrounding rock.

The method of vein formation, briefly stated, is as follows: The vein is a fissure or opening in

Fissure opening caused by simple contraction.

the earth's crust which is filled with metallic ore, that is gold, silver, copper, lead or zinc, as-

Fissure due to faulting.

sociated with other minerals. A familiar form of gold bearing ore is white quartz. Before the vein can be formed, an opening must first be made in the surrounding rock in order to allow room for the deposit of the metal. These openings may be made by the contraction of the earth's crust. At one time this was in a fluid or semi-fluid condition. The mass cooled unevenly and this uneven cooling caused irregular contraction, which set up strains in certain sections

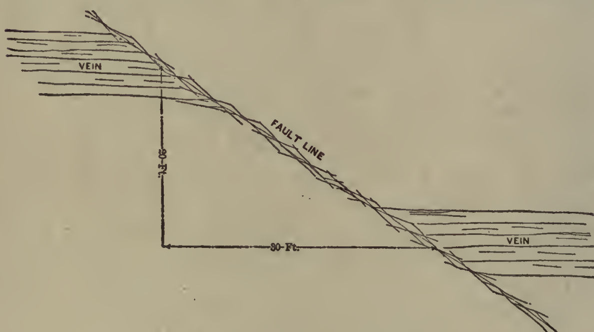
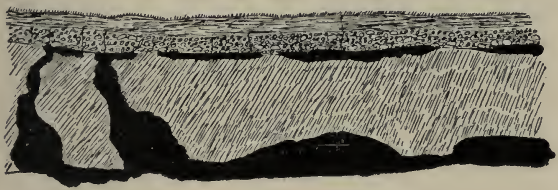


Fig. 3.

Diagram showing faulting.

of the rock resulting in fissures or cracks, just as a plate cracks by having hot water thrown upon it, or as glass is shattered by being suddenly thrust into hot water. Some of these cracks are of small extent but others go much deeper, through thousands of feet of the rock. Fissures are also formed by faulting, that is, by the slipping of one section of rock upon another, which causes them to move in different directions. Running water also causes fissures. The majority of all rocks are more or less soluble in water and all rock material will, in time, yield itself to the constant action of running water. Pure water possesses little dissolving power on rocks. It will, however, absorb from the surface layer materials such as carbonic acid and the like, which have the power of dissolving rocks. In its downward course the water containing



Fissures due to solution.

these solubles becomes heated, its dissolving power is greatly increased, and, as a result, fissures are formed. Limestone is one of the most soluble of the rocks occurring in great quantities. In volcanic regions the explosive action of steam confined by the earth's crust has frequently formed extensive fissures. These cavities are the spaces within which the metallic ores are deposited.

Various explanations of these deposits of ore in the cavities and fissures have been advanced. It has been argued that the deposits of ore have been injected into the cracks and fissures when in a fluid condition, by the influence of intense heat and pressure. The explanation generally accepted, however, is known as the "Theory of Ascension," which is as follows: Water is continually passing down through the surface of the earth through innumerable cracks and fissures, whose method of formation has just been described. This water, as it descends, takes up the minute metallic particles which in one form or another are widely distributed throughout the rocks through which it passes. As the water descends to the lower levels it becomes heated and expands, which increases its power of absorbing materials. This mineralized water frequently returns toward the surface through the fissures, which offer an easy passage, and as it rises, it deposits its mineral contents upon the sides of the fissure.

Ore deposits are sometimes formed in rocks where there are no open fissures, but where the mineral bearing solutions have percolated through the pores of the rock and deposited the ore in the pores, the one class of deposits where the ore has replaced the rock, particle by particle, without any fissures having been formed. In recent years, there are many geologists who are accepting the view that important ores are derived from waters which are given off by the buried volcanic rocks in cooling, and which correspond to the clouds of steam which are given off by lava flowing from recent eruptions.

The formation of the gold veins is well indicated by the accompanying illustration and diagram which show the occurrence of a celebrated vein in a West Australian mine. Quartz, or gold bearing metal, is clearly seen filling the fissures or cracks in the surrounding rock and the occurrence of the gold in quartz is clearly indicated. These veins sometimes proceed for thousands of feet without a break. Again, they may be broken off by the faulting of the strata through which they run, or they may be destroyed by the erosion of the water, or they may occur irregularly.

The gold in these veins is of two classes: (1) free milling gold, i. e., gold which has been freed by natural agencies from sulphur, arsenic and other impurities originally associated with it, usually found above the permanent water level; and (2) refractory ores, usually occurring below the level of standing water, and in intimate mechanical association with the impurities mentioned. In free milling ores the compounds

Illustration of a celebrated vein in Australian mine.

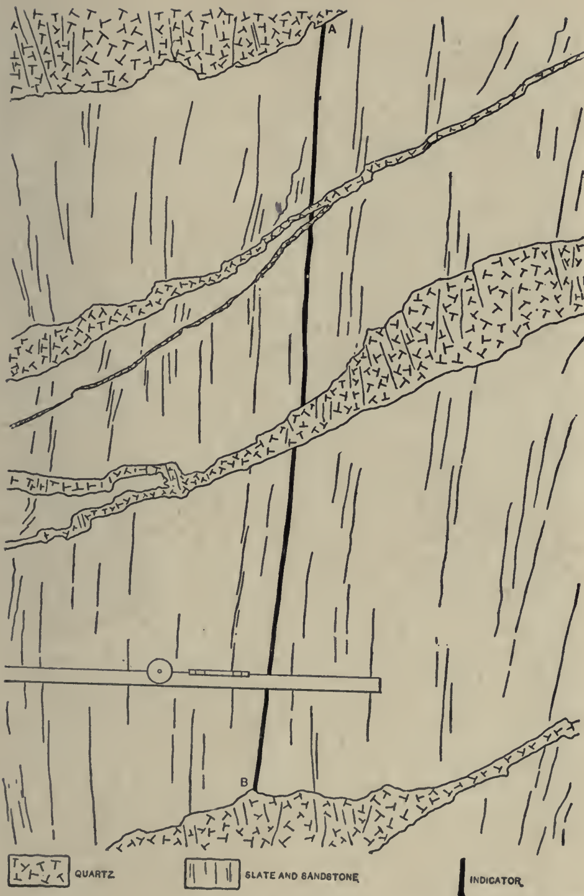
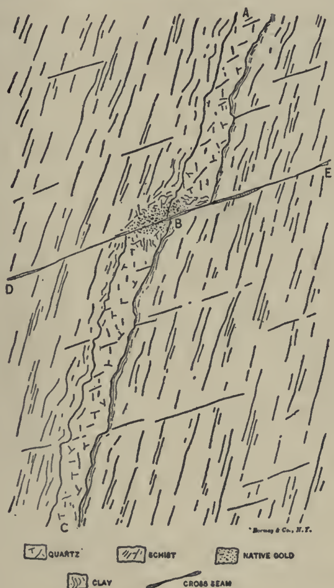


Diagram of the same vein.

of sulphur accompanying the gold have been removed by weathering. This may be defined as a process of chemical decomposition and mechanical disintegration in which oxidization is aided by the shattering of the rock due to the alternate expansion and contraction of the water present in its pores, seams and cavities. The impurities associated with gold can be oxidized or burned and, as far down into the rock as the oxygen of the air can be carried, this oxidization or burning of the impurities will operate. The depth to which these effects extend depends upon the facilities afforded for the penetration of the surface waters which carry free oxygen. Weathering ceases at the permanent water level where the descending surface waters, mingling with the larger body of neutralized water, lose their free oxygen. This process of weathering and oxidization is constantly separating the gold particles from their accompanying minerals, often without shifting the position of the gold, which in some cases is found in fine crystals which can be readily shaken loose from the quartz, which has been honeycombed by oxidization. The result of this process is to increase the richness of the vein, because it diminishes the weight of the ore without decreasing the amount of gold which it contains. The descending surface waters, as already shown, also carry the gold down to lower levels, collecting it from a large mass of rock, and depositing it, often in



Formation of Bonanza veins.

veins of great richness, far below its region of origin.

The separation of the gold from these descending waters often takes place at the intersection of fissures, or rock fractures, at which points the enormously rich bonanzas, which have given its character and reputation to gold mining as the means to sudden wealth, are generally found. The accompanying illustration shows the manner in which these deposits are formed.

A description of the deposit which is represented by this illustration is given by Mr. T. A. Rickard in an article on the "Formation of Bonanzas in Gold Veins,"[1] substantially as follows: "In California, especially in that mining region which follows the foothills of the Sierra Nevada, . . . the occurrence of pockets of rich ore full of native gold, is a notable feature of the superficial parts of the quartz veins. These pockets appear to be confined to the zone between the surface and the water level and to be dependent upon the results produced by the small cross-veins which encounter the main lodes . . . at the Rathgeb Mine in Calaveras County, the main lode consisted of five to eight feet of massive 'hungry-looking' quartz. The water level was 160 feet below the surface. Down to this point the country rock was oxidized, the hanging wall exhibiting only slight alteration, while the foot wall was softened and decom-

[1] "Transactions American Institute of Mining Engineers," Vol. 31, p. 214.

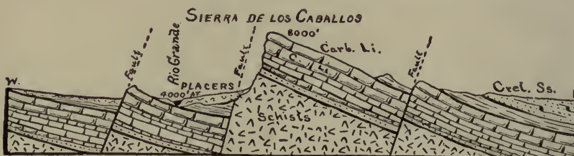
posed almost to a clay. This was traversed by numerous small veins which appeared to act as feeders, forming bunches of rich ore where they encountered the main lode. At the 120-foot level, south from the shaft, there were some old workings; and the examination of these led to the discovery of a small seam, about one-sixteenth of an inch thick, filled with red clay which carried a good deal of native gold, as was proved by washing it in a pan. An experienced miner was put to work with instructions to follow this small streak. It varied in thickness and occasionally opened out into small cavities containing a clay in which the gold was distributed like the raisins in a pudding. Each of these ' pockets ' yielded several hundred dollars' worth of gold. At length the streak widened to six or eight inches of quartz lined with clay. The amount of red clay commenced to increase; coarse gold became more frequent, and a big discovery was hourly expected. It was finally made. The vein became faulted (broken off) and at the place of faulting there was a soft, spongy, wiry mass of gold and clay—more gold than clay. The first handful contained three ounces of gold, within the next two hours this pocket gave up $3,000 and during the following week it yielded over $20,000, an amount which was obtained at a total cost of less than $200.''

Only a small portion of the gold bearing ores can be classed as free milling, by which term is meant ore containing gold which will readily unite with mercury, in the process of amalgamation, or which can, in some cases, be separated by the action of water. These free milling ores bear to the total mass of gold bearing rock much the same relation that the snow-capped peaks of the Sierras bear to the enormous mountain masses upon which they stand. Refractory ores, also known as sulphides, are much more difficult to work than free milling ores. The impurities with which the gold particles are closely associated interfere with the amalgamation process. These ores are also much less valuable ton for ton than the free milling ores, since the gold particles which, as we have seen, in the free milling ores are concentrated into veins, are, in the sulphides, scattered in fine particles throughout the rock. These ores require special mechanical and chemical treatment for the profitable extraction of their gold. We shall have further occasion to observe the importance of this distinction between free milling and refractory ore when we come to the methods of gold extraction.

CHAPTER III

THE FORMATION OF GOLD PLACERS

Gold in the ore does not differ essentially in its formation and methods of mining from copper, lead, iron or any other mineral. Gold in the placer, however, presents a unique form of occurrence which, until comparatively recent years, sharply distinguished the methods of gold extraction from those employed in the winning of other metals. Placer gold deposits have been formed by the disintegration of the gold bearing rocks and the carrying down of their contents into the beds of streams. Here the steady action of running water separates the gold from the lighter materials associated with it and, because of their lower specific gravity, carries them away faster than the heavy gold. The gold freed from its enclosing rock, which has been swept along by the force of the current, is frequently found in large quantities at the bars and riffles of the stream. It is also found scattered finely through the sands which form the beds of these streams. In this way, in every country where gold is found, nature has, to a large extent, anticipated the miner's work, and has left the precious metal in such a form that it can be easily and quickly obtained. The extraction of placer gold consists merely in the further application of nature's methods of turning running water upon the gold bearing sand and gravel, and where operations are carried on on a large scale, in the utilization of mercury to take

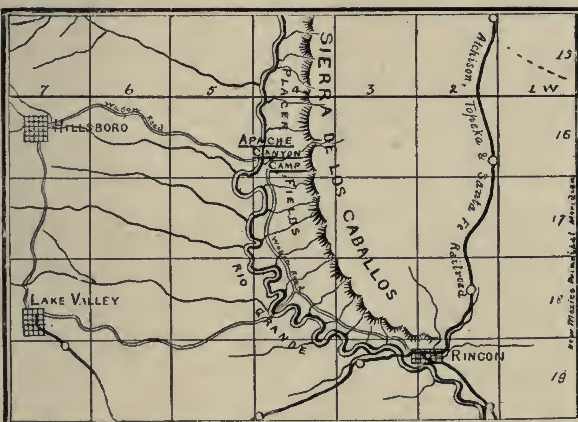


GEOLOGICAL SECTION OF SIERRA DE LOS CABALLOS.

Apache Canyon placers.

up the gold particles. This process of natural gold extraction has been going on ever since the veins were first filled with gold ore. In mountainous regions the breaking up of the rock is mainly caused by the surface water penetrating into the cracks and freezing. In this way the material out of which the alluvial or placer deposits of the valleys is formed is broken off. Returning again to our illustration, if the process of oxidization, which Mr. Rickard so vividly describes had been supplemented with the breaking down of the rock mass in which these processes of separation and concentration had been accomplished, we should have had the beginnings of a placer.

This rock so broken up is carried down into



SKETCH MAP OF GOLD-FIELDS OF SIERRA DE LOS CABALLOS.

Apache Canyon placers.

the streams, for the most part by the melting of the winter snows, and the streams at once begin the process of concentrating the gold from the ore, which continues until each particle has been separated by the surrounding rock and classified by the machinery of nature. The process has been summarized as follows: " Tailings " are the mud and sand which go to build new foundations upon the shores; " middlings " are the great masses of alluvium covering the plain; and the " heads " are the gold bearing gravel of the mountainous rocks. The soft is separated from the hard, the heavy from the light, until at length the material inclosed within the rock is set free, to be collected wherever the eager stream has so abated its force as to permit the particles of gold to find a quiet resting place.

This classification of gold bearing material according to its specific gravity is in Western Australia accomplished by the wind. In the vicinity of Kalgoorlie the dust storms are perpetual. The wind careers over the country in whirlwinds to which the natives give the name of " willy willy." In this region there are no streams, and these wind storms, which in their rapid progress across the plains swirl up everything along the surface, are responsible for the greater part of the transportation of the gold bearing material which weathering has disintegrated. " In traveling over the country one is soon called upon to notice the broken white quartz scattered over the ground in big patches many acres wide; these alternate with stretches, steel gray in the morning and blue black towards the close of the day, of ironstone fragments; the wind has scattered quartz, ironstone and dust. The latter has been scattered in contemptuous carelessness all over the face of the waste of desolation, but the heavy ironstone remains not far from where it was broken off until, shattered to powder, it is also winnowed by the dust storm. The numerous veins, large and small, traversing the country have contributed the quartz which the wind has collected, so that it sometimes covers the ground with the glittering whiteness of a snow drift." [1]

To mention one other peculiar instance of placer formation, the Ocean Beach Placers at Cape Nome have been formed entirely by the action of the sea. These beach placers consist of a strip of comparatively fine gravel and often 100 to 150 yards wide, extending parallel to the frontal edge of the "tundra," as the coast plain is called. In these placers, the gold is generally found in a blue clay lying next to the rock. Above the clay beds come classified layers of fine gravel and sand in which the amount of gold gradually diminishes. These beach beds are

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[1] T. A. Rickard in "Transactions A. I. M. E.," Vol. 28, p. 502.

the concentration of the gold which has been carried by the streams into the gravel and sand of the coastal plain, originally derived, as are all placers, from veins of gold for the most part long since destroyed by weathering. Fissures are constantly cut along the bar of the bluff that nearly everywhere forms the tundra on the seaward side. As the material is thus carried away, the gravel and sand is carried by the undertow, while the gold, because of its greater weight, is left on the wall and will work its way downward to the lower sands on the water line and may subsequently become buried."[1]

[1] F. C. Schrader and Alfred H Brooks, "T. A. I. M. E.," Vol. 30, pp. 242-244.

CHAPTER IV

THE METHODS OF GOLD EXTRACTION

Since the methods of gold mining are similar to those employed in the mining of other ores, it will not be necessary to go further in describing them than to say that they consist in the sinking of shafts to a sufficient depth to enable the excavation of galleries along the line of the vein. The arrangement of these galleries, as well as that of the main shaft, is graphically shown in the accompanying illustration, which shows the great Treadwell Mine on Douglas Island. The ore is broken down by blasts of giant powder, further broken to a size suitable for transportation and then hauled away to the shaft, whence it is taken by elevator to the surface, there further broken and pulverized, preceding the final process of extraction. In the pursuit of gold, shafts have been sunk to extraordinary depths. On the Rand gold is now being extracted at nearly 4,000 feet deep and in West Australia, also, mines have reached great depths.

The depths reached by the South African mines are graphically shown in the accompanying diagram.

After the gold ore has reached the surface it must then be thoroughly pulverized in order to separate the fine particles of gold from the inclosed rock. This is done in a stamp mill. A modern stamp mill consists of a number of mortars of steel in which are dropped stamps or hammers, ranging from 600 to 800 pounds in weight. The gold ore is put into a mortar and the stamp in its downward blow crushes the rock to powder. This crushing is done in water, and the resulting solution may be allowed to flow over amalgamated silvered plates on which the gold is collected, the sand passing off. When the mercury on the plates is saturated with gold, the amalgam is scraped off.

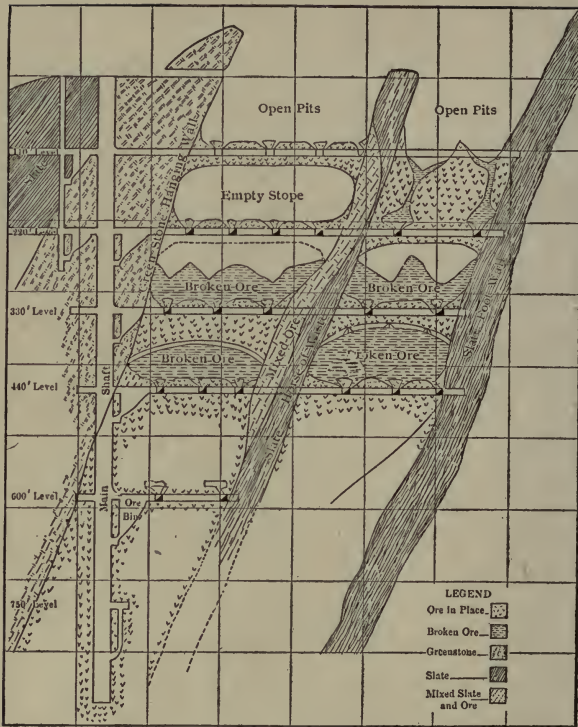
The separation of the gold from the rock may be accomplished solely by the use of water which sorts out, as we have seen, the heavy gold from the light material which accompanies it. Unless some other agency than water is used, however, a large part of the gold consisting of particles so fine as to float upon the surface of the water, will be carried away and lost. In order to recover this gold, a process of amalgamation with mercury is used. Mercury is the only known

Down in a gold mine.

liquid metal, and it has the power of dissolving gold just as water has the power of dissolving sugar. The combination of gold and mercury is known as gold amalgam and the gold can be recovered from this amalgam, just as sugar can be reduced from a solution of sugar and water, by heating the mixture until the liquid elements have been distilled.

In the process of amalgamation, when the mercury reaches the point where it will take up no more gold, which is known as the point of saturation, it is put into a retort and heated to the point where the mercury goes off into vapor. This distillation of the mercury is carried on until it is completely separated from the gold. The mercury is not lost when distilled, but is recovered at some little distance from the retort in a receptacle maintained at a low temperature, in which the mercury condenses on the sides. The gold, however, remains in the retort and is thus recovered. This process of amalgamation in modern gold milling is carried on at more than one point. In some mills, amalgamation takes place in the mortars which are supplied with mercury in order to take up gold which is liberated by the fall of the stamps. The batteries are also lined with copper plates covered with mercury in which much of the gold is taken

Treadwell Gold Mines, Douglas Island, Alaska.



Cross section of Treadwell Mine.

up. In some cases the ore solution, after leaving the mortar, is conducted over other amalgam plates, but the process of recovery is al-

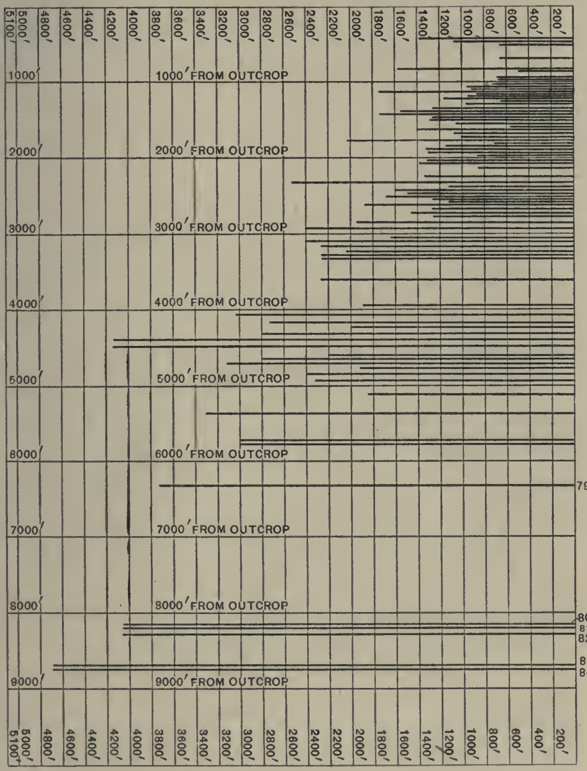


Diagram showing the depths reached by South African mines.

ways the same, and the principles involved are identical.

Placer working, compared with the extraction of the gold from the ore, is relatively easy. Placer gold is free milling gold which will readily amalgamate with mercury. It does not usually contain a large percentage of particles

Simmer and Jack stamp mill.

which can be carried off by water. Such losses as could be sustained from this cause have already taken place in the original formation of the placer. The only thing necessary in placer working is to separate the accompanying clay and gravel from the gold by the action of water through the difference in specific gravity which causes the heavy gold carried in a current of water to settle to the bottom of the sluice. In handling placer material in large quantities, and except where the gold occurs in relatively small amounts, mercury is also added. A small amount of gold is still taken out by the simple process of panning, by which the miner fills an iron pan with gold bearing gravel and water, and by a circular motion gradually sinks the gold into the bottom of the pan and shoves off the gravel from the top until it is possible to pick out the particles of precious metal. This, however, is a primitive method and is little used. An indispensable feature of placer working is the sluice, which consists of an inclined channel, through which flows a stream of water, carrying gold bearing material along with it. On the bottom of the sluice may be placed a blanket to catch the gold, or a shallow compartment filled with mercury, or mercury-covered copper plates which in addition to the riffles take up the particles of gold.

CHAPTER V

THE GOLD SUPPLY AND PROSPERITY

In the introductory chapter, we saw how intimate is the connection between the supply of gold and business prosperity. As the money supply increased or diminished so prices rose and fell. We have also seen that rising prices are synonymous with prosperity and falling prices with depression. To illustrate these propositions, as well as to introduce the discussion of the modern gold industry, let us briefly review the history of the production of the precious metals, which have from time immemorial been used as money, and note, in passing from one epoch to another, how the industrial welfare of the world waxed and waned with the flow and ebb of gold and silver.

From the earliest beginning of history there has been an eager search, especially among civilized peoples, for gold and silver. Every ancient civilization made large use of the precious metals, and their decline and decay were coterminous with the exportation of gold or the decline in the output of the mines from which they drew their supply. This gold was mainly derived from Asia,—in Asia Minor, Siberia and the Ural Mountains, and Thibet, although Africa, chiefly in upper Egypt, produced a large amount of gold. The accumulations of the precious metals by these Oriental monarchies were enormous. The capture of Ecbatana, for example, yielded Alexander the Great $200,000,000 in precious metals, and that of Persepolis $135,000,000. In Egypt the treasure of Ptolemy Philadelphus amounted to $900,000,000. These immense treasures existed for the most part in hoards, in royal treasuries and in the adornments of tombs and temples. They were drawn upon in national emergencies, but for the most part did not actively circulate as money.

With the expansion of the Roman Empire following the conquests of Alexander, these enormous treasures, the accumulations of thousands of years of production, were drawn into Southern Europe, supplemented by the product of the mines of Spain and, at a later period, of what is now Hungary. As a result of these immense importations of gold and silver into Italy, prices of all commodities, including land, increased. The price of wheat, for example, increased from six cents a bushel in about 350 B. C. to $1.75 at the beginning of the Christian era. The rate of interest, which in Athens at the time of its greatest prosperity had averaged twelve per cent., at the opening of the reign of Augustus Cæsar at one time disappeared, the first Emperor of Rome issuing an order that money should be loaned without interest to any who would give security in double the amount borrowed.

The Roman civilization was, however, based on conquest and not on commerce and industry. Under the Empire, the population of Italy consisted of a vast number of slaves and of citizens supported at public expense, and a comparatively small number of rich land-owners and officials through whose hands passed all the money, and who used it not to support industrial enterprises, toward which the Romans never showed any inclination, but to support themselves, their slaves and the citizens of the Empire who received, with few exceptions, regular donations for their subsistence; and to procure from the East a great variety of articles of luxury, and from Africa the food supplies which formed the principal subsistence of Italy. As a result, there soon set in a flow of specie to Asia and Africa out of Italy which continued throughout the entire period of Roman decline. At the same time the cessation of conquests dried up the supply of cheap slaves which in turn made mining unprofitable. The mining industry of Spain and Transylvania was also greatly interfered with by the incursions of the barbarians, and by the fifth century A. D. mining, throughout the Roman Empire, had practically ceased.

Jacob, in his "History of the Precious Metals," estimates that the amount of gold and silver in the Roman Empire in the year 14 A. D. was $1,800,000,000 and that owing to abrasion and other losses, together with the drain to the East, and the cessation of mining, this amount had fallen to $450,000,000 at the fall of the Empire. As a result the value of money steadily rose, the burden of debts, especially of taxation, increased; agriculture, the only form of productive enterprise largely undertaken by the Romans, was almost abandoned and the Empire, drained by the East of its money, literally dried up and withered away.

This process is described by Patterson in his "New Golden Age" as follows: "And so money began to grow scarce even in the heart of the Roman world. A great change of prices was gradually brought about. Money became dear and a deplorable calamity set in. Taxation in those times was almost entirely of the 'direct' kind; it fell upon individuals, rather than upon the commodities which they use. The tribute and the taxes were usually levied in fixed sums from states, townships or provinces. Accordingly, as money grew scarce, the weight of this taxation became proportionately increased. Gold and silver becoming scarce, a thousand pounds or ounces of these metals, or a thousand coins of the day, became as valuable as (say) fifteen hundred or even two thousand had previously been. Yet there was no reduction in the amount of the assessment. And so the towns and districts of Italy, although nominally paying no more taxes than before, became ground down by a taxation which, though nominally the same, actually was greatly increased. . . . As the dearth of money progressed, the districts or communities could no longer afford to pay the sums required of them by the State. Thereupon some of the population went away; but this only made things worse for those that remained, because the imperial assessment continued as before, while there was a smaller population to pay the amount. . . . At length the heart of the Empire was withered up; . . . Italy became neither able nor willing for self-defense. With the decay of the rural population came a scarcity of soldiers and growing gaps in the once formidable Legions. . . . So Italy became helpless, inviting her doom. . . . The Roman world which had so long lain like a beautiful garden around the Mediterranean Sea . . . that rich and lovely region, full of splendid cities and the gathered spoil of the known world, at length lay open to the Northern hordes who speedily trampled it into desolation."[1]

Other causes than the growing scarcity of the precious metals contributed to the decline and fall of the Roman Empire, but historians are generally agreed that the fall of prices, which resulted from the scarcity of money, because it increased the weight of taxation and discouraged agriculture, contributed largely to the final collapse of ancient civilization.

Throughout the thousand years of the Middle or Dark Ages, mining for the precious metals was prosecuted on a small scale. In Spain under the Moors there was some revival of activity in the old Roman workings, and in Saxony silver mining was an important industry. The annual production was, however, small, only about sufficient to maintain the supply, which from 800 to 1592 varied between $150,000,000 and $200,-

[1] Vol. I, pp. 290–92.

000,000. Throughout this period little trade was carried on. Society was organized for military rather than industrial purposes. Accumulations of wealth took the form of land. Of business, in the modern sense of the word, there was very little. Money was therefore not needed. What there was, however, owing to its scarcity, was of great value. About 997, for example, in England, the ordinary price of a horse was $9.00, of a cow $1.60 and of a hog 50 cents. Most transactions were carried on by barter. "Thus, for example, when a person owed another a certain sum of money he had not a sufficient quantity of coin to pay, he supplied that deficiency by giving a certain number of slaves, horses, cows or sheep at the rate set upon them by law."

The discovery of America put an end to this period of barter, industrial stagnation and low prices. It precipitated into Europe within one hundred years over two billions of money, ten times the entire monetary stock of Europe before the discovery of the New World. This mining of gold and silver in the Americas was from the beginning until 1800 controlled by the Spaniards. Gold was discovered almost at the beginning in Hispaniola and wherever the *conquistadores* penetrated, into Mexico, New

Granada, Peru, every part of Central and South America, they first appropriated the treasures of the natives, and then appropriated the labor of the natives to prosecute with merciless vigor extensive mining operations.

The plunder of the city of Cuzco yielded $2,000,000 in metal, and one Spanish writer states that Pizarro, the Conqueror of Peru, exacted $4,000,000 as ransoms from the Inca Atahualpa. These findings, however, were small compared with the enormous product of the mines under the forced labor of the natives. Thus from the richest silver mine, Potosi in Peru, in the twenty-one years ending 1600, nearly $30,000,000 of silver was extracted. The gold mines of Colombia and the silver workings of Mexico were also immensely profitable. Most of the labor was performed by slaves, and where wages were paid they were little more than the cost of subsistence. The high value of gold and silver, reflected in their purchasing power over other commodities, also made it possible to win them in large amounts from workings some of which cannot be profitably exploited even with modern methods and machinery.

The flow of precious metals from America into Europe to which Africa, at a later date, contributed largely, amounted from 1500 to 1829 to

$7,500,000,000, and as a result prices rose everywhere. Money exchange was introduced into every part of Europe. Trade, especially foreign trade, was quickened throughout the world. Spanish America was settled during this period and its agricultural resources extensively developed. The North American continent was also developed along its eastern boundaries, which gave rise to an important commerce. The trade with the Orient also grew to large proportions and prevented a far more extreme rise of prices than that which took place, which amounted, from 1500 to 1600, to 100 per cent. There was also a very large absorption of the precious metals into ornaments and plate. Especially was this true in Roman Catholic countries, where the shrines blazed with gold and silver. During the century ending in 1700, the population and wealth of Great Britain doubled and that of the Low Countries and France increased even more rapidly. This expansion of trade and industry went on in the north of Europe without interruption until the Napoleonic wars threw into the hands of Great Britain the world's trade.

The third period of the history of the precious metals ends about 1800. With the revolt of the Spanish colonies in America another period of scarcity set in, rivaling in its effects upon industry and enterprise the drain of gold and silver from the Roman Empire. Indeed, even while the Spanish American mines were in full operation, toward the end of the eighteenth century, as a result of the rapid growth of population, industry and commerce, which greatly increased the demand for money to accomplish their transactions, some scarcity of money was observed in a tendency of prices to decline. In other words, the increasing demand for money was forcing up its purchasing power. The scarcity became acute, however, when the Spanish colonies in America revolted from 1809 to 1819. Whatever the faults of the Spanish Colonial Government it had always maintained peace and afforded security. To the success of the revolution, however, immediately succeeded in every one of the "liberated" colonies a succession of military despotisms, with extended intervals of no government when society fell into anarchy. Under these conditions, there was no security for life or property and mining activity was everywhere abandoned. By 1816 the annual gold and silver production of the New World had fallen from \$50,000,000 to \$12,000,000. From 130,000 at the outbreak of the revolution in Peru, the population of Potosi dwindled to 9000 in 1826. The mines were plundered, their labor supply disappeared with the abolition of slavery, and the proprietors and managers left America. The mining industry of Spanish America has never regained the importance which it enjoyed before the revolution. As a result of the collapse of the precious metal industry in the New World, the stock of gold and silver coin in Europe and America, which was $1,900,000,000 in 1810, had fallen to $1,565,000,000 in 1830. In other words, because the principal source of supply had dried up, at a time when the demand for money was rapidly increasing with the great expansion of trade and industry which followed the Napoleonic wars, the supply of money to carry on this increased business was steadily and rapidly being reduced. As a result the period 1815-1850 was characterized by prolonged stringencies, often developing into panics and depressions and by an almost uninterrupted fall of prices, due, as we have already explained, to the increasing scarcity of money.

Writing in 1830, Jacob says: " In this country, where the cultivators are a class of capitalists distinct from the proprietors, their capitals have generally been diminishing, whilst the decline of the mines has been proceeding, and the application of their produce to other purposes than that of coin has been increasing. It certainly does not follow from these two courses having been in simultaneous progression, that one is the cause of the other. The same has been the condition of the cultivators of the soil in every other country, so far as it is accurately known. In every part of the continent of Europe the same complaints are heard, however various may be the tenures by which land is held. . . . The cultivators in North America assert that the prices of their productions yield them no profit. . . . The same is the case in the West India Islands and, according to the common reports, in South America, and in India. There must be some general cause producing such extensive effects, which are thus felt alike where taxation is high or low, under despotic or free governments; and whether the land is cultivated by slaves, by serfs, by hired laborers, or by proprietors." This general cause, to whose existence Mr. Jacob is unwilling to commit himself, he evidently believes to have been the scarcity of money, which was everywhere operative.

"For about twenty years prior to 1848," says Mr. Newmark, author of the "History of Prices in Great Britain," "the annual supplies of gold had been insufficient to meet the wear and tear of the coin in use, together with the requirements of the arts and the needs of encouraging industry and commerce and population. There had been a slow but steady and progressive tendency towards lower prices and therefore towards the discouragement of enterprises in which lapse of time and the state of distant markets had to be considered." And the English historian, Alison, says, " the whole period from 1819 to 1829 had been one of incessant fall of prices. The chief articles of commerce at that time had declined in money value fifty per cent., . . . many much more. Such a long continued and prodigious fall of prices filled all classes living on the sale of commodities with despair. True they bought everything cheaper, but what did this cheapness avail them when the wages of labor came down in a still greater proportion; when two million of destitute paupers in Ireland were at every moment ready to inundate the labor-market of England and employment even on the lowest rates was often not to be had, from the discouragement to speculation of every kind which the continual fall of prices occasioned." Some relief was afforded by the increase in the Russian output of gold which began about 1830, but in 1849, the date of the discovery of gold in California, the world was badly in need of an addition to its money supply.

Gold was discovered on Sutter's ranch at the confluence of the Sacramento and American Rivers on January 19, 1848. Sutter was a German settler who was erecting a mill to grind his grain. While the mill race was being dug, grains of gold turned up. The whole locality was found to be gold bearing, especially in the water courses. The news of the discoveries reached New York at the end of the year, and an enormous immigration into California immediately began. In June, 1850, the total white population of California was below 100,000. In November, 1852, the whites had increased to 170,000 and the total population of the state was 269,000.

The streams in the state were rapidly explored by thousands of eager gold seekers, and in 1851, the year of largest production, $81,000,000 of gold was taken out. The first gold discovered in Australia was in March, 1850, and in August, 1851, gold was discovered in large quantities at Ballarat in Victoria. Soon afterwards important discoveries were made in Victoria and New South Wales. The immediate result of these discoveries was a rush to the Australian gold fields similar to that two years before to California. Within ten years the mines of Victoria and New South Wales yielded nearly $500,000,000 of gold and during the same period California produced $700,000,000. During the twenty years following 1851, Australia and the United States added to the world's gold supply over two billion dollars. Not all of this gold, probably not more than two-thirds, some authorities have it one-half, went into circulation as money, the rest being consumed in the arts. The new gold also displaced a large amount of silver, which flowed off to the East and was absorbed in the hoards and stagnant currencies of India.

It is a safe conclusion, however, that at least a billion dollars was added to the currency of Western Europe and America from 1850 to 1870, and this was sufficient to cause a remarkable uplift in prices and a corresponding increase of prosperity. Taken as a whole, the period from 1850 to 1873 was the most prosperous that the world had ever seen up to that time. This period witnessed the development of the American West, the development of South Africa and of America, and also a great increase in population, industry and trade throughout Western Europe. The most significant figures showing the prosperity resulting from the gold discoveries are those of foreign trade. The exports and imports of Great Britain from 1850 to 1865 increased 106 per cent.; of France, 224 per cent., and the foreign trade of the United States from 1850 to 1860, 136 per cent. This was a period of railroad building in the United States and also on the continent of Europe. It saw the rise of the modern steel industry and the development of the American export trade in grain and meat. In spite of a series of destructive wars including the Crimean War, the war between France and Austria, the United States Civil War and the conflict between Prussia and Austria, the wealth of the world during this period, that is to say, the money value of the property in civilized countries, is estimated to have increased approximately 100 per cent.

A decline in gold production began in 1865 and continued until the lowest points were reached in 1874 and 1883. This decline in gold production was coincident with a series of disastrous commercial panics, followed by periods of prolonged depression, in which bankruptcies were numerous, the number of unemployed large, prices declining and trade stagnant and depressed. Practically the entire world experienced disasters of this character in the period 1872 to 1874, and these panics were followed by a depression which lasted until 1879. In 1882-1884 came another series of financial disasters, followed again by depression. After a brief recovery, the period 1890-1893 again witnessed a general industrial breakdown, which lasted in Europe until 1896 and in the United States until 1898. This long period of financial depression which lasted in Europe for twenty-three years and in the United States for a longer period, while variously explained at the time, is now known to have been fundamentally due to the decrease in the gold supply, which, as already noted, continued for over half the period. For twelve years the production of gold was not more than sufficient to supply the loss from abrasion and the demand from the arts, leaving nothing to go into the world's currency. All this time population was growing and production was increasing in spite of the depression due to decline of prices and periodical panics. In other words, the amount of business, the quantity of commodities to be exchanged by means of money, was steadily increasing and the foundation of the money supply which, as we have already shown, consists of the gold in circulation and in bank reserves, was not growing at the same rate. It was natural, under these circumstances, that prices should persistently decline and that the world should suffer acutely in the throes of a quarter century of industrial depression, marked by only brief intervals of recovery.

Beginning with 1885 and continuing without interruption up to the present day, the production of gold has advanced by leaps and bounds; from $123,000,000 in 1885, the lowest point ever recorded, it had risen to $200,000,000 in 1895, to $300,000,000 in 1902 and to an estimated amount of $411,000,000 in 1907. Coincident with this increase in gold production, although, owing to the shortage of gold from 1865 to 1883, the effect of the new gold was not immediately apparent, a period of industrial expansion and widespread prosperity began in 1897, which has had no counterpart since the time of the first gold discovery. During this period of twenty-four years, there was added to the stock of the gold in the world more than twice the amount produced from the discovery of America to 1883. The currencies of the United States and Europe were saturated with gold, the banks expanded their note circulation and their loans and the natural result was an extraordinary uplift of prosperity, extending to every class of the population and making an enormous addition to the money value of property. We see now how the decline of gold production following 1865 was directly connected with the industrial depression experienced throughout the civilized world during that period, and we have seen also that the enormous output of gold production of recent years is directly connected with, and primarily responsible for, the progress of the civilized world during the last decade. This brief survey of the business developments of the last fifty years furnishes a setting for the story of the evolution of modern gold production which has taken place during this period.

CHAPTER VI

DEVELOPMENT OF THE GOLD INDUSTRY SINCE 1850

Before 1850, the mining of gold from veins, generally speaking, was not practiced. The greater part of the gold production of the world since the discovery of America has been obtained from placers. Some free milling gold had been worked in various places, notably in South America and Mexico, but the method of extraction differed but little from placer mining, involving the breaking down of the rock by hand labor, its crushing and pulverizing in crude mortars and the washing of the resulting material in the same manner as gold bearing sand is washed. The pan, cradle and rocker were tools in general use. With the aid of these appliances the enormous gold production of California and Australia was accomplished. The working of these new fields was pushed vigorously by thousands of miners working with the primitive tools of the period, and in a few years the cream of the deposits was skimmed off until the majority of the workers, who were no longer able to make the ten to fifteen dollars per day originally earned in the mines, turned their attention to other lines of activity. The production of gold immediately began to decline, reaching its lowest point in California—$12,000,000—in 1892, a decline from $81,000,000 in 1851, and in Australia in 1883, having fallen to $27,000,000 from a maximum of $60,000,000 in 1863.

After the exhaustion of the placers came the scientific gold miner, tearing down the gravel banks with his hydraulic monitors and attacking the quartz veins from which the placers were derived. Quartz mining on a small scale began in California in 1851, when practically the entire production was obtained from the alluvial deposits. In 1881 one-half the gold yield of the state was taken from placers, and in 1892 only ten per cent. Vein mining in Australia began in 1857; in 1889 the ratio of placer mining to quartz production was 37 to 63; in 1892, 31 to 69. To-day, not ten per cent. of the world's gold production is obtained from placers. Vein mining is now the source of its gold supply. During the thirty years following the first gold discoveries the industry was being transformed from the simple methods of the prospector and

Interior of a mill.

gold washer, to a business in which billions of capital are invested and which, because of the complexity of its processes and because of its achievements in reducing the cost of production, stands at the very top of the mineral industries. During this period of readjustment, however, in spite of the fact that, with the decline of prices, gold was growing constantly more valuable, and in spite also of the tremendous demand for the yellow metal which came from the banks and treasuries of Europe and America, the production of gold, following the exhaustion of the placer, suffered a severe decline. After the difficulties of quartz mining and milling had been mastered, and following the discovery of a number of new gold deposits, the production of gold was increased, and, as we shall see later, is likely to increase for some years to come.

The transition from placer working to quartz mining, and the rapid increase of production from the veins, was the result of three forces which have been working upon the gold mining industry since the transition period began, about 1865. These forces are, first, the fall of prices dating from 1873; second, a progressive series of important gold discoveries which have broadened the field of production, and third, the installation of revolutionary improvements in the methods of mining and milling gold. In our story of the recent history of gold production, we will find it profitable to discuss these three forces in the order given.

First, then, we take the effect of the fall of prices upon gold mining. The equipment of a modern gold mine and mill may cost two and a half million dollars. How enormous those plants are may be seen from the accompanying illustration, which shows the interior view of one of the largest gold mills in South Africa. This money is spent on labor, on machinery, timber and stone. Plants are built and equipped, their operation requiring the use of very large amounts of various material, timber for construction and lumber and rails for use in the mine, a large amount of explosives for excavation, mercury, salt, sulphur, zinc, iron sulphate, lime, cyanide of potassium, coal and coke. At the Treadwell Mine in 1898, for example, the following quantities of various materials were used:

212,996	lbs. of dynamite
34,641	lbs. of drill steel
7,600	lbs. of candles
3,119	gal. lubricating oil
2,162	gal. quicksilver

39	flasks of quicksilver
2,201	cords of wood
440,000	lbs. sulphuric acid
583	tons salt
63,596	lbs. scrap iron

From a quarter to a third of the cost of gold extraction is represented by the prices of these various materials. We have seen that the effect of the decline of gold production, following the exhaustion of the large placers in California and Australia, was to cause a serious and prolonged fall of prices. This decline of prices affected every important commodity of commerce, including those which are used in the equipment of the gold mining industry and in its operation. From 1873 to 1896, for example, the price of iron in the United States fell from $42.75 to $12.56; coal from $6.35 per ton to $2.75 per ton; the price of mercury declined fifty per cent., and the price of pine lumber, which in 1873 was $22.00 per one thousand feet, was in 1896 $13.50, and so on through the list. Every article which entered into the cost of an ounce of gold fell from thirty to sixty per cent. during this period. Not only did the cost of materials decline, but, owing to the fall in prices of all commodities which are used as food, etc., by the working man, the cost of living was greatly reduced, and the rates of wages, following the cost in living, declined also. By the fall of prices, therefore, the cost of gold mining was reduced probably one-third from 1865 to 1896.

Gold is peculiar among all other commodities in that it has a fixed price and can always be exchanged at the mints for $20.67 in money. We need not go deeply into the explanation of this fact. It is sufficient for our present purpose that it should be stated and its significance pointed out. While, therefore, the gold miner, during all this period, was producing metal which he could sell at $20.67 an ounce, the amount of money that he must pay out of the proceeds of producing this $20.67, owing to the fall of prices and cost of labor, steadily diminished. To the producer of steel, as his cost of production declined, the cost of his product was also reduced. The farmer could buy his machinery and supplies at lower prices, but the price of his product had also decreased. From 1873 to 1897 every producer, excepting only the producer of gold, saw the price of his product rapidly falling, and he was hard pressed to keep his cost of production lower than his price. Not so with the gold producer. His costs of production fell even more rapidly than the costs of other great industries, but the price of his product was fixed and stable at $20.67 an ounce, so that every decrease in the cost of mining and extraction went into his pocket as profit. It is not surprising, then, when gold was the most profitable, and for a long period of time the only great industry which offered the probability of large profits, that men should everywhere have rushed into it, spending their labor and their lives in the searching out numerous sources of production; and investing enormous sums of money in the working of these veins when discovered.

The most important influence which falling prices exerted upon the production of gold by reducing its cost, was in making it easy to raise funds for new developments. Gold production, like every other form of mining industry, is at best an extremely hazardous business. Gold is very difficult to find, owing to the smallness of the veins and to the general absence of color combinations such as those which make the discovery of iron, or copper, from a reddish or greenish color of the rock, relatively easy. Not only are the gold bearing veins small, but they are uneven and uncertain in their direction. Numerous difficulties also operate to oppose the gold producer. His mine is often located in an inaccessible region where machinery and supplies have to be carried in on the backs of donkeys; where all the ore has to be carried out in the same manner on a slippery and rugged mountain trail. The miner may have great difficulty in obtaining water with which to run his plant; the climate in which he works may be deadly to white men; when his mine is in full operation he may encounter underground streams which flood the works and make the installation of expensive pumping machinery necessary; the ore may not yield readily to treatment, or the superintendent who is placed in charge may not be familiar with the processes which are necessary. Indeed the only certain thing about gold mining is that the sale of the product can be instantly secured at a fixed price. Aside from this, it is a business wherein new ventures appeal only to the adventurous and speculative.

Adam Smith, in his "Wealth of Nations," describes the hazards of gold mining in words as true to-day as in 1776 when they were first published: "Of all those expensive and uncertain projects which bring bankruptcy upon the greater part of the people who engage in them, there is none perhaps more perfectly ruinous than the search after new silver and gold mines. It is, perhaps, the most disadvantageous lottery in the world, or the one in which the gain of those who gain the prizes bears the least proportion to the loss of those who draw the blanks; for though the prizes are few and the blanks many, the common price of a ticket is the fortune of a very rich man. . . . But though the judgment of sober reason and experience concerning such projects has always been extremely unfavorable, that of human avidity has commonly been quite otherwise. The same passion which has suggested to so many people the absurd idea of the philosopher's stone, has suggested to others the equally absurd one of immense rich mines of gold and silver. They did not consider that the value of those metals has, in all ages, and nations, arisen chiefly from their scarcity, and that their scarcity has arisen from the very small quantities of them which nature has anywhere deposited in one place, from the hard and untractable substances with which she has almost everywhere surrounded those small quantities, and consequently from the labor and expense which are everywhere necessary in order to penetrate to and get at them."

It is true that long established mines, which have paid large dividends for many years, and where explorations have continued so far as to show the existence of ore reserves of great values, such mines as the Treadwell and Homestake, the Robinson Mine in South Africa and the Great Fingal Mine in West Australia, are as certain in their operation and earnings as the best silver, gold or copper mines, but such mines are not often encountered. Mr. J. H. Curle, the special mining correspondent of the London *Economist,* has laid down three rules by which to determine the permanence and security of a gold mining stock. The stock must first pay at least ten per cent., on its purchase price; that is, if it is purchased at ten dollars per share, the annual dividends must be at least one dollar per share in order to provide six per cent., on the investment, and to furnish a fund to replace the principal by the time the mine has been exhausted. Second, the value of the ore "blocked out," that is, located, sampled and analyzed, must equal sixty per cent., of the total market value of the stock, i. e., if the stock is worth $1,000,000 there must be at least $600,000 of ore discovered but not yet extracted; and finally, the lower part of the mine, the most recent discoveries, must disclose ore of increasing value. No gold mining investment, says Mr. Curle, which does not conform to these three conditions, can be called safe. Only a small number of even the most important and well-known mines can meet these requirements. The average gold mine operation is exceedingly risky. The man who puts his money into a new gold field, nine times out of ten, as a mining engineer put it to the writer, " must kiss it good-by," and if it ever comes back to him, he welcomes it as one risen from the dead.

How hazardous is this business of gold mining into which the people are being continually invited by alluring and mendacious prospectuses, may be seen from a few figures. South Africa has the most reliable gold mining district in the world; the deposits are regular and the returns can be calculated with much certainty, and yet, in 1903, out of 1333 mines in South Africa which had been opened, sixteen mines produced sixty-two per cent., of the gold output and paid six and a half million dollars in dividends, leaving 1317 mines producing only thirty-five per cent., of the output and paying only $465,000 in dividends. In this, the largest gold producing district in the world, where the most permanent and most profitable enterprises are located, only one mine in eighty-two was of the first class. Exclusive of sixteen of these larger mines, the remainder, in which an enormous amount of money had been invested, paid total dividends of only $350,000, most of them paying nothing to their owners. Another illustration of the risk of gold mining is furnished by a statement of the industry in the Dutch East Indies. Between 1893 and 1901 inclusive, fifty-three gold mining companies were organized for work in this territory. Most of these were floated in England. The total subscription amounted to $10,800,000. These companies spent $2,500,000 in exploration work. Up to 1901, however, not one of them had paid a dividend. When the risks of loss are so great, powerful incentives are needed to induce men to venture their money in buying gold mining stocks, which in most cases will never pay them any dividends.

Gold mining has, however, always exerted a mysterious fascination over men's minds. Not only is the lure of the golden fleece sufficient to draw thousands of men into danger and hardship at every rumor of a new gold discovery, but is sufficient to induce the stay-at-home investor to put his money into the stocks of mining companies. Perhaps, the most powerful influence in exciting the imagination of the investor and overcoming his native caution, has been the immense fortunes which have been made out of bonanza mines. The most celebrated case on record, and one which has been used in thousands of gold mining prospectuses to point the way to easy fortune, is the story of the Comstock. The four bonanza kings, Flood, Fair, O'Brien and Mackay, in the late sixties, associated together in the mining business and made $500,000 out of the Hale-Norcross Mine. This money from 1870 to 1872 they put into the Consolidated Virginia Mine at Comstock. In October, 1872, when their funds were practically exhausted, they struck a bonanza vein. These men took $150,000,000 out of the mine. In 1870, the stock of the Consolidated Virginia sold for $50,000. Five years later its worth was $160,000,000.

The story of W. S. Stratton also reads like a romance from the Arabian Nights. He was a carpenter, who in 1891 located a claim in the Cripple Creek district in Colorado. He offered to sell this to several people at a small price, without success, and continued to work at his trade of carpenter, doing sufficient work on his claim to retain the title. In 1893, by leasing a part of the property, he secured enough to develop the remainder. Soon after a large vein was struck, and for several years Mr. Stratton took $1,000,000 each year out of his mine, selling it finally in 1899 at a very high figure to an English syndicate.

In May, 1900, James Butler, a Nevada rancher and stockman, passed through the San Antonio desert of Southern Nevada while on a prospecting trip. He was attracted by the outcroppings on the low foothills of the western slope of the San Antonio mountains and took a number of samples. They showed 640 ounces of silver and

View of Tonopah.

$260 of gold to the ton. Butler located three claims which were afterwards sold to the Tonopah Mining Company, which has since that time paid out on its stock more than $3,000,000, built a railroad ninety-one miles long and completed a gold mill at a cost of more than $500,-

000. In a neighboring camp, Goldfield, which began shipping ore in 1903, the lessors of the Mohawk claim took $4,000,000 out of a tract four hundred feet square. Such stories of fabulous wealth found in a few months from mining claims usually located on public lands, and which have only to be discovered to make the finder rich, are continually coming forward and have, for many years, kept alive the interest in gold mining investments.

On the London Stock Exchange, between 1890 and 1896 $233,213,870.56 was put into mining, nearly all of it into gold mining. Hundreds of millions of dollars have been invested in South African securities alone and enormous amounts of money have gone into vein mining in Australia, British Columbia and the western part of the United States. The gold mining industry has, in other words, been transformed from a business in which $100 would buy the necessary equipment, into a business which ranks with the other great metal industries in the magnitude of its equipment and the scope and complexity of its operations.

The greater part of this enormous investment has been made in fields which were unknown thirty years ago, and the second factor in the production of gold since 1883 has been a progressive series of gold discoveries. Here, indeed, the influence of the fall of prices which was caused by the scarcity of gold, was even more appreciable. As the prices of other products declined and as one country after another fell under the affliction of panic and industrial depression, men turned eagerly to the only business whose product would not decline in value, and a number of important discoveries were the result.

The discovery of gold is largely a matter of chance. Geological knowledge, it is true, has greatly increased in recent years, and much of this has been made available for the use of the gold prospector. Geological surveys now plot out the strata over a large part of the territory where gold is likely to be found, and the intelligent prospector knows, in a general way, before he goes into a district, the character of the rock formations, and is thus saved unnecessary work. Gold is usually looked for in connection with eruptive or volcanic rocks, but some of the most important discoveries have been made in other rock formations, and the prospector can never be certain that the apparently barren rock which his predecessors may have rejected does not contain the materials of a great fortune. It was so in the Cripple Creek district, in West Australia and in many other mining sections that gold discoveries were made, in defiance of rules and precedents, in rock previously accounted worthless.

The old-time prospector has largely disappeared. As late as twenty years ago the merchants and bankers in important mining centers like San Francisco, Salt Lake City and Denver made a business of "grub staking" large numbers of explorers to look for mineral locations in their joint interest. They would supply food, provide a horse or mule and send out the prospector with the understanding that the profits of any discovery should be shared equally between the miner and his patrons. These agreements rested upon good faith and they were generally kept. In time, however, the mutual trust between the prospector and his backers weakened. Repeatedly it was found that discoveries had been made only to be hidden for subsequent location by the prospector on his own account; and as soon as it became necessary to draw up legal contracts, the whole system of "grub staking" went to pieces. In the West, also, the labor union has done much to break down the prospector's calling by insisting upon a fixed rate of wage.

Most of the exploration is now done by strong mining companies who hire on regular salaries experienced geologists and mining engineers, and who in this way reap the benefit of their discoveries. The requirements of a prospector or mineral explorer are various. It is a popular delusion that any man may at any time drop his

Thames gold field, New Zealand.

work in civilization, start out into the wilderness and discover gold, or silver, or copper. Thousands of men have made the experiment only to find, in the words of one writer, that "Nature demands a tuition fee which must be paid and in default of which she will send his corpse floating down some mountain river, or leave his bones to bleach in some lonely valley, or on some desolate mountain top, or, if in a kindlier mood, she may allow him to return to civilization in a few months, minus his outfit, a sadder and wiser man." The professional prospector devotes himself exclusively to his calling and succeeds in proportion to his knowledge and experience. The requirements of a successful prospector have been described as follows: "In this part of Alaska, the prospector should know how to sail and handle a boat; he must pack his supplies on his back when ashore; he must be a good woodsman and mountaineer; he must cook and mend and doctor; he must know when, how and where to camp; he must have, not only the courage to be at work in this inclement weather but he must have the constitution to stand it; he must have patience, perseverance, endurance and faith. If he has some knowledge of surveying and plotting, it will frequently be a great help, and the more he knows of mineralogy and geology the better. He may have all those advantages and a good outfit, yet he will be a failure if he has no 'sand' and plenty of it. It is the first requirement of a prospector in any country I have seen."

There is a third class of prospector, made up of all sorts and conditions of men, usually unsuccessful in other callings, and who hasten to be rich by making a lucky strike in the gold fields. Their number is especially large during periods of depression, when employment is hard to obtain. Every report of new gold discoveries, especially when these are of placers on which the single miner without much capital may have a chance of fortune, attracts a multitude of prospectors, most of whom have but little equipment for their task except the enthusiasm of greed, but whose efforts, fruitless for the most part, are yet responsible for a large number of discoveries, a portion of which, passing into stronger hands, may be developed on a large scale. Every producing gold district contains a large number of the disappointed, unsuccessful or adventurous, spending their money and their energy in a vain search for hidden treasure, joining in mad rushes to new districts and contributing in the aggregate very considerably to the advancement of a business of which they are at once the support and the victims.

A description of the feverish excitement which accompanied the rich discoveries in West Australia by Mr. T. A. Rickard, shows the spirit of the amateur prospector. "The development of a group of very rich lodes amid this desert country, dotted over with unhappy failures which are based on small pockets of specimen gold quartz, may not be obtained without a sad expenditure of money and even life. With the whisper of every new discovery, crowds of reckless gold seekers rushed madly into the outer desolation. Eager horsemen jostled the awkward camels, whose swinging gait carried them, in turn, past the mobs of diggers who trudged wearily to the scene of each successive excitement. One knows not whether to admire the pluck or deride the foolishness of men who died of thirst and perished of fever in the mad search for gold. The incident known as the 'Siberia rush' will be typical of early days. A man came into Coolgardie one night with the story that gold had been found at a locality thirty odd miles distant to the north. Hundreds started off on horses or camels; many went on foot, carrying their billies (iron vessels in which the miner makes his tea and does his cooking) and blankets upon their shoulders, or trundling their packs in wheelbarrows. Some took the wrong direction and many of these never reached their destination, but died miserably in the bush. Four hundred eventually reached Siberia, which has a mean annual temperature of 78° and whose summer heat is 112° to 120° in the shade. The only water near the discovery was a 'soak,' a morass in the desert, seven miles distant. It was soon drained dry by the crowd of diggers. News came to Coolgardie that a water famine was imminent. The superintendent of waterworks, a government official, instantly dispatched a dozen camels to the succor of the adventurers. In the meantime, they, realizing the impending danger, had left the gold and were making for the nearest water tank. Many died on that return journey and many more would have been lost save for the water brought by that camel train. In a few days there was another stampede in another direction. Thus the gold fields were opened up."[1]

Before 1883, with the exception of some placer discoveries in Montana and Alaska, few important discoveries had been made. Until 1882, prospecting activity was in the main unsuccessful. The decline in the rate of production seemed to justify the prediction of an approaching gold famine, when the world's supply of gold must consequently be trenched upon in order to supply the demands from the arts. Eduard Suess, an Austrian geologist, attracted con-

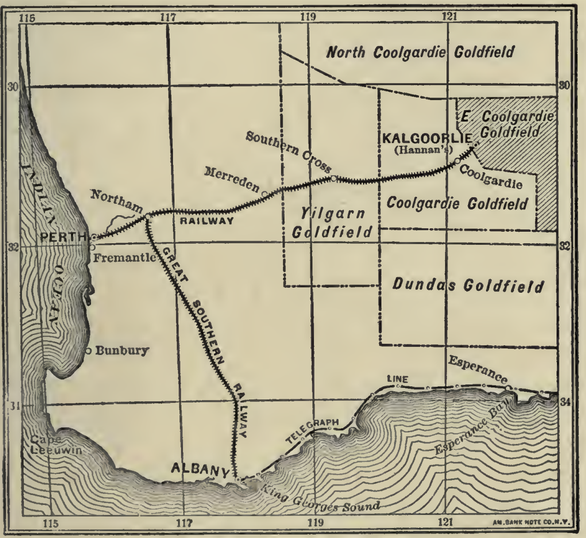
[1] "Transactions A. I. M. E.," Vol. 28, p. 496.

siderable attention during the early eighties, by stating with great positiveness, as a result of a careful study of all the conditions of gold production, that the decline in the output of the gold mines which had already set in would continue until a serious shortage would result. His arguments were made much of by those who advocated a larger use of silver in the world's currencies. This is the period in which commenced the free-silver agitation, a propaganda which seemed to be justified by the decreasing supply of gold, evidently not sufficient to prevent prices from steadily declining, and therefore indirectly responsible for the prolonged depression with which business was periodically afflicted.

With the steady increase in the purchasing power of gold, however, and the rapidly increasing profits made from gold mining, the search for gold became increasingly vigorous and finally resulted in a remarkable series of discoveries. In 1883, the production of gold began at the Mt. Morgan Mine, Queensland, a property which has paid large dividends ever since and which shows no signs of exhaustion. In 1886, the most famous gold mining district in the world was discovered in the Transvaal. This region had been explored for gold at intervals for twenty years without material result. In 1884, an expedition in charge of the Struben brothers discovered a deposit which was composed of "fine particles of quartz resembling a sandwich." This lead did not extend far in depth, and although a small battery was erected, after several tons of ore had been crushed, operations were abandoned. During these operations, a Dutchman named Geldenhuis was one day riding around his farm when his pony stumbled over a bowlder. As the animal was supposed to be sure-footed, Geldenhuis dismounted to look at the rock which had nearly brought him down. He returned to his farmhouse with a specimen, crushed it as he had seen the Strubens do and washed it in a saucer, getting a good indication of gold. He took this gold to Pretoria and told his friends what he had discovered, but everywhere met with derision. However, he was shrewd enough to secure his claims and started to work with some of his fellow Dutchmen with mortars, pickets and a tub to wash the metal. For two years enough gold was taken out of this mine to net the owner from twenty to thirty dollars a week and ultimately it was developed into one of the most famous deposits on the Rand.

The gold in the Transvaal occurs in zones, rather than veins. True placers are not found.

The occurrence of gold is in beds of conglomerate, masses of rounded quartz pebbles set in cement, called " banket " because of their resemblance to the Dutch cake of that name. The original formation was undoubtedly placers formed from veins which have long since disappeared. These placers were subsequently overlaid with other formations, and solidified by heat and pressure. After these beds had been laid down horizontally, they were disturbed by volcanic action, and tilted about in every direction; but the original strata have been preserved throughout. These deposits are phenomenal because of their evenness and regularity; the walls of sandstone which contain them are persistent; the reefs continue to great depths and, as a result, the yield of gold can be counted on with great regularity. Workings on the Rand extend for about thirty miles, and are carried on on three of these conglomerate beds, the main reef, middle reef and south reef. The ore is not especially high grade, having ranged in yield from twelve to fifteen dollars down to nine dollars per ton. It has been possible, however, on account of the regularity of the deposits, to invest enormous sums of money in developing and equipping the mines, and in this way to secure a sustained increase of production, which has placed this district in a class by itself as a gold producer. Starting with an average of less than $3,000,000 for 1884 to 1889, the production rose to over $9,000,000 in 1890, to $43,000,000 in 1896 and to



Gold map of Western Australia.

$81,000,000 in 1898. During the South African war the production of the Transvaal was almost totally suspended, but in 1903 it started again at $62,500,000, rose in 1904 to $80,000,000, in 1905 to over $104,000,000 and in 1906 to $120,000,000.

The mines of Western Australia were opened in 1885. The interior of West Australia is a narrow tableland, elevated 1400 feet above the sea. The principal gold fields are situated in the southwestern part of this plateau. It is a continuous plain, broken only by a series of alternating low rock ridges and slight depressions. "There are some 'lakes,' shallow basins with clay beds, in which, during the rainy season, a little water lingers and a few streams, channels where brackish waters can sometimes be found by sinking wells. The surface is devoid of vegetation, except in the spring, when flowers of a brilliant hue, but with the texture of hay, leap into brief existence. Animal life is infrequent. An occasional bustard may be provoked into leisurely flight, a troop of paroquets throws a momentary gleam athwart the dull gray of the bush, or a solitary kangaroo hops across the trail. These are, however, but infrequent interruptions to the sullen silence of the wilderness. The real nakedness of the region is hidden by the bush, consisting of a shrub from twenty to sixty feet high. . . . The roads are cut through it with the monotonous regularity of a canal. One portion of the journey is but a counterpart of another. The sameness is wearisome beyond words and when an elevated spot is attained, the eye commands from north to south, from east to west, one dark unbroken sea of trackless bush.''[1]

This district is entirely unproductive of food stuffs, the total rainfall is only about five inches, and fresh water can be obtained only by sinking wells or deep reservoirs for use in distilling off the salt. And yet, this absolute desert is one of the richest gold mining districts in the world and has produced in the twenty-one years which have elapsed since its discovery $379,014,062.82 of gold. The first discovery was made in 1889 at Yilgarn, 210 miles east from Perth, the capital of the Colony. Prospectors now began to scatter further inland. In 1892 Bailey discovered the Coolgardie district, and following a period of rich finds, Patrick Hannan in June, 1893, made a location at Kalgoorlie, twenty-five miles east of Coolgardie. In this district gold was found lying on the top of the ground. In the early days hundreds of ounces were picked up in a few hours by the man first reaching the rich spot. After this the underlying sand was worked, and finally, the mining operator attacked the veins. Gold in this large area is found in rocks which

[1] T. A. Rickard, "Transactions A. I. M. E.," Vol. 28, p. 495.

have been pushed up from below, probably by volcanic action. The veins persist at depth and the extensive investments made in the district have been justified by the results.

A new era of gold production began in 1893 in the United States. After the decline of placer mining in the sixties, the chief interest of America centered on silver mining. The production of silver, which was $16,000,000 in 1870, rose to $39,200,000 in 1880, and to $83,909,210 in 1892. This activity in silver production was supported by the monetary policy of the United States, which purchased, during the twenty years preceding 1893, over six hundred million dollars' worth of silver for coinage. Silver production, however, increased so rapidly, that in spite of the efforts of the government, and notwithstanding the large amount of silver which was exported to India, the price moved steadily downward. European countries had, twenty years before, from 1870 to 1875, generally abandoned the free coinage of silver. Only in India and the United States had any large demand existed for the white metal. In 1893 India ceased the free coinage of silver, and it was evident that the United States would have to abandon the attempt to uphold the price of the white metal. The repeal of the Silver Purchase Act in 1893 nearly ruined the silver mining industry, and the world's coinage of silver, which was 120,000,000 ounces in 1892, fell to 87,000,000 ounces in 1894, while the price declined from one dollar per ounce in 1890 to fifty-nine cents in 1895.

This collapse in the value of silver was a severe calamity for the western mining states. In Colorado, Nevada, Idaho and Montana thousands of men were dependent for their living upon the production of silver, and a decline in the price of the metal from eighty to sixty cents per ounce in the summer of 1893 was a severe blow to the silver industry. In Colorado three-fourths of the population of the state depended directly or indirectly upon silver mining. Gold mining, outside of California, had been little developed. In 1891 Colorado produced $27,368,384 of silver and $4,600,000 of gold; Montana produced $21,139,394 of silver and $2,890,000 of gold and Utah produced $11,313,131 of silver and $650,000 of gold. Gold production, it is evident, formed but an insignificant part of the mining industry of these states. In 1891, indeed, the total value of the gold produced in the United States was only $33,175,000, of which California alone contributed more than one-third. During the summer of 1893, following the decline in the price of silver, all but the richest and more productive silver mines shut down, leaving the silver output practically limited to the lead and copper mines in which silver was produced as a by-product. " In every silver mining town and camp, men were thrown out of work. The feeling was one of consternation. Men who were single packed their few things into bundles and started, generally on foot, for some other region in search of work and wages. Few who had any money would pay it to railroad companies for fare and frequently crews took possession of a railroad train and were carried for nothing. For a short time, the trouble with the railroads became so great from the crowds that were pouring out, that the companies issued orders to conductors to carry free those men who were leaving the country and were unable to pay their fare. Some mining camps of minor importance were entirely depopulated and in every portion of the West where men were employed in producing silver, there was a partial or entire stoppage of work."

This situation is interesting because out of it grew the phenomenal production of gold, which has transformed the mining industry of the West. The reader will recall that on page 64, in discussing the causes that have led to the increased production of gold, some importance was attached to the fall of prices which was experienced as a result of the shortage or scarcity of the gold supply in reference to the demands which were made upon it, and it was shown that since gold was, during much of this period, the only industry which offered large profits to the investor, an increase in its production naturally followed the results of its scarcity. Conditions in Colorado in 1893 furnish an excellent illustration of the effect of a fall of prices of one important commodity upon gold mining. The decline in the price of silver forced men to find gold. Although Colorado had been founded upon gold mining and although in the early days silver mining had not been carried on, the gold resources of the state were considered much inferior to the silver resources. Gold production at this time was confined to a few companies and the production of gold was slowly declining. Silver mining, on the other hand, was the basis of the state's prosperity. When the price of silver dropped below the cost of production, the attention of prospectors, capitalists and investors was turned to the gold producing regions. Skilled miners everywhere went into gold production. "Most of them, for want of capital, were forced to seek the gold particles in crevices, springs and beds. All the appliances they had were a rocker or Long Tom. In this way they could wash out in many places enough to furnish the barest necessities of life. At one time in the autumn of '93, there were at least three hundred men washing gold in pans within sight of Denver, making on an average of probably fifty cents a day. On the 24th day of February, 1895, there were a dozen or more men washing gold in pans within the city limits of Denver and making enough to buy bread and meal by so doing." Miners and prospectors, driven out of work by the closing of the silver mines, directed their attention to gold prospecting in all parts of the state, and the result was a remarkable series of discoveries.

The most important gold development in Colorado was in the Cripple Creek district in El Paso County. This ground had been thoroughly prospected for twenty years preceding without discovering any of the known indications of gold. Gold is here found associated with tellurium, and the appearance of the rock is utterly unlike those with which gold prospectors had hitherto been familiar. In 1891 the first year of report, the production of gold in El Paso County was $22,300; in 1892 $585,000; in 1894 $3,250,000 and in 1897 $10,131,855. The ores of this district were

Sluicing on the Bonanza.

exceptionally rich, often running as high as two and one-half ounces to the ton, and the result of the mining operations in the Cripple Creek region was a thorough exploration for ore of like character in Colorado and other states, and was directly responsible for the large increase of gold produced in other localities.

The laws against hydraulic mining were repealed in 1892 and the production in California quickly responded, rising from 580,000 ounces in 1892 to 737,036 ounces in 1896, a large part of which came from hydraulic operations. The production of every other gold mining state rapidly advanced throughout this period when business, the country over, was suffering from a severe depression, and when the only assurances of great prosperity were limited to the gold industry.

In 1894 came a series of gold discoveries in British Columbia and the production shot up from 530,000 ounces to 1,788,000 ounces. Business depression, as already noted, increased the prospecting activity in Australia and production quickly responded. Extensive gold fields were at the same time opening in South and Central America and the gold production of Mexico, mainly from mines which had been formerly worked but abandoned during the early part of the century, was rapidly increasing.

In 1897 came the discovery of rich placers in the valley of the Yukon River in the north-

Dawson and Klondike City (South Dawson) in September, 1898.

western portion of Canada, just across the American lines. The most important finds were made along the Klondike River and the Yukon. The first receipts of gold from the Klondike reached the United States in July, and the tales which were told of the rich fields were so marvelous that a rush immediately set in. In 1897 about two and a half million dollars was taken out of the Yukon district. Thousands of miners went into the region in the following year and the production shot up to $10,000,000 in 1898, and to $16,000,000 in 1899.

These Yukon deposits are alluvial in character, being concentrated in the sandy gravel on the banks of the rivers and the beds of small streams, from the numerous small veins in the surrounding rock. In the bottom of the valleys, deposits of rounded gravel stones, six to twenty feet thick, are found. The gold is in this gravel in particles from the size of flour up to that of a moderate sized potato, and extends usually from one to two feet into the bed of the rock. On the sides of the valleys "benches" of gravel are found extending fifty to sixty feet up the hill and which are often rich in gold. The entire country is covered with moss and frozen to bed rock. In sinking shafts, miners often pass through strata of blue ice two to three feet thick. In the early exploitation of these alluvial deposits, the usual method was to sink shafts and drop into them heated bowlders, where they melted the ice and broken ground. When they came out cold, they were heated and re-heated and the ground was thawed out. The operation was repeated until the bed rock was reached, when a horizontal excavation known as a "breast," thirty to forty feet wide, was carried forward by building a fire against the face of the gravel. The gold bearing gravel was hauled to the surface, where it froze and remained frozen until the hot weather, which lasts two or three months in this region. All the gravel mined during the eight months of winter could be washed in the two months of summer by the same men.

New gold fields were opened during this period in South and Central America, regions whose extraordinary richness in gold ore we shall have occasion to discuss on subsequent pages, and the production of Mexico, stimulated by the extension of railroads, had opened up numerous mines formerly worked but abandoned during the early years of the century. Mexico's gold production increased from $1,400,000 in 1893 to $9,277,351 in 1899.

The activity in gold mining has continued to increase for the last ten years. In 1896, for example, the total production of gold in the United States was $61,347,232, and ten years later, in 1905, it had increased to $87,948,237. Every producing state shared in the increasing production. The production of Canada, which in 1897 was only $6,000,000, had risen to as much as $14,500,000 in 1905, and that of Mexico from $9,-277,000 to $14,500,000 during the same period. Central America had risen above the million mark. The Transvaal had increased its production from $56,718,000 in 1897, to $100,000,000 in 1905, and Rhodesia, Madagascar and the West Coast, which produced together only $1,400,000 in 1897, by 1905 had increased to $11,900,000. Australasia had increased its production from $52,491,000 in 1897 to $85,970,000 in 1905, and the production of British India rose from $7,299,-000 to $11,224,000.

In 1907, contrary to expectation, the production of gold exhibited a declining tendency. Estimates of the total value produced vary from $404,000,000 to $411,000,000, which compares most unfavorably with a known yield of $407,-000,000 in 1906. The causes of this decreased activity in gold mining can all be reduced to manifestations of one influence, the extraordinary prosperity of other industries and the resulting high costs of labor and materials. Labor was, moreover, not merely expensive but hard to obtain. In 1908, which will be, in the United States at least, a year of depression, the value of gold produced may reasonably be expected to reach a much higher figure than in 1907.

CHAPTER VII

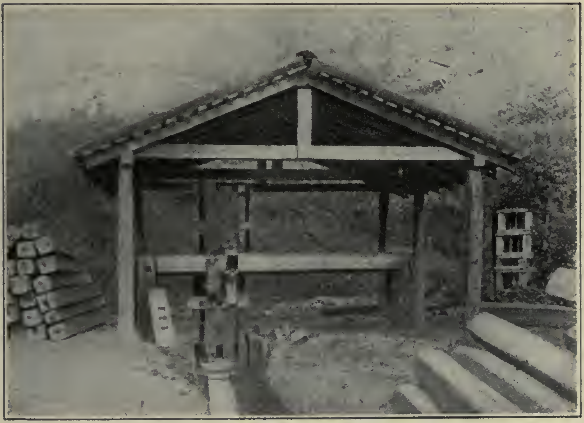
THE TECHNICAL DEVELOPMENT OF THE GOLD INDUSTRY

The second, and perhaps the most important, cause which contributed to the increase in the gold production during the last half century has been the improvements in the methods of mining and extraction. Before 1865, from the very beginning of the industry, little advance had been made in the method of gold mining. We find, for example, in Pliny's "Natural History," written shortly after the dawn of the Christian era, that gold was produced in two different ways: First, by washing, and second, by shafts. Pliny describes the method of mining as follows: "By the aid of galleries, driven to a long distance, mountains are excavated by the aid of torches, the duration of which forms the set time for the work; the workmen never seeing the light of day for many months together. Not infrequently clefts are formed suddenly, the earth sinks in and the workmen are crushed beneath; so that it would really appear less rash to go in

Interior of Valenciana mine.

search of pearls at the bottom of the sea, so much more dangerous to ourselves have we made the earth than the sea. Hence it is, that in this kind of mining, arches are left at frequent intervals for the purpose of supporting the weight of the mountains above. In mining, either by shafts or galleries, veins of silex are met with which have to be driven asunder by the aid of fire and vinegar, or more frequently, as this method fills the galleries with suffocating vapors and smoke, to be broken to pieces with a bruising machine, shod with pieces of iron weighing one hundred and fifty pounds, which done, the fragments are carried out on men's shoulders, high and dry, each man passing them on to his neighbor in the dark, it being only those at the pit's mouth who ever see the light of day. The mountain, rent to pieces, is cleft asunder, hurling its débris to a distance with a crash which it is impossible for the human imagination to conceive, and from the midst of a cloud of dust of a density quite incredible, the victorious miners gaze upon this downfall of nature. Another labor quite equal to this and which entails even greater expense is that of bringing rivers from the more elevated mountain heights, in many instances a distance of one hundred miles, for the purpose of washing the débris."

The methods of extraction known to the ancients, according to Pliny, were two; first, washing, which is the same as that used to-day, and second, the melting of the gold ore to free it from impurities. Little improvement was made in the methods of extracting these metals until



Old stamp mill in Ecuador.

within the past thirty years. In the old Spanish mines of Mexico and South America excavations consisting in some places of miles of galleries, were made by hand labor, and the ore was carried up to the surface on the backs of laborers in hide sacks, 250 pounds being an ordinary load.

When it reached the surface it was crushed in stamp mills where the dies were of stone and worked by water or animal power, or by the cruder mechanism of the bowlder crusher, which consists of a large bowlder with a short pole lashed to the top to serve as a lever in

Illustration of the patio process.

rocking it with the pole back and forth over the flat bed of stone upon which the ore is thrown so as to be caught under the rocking bowlder. When ores had to be roasted to expel the sulphur, the operation was carried on in heaps in the open air. Even when the use of mercury was introduced, the process of extracting gold was carried on in a very crude and wasteful manner.

The early method of extracting silver and gold from the ore in Mexico was known as the Patio process.[1] This process is still utilized in many localities. The ore is first broken up, usually by hand, and then is ground in what is known as an "arrastra," shaped like a horizontal waterwheel, in which heavy stones are used to do the grinding and which is worked by mule power. In this the ore is mixed with water and ground to a pulp. It is then placed in the patio, a large basin usually having several hundred feet of surface, where it is left for the water to evaporate until the mass is of the consistency of brick clay. Salt is then added, and the mass is thoroughly tramped by mules, after which mercury is added. After another treading, a hot solution of sulphate of copper is added. Several more treadings follow. The mass is then washed by being run through a settler, inside of which two men keep it in constant motion by treading. The resulting amalgam, after washing, is put into iron flasks and heated to free it from the mercury.

[1] The patio process is essentially a silver process, but has helped gold production chiefly as a by-product of the silver.

This process usually occupies not less than four weeks, large amounts of ore, quicksilver and amalgam are lost in the frequent handling and the method is both expensive and tedious. These crude and wasteful methods were made possible only by the cheapness of slave labor. All over Spanish America until the ninteenth century the gold mines were worked by slaves, who cost nothing but their food, and this, of the simplest character, was frequently produced, by other slaves, on nearby-plantations. These early mining operations, moreover, were entirely confined to the rich ores found above the water line. As soon as extensive drainage operations became necessary, the mines were abandoned.

The most serious drawback to the development of the mining industry was the absence of transportation facilities. Gold discoveries in the United States are generally made in mountainous regions, often at great heights, 11,000 to 15,000 feet. The important deposits of gold in Mexico lie for the most part in the Sierra Madre region, where precious metal mining is almost the entire industry. The Transvaal and West Australia are almost entirely given up to gold mining. Before the gold discoveries there was nothing to attract the railroad builder into these remote and inaccessible localities, and until adequate transportation facilities were provided, gold mining operations were greatly handicapped by the high cost of carriage. The absence of transportation facilities increased wages by raising the cost of every article of food and clothing, increased the cost of mining equipment and supplies, which often had to be carried on wagons or on the backs of pack animals, and, owing to its cost, made the use of fuel almost impossible. The production of gold was, therefore, limited to the rich ores which could stand the enormous cost of carriage. Without cheap transportation modern gold mining is impossible.

A few illustrations will show the difficulties which were encountered in the opening up of new mining districts. When gold was first discovered in 1859 in Colorado, all the appliances used in mining and milling had to be brought in wagons across the plains. In 1867 there was erected at Black Hawk, in Gilpin County, a smelting plant of twelve tons' capacity, every brick in the construction of which was brought by wagon 600 miles from the nearest point on the Missouri River, and to that point by railroad from St. Louis, and cost one dollar, delivered in Colorado. At the Smuggler Union Mine near Telluride, before the construction of the railroad, all the supplies had to be carried

Chilcoot Pass.

over the mountains to the mines on the backs of donkeys, which entailed an increased cost of five dollars per ton for every ton of ore extracted. In Peru, from Cerro De Pasco to Oroya, where important gold mines are located, before the construction of the railroad, the freight rate was from thirty-four to thirty-nine dollars per ton for a distance of fifty miles, and the means of transportation was the llama.

The opening of the Alaskan gold country was greatly hindered by transportation difficulties. Men " packers " were at one time paid as high as sixty cents a pound for carrying goods over the Chilcoot Pass. Over the White Pass, where horses were used, the rate was never less than ten cents and often twenty cents per pound. In the Cape Nome region, the cost of transporting supplies and machinery ten miles back from the sea was almost prohibitive, the hire of teams was twenty to thirty dollars per day, and an entire day was required to haul 1500 pounds ten miles. In 1897, in the Klondike, largely due to the high cost of transportation, wages were fifteen dollars per day, wood cost twenty to thirty dollars per cord, delivered, and lumber $130 per 1000 feet. At this time, miners could not afford to work gravel which yielded them less than seventeen dollars of gold per day. In West Australia at the outlying mines, which, in the early days, were as much as 200 miles distant from the railroad, freight rates paid for transportation on camels and wagons added twenty to thirty per cent. to the working costs. A sixty stamp mill and corresponding mine equipment cost for transportation 100 miles beyond the railroad terminus about $75,000.

This brief survey of the conditions confronting the early gold miner shows how gigantic was the work which must be accomplished before the modern gold industry, as we now see it, could be brought into existence. The methods of mining and extraction were extremely crude and the cost of transportation was almost prohibitive. Under these circumstances only rich placers or high grade free milling ore could be worked. In the western states, gold ores running less than $50 to $100 per ton were not considered available, and in localities far removed from the railroad, such as Mexico, $100 to $200 per ton was the minimum.

How great has been the improvement made in the gold industry, due to the improvement of methods and the cheapening of transportation, can be shown in no better way than in a brief statement of some recent costs of production. In 1905, at the Treadwell Mine, 876,234 tons of ore were mined and sent to the mill. This ore averaged $2.65 per ton, and the total cost of mining and milling was $1.35, showing a net operating profit for the year of $909,439, or $1.03 per ton milled, nearly forty per cent. of the assay value of the ore. At the Homestake Mine in South Dakota, in the same year, 1,398,100 tons were milled, which yielded an average of $3.75 per ton in bullion, and the cost of extraction was $2.67 per ton, leaving a net earning of $1.12 per ton. At the Great Fingall Mine in West Australia, the total costs of mining and milling have been reduced, in spite of the remoteness of the locality and the high costs of labor and material, below $4.00 per ton, and in the best South African mines the costs have been reduced below 20s. 8d. average of 56 miles for 1907 $6.00 a ton.[1]

The results of placer working are even more extraordinary. One company, operating hydraulic mines in California, reported in 1900 a working cost of .022 cents per cubic yard, and in 1903 another operator reported 1,251,399 cubic yards treated in nine months with a gross yield of .0252 per yard of gravel at a total cost of .021. One gold dredging operation which consisted of 2400 acres, reported in 1903 that the cost of working, which is naturally much higher than with hydraulic mining, was only seven cents per cubic yard, and in 1902 in Butte County, twenty-two dredges were working at an average cost of four cents per cubic yard. This extraor-

[1] Bull. A. I. M. E., May, 1908, p. 294.

dinary reduction in the cost of producing gold has been mainly responsible for the increase in production. New discoveries have played an important part, but it is certain that if the gold mining industry were to-day at the point of technical development which it had reached in 1870, even with all the discoveries which have marked its development during the past quarter of a century, the output would be but a small fraction of its present amount.

Most of the gold discoveries of recent years have been of ores which in the early days had been accounted worthless, and which have only been made available by a series of revolutionary improvements in mining and milling and by the extension of modern facilities of transportation into the mining districts. Most important of the influences which have operated to decrease the cost of gold production has been the building of railroads. In 1870 California, the principal gold producer of the United States, had 925 miles of railroad; Nevada, 595; Arizona, none; Utah, 257, and Colorado, 157. In 1900 the mileage of these states was as follows: California, 5,588; Nevada, 920; Arizona, 1,515; Utah, 1,581, and Colorado, 4,649. The construction of these railroads has made possible the building of large gold mills at central points, to which numerous small mines, without the means or the output to warrant the construction of mills for themselves, can ship their ore, after it has been concentrated by throwing out the worthless material, and can thus operate at a profit. A general concentration of gold mills has taken place in Mexico, in which 13,750 miles of railroads have been constructed since 1870. It is to the extension of railroads into Mexico that the extensive gold mining developments in that country have been primarily due. The railroads have not only decreased the cost of freight charges on ore and supplies, but have also permitted the introduction of machinery whose weight and bulk would have otherwise prohibited its transportation. This has made possible the application of new methods of mining and metallurgy in Mexican mines.

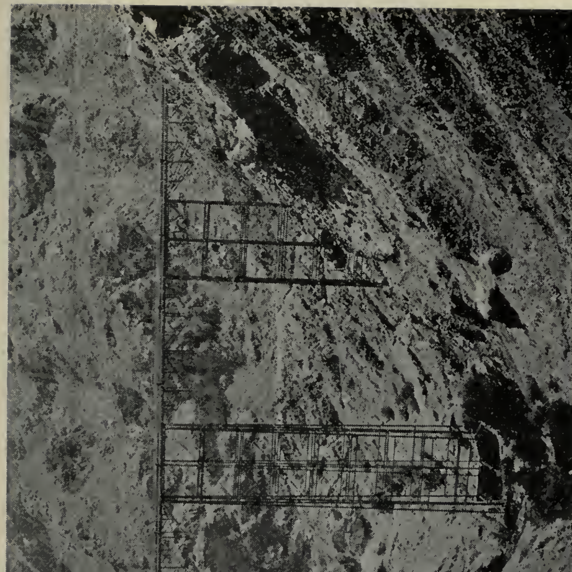
Before the advent of the railroads, the mining industry in Mexico was greatly disturbed by the scarcity of fuel. Some mining companies went so far as to buy timber lands partially deforested, and to replant them in order to guard against a failure of fuel in the future. The construction of railroads allowed the importation of coal from foreign countries and the working of gold in the northern frontier states of Mexico. By the construction of the railroads, coal, which formerly could not be used, can now be had from eighteen to twenty-five dollars per ton, the cost of salt has been reduced sixty-one per cent., and the cost of iron fifty per cent. Before the advent of the railroad, freight on wagon shipments from Pachuca to Mexico City by wagon was twenty dollars per ton. In 1902 this cost had been reduced to $5.50 per ton by railroad. The old rate from Vera Cruz to Pachuca in wagons was $120 per ton before the railroad, and in 1902 it had fallen to thirteen dollars per ton by railroad, and for coal twelve dollars.

In Alaska when the railroad was built over the White Pass in 1899, freight rates fell from a maximum of $40.00 to from $3.75 to $5.30 per hundred pounds for the 2500 miles from San Francisco to Dawson. At Cerro de Pasco in Peru, the construction of a railroad to Oroya has reduced the cost of transportation from $39.00 to $11.66 per ton. An interesting result of improved transportation comes from West Australia. We have already seen that the rainfall in this region is only four to five inches annually. This water collects in subterranean reservoirs and is heavily charged with salt. It must, therefore, be distilled for all purposes, and the cost of such distillation varies from two to six cents per gallon. Salt water costs from twenty-five cents

Railroad view in the Andes Mountains.

to $1.50 per 1000 gallons. In the milling of gold about 400 gallons per ton of ore treated was used and the cost of treatment from this cause was increased from twenty-five cents to three dollars per ton. The government undertook the solution of the problem by the construction of a pipe line 400 miles long from the Darling mountain range, which supplies Kalgoorlie and Coolgardie with 5,000,000 gallons of fresh water daily at a cost of sixty cents per 1000 gallons.

An important factor in lowering the cost of gold production in recent years has been the utilization of mountain streams for the generation of electricity for power and lighting purposes at mines located at high altitudes or accessible only by trails or unfrequented roads, conditions which would make fuel for steam power at such mines almost unavailable. The cost of power is one of the greatest obstacles which the mining operator in Mexico has had to encounter. By the introduction of electricity generated by water power, this problem is in a large measure solved. Where water power exists within a distance of 100 miles, it can be used for the transmission of electric power to the mines. An illustration of the use of power occurs at the Silver Lake Group of mines at Silverton, Colorado, located 13,000 feet above sea-level at a location



Viaduct of Verrugas, Oroya Railroad.

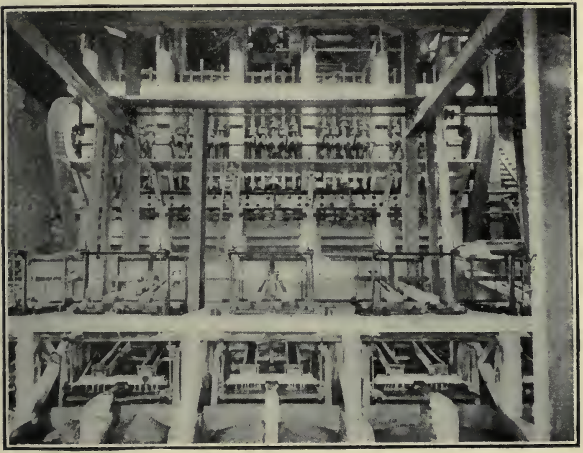
where the cost of coal would be prohibitive. These mines are operated by power furnished by a nearby mountain stream, and transmitted to the mines, where it is used in all the operations of mining and milling. At the El Oro Mines in Mexico, the introduction of water power reduced the total cost of mining and milling from $6.87 to $5.00 per ton, and the introduction of electric power into the Guanajuato district in Mexico reduced the cost of power over forty per cent.

Another factor almost equally important, has been the utilization of compressed air for the machine drills and the great improvements in the drills themselves. The early types of machine drills would do as much work as five men using hand drills, but the more recent types exceed these figures at a saving of fifty per cent. in power. The diamond drill is another aid to the mining industry. Its principal use is in prospecting. By the use of these prospecting drills, in place of sinking shafts through the solid rock to ascertain the quality of the ore which lies below, at an expense which, at great depths and in the absence of possible indications of rich ore, would be prohibitive, a small drill hole is sunk, and a core is lifted from the rocks which enables a sample to be taken in every foot of rock through which the drill passes. By the use of the prospecting drill, the continuity of the Rand reefs to great depths was demonstrated.

An excellent illustration of the improvement in the methods of ore treatment is furnished in the process of sampling and concentrating. The object of sampling ore is to ascertain, with approximate exactness, the number of ounces per ton which the ore contains. The old method of sampling was to spread the ore in layers, stretch a tape across it, and select pieces of ore. A pile was then selected of this ore, which was carefully shoveled over several times, and then quartered; three pieces being thrown into one pile, and one into another. The smaller pile was run into a crusher, and the crushed ore was made into conical piles, and again quartered, the opposite quarters being saved. This process was several times repeated; the ore being more finely reduced at each stage, until it was ready for the assayer. Contrast this crude and cumbersome process with the modern sampler. A number of funnels of varying diameters are superimposed one upon the other, space being left between them for the ore to pass between, from the top of the series to the bottom. These funnels are kept revolving by machinery in such a manner that a certain proportion of the ore, which is constantly fed into the mouths of the upper funnels, will pass through the opening in their sides at each revolution. The main bulk of the ore goes back to the sheds, while that which has been extracted is crushed and again put through the sampler, and is then ready for the assayer's office, the entire process being automatic.

The modern gold mining industry would be impossible without concentration. For every ton which is rich enough to mill as it comes from the mine, it has been estimated that there are ten tons which are too poor for profitable work. In order that this lean ore should be treated, its richer contents must be separated from the worthless material by concentration. As a result of the development of the concentration process, ores which, by the old methods, did not pay to mine, are now handled at a profit, and a large proportion of the low grade ores in mines, formerly ignored, is now utilized.

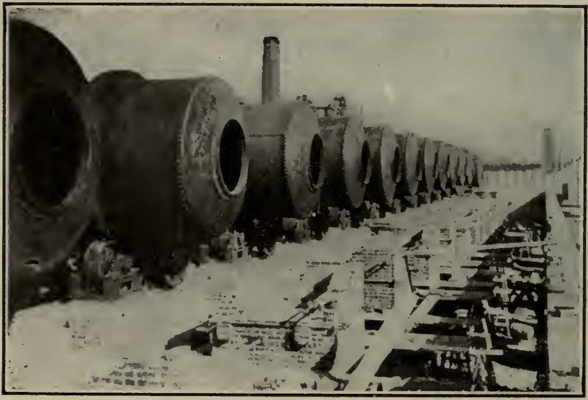
An old method of concentration, which is still in large use in Mexico, was that of hand picking. The ore was spread out in the yard, and broken several times by hand, after each breaking being carefully sorted by women and children, who threw out the worthless material. One modern concentrator consists of a broad rubber belt, revolving in an inclined trough. Fresh ores are fed into the upper part of this belt, in a stream of water, and the lighter worthless material is washed down the belt, which, receiving a con-



Stamps and plates in a Colorado mill.

stant series of sharp impulses from the side, in order to more perfectly segregate the heavier ores, carries the gold bearing material up the trough into the receiver.

Similar improvements have characterized the milling of gold. The fifteen stamp mill of to-day treats more ore than the sixty stamp mill of the old type. The usual capacity of the old mill was about one ton of ore per day per stamp. In the modern stamp mill, this has been raised to three or four tons per day. The roasting of ores, which is generally necessary when they contain sulphur, and which was formerly carried on in heaps in the open air, is now frequently conducted in automatic furnaces, in which the whole operation is under control from beginning to

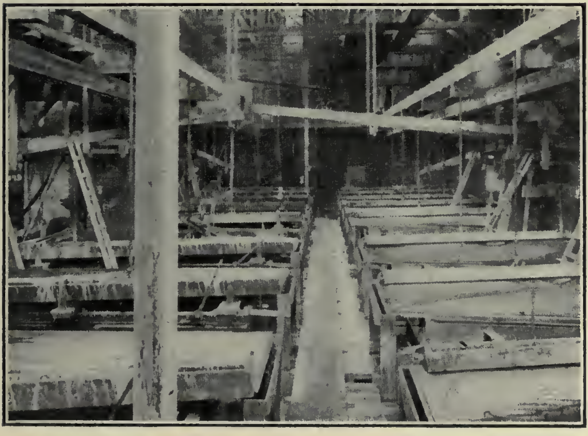


Roasters at a Denver smelter.

end, and the entire work of roasting the ore, including placing it in the furnaces, drying, roasting and removing, is entirely automatic. Much quicksilver was formerly wasted, the ground under some of the old smelting works being literally saturated with this valuable mineral.

This waste has now been largely done away with.

The most important improvements in gold milling, which have made possible the large increase in gold production of recent years, have been the cyanide and chlorination processes for treating the low grade and refractory ores. We have already seen that by far the greater quantity of gold ores lie below the water line, and are



Modern concentrating tables.

associated with sulphur, phosphorus, and other impurities. Surface, or free milling gold has been oxidized in the process of time by action of the air upon the containing substances. Below the water line, however, this oxidation has not taken place, and the ores are found in their original condition. In treating these ores, it is necessary to expel, so far as possible, these objectionable substances, by roasting them before they are sent into the stamp mill. Even after this process, however, a large amount of the material escapes from the batteries, without having united with the mercury. This material, which flows off from the batteries, is called tailings. Before the invention of the cyanide process, portions of these tailings could not be worked at a profit. The method which is now in vogue is as follows:

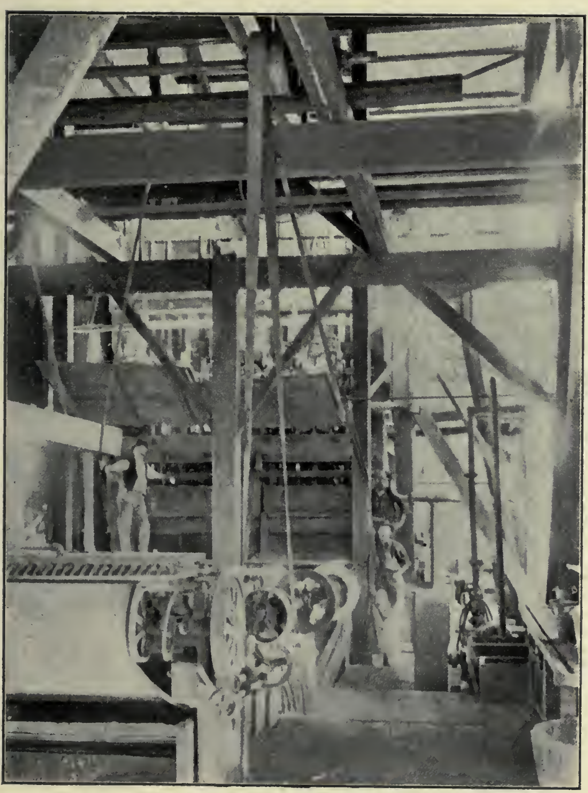
The pulp or residue from the stamp mill is first concentrated, the concentration depending upon the fact that usually the gold which escapes the mercury, and the stamp mill, is associated with minerals which are heavier than the bulk of the crushed rock, which, therefore, may be separated by the concentration process, which is merely the settling out of the heavier particles in running water. Advantage is also taken in these concentration processes of many other properties of the richer minerals besides the weight. Sometimes they are rougher or more brittle than the inclosing rock, and hence are found in larger or smaller particles than the waste material in the pulp from the mill. Sometimes they break into different shape from those of the useless material. Sometimes they adhere to films of oil,

Ore-sorting floor.

and so may be floated off from the waste in a tank of water. Sometimes they may be separated by electricity, and again richer materials will adhere to bubbles of gas, so they may be floated and skimmed.

After concentration, the tailings are treated either by chlorination or cyaniding or smelting. In the chlorination process the ores are usually subjected to preliminary roasting. The material to be treated is subjected to the action of chlorine gas, forming gold chloride, a substance which is soluble in water. This chloride is washed out of the tank in which the admixture of the chlorine gas takes place, leaving behind all impurities which were not removed by roasting. The gold is extracted from its combination with chloride, by adding a solution of sulphate of iron, which possesses the property of uniting with the chlorine, thus setting free the gold, which settles to the bottom of the vat in a purplish-black metallic powder, which is melted into bars. Chlorine gas is now manufactured at central points, and shipped in a condensed form to localities where transportation of the raw material forms a large part of the cost of treatment. Since its introduction, about 1885, the cost of chlorine has been reduced from an average of eight to twelve dollars a ton, to about a quarter of that amount.

The cyanide process, which was introduced on a large scale about 1891, and which is now universally used throughout the world, has this advantage over the chlorination process; it can treat ores without the preliminary roasting. It is more than a century since chemists discovered that a solution of cyanide of potash would dissolve gold and silver. The first working patent



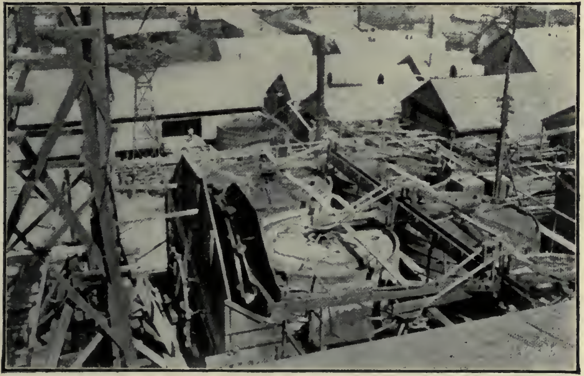
North Boulder stamp battery.

for the utilization of this discovery, however, was taken out in 1885 by Mr. J. W. Simpson of New Jersey, in which he proposed to treat the ores

Cyanide plant, North Boulder.

containing gold, silver and copper with a solution containing three per cent. cyanide of potash and nineteen per cent. of carbonate of ammonia. From this solution gold was to be recovered by passing it over plates of zinc whose effect would be to precipitate the gold from the solution. Other patents were soon after taken out in Great Britain and the United States, the most successful being those granted to McArthur and Forrest, two metallurgists of Glasgow.

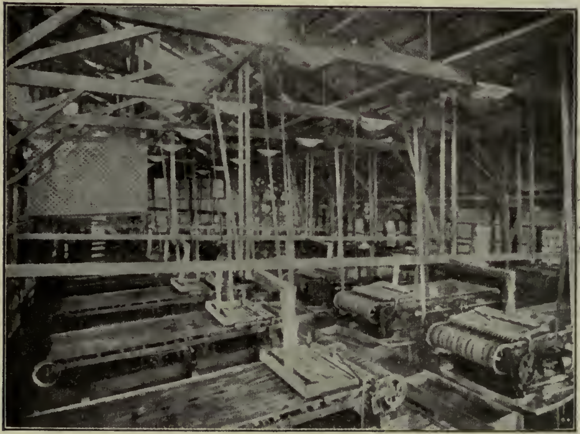
In the cyanide process, the ore is crushed to such a degree of fineness as to permit the solution to come into contact with the smallest particles of gold. The material is sometimes crushed so fine that it will pass through a screen running as high as eighty meshes to the inch. For this extremely fine crushing, the ordinary stamp mills prove inadequate, and a recent improvement, which has increased the profits of some com-



Cyanide plant, Lake View Consols.

panies twenty-five per cent. in a single year, has been the introduction of tube mills, which are cylinders lined with flint and partially filled with flint pebbles. Into these cylinders the material to be re-ground is fed after leaving the stamps. The cylinder is then revolved at a moderate speed, with the result that the tailings are crushed to the fineness of powder. After this crushing, the resulting material, called pulp, is run into a tank and a solution of cyanide of potash is added. The solution is left to stand a sufficient time to permit the absorption of all the gold, being passed through several tanks in the process, in which the strength of the solution is gradually increased.

After the gold has been thoroughly absorbed by the solution, it is run into sheet iron boxes



Frue vanners in the Wemmer G. M. Co. Mills.

filled with zinc shavings. The effect of the zinc is to precipitate the gold from the solution.

The gold is afterwards freed from the zinc by first washing and then adding sulphuric acid in small quantities to convert the zinc into sulphate of zinc. This zinc sulphate is then washed out by boiling water. The resulting material contains the gold, which is finally extracted as follows: Soda, borax and sand are added to the mixture, which is then placed in a crucible and heated to a high temperature. The three substances mentioned form a flux which takes up all the foreign material at the top of the molten mixture. When cooled, the gold bar can be separated from the slag by turning the mold, and tapping the adhering slag with a hammer. The modern practice recovers ninety-five per cent. of the gold originally in the ore; in some cases, as high as ninety-eight per cent. has been recovered.

The effect of the application of the cyanide process upon the output of the gold mill can be understood by taking a hypothetical case. Suppose the pulp from the stamp mill contains value of fifty cents per ton, which cannot be saved by the ordinary amalgamation process, but which can be concentrated at an expense of twenty cents per ton. The material containing this fifty-cent value may be separated into two portions, nineteen parts of waste and one part of concentrates, with all the values of the twenty parts. The value per ton of the concentrates is then twenty times fifty cents or ten dollars and the expense of treatment per ton of concentrates four dollars. We have then a net value in the concentrates of six dollars per ton which can be recovered at an average of, say, seventy-five cents per ton, leaving a profit of $5.25, on ores which, in the absence of these special processes, could not be treated at a profit.

The enormous influence of the cyanide process upon the gold milling industry is due to the relative abundance of ores of different degrees of richness. There is very little ore worth over a thousand dollars per ton. There is much more, but still a small amount of ore, worth over one hundred dollars per ton. There is much more worth over fifty dollars per ton, very much more worth over twenty-five dollars per ton and so on down to infinitesimal quantities. As we have already seen, the rich deposits, or bonanzas, represent the concentration of the gold contents of large masses of rock, and modern gold mining practice, instead of looking for the elusive bonanza, exploits the great rock masses from which it is derived. Before the introduction of the cyanide process, there were very large deposits which, owing to the impossibility of extracting gold from the tailings, fell just short of being profitable. These large low grade deposits of refractory ore, such as are met with in the Transvaal and which compose the resources of most important gold mining districts, it has been possible to utilize by the chlorination and cyanide processes.

The improvements in the methods of placer working have been equally important with those which have marked the development of vein mining. Though placer working, compared with the extraction of the gold from the ore, is relatively easy, it presents many difficulties after the rich alluvium of the river bars has been exhausted. The gradual exhaustion of the bars has forced the miner to improve his methods in order to profitably extract the gold which lies finely scattered throughout the sands of the river beds. The gold is sometimes found under a thick mass of worthless surface materials. In the case of deposits in old river beds, this covering is frequently hundreds of feet in thickness. Rich placers are also sometimes exposed in the dry beds of streams out of convenient reach of water. Where the gold occurs in clay deposits it cannot be treated by the ordinary processes.

The simplest appliances for placer working are the cradle and the sluice. The cradle is a box set on rockers, in which the gold bearing gravel is disintegrated by mixing with water and rocking. The sluice consists of an inclined channel through which flows a stream of water. Into this channel the gold bearing earth is thrown, the water carrying away the worthless material and cleaning the gold. In modern working, the capacity of these appliances has been greatly increased. For the " blanket " and apron of the cradle, and in place of the flat strips of wood or " riffles " placed at the bottom of the sluice box, has been substituted a riffle box, which is formed of shallow compartments filled with mercury and which takes up a much larger proportion of the gold. This has in its turn been supplanted by copper plates covered with mercury to which the gold adheres. Multiple sluices enable washing to proceed without interruption, one section of the sluice being cleaned up while the other is working. An under-current sluice is usually inserted under the last box of the main sluice, which is provided with an iron grating. The large and coarse material passes out while the fine matter containing most of the gold enters the lower sluice, which, with a slower current, catches much of the gold that would otherwise be lost. Great improvements have also been made in the appliances for pumping out alluvial workings, and for bringing the gold bearing earth to the head of the sluice, and powerful steam dredges are employed to strip the gold deposits where these occur at a moderate depth. For working gold found in connection with clay, machines are used which " puddle " or knead the gold bearing clay until the gold can be separated.

For extracting the gold scattered throughout the river beds the principal methods introduced in late years are " river lifting " and dredging. The method of extracting gold by the use of the steam dredge will be described at some length on a later page. In " river lifting " the stream is allowed to flow over a flume beneath which the exposed bed is washed for gold. Streams have thus been " lifted " for a distance of one-half to three-fourths miles. In other operations, where it is desired to expose the bed of the stream, parallel dams are built.[1] The water above the first dam is allowed to flow through a flume below the second, while the space between the dams is pumped dry.

The most interesting method of placer working is hydraulic mining. We have already mentioned the drifts on the western slopes of the

[1] These damming and lifting methods are replaced now by dredging.

Sierra Nevada range, formed by the filling up of valleys in which gold bearing streams originally ran. The gold occurs very irregularly in these drifts, and if it was to be profitably extracted, some method of rapidly handling large quantities of material at low cost must be devised. This method was found in hydraulic mining, which originated in California in the sixties and was carried to its greatest development during the next decade. It consisted in the use of water under pressure through a hose or pipe to wash large amounts of gravel containing gold. In the beginning canvas hose was used and the stream was directed against the material to be washed through an ordinary nozzle. The gravel, as it was washed down, was carried through a long line of sluices and caught in the riffles or on silvered amalgam plates. This method was superseded by the monitor, which greatly increases the amount of water and the pressure which can be applied. The monitor consists of a heavy cast-iron nozzle with a ball and socket joint, so that it can be turned in any direction. It is provided with a lever called a "deflector," which, when turned against the stream, utilizes the force of the water to move the mass as desired. Some of the large hydraulic mines have used a half dozen monitors at one time,

Hydraulic mining.

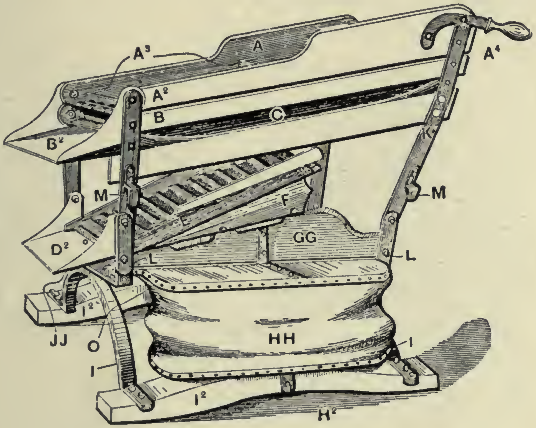
each discharging a powerful stream against the sides of the mountain, and washing down an enormous quantity of sand, earth and gravel in the sluice. As much as 24,000,000 gallons of water have been supplied to one monitor in twenty-four hours. The Spring Valley Mine, near Oroville, California, at one time used 36,000,000 gallons daily, three times the quantity supplied to the city of San Francisco. To supply this enormous volume of water, immense reservoirs were constructed high up in the mountains, and water was conducted, often many miles, to the point of application. At this mine the monitors were kept working day and night, electric power being used, and in the course of years they made an excavation one mile long, one-half mile wide and 300 feet deep.

The chief field in which the methods of hydraulic mining are employed is on the Yuba River in California, where the foothills merge into the Sierras. Here the gold is found in the channels of ancient rivers, covered with hundreds of feet of sand, gravel and clay, which must be removed to get at the gold deposits. The stream from the monitor under a pressure of 300 feet or more, and with a velocity of 300 feet per second, is so rigid near the nozzle that it cannot be cut with an ax in the hands of a strong man.

The roar of the stream can be heard a mile distant and bowlders of tons in weight are made to dance like pebbles. Between 1880 and 1890, when hydraulic mining on the Yuba was at its height, as much as 22,000,000 cubic yards were moved in one year and all the mines of California moved 46,000,000 cubic yards. To aid the work of the miner, blasting powder was employed, tunnels were bored into the face of the bank and tons of powder exploded at one time. It has been stated that the amount of material discharged into the Yuba yearly was sufficient to fill a street eleven miles long, 120 feet wide and seventy-five deep. Much of this material was carried down by the streams and spread over the farming lands of the valley. Over 40,000 acres of rich farming land was thus ruined, and 300,000 acres permanently damaged. Towns, cities and farming districts were put to enormous expense to build levees to protect them against floods, and navigation in some of the bays and in the Sacramento River was seriously impaired. This damage could not be permanently tolerated. Before 1890 injunctions had stopped hydraulic mining, except in a few districts where there was little agriculture to be affected.

Under the Caminetti Act, passed by Congress in 1893, a Débris Commission was created consisting of three federal engineers appointed by the President, who were empowered to make plans for improving navigation and to construct dams for impounding the débris, and also to permit, with suitable restrictions, such hydraulic mining as could be carried on without injury to farming lands. Under the act, up to 1904, 400 permits were issued, which provided that the débris be impounded behind locked dams. Hydraulic mining in California will, however, never reach the proportions of former years when similar operations earned more than a million dollars annually for their owners. Large use is certain to be made of this method, however, in South and Central America, whose placers have, as yet, been worked only by hand.

Dry blowing in West Australia presents an interesting form of placer working. The use of wind to extract the gold is extensively practiced. The absence of running water makes the cradle and sluice box of the ordinary placer mine unavailable, with the result that the prospector has learned to utilize the agencies that he sees incessantly at work in nature. The strong wind which constantly blows, replaces water. The method is as follows: " Taking two pans, the operator places one of them on the ground empty while in the other he places a shovelful of the 'dirt,' that is, the sandy detritus containing the gold. The material is shaken up so as to bring



Dry blowing machine.

the big lumps on top, and then, resting the pan on one knee and holding it with his left hand, he uses his right hand to skim off the coarse particles. Then standing erect and facing at right angles to the wind, he slowly empties the full pan into the empty one at his feet. As the stream of dry dirt falls, the wind selects the fine and blows it in a cloud of dust to leeward. The operation is then reversed, the pan which has just been emptied being placed on the ground so as to receive the contents of the other. This is repeated three or four times according to the degree of concentration effected. In a strong breeze one operation may prove suf-

Dry blowing.

ficient. To prevent a loss of the fine gold which is sometimes carried away with the dust, it is customary to spread a piece of canvas on the ground, one end being placed under the pan and the other extending to leeward. The next stage is to farther winnow the material by tossing it up and down in the pan. The latter is held slanting forward and is jerked so as to throw the dirt from the front to the back of the pan. The light particles are separated, as chaff is driven from grain. Then, giving the dish a vanning movement, the prospector again removes the

Dry blowing—old process.

coarser particles that come to the surface by skimming them off with his hand. There now remains about a half pint of material and this is diminished by panning, just as in water, the dry particles having a mobility permitting this method of treatment. Finally, he drops on his knee, and, holding the pan so that it is tilted forward, he raises it up to his mouth and uses the breath of his lungs to complete the process. The particles of gold are seen fringing the edge of the iron sand. If the yield consist of only a few minute particles, he puts his moist thumb on them, and so transfers them to his pockets; but if there be any coarse pieces—nuggets—they are put into the leather wallet attached to his belt."[1] This method of dry blowing duplicates very exactly the simplest method of gold washing. It has been supplemented and improved upon by the use of various mechanical appliances, some of which use bellows to separate the material.

The appliance which will be most largely used in working the placers of the future is probably the gold dredge. Mr. Alexander Del Mar, in the *Engineering Magazine,* describes this appliance as follows: "The gold dredge consists, first, of a wooden scow 80 or 100 feet long, 30 feet wide

[1] T. A. Rickard in "Transactions A. I. M. E.," Vol. 28, pp. 503, 505.

and 7 or 8 feet deep; second, of a medial upright frame and two side frames erected upon the deck, all of steel and carrying a tumbler and counter shafts; third, of a series of iron buckets lipped with steel, revolving upon a digging ladder, or girder, which can be adjusted so that the buckets will attack the gravel bank at any de-

Gold dredge.

sired altitude without its range, 30 feet or more below the water level, and carry the gravel up to the grizzlies and screens; fourth, of a series of grizzlies and screens to sift the gravel; fifth, of a series of sluice-boxes, tables, riffles and undercurrents, supplied with quicksilver, to wash the gravel and seize and detain the gold; sixth, of an elevator or stacking girder which carries off the stones and coarse material directly, and the fines, after they have been divested of their precious burden, depositing the entire lot of tailings 30 feet above water level; seventh, of two centrifugal pumps delivering 2000 gallons of water per minute into the screens and boxes; and eighth, of electrical machinery to perform the entire work and keep the dredge moving on to the bank until it is entirely worked."[1] The accompanying illustration gives an excellent idea of these appliances. These gold dredges, which can, if sufficient water is available, work systematically over a large amount of ground and handle practically every cubic yard of material which it contains, are especially applicable to the working of the low grade placers, where gold is found running from three to twenty-five cents per cubic yard and which are either not available for hydraulic mining or are in localities where hydraulic mining has been prohibited.

The field of application of the gold dredge is illustrated by the gold properties on the Snake River in Oregon and Idaho. The low lands on

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[1] *The Engineering Magazine*, Vol, 29, 1905, p. 490.

both sides of the river are from one-half to ten miles wide, forming broad and level valleys between bluffs about eighty feet high. The soil consists of volcanic earth sometimes overlying, to a depth of several feet, enormous beds of gravel, which often crop out at the surface and contain traces of gold up to values of two dollars per cubic yard. The gold occurs in flakes and also "colors," appearing large although their thinness makes them very light. The lava beds through which this river runs extend through Idaho and comprise several thousand square miles, containing everywhere traces of fine gold, which has evidently been obtained by the disintegration of the lava. This material can be handled profitably in no other way than by the gold dredge, and the district is being thoroughly exploited. Gold dredging is generally conceded to be, under proper conditions, a safe as well as an exceedingly profitable business. In one case cited by Mr. Del Mar, in the article above referred to, the cost of a dredge and equipment is $52,500 and only $12,500 of working cash capital is required in addition. The cost of operation is $16,000 per annum. The amount of work done by this dredge amounted to ten acres extracted to a depth of thirty feet, or 500,000 cubic yards, which yielded twenty cents per cubic yard, or a total of $700,000. The profit was 128 per cent. on the capital invested.

The causes of the great increase in the gold supply, which characterized the last twenty years, are now before us. The increased production of gold, like the advance in the production of every other important commodity, has responded to the improvement of transportation facilities, the increased activity in searching out new sources of supply and the improvement in the methods and machinery of production. It is a safe conclusion also that invention and improvement have been more active in the gold mining industry than in any other important branch of production. No such revolutionary discovery as the cyanide process is recorded in any other important industry during the last quarter century. Owing to the fact also, which has been already noted, that gold mining is for the most part carried on in remote and inaccessible localities, where costs of production have been increased by the difficulties of the location, the technical achievements of recent years, and especially the general improvements in transportation facilities, have been very effective in reducing the cost of extraction.

The long series of inventions has, moreover, been supplemented,—to repeat a former conclusion,—during most of the period under review, by a steady increase in the value of gold, which has made investment in gold mining properties unusually attractive, since, by decreasing the cost of the materials, machinery and supplies which are consumed in the industry, it has greatly reduced its operating costs. In this respect the gold mining industry has enjoyed a unique advantage. From 1873 to 1897 the purchasing power of gold over every other important commodity of commerce, with slight interruption, steadily advanced. The gold miner produced money, and as prices fell, the purchasing power of money advanced. The decline in prices, in other words, automatically increased the profits of the gold miner and encouraged him to extend his operations and enlarge his output. No explanation of the increase of the gold production is complete which does not give weight to this influence of declining prices in reducing the costs of the gold miner.

CHAPTER VIII

THE FUTURE OF GOLD PRODUCTION

The most important question which now confronts the industrial world, is the future of the gold supply. The United States has just passed through a period of extreme monetary stringency, caused by the inability of banks and other business concerns to secure enough money to meet their obligations. Although the crisis has passed without resulting in general disaster, yet a large number of institutions have failed and more failures are to come. In place of the advance of prices, which brought prosperity to every part of the country, and which raised the profits of capital and the wages of labor, we are now experiencing a decline in prices, with the closing of mills, reduction of sales, reduction of wages by all employers, a falling off in railway traffic and a general decrease in the purchasing power of the people. The connection between rising prices and prosperity and between falling prices and depression is so well established that its existence no longer needs any detailed demonstration. It is an axiom which every business man must constantly keep before his mind.

Since prices are declining because there is not enough money in the hands of buyers to keep them at their former figures, and since, so long as the decline continues, the return of prosperity is impossible, it is a question of vital moment whether the money supply will be increased by the output of the gold mines so as to reverse the movement and again start prices upward. The future of profits, salaries and wages, in other words, depends upon the output of the gold mines. During the past year this has risen to $411,000,000, about one-half of which, it is estimated, has gone into circulation and into bank reserves and government treasuries. In spite of this enormous supply of money, which surpasses all previous records, the demand for money during the autumn of 1897 was so intense that that currency in New York City for three weeks commanded premiums of three to five per cent., and the great banks of Europe and America fought over the surplus of gold which each country demanded to satisfy its obligations. The business of the world has increased more rapidly in recent years than the supply of money with which that business is to be done. When the limit of the money supply had been reached, which has happened everywhere during the past year, the advance of business had to stop until the means of doing business, which, in the last analysis, is the supply of gold money, should again overtake the demand which the enormous volume of transactions had thrown upon it. Whether the advance will again be resumed will depend on the ability of the gold mining industry to increase its output more rapidly than the supplies of wheat, cotton, iron, coal and timber can increase. The future of the gold supply is a matter of extreme interest to everyone who has anything to do with wages, profits, interest, rents or dividends; in other words, to every member of society.

In forecasting the future of the gold supply our first question naturally concerns the resources of the leading districts. For the moment we shall confine our examination to those countries in which the gold industry is carried on, on a large scale, by the use of modern machinery and appliances. In 1906 these were as follows:

United States	$ 96,104,100
Transvaal	119,609,373
Australasia	82,237,228

Out of a total production of $407,658,928 three-quarters of the world's gold production is thus obtained from those three countries, and the visible gold resources of each of these large producers are rapidly increasing. In the United States, the large gold resources of the country can be revealed in no way so well as by a statement of the total production by states. The large producers in 1906 were as follows:

Alaska	$ 21,251,100
California	18,633,900
Colorado	22,771,200
Nevada	9,815,800
South Dakota	6,822,700
Utah	5,172,200
Montana	4,585,800

Going back seven years to 1899, we find that the production of every one of these states, with the exception of Colorado, has either increased or has been well sustained. In California, for example, in 1899 $15,000,000 of gold was produced; in 1901 this had risen to $16,891,000; in 1904 to $19,109,600; and in 1906 the production was $18,633,900. South Dakota has maintained its production around $6,000,000 throughout the period. Colorado, which in 1900 produced $28,762,036, had fallen off, in 1906, to $22,771,200, but the yield in 1905 was almost $26,000,000.

The significance of these figures can be easily understood. A gold vein is not an immense mass of mineral which can be quarried out with steam shovels, or excavated with methodical certainty through many miles of underground workings. It is a tiny streak of mineral frequently invisible to the naked eye, extending often in an erratic and irregular course, and being frequently broken off at a time when its yield is the richest. To sustain the production of a state like California, new veins of gold must be continually uncovered. A properly managed mine keeps from eighteen months to two years ahead of its workings in its exploration operations. If exploration for gold were to cease in any district on January 1st of any year, within the next twelve months the yield of the mines of that locality would, it is safe to say, show a marked decline, and within two years would have fallen off fifty per cent. The fact, then, that these districts are sustaining and increasing their gold production shows that exploration work, both in old mines and in uncovering new deposits, has been generally successful, and indicates that the gold resources of the oldest and longest established districts in the country are not only far from exhaustion, but have not yet reached their greatest productiveness.

It is still more significant to trace the increase in gold production from the new localities. Alaska, for example, which began to produce on a large scale in 1897, in 1899 yielded $5,125,000 of gold. By 1902 this production had reached $8,345,099, in 1905 $14,925,600 and in 1906 $21,251,100. The development of Nevada is even still more spectacular. This state, until 1903, for many years had been only a small producer of gold. With the exhaustion of the rich mines on the Comstock, its yield fell off until, from 1899 to 1902, it produced only between $2,000,000 and $3,000,000. In 1903, however, with the new discoveries in the southwestern part of the state, the yield of Nevada rose to $3,388,000, in 1905 to $5,359,100 and in 1906 to $9,815,800. This increase is due to the discoveries of Tonopah and Goldfield, in districts where no one knew that gold existed. As prospecting activity increases, throughout that part of the state and over the boundary line into California, new discoveries are constantly being made.

This has been the history of gold production throughout the West. Of no district, no matter how thoroughly it has been explored, is it possible to say that the limit of its capacity has been reached. A continuation of exploration efforts is reasonably certain to disclose new resources, sufficient to keep old mines in operation, and to furnish a basis for new undertakings. It is of course impossible to predict the future gold production of the United States, but when we consider that it has risen from $53,088,000 in 1896 to $96,100,400 in 1906, and when we compare the large number of discoveries of valuable ore which are each year being reported, we are safe in the conclusion that the gold production in the United States will go on increasing for many years.

In Australia, prediction as to the future of the gold mining industry is more difficult. Some of the districts, such as Victoria and Queensland, have been producing gold for nearly half a century, and while their output shows as yet no signs of permanent decline, it is not to be expected that, in a territory which has been so long and so thoroughly explored, many sensational discoveries are yet to be made. In West Australia, however, the outlook is much brighter. Of this district, which in 1906 produced one-half the gold of all Australasia, 332,773 square miles is stated by the government geological survey to include gold bearing territory, but only about 2,000 square miles has, at different times, been carefully examined. The remainder of the territory yet remains to be prospected, and so much of it is covered by alluvium and ironstone gravel that it may at any time lead to a rich vein and open up new gold fields. Prospecting activity in West Australia has in recent years been greatly interfered with by the requirements forced upon the industry by the government, much under the influence of organized labor, that one miner must be continually employed for every six acres of land. It is so difficult, under this law, for prospectors to secure themselves in the results of their discoveries that they have quite generally abandoned exploration work. To this piece of stupid legislation, the failure of the gold production of West Australia to increase more rapidly in recent years is mainly ascribed.

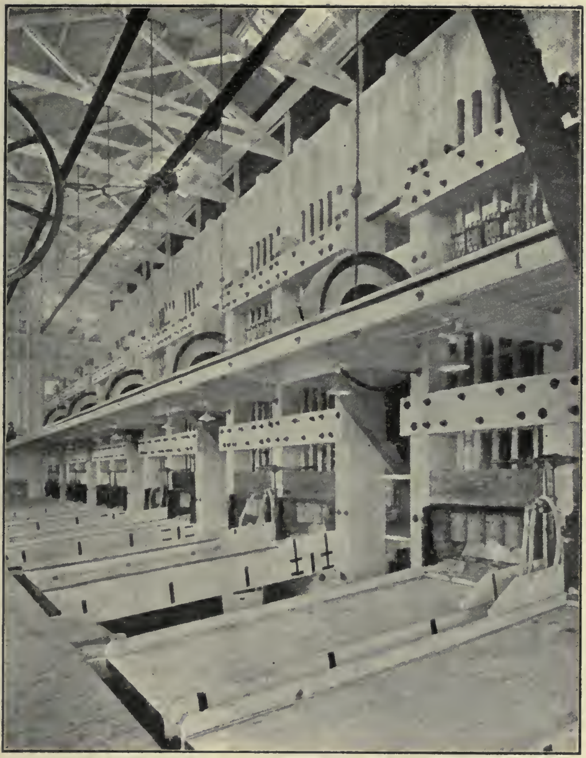
When we come to South Africa the possibilities of prediction are much greater. We have already seen that the gold in the Transvaal occurs in zones rather than in veins, more closely resembling in its formation a seam of coal than a thin vein of mineral. It has now been established that these beds are continuous throughout the district, and the regularity of the deposits indicates that the gold bearing strata run to great depths. It is this peculiarity that distinguishes South African mining from the gold production of every other part of the world. The regularity of its deposits is such as to warrant an enormous investment of money in their development. The estimates of the contents of these deposits have been greatly raised in recent years. In 1890 Herr Bergrath Schmeisser estimated that the supply of gold on the Rand yet to be extracted would amount to $1,020,828,355, or assuming a greater depth than had as yet been fully explored, the amount would be $1,710,506,000. In 1893 these estimates were confirmed by Hamilton

General view of a South African gold mill.

Smith, an American engineer who made a report for the Rothschilds on the Rand district. Subsequent explorations have shown that these original estimates were too low. It is reasonably certain that over $3,000,000,000 of gold, equivalent to seven years' production of the entire world at the rate of 1906, is yet to be extracted from the known deposits on the Transvaal.

If, then, the world was forced to depend solely upon the gold supplies of these three districts, there would be no reason to anticipate any gold famine for the next quarter century. Fortunately, however, the development in these three localities indicates only a small fraction of the deposits of gold placers and gold ores which are known to exist in other parts of the world. A survey of those resources warrants the conclusion that the world's production of gold will probably go on increasing for many years.

In the Yukon district, where steam and electric power have recently been introduced, the further extension of mining must depend very largely upon the operation of the mining company with sufficient capital to work on a large scale and to invest considerable amounts before receiving returns. The day of the poor man in Alaska has passed. For example, in the Klondike the thawing of the ground which is necessary in order to permit its working was formerly done by building a fire against the frozen ground. In the larger operations thawing is now done by steam, and steam hoists are also used to raise the gravel. In many cases, after the mines have been properly equipped, operations can be carried on through the winter, which was formerly impossible. Hydraulic mining is also coming into the Klondike. Large dams have recently been constructed for impounding water and expensive works have been constructed for carrying water long distances to points of application. What is going on in Alaska is found in every other gold mining region. The supplanting of the crude and insufficient methods of hand labor with modern machinery which is a hundred times more effective, is now everywhere in progress. Modern methods have created the gold mining industry of the Transvaal, the largest producing district in the world. They have been everywhere applied through the United States. The larger mines on the Rand have spent from $2,000,000 to $3,000,000 in exploration and development, and in equipment, before extracting a single ounce of gold. The Australian gold mining industry is fully equipped for economical production. What has been done in these three great countries of gold production will be done at no distant date in Siberia, in Mexico, in Central America and in many parts of South America, whose gold resources, as we



Stamp mill, Nourse Deep.

shall see, are enormous, and which as yet have been scarcely touched.

The application of modern methods to the gold mining industry means that within a comparatively few years, in every important gold mining district now being worked, and in many localities where only the beginnings of production have been made, not only will the placer gold, the relatively small accumulations of nature out of the gold bearing rocks, be exploited, but the veins themselves, from which in every case these placers have been derived, will be uncovered, and the gold miner, passing down from the free milling ore, which is too irregular in amount to form the basis of a large industry, will attack the large and comparatively uniform bodies of low grade ore from which the gold supply of the future will be obtained, and which contain many times more of the precious metal than the placers and free milling ores. The fact that a certain quantity of the precious metal has been produced from free milling ores in a given locality is evidence that there remains in the low grade ores a reserve many times greater in value than the amount which has been extracted. In Mexico, Central and South America, Siberia, Alaska and many parts of the United States, the supply of gold up to the present time has been drawn almost entirely from the free milling ores which lie above the perpetual water line, leaving the enormous reserves of refractory ores for the future.

More than this, we find that in the gold mining industry throughout most of the world, the quartz has been worked scarcely at all, the supply having been drawn almost entirely from the placers. In Mexico, in Central America, Brazil, Colombia, Ecuador, The Guianas, Peru, Venezuela, Russia, Madagascar, The West Coast, Borneo, China, East Indies, Japan, Korea and other countries which have been, up to the present, only imperfectly explored for their gold supplies, but in which as is well known, and as we shall subsequently see for ourselves, the gold resources are large, modern methods have, broadly speaking, not been applied at all. The production of these localities, which in 1905 was $64,243,848, was practically all derived from placers, and even these were worked in the crudest and most wasteful manner. When we consider, then, in how few localities the sulphide ores have been worked, and that at least one-third of the world's gold production is still taken from placers, we can form some idea of the volume of that production when scientific methods have been applied throughout the world, and modern gold mining industry has been established. The importance of this subject warrants a few detailed illustrations.

In the Guanajuato district of Mexico, the most important mining district of the Republic, there are two great vein systems, the Veta Madre and the La Luz. These deposits have been worked

Ancient smelter near Guanajuato.

for over 300 years with the crude appliances and wasteful methods which had been handed down from the early days, and yet, although precious metal mining in this vicinity has been confined entirely to a small portion of the ores which occur above the water line, the district is credited with a total production of gold and silver of $1,150,000,000. The Veta Madre vein system is seven miles long, and only two-thirds of this has been explored. From the northern half alone, however, $600,000,000 of metals have been extracted. No attempt has ever been made to work the tailings of this district, and it is estimated that over $120,000,000 has gone down into the streams in the tailings. After 1850, many conditions, such as the failure of the antiquated methods of mining to deal with the low-lying sulphide ores, the absence of economical transportation facilities, the enormous waste of gold in the process of treatment,—only twenty to thirty-five per cent. being saved—and the inability to keep the mines free from water, united to interfere with the mining industry. The increased cost of production, owing to the greater depths attained, the crude methods employed which were entirely unapplicable to low grade ores, together with the decrease in the yield per ton, which would naturally be expected as the shafts went deeper, made the margin of profit so small that nothing was left for adequate exploration or development work. As a result, after the ore in sight was finally worked out, mining declined throughout the district.

In recent years, however, a large amount of American capital has been invested in Guanajuato, power has been supplied from neighboring water-falls, regular mining operations have been renewed and gold mills and smelters have been erected. In place of the twenty to thirty per cent. of extraction, which was all that was realized in the old days, the best mills of the district now obtain ninety-six per cent. of the gold contained; the old mines are being pumped out, and the enormous accumulations of tailings, some of which are estimated to average twenty dollars per ton in gold, are being attacked. The enormous yield of Guanajuato was obtained entirely from the free milling ores, with great waste and at high cost. There can be little doubt as to the output of this district when modern methods of production and extraction are fully applied.

A still more striking evidence of the possibilities of applying modern methods to gold deposits which, though well known, have never been exploited, is furnished by the richest gold mining section in South America—the Republic of Colombia. The yield of Colombia, since the Spanish conquest, a yield derived by the application of crude methods, has been approximately $750,000,000. Nearly every state and province has its gold deposits. The state of Antioquia, although, because of its almost inaccessible location, its gold resources are not fully known, is the richest province of Colombia. Mr. J. D. Garrison, an engineer who made a survey of this region for the Intercontinental Railway, described the gold situation in Antioquia in the *Engineering Magazine* as follows:[1]

" Situated, it might be said, almost in the ' lap of the Andes ' and cross-seamed by many spurs from the parent chain, the state presents an almost unbroken area laced with gold bearing quartz veins of great value, while many of its streams have valley deposits of placer gold of almost incredible richness. Nearly $150,000,000 in gold have been taken out of the mines of this state during the present century, although most of the workings there have generally been limited to surface deposits easy to reach. A very large proportion of this amount has been taken from placer deposits in the valley of the Porce, a river that has long been known to be exceedingly rich in gold. . . . Through a good portion of this length (175 miles) it is fed by mountain streams

[1] *The Engineering Magazine*, Vol. XI, p. 983 ff, May, 1897.

and torrents that have cut their way, in deep canons, across the flanks of the Cordilleras, and that bring into the valley, with their detritus, gold from innumerable veins. As a consequence, the river has, for over sixty-five miles, an almost uninterrupted series of gravel bars, or flats, exceedingly rich in gold. So rich, indeed, are some of these bars that much speculation has been indulged in relative to the source of their supply. . . . Mining has been carried on in the valley to a greater or less extent for over 300 years. . . . Individual instances of great returns for working are on record. On the lower reaches of the river the natives have taken out, by diving, pans of gravel that yielded more than two pounds of gold. One proprietor, after spending nearly $75,000 for the introduction of water, washed out, in a few days, more than 10,600 ounces of gold dust, and from a small bar in the river valley, though hardly 500 feet long by fifty feet wide, more than $200,000 were taken. . . . An English engineer of some repute examined and reported on the richness of the Porce River; he estimated that the river contained gold in the proportion of 14 7-10 ounces per superficial square yard, and that in the lower fifty-mile reach of the river, there were more than 4000 tons of gold."

Similar conclusions can be formed concerning the gold richness of Siberia and Russia. It should be remembered that $20,000,000 a year of gold is extracted from these districts with old-

Siberian mine labor.

fashioned methods and appliances. At one operation, for example, where 900,000 cubic meters of sand were washed, equivalent to about 1,000,000 cubic yards, 2000 men and 500 horses were employed. The same amount of material could be handled in the United States with two moderate-sized dredges, employing possibly twenty men.

Opportunities for gold dredging in the United

States are not abundant. The territory about Oroville, in California, is one of the best loca-

Typical stream of Northern Ural.

tions. To the north and east of this point, the vast extent of mountain territory whose rocks are penetrated with gold bearing veins, has been

Typical valley of the Steppes, Southern Ural.

gradually worn down and carried into the bed of the Feather River, forming a valley of great width with moderate depth. Through this valley the gold particles, finely divided, are very evenly distributed. It is in these shallow gravels, less than forty feet in depth, that dredging enterprise was most successfully carried on. Over a large portion of the gold districts of Siberia, similar conditions are encountered. Broad,

Typical grand flat, Northern Ural.

shallow valleys filled with gold bearing gravel, the result of innumerable ages of wearing down the mountains, containing gold bearing veins, are everywhere met with in the gold producing districts in Central and West Siberia and Eastern Russia. This territory, geologically speaking, is very old. The Ural Mountains are mainly low rounded hills. High mountains at one time undoubtedly occupied this locality, but they have gradually eroded, leaving their débris behind, spread out very evenly by slow-running streams. Many of these deposits, a fact attested by the great success which has attended their working,

Type of Siberian gold-washing machine.

are extremely rich in gold, and over this great gold bearing area it is safe to say that if mining operations were carried on with the economy which characterizes them in the United States and New Zealand, the yield of production would be increased several times. Enthusiastic explorers of Southern Siberia have indeed estimated that an annual yield of $100,000,000 from the placers alone could be easily secured. Without placing too much credence in these statements, it is a fact reasonably well established, that the resources of the territory are enormous, and that when they are exploited by modern machinery, as will eventually happen, a large increase in the gold production of the placers alone, to say nothing of the remaining veins which are practically untouched, is to be confidently anticipated.

We have, finally, in our survey of the future of gold production, to take account of the deposits in localities where gold mining is not yet carried on on a sufficiently large scale for them to be seriously counted as factors in the present output. A rapid survey of these undeveloped gold regions will suffice for our purpose. Banket deposits, similar to that upon which the gold mining industry of the Transvaal has been erected, occur in other parts of South Africa. In the DeKaap district the quartz is especially rich, and beds of conglomerate also occur in the eastern, northwestern and western portions of the Transvaal. Similar deposits are found in Zululand, Matabele and Mashonaland, and in the Orange Free State. On the West Coast besides extensive alluvial deposits, there are large beds of the same conglomerate formation that occurs in South Africa. Mr. Hesketh Bell, Assistant Treasurer of the Gold Coast, said: "I doubt very much whether California ever presented to the naked eye the tempting wealth of gold which so forcibly attracts the attention of the traveler in the western districts of the Gold Coast." Madagascar is also reported to contain gold in large quantities, and in East Africa promising deposits have been discovered in German territory. The unexplored regions of Western Australia have already been mentioned. Valuable gold deposits are known to exist in southeastern Asia, both on the continent and on the islands. Russian exploration in Thibet shows the existence of extensive gold fields in that country and the precious metal is also found in large amounts in Manchuria. Gold occurs in large quantities in northern Asia Minor and in the Altai range.

In the Western Hemisphere the possibility of new gold discoveries is even more promising. Thus Mr. J. H. Curle, a mining expert of the London *Economist*, writing in that journal, says: "Much of what is probably the richest mineral country in South America has as yet been barely explored. The Argentine government is now building a line to the Bolivian border, which will eventually join with the railway running into Bolivia from the Pacific coast, and a great stretch of rich mining country now lying untouched for lack of transportation, will be brought into the economic sphere. We are now, I believe, on the verge of a great development in South American gold mining. This will come about, in the first place from gold dredging, and the district which will show the finest results is that part of Bolivia toward which the Argentine government's railway extension is now heading. All reports go to show that the river San Juan de Oro, running through the district, not only covers good values in gold, but shows unique facilities for dredging. Another immense field for dredging is the Matteo Grasso district of Brazil. From Terra Del Fuego, Argentine, Peru, the Guianas and from the Minas and Diamantina districts of Brazil, a great deal of evidence as to the existence of payable dredging areas has been obtained in the last two years.''[1]

Deposits of large extent are located in Bolivia, which have not yet been worked on any large scale. Bolivia has two main gold belts, one beginning in the northwest and extending south-

[1] London *Economist*, September 9, 1905.

east; the other beginning in the southwest and extending northeast joins the northern belt. Large deposits also occur in this country in the main range of the Andes in the extreme north. In the eastern part of Peru, gold occurs in large quantities, both quartz and placer deposits having been found. Large gold bearing alluvial deposits are found in the Eastern Cordilleras in Peru, and also in the northern part of the country. In Ecuador, there are extensive quartz deposits, and also large amounts of gravels so situated that they may be economically operated by the hydraulic process, with abundance of water, high dumps and with swift streams to carry away the débris. This region is located near the Colombian frontier and about thirty miles from the coast. Streams in this region are quite generally associated with immense beds of gold bearing gravel from fifteen to seventy feet thick. The placer deposits of Venezuela are of considerable extent, and large quartz deposits are also found. British and Dutch Guinea are also rich in gold, and a considerable mining industry has already been established. Mr. E. H. Teats, writing in the *Engineering and Mining Journal,*[1] makes the following comment on

[1] March 24, 1906.

the Guianas as gold producing localities: "Recent developments in British and Dutch Guiana have demonstrated that gold in paying quantities is found in the hills to a depth of several meters and that possibilities for successful hydraulicking are good. Nearly every known mining district in Dutch Guiana is rich in gold. From some of them have come yields that almost challenge belief. . . . Recent exploitation has demonstrated that there are great stores of wealth only waiting the advent of capital with suitable machinery in the hands of experienced men. . . . Instances of value, such as the following, are quite often reported. Thus $552 was washed from fifteen pounds of quartz, and many tests of the same vein where it had been prospected for a distance of 6000 feet showed values never less than eighteen dollars per ton. In another test, some fifty miles away, quartz boulders found in the gravel beds gave a value of over $12,000 per ton. I have seen over $8000 worth of beautiful quartz specimens taken from the gravel beds, where many hundred thousand dollars had been produced by hand work."

Finally, and nearer the United States, in Nicaragua, Costa Rica and Honduras, there are large gold deposits, both in quartz and in placers.

In Nicaragua the deposits are especially rich near the headwaters of the Coco River. This district was formerly worked by the Spanish to great profit, both veins and placers having been explored, but was later abandoned.

The question now immediately arises: Why is it, if gold deposits of such extraordinary richness are known to exist in so many parts of the world, that these deposits are not worked on a larger scale? The answer to this question has already been suggested and lies on the surface of the previous discussion. The mere enumeration of the localities where those deposits are situated, shows the difficulties which stand in the way of their exploitation. Most of them are located in barbarous or half-civilized countries, where life and property are insecure. Capital avoids these localities, and yet without a large investment of capital, as we have seen, modern mining methods cannot be employed. In one celebrated instance, for example, the Backus and Johnson Mining Company, located near Lima, was compelled to suspend operations for six months because the revolutionists had cut the railway leading up to the works, and refused to allow the shipment of supplies or bullion. In such countries as Colombia and Venezuela, as well as in Central America, no adequate security can be given for investment, and a profitable industry is likely to be made the object of official extortion.

Climatic difficulties in these regions are even more serious. A large part of the gold deposits which have not yet been developed lies in the tropics, where prospecting and mining are almost impossible owing to the dense vegetation. The climate of these localities is a very serious drawback to operating. The climate is largely responsible for the bad government and also for the bad transportation. In Colombia, the coastal and valley regions are the hottest, the valleys having the worst climatic conditions. Mr. J. P. Hutchins, writing in the *Engineering and Mining Journal*, says that he has " observed 103° F. in the shade. No breeze or other palliating circumstance tempered this almost infernal heat, and an atmosphere, seemingly supersaturated, added to the discomfort, almost painful in its intensity. The white man of temperate zones does not thrive in such pestilential conditions, and he must be selected with due consideration of his fitness. He will be exposed to yellow fever; bilious and intermittent fevers, dysenteries and beri beri are prevalent. They seem to be caused by poor food and exposure to infection, the numerous means for which air, earth and water all combine to supply. In many more ways does climate affect the economic working of mines; one is constantly confronted with problems due to rank vegetation, floods and other meteorological phenomena. The maintenance of a high tension electrical transmission system will involve all the difficulties due to the poles rotting, caused by insects, or being blown down in tropical tempests with danger to apparatus from severe electrical disturbances."[1]

Another writer, commenting on the probability of large gold production in New Guinea, says: "Traveling through the dense jungle of the tropics in a never ceasing moist, unwholesome atmosphere, where every article required has to be carried on men's backs, because horses cannot be used, is hardship which few gold hunters can stand. One traveler in the island reports that the existence of gold and its distribution over a large area is undoubtedly proved, but it still remains to be shown whether any alluvial deposit will pay the expense of finding and working, quite apart from the improbability of a mountainous, heavily jungled, tropical country, fever-laden in the lowlands, and muffled with moss and mist on its ranges, ever turning out a poor man's field."[2]

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[1] *Engineering and Mining Journal*, Nov., 1905, p. 810.

[2] Rothwell's "Mineral Industry," 1898, p. 810.

Another account of placer working in Northern Brazil refers to the climate: "Three weeks is the extreme length of time at any one camp. At the end of that time the placers are washed over (according to the primitive methods in use) or the majority of the miners are dead. I refer to the richest deposits which are in the northern part of Brazil. In the higher regions of Venezuela the conditions are much more favorable to life. A man arriving in the mining territory may live six hours or he may live a month. If a dysentery comes along, he had better make ready to bid farewell to the world. There is no known remedy for the dread disease. The best physicians of the cities of the coast told me they knew not of the cause nor could they suggest a cure. I came down the river with a party which numbered eight men when we started. When we reached the coast, three members of the party were alive."[1]

Labor difficulties are very serious in all tropical countries. The native labor is so incompetent and careless that it often pays better to employ primitive methods than to risk failure by introducing complicated processes and then only at exorbitant wages. In all Spanish Amer-

[1] *Mining Industry and Review*, February 6, 1896.

ican operations highly paid employees are constantly occupied in preventing the stealing of the gold. White labor can, with difficulty, be had at all, and then only at exorbitant wages. The labor situation on the Transvaal, the most important mining district in the world, constitutes a serious menace to the immediate future of the region. Owing to the necessity of importing practically everything which is consumed in the district, and to the cost of transportation, the cost of living is enormous. In 1903, the following comparative prices of leading food materials on the Rand and in England were published:

	England	Transvaal
Bread, four pound loaf...	$ .12	$ .36
Milk, quart..............	.06	.18
Sugar, seven pounds......	.26	.52
Eggs, dozen..............	.20	.92
Potatoes, fourteen pounds..	.14	.84
Meat, one pound..........	.12	.24

The average cost of decent subsistence for a family of five per month was stated as $122.40. These conditions necessitate high wages. A mine manager on the Rand will be paid $680 per month; a battery manager, $240; machine drillers, $160, and carpenters, $125. Common labor cannot earn high enough wages to permit them to live, so the mines are worked by native labor, Basuto, Zulu and Zambesi blacks, locally known as " boys." They receive from twelve to fifteen dollars per month and their board. They make fairly efficient laborers, but the cost of obtaining them is heavy, the supply is inadequate and they are constantly deserting to return to their homes, often 1000 miles distant, to enjoy the fruits of their labors, according to the native philosophy of life, which is as follows: " Six pieces of white man's gold will buy one cow, four cows will buy a nice little wife; half a dozen wives will tend my mealie patch while I smoke and look on."

The scarcity of native labor after the war led to the introduction into the Transvaal, in 1904, of Chinese labor under the indenture system which has worked so well in the West Indies. About 50,000 Chinese laborers were introduced and proved very efficient. The issue of " slavery " was raised in England, however, and the Liberal government has stopped the further importation of indentured labor, which prohibition, if continued, will in time return most of the Chinese laborers as their terms of service expire. It is recognized, however, that some new sources of labor supply must be opened to supplement the Kaffirs, if the output of the Rand is to increase.

Transportation difficulties, especially in the tropics, are even more serious, in part due to causes which have been enumerated, and also the inaccessibility, of the deposits. For example, the province of Antioquia in Colombia offers, as we have seen, a rich field for mining enterprise, and yet it can with difficulty be entered. It lies far inland, and is walled in by the Cordilleras on the east, south and west, while on the north it is bounded by almost impenetrable jungles and morasses. The roads everywhere are almost impassable for machinery and in the mountains these roads are generally narrow bridle paths, in some places clinging to the surface of the cliff. Saving the routes traversable by steamer or canoe and the few short lines of railway now existing, all travel is on muleback. Hence the weight of the packages of merchandise or pieces of machinery is limited to about 150 pounds each, up to 400 pounds. Railway construction in these South American countries has not progressed to any extent, and until these facilities are provided, gold mining will be carried on on a small scale.

The conditions of the problem are plain. If these hitherto inaccessible regions are to be opened to the gold miner in the near future, the stimulus of a high value of gold, by which we mean a low level of gold prices, must be continued. The value of gold, even in spite of the fact that its purchasing power over commodities has greatly declined in recent years, is still far below the figures reached from 1865 to 1873. If the world desires this gold, if it will pay the price, it can have the gold of South and Central America, China, West Africa and the Malay Archipelago in large quantities.

The gold is there. Hidden away in the impenetrable jungles of the tropics, ramparted by tremendous mountain ranges, blanketed by deadly vapors, or covered with ice and snow, guarded by situation, by climate, by political instability, by disease and death, the gold exists. Eventually, as the industrial development of the world continues to increase its demands upon the money producing industry, it is certain that these regions, at present so difficult of approach, will be opened to the miner; that transportation facilities will be provided; climate improved by drainage and clearing; labor attracted by high wages and the gold extracted. Long before that day, however, the never ceasing progress of industrial development will have doubled more than once the volume of exchanges, and the work which the world's gold reserves must accomplish, and when the untouched resources of the tropics yield up their treasures, they will not long anticipate the imperative need for the money which they will produce.

APPENDIX

APPENDIX

BRIEF SUMMARY OF THE MINING LAW OF THE UNITED STATES

BY JOHN CHRISTIE DUNCAN

Where minerals have been found in lands which are the property of the state or national government, they, in the absence of right in some one else derived from grant or reservation, belong to the state or nation. The government in such cases exercises over them the same rights as a private individual, owning everything which is of realty, from the center of the earth to the heavens.

From the foundation of the government until 1866, the settled policy of the United States government was not to part with the ownership of its mineral lands, but when the far Western and Rocky Mountain country became opened up, it was found necessary to change this policy. Very soon after the conquest of California and its cession to the United States by Mexico, it was found to be rich in precious metals and such was the influx of immigrants from the Eastern states, that the population of California at the time of its organization as a state in 1850 amounted to nearly 100,000.

It was entirely composed of mining camps and settlements engaged in mining these metals. As nearly all these mines were discovered on land whose title was vested by treaty in the government of the United States, it became important to determine what course the government would take with regard to this source of unknown wealth. The Spanish government, to which this territory at one time belonged, instituted a system by which private enterprise was invited to develop the immense wealth. From the persons so developing, a certain revenue was secured to the crown. Mexico inherited and perpetuated this system. Many Americans thought it advisable for the United States to adopt the same scheme, but before Congress could act, the country became filled. A large number of industrious and enterprising citizens had already staked out claims and opened workings, and had established conditions which neither Congress nor the state could overlook. The customs and regulations of the mining community obtained recognition in the legislature and courts of California. The latter, in order to give legal title to those who, under these customary regulations, were mining upon the public domain, adopted the fiction that the first appropriation of the public mineral land had a license for the mine from the government, and if, in his appropriation of the land, one complied with the regulations of the mining district, that license was protected as a property right. (Hicks v. Bell, 3 Cal. 219; Stoakes v. Barret, 5 id. 36; Henshaw, Clarke and 103 Chinamen, 14 id. 460; Tartan v. Spring Creek W. & M. Co., id. 395.)

By an Act of July 26, 1866, Congress passed a law by which the title to mineral land might be acquired from the government at nominal prices. This and the Act of May 10, 1872, have been consolidated in the Revised Statutes, Title 32, Chapter 6, and now govern, exclusively, the granting of mining lands by the United States and likewise the state of California and other Western states.

We must not, however, conclude that all the mineral lands in the United States, subject to the governmental control, are governed by these statutes. In May, 1876, Congress passed a law by virtue of which the mineral lands of Western Minnesota, Wisconsin and Michigan were to be acquired from the United States government in the same manner as are agricultural lands. In

1883 another law was passed by Congress including Kansas, Wyoming and Alabama, and in 1891 another to include Oklahoma.

This leads to the question as to what lands are open to location as mineral lands. According to the revised statutes, section 2319: "All valuable mineral deposits in lands belonging to the United States, both surveyed and unsurveyed, are hereby declared to be free and open to exploration and purchase."

Three things are necessary for these lands to be open to location as mining ground:

1. They must contain valuable mineral deposits.

2. They must belong to the United States and must be a part of the public domain at the time of the location.

3. They must be unoccupied and unappropriated by others under a claim of right.

On the first point,—that the land must contain valuable minerals,—there have been several decisions relating to what is meant by a valuable mineral. The land office has decided that the following, if they occur in lodes or veins, are to be so classed:

"All the valuable metals, borax, diamonds, fine clay or kaolin, iron, roofing slate, limestone or marble, mica, gypsum, carbonate and nitrate of soda, sulphur, alum, asphalt and phosphate of lime.'' However, if they are not found in lodes or veins, they must be located as a placer claim. Stone that is good only for building purposes cannot be likewise located as a placer claim by a Land Office decision in 1892.

By a decision of the United States Court, Faxon v. Barnard in 1880, one in actual possession of mining ground who has discovered and uncovered the lode, but has failed to take the other steps required by law to complete his location, cannot be ousted by a subsequent discoverer from the ground actually held by him. A location cannot be extended over a senior discovery in the actual possession of another.

The next point that is to be considered in relation to the question is: Who may locate on a mining claim? In all the states and in the United States the one essential for location is United States citizenship. The one who locates must either be a citizen or have declared his intention of becoming one. This holds true in every case. Even if the locator is a corporation, the members must all be severally qualified to make a location; hence, if one of them is an alien, the location is void. However, an alien may hold a claim provided he has acquired it from a properly qualified locator. The alien's title must be secured by conveyance, but the law will not permit citizens who are mere agents of foreign corporations, or under contract to convey, to enter such claim.

An interesting feature in relation to this matter was developed in the North Noonday Mining Company v. Orient Mining Company. The case came up in the United States Courts in California in 1880. Aliens had performed all the necessary acts to make a valid location and did the work necessary to keep the claim good. They had then sold out to the Orient, which was a California corporation. The claims proved to be valuable and the other company, composed of United States citizens, relocated the claim and tried to prevent the others from working, on the ground that their title was not good. The court held that their title was good, for the corporation was a citizen of the state and since none of its members were aliens their title was good even if the location was made by aliens. It was also decided in the Federal Court in the case of the Crœsus Mining Company v. Colorado Mining Company (1884) that an alien, on declaring his intention of becoming a citizen, may have advantage of work previously done, and of a record previously made by him in locating a mining claim on the public mineral lands, provided no other rights have intervened. What he has done towards locating the claim accrued to him as of the date of the declaration of the intention.

If we turn to the laws of the various states we find that the same laws and interpretations hold good. In the case of the Garfield Mining and Milling Company v. Hanna, the Montana Supreme Court gave, in 1886, the following two important decisions:

First: The right to possession of a mining claim is derived only from a valid location; if there be no location there can be no right under it. An action to acquire title to a mining claim where the plaintiff's ownership and right of possession are put in issue, must show affirmatively that he has complied fully with all the requirements of the Act of Congress, and the local rules and regulations, relative to the location of mining claims, and has made therefore, a valid location.

Second: In the absence of evidence, locators will be presumed to be citizens or have declared their intention to become such. It has also been decided that corporations, minors, and women may make entry provided they fulfill all requirements under the law.

We now come to the following questions:

1. What constitutes a claim?

2. What are the requirements necessary to make a valid location?

Aside from agricultural lands, there are two sets of claims that are considered in relation to mining:

1. The placer claim.
2. The lode claim.

A placer deposit is one in which the metallic ore occurs more or less distributed throughout a stratum of rock material. According to the United States Laws and the laws of most of the mining states, a placer claim cannot exceed 160 acres, when possessed by an association of individuals. The association shall in no case be less than eight. No individual may possess more than twenty acres in any one claim. The acreage may be of any shape so that it conforms with the legal subdivisions of the country. A lode or vein deposit is one in which the metallic ore occurs in a more or less concentrated form between the walls of the surrounding rock. A lode or vein claim cannot exceed 1500 feet along the length of the vein, and 300 feet on either side of the vein. These two statements are apparently exceedingly simple on first glance, yet the opportunities for legal entanglements in the lode claims are very great.

We have now to consider the questions:

1. What steps are necessary to make a valid location?

2. How is a mining claim held?

According to the practice of the states and the United States the method of locating a claim after it is found is as follows:

1. The locator gives a name to his location.

2. He gives the names of the locators.

3. He gives the date of the location.

4. He lays out the boundaries of the location, clearly and distinctly.

5. Then within sixty or ninety days, varying with the requirements of the laws of the states (Montana, 60; Nevada, 90; Oregon, 90; and California, 60), he must file the record of his claim in the Recorder's office of the county court in which he has his location.

6. Finally he has his claim surveyed under the authority of the Surveyor General of the state or territory in which the claim is situated. The Surveyor is to show with accuracy the exterior surface boundaries of the claim. These boundaries are required to be distinctly marked by monuments in the ground. This survey will give the total area of the claim and the areas, if there are any, which are in conflict with the surrounding claims. Claims very frequently overlap each other. When such overlapping takes

place, the rule of law is that the senior valid location holds and is the claim of the locator.

The next step is the holding of the claim. To secure a mining claim one may do one of two things:

1. Buy the patent to the mineral claim outright, as is done by buying the land from the government; or

2. Do assessment work.

According to the law, a claim can be held from year to year by performing on the land $100 worth of work annually. If, however, one does not perform the $100 worth of work within the year, the claim is forfeited and is open to relocation, but this forfeiture does not take place until the year has expired and may be remedied by performing the work, provided no one has located on the claim before its performance.

There have been many decisions made on this question, two of which may be well to cite: In the case of the Mt. Diable M. & M. Co. v. Callison, 1879, C. C. D. Nevada, the decision is: "Work on a claim is work done anywhere within the lines upon the surface and anywhere within those lines below the surface where they are carried down vertically below the surface. Work done vertically below the surface within the lines of the claim upon a vein whose apex is on another claim also holds the claim. Work done outside of a claim for prospecting purposes or developing it, holds the claim. The owner of several contiguous claims may form one general system adapted and intended to work them all. In such a case work in furtherance of the system is work on all the claims." In the case of the North Noonday Mining Company v. Orient Mining Company, 1880, C. C. D. California, the decision is: "If the first locator resumes work at any time after the expiration of the year, before relocation takes place, the claim is his." The question over which more litigation has taken place than anything else in relation to mining is: What does the claim include? According to the United States laws, and the laws of all the mining states, exclusive of those whose lands are classed as agricultural lands, one may follow the dip of the lode as far as it goes provided he locates as he follows.

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