GOLD AND SILVER

COMPRISING

AN ECONOMIC HISTORY OF MINING IN THE UNITED STATES, THE GEOGRAPHICAL AND GEOLOGICAL OCCURRENCE OF THE PRECIOUS METALS, WITH THEIR MINERALOGICAL ASSOCIATIONS, HISTORY AND DESCRIPTION OF METHODS OF MINING AND EXTRACTION OF VALUES, AND A DETAILED DISCUSSION OF THE PRODUCTION OF GOLD AND SILVER IN THE WORLD AND THE UNITED STATES

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PREFACE.

THIS work has been prepared with aid received from the Carnegie Institution of Washington, and is to form a part of the Economic History of the United States, which is to be published by that Institution. Its publication in this form has been permitted through the courtesy of Hon. Carroll D. Wright, Chairman of the Department of Economics and Sociology, Carnegie Institution, and the work has been conducted under the supervision of Mr. Edward W. Parker, who is in charge of the division relating to the history of the mining industry. The preparation of this work has occupied two years, it having been begun in January, 1906, and completed in January, 1908.

The preparation of an economic history of the precious metals, gold and silver, involves the consideration of a number of subjects if the record is to be complete. Among the subjects discussed in this connection, which are indicated in the headings of the various chapters, are the occurrence, both geographical and geological, association, production of gravels and ores, and methods of mining and extraction of values. As the history of the precious metals, including the discoveries of deposits and the industrial activities resulting therefrom, is necessarily of prime importance in a work of this character, its treatment has been broad and it has been approached from practically every side. In the chapter of the history of the precious metals a detailed account is given of the discovery of occurrences of metals and ores throughout the United States, the period covered extending from the earliest known records, including legends, up to the present time. This account has further been supplemented by a tabulated list of first discoveries, by whom and when made, and finally an extended chronology of the economic history of gold and silver mining is given.

Reference to the theory of ore-deposits has of necessity been brief, but is presented in a manner as to best prepare the reader for the information immediately following.

In the treatment of the geographical and geological occurrence of the precious metals an attempt has been made to condense the more important and valuable data regarding the occurrence in the various states and districts and supplement the facts given with references, thus enabling the reader to extend his information by application to the original sources.

The discussion of methods of prospecting, developing and working mineral, and especially gold and silver deposits, has been entered into in considerable detail, with many references to actual operations as obtained from the technical press. In like manner the milling and metallurgical processes have been outlined and elaborated upon with extracts from reliable authorities. Further, the historical development of mining, milling and metallurgy has been outlined at length.

The discussion of the production of the precious metals in the United States has been given in detail, being considered as a whole, with the various other producing countries and by individual states. Much tabulated data is also given which often correlates production with other operations and events.

Throughout the entire work constant and conscientious reference has been made to the various authorities quoted and referred to, and it is to all, but especially those not directly referred to by name in the text, that due acknowledgements are herewith made. Without the information obtainable from technical literature which is voluminous, and much of permanent value, this work would not have been possible, especially in the time available for its preparation.

. . . .

The object of this work with others of a series is to give a complete and accurate record of the development of the mineral resources of the country and its influence on the various industrial activities throughout the United States.

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CONTENTS.

CHAPTER I.

PRECIOUS METAL MINING — A FACTOR IN THE INDUSTRIAL GROWTH OF THE UNITED STATES.

CHAPTER II.

AN HISTORICAL ACCOUNT OF THE DISCOVERY OF GOLD AND SILVER.

CHAPTER III.

OCCURRENCE AND ASSOCIATION OF GOLD AND SILVER.

CHAPTER IV.

GEOLOGICAL DISTRIBUTION OF GOLD AND SILVER.

CHAPTER V.

MINING GOLD AND SILVER ORES AND GRAVELS.

CHAPTER VI.

EXTRACTION OF VALUES.

CHAPTER VII.

PRODUCTION OF GOLD AND SILVER.

APPENDIX OF TABLES.

LIST OF ILLUSTRATIONS.

ABBREVIATIONS.

Eng. and Min. Jour. — Engineering and Mining Journal.
Min. and Sci. Press. — Mining and Scientific Press.
Repts. and Bulls., U. S. G. S. — Reports and Bulletins, United States Geological Survey.
T. A. I. M. E. — Transactions American Institute Mining Engineers.
Am. Jour. Min. — American Journal of Mining.
Inst. Min. and Met. — Institution of Mining and Metallurgy.
Coll. Eng. and Metal Miner. — Colliery Engineer and Metal Miner.
Fed. Inst. Min. Engrs. — Federated Institute Mining Engineers.
Trans. Inst. Min. Engrs.— Transactions Institution of Mining Engineers (London).
Trans. Lake Sup. Inst. Min. Engrs. — Transactions Lake Superior Institute Mining Engineers.
Trans. Wis. Acad. Sci. Arts and Letters.— Transactions Wisconsin Academy of Science, Arts and Letters.
Am. Jour. Sci. — American Journal of Science.
Jour. Can. Min. Inst. — Journal Canadian Mining Institute.

GOLD AND SILVER.

CHAPTER I.

PRECIOUS METAL MINING. A FACTOR IN THE INDUSTRIAL GROWTH OF THE UNITED STATES.

Precious metal mining in North America had its beginnings in the southern portions of the vast area extending from the Tropics to the frozen fastnesses of the Frigid Zone. These beginnings, though small, rapidly grew to great importance, and were directly responsible for the colonization and development of the territory farther north. The subsequent history of the territory lying now within the borders of the United States, is but an account of a series of brilliant advances in the development of the resources of the country, and among the factors which have contributed in large part to the advancement made none stands out more prominently than does the mining industry.

Although this work has to do with precious metal mining only, yet we may be pardoned if, in this connection, occasional reference is made to the mining industry as a whole.

Civilization. — In the deliberations of our government concerning the purchase or annexation of new territory the fact that it contained valuable mineral deposits was always a potent factor in hastening or closing the negotiations. This was the case in regard to the Louisiana Purchase and particularly so with regard to the annexation of California. And, in fact, so well understood is the principle of internal wealth, especially in the form of mineral resources, that all nations seek to acquire territory rich in mines of metals and fossil fuels. Further, no nation has made material advance in civilization without such mines, while by some authorities this claim has been narrowed down to include mines of the precious metals only.

Reference may be made to Persia, Egypt, Greece and Italy, all of which prospered in proportion as they owned or controlled the products of gold and silver mines. With regard to Greece, Xenophon stated that she got her gold and silver from Thrace. Rome in the days of her prosperity worked with her soldiers and slaves the mines of Italy and Spain.

Those nations that have learned to mine and work the metals so derived have invariably become both rich and powerful and have subdued their neighbors either by force of arms or industrial activity. The mining industry is indeed the foundation of all civilization and the basis upon which all industries must rest, being at the same time the principal element in progress.

It may be said, in general, that the history of the mining industry of a country is the history of the state of civilization at the time. That nation that has the greatest output, or can control the production of the precious metal, and combines with that advantage an intelligent policy, would be a potent factor in shaping the affairs of the world's community.

It has been remarked that money is as essential to civilization as is language, for by language thought is exchanged, while by money commodities are exchanged which are directly the fruits of labor, such interchange being essential to civilization.

Iron and steel have been called the mainspring of modern civilization; gold and silver may then be likened unto the balance wheel by which the movement of our industrial activity is regulated and maintained without serious disturbance.

Following the discovery of the New World, the wealth of Mexico and South America was diverted to the treasuries of Europe. With the great increase in circulation of money a new civilization sprung up, which was created by and was dependent upon this money — modern civilization dates its origin from this time. For some 300 years (1500–1800) the wealth of the New World maintained these conditions in Europe, then the supply suddenly ceased owing to the Spanish-American wars, and a money famine resulted. The discoveries of gold in California and Australia soon followed, however, and the stream of gold soon reached and passed the high mark previously attained, with a consequent still further expansion of trade and commerce.

Wherever the prospector leads, civilization follows as a natural result. His achievements are seldom adequately rewarded, much less his importance as a civilizing agency recognized. California, practically unknown in '48, is now in the front rank of the States of the Union both in population and wealth. It is true that a considerable emigration from the Western States had set in toward the Pacific coast as early as 1846, which in the course of time would have materially increased the population of this western country. Further, of these early pioneers the majority were homeseekers, while of those who entered the country during the twenty years following the discovery of gold the larger part was transients, and as was subsequently shown only ten per cent remained permanently.

Of the 90 per cent of those who went to California as a result of the gold excitement, there were many undesirable individuals, many, in fact, who were wanted for misdemeanors in the States and other lands. It is not strange then that lawlessness, crime, and a generally low standard of morality developed, and so general is this condition of affairs in new mining districts that it has led some one to remark that, " Gold as a promoter of good morals and solid progress has been found wanting." But such conditions only mark the stages in the growth of a country; perfection cannot be reached at once, but is attained only through long and strenuous endeavor, often with an occasional dark day and dark deed interspersed between.

The transition from an older to a newer civilization is well illustrated by the events following the discovery of gold in California, when the old Spanish landlords were ruthlessly deposed and expatriated by the throngs of adventurers drawn thither by the lure of a new country, with its charm of freedom and unlimited wealth. The following sketch may serve to give an idea of the condition of affairs existing at that time: "The old ranch-house, a great quadrangle of abode, built around a courtyard, the seat of a little empire of thirty square leagues of land, much of it the very best in Southern California. The great walls, nearly a yard thick, hint strongly of cool days in summer and warm nights in winter. The long massive beams, cut in the mountains thirty miles away; the rafters lashed with raw-hide instead of being nailed; the old red tiles made by the Mission Indians and held in place by their own weight — all speak of the difficulties of building in those days. Yet the whole is massive and strong and will stand for many years to come when far more costly structures are decayed. Here still, as in bygone days, may be heard the whizz of the riata thrown by the skillful hand, for there yet linger a very few of that most extinct race, the old vaqueros of California — men who could, single-handed, ride down, lasso and bind the wild bulls of the hills on a mountain side where a city rider would hardly dare to lead a horse.

"Rude was their system of justice; but they had no probate courts or public administrators. They had no doctors or lawyers; but then they died without expensive assistance, and their families got at least one per cent of the property they left. Living in true patriarchal style, surrounded by plenty of the solid necessaries of life, with plenty of servants that cost only their board, with nothing to do but look after their herds, roll *cigaritas*, attend *fandangos* and *meriendas*, and warble their beautiful language, they drifted down the stream of time without touching oar or rudder, or striking sand-bars or snags. That soft

Arcadian day is gone. Its twilight still lingers in a few places, but its sun has set forever. Our countrymen came and were welcomed, for, contrary to the common belief, the majority of Californians were anxious for the change. We came with our usual Yankee conceit, and our prejudice against everything that comported not with our notions of 'progress'—all strengthened by the prejudice against Mexicans imbibed during the war with them. We came to load them with ruinous costs and atrocious lawyers' fees to maintain those vested rights of property which all nations respect, to squat on their ranches and live on their cattle; to pass laws to destroy their only industry, and as time has proved, the best industry of this southern country. We came to lend them money at five per cent a month, and trap them into contracts to pay it for a long enough time to sweep away their homes with the mortgage. We came to turn up the parvenu proboscis at Indian-bred and Castilian-bred alike, and treated as 'greasers' some who were our equals in every respect, and the superior of many of the upstart Americans who sneered at them," etc., etc. Min. and Sci. Press, Vol. 46, p. 402.

What kind of a language would have resulted from a natural mingling of the different races on the Pacific coast had not gold been discovered, is a question well worth consideration. It would probably have been a mixture of pure Castilian and the Indo-Spaniard with the Western pioneer, the Kanak, the Mongolian and the Mormon. Social and educational standards would have been low, while industrial progress would have been backward and lacking in the enterprise which is distinctively American. However, fortunately, such conditions did not obtain, owing to the flood of well-educated people from the Eastern States, who gave shape and direction to public affairs and impressed American ideas on the institutions of the country.

This is an old story which has been retold many times, although with a new setting of localities and a new coloring of various peoples. In the Northwest, Oregon and British Columbia in particular, there developed a trade lingo established between the Hudson Bay Fur Company and the aborigines which was known as the "Chinook jargon." The Chinook language was spreading rapidly, but was checked and almost wholly wiped out by the influx of more educated people drawn thither by the discovery of gold.[1]

It can be claimed for mining that, however rapidly the Star of Empire might have made its way westward, it certainly would have been many years before its light would have reached the coast of California.

From California the pioneers passed to the north and eastward,

[1] Min. and Sci. Press, Vol. 54, p. 124.

penetrating the territories of Washington, Oregon, Montana, Nevada, Utah, Arizona and New Mexico, thus developing them and opening up avenues of trade and sending out a stream of gold and silver, which increased the wealth and importance of the United States as a whole and placed it among the powers of the world.

Abroad, similar changes have resulted from the discovery of gold and silver mines, as, for instance, in Australia and South Africa: in the former case a convict colony has risen to a magnificent colonial possession of Great Britain; in the latter case there was a country misunderstood and misruled, and a constant source of inconvenience and annoyance to the Colonial office, but with the discovery of diamonds and gold there came a tide of emigration which well-nigh submerged the Griqua, the Hottentots, and the Dutch Boers. Social and political conditions were soon adjusted, however, and the rights of all were respected.

The story of the momentous results in the world's history, and in the territorial changes, traceable directly to the discoveries and search for precious metals and stones, was outlined in an interesting lecture by Mr. G. F. Kunz, before the Franklin Institute.[1]

Agriculture. — The first effect upon those resident in California, as well as the new arrivals, was to abandon all and engage in mining, but the hardships encountered, together with the uncertainty of adequate remuneration for work done, soon discouraged many. The work having lost its charm thousands turned to the tilling of the soil and cattle raising; thus did California gain wealth other than from her mineral resources.

The narrow strip of country comprising the State of California, has, through the influence of the mines, probably developed more agricultural land throughout the United States than has been developed by other means. It was not only the people of the States that were scattered over the great expanse of country between the Atlantic and Pacific Oceans, but thousands of emigrants from the Old World who came and made their homes in the West. Even at the present day only a relatively small part of the tillable land of the United States is under a proper state of cultivation; vast regions remain untouched, and as there cannot be successful agriculture or any form of business without gold and silver, so long as they are the measure of all credit, the development of the mines is absolutely necessary.

"Wonderful as are the advances in crop raising during the past

[1] Mines and Minerals, Vol. 18, p. 14.

decade, the soil surveyors declare that only 420,000,000 acres — not one-half the farms of the country — can be classed as improved land, and but one-third, or about 290,000,000 acres, is fruitful."[1]

An anomalous state of affairs resulted when agriculture, which had been created and maintained by the mining industry, caused the overthrow of one of the most important branches of that industry, namely, hydraulic mining. Through the contention by the agricultural and grazing interests that hydraulic mining was a nuisance and must be abated, the courts issued a perpetual injunction against its continuance.

Dredging has also come in for its share of blame for the destruction of agricultural and grazing land, and were it not for the fact that the area of ground to which dredging is applicable is much more limited than that to which hydraulic mining is applicable, it would probably in time go the way of the latter. The following statement of the facts is of interest: The agriculturist is looking for soil, and while it is understood that a thin layer of virgin soil underlain by a deep and porous gravel bed will produce for a few seasons, yet without due fertilization annually thereafter it cannot remain a permanent agricultural proposition. The land therefore must be considered from a standpoint of its greatest value, and that it will be so considered there is no doubt, as neither mining nor agriculture is undertaken at the present time for sentimental reasons. On a cold, hard basis of facts and figures it will be found that not over five per cent of the limited acreage of dredging ground in this state (California) was orchard, vineyard, or planted ground. A large portion of it was uncultivated bottom land which afforded a somewhat precarious pasturage at some seasons of the year, and a further large portion was the partially overgrown piles of tailings left by the hand workers of the days since '49.[2]

Transportation. — Owing to the great increase in the production of gold which occurred during the middle of the last century a great impetus was given to commerce. A very material rise in price of certain articles, especially those required in the mining regions of California and Australia, was the immediate effect; and further, what was ultimately to be of great importance was a demand for means of transporting such supplies, together with the miners and traders passing to and from these gold fields. A still further and subsequent effect was the disturbance in relative values of

[1] New York Times, Nov. 30, 1907.

[2] California Miners' Association Annual, 1906, p. 103.

products, gold being the recognized standard of value. High prices resulted, thus stimulating production and creating new markets for exchange with new and enlarged facilities for effecting them. These requirements were soon and quite completely met in the establishment of steam communications between the Atlantic and Pacific coasts, via New Grenada. A mere outline of the events of the approximately twenty years following this new and urgent demand upon American commerce is sufficient to show the far-reaching effect of gold mining in California: steamship lines were organized to connect New York with the Pacific coast; a railway was built across the Isthmus of Darien; a new city was founded on the Pacific coast; a submarine cable was constructed across the Atlantic Ocean; a railway was built through the Rocky Mountains; and finally, direct steam communications were established between the United States and the Far East — Japan, China and the East Indies.

Gibbons regarded the Romans as the most remarkable road builders of the world, but the people of California had in fifty years done more road building within the confines of their state, than had the Romans in their entire empire in fully ten centuries. As the Westminster Review states, " they made their country first the treasury and then the garden of the world."

The remarkable development of Alaskan resources is almost wholly due to the improved facilities in transportation by water, rail and wagon road, and the same is true of many other localities. The development of Montana is directly due to the mines, which have caused railways to be built and then maintained them.

As transportation facilities are increased by the requirements of the mining industry, so in like manner are mining districts directly benefited by the opening up of railway communications, thus creating a market for the products of the mines and often, as in the case of the establishment of smelters in a district, bringing the market to their very doors.

As has been pointed out, the isolation of San Francisco resulted in the building of the Pacific railway; in like manner the isolation of the Ballarat gold fields of Australia from the coast, resulted in the building of a railway from Melbourne to the mines. The Lulea-Gellivare railway was built for the purpose of transporting iron ore from the Gellivare mines, Sweden, to the seaport at Lulea. This road bears the distinction of being the first railway to penetrate the Frigid Zone, lying as it does above the Arctic Circle. However, the finding of the sea-way from Europe to the East Indies and the discovery of America, with the ultimate discovery of the gold and silver mines, have resulted disastrously to the mining industry of many of the countries of Europe. Further, the rapid extension of the railway systems of the West is largely due to the ore traffic, and by the enlarged facilities for transportation the producers of remote districts can market their mineral products, while the smelters can draw from a wide range of territory for ore, fuel and flux.

The following reported extracts are taken from an address by Dr. James Douglas regarding the Relations of Railway Transportation to Mining and Metallurgy:[1]

"Starting from the period (about 1830) of the first railways in England and the United States, large enough to be commercial factors, Dr. Douglas traced the growth of the railway and the increase of tonnage of iron ores smelted. Thus the stimulus given to the iron trade in England in 1830–40, by the construction of 3000 miles of railroad, raised the production of pig iron from 677,417 tons to 1,396,400 tons in 1840. She mined about 50,000 tons of coal, made 11,500 tons of copper, about 58,000 tons of lead, and 4400 tons of tin. Since then her railroad mileage has increased to 22,700, her production of pig iron to 9,000,000 tons; her lead production, however, has declined to 20,000 tons, and her production of copper has become a negligible quantity; her tin production has not increased.

"Meanwhile our production of pig iron has risen to 22,822,380 tons (from 135,040 tons in 1830); our coal, from 209,000 tons in 1830 to 314,562,880 tons; copper from nothing to 462,000 tons; and our lead from 10,000 tons in 1830, to 322,886 tons. These results have been in keeping with and dependent on the growth of the railroads. The early railroads were laid with 'strap rails;' T-rails were not rolled in this country till 1844.

"Pennsylvania early held the chief place in smelting by reason of her home supply of ore and coke. Yet to-day, by reason of railroad facilities in bringing ore from the Northwest, she is independent of local ore. In 1904, Pennsylvania furnaces made 7,644,321 tons of pig iron; yet her own mines turned out only 397,107 tons of iron ore. Herein lies the potency of transportation. Pittsburg possesses coal and coke; Michigan and Minnesota have the largest, finest, and (considering their quality) the most cheaply mined ores in the country. It is, at present, cheaper to bring the ore to the fuel (and to the people who buy and consume the iron), than to take the fuel to the ore and carry back most of the finished product.

[1] Eng. and Min. Jour., Vol. 81, p. 1247.

"The revolution in the last half-century in the iron branch of metallurgy has been brought about by the railroad and the steamboat. Of the 50 million tons of iron ore treated in this country last year, 34,353,456 tons came from the Lake Superior district.

"Among the strange contradictions is the persistency with which the copper-and-brass trade has adhered to the Naugatuck Valley in Connecticut. Some of our large iron works are now also in ill-suited conditions; but they were originally started near small iron deposits which are now exhausted.

"But it is not only in the iron trade that low rates of carriage have helped the metallurgist. Montana copper largely draws her coke from Pennsylvania, or from ovens on Lake Superior fed with Pennsylvania coal. The Copper Queen, after depending on coke at exorbitant rates, now brings it at one-third the cost from northern New Mexico, though over a haul of from eight hundred to a thousand miles, and uses oil from Texas and California brought in at a rate not exceeding three-quarter cents per ton per mile.

"The interdependence of mines and railroads is also shown in the mines of Butte which largely send their ore to Anaconda (26 miles at 14 cents per ton); or to Great Falls (170 miles) where advantage is taken of water power. Another instance is the shipment of copper-matte from Tennessee to the heart of Mexico, where it has been used to collect gold and silver from 'dry ores,' the black copper being returned to the United States for refining and separation of the gold-and-silver content. Again, the Globe district, Arizona, languished for want of sulphur- and iron-flux; but the railroads issued a tariff which brought in pyrite from distant districts. As a result, the production rose rapidly to three million pounds of copper per month."

Dr. Douglas commented also on the wasteful consumption of our supplies incidental to our great railroad development. He said: "But vast as our resources are, they are not inexhaustible. Mr. Carnegie, in his St. Andrew's address, assigned to our own iron deposits a life of 60 years, while Professor Shaler, in his book on the 'Earth and Man,' reduces that span to 50 years. Our anthracite is a rapidly vanishing quantity, and, vast as are our bituminous coal fields, they will not last forever. And we are using nature's resources with most wasteful prodigality. We are saving only 60 per cent of our anthracite, burning away the by-product of 90 per cent of all our coke ovens, and cutting down our vast forests without replanting. In fact, except in the Northwest, our timber resources are almost exhausted, and we are borrowing largely from Canada and from abroad. And we shall sooner or later have to borrow more than timber. When we reach that stage we will make less money, which will be far from an evil, for it may oblige us to replace some of our pelf with humility and meekness of spirit.

"'As our resources fail, however, we shall not lack for raw material, as long as the world's supply lasts, for transportation charges by land and water will grow steadily less, and we cannot but believe that many of the selfish barriers which now separate nations commercially will be swept away by the spread of saner notions on political economy, and more unselfish international relations.'"

The development of the iron mines of the Lake Superior region has created a lake marine service which is shared in like measure by the grain, lumber and fuel industries.

The tremendous advantage of the development of a mineral or fuel industry, as for instance the oil industry at Bakersfield, California, to the transportation companies and manufacturing interests of the state, is shown by the following figures: Prior to the discovery of oil it required 30 tons of coal to move a train from Bakersfield to San Francisco, which at $4.375 per ton plus $25 for labor amounted to $150. With oil at 20 cents a barrel, and three barrels equal to a ton of coal, the cost per ton rate is 60 cents, and counting 100 barrels of oil equivalent to 30 tons of coal, the cost would be $20 as against $125 formerly required to move a train of cars. With labor counted in, the costs before and since the discovery of oil are $150 and $45.[1]

As transportation facilities are increased by the requirements of the mining industry, so in like manner are mining districts directly benefited by the opening up of railway communications, thus creating a market for the products of the mines, and often, as in the case of the establishment of smelters in a district, bringing the market to their very doors.

Labor. — As a rule every actual producer in the world is, by choice or necessity, forced to support by his labor a number of non-producers, the number varying somewhat with the country and occupation. This condition of affairs is well illustrated by labor in mining camps, where the usual number of non-producers, two or three, is often increased to four and five. After the first excitement has worn off and the camp has settled down to hard work, there are

[1] California Miners' Association Annual, 1906, p. 94.

comparatively few non-producers, but as it grows and becomes prosperous and the future of the camp becomes assured, the population increases rapidly until there are from four to five times as many people living in the camp as there are miners, who are the real producers. In time there may come a decadence owing to a falling off in production of the mines or a decrease in the market value of the metal mined, then the superfluous population begins to drain off, and finally only the miners remain. Further, it is almost invariably the case, that that portion of the population which comes and goes with the prosperity of a camp carries with it when it goes the miners' money, while the miners who earned and spent it are without any.[1]

In the early days of mining in the Western States, say during the twenty years following the discovery of gold in California, the number of dead and abandoned towns and hamlets could be numbered by the hundreds. This was especially true of the towns that sprang up in placer mining districts, but was by no means confined to them. Many of such were boom towns that failed to boom, but for the failure of which mining has been blamed. Others served their purpose and with the exhaustion of the mines died a natural death. Still others were forced to yield up their site owing to the greed of man for gold, the values underlying the property far exceeding the value of the real estate and the buildings combined, while still others were devastated by fire and water, the latter, especially, resulting from the filling of the river channels by mining débris.

The following extract is taken from an address by N. P. Hulst:[2]

" One of the most conspicuous of the results flowing from this activity in mining, which began in the Far West, was the impulse given to the effort, which has extended to all industries, to so improve all mechanical devices that manual labor would be minimized. In this region where only the search for wealth, sudden wealth, was the inspiring motive of the population, each man was his own employer to a large degree. In consequence labor was scarce and high priced. Necessity is ever the mother of invention, and the great want of the region — a full supply of labor — together with a thirst for wealth, pressed hard as incentives to obtain a substitute for the one, and also to secure the other, by labor-saving devices. No wonder that the search was active, was incessant, in all directions. No wonder largeness of operations captivated the venturesome in search of

[1] Min. and Sci. Press, Vol. 42, p. 88

[2] Trans. Lake Superior Min. Inst., 1894, pp. 17, 18.

wealth, when the every-day, familiar object lesson of hydraulic mining taught that ample profits depended quite as much, if not more, upon the magnitude of the work than upon the richness of the material subjected to the work. Into this whirl of the mining fever men of all kinds of occupations had been drawn. Of the conventional, traditional miner there were not enough of them to go round in the places to be filled by skill. It was a free for all in the race for wealth, in which the mechanic, the tradesman, the farmer, men of all trades and professions, took a hand at mining. Throughout this multitude of workers there was an almost utter ignorance of the ruts of the profession or art of mining as taught in the foreign schools, the only schools, so that each started out with fresh ideas for the work in hand and worked along new lines. The continued friction of so much fresh, energetic thought, in no great time brought about almost a revolution in all mining work, as well as in its implements and accessories.

" The steam hammer suggested the steam stamp to Wilson and Ball, and they were quickly adopted in the Lake Superior copper region.

" By skillful improvements they have been increased in efficiency until from a few tons per day they are now capable of crushing several hundred tons per day in regular work in that length of time.

" The machine drill was another offspring of the steam hammer. Its great assistance to the miner has quite revolutionized his work. The Blake crusher, originally devised for crushing rock to make New England macadam roads, was quickly seized upon by the gold miners, as a *sine qua non*, for their mills. At the hard iron ore mines of the Lake Superior region, since the soft ore miners are having their innings with the furnace men, Blake crushers of enormous size have been installed, in order to reduce the hard iron ore to small pieces so that it may be as acceptable to the furnace men as the soft ores."

Finance. — The effect of gold and silver mining is to create new wealth or purchasing power, and is the direct acting means of opening up new avenues of industry and trade, which, but for it, would not be known or required. It has the same effect on the finance, trade and commerce of the world as steam has on locomotion. Trade and commerce being merely exchange of commodities between the several sections of the community, as also between different countries, do not create new wealth, but merely concentrate existing wealth, i.e., finance, trade and commerce do not add to the stock of bullion; the wealth made by it is the enhancement of the value of properties and merchandise, and the extension of credit and paper currency on the business done. All the trade of London or New York will not add one ounce of gold to the currency or actual capital of the world's wealth. Any party of miners producing any given quantity of new gold from the earth does more real good to the community than do the business transactions of any similar body of men engaged in any other occupation, because the gold so raised by the miners becomes an immediate addition to the working capital of the country, or community, by affording additional means of extending the credit and securing its liabilities. Thus any given quantity of gold raised is not only so much more money in immediate circulation, but it is also the basis from which radiates additional capital, in the shape of credit or paper currency, that is issued and recognized as money on the basis of gold. The continuous production of gold has become a necessity to the requirements of monetary institutions, by whose aid trade and commerce have extended to such a wonderful extent. Although the production of gold during the thirty years prior to 1881 was of vast proportions, its influence was extended by means of credit and confidence in its security, by almost arithmetical proportion. No figures or calculations can estimate the real advantages that have been gained by its dissemination throughout the channels of trade and commerce. Its results have been to raise the value of commodities, labor, materials, land, houses and other properties. It has given an immense impetus to all trades, manufactures, arts, sciences, and learning. There is danger, however, that should the production of gold fall off materially the credit based on the large supply of new gold would be seriously affected and business would receive a pronounced setback.

According to Gibbon, the decline of Roman wealth began even before the incursions of the barbarians. The administration of the Roman emperors may have been one cause of the amazing desolation which had become so obvious after the footsteps of the barbarians had been seen in Italy; but another cause had been operating, which, from its almost imperceptible progress, may have equally escaped the observation of the government and the notice of historians of their deeds. While the production of the precious metals from the mines had ceased, and the countries near the mines had poured the whole, or the greater part of their long accumulating treasures into the universal empire, there would be a consumption, a decay of the quantity of gold and silver in constant progress, which, by lowering the metallic price of all other commodities, would check that industry by which alone any country can continue to prosper. Gibbon's Rome, and the History of Gold and Silver, Comstock, 1849, p. 72.

The production of gold might be decreased by causes outside the direct curtailment of gold-mining operations, such as, for instance, a falling off in the production of copper and other miscellaneous smelting ores, also from a reduction in the price of copper and silver.[1]

However, over-production has its drawbacks as well, as was shown in the case of the gold-mining booms of California, Australia and Russia. Both labor and capital were attracted to these districts from all over the world and the yield became so great that the purchasing power of gold declined from 9 to 15 per cent according to Jevons, which was the direct cause of Holland adopting the single silver standard and other countries bimetallism.[2]

No attempt is made to enter into a discussion of the mining risk. It is true that much money has been squandered on mining enterprises, even when the element of speculation is eliminated, and it is commonly remarked that more money has been spent in mining than has been made. This may be true of certain districts, but by no means of all or a majority even. Even in California as late as 1880 mining had paid 18 per cent on the money invested, and that, too, in spite of inexperienced, impractical and unscientific work and in a variety of mines. Further, besides this return, mining had built up and peopled a great state and had created industries for both city and country.[3]

Science. — " In a general way mining has done much for science. It has stimulated men of all modern time to strive more earnestly to solve the problems which relate to the character and structure of the earth's crust and the forces which have produced these structures. And in turn, science has done much for mining. During the past 100 years, the geologists in all civilized countries have labored in season and out of season, trying to unravel the problems relating to the earth's structure, and they have helped greatly in reaching an intelligent understanding of many of these structures in their relation to the extent, nature, and origin of ore deposits. This has been carried so far by the geologist and mining engineer, that

[1] T. A. I. M. E., Vol. 33, p. 828.
[2] Mineral Industry, Vol. 3, p. 304.
[3] Eng. and Min. Jour., Vol. 40, p. 306.

these experts can to-day do much toward indicating in advance the entire absence of certain great classes of mineral deposits from large portions of the earth's crust; and, in the regions where these mineral deposits do occur, they can, with the aid of a limited amount of exploitation, go far toward determining the extent and nature and value of many of these deposits.

"The chemist, also, has made most valuable contributions to the mining development in the study of the character and composition of the various ores and minerals, thus making known more generally and by more accurate methods the extent and richness of the ore deposits. The chemist has, furthermore, coöperated with the metallurgist in discovering, from time to time, new and cheaper methods for the treatment of these ores. The chemist and metallurgist have also done much, at times, to stimulate mining, by discovering new uses for different metals and other mineral products — discoveries which made not only possible, but profitable, mining operations which previously could not be successfully prosecuted.

"The latest of the great contributions from science has been in connection with the modern development of electricity. The electrical engineers have of late made most important contributions to the mining industry, especially in the arid and semiarid regions, by the development of isolated water powers, transmitting this power many miles for the purpose of operating mining machinery; and now the electrical furnace and other electro-metallurgical processes are doing much toward making possible the reduction of many ores and the refining of many metals. Furthermore, the electric furnace is to-day manufacturing graphite and other materials which are being used in the lining of metallurgical furnaces."

Mining Schools. — "Until during the last few decades the mining school exerted but little influence in the development of mining interests of this and other countries. Indeed, most of the mining in the world has been done by men who picked up their information in the field, in the gulch, and on the mountain side, and the average intelligence and aptness of the American miner has been such that he has gained a vast amount of practical information in this way. But, from time to time during the past several decades, the young mining engineers who have gone out from the Columbia School of Mines and other later institutions, have taken to the pick and the shovel and the drill, and have worked their way up and made their influence felt in the development of American mining. More recently other mining schools have been established in this country, especially by the Western States, as here in Montana, Colorado, Michigan, South Dakota, New Mexico, Arizona, Missouri, and others; and mining departments have been established at several of the State universities, as in Wyoming, Idaho, Washington, California, Texas, North Carolina, Virginia, and others. These various mining schools and departments are now annually turning out a number of young men who are trained in the theory of mining and metallurgy, and these also are going into the field, and are taking up the pick and the shovel and the drill, making themselves masters of their profession. In the future these will become more and more an important factor in stimulating mining developments."[1]

Our large mines have proven to be veritable mining schools; for instance, the Comstock mines have furnished every country with superintendents. In times past the mines of Mexico, South America, Alaska, Australia, Africa, India, China, and Japan have drawn their leading mining men from that source, and the foremen and assistants were not loath to go as promotion was slow in the mines of the Comstock lode.

Looking back over the history of the United States as well as that of every other country, and especially those in which material prosperity has made rapid and brilliant progress, it is evident that there is much that is wanting which has been pointed out by another in eminently fitting words:[2]

" But let us conceal from ourselves the fact that mere growth in wealth, mere development in industry, mere increase in population, are not the best evidences of national greatness; and unless our progress in art, learning, morals, and religion keep pace with our material growth we have cause rather of humiliation than for glorification."

" Whatsoever things are true, whatsoever things are honest, whatsoever things are just, whatsoever things are pure, whatsoever things are lovely, whatsoever things are of good report " constitute the real glory of a nation, without which the magnificent national structure which in a century we have reared, will disappear " like the baseless fabric of a vision."

Development of Mining. — Prior to the discovery of gold in California in 1849 gold mining in the United States was confined largely to Southern States, as Virginia, North Carolina, South Carolina, Georgia and Alabama. The last half of the nineteenth century

[1] Mines and Minerals, Dec., 1902, p. 220.
[2] T. A. I. M. E., Vol. 5, p. 173.

witnessed the growth of a great gold and silver mining industry in the Western States; an iron industry of stupendous proportions in the Lake Superior region; lead and zinc in the Mississippi Valley; while coal is found in large quantities in almost every section of the country.

"The greater development of our mining interests, like the greater development of the country itself, has taken place during the past few decades. This is shown by the fact that the total value of the mineral products of this country has grown from about $370,000,000 in 1880, to more than $600,000,000 in 1890, and to more than $1,000,000,000 in 1900. This means that while the United States is expanding over the surface of the earth it is also expanding underground; it is producing the gold with which to purchase the other countries as they are offered for sale."

"Copper now ranks second in the value of its product, the more important metals ranging in 1900 as follows: Pig iron, $260,000,000; copper, $98,500,000; gold, $79,000,000; silver, $74,500,000; lead, $23,560,000; and zinc, $10,650,000."[1]

The following summary of the yield of the various mineral products as late as 1897, gives an idea of the growth of the mining industry and the development of the country.[2]

"If we fail in an appreciation of the extent of the mining industry we are equally at fault in recognizing the influence which it exerts upon our development. The utilization of 150,000,000 to 175,000,000 long tons of coal annually, won from American mines, for industrial and household purposes, may, perhaps, be approximately gauged; or we may measure the advance in wealth due to the exploitations of the minerals each year to produce 55,000,000 to 60,000,000 ounces of silver, 2,000,000 to 2,250,000 ounces of gold, 350,000,000 to 400,000,000 pounds of copper, 170,000 short tons of lead, 90,000 short tons of zinc, quicksilver to the amount of 36,000 flasks, more than 500,000 to 1,000,000 pounds of aluminum, 53,000,000 barrels of petroleum, 8,000,000 to 9,000,000 barrels of cement, 11,500,000 to 13,500,000 barrels of salt, clays valued at $10,000,000, $35,000,000 worth of building stone, $13,000,000 worth of natural gas, 12,000,000 to 14,000,000 pounds of borax, 15,000,000 to 16,000,000 tons of iron ore, etc. But even this array of figures does not convey a just idea of conditions, and few truly realize what has been and what is being done by the mining industry to advance our nation."

[1] Mines and Minerals, Vol. 23, p. 219.
[2] Colliery Engineer, Vol. 18, p. 13.

The growth of the mining industry has been of direct benefit to the manufacturers of machinery and, in fact, all commodities, although the manufacturing of mining machinery is in itself one of the large industries of the country. Taking dredging machinery alone: It is claimed that in California, in 1906, more machinery was purchased in weight and cost of manufacture (by that industry) than any other mining industry.[1]

In a paper entitled, "The Relation of the Mining Law of the United States to the Development of Its Mineral Resources," Dr. R. W. Raymond makes the following statements:[2] "Enough has been written, perhaps, concerning the curious, haphazard origin of our unique mining law and the innumerable disputes which its eccentric, vague, inconsistent and ill-considered provisions entail upon mine-owners — though, perhaps, all these things will need to be reiterated again and again before they will be realized by all parties whose coöperation is necessary to a radical reform.

"Enough has been written likewise, perhaps, concerning the object lesson presented at this time by the mining districts of the world, including the greater part of the mining industry of this country, in which mining litigation (in the sense of disputes over the boundaries of mining rights, otherwise held by perfect title) is unknown, while in certain of our States and Territories such litigation burdens the courts, oppresses the owners and operators of mines, and enriches only lawyers and experts. This lesson also may need to be enforced hereafter by repeated exposition; but only because of the slowness of the pupils who should have learned it long ago.

"The full development of the mineral resources of the West will never come to pass until the capital it requires is better protected by definiteness in title and boundaries of mining property. And that cannot be done, in my judgment, by any amendment of the present law which shall leave in it the present abnormal, irregular, indefinable, precarious and mischievous 'extra-lateral right.'"

The causes of failure in mining are many and varied, varying somewhat with each locality and material produced. The principal causes of failure are probably: lack of proper foresight in the development and equipment of the property; extreme positions taken by the management, i.e., either too lavish expenditure in equipment, or lack of appreciation to provide sufficient funds for the proper develop-

[1] California Miners' Association Annual, 1906, p. 115.

[2] Mineral Industry, 1894, pp. 711, 713.

ment of the property (a gold mine because it is such cannot be operated extravagantly, but on a sound business basis); too great an expenditure for speculative purposes and too little for practical mining; too great an expense in extracting ores and too great a loss in the extraction of values. Other minor causes are: basing estimates of ore obtainable and value of the same on small extent of openings and on a few assays; lack of experience and knowledge of operation of mines; erecting mills before mine is assured; holding mines without working them; ill-adapted methods and machinery; high salaried officials; encountering much water; and excitements.[1]

In closing this introductory chapter we can hardly do better than to quote the words of Dr. R. W. Raymond:[2]

"Thus East and West bear witness of our great inheritance of natural wealth. Every period of geological change has been laid under contribution to endow with rich legacies some portion of our land. Our territory epitomizes the processes of all time and their useful results to man. Divided, yet in a stronger sense united, by mountain chains and mighty rivers, our diversified mineral resources may figuratively represent, as I firmly believe they will literally help to secure and maintain our characteristic national life, a vast community of communities, incapable alike of dissolution and of centralization; one, by mutual needs and affections, as the continent is one; many, by multiform industries and forms of life, as the members of the continent are many."

[1] T. A. I. M. E., California Mines and Minerals, 1898, pp. 4, 9, and Min. and Sci. Press, Vol. 29, p. 88.

[2] T. A. I. M. E., Vol. 1, p. 39, 1873.

CHAPTER II.

AN HISTORICAL ACCOUNT OF THE DISCOVERY OF GOLD AND SILVER.

First Discoveries and Legends. — Legends concerning the presence, occurrence and use of the precious metals in the United States are almost entirely lacking. However, relics of mining operations prior to the earliest recollections of the aboriginal Americans are not altogether wanting. Such indications of prehistoric mining on the North American continent were found and are yet to be seen in the Southern coastal States and those States and Territories bordering on Mexico, both of which localities were formerly occupied by the Spanish. Further, similar indications of early mining have been found in Alaska and Michigan. However, it is only through careful search of the records of early European explorers of the more civilized nations that it is possible to get a glimpse of the conditions and traditions of the peoples inhabiting a land that was a virgin wilderness from sea to sea.

Necessity is the mother of invention and adaptation, but necessity had not called, and up to the earliest times that we have authentic records of the inhabitants of North America, there had been no evident or pressing demand for the use of the precious metals and their adaptation as money or jewels, and it was then only on the advent of the foreigner with his ideas of trade and barter that the need of a medium of exchange was created. In like manner was the primitive taste for decoration by leaves and shells developed into the elaborate and ostentatious display of jewels, of precious stones and precious metals.

Regarding the existence of such pronounced evidences of previous mining operations as pits and shafts sunk in hard rock, walls and ditches made for the control of loose materials and water, and buildings erected evidently for the treatment of mineral and the possible reduction of ore, practically no word comes to us from the past. The vastness of the territory compared with the number of the inhabitants and the dreary, rough, uninviting character of the country in which deposits of the precious metals have in many cases been found, together with their inaccessibility, must have been largely responsible for the remarkable lack of knowledge evinced by the early inhabitants of the country. Further, extreme climatic conditions coupled with scourges of disease may have eliminated portions of tribes who perchance had acquired such information, either through their own efforts or on the discovery of other people's work, before it could be transmitted by word of mouth to surviving members of the tribe.

Dr. D. G. Brinton is of the opinion that the Indians are responsible for some of the development, at least, in the Southern States.[1] And it would seem that many of the supposed ancient workings, especially in the Nacoochee Valley, were made by them instead of the Spaniards to whom they are attributed — the work seems to have been done comparatively recently.[2] That the Indians of Georgia knew where gold and silver was to be found can hardly be doubted, for when questioned regarding it they indicated the direction in which it was found, which corresponds well with the known localities. However, it is known that they prized copper as highly as they did gold, and it is possible that the two metals were thought of and spoken of by them in such terms as to confuse their inquirers. According to Mr. R. L. Packard there is good reason to believe that the principal source of native copper was the Lake Superior mines.[3]

Lemoyne in his Brevis Narratio of the journey made by Laudonnière in 1564 says: "That chief sent me a sheet of copper dug from those mountains (Appalachian), from the base of which flows a torrent rich in gold, or, as the Indians think, in copper, for from this stream they draw up sand in a hollow cane-like reed until it is full, then by shaking and jarring it they find grains of silver and gold mingled with the sand. Hence they conjecture that there is a vein of this metal (*sic*) in those mountains." Further, he says: "Plenty of gold and silver is found among them and they use them in internal commerce. As I learned from themselves, these metals were obtained from the wrecks of ships which had been thrown on the coast, and I am readily persuaded that this is true, for in the neighborhood of the Promontory (Florida) silver is more plentiful than to the northward. They assert, however, that in the Appalachian Mountains there are veins of copper (aes)."

Charles C. Jones says, in his paper on Antiquities of the Southern Indians, particularly of the Georgia Tribes: "Gold and silver, to a

[1] Notes on the Floridian Peninsula, 1859.

[2] Hernando de Soto, by Charles E. Jones, Jr., Savannah, 1880.

[3] American Antiquarian, Vol. 15, 1893, pp. 67, 152.

limited extent, were employed in the fabrication of ornaments. Small masses of these precious metals were picked up by the natives in pockets, or gathered in the beds of streams flowing through auriferous regions, and perforated and worn as pendants. Gold beads — evidently not European in their manufacture — rudely hammered into round and oval shapes, with holes drilled through their centers or upper portions, have been found in the Etowah Valley, in the vicinity of the large mounds on Colonel Tumlin's plantation. "In 1834, Colonels Merriwether and Lumsden, while engaged in digging a canal in Duke's-Creek Valley, unearthed a subterranean village consisting of thirty-four small cabins . . ., above these little houses . . . trees were growing from two to three feet in diameter. The estimated age of these trees was somewhat over two hundred years. In Valley-River Valley, eleven old shafts have been found, varying in depth from ninety to one hundred feet. Six miles southeast of this locality are five other shafts similar in age and construction. The presence of iron and the marks of sharp metallic tools prove that these ancient mining operations cannot be referred to the labors of the Indians."

Early records state that the Indians of southeastern Kentucky in Daniel Boone's time and later, exchanged native silver with the white men in barter for other goods. Further, it is related that the silver thus obtained had been smelted or reduced into a rough bullion by a process unknown to the white men. The veins from which the silver was obtained were never located.

In 1516, however, Diego Miruelo obtained a little gold from the natives,[1] and in 1519 Pineda, who coasted along the western coast of the peninsula[2] and along the Texan coast, reported that many of the rivers contained gold, and that the natives wore golden jewels.

Pamphilo de Narvaez, who landed at Tampa Bay in 1527, reports seeing traces of gold, and was informed by the natives that it was to be found in considerable quantities in a province called Apalache.[3]

A Jesuit named Father Kino in 1701 revisited a station (San Dyonisius) on the Colorado River, above the mouth of the Gila, which he had established in 1700, and states in his journal that the Yuma Indians, among whom he had labored, had an abundance of ornaments and charms of gold which they obtained from washing

[1] Barcia, Eusaio Cronologico Año MDXVI, fol. 2.

[2] Navarrette, Vol. 3, pp. 147–153.

[3] Relation d'Alvar Nuñez Cabeca de Vaca: Ternaux-Compans, Chap. IV, p. 29.

the dirt of the hillsides on the California side, just across from the newly established station.[1]

The Cocopahs in lower California have had access to gold as far back as we have any record of them, which they have used as a medium of exchange in barter, also as ornaments — some exceedingly rare specimens of virgin gold having been found among them.[2]

It is evident from discoveries made in the Nome region that at least a part of the fields was known prior to the advent of the American miner. Evidence exists that the gravels were worked intelligently. Extensive gravel workings seem to have been conducted at Gold Run, for in 1900 a fairly well made stone wall was encountered, which for some purpose had been built up from bed-rock, and must undoubtedly have required some engineering skill. However, this work must either have been carried on prior to the advent of the present race of people into the country, or was carried on without their knowledge, for the Esquimaux have no tradition regarding the presence of gold or strangers, at least had not mentioned it to traders as far back as 1850-70.[3]

That the Esquimaux knew of gold at a later date, if not before, is shown by the fact that two Laplander reindeer herders deserting from the Government station at Port Clearance in the fall of 1898, stopped with Esquimaux at Cape Rodney on their way to St. Michael. Here they saw crude golden ornaments made of nuggets, which led them to search for gold as they worked down the coast. Near the present location of Nome they discovered gold on Anvil Creek.[4]

Regarding the occurrence of gold and silver in the northern states, especially Michigan, there is also a decided lack of definite information, although it is likely that the natives would have noticed them and made use of them sooner than might be expected of people not so familiar with native metals as were these northern tribes with copper, which occurred abundantly both in glacial drift and in veins.

However, the northern Indians were not without traditions regarding the occurrence of mineral riches, but their accounts usually referred to some distant locality. Charles Whittlesey in his paper "Ancient Mining on the Shores of Lake Superior" says:

[1] Min. and Sci. Press, Vol. 81, p. 280.
[2] Min. and Sci. Press, Vol. 27, p. 347.
[3] Min. and Sci. Press, Vol. 86, p. 303.
[4] Eng. and Min. Jour., Vol. 69, p. 105.

"I have listened to many wonderful tales concerning distant mineral riches. An aged Chippeway, by the name of Kimdickan, whom I met on the Ontonagon in 1845, stated that as he was one day sailing along the western shore of the Gogebic (or Akogebe) Lake, at the head of the west branch of the river, he heard an explosion on the face of a rocky cliff that overlooked the water, and saw pieces of something fall at a distance from him, both in the lake and on the beach. When he had found some of them, they proved to be a white metal, like 'Shuneaw' (money), which the white man gave to the Indians at La Pointe."[1]

Father Jacker, a priest who made diligent search into traditions of the inhabitants regarding the early miners of Lake Superior, found but one Indian, John Metakosigo ("the smoker of pure tobacco") who seemed to know the identity of these early workers. He stated that it was Gete Wemitogojiwag, i.e., "the people possessed of wooden boats," which would apply equally to the French and Canadians. It has, however, been pointed out that they could hardly have been responsible for the workings, owing to the large accumulations of débris in them, together with the extensive growth of timber. Furthermore, the masses of copper they extracted from the pits could hardly have been transported in the light Indian canoes of to-day. There might, however, have been another people possessed of wooden boats, known to the ancestors of the present Indians; when and why they left these shores is idle to conjecture, but it was probably at least four hundred years ago. If this is true there is little wonder that traditions are scarce and fragmentary.[2]

Naturally, most of their legends related to copper, but as Mr. Whittlesey points out, this was considered more as a god (a sacred Manitou) than an object of daily use. Further, they had a "superstitious dread" of revealing the locality of mineral bodies to foreigners, evidently fearing the wrath of the gods.

"If the Indians possessed traditions from their ancestors relating to ancient mines, or the people who worked them, those must also have come to the ears of the Jesuits. It also seems to be highly improbable that their ancestors either knew of ancient mines, not worked by themselves, or the people who wrought them. Tradition is the only history of savage nations, and the fault of this species

[1] Ancient Mining on the Shores of Lake Superior, Smithsonian Contributions to Knowledge, Vol. 13, p. 2.

[2] American Journal of Mining, Vol. 1, p. 297.

of knowledge is not in the absence, but in the excess of materials, such as they are." [1]

Probably the first mention of the discovery of native copper is made in the " Relations de ce que s'est passe de plus remarquable aux Missions des peres de la compagnie de Jesus au la Nouvelle France " for 1659-60, which cites the report of an Indian, named Awatanick, who had journeyed from Green Bay to Lake Superior in 1658. He says: " that its borders were enriched with lead minerals and copper of such excellent quality that it is already reduced in pieces as large as the fist. There may also be seen rocks which contain large veins of turquoise " (green silicate of copper).[2]

Mention is made in the same connection " of the existence of gold on St. Joseph's island, and that the rivers of Lake Superior bring down grains of gold."

It is evident from the above that the scant amount of legendary information we have is limited to that portion of the United States now composed of the coastal and bounding states, the fringe, as it were, of a vast country, the interior inhabitants of which were wholly ignorant of the presence of the precious metals. What metals they had in their possession and their knowledge of them seems easily traceable to a few of the principal localities where such metals are now known to exist and usually lie in this bordering zone.

Masses of native copper with pieces of native silver attached have been found in the mounds of the Mississippi valley, which would seem to indicate that the Indians were not acquainted with methods of treating metal other than by pounding or hammering them. If melted, the silver and copper would form an alloy. Dr. John Locke, of Cincinnati, had such a piece of copper which had been flattened by hammering, yet still showed the native silver.[3]

Arkansas is situated far enough south to have felt the influence of the Spanish invasion, and it is probably largely due to the legends regarding the early workings of the Spaniards that prospecting and mining have been so persistently prosecuted — a charm, as it were, being lent to the search for the precious metals in a most unlikely

[1] Ancient Mining on the Shores of Lake Superior. Smithsonian Contributions to Knowledge, Vol. 13, pp. 2 and 3.

[2] Report of the Geology and Topography of a Portion of the Lake Superior Land District in the State of Michigan, by J. W. Foster and J. D. Whitney, Doc. No. 69, p. 10, 1850.

[3] Ancient Mining on the Shores of Lake Superior. Smithsonian Contributions to Knowledge, Vol. 13, p. 27.

locality, which has, however, been largely dispelled by subsequent explorations.

Early History. — In the following accounts of the early discovery of gold and silver in the United States no attempt is made to group the history of the various sections into contemporaneous periods, but rather to make a more or less arbitrary division in time between what may be considered legendary and early history as the beginning, and certain dates made prominent by the occurrence of some important event, as the close of the early history and the opening up of a new chapter of recent history. Further, the events will be given in chronological order rather than by localities or states, owing to the more or less interrelated occurrence of events, requiring the constant reference to and remention of various localities in the same general region.

The more trustworthy reports regarding the presence of gold in that portion of North America now occupied by the United States antedate its colonization, as is shown by the following account by localities.

The East and Southeast — The Southern Appalachian States. — The first authentic statement relative to the presence of gold is that on June 4, 1513, while Ponce de Leon lay off the coast of Florida, he was informed that a cacique at no great distance contained some gold.[1] In 1516 and 1519, Diego Miruelo and Pineda reported the presence of gold and the fact that some was secured — the latter especially while cruising along the western side of Florida and along the Texan coast. In 1527 Pamphilo de Narvaez reports seeing gold and hearing that its source was the Apalache province.

In 1539, Hernando de Soto landed at Tampa Bay. He made extensive search for gold as the numerous relics of his fortifications and exploratory works indicate. The Chattahoochee River, "so called in the Cherokee tongue from rubies being found in its sands," was probably his western base of supplies while on his conquering march through the Creek, Seminole and Cherokee nations. The Chattahoochee and Chestatee rivers, as well as other streams traversing the gold belt, have been productive of many and quite extensive auriferous gravel deposits. It is therefore rather surprising that De Soto did not find more of the golden wealth that he sought, unless, as has been suggested, "the narrative of his expedition shows that he was too busily occupied with obtaining supplies and his

[1] Herrera, Dec. 1, Book 9, Chap. V.

favorite 'sport of killing Indians' to undertake any serious mining operations."[1]

It is possible, as previously stated, that the Indians were responsible for some of the workings presumably made for mining purposes, although Mr. C. E. Jones is inclined to attribute them to Tristan de Luna, citing J. Lederer to the effect that the Spaniards were occupied in mining here as late as 1669 or 1670.[2]

There are traditions to the effect that the lead and silver mines of Newburyport, Massachusetts, were known prior to the Revolutionary War and that masses of galena were obtained from which bullets were made. These mines were not worked, however, until 1874 or thereabouts.

In a report by Thomas Jefferson in 1782, a brief account is given of the finding of a piece of ore on the Rappahannock, Virginia, and the statement is made that no other indications of gold were noticed.[3]

The Southwest and West — Texas, New Mexico, Arizona and Southern California. — The history of the early discoveries of gold and silver in what is now the southwestern part of the United States can hardly be segregated to advantage and given as complete accounts of the various portions of the whole, as it now stands subdivided into states and territories. It will then be considered chronologically instead of by states or given areas.

It is very probable that gold and silver were discovered and worked at an early date in Texas, New Mexico, Arizona and Southern California by Spaniards who gradually worked their way northward with missionaries of the various religious orders, or shortly after they had penetrated the wilderness and established a few and widely separated stations.

The period in which the Spanish were most actively engaged in working the mines of Mexico was between 1521 and 1810 — the conquest of Cortez and the Mexican War of Independence. According to Humboldt's map, "New Spain" reached to Tucson, Arizona, on the north, and to Lake Charles, Louisiana, on the east, being subdivided into twelve provinces, or *intendencias*, which were still further subdivided into thirty-seven mineral districts each, known as *disputaciones de minera*. Fully three thousand mines were included in this area, which could be roughly grouped into about five hundred

[1] Gold Fields of the Southern Appalachians, U. S. G. S. 16 Rept., pt. 3, p. 254.

[2] From Harris's Collection of Voyages and Travels, Vol. 2, 1705, Appendix, p. 19, including references to the Spanish mines.

[3] Notes on Virginia, 1787.

mining camps or *realitos*. The southwestern portion of the United States was then Spanish land by right of conquest and was included in the above classification.[1]

Conorado as early as 1539-40 explored the country lying between the head of the Gulf of California (the Vermilion Sea) and Santa Fé, when the dry placers of the district of northern Sonora were discovered, together with the ancient ruins known as the Casa Grande in the Gila Valley. The lack of success of this expedition discouraged further explorations in this region for a number of years. Subsequently the English navigator, Sir Francis Drake, visited the western coast of North America, entered the bay to which he gave his name, and remained for several weeks. This was in 1579, at which time he took possession of the country in the name of his sovereign, Queen Elizabeth, giving it the name of New Albion. His representations of the country on his return to England were that of a land abounding in gold. This led the historian, Hakluyt, to make the statement that "there is no part of the earth here to be taken up wherein there is not a reasonable quantity of gold or silver," which, as has been pointed out, was evidently far from the truth, as little or no gold or silver has ever been found in this locality. However, it is possible that Drake got his information secondhand and not through any investigation of his own.

It is not impossible, however, that the tales told and reports made regarding the abundance of gold were promulgated with the intention of removing suspicion from his method of acquiring the great store of precious metals which he brought back with him. If the current reports are true, he looted the churches with a masterful and greedy hand. It appears that contemporaneously with his visit a book was published at Lorraine, in which may be found the statement: "The soldiers of Vasquirus Coronatus having found no gold in Vivola, in order not to return to Mexico without gold, resolved to come to Quivera (California), for they had heard much of its gold mines, and that Tatarraxus, the powerful king of that country, was amply provided with riches."

It appears that the province of New California was explored for the first time in 1602 by Don Sebastian Viscaino, Spanish Admiral, Viceroy of Mexico and Count of Monterey, who reports the fact that he saw specimens of native gold.[2]

[1] Eng. and Min. Jour., Vol. 80, p. 1105.
[2] Min. and Sci. Press., Vol. 54, p. 282.

Fully twenty expeditions were sent out from Mexico into the region to the north with the expectation of finding gold, silver and even precious stones, in abundance. Practically their only source of information was that obtained from the Indians, which was in every case proven worthless, the expeditions returning discouraged and much the worse physically from the hardships encountered. These excursions into California, Arizona and New Mexico took place after the conquest of Mexico by the Spaniards, between the years 1610 and 1660.[1]

Various evidences of crude, prehistoric mining have been found at various times and places in what is now Arizona. However, it is not certain whether this early work was done for gold and silver or copper. Discoveries made along the Salt River by Lieutenant Cushing, of ancient oven furnaces in which considerable copper was found, would seem to indicate that the ores treated were copper carbonates.[2]

The valley of the Rio Grande was thoroughly explored by the Spaniards for mineral wealth prior to 1680. The mountains of New Mexico hold numerous ruins of mining settlements and works, which indicate that the mining industry, though crude, was extensive. Here as elsewhere the natives wrought in the mines for their masters, the Spaniards, whose yoke became so grievous to bear that an insurrection broke out in 1680, or thereabouts, and although not particularly successful, practically put an end to mining for a period of one hundred years or more.[3]

Santa Fé, the city of the holy faith of St. Francis, is the capital of New Mexico. Previous to the fifteenth century a settlement of Pueblo Indians (aboriginal New Mexicans) had existed on this site, then called "Ogaphage." When the Spanish (Conquistadores) under Cabeza de Vaca came up the Rio Grande from Old Mexico in search for gold and for the treasures of Cibolo (the seven cities), they found a flourishing Tegua Pueblo village as early as 1538. When the Pueblo Indians revolted against Spanish rule in August, 1680, being forced to work in the mines as slaves under the "martio" law and driven to despair by the terrible Spanish inquisition, they drove out their oppressors after besieging the city for nine days, killing twenty priests and every Caucasian to be found. The city was recaptured in 1692, under Diego de Vargas. — Eng. and Min. Jour., Vol. 51, p. 654.

In 1692 Father Kino established a mission at Tucson, then called San Xavier del Bac, but owing largely to his protracted absence

[1] Min. and Sci. Press., Vol. 47, p. 292.

[2] American Anthropologist, Jan., 1904, pp. 95, 96.

[3] Am Jour. Min., Vol. 2, p. 386.

on exploratory expeditions, the work languished and was not revived until 1736, which was followed in 1736-41 by a rather extensive silver excitement at a point close to the Arizona line and supposed to have been not far from Oro Blanco. Records left by Father Sedelmair, who visited the place in 1750, show that gold mining was being carried on to a limited extent. Father Anga established a mission here in 1774, which was called the Concepcion, which from its location would seem to have been especially for the miners. These mines were worked both by Indians and Mexicans, especially the latter, but always peaceably. Prior to 1860 most of the gold produced here found its way to Altar in Sonora, but later, when a United States Government post was established, it was turned to Los Angeles and San Francisco.[1]

The monks of the order of St. Francis at El Paso are credited with the discovery of mines in 1680, which were worked profitably for years, the silver from which went to the churches in northern Mexico. There were, however, strife and jealousies among the different orders of the Jesuits, and that order whose friends were in power in Spain dominated the church in Mexico. In the course of time the Franciscans were deposed, being deprived of all their rich possessions. Those at El Paso on hearing of the probable change quietly filled or covered up the mines, and so well was the work done that some of them are undoubtedly still unknown to this day. It was not until July, 1793, that one of the mines at El Paso was reopened and worked by the Mexicans. The mine was again closed and forgotten, following the revolution which led to the independence of Mexico, 1810. In 1872 both the history of the mine and its location were learned from the church records and it was again opened.[2]

In an old Spanish work entitled " Apostolic Labors of the Society of Jesus " an account is given regarding the discovery of gold and silver in the Santa Rita mountains:

" In the year 1769, a region of virgin silver was discovered on the frontier of the Apaches, a tribe exceedingly war-like and brave, at the place called Arizona, on a mountain ridge, which hath been named by its discoverers Santa Rita. The discovery was made known by a Yaqui Indian, who revealed it to a trader of Durango, and the latter made it public. News of such surprising wealth attracted a vast multitude to the spot. At a depth of a few varas masses of fine silver were found, of a blobular form and one or two

[1] Min. and Sci. Press, Vol. 81, p. 280.
[2] Min. and Sci. Press, Vol. 27, p. 394.

arrobas in weight. Several pieces were taken out weighing upwards of twenty arrobas; one found by an inferior official attached to the government at Guadalajara weighed 140 arrobas (an arroba is 25 pounds). Many persons amassed large sums; whilst others, though diligent and persevering, found little or nothing. For the security of this mass of treasure the captain of the Presidio of Altar sent troops who escorted the greater bulk of this silver to headquarters, whereupon the officer seized the property as being the property of the crown. In vain the finders protested against this treatment, and appealed to the audience chamber at Guadalajara, but for answer the authorities referred the matter to the court at Madrid. At the end of seven years the King made the decision, which was that the silver pertained to his royal treasury and ordered that henceforth the mines should be worked for his benefit. This decree, together with the incessant attacks of the hostile Indians, so discouraged the treasure hunters that the mines were abandoned, as needs must be until the savages were exterminated." It is interesting to note that neither extermination nor passification were accomplished until about 1880 — the Indians being full and complete masters of the country until then.[1]

In an old document discovered in the archives at Tucson in 1755 further mention is made of Santa Rita, which also serves to corroborate the above: "In the vicinity of Aribac (or Arivaca), about seven leagues away, are, they say, many mines of rich metals, three in particular, one of which yields a silver mark for one arroba of ore; the second, six marks for a load (100 pounds); the third a little less. Three leagues beyond this, in the valley of Bobocomori, they allege the existence of fine gold placers known to the whole community of Tubac, who went to view it; and in the Santa Rita five silver mines are spoken of." Further, it says: "The silver mines are known, but cannot be worked because of the Apaches, who live there and continually pass to and fro to the hot springs four leagues away."[2]

Regarding the early discoveries of the Mexicans in California it has been said: "That they failed to find anything is proven by the fact that prior to 1848 only a few placers, poor and comparatively limited in extent, were found in California, so unimportant, in fact, that they were not heard of outside the country. The first placer discovered was found by the Mexicans as early as 1775, and is

[1] Min. and Sci. Press, Vol. 40, p. 296.
[2] Min. and Sci. Press, Vol. 40, p. 312.

situated near the Colorado River in the extreme southeastern angle of the state.

Fifty years later, deposits of free gold were found at San Isidro, one hundred miles further west, in San Diego County. In 1833, a little gold was gathered in the valley of the Santa Clara River in the northwestern part of Los Angeles County. Five years later, the San Franciscoquito placers, located in the Sierra San Fernando, forty-five miles northwest from the Pueblo Los Angeles, were discovered. These were the most productive deposits so far found and were worked in a small way for twenty years or more." [1]

Placers in the neighborhood of the San Fernando mission were known and worked by the natives for many years, but in a desultory way, owing to the opposition of the Padres, who feared the loss of their flocks.[2]

The discovery of the San Franciscoquito placers was, as stated above, in 1838, but given by other authorities as 1841 and 1842,[3] was made by Francisco Lopez while searching for strayed cattle. He discovered grains of gold in the earth adhering to the roots of wild onions which he had pulled up.

A letter published in the City of Mexico in 1845, and written to the President of the Republic by Manuel Castanares, Representative in the National Congress from the Department of California, shows what extended knowledge the Mexicans had at that time of the mineral wealth of California. It reads: "The gold placers discovered in the course of the last year have attracted the greatest attention, for they extend nearly thirty leagues. The good quality of this metal is made manifest by the certificate of its assay, which was made at the Mint of this Capitol, and by the sample which I sent to your Excellency, etc." Not long after this he again wrote: "The mineral interest in California is of great importance, and I have the satisfaction of assuring you that it forms one of the most valuable resources of the Department. Besides the silver mines which are found there, and various other mines which have actually yielded metals, the gold placer, especially, is worthy of great attention, which extending nearly thirty leagues, was discovered lately, together with mines of mineral coal, etc." [4]

[1] Min. and Sci. Press, Vol. 47, p. 292.

[2] According to some authorities these placers were first discovered in 1812. Trans. Am. Inst. Min. Engrs., California Mines and Minerals, p. 397.

[3] Gold. Its occurrence and extraction, A. G. Lock, p. 124. Min. and Sci. Press, Vol. 51, p. 322, and T. A. I. M. E., California Mines and Minerals, p. 397.

[4] Min. and Sci. Press, Vol. 47, p. 292.

That Mexico was just awakening to a realization of the importance of this more or less isolated portion of her territory is evident and was probably realized by the American officials, for there seems to have been a decided tendency toward unusually prompt action in the diplomatic proceedings which led to the negotiations and signing of the treaty ceding to the United States this country. Only six weeks intervened between the discovery of gold at Sutter's Mill and the signing of the treaty. It is claimed that the knowledge of the discovery was not known to the Mexicans, while the American officials affected ignorance.

The following extract from an unofficial letter written on March, 1846, by T. O. Larkin, then United States Consul at Monterey, to James Buchanan, Secretary of State, would seem to indicate probable knowledge: "There is no doubt but that gold, silver, quicksilver, copper, lead and coal mines are to be found all over California and it is equally doubtful whether, under their present owners, they will ever be worked." "The implication here is that if the country were only transferred to the American flag, these mines, of whose existence he knew nothing save by surmise or by the assertion of incompetent persons, would soon be opened and worked. In sixty-six days after that letter was written, the stars and stripes were hoisted in Monterey, and now California is working mines of all the minerals mentioned by Larkin save lead, which also might be produced if it would pay, since there is no lack of its ore." [1]

A story current in Mexico, and published in a Mexican newspaper, attributed the discovery of gold to the Indians, and states that the knowledge was imparted to the North Americans through a Russian from Russian America, who after living among the Indians of the tribe of Salsoma became their chief and thus learned the existence of the gold placers. The year 1846 is given as that in which the knowledge was acquired. There seems, however, to be a confusion of dates, for it further says: "In 1847 they seized by force of arms this rich country of our Republic, and on Jan. 19, 1848, accidentally made the first discovery of gold which the waters of the Sacramento were concealing." [2]

Prior to 1855 the Indians of Nevada told many stories of a wonderful place where there was "mucho oro" and "malos" Indians, which so impressed the white men that in 1855 exploring parties set out to locate this mysterious land. The result of this explora-

[1] Mineral Resources of the West, 1867, J. Ross Browne, p. 14.

[2] Min. and Sci. Press, Vol. 54, p. 282.

tion was the discovery of the Yosemite Valley, but there is no record of the discovery of gold.[1]

The early history of Alaska is given in considerable detail by H. B. Goodrich in the "History and Conditions of the Yukon Gold District to 1897,"[2] to which the reader is referred for a more detailed account.

The Northwest — Alaska. — The early history of Alaska is at best but recent compared with that of the southern and northern portions of the United States, but while chronologically somewhat out of order, it is considered advisable to treat it in like manner with the other regions.

At the beginning of the eighteenth century there were two forces at work in the Northwestern Territory, namely, the great Russian-American monopoly and the Northwest Company; later the Hudson Bay Company, whose object it was to explore and open up this vast, unknown and largely unpeopled region. The former organization first establishing itself on the southeast coast and even extended its operations up the Kwikpak (Yukon) River some hundreds of miles. As their trade grew they pushed along the coast eastward from both the Pacific and Bering Sea. In the meantime the English were rapidly carrying their trade westward from posts on the Mackenzie River. The fur trade was the incentive in both cases for the vigorous campaigns, and, as previously pointed out, no definite information had been acquired by the traders regarding the presence of gold, especially from the Indians, up to 1850.

La Perouse, in 1786, undertook, for the French Government, to find a northeast passage to the Hudson Bay from the west. His explorations ended at Litua Bay, he being persuaded that there was no such passage. In 1816, Kotzebue made a similar attempt, but with no better success.

J. McLeod, in 1834, sought communication with the Pacific coast through some westward-flowing stream. He discovered Dease Lake, crossed to the head of the Stikine, which later received the name of Frances River.

In 1838, Robert Campbell established a post on Dease Lake, which was later abandoned. About this time the Hudson Bay Company obtained a lease of the "Coast Strip" of Alaska for an annual rental of $2000. This turned the movement of furs down

[1] Min. and Sci. Press, Vol. 26, p. 402.
[2] U. S. G. S. 18 Rept., pt. 3, p. 103.

the Stikine River. Frances Lake was discovered by Campbell in 1840 while exploring the Colville River. Subsequently he discovered the Pelly, which he named after the governor of the company. In 1842, Pelly Banks Post was established at the head of Pelly.

In the meantime a post had been established on the Yukon. In 1842, J. Bell explored the Peel and Porcupine rivers as well as the country lying between them, and in 1847, some two years prior to the founding of Fort Selkirk by Campbell, built Fort Yukon. Many of the tributaries of the Yukon still bear the names given them while on their journeys. A trip made by Campbell from Fort Yukon to Fort Simpson by way of the Porcupine, thence across to the Mackenzie, proving less arduous and dangerous than that of the Frances to Fort Selkirk, led to the abandonment of the posts at Fort Frances and Pelly Banks. Fort Selkirk was, however, maintained until 1852, when it was sacked by the Chilkats, who had grown jealous of the white traders — their trade having been seriously affected by the strenuous efforts of the posts.

After the transfer of the territory to the United States, Fort Yukon was maintained as the most westerly post of the Hudson Bay Company.

In 1863, Ivan Simonsen [1] made the first trip to Fort Yukon from the west coast. It seems that the Yukon River, as known to the English, was considered by both themselves and the Russians as distinct and separate from the River Kwikpak. It was not, however, until 1866 that Ketchum and Lebarge, of the Telegraph Expedition, proved conclusively that these supposedly two separate rivers were one and the same.

In 1868 there was a question raised regarding what territory Fort Yukon stood in, and to settle it once for all Capt. Charles W. Raymond was detailed to determine it by a survey. The result was that Fort Yukon was declared to be on American territory and it was taken possession of as property of the United States.

In his report on the country, Captain Raymond says: "No valuable mineral deposits in workable quantities have been found up to the present time." It is evident then that the trading companies neither sought for minerals nor encouraged others to do so; in fact, it is well known that their attention had in several instances been called to the discovery of gold, but instead of encouraging further search and development, they had even ordered all such work to be abandoned. A story is told to this effect of Baranof, chief man-

[1] Alaska and Its Resources, Boston, 1870, pp. 276–277.

ager of the Russian-American Company.[1] It was to be a fur producing country to the exclusion of all other industries.

Darrehan (or Doroshin), an engineer, was sent by the emperor to make an examination of the shores of Alaska. This was in 1855; in 1858 he made an unfavorable report. It is rather remarkable that a man on such a mission should, through oversight or failure to visit certain localities, make such a blunder, yet it seems to have been the policy of the Russians to suppress all information relating to mineral wealth; while the English, although doing nothing to discourage the work, evidently desired that it remain undeveloped.

It was, however, absurd to suppose that such knowledge could be held in abeyance indefinitely, and such was the case. In 1857, the agents of the Hudson Bay Company at posts on the Fraser and Thompson rivers, in British Columbia, received 300 ounces of gold from the Indians, who had collected it unaided by white men. This led to the sending of a report by Governor Douglas, which was responsible for another great mining excitement and stampede, and it is estimated that fully thirty thousand miners started immediately for Alaska. As has been said regarding this particular movement of prospectors and adventurers: "The third great Devil's Dance of the nations within the decade seemed about to begin." The disorder and hardships experienced by the miners of '49 in California paled beside those of this mad rush, which were accentuated by the rigorous climate of this northern land. However, all but about 3000 of these pioneers left the country within the year.

Work was begun on the Fraser River in 1859, and in the following year the Cariboo district was discovered. Omencia was located in 1860, but was not worked until 1867; following which came the discovery of the Cassiar in 1874 and later that of Sitka. By this time the fact that gold existed in Alaska in paying quantities was established beyond question and her ultimate development was assured, but as yet the vast unexplored interior remained an unknown quantity and offered an inviting field for the prospector.

The later history of Alaska will be taken up under the heading of recent history, and will give the incidents relating to the development of the northernmost possessions of the United States.

The Northern Country — the Lake Superior Region (the North Shore, Canada, and the South Shore, the United States). — Although the silver mines of the north shore of Lake Superior are in Canada,

[1] Rept. Director U. S. Mint upon production of precious metals in U. S. during 1883, p. 19.

and therefore would not be included in a discussion of gold and silver mining confined strictly to the United States, yet owing to their proximity and remarkable richness it has been considered both advisable and desirable to speak of them briefly in this connection.

Explorations for copper were responsible for the discovery of silver, as the two metals are nearly always associated in the Lake Superior region.

During 1846 Mr. Forrest Sheppard conducted an extensive search for silver with a party under the auspices of the Montreal Mining Company. The shore of the lake was carefully examined from Sault Ste. Marie to Pigeon River, covering a distance of fully 500 miles, and eighteen separate locations were made. The locations were rather extensive, being two miles in width and five miles long. Silver Islet was included in one of the locations, although silver was not known to exist there until twenty-one years later. Prince's location on Thunder Bay, some distance west of Kaministiquia, was probably the first locality where silver was discovered, and was obtained in what was considered large quantities. It is reported that gold also occurred with silver. Work here was abandoned in 1850.

In 1856–57, the same company, under the superintendency of Mr. E. B. Borron, begun developing their location at Point Mamainse. Copper, lead and silver (native and minerals) were found here. Although at least five shafts were sunk to depths ranging from 14 to 60 feet, no ore in sufficient quantities for working was discovered, and operations ceased in 1857.

Both the Prince and Mamainse mines were preëminently copper mines, the silver being an accessory metal.[1]

Considerable exploratory work was done in the neighborhood of Thunder Bay, between the years 1863 and 1867, by McKellars, who reported the discovery of silver at a number of points. One of the discoveries, that at Current River, was developed to a certain extent by the Thunder Bay Silver Mining Company as late as 1868-69, but with little success.

Other localities found to be silver-bearing were located prior to 1875, one of the most prominent being the Duncan mine in May, 1867, formerly the Thuniah (or Shumiah), not far from Prince Arthur's Landing on Thunder Bay. After expending fully a half million dollars, for a return of only $20,000, the operations were suspended in 1882. Another vein, producing ore which compared

[1] Trans. Lake Superior Inst. Min. Engrs., Vol. 2, p. 64, 1894.

favorably with that of the Silver Islet mine, is situated on Pie Island.

In 1868, silver was discovered at Silver Islet, on the northwest shore of Lake Superior, which was not, however, the first discovery of silver in this locality, although probably of the most importance until recent years. The discoveries at Cobalt may, but probably will not, eclipse in size and value of ores those of the far famed Silver Islet mine. Silver had been mined as early as 1846 on the property of the Montreal Mining Company, and later by the British American Mining Company on Prince's Location.[1]

In 1846, Professor Sheppard examined the property of the Montreal Mining Company, but apparently without any definite results. However, Macfarlane examined the locations about 1868 and reported encouraging indications of native copper and silver and their sulphides. The first work of extracting ore was begun in 1869, which was accomplished by surface blasting of the rock, but it was not until about 1870–71 that active mining operations were begun, which were carried on with considerable difficulty owing to the exposed position of the island and severe cold of the winter months — influx of water was also a serious inconvenience.

In the four years following the beginning of vigorous mining development this mine yielded over two millions of dollars. From 1874 to 1876 the mine was nearly forced to stop operations owing to the running out of the ore and failure, after the most strenuous efforts, to discover any new bodies. However, in the summer of 1878, its fortune changed for the better, and the mine "sprang suddenly from its feeble, tottering decline into bewildering productiveness of unheard of mineral riches,"[2] on the discovery of the second bonanza. Although the Silver Islet mine still continued to be productive after the body of the second bonanza had been extracted, yet it was ultimately abandoned without the discovery of other phenominally rich portions.

The discovery of silver-bearing veins was made by Mr. Oliver Daunais, in 1882 and 1884, in Rabbit and Silver Mountain districts, respectively. Their general location was indicated by an Indian named Tchiatong, whose daughter Mr. Daunais had married — the native reluctance to reveal the location was overcome and sufficient information given to enable him to locate the deposits.[3]

[1] Geology of Canada, 1862, p. 707.

[2] Eng. and Min. Jour., Vol. 26, p. 388.

[3] Trans. Lake Superior Inst. Min. Engrs., Vol. 2, p. 66, 1894.

The not inconsiderable information acquired by the English from various sources, led them to consider the land they had obtained possession of in 1763 to be rich in mineral wealth, especially in silver.[1] This assumption is amply verified by the fact that in six years after taking possession of the country a company was formed in London, with Alexander Henery as general manager. A boat was first built to serve for the transportation of supplies, ore, etc., and as early as 1769 a company of Cornish miners were landed at the Ontonagon River, some distance above the falls, and at the location of the famous copper boulders. Development work was begun in Porcupine Mountain, on the north shore of Carp Lake. These old workings were so extensive as to be readily located as late as 1845–46. It is probable that still further exploratory work was done on Isle Royal and Michipocoten. Silver was not, however, found in paying quantities and the project was abandoned in 1770. Nevertheless, in spite of this failure, silver would seem to have existed, and possibly in paying quantities, for the Indians were constantly bringing for barter native silver, and in some considerable quantities, and, what was more encouraging, in pieces as large often as a man's fist. The Indians could not be induced to reveal its source either by bribery or threats of coercion.

The death of Dr. Houghton, who was drowned in the Lakes, was responsible for a report in 1846–47, which gained considerable credence, that he had discovered a silver vein on the Eagle River between the falls and the Phoenix mine. Nothing of importance was ever discovered here.

In a report on the Phoenix mining property (copper), Dr. C. T. Jackson states that so much silver was found in one of the western branches of the main vein, that it might be regarded more as a silver than a copper lode.

There are few copper mines on Keweenaw Point in which native silver does not occur, but in such small quantities as not to pay for its extraction.[2] The usual occurrence of the silver is in small specks, and irregular bunches, both within the body of, and adhering to the surface of the copper. It is claimed that the Cliff mine realized $5000 a year in silver alone.[3]

[1] Eng. and Min. Jour., Vol. 20, p. 575.

[2] Rept. on the Geol. and Topography of a Portion of the Lake Superior Land District in the State of Michigan, Doc. No. 69, 1850, p. 179.

[3] Eng. and Min. Jour., Vol. 20, p. 575.

Messrs. Foster and Whitney make the following statement regarding the economic importance of the occurrence of silver in the copper ores:

"Up to the present time, the quantity of silver occurring with the copper in the Lake Superior region has not been sufficient to render it worth while to erect the furnaces and make the required outlay for separating these two metals; but, should the number of mines be much increased, and the quantity of silver obtained be considerable, it will be expedient to make suitable preparation for separating this metal. At present, at the Cliff mine, the particles of silver, which are so flattened by the stamps as to be easily seen, are separated by hand, the coarse metal from the stamps being picked over with care for that purpose. The silver occurring only occasionally, and then often in masses of considerable size, there can be no doubt that a very considerable amount is purloined by the miners, who seem to consider the silver found in the vein as their property."[1]

Although considerable time has elapsed since then (1850), yet no large amounts of silver have been found and no further attempts have been made to separately treat it.

In 1846, the argentiferous galena deposits of the Iron River were noticed by Bela Hubbard, which were later worked to a limited extent.

Further discoveries of silver were made by Mr. Austin Corser in 1855, on the Little Iron River, not far from the Pewabic River. During 1873–75, regular mining and milling operations were inaugurated. In 1876, the boom collapsed and all the mines were closed, the Cleveland stopping last of all.

Recent History by States and Territories. — The historical development of the mining industry, so far considered, has for convenience been divided into two parts, namely, legendary lore and early historical records, presumably authentic, the reliability of which can, however, be readily determined by the reader for himself by reference to the authorities cited. Owing to the exceedingly rapid development of the mining industry during comparatively recent times, it would seem necessary and advisable to give the historical account of the development in a somewhat different manner than that employed for the earlier history. The chronological order between states, as previously employed, will then

[1] Rept. on the Geol. and Topography of a Portion of the Lake Superior Land District in the State of Michigan, Doc. No. 69, 1850, p. 179.

be dropped, and they will be taken up alphabetically; the chronological order will, however, be maintained, so far as possible, with respect to the events in the individual states. As a further aid to the reader in following the order of events in their proper sequence, a table has been prepared in which can be traced the discoveries of the principal mines and districts in their chronological order, both with respect to the whole country and to the individual state or territory. No attempt will be made to give a complete and exhaustive account of the discoveries and events in connection with the development of all the mines or districts even, as it would necessitate needless detail and make the work too voluminous. However, the principal historical facts will be treated in accordance with their relative importance and in so far as available and authentic records will permit.

Alabama. — According to Dr. W. B. Philips, the probable date at which gold was discovered in Alabama is 1830.[1] Gold mining in Georgia and Alabama was begun somewhat later than in North Carolina and Virginia, owing probably to their being under the control of the United States as an Indian reservation. Yet in spite of the fact that it was forbidden ground and not open to mining operations, considerable prospecting was done by intruders. "After the discovery of gold, the long-pending efforts of the States to acquire these Indian lands were stimulated and accelerated by the added thirst for the precious metal, and were finally successful in 1830, when the state laws were extended over the nation (Cherokee), and the Indians were removed." [2] It has been caustically remarked "that intrusive mining ceased then and there and swindling mining commenced."

In the early days of 1830 to 1850, considerable mining in a crude way was done, but the most important work was confined to the ten years ending with 1855. Probably the two most prominent camps in the state were Arbacoochee and Goldville; at the latter place there was a population of fully 3000.

According to Tuomey, ground sluicing of hill-side deposits was carried on at Arbacoochee in 1854, in connection with which mercury was used.[3]

"Of the yield of gold there is no record, or indeed of anything in

[1] Gold-Mining in the Southern Appalachian States. T. A. I. M. E., Vol. 25, p. 679.

[2] U. S. G. S. 20 Annual Rept., pt. 6, p. 112.

[3] Second Biennial Report on the Geology of Alabama, p. 70, Montgomery, 1858.

connection with the matter, except that at such and such localities large numbers of men were engaged in the work and that at certain places it was said to be profitable."[1] There were, however, no mint-returns from the state until 1840.

Little work was done in the state during 1892 and for some years previous. In 1895, gold was discovered along the Tennessee River, in Marshall County and considerable excitement resulted, but it was proven to be of small economic importance. This discovery stimulated prospecting and development. The Silver Hill mine and Pinetuckey mine, Randolph County, were operating. Preparations for hydraulic working were underway.

In 1906, the Idaho mine of Clay County was reopened and dredges were successfully operated on the Chestatee River. Taken as a whole, the outlook for mining is considerably more encouraging than in 1893, when the Lucky Joe, Hicks-Wise and Pinetuckey mines suspended operations.[2]

Alaska. — In 1863, Mr. W. P. Blake visited the interior of Alaska along the Stikine River and made a prediction regarding the possibility of finding gold there, which is probably the first word we have regarding it from one competent to judge. He states, that "there is every reason to believe that the gold region of the interior extends along the mountains to the shores of the icy sea, and is thus connected with the gold regions of Asia."[3] Based upon this authority the work of prospecting the interior began. Mr. H. H. McIntyre made a somewhat similar statement, though broader in scope, to the Secretary of the United States Treasury in 1869. His conclusions were deduced from a study of the geological structure of the Sierra Nevada Mountains of California and the Rocky Mountains of Alaska — a great similarity being noticeable. The correctness of these conclusions has been amply verified.

Members of the Telegraph Expedition of 1867 discovered gold on the upper Yukon. No systematic prospecting was done, however, until George Holt's trip, which occurred in 1872, 1875, or 1878, according to various authorities.[4] It is possible that all of these dates are correct, as he is known to have made several trips. Holt was a prospector, and is undoubtedly the first of his kind who

[1] W. B. Phillips, Geol. Surv. of Alabama, Bull. 3, 1892, p. 10.

[2] Mineral Industry, for 1892 to 1906.

[3] House of Rep. Ex., Doc. 177, pt. 2, Fortieth Congress, second session, p. 6.

[4] Alaska Coast Pilot, 1883, p. 200.

found gold on the Yukon. It is stated that he was murdered by an Indian at Knik River, on Cook Inlet.[1]

In 1873, Harper, agent at Fort Selkirk, and Fred Hart, a successful miner of Forty-mile Creek, prospected the Stewart and White River countries. White River was found to yield some fine gold but the Stewart yielded nothing, which is surprising seeing that it was later the scene of considerable excitement.

Had they, however, ascended the river far enough, the results might have been considerably different, and the rush to Alaska would have taken place twelve years earlier. Other reports of like character kept drawing the prospectors further inland. But the natural roughness of the country presented serious obstacles toward their ready ingress to the interior. There were four passes connecting the water courses of the interior with the coast, namely, the Chilkat, Chilkoot, Taku, and White. The Chilkoot Pass, although rough, was less hampered by portages, for which reason it was commonly chosen. However, the White Pass was chosen by many, and less frequently the Chilkat and Taku.

Probably the first white man over the Chilkoot Pass, was an employee of the Hudson Bay Company, who attempted the passage from Fort Selkirk in 1864 or 1865. He was imprisoned by the Chilkoot Indians, but was later turned over to Captain Swanson of the company's steamers in Lynn Canal. There are, however, serious doubts as to the truth of the report, especially as Fort Selkirk was in ruins at that time. Nevertheless, it is not entirely improbable, as it is well known that the Chilkoot and Chilkat Indians, coast tribes, had from the earliest times traded with the Wood or "Stick" Indians of the interior, yet had never allowed them access to the coast, but, acting as intermediaries between them and the whites, had established an exceedingly profitable business, and were reluctant to let it pass from under their control — strangers were therefore promptly excluded. In 1869, Mr. W. S. Dodge says: "Nor will the coast Indians permit any white man to pass to the upper country to trade; the penalty they threaten is death. All trade must be made with them and through them. Hence is evinced a monopoly, powerful and extensive in character."[2] Apparently then all prospectors had failed to gain access to the interior over the coast range, with the exception of Holt, who crossed in 1872, and access to the country from this side had been seriously interfered

[1] Shores and Alps of Alaska, H. W. Seton Karr, London, 1887, p. 131.

[2] Senate Ex., Doc. No. 59, Forty-fifth Congress, third session, p. 97.

with and delayed. However, in September, 1879, this opposition was diplomatically overcome through the efforts of Captain Beardslee, in charge of the government vessel, *Jamestown*, then stationed at Sitka. In the winter of 1879–80, a party of twenty-five, under the leadership of Edmund Bean, landed at Taiya, and were assisted over the pass in June, 1880, by the Indians.

Gold-bearing ledges were discovered near Taku, together with other gold ledges and placers in Silver Bow Basin, which were located, in the same year, by Joseph Juneau, just above the town which bears his name.

Rich placers were discovered on Cummins Creek, which, in 1893, were worked extensively. The Big Salmon River was prospected by a small party of miners who came over the pass in 1881.

In 1882, a prospecting party of forty odd members, under the leadership of Edward and Eff Schiefflin, ascended the Yukon from St. Michael, by steamboat, wintering at Nuklukayet. Rich gold bars were prospected some eighty miles above Nuklukayet. The next spring (1883) other rich placers were located at Rowetka. This ended the work of the expedition and it returned to St. Michael and thence to San Francisco.

"Their conclusion in regard to the country was that it would never pay for mining operations on account of the severity of the winter and the shortness of the open season, but, while dissatisfied with the opportunities afforded for mining, the Schiefflins must have been greatly gratified at proving to their own satisfaction, at least, their theory that there is a great 'mineral belt' encircling the world from Cape Horn through Asia and the New World. They had found this mineral belt at several points along the Yukon."[1]

This is, in fact, the first report of the finding of gold in the United States possessions; all other expeditions and discoveries had been in British Territory. Mynook, Hess and Shevlin creeks were probably those referred to by this party. The latter is probably named after the head of the party, Schiefflin.

River-bar mining was in progress on the Lewes in 1883, the same year in which Schwatka made his military reconnaissance. In speaking of the presence of gold on the Big Salmon (called by him D'Abbadie) he says "a panful of dirt taken with discretion from almost any bar or bank will, when washed, give several colors."[2]

[1] U. S. G. S., 18 Annual Rept., pt. 3, p. 111.

[2] Along Alaska's Great River, p. 190.

Bench gravels containing gold were found at Von Wilczeks Valley, 20 miles south of Pelly River.

From this time on the number of men who came over the passes rapidly increased, fully two hundred crossing in 1883, and the stories of finds of marvelous richness came in from every side — statements that men had made $100 to $150 a day were mild exaggerations.

In the fall of 1883, report was brought into Juneau that rich gold placers were to be found on the Yukon, which was corroborated by the exhibition of $1000 of coarse gold. The Cassiar district in British Columbia having been abandoned recently there were many idle miners to whom this reported find came as an alluring call, and great excitement prevailed. Next spring fully three hundred men crossed the summit for the new gold fields.

However, " The Cassiar district was, in a way, the training school of the Yukon miners, and to the experience gained there the latter owe to a great extent their ability to cope with the natural disadvantages, for the conditions are similar in each. The early miners were obliged to enter the Cassiar field over a steep mountain trail more than 150 miles long, bringing all their provisions with them, and when they arrived had to contend against severe winters and short working seasons, in a country far from the base of supplies. Cassiar traditions, then, had great weight among the first miners of the Yukon, and Cassiar methods were followed." [1]

However, in 1884, the diggings having been practically exhausted were abandoned, only Chinese remaining to work over the rich tailings. In speaking of the Stikine River, in 1888, Dr. Dawson says: " Not more than $1 to $3 per day can now be got, and work has practically ceased." Further, S. B. McLenegan, who had explored the Kowak River, in 1884, says: " In regard to the existence of gold in this region, there seems to be little doubt. In almost every stream, large and small, we found the color of gold." [2] Nevertheless, he was of the opinion that conditions were not especially suited to the profitable working of these deposits.

The rush to the interior still continued in 1885 and considerable work was done on the Stewart River. A few especially rich finds kept the excitement up, thus materially increasing the number of miners on the Upper Yukon.

[1] History and Conditions of the Yukon Gold District to 1897, and U. S. G. S. 18th Annual. Rept., pt. 3, p. 112.

[2] Cruise of the United States Revenue Steamer *Corwin,* 1884, p. 107.

In the spring of 1886, Cassiar bar, ten miles below the mouth of the Big Salmon River, became a rivaling point of attraction.

Then there followed in quick succession the discoveries of the Forty-mile district in 1886, and the Birch Creek district in 1893, with their subsidiary locations, all of which form connecting links in a chain of events continuous, but far from permanent in character. The effects upon the development of the country have, however, been more or less permanent and far reaching.

There are, however, several particular locations without which the history of Alaska would not be complete, namely, the Klondike, Cape Nome and Fairbanks districts. The discovery of the Klondike in British territory, and the excitement incident thereto, occurred in August, 1896. The report spread that gold had been found on Klondike River. Klondike is a corruption of the Indian name Thronduik (" water full of fish "). This river flows into the Yukon some forty-five miles below the mouth of Sixty Mile Creek. Probably 350 men wintered on the Klondike and at Dawson, built up on the banks of the Yukon at its mouth, and by 1898, fully 40,000 people were camped along the Yukon near where Dawson stands. The most important parts of the districts are, at present, upon Bonanza and Hunker creeks; the discovery being made upon the former in August and September, 1896.

The auriferous gravels of Cape Nome were discovered in the fall of 1898, by two Laplander reindeer herders deserting from the government station of Port Clearance, who, while on their way to St. Michael, sought shelter with Esquimaux at Cape Rodney. Here they saw gold nuggets used as ornaments, and on inquiry learned that they had been picked up on the beach. Working down the coast they found gold on Anvil Creek.[1] Later gold was discovered in the beach-sands where Nome now stands. However, before gold was actually found at Nome, it had been found and worked at points on the Golofnin Bay, in the southwestern part of the Seward peninsula, which is now divided into the Bluff, the Cheenik, the Council, the Kougruk and the Port Clearance districts — Nome is of the most importance.

The discovery of gold in the beach-sands at Nome was the signal for another mad stampede, not only from the surrounding districts, but from all over the states, which although insuring an increased output for the district, was in itself the cause of delay in the development of the district and kept the output below what it might have

[1] Eng. and Min. Jour., Vol. 69, p. 105.

been, owing to the grasping disposition of many of the newcomers. In 1899, numbers of men came from the states armed with the powers of attorney for various other people and immediately staked out claims by the wholesale, but as no assessment work was done on the majority of these claims they were forfeited within a year at least.

Considerable prospecting was done at Nome in 1899–1900 by sinking shafts in the tundra lying between the hills and the Bering Sea. The work was abandoned owing to the severe cold and scarcity of fuel. It was resumed, however, in the winter of 1901–02, and was satisfactory in that it proved the occurrence of deep pay gravels. The depths of the shafts sunk varied from 65 to 120 feet. Unfortunately the information thus obtained was entirely local in nature as the shafts were unsystematically arranged and far apart.

The discovery in 1900–02 of the high-beach gravels on both sides of Anvil Creek, Seward peninsula, was an important development, and materially extended the field of placer mining.

The history of the development of mining in Alaska, from the earliest known explorations to the end of 1896, has been given in considerable detail by Harold B. Goodrich in a paper on the history and condition of the Yukon gold district, to which I am much indebted.

The discoveries and development of the auriferous gravels in this vast territory have come at times with bewildering rapidity, then for periods remaining practically dormant, only to break forth again with startling suddenness — a peculiarly characteristic condition for a country passing through the placer stage into the more staid but less profitable period of vein mining.

Naturally, with the exhaustion of the placers, the attention of the miners was turned toward the source of such gold, which in many instances was revealed by the ordinary operations of working the placers, the gravels being gradually worked up stream until the ledges, from which the gold was derived, were uncovered, or the sudden discontinuance of the occurrence of gold pointed to the probable presence of gold-bearing ledges on the banks immediately contiguous to the gravels. Further, if gold-bearing veins of sufficient size and value could be found, the gold mining industry would be placed upon a much more permanent and economic basis. Therefore, even from the time of discovery and working of the placers, certain persons were occupying themselves with the search for gold-bearing lodes.

Quartz mining in Alaska is still in its infancy, yet there are undoubtedly great possibilities before the Alaskan miner who perseveres. It is carried on successfully and profitably at the Treadwell and other mines in Southern Alaska, and on the Solomon River in the Seward peninsula; elsewhere the work is largely "small scale" and unprofitable. "In both Alaska and the Klondike, gold-bearing quartz-veins occur in the rocks of the placer regions, and they have been prospected in many places, but have as yet proved of too low-grade, or of too small size, or both, to pay to work under existing expensive conditions." [1]

Among the first discoveries of mineral veins of value were the copper-bearing deposits of the Ketchikan district, which were located by W. C. Ralston of San Francisco, during a period of four years, ending with 1874. Little was done, however, and the district seems to have been lost sight of for a time.[2]

In 1880, placers were discovered in the Silver Bow Basin, and the following year those of Douglas Island were located. The Paris claim on Douglas Island was found to overlie a gold-bearing lode, which ultimately became the site of one of the large open-cuts or "Glory Holes." This claim was purchased from French Pete, by John Treadwell, for the sum of $4,000. Work upon the lode revealed the ore-body upon which the Mexican mine is located.

A silver-lead mine, the Omalak, which in 1894 was claimed to be the northernmost mine of Alaska, was discovered in 1881. It is located on Fish River near Golofnin Bay, about sixty miles north of St. Michael, at a latitude of 65 degrees north, and is practically under the Arctic circle. Up to 1894 it had been operated for twelve years.[3]

Regarding the Ketchikan district, Miner W. Bruce says in his report on the Eleventh Census: "The indications on the surface are that Prince of Wales Island contains much mineral. Gold, both free-milling and in sulphurets, silver, galena, copper and iron, have been found in many places, but as yet no extensive efforts have been made to demonstrate whether any of the ores mentioned exist in paying quantities. If minerals exist in other portions of the district, the very limited prospecting done has failed to show it. Annette Island may be an exception, and also Dall Island. Some of the finest specimens of gold-bearing ore I have seen in my journey are said to have been taken from Dall Island."

[1] Eng. and Min. Jour., Vol. 76, p. 807.
[2] Min. and Sci. Press., Vol. 83, p. 98.
[3] Eng. and Min. Jour., Vol. 58, p. 610.

It is claimed that the salmon fishers were probably largely responsible for the discovery and development of the Ketchikan district. The discoverer of the gold deposits on the east side of Annette Island was one such, James Bowden by name, who seemed to be most active in exploratory work during the 90's.

In 1897, gold was found on Gravina Island, and near Boca de Quadra, while the Gold Standard property on Cleveland peninsula was located in 1898.[1] Large quartz ledges of low-grade ore were discovered on Ravillagigido Island in 1897.

The difficulties formerly experienced by the prospectors and miners in exploring this northwestern territory have, in many cases been largely removed, yet the greater portion of the interior is still difficult of access.

The case has been summed up by R. A. F. Penrose, Jr., as follows: "The production of gold in the extreme northwestern part of North America is accompanied with many difficulties not found elsewhere. The country is remote, the seasons are short, the ground is perpetually frozen, with the exception of eighteen inches or two feet of surface that thaws in summer; fuel is often scarce and sometimes entirely absent; supplies are expensive and travel difficult. Along the coast and the navigable rivers, trading and transportation companies have established posts, so that in these vicinities the miner fares very well, and traveling is not especially difficult; but where an attempt is made to go overland, conditions are met which will always make exploration in this region slow and tedious. The frozen soil of the tundra, thawing on its surface in the summer, leaves a boggy mass of moss and earth, in which man and beast sink to the frozen ground below; while he who attempts to haul supplies in a wagon often finds his outfit upset many times a day, and frequently mired hopelessly in the tundra."[2]

Arizona. — As previously pointed out under the head of Early History, the early records state that gold was discovered as early as 1769 in the Santa Rita Mountains, but after passing through various vicissitudes the mining operations were abandoned about 1775 or 1776, and were kept closed very effectively by the warlike Apaches until about 1880. Further, the almost complete absence of military protection following the Mexican and Civil wars was largely responsible for the lack of development of the territory during the early days.

[1] U. S. G. S. Professional Paper, No. 1, p. 38.
[2] Eng. and Min. Jour., Vol. 76, p. 807.

Gold was reported on the Gila River as early as 1858.

Tombstone, Cochise County, was discovered, in 1878, by a prospector, E. L. Schiefflin, "who christened the district 'Tombstone' as a reminder of the object that his friends said he would most need, if he dared enter this country of the Apache raids to search for minerals." [1] Within four years Tombstone became one of the largest cities of the southwest; however, but few mines can withstand a long-drawn-out contest with fire, water and litigation, and these mines were no exception — during the 80's Tombstone's fortunes were at low ebb. In 1900, under a new management, the mines of the district promised to again become successful producers. These mines yield gold, silver, and lead.

Some of the best placers worked in the territory were found in Yavapai County, in 1863, and for several years the placers on Lynx Creek, the Big Bug, the Hassayampa, and a number of other streams have yielded considerable gold.

The following summary of mining conditions in Arizona, in 1868, is taken from the address of Governor McCormick to the fifth legislature at Tucson, November 16, 1868, and will give an idea of the extent of the mining industry at that date.[2] "The Wickenburg gold mines are worked without interruption, and steadily yield a large revenue. The Vulture lode, the Comstock of Arizona, now has a wide and merited fame. It is one of the richest, most extensive, and remarkable deposits of gold quartz upon the continent; and its returns, up to this time, are believed to be but an earnest of what may be expected from it in the future. Unfortunately the mills erected in the vicinity of Prescott were either upon worthless lodes or upon those in which ores predominate which cannot be made to pay by ordinary treatment. From the Eureka district there is a steady and profitable shipment of lead ore to San Francisco; and work upon several silver lodes in that district is vigorously prosecuted, as it is upon several gold lodes near La Paz and Hardyville. Below the Gila the Cababi mines continue to yield a good return of silver, and a fine mill is in process of erection at Apache Pass, where the gold lodes are attracting much attention and give excellent promise. Confidence in the mineral resources of the territory is unshaken, and those most familiar with them believe that, once secure from Indian depredations, and made accessible by the iron rail, Arizona will take

[1] Mines and Minerals, Vol. 27, p. 371.

[2] The Mines of the West, Raymond, 1869, p. 167.

front rank among the gold and silver producing districts of the world."

In 1871, most of the gold taken from placers was obtained by dry-washing, and, therefore, practically only the coarse gold was saved. The principal placers are at La Paz, on both sides of the Gila River, in the neighborhood of Gila City, Los Elores and Oroville, along the upper Hassayampa, the Linx and Big Bug creeks.

The discovery and development of the Silver King mine is important in that it was largely through such efforts that the southwestern and central parts of Arizona were taken from the control of the murderous Apaches.[1] It was while General Stoneman, later Governor of California, was in command of the military department of Arizona, that it was found necessary to pacify the savages. He therefore, in 1873, established a camp in the Pinal Mountains near their trail on Queen Creek, and began the construction of a pack-road into the mountains. This pack-road commonly known as "Stoneman's Grade" was, in the 80's, the main traveled route to the Globe and Pioneer districts.

A soldier, named Sullivan, while engaged in this road-buiding accidentally picked up a fragment of rock and noticing that it was malleable carried some pieces along with him, but made no mention of his find on returning to camp. Later he left the service and went to the ranch of a Mr. Mason, on Salt River, near the present site of Phoenix. From time to time Mason heard Sullivan speak of his find and show the specimens. Sullivan suddenly disappeared one day and was supposed to have been killed by the Indians. Mason with others then sought the location of the vein from which Sullivan had got his specimens. In March, 1875, they were attacked by Apaches, and it was while being pursued by the Indians, who had killed one of their number, that the ledge was accidentally rediscovered. The sequel is not without interest as showing by what narrow margin fortunes are often won and lost: one day, in 1879, an aged man came to the mill of the Silver King mine and seemed to be very much interested in what he saw. Later, he told that he was Sullivan, the original discoverer of the mine. The story he told showed that it was not lack of faith, but lack of funds that had prevented him locating the mine for himself.

In 1887, Mr. John Lawler discovered the Hillside mine of Yavapai County, a gold and silver mine of some note during the 90's.

In 1892, the mining industry of Arizona suffered from the great

[1] Eng. and Min. Jour., Vol. 35, p. 238.

depreciation of silver, along with the rest of the Rocky Mountain country, which was largely responsible for the increased development of gold properties. The richness of the pyrites of the Congress and Crown King mines attracted special attention to their treatment. The discoveries at the White Hills, Mohave Country, still further enhanced the value of gold properties. Haqua Hala of Yuma County and the Vulture and Union mines of Maricopa County were actively operated. In Pinal County the Silver King and Mammoth mines were the principal features.

Very little silver mining was done except at the Seven Stars, formerly the Hillside mine in Yavapai County, which is both a gold and silver property.

During 1894, there was a marked increase in the production of gold, while in the following year there was a decline, owing probably to the closing of the Haqua Hala and the Mammoth; work at the White Hills also showed a decline.

The Pearce, a gold and silver mine, was discovered on the 10th of March, 1895, by two cow-boys, sons of a miner, who combined prospecting with " punching cows." The mine is located in Cochise County, south of Wilcox. For two years at least this mine paid at the rate of $100,000, although the ore from all outward appearance is " most unpromising stuff." [1]

In 1896, the Fortuna in Yuma County and the Mohawk of Tucson, both practically new mines, assisted in increasing the output. The Mammoth was closed, while the Congress, Crown King and McCabe, and Little Jessie in Yavapai County, increased their output. The Placeritas was discovered and opened up. During the following year the increase in production was largely due to operations in the Pearce and Fortuna mines — the Pearce standing first.

The production of gold still increased during 1898–99, while in 1900 there was a pronounced tendency toward prospecting and development. The Haqua Hala mines resumed work and the Tombstone mines still shipped silver-gold ores.

In 1901, the mining interests at Tombstone were consolidated, and it became an important mining center again, and during the same year the Congress mine was actively developed.

The Bradshaw mountain district was the scene of considerable active developments in 1903. The Poland mine was opened up and promised to be a good producer. The Congress and Tombstone mines increased their outputs materially. The pass-

[1] T. A. I. M. E., Vol. 29, p. 224.

ing of the eight-hour law was an important event in mining circles.

During 1905, the principal source of gold was the smelting of copper ores.

Arkansas. — Although no definite statement is to be found regarding the first discovery of silver in this state, yet the year 1880 is noteworthy in that a number of prospects were located and some mining was done. So encouraging were the reported values of the ore in these mines that there was quite an excitement worked up. The district was known as the Silver City mining district, and was situated about 32 miles due west of Hot Springs — the "silver belt" extending north and south about 60 miles and probably 100 miles east and west.

The mines worked at the time were the Mountain King, Ozark, Great Discovery, Little Boss, Canadian and others. A shipment of 280 sacks of ore to St. Louis is said to have assayed $500 per ton.[1] It is further claimed that both silver and gold have been found in the lead ores of this state, ranging as high as $9 to $12 gold, and 216.77 ounces silver per ton.

Mention is made in a report of the Arkansas Geological Survey of the finding of a deposit of limonite, bearing gold and silver, about the year 1887. This occurs in Saline County, and the presence of the metals is attributed to the action of chalybeate springs.[2]

"Samples collected yielded traces of both gold and silver, but they are not to be regarded as representative of the deposit, having been taken as random specimens. Specimens said to have been collected from this range were reported by an assayer as carrying $2.50 in gold and $12.50 in silver; the amount was so low it would prove unprofitable for working. Subsequent explorations have not developed profitable deposits in this district. In the vicinity of Hot Springs the quartz and pyrite deposits have led to much exploration for gold, but no significant amount has yet been found."[3]

Quartz veins are found in Montgomery County, which have been prospected but without results.

The Gray Eagle and Golden Wonder belts extending into Garland County have been the scenes of active explorations notwithstanding the adverse reports of reputable assayers. The most noted mine of the county, the Sand Carbonate, has proven worthless.

[1] Eng. and Min. Jour., Vol. 29, p. 385.
[2] Annual Rept. Ark. Geol. Survey, Vol. 1, p. 37, 1888.
[3] Trans. Lake Superior Min. Inst., Vol. 5, p. 49, 1898.

The Patsey's Pride mine, on the Glenpatrick vein, near Hot Springs, has yielded a slight amount of gold per ton and no silver. The gold occurs in pyritiferous shales, with graphite as an accessory.

The Bear City district lies due west of Hot Springs, which is also characterized by the occurrence of graphitic shales. The Golden Wonder and Lost Louisiana mines are probably the most prominent.

Prior to 1888, the work of exploiting the gold and silver mines of the state had been largely in the hands of ignorant and often unprincipaled persons, which led the State Survey to settle once for all the possibilities of the districts.[1]

Samples collected from various localities around Blocher, Saline County, have shown traces of gold, but not more than an ounce of silver was obtained from several assays.

California. — A somewhat detailed account has already been given regarding the history of gold and silver mining prior to the discovery of gold at Coloma. However, a brief résumé of the events immediately preceding that discovery, together with a few points of interest, not previously mentioned, will be added.

The Mission of San Francisco was established October 9, 1776, the month following the founding of the Presidio of the port. This may be considered as the first serious effort toward civilizing the natives of the western coast. In 1802, a mineral vein of silver was discovered in the district of Monterey, at Olozal, and although it attracted considerable attention it was not worked.[2]

Gold was discovered near the Spanish Mission of San Fernando, in Los Angeles County, in 1812 (there are various other dates given to this discovery). Gold collected here was sent to San Diego in 1828.

That the mineral wealth of California was not generally considered of much importance in the states, as early as 1835 at least, is evident from the following statement in Forbes' History of California: "No minerals of particular importance have yet been found in upper California, nor any ores of metals."

In 1841, other gold placers were discovered in the San Feliciana Cañon, about 40 miles northwest of Los Angeles.[3] During the same year, J. D. Dana, acting as mineralogist to Commodore Wilks's exploring expedition, observed gold in the Sacramento Valley, which

[1] Trans. Lake Superior Min. Inst., Vol. 5, p. 50, 1898.

[2] Mineral Resources of the West, J. R. Browne, 1867, p. 13.

[3] California Mines and Minerals, Spec. Vol. of T. A. I. M. E., p. 395, and Min. and Sci. Press, Vol. 47, p. 292.

he mentions in his book on mineralogy written in 1842. He further states that auriferous rocks were observed in Southern Oregon, but considered them of little importance.[1]

Mr. A. B. Paul states that in 1845, Captain Cleme, an Englishman, working in the Lake Superior copper mines, told him that while in Brazil he had seen gold which had been brought from upper California by natives from that country.[2] If this statement is correct, gold must have been mined in Northern California about 1800.

In 1845, Senior Castillo, of New California, presented to the School of Mines of Mexico specimens of gold, silver, lead, cinnabar, and other evidences of the mineral wealth of that province, and at that time tried to induce his government to protect these interests.[3]

On the 19th of January, 1848, James W. Marshall discovered gold in the race of a saw-mill in the Sacramento basin, at a place afterwards named Coloma.[4]

Of the various accounts of this important find there are many disagreements both with respect to the details of the discovery and the exact date. However, Marshall's own account of his personal experience should be, and generally is, considered authentic, and is essentially as follows: Finding that the race or waterway below the mill was not sufficiently deep he had hit upon the plan of cutting the excavation deeper by the action of running water, accomplished in this case by turning on a full head of water from the mill-pond by simply raising the gate. Examining the cut one morning to note the progress made, he observed a small piece of yellow metal lodged in a crevice of the soft granite bed-rock. On pounding it with a stone he found it malleable and suspected that it was gold. With him at the time was a laborer (Peter Wimmer) who subjected it to a still further and more conclusive test by boiling it in strong lye. The fact that Marshall and Wimmer did not divulge the secret of their find with the other men, fearing, as Marshall stated, that they might stop work, may be responsible for various dates being given as the probable time of discovery; as for instance the 24th, which is considered correct by many persons.

Many so-called discoveries of gold in California, like false prophets, have arisen to share the honor, but most of them have been readily discredited. However, it is possible that others may have blundered on to the secret as did Mar-

[1] Min. and Sci. Press, Vol. 47, p. 292.

[2] Min. and Sci. Press, Vol. 44, p. 380.

[3] Min. and Sci. Press, Vol. 54, p. 282.

[4] The Indian name and pronunciation is Cul-lu-mah, meaning beautiful vale, now Americanized to Coloma.

shall, but owing to untoward circumstances or lack of faith in their supposed find it was not mentioned until after Marshall's find. As an illustration of the not improbable, the following narrative is given for what it is worth: Among the early immigrants journeying to California in 1846 was the Donner party. While attempting the passage of the Sierra Nevadas the party became snow-bound while still on the eastern slope and at a point near where Truckee now stands. One of the party, Denton by name, while idly chipping the rocks used as a fire-place in the cabin they were occupying, noticed shining particles which proved on examination to be gold. Collecting several ounces of this gold quartz, he carefully wrapped it in a piece of buckskin. He, however, failed to survive the passage of the mountains and was buried, and with him the gold he had collected. But why none of the surviving members of the party did not return to search for gold is not satisfactorily explained. Min. and Sci. Press, Vol. 54, p. 188.

However, the knowledge of Marshall's find became known to the men, but they did not seem to take much interest in the matter, although from time to time various ones picked up small gold nuggets in the race. A Mr. Bennett, who was working at the mill at the time of the discovery, left for San Francisco about the middle of February, taking with him some of the gold. There he met Isaac Humphrey, who had worked in the Georgia gold mines; he at once pronounced it gold and immediately made preparations to go to the mill. Arriving at Coloma on the 7th of March he found the men working as usual. After making a few tests he declared that the material was richer than that in Georgia. This statement, from a somewhat experienced miner, precipitated matters and immediately a great rush to Coloma began.

Kemble, editor of the *Californian Star*, after making a visit to Coloma, wrote, on the 20th of May, that a fleet of launches had left on the 14th and 15th of the month, laden with "superlatively silly" people who had set off for the scene of the excitement with the idea that the mines were rich and extensive enough for 2,000 people to dig two ounces of gold a day, adding that: "We believe the reported wealth of that section, three miles in extent, a sham." It has been remarked that: "The dirty work of washing the sand had not appealed to his æsthetic eye, especially since he probably missed the most exciting part of the operation, namely, 'panning out.'"[1]

The direct effect of this discovery was the opening up of gravel mines, at widely separated points, on various rivers where conditions seemed similar to those on the Sacramento. Among the first to think of looking for gold elsewhere were Pearson B. Reading, a ranch owner on the upper Sacramento, and John Bidwell, later

[1] Min. and Sci. Press, Vol. 51, p. 210.

representative to the United States Senate; the former began work on Clear Creek, nearly 200 miles northwest of Coloma, the latter on Feather River some 75 miles northwest of Coloma.

The news of the discovery spread slowly, but gained momentum with the passage of time, as new discoveries, with their exaggerated reports of riches found, came in and dispelled suspicions and doubt until everything was swept before the excitement that burned at fever heat.

"The towns and farms were deserted or left in care of women and children, while ranchos, wood-choppers, mechanics, vaqueros, and soldiers and sailors who had deserted or obtained leave of absence, devoted all their energies to washing the auriferous gravel of the Sacramento basin. Never satisfied, however much they might be making, they were continually looking for new placers which might yield them twice or thrice as much as they had made before. Thus the area of their labors gradually extended, and at the end of 1848, miners were at work in every large stream on the western slope of the Sierra Nevada, from the Feather to the Tuolumne River, a distance of one hundred and fifty miles, and also at Reading's diggings, in the northwestern corner of the Sacramento Valley."

A newspaper of San Francisco on the 29th of May following the discovery of gold, suspended publication with the announcement that: "The whole country, from San Francisco to Los Angeles, and from the sea-shore to the base of the Sierra Nevada, resounds with the sordid cry of gold! gold! gold! while the field is left half planted, the house half built, and everything neglected but the manufacture of picks and shovels, and the means of transportation to the spot where one man obtained one hundred and twenty-eight dollars worth of the real stuff in one day's washing; and the average for all concerned is twenty dollars per diem." [1]

Captain Sutter, for whom Marshall was working and near whose place the discovery of gold was made, took samples of the gold to Monterey to the military authorities, General Mason being at that time Military Governor with headquarters at that place.

The official report of the discovery with specimens of the gold was forwarded by special messenger, Gen. E. F. Beale. The news was received with incredulity and ridicule and did not excite the interest anticipated, but before General Beale could reach California on his return, another mad rush had taken place to the gravel beds

[1] Mineral Resources of the West, J. Ross Browne, 1867, p. 15.

of the north, and he found San Francisco in a state of wild excitement. This was late in 1848.[1]

The cause of this new excitement was the finding of a so-called gold nugget, weighing some twenty or twenty-five pounds, by a soldier of Stevenson's regiment, while drinking from the Mokelumne River. This specimen was placed in the care of General Mason, who sent it by General Beale to the eastern states. On its exhibition in New York City the last doubts were dispelled and the whole nation became wild with excitement.

Interest in the new gold fields was not confined to the United States alone, but Mexico, South America, Europe and the islands of the seas sent their hundreds and thousands to assist in the golden harvest.

It is only necessary to cite the increase in population at this time to show the movement toward this new Eldorado. Before 1850, the population of California had risen from 15,000, as it was in 1847, to 100,000, and the average increase annually for five or six years was 50,000.[2]

Some surprise has been expressed that Fremont did not discover gold while passing through the Sacramento Valley, but it is not to be wondered at since it is known that his party was in such an exhausted condition that he was forced to slaughter his pack animals for food; then too he was looked upon with suspicion by the Mexican authorities, who suspected that he had revolutionary motives in invading the country.

As previously referred to, gold was discovered on the Feather River, in Butte County, by John Bidwell in March, 1848, and some two weeks later on Butte Creek, the west branch of the Feather; while on July 4, 1848, he located Bidwell's Bar three miles above the present town of Oroville. On May 16, 1848, Claude Chana discovered gold in Auburn Ravine, which locality was later known as the "North Fork Dry Diggings," and still later changed to Auburn.

An early, if not the earliest, discovery of silver in this state was made by a party of emigrants in August, 1849, who under the leadership of a Mr. Rhodes crossed the plains and entered Death Valley from the east through the Furnis Creek pass. There they camped at the so-called "Poison Springs." Shortly afterwards many of their number were taken sick and twenty-two died. Thinking that

[1] Min. and Sci. Press, Vol. 43, p. 177.

[2] Mineral Resources of the West, J. Ross Browne, 1867, p. 16.

the water of the spring was poisonous they made haste to get away, abandoning practically everything. However, their first thought was for water, and horsemen were sent out to search for it, and it was while thus engaged that one of their number picked up a piece of float-rock with pure silver attached to it. This specimen, it is claimed, could be seen at Oroville, California, as late as 1884, being in the possession of an old lady, a survivor of the party.[1]

On reaching their destination the specimen was shown and considerable interest was aroused, resulting in many parties making diligent search for the locality from which it came, but without success.

The discovery of Grass Valley dates back to 1849, when the first lot of pioneers, nearly exhausted by their journey across the continent, came to it, and they and their worn animals rested and recuperated — it was then named Grass Valley. In the same year gold placers were discovered there, following which gold-quartz ledges were located in June, 1850. In October, 1850, McKnight discovered gold on Gold Hill — the quartz being literally filled with gold. Immediately following the discovery on Gold Hill, and in the same month, rich quartz ledges were discovered on Massachusetts, Ophir and Rich hills by G. D. Roberts. The location of the Empire mine on Ophir Hill was one of the most important finds. However, the discovery on Gold Hill is of historical importance in that the first quartz mining in the same state had its beginning there.

The placers of Plumas and Sierra counties were discovered in 1850–51, and following their exhaustion the ancient river gravels were worked. In 1851, the famous Plumas-Eureka gold ledge on Gold Mountain was discovered.

In the spring of 1850, fabulous stories were circulated regarding the occurrence of gold at Gold Lake, a small body of water east of the present town of Downieville. This proved to be a delusion and a snare, and many returned poorer than they started. During 1851, Gold Bluff, on the sea-shore about latitude 41 degrees, was the scene of considerable excitement. Large numbers of miners flocked to this place and much work was done, but owing to the character of the gold and the associated minerals, the separation of the gold could not be made to pay, at least at wages that the miners would be satisfied with.

In July, 1878, attention was again called to the ocean beaches owing to discoveries made by John Frazer. Shortly after the

[1] Min. and Sci. Press, Vol. 40, p. 230.

discovery the whole beach from north of Ocean Side House as far south as Point San Pedro was staked off.

The discovery of a pocket mine on Bald Mountain, Tuolumne County near Sonora, in 1852, is the first of any importance found in the state. It was located by Mexicans, who are reported to have taken a large amount of gold from the mine.

J. F. Talbott discovered the placer deposits at Indiana Hill in the spring of 1852. These were the first diggings found between the North Fork and Bear River.

The Amargoza mine of San Bernardino County and in Death Valley, was discovered by immigrants on their way to the gold fields. Returning to the country at a later date to work the property they were killed by Indians. The mine was rediscovered in 1876, by J. B. Osborne and others.

Gold in both placers and veins was discovered at Sulphur Creek, Colusa County, in 1863. The principal mines worked are the Manzanita, Monticello and Clyde.

A quartz vein at Nashville, El Dorado County, was first located and opened in 1851, but it was not until 1868 that any systematic work was done.

From 1850–56 river mining was extensively carried on in practically all of the streams in the gold regions, while in 1852, Edward E. Mattison invented hydraulic mining in placer deposits.

In 1855, Kern River was the point of attraction and drew a motley crowd of adventurers; they were, however, doomed to disappointment. A notable and somewhat remarkable find of ancient river beds at Columbia, in Tuolumne County, occurred in October, 1855. These ancient channels were soon found to be of quite common occurrence, but the largest and most noted was probably the Blue Lead, which runs through the middle of Sierra and Nevada counties. These new-found repositories of gold added immensely to the resources of the state.

In 1856, the main center to which public interest was drawn was the Fraser River. Rich bar-diggings were found and another rush took place, but the excitement did not last long.

During 1863–64, attention of the mining world was directed particularly to the silver and gold mines of Nevada and Colorado, and gold mining in California languished, but did not cease altogether.

In 1881, an important discovery of silver was made in the Calico district of California.

After the Comstock Lode and adjoining territory had been thoroughly prospected and most of the ledges which gave promise of containing values were located, the prospectors and miners began to seek new fields for their labors, and as a result numerous new districts were opened up, and in many cases mines, abandoned under the stress of previous excitements, were reopened and worked with profit. Thus mining in California was revived, and for the following twenty odd years slowly increased in importance and magnitude, largely through the introduction of improved methods of mining and treating the ores.

Gravel mining in its various forms and phases had steadily increased, both in magnitude of operations and extent of ground covered, until about 1884, when after a series of state and federal injunctions against hydraulic mining the industry was forced to stop operations. However, in March, 1893, Congress passed the Caminetti Act, which permitted the mines to be operated again under certain restrictions.

In 1892, Amador and Nevada counties were the largest producers of gold. Little silver was produced in the state.

Electricity was applied to the principal mines of the Bodie district, power being generated in Mono County. There was a marked increase in the production of gold during the following year.

In 1895, gold mining had become the most important single industry in the state. No silver mines of importance were to be found outside the Calico district, San Bernardino County. The Randsburg district was discovered. During 1897, hydraulic mining had increased materially in volume under the Caminetti law. Considerable activity was manifested both in new and old developments; there was a marked movement toward the Angel's Camp.

The serious drought experienced in many of the placer-mining districts was responsible for the falling off in the gold output in 1898. However, the Randsburg district began to show up well. Gold was mined in thirty-one out of fifty-seven counties. The Vanderbilt mine was an important producer. River dredging began to form an important industry of the state. A marked increase in gold production occurred in 1899 and 1900, due probably both to weather conditions being more favorable and rapid development of the dredging industry, which had extended to ten states.

In 1905, after several years of fluctuating yields, especially of gold, a pronounced increase was obtained, and although no new developments of importance in quartz mining were noted, yet the southwestern portion of the state received much attention from prospectors. However, dredging operations were of the most importance — fully fifty dredges being actively at work and others were building.[1]

The precious metals are widely distributed throughout California, and are as a rule, found under favorable conditions for cheap exploitation. The principal gold field extends north and south for a distance of fully seven hundred miles in almost unbroken continuity, besides which there are several other outlying districts yielding both gold and silver.

The Carolinas. — The first record we have of the finding of gold in North Carolina is that of the Reed nugget, which, according to Wheeler in his History of North Carolina, was found by Conrad Reed, son of John Reed, in 1799, while shooting fish with bow and arrow in Meadow Creek. He noticed the yellow gleam of a substance in the water and on removing it found it to be metal. It was taken to his home, but as gold was unknown in that part of the country its true nature was not suspected, and it was used as a door stop for a number of years. In 1802, Mr. Reed took the nugget, weight 17 pounds, to a jeweler, at Fayetteville who told him that it was gold and offered to flux it for him. On his return he found a gold bar (6 by 8 inches long, thickness not given) which he was induced to sell for the sum of $3.50. The following year he, with several others, discovered another piece of gold and quartz weighing 28 pounds, and from that time on other pieces weighing from 16 pounds to several ounces were collected.

The veins from which the nugget originally came were discovered in 1831.

From 1804 to 1827, North Carolina furnished all the gold produced in the United States, which amounted to something like $110,000. Mills in the "Statistics of South Carolina," mentions the occurrence of gold as early as 1826, in the Abbeville and Spartanburg districts; the first mint-returns from this state were not, however, given until 1829.

A curious bit of history affecting the accuracy of the statistics, is the coinage of gold by one Bechtler, in North Carolina, about 1833 and for many years afterwards. It is said that for some time

[1] Mineral Industry for 1892 to 1906.

these coins and Mexican silver constituted the chief currency of large districts. To insure their reception, the Bechtler coins were made slightly overweight, which of course led to their rapid disappearance.[1]

Vein mining probably began in 1825, in Montgomery County, North Carolina. Some of the more prominent localities which assumed the importance of regular mining-camps and where operations were both extensive and fairly continuous were Gold Hill and Brindletown, North Carolina. However, the Califorina excitement was responsible for the rapid decline of mining in the Southern States beginning with 1849.

Gold was discovered at the Portis mine of eastern North Carolina, about 1840, being found sticking in the clay daubing of a log cabin standing on the property, which led to the discovery of some very rich mines.[2]

The only mine it is claimed in the United States which could properly be spoken of as a silver mine, was operated in Davidson County, North Carolina, prior to the discovery of the Comstock lode. The ore consisted of argentiferous galena.[3]

Hydraulic mining was, according to Lieber,[4] first practiced at Pilot Mountain in Burke County, North Carolina, some time prior to 1859.

The successful treatment of sulphurets was accomplished about 1879. For an excellent detailed account of the mining operations in the Southern gold mines, the reader is referred to the paper by H. B. C. Nitze and H. A. I. Wilkens.[5]

In 1892, there was a decided falling off in output of gold in North Carolina. The Marion Bullion Company at Deming, erected a concentrating plant and chlorination works, while the Silver Valley mine of Davidson County was shipping ore to the smelter at Thomasville. In South Carolina the Haile and Brewer mines were practically the only ones in operation. During 1895, the North Carolina mines were producing but little, while the Haile mine of South Carolina had increased the production of the state fully one-fourth, which was due largely to the successful working of the low-grade sulphurets by the chlorination process.

[1] U. S. G. S., 16 Rept., pt. 3, p. 257, 1894–5.

[2] Eng. and Min. Jour., Vol. 77, p. 168.

[3] T. A. I. M. E., Vol. 25, p. 804, and the Mining Magazine, Vol. 2, p. 605.

[4] Supplementary Report to the Survey of South Carolina, 1859, p. 154.

[5] The Present Condition of Gold Mining in the Southern Appalachian States, T. A. I. M. E., Vol. 25, p. 661, 1895.

In 1898, several old mines were reopened and considerable work was done both in the mountain and midland counties.

Fifteen mines were operating in North Carolina in 1901, principally in Cabarrus, Macklenburg, Stanley, Montgomery, Burke and Rowan counties. The principal developments were at Gold Hill, Rowan County, North Carolina, while the chief producer in South Carolina was the Haile mine, Lancaster County.

In 1902, the Iola gold mine, the Russel, Fentress and McMackin, were all producers, while in 1903 the Barringer and Iola were the only mines working continuously in North Carolina.[1]

As to the future of the mines the closing paragraph of the above-mentioned paper is quoted:

"Gold mining in the South has its favorable features, which should facilitate the economic working of the ore deposits as legitimate business undertakings, with close and intelligent management. A considerable number of properties are at least worthy of investigation, and to the best of our belief such investigation will disclose remunerative working opportunities, and will ultimately lead to a reasonable revival of gold mining in the South. Examinations would be greatly stimulated by more disinterested coöperation and reasonable demands of the mine owners, ultimately to their benefit. Speculative investments in the Southern gold mines have had their day, and unsophisticated capital is becoming rare."[2]

Colorado. — The history of mining in Colorado has no parallel in the United States nor in fact in the world, and as has been said: "The history of this state is that of one generation." The year 1859 may be given as that in which gold mining really began in the state, and in forty years it stood first of all the states in the Union as a gold producer.[3]

No better account of the development of mining in Colorado has been written than that of T. A. Rickard in the Transactions of the Am. Inst. Min. Engrs.,[4] to which I am greatly indebted for much of the information contained in the following pages: It is not unlikely that the Dolores River had been explored by early Spanish

[1] Mineral Industry for 1892 to 1905.

[2] T. A. I. M. E., Vol. 25, p. 795.

[3] Reference is made by William Gilpin to the discoveries of gold in Colorado in 1859 and he predicted the finding of gold and silver in "mass" and "in position," together with precious stones in the Sierra San Juan, Sierra La Plata, and Sierra Wasatch. The Central Gold Region, pp. 96, 140.

[4] T. A. I. M. E., Vol. 26, p. 834.

prospectors, but the first white men known to have entered the district were trappers under W. G. Walton, who came from St. Louis by way of Taos, New Mexico. They spent the summer along the Dolores River camping near or on Trout Lake, not far from the present site of Rico. In 1861, Lieutenant Howard, and five years later Colonel Nash, prospected the Dolores; the latter by way of the Santa Fé and Salt Lake trail. In 1869, Sheldon Shafer and Joseph Fearheiler explored the region around Rico, locating the Pioneer claim in July, 1869.

A party of seven Georgians, in the summer of 1849 while on their way to California, reached Camp Lyon, on the Arkansas. Being persuaded that it was too late to cross the mountains that season, they established winter camp on the Platte at the mouth of Cherry Creek. On prospecting the sand-bars, gold was found, which was for convenience placed in wild goose quills. Early in the following year they proceeded to California. In 1857, they, with others, sold the claims they had been working in California, and returned to Georgia, but with the understanding that they would later prospect western Kansas.

In 1858, practically the same party organized a prospecting expedition and set out from St. Louis following the military road past Camp Harney, from Leavenworth. In August they reached their former camp on the Platte. From this point as a basis, they sent out prospecting parties; one party found gold on the left fork of Boulder Creek and named the place Gold Run, while another party discovered gold in a gulch which was named Russell Gulch. Six of the party returned to the East for provisions while the remainder wintered on the Platte.

News of the discovery spread rapidly and many crossed the plains to the new gold fields. Among the newcomers were John Hamilton Gregory, J. M. Cotton and his brother, William Cotton, who formed a party and immediately proceeded up Clear Creek. On the 6th of May, 1859, the outcrop of Gregory lode was discovered. This date is the birthday of Colorado's mining industry.

Following this were many other discoveries which ultimately made Gilpin County the leading gold producing region of the Rocky Mountains. Boulder was discovered in the same year. The Columbia, Hoosier and other veins were located in 1860-61, and formed a nucleus for the growth of the Ward district.

Jackson's Bar, afterwards Idaho Springs, was discovered by George Jackson in January, 1859, on Chicago Creek. Other prospectors following up Clear Creek discovered the veins above Georgetown and Silver Plume.[1]

The Whale lode was first worked in 1861. Silver ores were also recognized especially in the Running lode. The Pelican and Dives mines were located in 1868. The Specie Payment at the head of Virginia Cañon was opened in 1876.

The placers at Hahns Peak were discovered in 1865.

The placers of the Blue River were discovered by Reuben Spalding near where Breckenridge now stands. This was the beginning of life in Alma and Fairplay. Working the placers led to the discovery of the veins of Summit County in 1880.

John O'Farrell, one of a party of prospectors who were following up the Arkansas, found gold at Iowa Gulch while digging through the snow for water. This was on April 6, 1860, and not long after George Stephens and others located placer claims above the site of the A. Y. and Minnie mines. Gold veins were discovered on Printer Boy Hill by California Gulch miners in the early sixties.

In 1874, W. H. Stevens and A. B. Wood, prospected Dome Hill on the Rock claim. Low-grade ore was found in the fall of 1875. Later the outcrop crossing California Gulch and showing on Iron Hill was uncovered. The following year the whole outcrop was staked. Several smelters were erected between 1877-79 for the treatment of the lead carbonate ore mined here.

During 1878, George Fryer prospecting by shaft in Stray Horse Gulch found carbonate ore. The ore-body here found proved to be very rich and remarkable in many ways. Previous to this, however, veins near Rosita, Custer County, were discovered in 1872; while the location of the Bassick in 1877 was responsible for the excitement at Silver Cliff.

The Trout and Fisherman mines were discovered in the autumn of 1875 by two prospectors working on a " grub-stake " for Edward McIntyre. While fishing on Cañon Creek, some 150 yards above where it and the Uncompahgre join, they observed a quartz ledge which was brightly stained blue and green. Following the bent of their profession a piece was broken from the ledge which revealed the values contained therein. Apropos of their occupation the claims staked off were called Trout and Fisherman.[2]

[1] It is claimed that gold was first discovered at the mouth of Clear Creek in Arapahoe County in 1852 by a Cherokee cattle trader. Special Report of the Census office. Mines and Quarries, 1902, p. 184.

[2] Eng. and Min. Jour., Vol. 27, p. 239.

The Fuller placers were worked in 1877. They are located on the three forks of the Swan River (North, South, and Middle); however, as the Middle and North forks are practically barren, most of the work has been done on the South Fork.

Following Gregory's discovery came that of the Bates on May 15, 1859, the Gunnell, and others on the 25th, and the Bobtail in June.

For several years prior to 1868, a serious depression was felt in the district owing to the exhaustion of the rich and easily amalgamated surface ores, and the occurrence of hard pyritic minerals in depth. However, improved methods in smelting saved the district by tiding the mines over the period of experimentation in milling processes.

In 1871, the Little Giant vein was discovered by Miles T. Johnson, which is located just above Silverton. Following this discovery the veins of Red Mountain were located. In August of 1882, the Yankee Girl was accidentally found by Andrew Meldrum.

The discovery of the Grand View and Atlantic Cable claims were responsible for the rapid growth of the town of Rico. The gold of Wightman's Gulch was discovered in June, 1870, and the development of the Summitville district began with the location of Little Annie in September, 1872.

Professor Hayden has been credited with being the first one to " stick a stake " in the Grand View while on his geological survey of 1875.

The Smuggler-Union vein of Ophir and Mount Sneffels followed the discovery and working of placers on the San Miguel River in 1874. The Sheriden claim was located in 1875 by John Fallon, the discoverer of the Smuggler-Union.

The Summit mine lying beyond the southern ridges in the Ophir district was located in 1874, and proved to be a good producer.

The La Plata Mountain district between Durango and Rico was revived in 1873, but owing to the refractory complex telluride ores little was accomplished, and it was not until 1894 that the outlook became more promising.

The first discovery at Aspen, in the Roaring Fork district, was the Galena mine in 1879. Messrs. Allbright and Fuller located the Little Rock claim which covers a part of the present Smuggler mine. This was on July 5, 1879, and on the 30th of August the Smuggler was located by Charles Bennett.

Ten years after the location of the site of Aspen as a placer claim the district became of importance. In 1889, the Aspen, Aspen-Compromise and Compromise mines were large producers, and two years later the Mollie Gibson ore-body was discovered.

Attention was drawn to the King Soloman district by the discovery of the Holy Moses vein on West Willow Creek in 1889. The Last Chance and Amethyst claims were located on Bachelor Mountain on August the 8th, 1891, by N. C. Creede.

The following year the camp became very active and a boom of considerable proportions closed the year.

Creede and Cripple Creek were of about equal importance in 1891, but with the collapse of the Silver market in June, 1893, Cripple Creek immediately forged to the front, and in 1900 the mines of Teller County stood first in gold production. The first recorded location at Cripple Creek was in 1891, although the district had been prospected as early as 1874. Silver is reported to have been found close to the Elkton mine. The Mount Pisgah excitement occurred in April, 1894 — rich placer ground having been reported as found there. It has been called the "Mount Pisgah fiasco — a horde of deluded prospectors were drawn thither by the assay obtained from certain claims whose croppings had been subjected to the Keeley cure and inoculated with chloride of gold at the hands of designing schemers." [1]

It is reported that the Gold Coin mine was discovered while excavating for the foundation of a hotel.[2]

Robert Womack may be considered the discoverer of Cripple Creek. He located a prospect in Poverty Gulch. Houghton was also a prospector at work on Gold Hill and it was he who first called Stratton's attention to the locality by showing him specimens that he called galena.

Stratton on examining them with a glass detected cubes of rusty gold, but did not recognize the sylvanite, which had been taken for galena by Houghton. Further, it is not recorded who was first to recognize the tellurides of Cripple Creek, but there is a story to the effect that the ore was melted in a fire by miners and thus first revealed its true character. According to Stratton a piece of float which was full of gold was picked up by him where Goldfield now stands, and here the prospecting began. Later, seeing a piece of rock from Battle Mountain, Stratton immediately went thither to prospect, which work ultimately led him to a big granite outcrop —

[1] Min. and Sci. Press, Vol. 72, p. 284.
[2] Colliery Engineer, Vol. 17, p. 210.

this was the Independence lode. Not suspecting that the lode was the vein yielding gold in the loose dirt and porphyry, he ignored it. He had samples of the various veins in the neighborhood assayed, but with results less encouraging than his panning tests had shown. It then came to him that the granite must be the lode and he proceeded to locate his claims — the Independence and the Washington on the Fourth of July, 1891. The following day he had samples assayed at Colorado Springs, with the result that they showed nineteen ounces in gold per ton.[1]

The absence of prominent outcrops, due to the small per cent of silica in the rocks, is probably the reason why Cripple Creek was not earlier discovered.

In 1895, for the first time in a quarter of a century the annual gold yield of Colorado had exceeded in value the silver product. During 1897, a new telluride district was opened at Eldora in the southwestern corner of Boulder County. Although there were no new discoveries of note in the state, yet mining experienced an unparalleled degree of prosperity, which was due largely to improvements in transportation, especially installations of tramways, and the establishing of several water-power plants and lines for the electrical transmission of power to the mines.

As previously noted, 1899 was the record year for the state in gold production, with the Cripple Creek mines leading.

In 1902, mining was somewhat depressed by the decline of silver, and the exhaustion of some large gold mines, with no commensurate increase from developments in new districts. And although the tonnage of the Cripple Creek mines was materially increased the gold production was increased but little, showing that lower-grade ores were being worked.

Probably the most interesting event of 1903 was the starting and completion of the drainage adit, which made connection with the El Paso mine on September 6, 1903. This tunnel proved conclusively that all of the mines of the district, with the exception of a few on the east side, are more or less connected by water channels.

The most important discovery of the year was that of the Old Gold on Beacon Hill. In 1904, the effect of the lowering of the water-level was the discovery of ore-bodies, especially on Beacon Hill. Discoveries in the Reindeer and Conorado mines have infused new life in the Leadville district. Stimulated by more favorable smelter

[1] Eng. and Min. Jour., Vol. 68, p. 67.

rates, the old districts of Gilpin and Clear Creek were still active. Placer mining, especially at Snowstorm in the Fairplay and Alma districts, had a good season; two electrical dredgers were operated at Clear Creek.

Although there were no sensational finds in 1905, yet there was a decided advance in production. Leadville had been benefitted by the rise in silver and was in excellent condition. Camp Bird was the principal producer of the San Juan district. The Smuggler-Union, Liberty Bell, and Tomboy of Telluride were prosperous, while in the Silverton district the Silver Lake, Gold King, and Sunnyside continued to be the principal mines.[1]

"Thus, from humble beginnings, a great and complicated industry has been created. Its development may be summarized in four periods: the discoveries in Gilpin County and the adjoining camps in the granite rocks of the Front range; the era of silver mining in the carboniferous limestones of Leadville, Aspen, and Rico; the development of the fissure-veins in the andesites of the San Juan; and lastly, the revival of gold mining consequent upon the uncovering of a great series of ore deposits in the volcanic complex of the Pike's Peak region."[2]

Connecticut. — Probably the first of the early colonists to turn his attention to the mineral wealth of this state, in particular, was Governor Winthrop[3] who interested himself to a considerable extent in examining the metalliferous deposits of the Connecticut Valley, especially in the vicinity of Haddam and Middletown, during the period 1650 to 1660. However, we have no record of any actual mining being done.[4]

Considerable galena is found in the state which is often highly argentiferous. Probably the most important silver-lead mine was near Middletown, and was worked in a limited way during 1852. It is supposed that this mine was operated many years prior to the Revolutionary War.[5]

[1] Mineral Industry for 1892 to 1906.

[2] T. A. I. M. E., Vol. 26, p. 848.

[3] The license received by Governor John Winthrop permitted him to work mines of "lead, copper, or tin, or any minerals as antimony, vitriol, black-lead, alum, salt, salt-springs, or any other the like," and "to enjoy forever said mines, with the lands, woods, timber, and water within two or three miles of said mines." Trans. Am. Inst. Min. Engrs., Vol. 5, p. 169, 1876–77.

[4] Whitney's Metallic Wealth of the United States, 1854, p. xxii.

[5] Whitney's Metallic Wealth of the United States, 1854, pp. 393, 394; and Report of the Geol. Surv. of Conn., p. 52.

Galena and silver were found disseminated through a quartz-bed at the Lane's mine, Monroe, Connecticut. Silver predominated, although, according to Professor's Silliman's analysis, there were present from 2 to 3.5 per cent of lead.[1]

Georgia. — Gold was first discovered in the state about 1829, although exactly when and by whom found is a disputed point. John Witheroods, a North Carolinian, claims to have made the first discovery at Dukes Creek in 1829 — the exact locality being near Nacoochee, Habersham County. However, Jessie Hogan, also of North Carolina, lays claim to a previous discovery in a branch of Ward's Creek, near Dahlonega. The earliest mint-returns were in 1830.[2] Following the discovery in 1829, there was a rush to diggings in the northern part of the state, but the excitement was of short life.

This event is interesting, as it is undoubtedly the second gold excitement of which there is record in the United States. The scene of the excitement was Leather's Ford and Dahlonega[3] on the Chestatee River. The mineral lands were claimed by the state and were disposed of by lottery.[4]

Auraria and Dahlonega were the principal localities in which gold was regularly mined in the early days.

Placer mining by the hydraulic method originated in 1868, although gravels had been washed for many years previous. At this time a combination method consisting of hydraulicing, sluicing and milling was inaugurated in a number of the mines, being known as the Georgia or Dahlonega method.

Mechanical dredges were operated on the Chestatee River, some time after 1844, while the hydraulic gravel elevator was employed about 1883 at Dahlonega. The Hendy lift was in use the same year in the mines of Dawson County.

Vein mining began sometime prior to 1834, on the discovery of the Reynolds vein, lot No. 10, near Nacoochee, White County.

An argentiferous lead vein was discovered in Davidson County, North Carolina, sometime prior to 1853. This deposit was subsequently worked and was known as the Silver Hill mine. Beauti-

[1] Whitney's Metallic Wealth of the United States, 1854, p. 392.

[2] U. S. G. S., 20 Rept., pt. 6, p. 112, 1898–99.

[3] Dahlonega means in the Cherokee language "yellow money," being so named by John C. Calhoun, who owned property in the vicinity. The Gold Mines, Scenery and Climate of Georgia and the Carolinas, R. C. Stone, p. 20.

[4] Eng. and Min. Jour., Vol. 52, p. 615.

ful specimens of crystallized carbonate of lead and other crystalline products of alteration of galena were found near the surface.[1]

The first regular California stamp-mill was built at the Shingleton mine in 1866, by Dr. Hamilton.

The chlorination process was experimented with at Dahlonega, and the Clopton mine, Villa Rica; at the former some years ago, at the latter recently. In 1892, increased interest in mining was shown by the erection of cyanide works at the Franklin mine, Cherokee County, while three years later a chlorination plant was installed at the same mine.

During 1895, considerable prospecting and development was being done, especially at the Camille, Franklin, Piedmont and Walker mines. In the following year the Creighton and Walker mines were the main source of the gold production. The Old Camille mine was rechristened the Royal and was successfully reopened.

In 1899, the Dahlonega Consolidated Gold Mining Company placed considerable new equipment. A revival of mining interests was especially noticeable in 1900 at the Lumpkin and Cherokee County mines, the most important work being done at the Old Cherokee mine. A suction dredge was tried but without much success.

During 1902, the Parks and Columbia mines were the largest producers.

In 1904, the gold placers of Harlson County were operated. These placers are on the Tallaposa River twelve miles from Buchanan, and are composed of quartz gravel.[2]

Idaho. — Although there was a Jesuit mission established on the St. Joseph River in 1842, for the Coeur d'Alêne Indians and was later moved to its present site on the Coeur d'Alêne River, yet no knowledge of gold or silver seems to have been had until years later. Gold gravels were discovered in the Pen d'Oreille River as early as 1852 by a French Canadian, and seven years later on the Sunelkameen River. In the spring of 1860, a rush occurred, and for a time excitement ran high. Placers rivaling those of California, so claimed, were located on the Oro Fino Creek by a Mr. E. D. Pierce and party in the fall of 1860. In May, 1861, auriferous gravels were found at Elk City covering an area of fully twenty miles square and consisting of gulches, bars, and flats. This was at the head of the Clearwater River. A small area about two

[1] T. A. I. M. E., Vol. 25, p. 804 and Mining Magazine, Vol. 1, pp. 360–370.
[2] Mineral Industry for 1892 to 1906.

miles square was discovered in August, 1861, on the creek tributary to the Salmon and was probably the richest gold placer ever worked. In August of the following year, James Warren discovered the digging southeast of Florence which was named after him. About thirty miles further up the river in a depression were located the mines of the Boise Basin, discovered by one Grimes, in 1862, who led a party (prospecting) from Walla Walla. Grimes was killed by Indians and the party driven off, but later returned and worked the placers.[1]

In 1854, General Lander discovered gold while making explorations for a military road from Columbia River to Fort Bridger.

Probably the earliest record relates to discoveries in the Coeur d'Alêne Mountains in 1858-59, and were made by a party under Captain John Mullan after whom the Mullan road was named. This road was built in 1855.[2]

The Buffalo Hump district was discovered in 1861. It is a free-milling gold district and is located to the west of the Bitter Root Range.

The placer mines of Silver City and DeLamar were discovered some distance below DeLamar in 1863, by a party under Jordan.

The veins of the Warren district, often known as the Washington district, lying in the Owyhee Mountains south of the Salmon River, were discovered in 1862, but mining did not really begin until 1866.

After the exhaustion of the placers of Silver City and DeLamar, attention was turned to the quartz mines which were located in 1863. The Oro Fino and War Eagle mines were the first of importance discovered, which were followed in 1865 by the Golden Chariot and Poorman. The first mill was built in 1864. In 1868, the Oro Fino was one of the most productive mines of the state.

In 1866, quartz mining was carried on in Boise, Alturas, and Owyhee counties, the latter being largely silver producing.

The Tiger-Poorman mines were discovered in 1884, and the Bunker Hill and Sullivan on September 17, 1865. The latter was discovered by W. M. Kellogg, and in connection therewith is an amusing story of how a donkey participated in the discovery. The following is from the Tanana *Daily Miner:* "The story of how a learned judge of the Supreme Court decided that a donkey discovered the Bunker Hill and Sullivan mines, now worth $15,000,000, and thereby caused the court to award his master a third interest

[1] Am Jour. of Min., Vol. I, p. 133.

[2] Eng. and Min. Jour., Vol. 60, p. 172.

in the mines, was recalled last week by the death of O. O. Peck, owner of the donkey, at his home in this city.

"Though the story is stranger than fiction, it is literally true, and the facts are familar, not only to all mining and business men in the territory, but can be substantiated by the court records. Peck and W. M. Kellogg were prospecting through the Coeur d'Alêne Mountains when the famous mine was discovered. Two weeks prior to the actual discovery they dissolved partnership. But Kellogg retained a donkey that belonged to Peck. Kellogg appropriated the donkey, using it as a pack-animal, and they were together when the great mineral deposit was found. According to the Supreme Court, the donkey's participation in the discovery entitled Peck to an interest. Baer and Goetz, of this city, who had grub-staked Kellogg, shared the latter's interests, and he fared more poorly than Peck. Goetz and Baer subsequently sold their fractional interest for $200,000."

According to Kellogg he had been prospecting on the mountain, and while so engaged the donkey wandered further up the slope. On going for him Kellogg's attention was attracted to an outcrop which had been exposed by the donkey stepping upon it; thus was the ore-deposit discovered.

The Morning mine was located in 1885; the Empire State in 1886; the Hecla and Standard in 1887; and the Hercules in 1889.

In the early eighties placers on Prichard Creek, a tributary to the North Fork, were worked at Murray and Delta and attracted considerable interest.

In Custer County extremely rich gravels were found at Robinson Bar on both sides of the river, and both river and bar mining were employed. Loon Creek proved an attractive place for miners in 1870, and for Chinese as late as 1879, when they were driven out by the Indians.

The Ramshorn mine, Bayhorse, Custer County, was the deepest and best developed copper-silver mine in the state in 1900.

In 1899, a steam gold dredge was in operation on Baboon Creek in the Florence district. The comparatively low-grade gravels of the Snake River have been worked successfully by dredges, and in 1895 a suction dredge was in successful operation.

In 1892, the chief event was the strike which closed many of the mines in the Coeur d'Alêne district.

During 1897, the Boise Basin and DeLamar district produced most of the gold. In the vicinity of Elk City, Idaho County, there were five large hydraulic plants operating. Some work was also being done on Newsome Creek.

In 1899, the DeLamar still continued to lead in the production of gold. Extensive placer operations materially added to the yield from Elmore County. The placer working still continued to swell the gold production in 1900, most of which came from dredging on Snake River.

In 1901, gold was found on Thunder Mountain in the central part of the state. During the following year Thunder Mountain did not come up to expectations. However, Owyhee, Boise, and Lemhi counties produced over $300,000.

Silver had become the most important product of the mines in 1904. An important discovery of telluride ores was made in the Iron Spring mine, located on a tributary of the Rapid River. Thunder Mountain made good progress.

During 1905, the gold production decreased somewhat owing to several causes, namely: first, light snowfall and short winter season which seriously affected the placer mines, and second, the burning of the Kittie Burton mine in Lemhi County. Gold was discovered near Elk City, Idaho County. The Coeur d'Alêne district was the principal silver producer.[1]

Illinois. — The following statement is quoted from a report on the Geology of Illinois, about 1866:

" In a few instances minute particles of gold have been found in the drift, and sometimes charlatans, professing to be geologists, have availed themselves of this fact to proclaim to the world wonderful and valuable discoveries of gold and silver." [2]

Gold was found in Hardin County in 1868, and in 1870 it was found in thin gravel beds, " but not in sufficient amount to be anything more than a periodical source of excitement to the ignorant." [3]

Indiana. — Wherever gold is found in the state it is always associated with the glacial drift. It is seldom found along the larger streams, but occurs in the sands and gravels of the small streams which skirt the southern border of the drift and the area of the terminal morain. The counties in which gold has been discovered in noticeable quantities are: Brown, Jennings, Morgan, Franklin, Northington, and Warren.

[1] Mineral Industry for 1892 to 1906.
[2] Geology of Illinois, Vol. 1, p. 35.
[3] Geology of Illinois, Vol. 4, p. 263, 1870.

Gold was discovered in Morgan County as early as 1837. D. D. Owens is reported to have made some observations on the gold found in Bean-Blossom Creek (Rept. State Geologist of Indiana, Nos. 8, 9, and 10, 1879). In 1850, miners returning from the California gold mines prospected the black sands of Brown and Morgan counties. The gold occurs in exceedingly fine grains and scales: the loss in washing is therefore great. However, as much as 50 cents to $1.00 a day was made by panning. The statement is made that the glacial drift, which is gold-bearing, covers thousands of square miles and ranges from 10 to 500 feet deep (13th Annual Rept., 1883). According to the First Annual Report of the State Geologist issued in 1869, gold was found in Franklin County on Sein Creek, but in such small quantities that it took a pailfull of sand and gravel to yield from two to three particles, usually scales, and never larger than a grain of wheat. Mention is made of the finding of gold in Bean-Blossom Creek (in the Sixth Report, 1875, Folio CVII). The fineness is said to be twenty-four carats, which is attributed to the glacial action. The largest nugget found was worth $1.10. The yields given vary from $2,900 to $10,000. The report for the following year states that gold was found in black sand in the bed of the Muscatatuck Creek. In Northington County the drift has a depth of 100 to 150 feet and covers practically the entire area.

Gold was reported in 1873 at Mooresville, on a small creek. The sands and gravels were claimed to have yielded from 25 to 200 colors to a pan.

Seventy dollars were reported collected at Gold Branch of Pine Creek in 1873.[1]

Silver mines were mentioned in the mining journals about 1888, as being worked in Dubois County, and the run of a local smelter on 1500 pounds of ore is given at 58 ounces in silver and 4.10 ounces in gold per ton.[2]

Kansas. — As previously mentioned under the head of Colorado, gold was found in western Kansas in 1849 by a party of Georgians bound for California. However, the mountains of Colorado have always proven more alluring than the plains of Kansas, therefore in the early days little prospecting was done within the state.

Attention was first called to the occurrence of gold in central western Kansas in 1895, when H. H. Artz and others sunk a shaft on the bank of the Smoky Hill River while prospecting for zinc. The

[1] Geology of Indiana, 1873, p. 224.

[2] Min. and Scientific Press, Vol. 56, p. 102.

report that the shales at this, and other points in Gove, Trego, and Ellis counties, contained gold, caused quite a flurry of excitement in the state, and although the price of land rose somewhat, there was no rush to the locality.

Dr. J. T. Lovewell of Topeka, in a paper read before the Kansas Academy of Science, 1902, made the statement that of several hundred assays the average value was $2 to $3 in gold and silver per ton, and one series of assays gave an average of $10 per ton. Dr. Ernest Fahrig of Philadelphia (Kansas *Daily Capital*, Topeka, May 3, 1902) obtained from actual mill runs in an experimental plant an average yield of $2.80 per ton.[1]

Tests were run by various persons and emphatic denials made regarding the existence of gold in any quantity.[2]

Samples of the shale were collected and assayed under the direction of the United States Geological Survey and the following report was made by Dr. E. T. Allen: "I have examined 19 samples of shales from western Kansas, collected by Mr. Lindgren, and find no gold in any of them." However, in one sample .005 of an ounce of gold per ton was obtained, while the silver values ranged from .007 to .097 ounce per ton. The total value of the shale per ton ranged from $0.004 to $0.06 per ton.[3]

Kentucky. — Practically no gold or silver has been found in the state[4] although, as previously stated, the Indians in early days seemed to have a limited amount of silver, but as no mines were ever located in the state it is reasonable to suppose that the source of that metal was without the state and very likely in Tennessee.

As early as 1856, silver was claimed to have been found below the falls of the Cumberland and in Whitley County, but extensive search for the same has been fruitless.[5]

Maine. — The Lubec lead mines were discovered in 1832.[6] Al-

[1] Eng. and Min. Jour., Vol. 74, p. 111.

[2] Kansas Semi-Weekly Capitol, Topeka, June 6, 1902. Mineral Resources of Kansas for 1898, Lawrence, Kan., 1899.

[3] Eng. and Min. Jour., Vol. 74, p. 111.

[4] Early records state that the Indians of southeastern Kentucky in Daniel Boone's time and later, exchanged native silver with the white men in barter for other goods. Further, it related that the silver thus obtained had been smelted or reduced into a rough bullion by a process unknown to the white men. The veins from which the silver was obtained were never located.

[5] Rept. Kentucky Geol. Surv., 1856, p. 235.

[6] Whitney's Metallic Wealth of the United States, 1854, p. 388.

though not definitely stated it is probable that the ore from this mine was slightly argentiferous.

Various mines yielding small and variable quantities of gold and silver have been worked in this state, the most active mining operations having been carried on during the early eighty's. At Milton Plantation, Mount Glines, Oxford County, gold was reported, but if present is of rare occurrence. Assays by members of the United States Geological Survey show the following results.[1]

Gold	None	None	Trace
Silver (ounces)	"	"	3.50
Copper (per cent)	0.16	0.18	3.33
Lead (per cent)	0.25	0.08	47.95

The Cana mine yielded gold, silver, lead, and copper. The Sullivan mine yielded gold and silver.[2]

Gold-bearing quartz found in pyritous mica-schist occurs at Baileyville on the Maine side of the St. Croix River.[3]

Professor C. H. Hitchcock thinks that the Ammonoosuc gold field of New Hampshire and Vermont probably extends into Maine.[4]

Maryland. — Although gold was known to exist on the south side of the Potomac as far back as Colonial times, yet the first authentic record we have of its discovery on the north side of the Potomac or in Maryland is in the Proceedings of the American Philosophical Society for April, 1849, where mention is made of gold-bearing quartz veins on the farm of Mr. Samuel Ellicott, in Montgomery County, some thirty miles west of Baltimore. Reported assays of samples from these veins show, it is claimed, a range in value of \$168, \$610, and \$787 per ton. As no further record of this locality is obtainable, it is reasonable to suppose that its exploitation begun and ended with the observation noted.[5]

Many gold-bearing quartz veins are to be found in the immediate vicinity of Washington,[6] but prospecting has been limited to panning gravels and soils. However, the principal developments of gold were made in the vicinity of Great Falls, from fifteen to sixteen

[1] U. S. G. S., Bull. No. 225, pp. 82–84.

[2] Current Issues of the Eng. and Min. Jour., and local newspapers.

[3] Holmes and Hitchcock, Second Annual Rept. Geol. Maine, 1862, p. 423.

[4] U. S. G. S., 16 Annual Rept., pt. 3, p. 330, 1894–5.

[5] T. A. I. M. E., Vol. 18, p. 393.

[6] Veins in gneiss and schist country-rock, with quartz-filling, showing traces of gold, are quite common in the District of Columbia. Mineral Resources of the United States, 1887, p. 719.

miles west of the city. Reports say that gold was discovered by California volunteers who camped in the neighborhood during the war. The Maryland mine was opened in 1867, and is located midway between Great Falls and the Harrison estate.

Early in 1888, gold was discovered on the Harrison farm by Mr. Kirk, a Georgia miner, who after prospecting, did some exploratory work by sinking pits. The following year it came into the possession of Dr. W. Kempster and others who carried on some systematic developments. A three-stamp mill was erected and later a ten-stamp mill took its place.

In 1889, owing to the successful operation of the Harrison property, a number of other properties were developed, the most important being the Allerton-Ream, the Pine Hill, Broad Rock, Eagle, etc., all not far distant from the Harrison property.[1]

Although mining may be said to have begun in 1849 on the Ellicott farm, the mint reports show no returns previous to 1868.

Massachusetts. — Early records state that mines of gold, silver, and lead were known in Revolutionary times at least, but the first mine of which we have accurate information is the Newburyport mine. The first discovery of gold in this locality was made about October 10, 1874; however, the first pit was sunk in May, 1874. A ton of picked ore from the mine yielded about $33.60 in lead, $28.60 silver, and $4.37 gold.[2]

Michigan. — The Cliff mine, Keweenaw Point, in which native silver is found associated with native copper, was discovered in the summer of 1845. Considerable silver has been obtained from this mine during its operations.[3]

The gold veins northwest of Ishpeming were first examined by Mr. Julius Ropes, who had his attention called to them in 1863. The mines were, however, first worked for argentiferous galena, but finding that a number of assays showed gold in paying quantities a more thorough search revealed the veins bearing the gold. The gold veins were not discovered, however, until 1881. Regular mining was begun in October, 1882, and within a year a five-stamp mill was erected. As has been remarked: "This is the only genuine gold mine in Michigan, and its history has not been an enviable one."

In 1885, gold was discovered about three miles west of the Ropes

[1] T. A. I. M. E., Vol. 18, p. 398.
[2] T. A. I. M. E., Vol. 3, pp. 443–444.
[3] Foster and Whitney's Rept., 1850, p. 128.

mine, following which was much excitement, but the mine or prospect yielded nothing but samples, some of which were excellent.[1]

These mines have probably yielded one million dollars in gold alone since 1883, when $1,286.74 was realized by the Ropes mine.

Minnesota. — In 1866, H. H. Eames reported the discovery of gold and silver, which caused much speculation regarding the value of the deposits found. Vermillion Lake was the scene of much activity, but neither profitable nor paying deposits were located. The losses experienced here cooled the ardor of most of the would-be miners and in a year or two practically all work had ceased. During 1870, a vein was discovered in Benton County and considerable work was done, but it, too, closed in a few years. Auriferous gravel was found in the glacial drift in Fillmore County. Small quantities of gold were also found at Jordan and Spring Valley. However, the locality in which the most gold was found as a gravel-content, was from Rochester to the Wabasha County line on the Zumbro River, Olmsted County. Next in order of importance come Itasca, Saint Louis, Wabasha and Kandiyohi counties. As late as 1893, there was considerable excitement aroused over the discovery of the Delhi mine, Redwood County, but assays showed the gold-content to be extremely small. In the early eighties there was an excitement over a quartz-vein near Granite Falls, Yellow Medicine County, and quite a little work was done, notwithstanding never more than a trace of gold was ever found. A belt of slates and schists extending from Thomson and Carlton to and beyond Little Falls, contains many quartz-veins, and much work has been done with little or no returns.[2]

In comparatively recent years interest has been centered almost entirely in a region along the international boundary, particularly the Rainy Lake district.

The Rainy Lake region lies in the western part of Ontario extending for a distance of approximately two hundred miles north and south, and fifty miles east and west. It is known to reach, and even extend beyond, the line of the Canadian Pacific Railway on the north, and to occupy considerable area in northern Minnesota on the south. Although the region was carefully studied and mapped by A. C. Lawson of the Dominion Geological Survey, in 1885-87, yet no mention was made of the presence of gold. He, however, inferred its presence from a knowledge of the occurrence of the

[1] Trans. Lake Superior Inst. Min. Engrs., Vol. 2, p. 68, 1894.
[2] Trans. Lake Superior Inst. Min. Engrs., Vol. 5, p. 55, 1898.

Keewatin rocks which bear gold in the district of the Lake of the Woods. The first discoveries of gold in this region were made late in 1893, and from recent developments it is probable that it will become a valuable acquisition to the gold fields of the United States and Canada.[1]

Mississippi. — The occurrence (possible) of gold was reported as having been discovered in the state, Jackson County, as early as 1854.[2] No further record of the finding of gold in the state is at hand.

Missouri. — Search for the precious metals in the Mississippi Valley began as early as the eighteenth century. In 1705, the governor of Louisiana led an expedition to the mouth of the Kansas River.[3] Similar exploring parties located the lead mines of Missouri, both of the eastern and western parts of the state. M. de la Motte Cadillac discovered, in 1715, the mine since known by his name.[4] In 1719, active mining was begun on the Meramec River, by the Sieur de Lochon, while in 1721, the Renault mine was discovered by the superintendent of the Meramec mines, which was worked in 1742. Further, the Potosi mines and the southwestern Missouri mining district were discovered in 1798 and 1851, respectively.[5] Although the ore obtained from these mines is largely galena and blende, yet it contains some silver, in such quantities, in fact, as to permit of separation.

Silver Creek in St. Clair County, took its name from the explorers under Renault, and tradition says that a considerable quantity of silver ore was raised and sent to France. It is doubtful, however, whether any successful discoveries were ever made.[6]

Gold was reported to have been found in the state as early as 1855.[7] Regarding the occurrence of gold, Nason says: " Gold has never been found, and it is a metal which is probably entirely foreign to this area." [8]

In 1875, C. P. Williams, head of the School of Mines, at Rolla,

[1] Eng. and Min. Jour., Vol. 58, p. 581.

[2] Trans. Lake Superior Inst. Min. Engrs., Vol. 5, p. 57, and Reports on the Agriculture and Geology of Mississippi, Wailes, B. S. C., 1854.

[3] Geol. Surv. of Missouri, 1873–74, Vol. 1, pp. 11, 12.

[4] State Mine Inspector of Missouri, 1902, 16 Annual Rept., p. 146.

[5] Geol. Surv. of Mo., 1873–74, Vol. 1, p. 11, 12.

[6] Western Annals, 1850, p. 673.

[7] First and Second Annual Repts. of the Geol. Survey of Missouri, 1855, p. 164.

[8] Missouri Geol. Survey, Rept. on Iron Ores, Nason, 1892, p. 95.

made a thorough examination of the properties where gold was reported as found. The gold was found in small particles in the glacial drift formation, the productive part being composed of three strata of gravel, which on panning showed colors. However, tests did not show that sufficient gold could be obtained to pay for working. The area covered by the drift is quite large, extending from Macon County, northward, beyond the Iowa line. Boulders of granite syenite, hornblende, greenstone, trap, and quartz, together with the gravel, are estimated as being 65 feet thick. The principal occurrences were along the Great Charlton River, although traces have been found in many localities, especially at Kirksville in Adair County, where considerable excitement had been worked up.[1]

Montana. — The first discovery of gold in the state is claimed to have been made by an old Mexican miner, known as "Gold Tom," in 1861. The location was about five miles below Pioneer Village.[2]

The placers of Bannack were the first successfully worked in the state — they were discovered in the summer of 1862. July of the following year saw the discovery of the Alder Gulch placers, which caused the almost complete abandonment of the Bannack working by the following spring. Work was, however, revived again in 1866, and they were actively operated for many years. Other diggings discovered in the meantime, such as the Ram's Horn, Radersburg and Cow Creek, and Last Chance were worked for a few feet, then supposing that the ground below was barren, they were deserted, but were again opened up and worked to a depth of 40 to 50 feet in 1869.[3]

In 1863, the placers of Horse Prairie Creek were discovered, and two years later those at Helena were located.

The placers of Bear Gulch were discovered in October, 1865, by prospectors under Jack Reynolds. A rush began March, 1866, and during the same year the first quartz location was made by a Mexican named Guayness.[4]

The first lode said to have been located in the Phillipsburg camp was discovered by Hector Horton in 1865, and was named the Cordoba.

[1] Min. and Sci. Press, Vol. 31, p. 338.

[2] Quotation from the Mineral Resources of the U. S., 1868, pp. 38, 39. Rept. Director of the Mint., 1882, p. 215.

[3] The Mines of the West, R. W. Raymond, 1869, p. 143, etc.

[4] Rept. Director of Mint, 1882, p. 215.

Rich gold deposits were located in the valley of Trout Creek by hunters in 1866.

The Elkhorn district was early prospected, and a number of quartz lodes were located as early as 1869, but it was not until the A. M. Holter lode was developed that the district came into prominence.

The Elkhorn mine was located on the Holter lode on January 2, 1875, and has been the principal producer of the district.[1]

Gold was probably first discovered in the Boulder district on Baboon Mountain in 1864, by two prospectors, John Allen and Barney Hughes.[2]

The Marysville district was opened up first as a placer field in the early seventies, which led to the discovery of ledges which have made the district famous. The first placers worked in this district were at Silver Creek.[3]

The placers of Flint Creek, ten miles south of Drummond Mountain, were worked as early as 1873, while those of Cedar Creek in Missoula County were first located in 1870. It was not until 1895 that an attempt was made to install hydraulic machinery.

When the principal gulches, as the Prickly Pear, Grizzly, and Last Chance, with a recorded yield of some forty million dollars, were exhausted, placer mining in the state practically ceased.

Butte was first known as a placer camp as early as 1864, when the gravels of Missoula Gulch were washed. Owing to the prominence of the quartz ledges they were soon examined and found to contain silver. No great success rewarded these early efforts until the discovery of rich silver ore was made in the Travona in 1876.[4] The ores were shipped to Salt Lake City and attracted the attention of capitalists which led to the opening up of other mines — the Alice mine, in Missoula Gulch, was opened in the following year.

The first railway entered the Butte district in 1881, from which time the development has been steady and rapid.

In 1892, gold and silver mining was particularly prosperous. The Alice mine (silver) was in bonanza. The Drumlummon at Marysville barely paid expenses. The silver-lead mines of Jefferson County were profitably operated. The Cumberland mine had shut down, while the Elkhorn continued to pay large dividends. The Helena and Victor mines of Missoula County were reasonably pro-

[1] U. S. G. S., 22 Rept., pt. 2, p. 411, 1901.

[2] Eng. and Min. Jour., Vol. 60, p. 583.

[3] Economic Bull., 213, U. S. G. S., p. 66.

[4] Ore deposits of the United States and Canada, J. F. Kemp, 1905, p. 200.

ductive. The Boulder region, some 60 miles south of Livingston, has produced some of the most valuable mines of the state.

During 1895, a large dredging plant was installed on Grasshopper Creek near Bannack. Most of the silver-lead mines, especially those of Castle, were quite active.

The silver production of 1897, came largely from the copper-silver ores of Butte and to a less extent from the silver-lead ores of Castle, Barker, and Neihart. Several new ore-bodies discovered in the old Drumlummon mine have revived operations there. The Bald Butte mine of the Marysville district was a good producer. Four dredges were operating at Grasshopper and Alder Gulches, and ordinary placer-workings at Bannack and Helena.

In 1898, although there was an increased production, there were no new developments of importance, while during the following year the production of gold decreased, that of silver increasing.

Successful operations in the Judith district had materially increased the production of gold for the year 1902, while the operations in the silver mines of Fergus County had been retarded owing to the depression in the silver market. Extensive installations of electrical equipment of the Butte mines were under way.

In 1903, the extension of the Montana railway from Harlowtown to Lewistown acted as a stimulant to the gold industry of Fergus County. Both the Drumlummon and Cable mines were still operating. Five gold dredges were operating throughout the season: three at Laurin in the old Alder Gulch placer, one in French Gulch, and one at Bannack.

During 1904, the Whitlace mine was reopened after lying idle for 27 years. In 1905, about four-fifths of the silver came from the Butte copper mines. Fergus County led as a gold producer, the chief center being Kendall. During this year the only placers working were those at Grasshopper and Rattlesnake creeks.[1]

The importance of Montana as a precious metal producer is shown by the record of production for the year 1905; she stood first among the states in the production of silver and fifth in the production of gold.

Nebraska. — This state like most of the central states of the Union has been subject to gold excitements from time to time. However, the most important discovery of gold was that at Milford in 1895 and 1897. There are two possible sources of gold in the state, namely: the glacial drift in the south and east, and that from

[1] Mineral Industry for 1892 to 1905.

the Rocky Mountains on the west. Throughout the drift, especially in the southern counties, there have been found from time to time small quantities of fine gold, and occasionally a pebble rich in free-gold. Unauthentic records of assays give results ranging up to $200. Assays of the gravels at Crete and Milford are reported to have shown an average of $.62 to $5.50 and $8 to $10, respectively. Forty tons of gravel washed under the supervision of Mayor Norris of Crete, yielded $12, approximately thirty cents per cubic yard. The centers of excitement were chiefly Seward, Stanton, and Franklin counties, but it extended also as far as Harlan County. It is reported that one citizen spent at least $1,000 in 1896 prospecting for gold. At Scott's Bluff, in the high terraces of the Platte River, several hundred claims were staked out during the years 1898-99. Lincoln was the center of dry-concentrating apparatus manufacture for these dry placers.

"Gold in minute quantities is occasionally found in the sands of the Platte, Nebraska, and other streams. . . . The minute quantities along our river beds no doubt came from the mountains by drift agencies." [1]

It has been aptly said: "The mineral resources of such a state lie in her soil, from which more gold can be extracted by the plow than otherwise." [2]

Nevada. — The first district to produce free-milling metals in the United States was discovered in this state, the first mines of importance being those of the Comstock lode.

The first discovery of gold in Nevada is credited both to emigrants and prospectors; to the former in the spring of 1849, to the latter in the summer of 1850. However, as the former is authentic history it will be considered as the first discovery of which we have record in this state.

The first settlers to enter the state were Mormons, and settlements were made by them as early as 1848. The gold excitement of 1848 attracted Mormons, as well as others, and considerable numbers went to California from Salt Lake City. In 1849, a party of Mormons, while camping on the Carson River at McMarlins' Station waiting for the mountains to become passable, panned some of the sands of Gold Cañon, and to their surprise discovered gold. On passing on to California later they reported to the miners of Placer-

[1] Sketches of the Physical Geography and Geology of Nebraska, Samuel Aughey, 1880, p. 316.

[2] Eng. and Min. Jour., Vol. 67, p. 408.

ville that one-half ounce diggings were to be found on Carson River. Immediately prospectors crossed the mountains and worked the gravels, but the gold was low-grade owing to the presence of silver. It was not until about 1852-53 that much interest was felt in the discoveries.[1] The following account possibly relates to the same event, although probably it was an independent discovery.

In May, 1850, two prospectors, by name Prouse Kelly and John Orr, set out in the first wagon train leaving for California; while stopping to rest on the bank of the Carson River, Kelly took a milk pan and washed some of the gravel and found values worth a few cents in a few minutes' work. He then named the place Gold Cañon, which name it still retains. This is claimed to be the first discovery of gold in Nevada. It is further related regarding Kelly and Orr, that later, returning to the place to prospect, they found a gold nugget worth about $8.25 at a point further up the cañon. This latter discovery was in June, 1850.[2]

According to Degroot:[3] "Gold mines of considerable richness have been worked since 1850, at various points along Carson River, and recently silver ore of unexampled value has been found, extending over a large scope, the area of which is likely to be augmented by further explorations."

In 1857, gold was discovered in Six Mile Cañon, the next large cañon north of Gold Cañon; the gold discovered here was at a point about a mile below the location where silver was first found. Thus the search for gold was leading the prospectors slowly but surely toward the Comstock lode.

In January, 1859, three prospectors, James Finney (or Phinney — known as "Old Virginia"), John Bishop and H. T. P. Comstock, were prospecting up towards the head of Gold Cañon, near the present site of Gold Hill, and happened to begin operations upon the decomposed outcrop of what was later known as the Comstock lode. They, however, thought it was a gold placer and worked it quite profitably as such, making from $5 to $25 per day. Although this was on the famous silver lode, yet, as subsequent operations showed, the silver ore was at least 300 feet below the surface at this point.

Peter O'Reiley and Patrick McLaughlin were also working on Gold Hill, but in a low depression at the head of the Cañon. Later, they went above all signs of previous work and began prospecting.

[1] Eng. and Min. Jour., Vol. 52, p. 637.
[2] Min. and Sci. Press., Vol. 40, p. 342.
[3] Twelve Years in the Mines of California, 1862, p. 79.

Their success was small, however, and as was customary, a ditch was cut up the slope with the hope that the gold might increase in quantity — it decreased instead. Being in need of water they proceeded still further up the slope and dug a pit in which to collect it, but were forced to dig deeper than they previously had, and so by mere chance came to the rich black sulphuret ore in the decomposed cropping of the Comstock lode — thus was the Ophir mine discovered. The gold occurred in the loose, decomposed mass in small grains and flakes, being both light in weight and color. So rich was the material that they were soon washing out as much as $1,000 a day with rockers.

The prospect proved to be a puzzle to them, both with regard to the peculiar black appearance of the material and its shape, being angular instead of rounded like ordinary gravel. They finally concluded that it was not gravel and proceeded to stake off claims — one each of 200 by 300 feet, and an additional one by right of discovery. About this time, Comstock came along, and on seeing the prospect and the gold it yielded, suspected a big strike; then, as was characteristic of the man, he immediately determined to acquire a share of it for himself, which he shortly succeeded in doing by laying claim to the ground upon which it was located together with the spring and practically everything in sight. He also demanded an additional 100 feet for an assumed water right and lastly a share for a friend, Emmanuel Penrod. Fearing trouble, a compromise was effected embodying all of Comstock's claims, whereupon he at once became to all intents and purposes the chief owner and spokesman for the company, and although the mine had already been named the Ophir, mine and lode were known as the Comstock, which name has ever since clung to the lode.[1]

A claim is made for the Grosh Brothers, Allen and Hosea, sons of a Universalist clergyman, as the possible first discoverers of the famous silver lode. They arrived in San Francisco harbor on the 30th of August, 1849. They found their way to Gold Cañon in 1853, but meeting with discouraging results, returned to California the next year. However, they returned to Gold Cañon in 1856, and in a letter dated the 3d of November, 1856, they said: "We found two veins at the forks of Gold Cañon. . . . One of these veins is a perfect monster." And later: "We have hopes almost amounting to certainty of veins crossing the cañon at two other points." Again quoting from a letter written by Allen while at Gold Cañon: "Our

[1] Eng. and Min. Jour., Vol. 52, p. 637.

first assay was one-half ounce of rock; the result was $3,500 of silver to the ton, by hurried assay, which was altogether too much of a good thing . . . We are very sanguine of ultimate success."[1] Notwithstanding this remarkable and extraordinary evidence as to their right to the discovery, no definite and conclusive evidence other than this written word is extant, and when due consideration is given to the excited state of mind of most of the early prospectors, it is well to take such statements with a grain of allowance.

It is possible that the discovery of Comstock lode dates further back than the date given above, for there was a persistent report in the early days of work having been done there. It is claimed that the early pioneers to this section found Mexicans engaged in working the gold veins on Gold Hill and operating a number of arastras, which was carried on as late as 1857 — two years prior to O'Reilly's and McLaughlin's discovery. The reason why these early workings have not since been discovered, if they ever existed, is accounted for by a Mexican who said that the mine was owned by one Moldonado and was worked by Savariano, the ore mined being so rich that the amount carried by a single mule was worth from $1,000 to $1,200, and was packed to California. It was found one morning that Savariano had decamped between suns with a pack train of ore, and had so carefully concealed the locality of the mine that it has always remained undiscovered.[2]

There is another story regarding the manner in which Comstock acquired a share in the Ophir property;[3] however, from the information at hand the above account seems the most plausible.

With regard to the first assay of the Comstock ore, and by whom made, thus establishing its identity and value, there is also much controversy. We will, however, cite what appears to be a reasonable statement, referring the reader to the other claims from which he can draw his own conclusions.[4]

It is claimed that the first assay of the ore from the Ophir mine was made by Mr. Melville Atwood, of Grass Valley, on June 27, 1859, at the request of Judge Walsh, who had received the ore from a Mr. Stone, it having been brought from the Comstock by B. A.

[1] Mrs. L. M. Dettenrieder, Virginia City, Nevada — Letters of.

[2] Min. and Sci. Press, Vol. 34, p. 290, and Vol. 33, p. 65.

[3] Rept. upon the Mineral Resources of the States and Territories west of the Rocky Mountains, 1867, p. 88.

[4] Min. and Sci. Press, Vol. 45, p. 392, Ibid. Vol. 46, p. 266, and Ibid., Vol. 46, p. 354.

Harrison. The results showed a value of $3,000 in silver and $876 in gold. To verify these results, Mr. Stone took some of the ore to Nevada City where it was assayed by J. J. Ott, on July 28, 1859. Although there was considerable difference in the two assays, the extreme richness of the ore was manifest and a mad rush ensued.

The following extract from a letter written in Virginia City in April, 1860, gives an idea of affairs at that time:

"Of a certainty, right here, is Bedlam broke loose. One cannot help thinking, as he passes through the streets, that all the insane geologists extant have been corraled at this place. Most vehement is the excitement. I have never seen men act thus elsewhere. Not even in the early stages of the California gold movements were they so delirious about the business of metalliferous discovery. Hundreds and thousands are now here who, feeling that they may never have another chance to make a speedy fortune, are resolved this shall not pass unimproved." [1]

In 1859-60 an early winter set in and a severe one, practically stopping all work on the Comstock lode, and as a further set-back, an Indian war broke out. It was not until the spring of 1861 that the work of mining was actively resumed, following which came a period of uncertainty and a reaction set in. Not until the discoveries and excitements of the Reece River district occurred did the work of prospecting and development on the Comstock lode become active again. The stampede to the White Pine district, coming at about this time, marked the culminating point in vein-mining excitements of the period.

The Buena Vista, Eldorado, and Gold Run districts of Humboldt County were organized in 1861, 1862, and 1866, respectively.

The direct result of the discovery of rich mineral in Nevada was an increase in population, which was, of course, localized at Virginia City; the indirect result was the exploration and development of the surrounding country, which would not have been done so effectively in scores of years had it not been for the great and permanent attraction of the Comstock lode. In 1860, the silver districts of Esmeralda, Potosi, Coso, and Humboldt were discovered, together with others of less note; however, the Comstock was the center of attraction and became the home of a large and excited population.

Ore was first discovered in quantity in the Eureka district in

[1] Report upon the Mineral Resources of the States and Territories West of the Rocky Mountains, 1867, p. 28.

1863 or 1864, and at a point near the "76" mine in New York cañon. The deposit was worked to a depth of 48 feet between 1857-63. The first claims were very rich but were soon exhausted and were shortly abandoned. The district lay idle until about 1868-69, when work was resumed on Mineral Hill.[1]

The Eureka mine was first located on February 7, 1851, and closed in 1877, but was not developed to any extent until 1863 or 1864, only an 8-foot pit having been sunk. The mines at Pioche were first worked in the seventies, when no attempt was made to save any but the gold and silver values. It is claimed that the copper values left in the mine and on the dumps exceeded those recovered in gold and silver.[2]

The first discovery in the Esmeralda district occurred on August 22, 1860, and was made by three prospectors: James M. Brady, J. C. Corey and E. R. Hicks. The first discovery of ore at Aurora was made in 1862, and in a few months fully 16,000 people were on the ground; however, the excitement did not culminate until 1863, the boom holding on until 1864. In 1882, a New York company purchased the Cortez mine on Silver Hill and began active developments which resulted in the uncovering of several bonanzas. These mines produced both gold and silver.[3]

The White Pine district was organized in 1865, although it was not until two years later that it became the scene of a great excitement due to the discovery of the rich mines of Treasure Hill. It is reported that an Indian offered to show the miners a place where ore similar to that mined at the Monte Cristo could be found in abundance, and forthwith guided them to Treasure Hill where the Hidden Treasure mine was located on September 14, 1867. The abundant covering of white pine timber gave White Pine mountain its name. The discovery of the Keystone and Eberhardt deposits followed immediately after that of the Hidden Treasure.[4]

Regarding the Pahranagat district, Lincoln County, Raymond said in 1870: "The developments in this district are both costly and extensive, but have been conducted with such conspicuous absence of skill and common sense, that they may be said to have produced hardly any results whatever." The excitement following the

[1] U. S. G. S., Monograph VII, p.3, and Bean's Directory of Nevada.

[2] Min. and Sci. Press, Vol. 35, p. 8, and Bean's Directory of Nevada.

[3] School of Mines Quarterly, Vol. 3, p. 133, and Min. and Sci. Press, Vol. 36, p. 296.

[4] The Mines of the West, Raymond, 1869, p. 85.

development of the White Pine caused most of the mines to be abandoned.

The principal districts in which mining was carried on in 1881, and for the following five or ten years with a large increased production from development therein, were: the Elko mines in Tuscarora; the Northern Belle in Columbus district; the Gold Mountain district; the Richmond mine, Eureka district; the Keystone mine, Central district; the Starr-Grove mine, Lewis district; the Mayflower mine, Bristol district; the Raymond and Ely mine, Pioche district; the Belmont, Monitor, El Dorado, etc., Gold Park district; the Star mine, Ward district, etc.

Between the years 1866 and 1868, the Battle Mountain and Columbus districts were organized, while the Eberhardt, Lander County, was located by prospectors in December, 1867.

In May, 1900, J. L. Butler while prospecting near Klondike discovered the outcrop of the Mizpah vein from which he took samples, but not liking the looks of them and not having much money decided to have them assayed on shares. They were given to T. L. Oddie, a lawyer and also manager of the Stokes mine at Austin; Oddie in turn gave the sample to W. C. Gayhart with a similar promise. Gayhart at once pronounced them worthless and threw them away. However, on discussing the matter with Butler later, Oddie decided to have an assay made, which was done at Austin, with the result that high values in gold and silver were shown. Butler and Oddie then went to the scene of the discovery and staked out claims; with them was Wilse Brougher who furnished tools and provisions necessary for prospecting. The cash assets of the three on reaching the place was $25. This was in August, 1900; in October, they leased the property at 25 per cent royalty. During the early part of 1901, mining operations were actively carried on, and the district began to come into prominence. The eight claims owned by this company were bonded by O. A. Turner for $336,000, cash $50,000 being paid down.[1]

The occurrence of piles of quartz makes it evident that Mr. Butler was not the original discoverer of the district, and as the monuments are old, the locality must have been prospected many years ago, but by whom remains a mystery.

The district was named Tonopah by its discoverer, being Shoshone for " water bush." Eight ledges were known in 1901, which

[1] Min. and Sci. Press, Vol. 86, p. 338, and Ibid., Vol. 88, p. 364.

with others discovered later are arranged into three groups: first, the Butler; second, Gold-Hill; and third, the Clifford.[1]

The development of the district by a system of small lease-holds has proven to be a great bonanza for the lessees.

Float gold was discovered on Columbia Mountain in the fall of 1902 by Harry Stimler and William Marsh, at which time the Sandstorm and Kendall mines were located, the former being staked in December. As the deposits discovered were not especially promising, most of the miners left the district for the winter. A. D. Mayers and R. C. Hart remained behind, however, and on May 24, 1903, had located the Combination lode, beginning development work at once. This stimulated prospecting, but it was not until the summer of 1904 that ore was being shipped from the district, the principal producers being the Jumbo, Florence and January mines. Thus were the districts of Goldfield and Bullfrog opened up: Goldfield is in the southwestern part of Nevada, and was first called "Grandpa" district; while Bullfrog is situated in Nye County, also in the southwestern portion of the state and south of Goldfield. The original Bullfrog mine, which gave its name to the district, is about three miles west of Rhyolite.[2]

In 1892, there was a serious decline in the production of silver owing to the depreciation of that metal. The depression was especially keenly felt at the Comstock mines, at Eureka, in the Cortez, White Pine, and the Tuscarora mines.

The Diamond was the only producer of importance at Eureka, while in Esmeralda County, the Mount Diablo mine began operations near the end of the year. The litigation which had tied up the Indian Queen and Poorman mines for a number of years, having been settled, work in them was resumed.

During the year 1893, a notable discovery was made, being the De Lamar mine, Lincoln County — this mine has had a marked influence on the gold production of the state, which was felt as early as 1895. In 1897, the De Lamar mines led in the production of gold in the state. However, in 1899, the Tuscarora and Philadelphia mines also contributed to the production of gold; and during the same year an important strike was made in White Pine County at the Chainman mine.

In 1900, the introduction of electric power into the Comstock

[1] Min. and Sci. Press, Vol. 83, p. 192.

[2] U. S. G. S. Economic Bull. 303, 1907, p. 8; the Min. and Sci. Press, Vol. 90, p. 393, and Ibid., Vol. 90, p. 273.

mines was begun. The development of the Tonopah Lake district, Nye County, was stimulated by a system of leasing whereby small leases could be operated profitably.

The year 1902 showed considerable activity in the installation of mine and mill equipments, which was especially noticeable at the De Lamar mine.

In 1905, the Tonopah district was the most important in southern Nevada, the Tonopah mine being the best in the district, the Montana coming next.[1]

Nevada entered the Union in March, 1864, and is known as the "battle born state." During the ten years following the entrance into statehood, Nevada could boast of containing within her borders the most prosperous mining camps on earth — the Comstock lode became the greatest "Mining School" in the world. Bonanzas were discovered at Virginia City, Reese River, Aurora, Eureka, White Pine, Pioche, Tuscarora and to a less extent at Cornucopia and Candelaria. During recent years the De Lamar, Tonopah, Goldfield, Bullfrog and various minor districts have been the chief producers.

The history of mining and especially silver mining in Nevada, is in some respects a peculiar one owing largely to the irregular character of the ore-bodies worked. The growth of the mining industry has, however, been continuous, but far from uniform; the production, at times, meager, at other times, reaching stupendous proportions, the average being normal and taken by periods showing a marked increase, while the development has been sporadic and in many cases used more as a means to manipulate the stock market than to prove ore-deposits and put the mines on a paying basis.

New Hampshire. — The presence of gold in certain rocks of the state has been known for some time, but has usually been found in such small quantities as not to warrant any attempt at extraction. Gold was discovered in the Townships of Franconia and Lisbon, north of Mount Washington and on the lower Ammonoosuc River as early as 1866.[2] The Eaton lode was discovered in 1826,[3] and yielded lead-silver ore. The Ammonoosuc gold field has been described by Professor C. H. Hitchcock as auriferous slates and schists occurring along the Connecticut River, and lying mostly in New Hampshire.

[1] Mineral Industry for 1892 to 1904.

[2] American Jour. of Min., Vol. 2, p. 386.

[3] Whitney's Metallic Wealth of the United States, 1854, p. 389.

Up to 1877, a production of $50,000 is reported to have been made by the Dodge vein in eastern Lyman. The Lisbon, Cook and Brown mines yield both free-gold and auriferous mispickel, but were not of much importance as producers of the precious metals.[1]

New Jersey. — The Bridgewater copper mine of this state is said to have yielded considerable native silver. This mine has not been operated for years as far as we can learn, but there is a family tradition to the effect that the ores obtained from it by Aarent Schuyler contained sufficient silver to cover the cost of smelting abroad, and that some of the silver was always returned to the United States in the shape of English coin.[2]

New Mexico. — The mines of this Territory are among the oldest in the United States, having been worked under the Spaniards as early at least as the 15th century, but owing largely to their inaccessibility they have not been developed as much in proportion to their importance as have most of the other precious metal-bearing districts of the country.

The first gold mined by white men came from placers, which were worked on both sides of the Rio Grande, especially in Sierra County, also at San Xavier, Santa Rita district. The Santa Rita was a flourishing gold-producing district in 1770, being known to the American prospectors as the "Pot Holes," but was formerly known as San Dyonisius and later included in the Mission of Concepcion.[3] Gold-bearing lodes were discovered at Pinos Altos as early as 1866.

The mines of Silver Lake were discovered in August, 1878, by G. W. Lufkin and were worked practically continuously until 1893. It is remarkable that these ore-bodies were not discovered by the Spaniards, occurring so close to the surface — nevertheless the Spaniards passed by them for three centuries apparently without suspecting their presence.[4]

The principal gold-bearing counties are: Grant, Doña Aña, Lincoln and Socorro, besides both gold and silver were found in Santa Fé, Bernalillo, Colfax, and Taos counties. The famous placers of Bernalillo and neighboring counties have yielded large quantities of gold, and their exploitation has disclosed the occurrence of rich gold and silver lodes in the mountains bordering the Cerrillos district. Before the discovery of gold in Pike's Peak country, Colorado, gold

[1] U. S. G. S., 16 Annl. Rept., pt. 3, p. 329, 1894–95.
[2] Eng. and Min. Jour., Vol. 33, p. 90.
[3] Min. and Sci. Press, Vol. 81, p. 280.
[4] T. A. I. M. E., Vol. 24, p. 138.

had been found near Taos, being known to army officers stationed at old Fort Massachusetts and other posts.[1]

The principal gold- and silver-producing districts in 1881 were as follows: the Chloride, Georgetown, Burro Mountain, Virginia, Lordsburg, Lone Mountain, Hillsborough, Organ Mountain, Magdalena, etc.

As late as 1892, conditions in the mining camps of New Mexico were not encouraging; however, considerable work was done, especially in the Pinos Altos district, which led in gold production. The Old Abe mine, which gave promise of being a good producer, was being developed during the year. Considerable ore was mined at Cook's Peak.

The principal mines operating in 1894 were the Grande, Bella and Apache; during this and the following years, although work was actively carried on in the Cochiti and other districts, there was no adequate increase in production.

In 1899, the Cochiti district came to the front and it was proposed to open up the San Pedro grant.

The Sierra de Mogollon mining properties were being developed in 1902, while large bodies of medium-grade ore were reported in the Black Range and the Sierra Blanca. In spite of considerable development in both new and old districts, the gold production showed a steady decrease for a number of years, being still low in 1904.

The dredging operations on the Moreno placers, Colfax County, especially with the El Oro dredger, were very successful. Other counties producing placer gold were: Grant, Sierra, Santa Fé, Taos, Lincoln and Socorro; while the richest gold mining districts were the Mogollon, the Red River and the Elizabethtown.[2]

In 1905, gold dredging had become a fixed and profitable industry.

New York. — Gold occurs in a number of countries in New York State, which have been arranged into four districts as follows: first, Hamilton, Fulton, Saratoga, Herkimer and Washington; second, Dutchess; third, Westchester and Rockland; and fourth, Erie and Alleghany. Gold is also found on Manhattan Island.[3]

No record is at hand as to when the presence of gold in the state was first discovered.

Argentiferous lead deposits occur in the metamorphic rocks of

[1] Rept. Director of Mint, 1882, p. 339, etc.

[2] Mineral Industry for 1892 to 1905.

[3] Annual Rept. Am. Inst. City N. Y., Vol. 25, p. 827: Am. Jour. Sci. and Arts, Vol. 47, p. 139; and Am. Jour. Min., Vol. 6, p. 370, 1868.

Columbia, Dutchess, Washington and Rensselear counties. Probably the most important mine was the Ancram or Livingston, in Columbia County. Further, lead mines were prospected for by German miners southeast of Pine Plains, in Dutchess County, as early as 1740. Following and, in fact, during the Revolutionary War limited mining operations were undertaken by the Committee of Public Safety, in an endeavor to supply the army with lead. This ore is said to be rich in silver.[1]

Ohio. — Gold occurs in glacial drift in this state also. Old miners claim to see a marked resemblance in the channels and general occurrence of gold here to those of California, the floor of the gravel beds often being rough and in most part covered with considerable depth of gravel. In 1868, gold to the value of $17 was taken from the drift north of Brownsville in Bowling Green Township — the largest particles were the size of wheat grains.

Regarding gold in Licking County, Professor Andrews reports the quantity to be small, but quite uniformly distributed, as nearly every panful washed showed colors. The gold comes mainly from the clay, sands, and gravels of small streams that cut a range of terraces extending along the Licking River. It is also stated that gold was found in quartz.

Professor Orton writes (Folio 71): "A few years since, the Clermont gold mines attracted a short-lived notoriety . . . Clermont County has no monopoly of the gold-bearing formations of Ohio . . . This formation should be called the drift gold field rather than the Clermont gold field."[2]

Gold has also been found at Bellville, in southern Richland County, while about 1898 gold was discovered at Malvine, Carroll County, in an old Indian cave. Here the gold occurred in a yellow sandstone.[3] Nothing more substantial than excitements have resulted from the discovery of gold in this state, and it is safe to predict that future and past history will concur in this respect.

Oklahoma. — What was formerly the Indian Territory,[4] but

[1] Whitney's Metallic Wealth of the United States, pp. 394–396, 1854.

[2] Rept. Geol. Survey of Ohio, Vol. 1, Folio 462, and Ibid., 1874, Folio 70.

[3] Trans. Lake Superior Inst. Min. Engrs., Vol. 5, p. 57.

[4] Gold in small quantities has been found in the Wichita Mountains situated in that part of the Indian Territory which was later known as Oklahoma. Mining excitements have from time to time brought numbers of people to this locality, the latest and probably most extensive movement having taken place during 1902 and 1903. U. S. G. S., Mineral Resources, 1887, p. 730, and Ibid., Bull. No. 225, pp. 120–122, 1904.

later (in 1907) united with the territory of Oklahoma to form the state Oklahoma, yields no gold or silver, no trace of either having been reported to our knowledge.

Rumors of the existence of rich gold and silver mines, especially in the Wichita Mountains, have been circulated for many years and have been largely responsible for much prospecting in the district.

Legends of Spanish mines and miners are connected with this locality as with many others of the Mississippi Valley, and are largely responsible for the constantly recurring periods of excitement which come to those resident in the region, the subsidence of which leaves disappointed and embarrassed individuals.

Owing to considerable friction growing out of the filing of mineral claims on settlers' land, the United States Geological Survey undertook, in 1903, to ascertain the truth regarding the occurrence of gold in these hills. The result of tests on samples taken showed no trace of gold, and later samples of ore, collected by those interested in the so-called Beam process of gold extraction, were taken to Washington and assayed with similar results. It is evident that if gold does exist in the rocks of the Wichita Mountains it is in such small quantities as to be of no economic importance.[1]

Oregon. — Auriferous gravels were discovered in this state shortly after gold mining began in California. Gold was discovered in Josephine County in 1851, and placer mining was actively carried on along the Applegate, Illinois, Josephine, and Galice rivers. It is estimated that fully $9,000,000 in coarse gold were obtained during 1851-55. Much of the gold subsequently obtained from mining operations came from the ancient river channels, the occurrence being similar to that in California.[2]

The Bohemia mining district of western Oregon was discovered in August, 1858, by Dr. W. W. Oglesby and Frank Brass. The region was named after James Johnson, called Bohemia Johnson, who with George Ramsey explored it by way of the North Fork of the Umpqua River and Steamboat and City creeks in 1863. The free-gold was soon exhausted and in 1891 the Musick ledge, the first of importance, was located.[3]

The discovery of gold in the Blue Mountain district did not occur until the fall of 1861, when it was found by a prospector named

[1] Eng. and Min. Jour., Vol. 76, p. 896, and Vol. 77, p. 148.
[2] Eng. and Min. Jour., Vol. 74, p. 582.
[3] U. S. G. S., 20th Rept., pt. 3, p. 7, 1899.

Griffin, who with others was prospecting the Powder River and its tributaries. The discovery was made in Griffin Gulch southwest of Baker City. The rich placers of Auburn were located in the following year by D. Littlefield and several others, while prospecting in the neighborhood, and in the same year the John Day's River placers were discovered. Quartz mining followed soon after, the Virtue mine being discovered in 1862. Ten years later the Connor Creek mine was located.

Lack of facilities in transporting supplies and ore was responsible for the slow development of quartz mining, and it was not until about 1885 that the mining industry took on new life, owing to the construction of the transcontinental railroad. In 1886, several valuable discoveries were made in the Eagle Creek Mountains at a point near Cornucopia.[1]

The Annie, now the Noonday, mine was located and opened in 1892.

The gold-beach deposits of Oregon are among the richest on the Pacific coast, the two most important locations being at the mouths of the Coquille and Rogue rivers. The former is in the southwestern part of the state, the gold occurring with platinum, while the latter were once among the richest placers in the state.

The principal gold mining sections in 1892 were in the southwestern part of the state, Baker and Union counties being the most progressive. At this time the Monumental, a silver mine, Baker County, was the only one equipped with a stamp mill; however, the Champion installed a 10-stamp mill in 1895. The production of both gold and silver showed a marked decrease, which was followed in 1896 by an increase in gold production, due to the Baker City mines and both the quartz and gravel mines of the southern part of the state. During the following year the Baker City mines were still the chief producers of gold.

In 1898, the production of gold fell off again. Dredging operations on the alluvial gold deposits were begun in 1899.

A new property, the Oregon King, was opened up in 1901, south of the North Pole and Galconda mines, which are the two largest producers in the district. Placers were also operated in Josephine County, but were reported as exhausted in 1902.

Considerable development work was done in the Sumpter district during 1902, which is one of the richest districts in the state.

In 1904, interest was centered principally in the Cornucopia

[1] U. S. G. S., 22nd Rept., pt. 2, p. 563, 1901.

camp some 60 miles east of Baker City. During this year attention was turned to placer mining in southern Oregon.[1]

Pennsylvania. — Lead-silver mines with some gold are worked in Montgomery and Chester counties.

A mine in Chester County was opened in 1850, following which a number of other mines were developed.[2] Gold was found in the clay underneath the city of Philadelphia in 1861. The clay bed has an extent of 3 square miles and averages probably 15 feet in thickness. The gold-content, based on samples assayed, is 1 to 1,224,000 by weight.[3]

Porto Rico. — Evidences of early or prehistoric mining in these islands are lacking, although the presence of certain of the metals was known to Ponce de Leon in the early part of the sixteenth century. Probably mining by the Borinqueños or their Spanish conquerors was done only in the most primitive and desultory way. As early as 1788, gold was sent to Spain and was probably obtained from river washings by slaves.[4] However, as early as 1530, following the great hurricane, the statement is made that the mines were all submerged by the overflow of the rivers.[5]

The following is an extract from a report on Porto Rico:[6] "Gold placers were worked for some years by the Spaniards in the first century of the conquest, and, according to official statistics, 2,700 pounds of gold were sent to Spain from the year 1509 to the year 1536. It is believed that that figure only represents the part belonging to the crown of Spain — that is to say, the fifth of the total production during that period of time.

"The Sierra de Luquillo, the more abrupt and the highest of all the mountains in Porto Rico, belongs to the main cordillera, or chain, which cuts the island from east to west, with a prolongation to the Windward Islands, by the east, and to the little island of Desecheo, situated opposite to Mayaguez and Añasco, by the west. That mountain, or sierra, is in the northeastern part of the island, and owing to its situation and the elevation of its hills — the highest being El Yunque, 1,200 meters (3,937 feet) above sea level — is

[1] Mineral Industry for 1892 to 1905.

[2] Whitney's Metallic Wealth of the United States, 1854, pp. 328, 396–398, and U. S. G. S., Mineral Resources, 1887, p. 784.

[3] Sci. American, n.s.v. 247, and Gold, Its Occurrence and Extraction, A. G. Lock, 1882, p. 181.

[4] History of Porto Rico, Fray Iñigo, 1788.

[5] Special Rept. Census Office, Mines and Quarries, 1902, pp. 1075, 1076.

[6] Second Ann. Rept. of Governor of Porto Rico to the President of the U. S.

the first vessels can distinguish in coming to Porto Rico. From El Yunque and the hills named Cuchilla Firme, Meseta, Peña, Parada, and others, various rivers flow in which gold has been found. The Mameyes, one of the richest in gold, has as tributaries the rivulets known as Filipina, Cajones, Guaraguao, La Mina, La Máquina, Tabonuco, and Anon. In this last named, the Anon, some thirty-eight years ago a rich concern did some work in the washing of sands or auriferous alluvia, obtaining from one to two pounds of fine gold per day. The rocks more abundantly found in the watershed of Mameyes River are eurite and porphyry, crossed with veins of quartz and iron pyrites. The alluvial lands occupy a good extension of the middle and lower parts of these watersheds, and are composed of clay, sand, and bowlders, forming deposits of analogous nature. Their depth is variable. In the valley of the Anon there are some cuts, from six to eight meters (20 to 26 feet) deep, made in such alluvial deposits with the view of exploiting the auriferous strata.

"It is known that the watershed of the rivers Corozal, Negros, Congos, Cibuco, Navilla, and Manatí contain auriferous sands. The idea which occurs to one examining the vicinity of Corozal is that that valley was emptied, through a process of erosion, by the diluvial waters, which produced in the calcareous soil cuts more than 130 meters (427 feet) deep, through which ran a stream. It is believed that the waters of that stream deposited the quaternary alluvia. The calcareous soil, said to be of the Tertiary formation, occupies the right shore of the river and extends itself by the north toward the sea. On the left shore, and in the bed of the river, the limestone has disappeared, giving place to potent strata of sandstone, on which the auriferous quaternary alluvia lay. The alluvial deposits are more potent the lower they are, and gold is found very near the surface in the higher and hilly parts, while, on the contrary, in the great deposits of the lower parts of the valley the auriferous strata are covered by sterile masses. Near the source of the Congos River, in the bed of it, and 25 centimeters (9.8 inches) deep, some pieces of quartz have been found containing from 8 to 10 grams (123 to 154 grains) of pure gold. In the jurisdiction of Corozal some washing machinery was established, and the result was from $2.17 to $4.30 for each ton of sand.

"There are also, according to official information, some gold placers in Mayaguez, San German, Yauco, and Coamo. The gold is found in grains or nuggets of $2 or $3 value, and, rarely, nuggets of even higher value. In the Fajardo River a piece was found which weighed 4 ounces, and in the Congos another piece of 1 pound was also found; but the biggest piece of pure native gold was discovered in the lands belonging to Mr. Bou, in the jurisdiction of Corozal. That piece was sold to Mr. Bou by the finder for $200 in money and some other valuable things. In the bed of the Filipina rivulet there were obtained from 60 kilograms (132 pounds) of sand, six-tenths of a gram (9 grains) of pure gold, which make 10 grams (154 grains) for 1 ton of sand. The enterprises mentioned were abandoned, and the only work on the mines was done by the " lavadores," washmen. They use an instrument called " gaveta," made of wood, shaped like a plate, of 40 centimeters (16 inches) in diameter and 12 centimeters (5 inches deep). In the watersheds of Mameyes River and in all the rivers crossing the jurisdiction of Corozal, numbers of peasants can be seen engaged in the work of washing auriferous sand, from which they obtain gold in amounts sufficient to pay for their support.

" Since the American occupation, work on the mines has had renewed life, and the number of applications for mining concessions filed in the Bureau of Agriculture and Mines has increased. Up to July, concessions have been granted for 107 hectares (264 acres) of land.

" The existence of silver in the island has been officially recognized. On July 19, 1538, the ' oficiales reales ' wrote to the King of Spain that ' veins of lead containing some silver have been found,' and on March 29, of the following year they wrote, ' With respect to the silver mines here discovered we arranged that that mineral be fused here, but there is no person who knows how to do it. In some places veins of that metal have been found, but nothing has been done, waiting the arrival of some one who knows how to fuse and work it.' In the ' History of Porto Rica,' by Fray Iñigo Abad, with notes by Don José Julian Acosta, the statement is made that in the Serrania de Añasco there was a mine containing silver; and in a report prepared in 1879 by the chief engineer of the bureau of mines, reference is made to certain samples of silver found in the barrio Llamos, of the municipality of Isabela. In other official documents the existence of silver in the northwestern part of the island is affirmed. Concessions have been made of silver mines in Naguabo, Corozal, Rio Grande, Fajardo, Lajas, and Las Piedras."

In a report on Cuba and Porto Rico, by Robert T. Hill,[1] the

[1] U. S. G. S., " Cuba and Porto Rico," Robert T. Hill.

following brief statement is made: "A little placer gold is found in the rivers of the Sierra Luquillo and Corozal, . . . Gold was formerly mined by the early Spanish settlers and is still taken out in small quantities by the natives."

South Dakota. — The exact date of the beginning of mining in the Black Hills of South Dakota is unknown, but from relics such as stone walls, remnants of log cabins, picks and spades, skeletons, excavations and inscriptions cut in rocks, it would seem to indicate that this locality was visited as early as 1852, or earlier.[1] However, gold was actually known to exist in the Black Hills as early as 1868, which fact is mentioned in an early report by Hayden. Further, it is very probable that gold was known to traders in the Hills, who of necessity came in contact with the Sioux. The Indians tell that Father De Smet, a Jesuit priest who spent much time with them, cautioned them against showing gold or making any mention whatever of it to white men, which, if true, showed his wisdom and thoughtfulness of the Indians' welfare.

In 1874, a half-breed Indian exhibited at an Indian agency (Fort Larmie, Wyoming) a few grains of placer gold which he had collected and placed in quills. He stated they were found in the eastern foothills of the Black Hills. During the following year the rush to the Hills began and was swelled to still larger proportions after the discovery of Deadwood Gulch in 1876.

The first gold discovered by the miners was in Custer County, on French Creek, but the returns were small and did not warrant extensive working.[2]

Although the Black Hills were included in an Indian reservation until 1876, yet, notwithstanding, large numbers of men defied both law and Indians and penetrated to the heart of the Hills, and the persistent demands of the miners were largely responsible for its opening.

Besides the placer at French Creek others were located on Spring, Battle, Castle and Rapid creeks. The Goldon party while searching for lost or stolen horses entered what is now known as Deadwood Gulch, and there found a gold bar, about one and one-half miles above the present site of Deadwood City. This turned out to be one of the richest strikes yet made.

A search for quartz lodes soon followed, and ultimately led to the discovery of gold in outcrops of the hard ferruginous conglomerate. The Manuel brothers were among the first to look for quartz

[1] Min. and Sci. Press, Vol. 36, p. 370.

[2] Min. and Sci. Press, Vol. 90, p. 391.

deposits, and in 1876 located the Homestake on the western side of Gold Run, on an outcrop of deep red quartz.[1] This was so low in value as to cause little comment; to them, however, it seemed good and they therefore called it "Homestake," and it has proven to be an eminently fitting appellation.

Owing to loose and ill chosen methods of mining, disastrous caves occurred, which danger was reduced to a certain extent by the use of square-set timbering, and in 1878 the open-cut system was adopted where possible in the Homestake mines.

Silver was found in Dakota contemporaneously with gold, but as gold could be obtained much more readily than silver, the former was disregarded, except for the location of claims. However, on the exhaustion of many of the gold-bearing lodes the silver mines began to be opened up.

The discovery of the Ragged Top district of the Black Hills was made by a prospector, who discouraged, with much hard, useless work, made a last try as a "drowning man catching at straws," and had samples of the bowlders assayed and was astonished to find they were high-grade ore. This was all the more surprising, seeing that the district had been both traveled across and prospected for years by miners without number.[2]

The "cement deposits," which are undoubtedly gold-bearing gravels cemented into a conglomerate, are located near Central City, and as late as 1880 were worked with considerable profit.

In 1881, gold and silver mines were worked on Bald and Green mountains about seven miles distant from Deadwood. The Philadelphia Bar above Pactola, and Stockade and Swede bars below, have been profitably worked. These mines are in Pennington County, while in Custer County a number of hydraulic mines were in operation.

During 1892, mining in South Dakota was very active and many low-grade ores were being developed. The Big Missouri, the Hawkeye and Minnesota mines of the Homestake belt were started. Between 1892-95 the mines lost ground to a certain extent from the standpoint of production, but by 1896 the production had increased considerably, due to the operation of both amalgamation and chlorination mills. The production for 1897-98 was augmented by activities in the Black Hills. The Holy Terror mine at Keystone made a phenomenal yield.

[1] Min. and Sci. Press, Vol. 90, p. 391.
[2] T. A. I. M. E., Vol. 29, p. 225.

The year 1900 was noted for the great activity in construction of cyanide plants. The output during 1901-02 was increased owing to the operation of both old and new mines, and to the improved equipment. Up to the close of 1905, mining operations had been actively carried on, although gold mining especially was confined largely to the Black Hills, which occupies an area about 40 miles wide by 80 long. In 1905, properties were being developed in the southern Hills.[1]

Tennessee. — The many relics of mining operations in the shape of tools and workings on copper, lead and zinc veins in the state would seem to indicate that the Spaniards had once been actively engaged in mining operations, not for these base metals but with the expectation of finding gold and silver.

The first mint-return from the state was in 1831, but as it is an exceptional case when sufficient production is obtained from metal mining operations, and especially precious metal mining, to have it reported in the mint-returns during the first years of such work, it is probable that mining had been carried on somewhat earlier. However, the first mention made regarding mining was that gold was found in Coca Creek, Monroe County, as early as 1831.[2]

Mention has already been made regarding the silver which the natives of Kentucky and eastern Tennessee were known to collect and probably smelt by some crude process and which they tendered to the early settlers in barter.[3] Although the mines were never located, it is evident that they must have existed or that the Indians had by chance blundered on to a cache of the Spaniards.

Gold has been discovered at numerous localities along the belt of Ocoee slates and shales and between the French Broad River and the Georgia line. The principal localities in which gold has been found are: Montvale Springs, Blount County; Citico and Cane creeks in Monroe County, etc. The Coca Creek district has produced the largest part of the gold yet mined in the state.[4]

The following is extracted from an article in the *Mining Magazine:*

"Independent of the trace of silver-ore to be found on analysis in the lead-ores of Tennessee, the late Dr. Troost describes in his Fifth Report, for 1834, two specimens of the sulphuret of silver

[1] Mineral Industry for 1892–1906.

[2] Sanford's Geology of Tennessee, 1869, p. 489, and Resources of Tenn., J. B. Killebrew, 1874, p. 265.

[3] Min. and Sci. Press, Vol. 43, p. 302.

[4] Trans. Am. Inst. Min. Engrs., Vol. 5, p. 59, 1898.

found by him in the waters of the Cumberland Mountains. . . . We will give his own account:

'I had the good fortune, during my last excursion, to make a discovery which may, eventually, be of great importance. Stopping for the night at the house of Captain Eastland, on Clift Creek, . . . he handed me some small fragments of ore . . . next morning I left the place, and, passing through Sparta, I descended to the Calf-Killer Creek to water my horse; my attention was then attracted by something uncommon among the gravel; I dismounted and took up the substance which had drawn my attention. . . . When at home, I examined both these ores, and found that the fragment of Captain Eastland, as well as that found by me on the Calf-Killer Creek, was sulphuret of silver. . . . I am at a loss to make any conjectures as to the locality of this ore. . . . I do not know from whence Captain Eastland obtained his specimen . . . as he told me it was about fifteen miles from his residence.' "[1]

Texas. — The mines of El Paso were probably among the first worked in the state. Their early history has already been given, and their rediscovery from the church records in 1872 bring us up to comparatively recent times.

The Presidio mine was discovered in 1880 and opened in 1884, and has produced constantly ever since. This is a silver mine located near Shafter in Presidio county.

The Hazel mine, El Paso County, had produced fully $60,000 of ore up to 1901 — it closed in 1902.[2]

In 1892, the state continued to be a small producer of gold and silver, the principal districts being in Llano, Mason, and adjoining counties and in the Trans-Pecos.

During 1895, no gold was produced, but there was a gain in the production of silver from the Presidio, Cibolo, and mines in the Trans-Pecos district.

Some gold was produced in 1902, but the largest part of the product was silver, most of which came from the Presidio mine at Shafter. The ore produced here is silver chloride, carrying small quantities of gold and lead.[3]

Gold occurs in small quantities in Gillespie County, and veins carrying traces of gold are of common occurrence in Quitman Mountains.

[1] Mining Magazine, Vol. 8, p. 238.
[2] Eng. and Min. Jour., Vol. 74, p. 150.
[3] Mineral Industry for 1892 to 1905.

The Burnetan rock system of central Texas also contains gold, but the quantity is small as reported by the Geological Survey of Texas.[1] Gold has also been found in the gravel hills near the Rio Grande between Eagle and Quitman Mountains.[2]

Utah. — In October, 1862, General Connor's command of United States volunteers from California arrived in Utah and established a post at Camp Douglas. As this command was largely composed of California miners it was but natural that they should be on the lookout for gold, and considerable prospecting resulted. Lieutenant Weitz and others discovered the outcrop of a lode in Bingham Cañon in 1863; while in the following year, the government reserve, Company L, stationed at Rush Valley, located a number of argentiferous galena veins. The first mining district was organized in 1863, and was named the "West Mountain Mining District." This district included the whole of the Oquirrh range west of Jordan Valley. In 1864, it was subdivided, the original name applying to that portion lying on the eastern slope of the mountains, while the western slope was called "Rush Valley Mining District." The principal discoveries in the Rush Valley district were made during the years 1864, 1865, and 1866. The Subjugation was the first discovery made in 1864, and was followed by the Wild Delirium, Saint Louis, Mountain Gem, and others. Other locations were: Great Central, August, 1864; Bolivia in 1865; the Eureka in 1864; Hard Times in 1864, and the Lady Douglas in 1865.[3]

Gold veins were first discovered in the Bingham district by a party of prospectors who returned from Montana in the fall of 1864 to winter at Salt Lake City. They were not worked, however, until the spring of 1865. Placers were discovered in the fall of 1866 by Peter Clays and G. W. Crowdy.[4]

In 1898, hydraulicing operations were carried on in the Argonaut mine situated at the mouth of Carr Fork, while the placer mines of Bear Gulch at Dixon Bar were operated in rather a desultory way by the old gravel miner, Bartholomew Gardella, as late as 1902.[5]

The mines first developed in the Bingham Cañon were silver-lead properties, the most prominent being: the Winnemucca, Tiewaukie, Telegraph, Galena, Nast, Giant, Roman Empire, Spanish,

[1] Geol. Sur. Texas, 1 Annual Rept., 1889, p. 331.
[2] Trans. Lake Superior Min. Inst., Vol. 5, p. 59, 1898.
[3] Silver and Gold, Rept. of 1872, Raymond, pp. 304, 306, 307.
[4] U. S. G. S., Economic Bull. 213, p. 119.
[5] U. S. G. S., Bull. 213, p. 119.

Stewart and Jordan. The first attempts at smelting the ores were not very successful, until in 1871, when it was successfully accomplished by Colonel David Buell of Nevada.[1]

Work was begun in the Silver King in 1865, in the Defiance in 1870, and the Legal Tender in 1871.

The principal mines of the Ophir or East Cañon district in 1871 were: the Tampico, Mountain Lion, Mountain Tiger, Petaluma, Zella, Silver Chief, Defiance, Virginia, Monarch, Blue Wing, and Silveropolis. Five hundred locations had been made up to April, 1871.

In an interview in Salt Lake City in 1869, Mr. Brigham Young, president of the Church of Latter Day Saints, said: "What we used to call lead and dig and melt into bullets, these fellows call silver now. But if anybody is fool enough to come and mine it, he may do so, and welcome."[2]

The Emma mine situated in Little Cottonwood Cañon was discovered by two prospectors, Woodman and Chisholm, in 1868. In 1872, the available stock of ore having been exhausted the mine was closed, and was not reopened until about 1883.[3]

The Tintic district is one of the oldest mining camps in the state, ore having been discovered in December, 1869, by a party of prospectors returning from the western part of the state. The Stockton and Little Cottonwood districts were discovered in 1868.

The first discovery in the Tintic district was the Sunbeam on December 13, 1869, following which was the Black Dragon on January 3, 1870, and the Mammoth on February 26, 1870.[4] Since 1872, the Mammoth mine has been the chief producer of the district. It yields gold, silver, copper, lead and bismuth.

The Mercur mines were discovered by prospectors in 1871, in Lewiston Cañon, about seven miles northwest of Camp Floyd. These mines were not worked long and were abandoned until in the latter eighties when some work was done, but actual development really began in 1891. About this time it was discovered that the values could readily be extracted from the ore by means of the cyanide process, and since its application no trouble has been experienced.[5]

[1] Mines and Minerals, Vol. 19, p. 377.
[2] The Mines of the West, Raymond, 1869, p. 168.
[3] Min. and Sci. Press, Vol. 46, p. 272.
[4] U. S. G. S., 19th Annl. Rept., pt. 3, p. 613.
[5] Mines and Minerals, Vol. 19, p. 81.

Probably the earliest mining done in the Park City district was in the Miller mine situated at the head of the American Fork Cañon, also in the Emma, Flagstaff and several mines near Alta, at the head of Little Cottonwood Cañon. Other mines operated about this time were in districts near the head of the Big Cottonwood Cañon and Snake Creek.

The Ontario mine discovered on June 15, 1872, by Rector Steen, is usually considered to mark the beginning of actual mining operation in the district.[1]

The silver-bearing sandstones of Silver Reef, Washington County, were discovered by John Barker in 1873. It is said that the presence of silver in the rocks was accidentally discovered by the heat from a camp fire melting the silver so that it showed on the surface. During the following year there was a rush to the district, especially from Nevada, Utah and Montana.[2]

The State Line district in the southwestern part of the state, Iron County, was located in 1886. The ores are free-milling gold and silver.

The Chloride Point mine was worked prior to 1873, and was still producing considerable, smelting one as late as 1897.

Little placer mining has been done outside of the Bingham district, which is the locality where placers were first found, and considerable work was done in 1871.

On April 30, 1879, a German named Arie Pinedo located the Mercur lode in the Camp Floyd district, and believing that he had discovered a mercury mine so named it the Mercur. Cinnabar was found but not in paying quantities, and the claim was abandoned. It was again located in 1883, and six years later Captain Joseph Smith erected a mill at Marion for the treatment of the ores.[3]

In 1882, the principal mines operating in Washington County were: the Silver Point, Silver Crown, Hillside, Great Western and Northern Light. In Beaver County the Horn Silver, Carbonate and Cave were worked. Some of the shipping mines of Salt Lake County were: Old Telegraph, Spanish, Yosemite, Neptune, Lead, Alladdin, Live Yankee, Giant Chief, Tiewaukie, etc. The mines of Toole County were the Great Basin, Leonore, Quandary, National, Silver King No. 2 and the Maybell.

[1] U. S. G. S., Bull. 213, p. 34.
[2] Mines and Minerals, Vol. 20, p. 323.
[3] Eng. and Min. Jour., Vol. 63, p. 403.

The Daly West and Ontario mines were the first mines of importance in the Park City district. The latter was closed in 1897.

During 1892, five counties contributed the bulk of the ore, viz.: the Summit, Juab, Salt Lake and Beaver. The Ontario and Daly West were the most important mines of the Territory, while the silver producers were the Anchor, Crescent, Woodside, Mayflower and Silver King. The Big and Little Cottonwood districts, Salt Lake County, were large producers and contain such mines as the Emma, Flagstaff, Maxfield, and Vallejo, all of which are famous. The gold placers of Bingham Cañon were still worked. Juab County ranked first as a gold producer, and second in silver production; the principal mines being the Eureka Hill, Bullion-Beck and Champion, Mammoth, Centennial-Eureka, Caroline and Gemini. The Horn Silver mine was the only mine of importance in Beaver County.

In 1895, the Ontario and Daly West were still prosperous. During this and the following year there was considerable activity in gold mining in the states, especially in the Camp Floyd district. Nevertheless there was a decrease in the gold production for the following year, 1897, which was caused by the fall in value of silver, increased smelter and railroad rates and higher price for powder.

During 1898, the Camp Floyd or Mercur district continued to be the chief producer. The gold production steadily increased to 1902, although no new camps were opened up. The Annie Laurie mine, Pinto County, has proven to be a good producer of both gold and silver.

A number of gold-bearing veins were discovered in Box Elder County, the northeastern part, or Park Valley, in 1900-01.

In 1903, there seemed to be a falling off in the Mercur camp. The Eureka, Robinson, Mammoth, Silver City and Knightsville mines had come to the front again.

In 1904, there was a marked increase in gold and silver production, which was mainly contributed by the Bingham district. The gold districts of the southern part of the state felt the stimulus of increased railroad facilities, connection being made with the Pacific coast.

During 1905, a large part of the gold came from the smelting of copper.[1]

Vermont. — It is not stated definitely in the published records, exactly when gold was first discovered in the state, but it was probably much earlier than the beginning of mining operations.

[1] Mineral Industry for 1892 to 1905.

According to Rev. Z. Thompson[1] a gold nugget weighing 8½ ounces was found in Newfane in 1826; it was mostly gold with a small piece of quartz attached.

Two gold nuggets were found at Plymouth in 1855-1861, worth $9 and $14 each.[2]

Work was done on the Taggart vein in 1859, which is situated on the old Thompson farm, about a mile west of Bridgwater Center. Gold was discovered in the town of Bridgewater about 1853 or 1854, and within the next ten years two quartz mills had been built to treat the ores. Silver also occurs with the gold. "At Plymouth Five Corners a mill pond was once drained and worked for placer gold. Sluice boxes and rockers were used, and the result is variously reported at from $9,000 to $13,000."[3]

There is a belt from ten to twenty miles wide, mostly on the eastern side of the Green Mountains, which is known to contain gold, in which area there has been found many traces of float gold. The Ammonoosuc gold field along the Connecticut River, and lying mostly in New Hampshire, also extends into Vermont, and may be connected with the Chaudière region of Quebec.[4]

The Virginias. — As Virginia was one of the earliest states settled, it is but natural to expect some mention of the discovery of gold or some knowledge of its presence and use among the Indians, provided it was to be found in the country. Tales of the wealth of the New World in gold and silver had undoubtedly reached England from Spain, and without doubt the early emigrants fully expected to find the precious metals in abundance. In fact, the great charter granted by King James in 1606 to the London and Plymouth Companies giving them the right to explore and settle the North American continent, provided that one-fifth of the gold and silver and one-fifteenth of the copper discovered should go to the crown.

An expedition under Captain John Smith sought to establish connection with the Pacific Ocean by way of the Chickahominy River. Some time later, a mining excitement, probably the first in the United States, occurred, which was caused by the discovery of what was supposed to be gold. A large quantity was sent to London where it was found to be only iron-pyrites; yet, strange enough, gold act-

[1] Appendix to Thompson's Vermont, p. 48.

[2] U. S. G. S., Bull. No. 225, p. 85.

[3] Rept. Vermont State Geologist, G. H. Perkins, 1903–04; pp. 56–57; U. S. G. S., Bull. 225, 1903, G. O. Smith, pp. 85–88.

[4] U. S. G. S., 16 Rept., pt. 3, p. 329, 1894–95.

ually does exist in the locality whence this material was taken, and it is not surprising that there should have been some confusion in the minds of the people regarding the identity of the two substances.[1]

Gold is said to have been first discovered in the state by the English as early as 1799.[2] Jefferson mentions the discovery of a nugget of gold below the falls of the Rappahannock River in 1782, but there were no mint-returns until 1829.

The Tellurium and Vaucluse mines were discovered in 1832, which probably marks the beginning of vein mining in the state.[3] An attempt was made to smelt the ores of the Vaucluse mine in 1847, but without success.

A gold-quartz vein was discovered in Louisa County in 1845 by George Fisher, and was developed by him.

Gold and silver were reported as occurring in the shales of the coal measures of the Panhandle, West Virginia, in the early 50's, but no extensive mining has been done.

No mention is made regarding the mining operations in Virginia in the report of the director of the Mint for 1881; we must, therefore, conclude that the amount of work done was comparatively insignificant. Further, the Mineral Industry for 1895 says: "In Virginia the production of gold was trifling in amount, and very little legitimate work was done." Other references to later developments are fully as meager.

Washington. — The Peshastin Creek placers were discovered in 1860, and have been worked very irregularly. The Swauk placers, located in 1868, have been much more successfully operated. Gold-bearing veins were discovered in the Peshastin district in 1873, in the Swauk in 1881.[4]

The first discovery in the Peshastin district was by Culver and Saunders, and was called the Culver vein. In 1879, J. Black discovered a pocket from which was taken $60,000.

The Republic mine was located and staked on March 5, 1896, by Ryan and Creasor, prospectors from the Coeur d'Alêne district. Fifteen days later the Mountain Lion mine was discovered by Arthur Best, while on September 7, the Fraction, Flat Iron and Last Chance were located by George Rennels and J. Bell.[5] In 1900

[1] T. A. I. M. E., Vol. 5, p. 166.
[2] Am. Jour. Min., Vol. 1, p. 313.
[3] T. A. I. M. E., Vol. 25, p. 682, 1895.
[4] U. S. G. S., Bull. 213, p. 76.
[5] Eng. and Min. Jour., Vol. 68, p. 635, and Vol. 69, p. 285.

the Mountain Lion mine ranked next to the Republic as one of the great mines of the Eureka district and consists of six claims, of which three are given above, the others being the Mountain Lion Fraction, Navahoe and Zeta.

In 1881, the mining operations were practically confined to Yokima, Peshastin district, and Spokane counties and to the Snake River in Columbia, Garfield and Whitman counties. In Stevens County are the Mount Chopaco mines, often known as the "Smilkameen." The mining operations were confined to eight counties including the above.

The Lone Pine and Last Chance were among the first recorded locations in the Mercur district, being staked on February 28 and 29, 1896. The Pearl claim was located on March 5, the Surprise on July 18.

The largest producers of silver in 1898 were in Stevens County. The first discovery in the Embry camp occurred in 1883, about two miles east of Chewelah, the most noted mine being the Eagle, which consists of six claims. Other important mines in this locality are the Alice, Copper King, Jay Gould and Golden Crown. These mines produce gold, silver, lead and copper. The north half of the Colville Indian reservation was open to mineral entries in February, 1897, and since then much development work has been done. North of Colville is the Old Dominion mine. Near Marcus is the Old Gold Hill property, which was successfully worked in 1898. Other noted mines near Northport are the Clara and Lakeview on Red Top Mountain.[1]

In 1892, three small hydraulicing operations were underway in Kittitas County, the best claims being the Black, Bigny and Delig.

During 1895, there was a decrease in gold production in the state. In 1899, the mines of the Republic district were actively developed, but owing to the closing down of the Republic mine the output was still low. During 1902, practically all of the Republic mines were operating, while in 1904 both the gold and silver production had increased.

The Sherman District some ten miles northwest of the Republic was again attracting attention in 1904.

The mining industry of Washington needs capital to develop the different districts which are widely scattered; further, the season is short and therefore restricts operations to a shorter period of yearly activity than is enjoyed by the districts further south.[2]

[1] Mines and Minerals, Vol. 18, p. 313.
[2] Mineral Industry for 1892 to 1905.

Wisconsin. — The Keweenawan system of rocks that are silver-bearing in Michigan, near Ontonagon, also occurs in Wisconsin, and according to R. D. Irving traces of silver have been found along the Montreal River. When silver was first reported from this locality is unknown. Regarding the occurrence of silver in this locality the state geologist of Wisconsin says: "The unfavorable experience of the operations in Michigan, however, leaves little ground for expecting rich deposits in that horizon, though nothing is known to forbid it." He further says: "While silver has very frequently been unauthoritatively reported from various parts of the state, and undoubtedly occurs not infrequently in minute quantities, nothing is known that gives substantial grounds for expecting any valuable discoveries. Experience and observation give an adverse probability.[1]

According to the same authority although gold might be expected to occur in the crystalline rocks of northern Wisconsin, yet in one instance only was it and silver found in quartz associated with pyrite and arsenopyrite, in northern Clark County.[2]

Gold has been found in ledges of diabase in Douglas County. The Chippawa mine further up the range gives a yield of from $2 to $11 per ton in gold.

The discovery of gold in the iron ores of the Emmet mine in 1879 created quite an excitement, which was, however, rather short lived.[3]

In 1902, gold was found in glacial drift at St. Croix Falls, at the head of St. Croix River. Very little gold has been obtained although worked from time to time.[4]

Wyoming. — With the main range of the Rocky Mountains extending across the territory from southeast to northwest, together with the Big Horn, Wind River and Medicine Bow mountains and Black Hills lying partly within the state, Wyoming would seem to be an ideal country for prospecting. However, the powerful and warlike Indian tribes inhabiting the regions where the prospectors would naturally go in search of mineral deposits were an effectual set-back to all such work. Following the subjection of the Indians

[1] Geology of Wisconsin, Vol. 1, p. 661, 1873–1879; Ibid., Vol. 2, p. 27; Ibid., Vol. 3, pp. 201, 206, 358 and 669; and Ibid., Vol. 4, pp. 382–383.

[2] Trans. Wisconsin, Academy Sci. Arts and Letters, Vol. 1, and Geol. of Wis., Vol. 1, pp. 310 and 661, 1873–1879.

[3] Geology of Wisconsin, Vol. 3, p. 669.

[4] Eng. and Min. Jour., Vol. 74, p. 248.

the country became a great grazing range, and for a time the prevalent opinion was that the territory was preëminently a stock country. Lack of railroad facilities also retarded the growth of the mining industry.

Ex-Governor J. W. Hoyt, formerly state geologist of Wisconsin, says in his last message: "I know of no region in the United States in which gold appears so widely distributed as in Wyoming, and I cannot doubt that eventually numerous mines of much value will be worked, thus placing this great territory, so rich in other resources, among the most important of the gold sections. We have many mines that already yield handsome returns whenever the requisite combination of energy and skill with sufficient capital can be brought about."[1]

Probably the first discovery of gold was made in Wyoming, in 1867, in which year the placers of the Sweetwater River were located. That such discovery had not been made prior to this date is rather surprising, as the territory had been traversed ever since the discovery of gold in California by parties of prospectors, and by Mormons on their way to Utah — the Laramie trail being one of the principal highways.[2]

It appears that silver mines were discovered in the Seminole Mountains as early as 1869 by three prospectors who were subsequently killed by Indians. Although the discoveries then made were not located, gold-bearing veins were found instead.

"Gold has been found in nearly every gulch in this district, and some have proved almost as rich as the famous Dutch Flat diggings in California, though of far less extent, the ravines being narrow. But their large yield is the best evidence of the number of rich lodes in this district."[3]

The Bald Mountain district began its existence as a placer camp, following which a large deposit of gold-bearing conglomerate was located and developed.

In October, 1898, the discovery of the Rudefeha or Haggerty-Ferris mine was made near Battle Lake in the Grand Encampment district. The mines of both the Grand Encampment and the Saritoga districts yield copper, lead, silver and gold. During this year numerous discoveries of minor importance were made; further,

[1] Rept. Director of Mint, 1883, pp. 594–595.

[2] King's Handbook of the United States, pp. 906 and 907, also Special Report Census Bureau, Mines and Quarries, 1902, pp. 346, 347.

[3] Rept. Director of Mint, 1883, pp. 371–375.

there was an attempt made at working some dry placers by steam shovel.

Conditions remained about the same up to 1902, although the Carissa had forged to the front as the largest producer. There was also considerable activity in the Sweetwater district, which in 1902 led in the production of gold and silver. At this time there was marked advance noticeable in all mining operations, and the mining industry seemed to be on a better footing than ever before.[1]

CHRONOLOGY OF GOLD AND SILVER MINING IN THE UNITED STATES.

The following brief statements regarding the discovery of mines and mineral properties and the events which have been influential in the development of mining districts and the mining industry as a whole, are given in order to epitomize the history of precious metal mining, and summarize the more detailed account previously given.

1513.

A cacique of gold was reported to Ponce de Leon while lying off the coast of Florida.

1516.

Diego Miruelo reported that he had obtained gold from the natives of the Atlantic and Gulf States.

1519.

Pineda while sailing along the coast of Florida and Texas is reported to have observed gold in the rivers, and its use as ornaments by the natives.

1521.

The mines of Mexico were actively worked by the Spaniards during 1521–1810.

1527.

The first definite information regarding the occurrence of gold was made by Pamphilo de Narvaez who landed at Tampa Bay Florida.

1538.

The Spaniards while exploring the valley of the Rio Grande discovered a Tegu Pueblo village and mines worked by the natives, whom they forced to work for their own benefit. In 1680 the

[1] Mineral Industry for 1892 to 1905.

Indians revolted and drove out the Spaniards. The village was recaptured in 1692.

1539.

Conorado discovered the dry placers of northern Sonora, Mexico. De Sota explored the Southern states for gold and silver, and probably did some mining.

1564.

Lemoyne, historian for Landonnière, describes a method of washing gold sands, employed by the Indians, in hollow reeds. He also reported gold as being found in the Appalachian Mountains.

1579.

Sir Francis Drake touched the coast of California, and reported gold as occurring in abundance.

1610.

After the conquest of Mexico by the Spaniards they made some twenty expeditions in the country, which is now Arizona, New Mexico and California, in search for gold, but with no definite results.

1650.

A grant to work silver-lead mines at Middletown, Connecticut, was given to Governor John Winthrop. Governor Winthrop of Connecticut became interested in the silver-lead deposits of Haddam and Middletown, but no active mining was done.

1660.

A charter was granted to the London and Plymouth Companies of Virginia by King James, giving them the right to explore and settle the North American continent, provided that one-fifth of the gold and silver and one-fifteenth of the copper discovered should go to the crown.

The discovery of gold on the Chickahoming River, Virginia, by an expedition under Captain John Smith, occurred subsequent to 1660, exact date not available, and considerable excitement followed, this was probably the first gold excitement recorded in the States.

1680.

The monks of the order of St. Francis discovered and worked the silver mines of El Paso, Texas. These mines were closed and hidden by them, remaining unknown until 1793, and were reopened in 1872.

1701.

Father Kino, a Jesuit priest, reported the presence of gold and silver among the Yuma Indians on the Colorado River above the mouth of the Gila in Arizona.

1736.

During 1736 to 1741 there was a silver excitement at San Xavier del Bac, near the Arizona line.

1740.

Lead mines were prospected in New York, southeast of Pine Plains, Dutchess County.

1769.

The silver mines of Santa Rita, New Mexico, were made known to the white men by a Yaqui Indian. After much trouble with the Indians the mines were closed until 1880.

A company of Cornish miners were landed at Ontonagon River, Michigan, to mine silver. The project was abandoned in 1770.

1770.

The Santa Rita gold district, New Mexico, was flourishing, and was known to the American prospectors as the " Pot Holes."

1775.

The placers of southeastern California were discovered by Mexicans.

1776.

The Mission of San Francisco was founded on October 9.

1782.

Jefferson mentions the discovery of a gold nugget below the falls of the Rappahannock River in Viriginia.

1786.

La Prouse undertook, for the French Government, to find a northeast passage to the Hudson Bay from the west coast of America, but got no further than Litua Bay. A similar attempt was made by Kotzebue in 1816.

1792.

The legal ratio between gold and silver, in the United States, was made 15 to 1 by act of Congress, a mint being created.

The famous bonanza at Sombrerete, Zacatecas, Mexico, was discovered.

1798.

The great silver bonanza at Ramos, Mexico, was discovered.

1799.

The Reed nugget was discovered which led to the location of the Reed mine, in North Carolina, in 1813.

Gold is said to have been first discovered by the English in Virginia.

1802.

A silver vein was discovered at Olozal in the district of Monterey, California.

1812.

Gold placers were discovered near the Spanish mission of San Fernando in Los Angeles County, California.

1825.

Gold ores were reduced by hand mortars in the Southern Appalachian states. Vein-mining probably first began in Montgomery County, North Carolina.

The San Isidro placers were discovered in San Diego County, California.

1826.

A gold nugget weighing eight and one-half ounces was found in New Fane, Vermont.

1828.

The Eaton lode, yielding lead-silver ore, was discovered in New Hampshire.

1829.

Gold was discovered in Georgia following which was an excitement, probably the second of the kind occurring in the United States.

The first period of activity in placer mining, in the Southern Appalachian states, began, and ended in 1836.

1830.

Gold was discovered in Alabama, and considerable mining was done up to 1850.

1831.

Gold was found and worked on Coca Creek, Tennessee. The first mint-returns were reported.

1832.

The argentiferous lead mines of Lubec, Maine, were discovered. Assays on the ore from Mount Glines, Maine, showed values in gold.

The Tellurium and Vaucluse mines were discovered in Virginia and their development marked the beginning of vein-mining in the state.

1833.

The Bechtler gold coins were made slightly over weight to ensure their reception in competition with the Mexican silver coins in North Carolina.

Gold placers were worked in the valley of the Santa Clara River, California.

1834.

Dease Lake was discovered by J. McLeod while seeking a passage to the Pacific coast through some westward flowing stream in the Northwestern territory.

Several specimens of silver sulphide were found in the Cumberland Mountains, Tennessee. The legal ratio between silver and gold was made 16 to 1 in the United States. Vein-mining began at the Reynolds vein, Georgia.

1835.

Stamp mills (called vertical mills) were in use in mills of the Southern states, that at the Tellurium mine, Virginia, is claimed to have been the first used in the United States. Rolls were also used together with the Tyrolese amalgamating bowls.

1836.

The Washington mine, later known as Silver Hill, Davidson County, North Carolina, is claimed to be the first silver mine worked in the United States, was worked till 1852, was reopened in 1855.

1837.

Gold was discovered in Morgan County, Indiana, also in Franklin County, on Sein Creek in 1869, and at Mooresville in 1873.

1838.

The placers of San Franciscoquito, California, were discovered.

Robert Campbell established a fort on Dease Lake, British Columbia.

1839.

The second period of activity in mining in the Southern Appalachian states began and ended in 1849, and was brought about largely by vein-mining.

1840.

Robert Campbell while exploring the Colville River, British Columbia, discovered Frances Lake.

First mint-returns reported from Alabama.

The Portis mine was discovered in North Carolina.

1841.

Placers were discovered in the San Feliciana canyon, some 45 miles northwest of Los Angeles, although other authorities give the date of discovery as 1838.

1842.

Pelly Banks post was established in British Columbia.

1845.

A Chippeway Indian reported finding native silver on the Ontonagon River, Michigan.

The Mexicans began to recognize the mineral wealth of California, as is shown by letters to the President from that province.

Senior Castillo of New California presented to the School of Mines of Mexico, specimens of gold, silver, lead, etc., and tried to induce his government to protect its interests.

The Cliff mine of Michigan was discovered. This mine produced native copper and silver.

A gold-quartz vein was discovered in Louisa County, Virginia.

1846.

T. O. Larkin, United States Consul at Monterey, wrote to James Buchanan, Secretary of State, regarding the mineral wealth of California, and inferred that it would be better under the American flag.

Mr. Forrest Sheppard led a prospecting party along the north shore of Lake Superior, and made a number of locations on silver veins. The silver Islet mine was included in one of the locations, but no silver was at that time known to exist there. The Prince's location in Thunder Bay was probably the first to be developed, but was abandoned in 1850.

1847.

Concentration of sulphurets was effected at the Vaucluse mine, Virginia, by means of tables and strakes. Raw amalgamation was also practiced here, and was probably the first application of the process in this country. Pyritic smelting was also tried at the Vaucluse mine by Commodore Stockton, but was abandoned.

Robert Campbell founded Fort Selkirk, British Columbia.

1848.

Gold was discovered at Coloma, on the Sacramento River, California, by J. W. Marshall, on the 19th of January. Later a soldier of Stevenson's regiment found a nugget in the Mokelumne River, which resulted in a fresh excitement. This nugget was sent east in care of General Beale, and when shown in New York City created great excitement, and the rush to the gold fields of California began.

John Bidwell discovered gold on the Feather River, Butte County, California, in March, and two weeks later on Butte Creek, and located Bidwell's bar near Oroville on the 4th of July. The North Fork Dry diggings were discovered on May 16. The long-tom was introduced into California from Georgia.

The argentiferous galena deposits of Iron River, Michigan, were discovered.

Mr. William Tingle began mining lead-ore some two miles east of Joplin, Mo.

1849.

Silver was found on Furniss Creek, near Poison Springs, California.

Grass Valley, California, was discovered by emigrants to California.

The California gold excitement was responsible for the decline of gold mining in the south.

Gold was found on Cherry Creek, Colorado, at the mouth of the Platte, by a party of Georgians bound for California. The same party discovered the placers of Gold Run and Russel Gulch in 1858.

Gold-bearing quartz veins were discovered in Montgomery County, Maryland.

Gold was discovered in Gold Cañon, Nevada, which led to the discovery of the Comstock lode.

1850.

Quartz-mining began in California.

Lead-silver mines were operated in Chester and Montgomery counties, Pennsylvania, but were not of much importance.

Mining began near Granby, Newton County, Missouri. There was a considerable output of lead from the mines in 1857.

The first ditch was constructed for carrying water for hydraulic-mining in California, and in 1860 there were 6,000 miles of canals in the state.

River-mining was most actively carried on in California during 1850–56.

Machine drills were first used in the mines of the United States.

The first quartz mill was erected at Grass Valley, California, by two Germans, which was purchased in 1852 by an English company and enlarged to twenty-one stamps in 1853.

Gold placers were discovered at Grass Valley, California, in June, quartz ledges were located. In October gold-quartz veins were discovered on Gold Hill, and following this similar finds were made on Massachusetts, Ophir and Rich hills. The placers of Plumas and Sierra counties were discovered in 1880–81.

The reported discovery of gold at Gold Lake, California, and the resulting excitement occurred in 1850.

1851.

A quartz-vein was located at Nashville, El Dorado County, California, but was not worked until 1868.

Mining began in southwestern Missouri, near Minersville on Center Creek. The locality is now called Oronogo. Lead and zinc mining is carried on here.

The famous Plumas-Eureka gold ledge of Gold Mountain, California, was discovered.

The Ocean beach at Gold Bluff, California, was worked for gold.

The Eureka mine, Nevada, was located on February 7, and closed in 1877.

Placers were discovered in Josephine County, Oregon.

1852.

The first riffles for catching gold were patented.

The Blake jaw-crusher was invented by E. W. Blake, but it was not until 1860 that it was employed in breaking ore.

Pocket mines were discovered on Bald Mountain, Tuolumne County, near Sonora, California.

The placers at Indiana Hill, California, were discovered which were the first diggings between the North Fork and Bear River.

The silver-lead mine of Middletown, Connecticut, was worked.

Auriferous gravel was discovered on the Pen d' Oreille River, Idaho.

The Black Hills, South Dakota, were prospected.

1853.

Gold was discovered at Bridgewater, Vermont.

E. E. Mattison invented the hydraulic method of mining.

Silver was reported as occurring in shale below the falls of the Cumberland River, Kentucky, in Whitley County, but tests did not substantiate the report.

Blankets were first used in saving gold and sulphurets, being used on tables in the mills of Grass Valley, California.

1854.

According to Tuomey, the first bench gravels worked at Arbacoochee, Alabama, were ground-sluiced.

General Lander discovered gold on the Columbia River, Idaho.

The presence of gold was reported in Jackson County, Mississippi.

1855.

Two gold nuggets were found at Plymouth, Vermont, during 1855–61.

The Mowry mine of Tucson, Arizona, was purchased by Major Ewell and others.

The ancient river channels of Tuolumne County, California, were discovered.

Important changes were made in the construction of stamp mills, notably increased height of mortar box in order that it might contain both feed and discharge openings. Iron mortar boxes were devised and iron stems introduced.

The first automatic ore feeder was devised by C. P. Stanford.

Inside plates were employed in the mortars at the Wiggam mill, Nevada City, Nevada.

The Yosemite Valley was discovered as a result of the search for gold.

Doroshin was sent to report on Alaska by the Emperor of Russia, but made an unfavorable report as to its mineral resources.

Silver was discovered on the Little Iron River, not far from the the Pewabic River, Michigan.

Ground-sluicing was carried on at Arbacoochee, Alabama, mercury being used.

Kern River, California, was a point of attraction during the year but was a failure.

Gold was discovered in glacial drift in Missouri, but in too small quantities to be worked.

1856.

A forty-inch pipe line was constructed for hydraulicing purposes in California.

The Fraser River, British Columbia, held the attention of miners and prospectors.

1857.

The Chavanne brothers made the first attempt to save auriferous sulphurets in Grass Valley, California.

The Hudson Bay Company received from the Indians at points, on the Fraser and Thompson rivers, British Columbia, 300 ounces of gold. This led to a report by Governor Douglas of Alaska and a great excitement resulted.

Gold was discovered at Six mile Cañon, Nevada.

1858.

Rich veins of lead ore were discovered at Guymard, New York.

The Mowry mine, Arizona, passed into the hands of Lieutenant Sylvester Mowry, who from this date, operated it on a considerable scale. This is probably the first silver-lead mine worked extensively west of the Rocky Mountains. It is claimed that lead for the Confederate army came from this mine.

The Howland rotary stamp, probably the first form of revolving stamp employed in this country, was introduced at this time.

Shaking tables (copper plates) were first used in the mills of Montana.

Deetkin attempted to smelt the sulphurets of Grass Valley, California, in a reverberatory furnace also in a blast furnace, but owing to the lack of lead and cheap fuel it was abandoned.

Captain John Mullen discovered gold in the Coeur d'Alêne Mountains, Idaho, in 1858 or 1859.

The Bohemia mining district of Western Oregon, was discovered in August.

1859.

The Comstock lode, Nevada, was discovered at the point where the Ophir mine is located.

Pike's Peak excitement; discovery of gold placers in Gilpin County, Colorado, at California Gulch and at Breckenridge. Mines of Georgetown, Colorado, were discovered.

Hydraulic-mining was first practiced at Pilot Mountain, Burke County, N. C.

Work was done on the Taggart vein near Bridgewater Center, Vermont.

Gold is said to have been discovered at Idaho Springs, Colorado, January 21. This is claimed to have been the first discovery in Colorado.

Placer-mining began on Fraser River, Alaska, and was actively carried on.

Mining in Colorado really began in this year.

The Gregory brothers and others discovered the Gregory lode on Clear Creek, Colorado, on May 6. Boulder was also discovered.

Jackson's Bar on Chicago Creek, Colorado, was discovered in January.

The first assay of Comstock ore was made on June 27 and served to identify it; following which a mad rush began to the Comstock lode country.

1860.

Washoe pan process was probably invented by Almarin B. Paul and James Smith.

The Gould & Curry and Savage bonanzas, Comstock lode, were discovered.

The Boise Basin gold placers, Idaho, were discovered.

Square set timbering was devised and introduced into the Ophir mine of the Comstock lode, by P. Deidesheimer.

Mr. A. B. Paul built the first stamp mill in Gold Cañon, Nevada; the first work was done on August 11.

Stamp mills of the California type were introduced into the mills of Gilpin County, Colorado, prior to 1860.

The placers of Iowa Gulch, Colorado, were discovered on April 6.

The Cariboo and Omerica, British Columbia, were discovered, but the Omerica was not worked until 1867.

The Columbia, Hoosier and other veins in the Ward district, Colorado, were discovered during 1860–61.

The Pen d'Oreille placers, Idaho, attracted considerable attention. Placers were also located on Oro Fino Creek in the fall of the year.

The silver districts of Esmeralda, Potosi, Coso and Humboldt, Nevada, were discovered. The first discovery was made in the Esmeralda district on August 22.

1861.

Rich placers were discovered in Oregon.

The first steam hoist was installed at the Ophir mine, Comstock lode.

During 1861 there were 76 mills erected adjacent to the Comstock lode for treating the ores.

The Dolores River, Colorado, was prospected by Lieutenant Howard, and five years later by Colonel Nash.

The Whale lode, Colorado, was discovered.

Auriferous gravels were located at Elk City, Idaho, in May.

The Buffalo Hump district, Idaho, was discovered, free-milling gold being found.

The discovery of the gold placers of Pioneer Village, Montana, was claimed to have been made by an old Mexican miner.

The Buena Vista, Eldorado and Gold Run districts, Humboldt County, Nevada, were opened during 1861–62, and 63, respectively.

Gold was discovered in the Blue Mountains, Oregon, in the fall of the year.

1862.

There was a suspension of specie payments in the United States.

The Reece River silver district, Nevada, was discovered.

The plant of the Mowry mine, Arizona, was destroyed by Federal troops.

An O'Harra mechanical furnace was erected at Dayton, Nevada, to treat the Comstock ores. This was the first furnace of the kind to be erected in the west.

The mines of Boise Basin, Idaho, were discovered by Grimes.

The Warren district, later known as the Washington district, Idaho, was discovered but was not worked until 1866.

The Bannack placers, Montana, were discovered, and in July, 1863, the Alder Gulch placers were located.

The first discovery was made at Aurora, Nevada, and a great rush began. The excitement here culminated in 1863, the boom holding on till 1864.

The Virtue mine, Oregon, was discovered.

1863.

The discovery of argentiferous lead ores was made in Little Cottonwood Cañon, Utah. The Jordan mine was located in Bingham Cañon, Utah.

Silver-lead ores were discovered at Castle Dome, Arizona, but owing to Indian troubles the mines were not worked until 1869.

The placers of Silver City and De Lamar, Idaho, were discovered by a party under Jordan. The quartz mines of Silver City and De Lamar were located during the same year.

The Ropes gold veins of Michigan were worked as argentiferous lead lodes, but it was not until 1887 that the presence of gold ores was known.

The Horse Prairie Creek placers of Montana were discovered, and two years later those near Helena were located.

The first mining district in Utah was organized, being known as the " West Mountain Mining District."

The mill building boom on the Comstock culminated and was followed by a panic in stock during 1864.

The Hendy shaking table was first employed at the Keystone mine, California.

Ivan Simonsen made the first trip to Fort Yukon, Alaska, from the west coast.

Mr. W. P. Blake visited Alaska and subsequently predicted the occurrence of gold in paying quantities.

Some of the best placers of Yavapai County, Arizona, as the Linx Creek, Big Bug and Hassayampa, were discovered and worked.

Placers and gold veins were discovered at Sulphur Creek, Colusa County, California.

Ore of considerable value was first discovered in the Eureka district, Nevada, at or near the "76" mine in N. Y. Cañon. The first claims were soon exhausted, and the camp lay idle until 1868, when work began on Mineral Hill.

1864.

Placers were discovered in Last Chance Gulch, Montana, also at Butte.

The Yellow Jacket-Kentcuk-Crown point and Belcher bonanzas of the Comstock lode were discovered.

The first flexible goose-neck hydraulic giant was used.

The stamp mill of the Wide West mine, Esmeralda district, Nevada, was built, being the first in the district.

The first mill built in Idaho was at the Oro Fino mine.

An employee of the Hudson Bay Company was the first white man over the Chilkoot Pass, Alaska.

The first discovery of gold made in the Boulder district was on Baboon Mountain, Montana.

Placer-mining was carried on at Butte, Montana, in Missoula Gulch.

Nevada entered the Union in March, and is known as the "Battle born State."

The Subjugation mine was discovered, being followed shortly by the Wild Delirium, Saint Louis, Mountain Gem, etc., in Utah.

Gold veins were first discovered in Bingham district, Utah, but were not worked till 1865.

1865.

The silver lodes at Phillipsburg, Deer Lodge County, Montana, were discovered.

The Chollar-Potosi bonanza of the Comstock lode was discovered.

Smelting works were erected and operated at Argenta, Montana, which are credited as being the first beginnings of silver-lead smelting in the United States.

The placers of Hahns Peak district, Colorado, were discovered.

The Bear Gulch placers of Montana were discovered in October, and the rush began in 1866.

The White Pine district, Nevada, was organized, but the excitement did not come until the Treasure Hill mines were located.

Work was begun at the Silver King mine, Utah.

1866.

The Overman-Segregated, Belcher-Caledonia and Hale and Norcross bonanzas on the Comstock lode were discovered.

The Selby smelting and refining works were established at San Francisco.

A smelting furnace for treating Comstock ores was erected at Galena, Nevada.

Placers were discovered in the Bingham district.

The Reservoir mill was built by the Gould and Curry Company, Comstock lode, for the treatment of tailings, and was the first of the kind built in the United States.

The first California stamp was built in Georgia by Dr. Hamilton.

Quartz-mining was carried on in Boise, Altruras and Owyhee counties, Idaho.

The first gold-quartz location was made near Bear Gulch, Montana.

Rich gold deposits were discovered in the Valley Trout Creek, Montana.

The Battle Mountain and Columbus districts, Nevada, were organized during 1866 and 1868, the Eberhardt being located in December, 1867.

Gold was found in the lead-silver mines of Franconia and Lisbon townships, New Hampshire.

1867.

Rich deposits of silver ore were discovered at White Pine, Nevada. These are the first large bodies of silver ore found in limestone in the United States.

The Boston and Colorado smelting works were established at Black Hawk, Colorado, and was an important step in the development of the Gilpin County mines.

Silver-lead ore was discovered in the Magdalena Mountains, New Mexico.

Smelting was begun at Oreana, Nevada.

The Bruckner furnaces were introduced into Colorado, and proved successful in operating on the gold and silver sulphurets.

The Duncan mine, Canada (formerly the Thuniah), was located in May, 1867.

The Telegraph Expedition discovered gold on the upper Yukon.

The Maryland mine, Maryland, was located.

H. H. Eames reported the discovery of gold and silver in Minnesota, and Vermillion Lake was the scene of considerable excitement.

The Hidden Treasure mine, Nevada, was located on September 14.

Probably the first discovery of gold in Wyoming occurred when the placers of the Sweetwater River were located.

1868.

The Emma silver mine of Little Cottonwood Cañon, Utah, was located in August, the first shipment of ore was made in July, 1870. It was closed in 1872, the available stock of ore having been exhausted, but was reopened in 1883.

The Sierra Nevada bonanza was discovered on the Comstock lode.

The Dahlonega method of hydraulicing was originated and employed in the Southern States.

The lixiviation process was first employed at La Dura, Sonora, Mexico.

Fort Yukon, Alaska, was declared to be in United States Territory.

The Silver Islet mine was located on the northwest shore of Lake Superior, on Thunder Bay.

The Pelican and Dives mines, Colorado, were located.

The Oro Fino mine in Idaho was the most prosperous.

Gold was discovered in Hardin County, Illinois.

Glacial drift was washed for gold in Ohio, at a point near Brownsville.

Gold was not known to exist in the Black Hill, South Dakota, until this year.

The Stockton mine, Utah, was discovered.

The Swauk placers of Washington were discovered.

1869.

The American practice of lead smelting developed chiefly from the methods adopted in the Eureka district, Nevada.

The Pacific railway was completed — the Union Pacific and Central Pacific tracks joined at Promontory, Utah, on May 10.

The Sutro tunnel, tapping the Comstock lode, was begun on October 19.

Silver deposits were discovered at Pioche, Nevada.

Copper-silver ore was discovered at Butte, Montana, and a smelting furnace was erected at the Parrot mine.

The Central Pacific railway was completed to Salt Lake City in December, 1869, which served to stimulate prospecting.

The silver-lead mines of Cerro Gordo, California, were developed.

Dynamite was beginning to be used in the mines of the west.

The first mining was done at the Silver Islet mine, Ontario, Canada, — the ore was blasted from the outcrop.

The region around Rico, Colorado, was explored, and the Pioneer claim was located in July.

The Elkhorn district, Montana, was prospected and several lodes were located.

The Tintic district, Utah, was discovered, the first location being the Sunbeam on December 13.

The lixiviation process was employed at Trinidad, Sonora, Mexico, also at San Marcial, Sonora.

Silver mines were discovered in the Seminole Mountains, Wyoming, by prospectors who were killed by Indians; subsequently gold-bearing veins were located.

It is claimed that the Spaniards worked gold mines on the Chattahoochee and Chestatee rivers in the Southern States.

The placers of Ram's Horn, Radersburg and Cow Creek, Montana, were opened and worked slightly then abandoned, but were finally reopened and worked to considerable depth during 1869.

The Rudefeha or Haggerty-Ferris mine, near Battle Lake, Wyoming, was discovered in the Grand Encampment district.

1870.

The silver mines of Eureka and Pioche, Nevada, became large producers.

The first important developments were made in the Big and Little Cottonwood and Bingham Cañons, Stockton and Tintic districts, Utah.

The Loon Creek placers, Idaho, attracted miners as late as 1879.

A gold vein was discovered in Benton County, Minnesota, but operations ceased in a few years.

The placers of Cedar Creek, Missoula County, Montana, were discovered, but hydraulicing machinery was not installed until 1895.

Work was begun at the Defiance mine, Utah.

The Black Dragon mine, Utah, was discovered on January 3, and the Mammoth on February 26.

The Miller mine in American Fork Cañon, Utah, was discovered, but was not worked extensively until 1871.

The construction of the narrow-gauge railroad system was begun in Colorado by the Denver and Rio Grande Railroad Company.

The mines of Rosita, Colorado, were discovered.

The Emma mine Little Cottonwood Cañon, Utah, began shipping ore.

Important discoveries of lead and zinc ore at Joplin, Missouri, were made, which were followed by the rapid development of the district.

The first double-jointed hydraulic giant was introduced into California mines.

The first steam stamp was invented by T. R. Wilson, it was tried at Silver City, Nevada.

Gold was found in Wightman's Gulch, Colorado, which led to the development of the Summitville district, and the location of the Little Annie in September.

1871.

The mines of Big and Little Cottonwood Cañon, Utah, were large producers.

Silver-lead ore was discovered in Parley's Park district, now Park City, Utah.

Chicago became an important smelting and refining center.

The first mill was erected at Homansville, Utah.

The lixiviation process was employed at Bronzas, Sonora Mexico.

The dry placers, especially along the Gila River, Arizona, were worked.

The Little Giant vein was discovered near Silverton, Colorado.

Work was begun in the Legal Tender mine, Utah.

The Mercur mines, Utah, were discovered in Lewiston Cañon, 7 miles northwest of Camp Floyd, although actual development did not begin until 1891.

The Crown Point-Belcher bonanza, Comstock lode was discovered.

Considerable placer mining was done in Bingham Cañon.

1872.

The silver veins at Park City, Utah, were located on June 19.

Silver was discovered at Georgetown, New Mexico.

Refining of lead began at the Germania works, Salt Lake City, Utah.

Cast iron water-jackets were introduced at the Winnamuck smelting-works, Utah. This was the first use of water jackets in the smelting practice of Nevada and Utah, also the first employed anywhere.

Lead ore was discovered in Cherokee County, Kansas.

George Holt and others prospected the upper Yukon during 1872–78.

The Mammoth mine was the chief producer in the Tintic district, Utah.

The Ontario mine, Utah, was discovered.

1873.

The United States by act of Congress, February 12, discontinued the coinage of silver dollars. This act in effect demonetized silver. It authorized the coinage of one-half and one-quarter dollars and dimes below standard weight, and a coin called the "trade dollar" for Asiatic commerce. The latter coin were of standard weight, but could not be used as legal tender for sums above $5 for any one payment.

The Big Bonanza was discovered in the Consolidated California and Virginia mines on the Comstock lode.

Silver-lead mines were discovered in the Wood River district, Idaho.

Blankets were in general use in the gold mills of California.

Silver mining on Little Iron River was carried on until 1875, collapsing in 1876.

The Stewart River, British territory, was prospected, and gold was found on White River, also in British territory.

The Silver King mine, Arizona, was discovered.

The district between Durango and Rico, Colorado, was opened, but owing to the refractory complex telluride ores little was accomplished.

The placers of Flint Creek, south of Drumlummon Mountain, Montana, were discovered.

The silver-bearing sandstone of Silver Reef, Utah, Washington County, were located.

The Chloride Point mine was located about this time, and was a producer until 1880.

The Peshastin gold-bearing veins were discovered, and in 1881 those of the Swauk district, Washington, were located.

1874.

The "Big Bonanza" yielded largely, and another discovery was made in the Ophir mine, Comstock lode.

Argentiferous lead-carbonate ore was found on Iron Hill, Leadville, Colorado, the Lime and Rock claims being located.

Silver-lead ore was discovered at Darwin, Inyo County, California.

Dust chambers were installed at several western lead smelting-works, and other adaptations were made in the treatment of matte.

The price of mercury more than doubled, raising from 60 cents to $1.30 per pound, which, with the fall in price of silver, and trouble with tailings, seriously crippled the milling industry of the Western States.

Mr. G. Kuestel introduced the lixiviation process at Melrose, California.

The Newburyport mines, Massachusetts, were discovered October 10, and were worked. The ore is silver and lead.

The Cassiar district, British Columbia, was discovered.

Following the discovery of the placers on the San Miguel River, Colorado, the Smuggler-Union vein was located and developed.

Gold was shown by a half-breed Indian at Fort Larmie, Wyoming, who stated that he had found it in the Black Hills, South Dakota.

1875.

The Emma mine of Little Cottonwood Cañon, Utah, was exhausted.

The Horn Silver mine at Frisco, Utah, was discovered.

There was great activity in Hydraulic-mining in California.

Smelting ores were discovered at Leadville, Colorado, above the placers of California Gulch.

The Trout and Fisherman mines were located in Colorado.

The Sheridan claim, Colorado, was located.

Local interest centered in the drift gold of Missouri, and examinations were made by C. P. Williams of the Missouri School of Mines. He reported it too low-grade to work.

The Elkhorn mine, Montana, was located on Holter lode on January 2.

1876.

The first shipment of ore was made from Leadville, Colorado.

Investigations by Anton Eilers and others determined the correct principles in preparing charges of ore for smelting, which was a development of great economic importance.

The first suit was brought by farmers in California against hydraulic-mining.

The Travona mine (silver ore) was located at Butte, Montana. The Alice mine, in Missoula Gulch, was opened during 1876–77.

The rush of miners began to the Black Hills, South Dakota, being augmented by the discovery of Deadwood. The Black Hills were an Indian Reservation till this time.

The Homestake mine, South Dakota, was located by the Manuel Brothers.

The Drumlummon gold ledge was discovered at Marysville, Montana.

By act of Congress of the United States on August 15, a silver commission was created, which reported on March 2, 1877.

The Amargoza mine of San Bernardino County, California, was discovered in 1852 by emigrants, but its location was lost. It was rediscovered by J. B. Osborne in 1876.

The Specie Payment mine was discovered at the head of Virginia Cañon, Colorado.

1877.

The Bassick mine, Silver Cliff, Colorado, was discovered.

The Fuller placers in Colorado were discovered.

The first smelting works were erected at Leadville, Colorado.

The Omerga mill was erected, and was probably the most successful on the Comstock lode.

A Stetefeldt furnace was installed and operated on argentiferous ores at the Ontario mill, Utah.

The argentiferous zinc blende ores were treated by the lixiviation process at Galena, Nevada, having been previously concentrated by the Krom dry system.

1878.

Lixiviation was employed at the Advance mill, Monitor, California.

A gold nugget was found on the Rappahannock River, Virginia.

The second bonanza was discovered in the Silver Islet mine, Ontario, Canada.

The Lake Valley silver mine, New Mexico, was discovered in August, and was worked continuously until 1893.

Tombstone, Arizona, was discovered by E. L. Shiefflin.

John Frazer discovered gold on the beach near Ocean Side House, California, and another rush to the beach began.

Blankets were used in saving sulphurets in the first mill built by the Homestake Mining Company, South Dakota.

Open-pit or " Glory hole " mining began at the Homestake mine, South Dakota.

Lead-carbonate ore was discovered in the eastern part of Gunnison County, Colorado.

The Hecla Consolidated Mining Company at Glendale, Montana, began producing ore. The silver-lead deposits of Sierra Mojada, Coahuila, Mexico, were discovered.

New discoveries with resulting excitement at Leadville, Colorado.

Congress passed an act on February 28 ordaining the coinage of from 2,000,000 to 4,000,000 silver dollars at most, on Government account, of 412½ grains, 900 fine and of full legal tender, except when otherwise specified by contract.

1879.

Sulphurets were successfully treated by the chlorination process in the Carolina mines, also those of other Southern States.

A pocket of ore was discovered in the Peshastin district, Washington, from which $60,000 were taken.

A Mears chlorination plant was installed at the Phoenix mine, North Carolina.

The lixiviation process was applied at the Tarshish mine, Moniter, California, by O. Hofman, but was not successful.

The opposition of the Indians to white men crossing the Alaskan coast range to the interior was overcome by Captain Beardslee, and during the same year a party of twenty-five prospectors made preparation to cross over and were later assisted by the Indians.

The first discovery at Aspen, in the Roaring Fork district, Colorado, was made at the Galena mine on July 5.

The Mercur lode was located on April 30, in the Camp Floyd district, Utah, but was soon abandoned. It was again located in 1883, and six years later Captain Joseph Smith erected a mill at Marion for the treatment of the ores.

Gold was discovered at the Emmet mine, Wisconsin, and created quite an excitement, which was, however, short lived.

Specie payment was resumed by the United States.

The first important discoveries were made in the Wood River district, Idaho. Ore had been known to exist in this district since 1873, but development was checked by Indian trouble; consequently active mining did not begin until 1880.

Lead-carbonate ore was discovered at Rico, Colorado, also at Red Cliff and Kokoma.

1880.

The Presidio mine, Texas, was discovered, and opened in 1884, and has worked continuously ever since.

The Southern Pacific railway was completed through Arizona, and the Denver & Rio Grande reached Leadville, Colorado.

The Silver Valley mine of Davidson County, North Carolina, was discovered.

A strike was made at Leadville, Colorado.

There was considerable excitement in the Gunnison County district, Colorado, which did not, however, materialize into developments of great importance.

The first hydraulic elevator was erected at Yreka Creek, Siskiyou County, California.

There was a great decrease in the annual gold production of California, amounting to some four and one-half millions of dollars up to 1891.

A Stetefeldt furnace was employed in treating the auriferous ores of the Panamint, California, at the Surprise mill, also at Austin, Nevada.

A Pardee furnace was installed at the Algonkian mill, Phillipsburg, Montana. The Davis and Tyson Metallurgical works were built at Salisbury, North Carolina. This was a chlorination plant, but differed from the Theis process in method of precipitation of gold.

The lixiviation process was successfully installed at the Silver King mill, Arizona.

The Hunt and Douglas ferrous cyanide process was installed at the Conrad Hill mine, North Carolina.

The placers of Silver Bow basin, Alaska, were discovered.

There was considerable activity in mining and development of silver veins in Arkansas.

The "cement deposits" of the Black Hills were discovered and located near Central City, South Dakota.

1881.

Mining began at Douglas Island and principally by open-cuts, operations beginning by working of placers.

Matte smelting and refining in reverbertory furnaces was attempted on the ores of the Conrad Hill and the North Star mines, North Carolina.

A Davis chlorination plant was installed at the Reimer mine, North Carolina.

The gold lode of the Alaska-Treadwell mines of Alaska were discovered.

The Omalak mine, on Golofnin Bay, Alaska, was discovered. This is a silver-lead mine, and probably the northernmost mine in the territory.

The Calico district, California, was discovered.

The Ropes gold veins, Michigan, were discovered and operated, but not actively until 1882.

The first railroad entered the Butte district, Montana, from which time the development was rapid.

Gold and silver mines were worked on Bald and Green mountains near Deadwood, South Dakota.

No work was done in Virginia gold mines, as is shown by the fact that there were no mint returns.

Mining operations in Washington were practically confined to Yokima, Peshastin district and Spokane County, also on Snake River, Columbia County.

1882.

Injunctions by State and Federal courts closed the hydraulic mines in the valleys of the navigable rivers of California.

The Viola mine at Nicholia, Idaho, was discovered.

Red Cliff, Colorado, became quite a large producer.

The first endless-chain bucket dredger was introduced into the United States, at Grasshopper Creek, Montana.

The mines of the South end of the Comstock lode were flooded while driving a connecting passage between the Yellow Jacket and Exchequer.

The Plattner chlorination process was installed at the Tucker mine, North Carolina, but was not successful, the Mears process being adopted.

Krom rolls and the lixiviation process were both successfully employed at the Bertrand mine, Geddes, Nevada.

The Designolle process was applied to the ores of Charlotte, North Carolina, during 1882–83.

Silver-bearing veins were found in Rabbit and Silver mountain districts, Canada.

The Schiefflin party ascended the Yukon, and prospected at a point some eighty miles above Nuklukayet, Alaska.

The Yankee Girl mine was discovered in Colorado.

Owing to a change in management the Cortez mine of Silver Hill, Nevada, began active development which resulted in the discovery of several bonanzas.

The Silver Point, Silver Crown, Hillside, Great Western and Northern Light were the principal mines operating in Washington County, Utah. In Beaver County the Horn Silver, Carbonate and Cave mines were worked.

1883.

Leadville, Colorado, attained its maximum output.

The Monarch district, Colorado, began to be a large producer of lead, reaching a maximum in 1885.

The Viola mine at Nicholia, Lemhi County, Idaho, began to be productive.

Krom rolls and the lixiviation process were installed at the Mount Cory mine, Nevada.

The Designolle process was put in operation at the New Discovery mine, North Carolina, and at the Haile mine in South Carolina.

River-bar mining was in progress on the Lewes River, Alaska. The number of prospectors and miners rapidly increased from this time on in Alaska, fully 200 crossing the passes.

The Embry camp, Washington, was discovered, the most noted mine being the Eagle.

1884.

Aspen, Colorado, became an important producer of lead ore.

The Neihart district, Montana, began to attain prominence.

Extensive bodies of lead-carbonate ore were opened at Cook's Peak, Grant County, New Mexico.

The first discoveries were made in the Coeur d'Alêne district, Idaho.

By this time the lixiviation process was quite extensively used in Mexico.

The Tiger-Poorman mines, Idaho, were discovered.

1885.

Further discoveries were made in the Coeur d'Alêne district, Idaho, especially of silver-lead ore, the Bunker Hill and Sullivan mine being located on September 17.

The rush of miners to the interior of Alaska still continued, and considerable work was done on the Stuart River.

The Morning mines were located in Idaho.

Gold was discovered at a point some three miles west of the Ropes mines, Michigan, which was followed by considerable excitement. These mines yielded nothing but specimens.

The building of the Transcontinental railway revived the mining industry of Oregon.

1886.

The Wardner district on the South Fork of the Coeur d'Alêne River, Idaho, was discovered.

The mines of the Coeur d'Alêne district, Idaho, began to produce silver-lead ores.

E. G. Spilsbury carried on experiments on matting the auriferous sulphides of the Haïle mine, South Carolina, but without success.

The placers of Forty-Mile Creek, Alaska, were discovered.

The Empire State mines, Idaho, were located.

Important discoveries were made in the Eagle Creek Mountains, near Cornucopia, Oregon.

The State Line district, Utah, was located in the southwestern part of the state, in Iron County. The ores are gold and silver-bearing.

1887.

There was a contest between the local and valley smelters, in Colorado, in the market for Leadville ore, with advantage in favor of the latter, owing to railroad discriminations.

The Hillside mine of Yavapai County, Arizona, was discovered.

1888.

Gold was discovered at the Harrison farm, Maryland, by Mr. Kirk, and during the following year a number of other properties were developed, owing to the successful operations at the Harrison property. These mines never proved of any great importance.

1889.

California held the first rank among the states in gold production.

From 1889 on there was a material increase in silver production from Utah, while that from Nevada steadily declined.

The Holy Moses vein was discovered on West Willow Creek, Colorado.

The Hercules mine, Idaho, was located.

1890.

By act of Congress, July 14, the law of 1878 was repealed. The act also provided for the purchase of 4,500,000 ounces of silver monthly, against which certificates are issued, redeemable in both gold and silver.

The establishment and rapid development of the silver-lead smelting industry in Mexico greatly reduced the supply of ore available for the American smelters.

The Northern Pacific and Oregon railroad and Navigation Company completed their line into the Coeur d'Alêne district, Idaho.

1891.

Gold was discovered at Cripple Creek and silver at Creede, Colorado.

The cyanide process was first successfully applied to the commercial treatment of ores by Captain J. R. De La Mar at the Mercur mines, Utah.

The Last Chance and Amethyst claims were located on Bachelor Mountain, Colorado, on Aug. 8.

Creede and Cripple Creek were about of equal importance.

The first recorded location was made in Cripple Creek when the Independence and Washington claims were staked on July 4.

1892.

The Annie, now the Noonday, mine, Oregon, was located.

The principal gold sections of Oregon were in the southwestern part of the state, Baker and Union counties being the most prosperous.

The Monumental mine, Oregon, was the only one having a mill.

Mining was very active in the mines of South Dakota, especially in low-grade ores. From 1892–95 the mines lost ground, but during 1896 the gold production increased, owing to the application of the amalgamation and chlorination processes.

Texas was a small producer of gold and silver, the principal districts being the Llano, Mason and the Trans-Pecos.

Small-scale hydraulicing operations were underway in Kittitas County, Washington.

The price of silver reached 82 cents, the lowest point ever recorded up to this date.

Large bodies of silver-lead ore were developed at Cook's Peak, New Mexico, and heavy shipments of ore were made.

The Maid of Erin mine, Leadville, Colorado, shipped its last lot of lead-carbonate ore in December, having exhausted its great deposit, and practically marking the end of the production of that class of ore at Leadville.

There was a strike of the miners in the Coeur d'Alêne district, Idaho, owing to a reduction of wages.

The Howard skimmer for handling zinc crust was invented, which was one of the most important of the mechanical improvements in the Parkes process of desilveration. It was first put into practical use at the works of the Pueblo Smelting and Refining Company at Pueblo, Colorado. The Howard process was invented some time later.

The cyanide process was introduced at Bodie, Cripple Creek, Colorado.

Experiments were made by Mr. Richard Eames on the cyaniding of the ores of Gold Hill, North Carolina. A ten-ton plant was built during 1893 at the Moratock mine, North Carolina, but owing to leanness of ores was abandoned.

The mining industry of Arizona suffered from the great depreciation of silver as well as all of the Rocky Mountain country.

There was a decided falling off in gold production in North Carolina.

The silver production of Nevada also suffered from the depreciation of silver.

The Indian Queen and Poorman mines, Nevada, began work, litigation having been settled that had tied them up for several years.

1893.

The discovery of the Dehli mine, Minnesota, caused considerable excitement.

The first discoveries were made in the Rainy Lake region, and subsequent work has been encouraging.

The De La Mar mine, Lincoln County, Nevada, was discovered, and subsequently had a marked influence on the gold production of the state, leading in 1895.

The Champion mine, Oregon, installed a mill for treating its ores.

The report of the Herschell committee, closing the Indian mints to the private coinage of rupees, was published June 26, causing a decline in the price of silver from 81 to 62 cents per ounce, and contributing to the industrial panic which occurred this year. It led among other things to the suspension of operations in many silver-lead producing districts of the United States.

All of the mines of the Coeur d'Alêne district were temporarily closed on account of low prices for silver and lead.

All of the smelters at Leadville, Colorado, suspended operations in the autumn, only two of them subsequently resuming.

An electrical power plant for the operation of mining machinery was installed at Bodie, California.

The Caminetti Act passed by Congress regulated the hydraulic mining industry in California.

A chlorination plant was erected at Gillet, near Cripple Creek, Colorado.

Rich placers were discovered on Cummins Creek, Alaska; the Birch Creek placers were also located.

With the collapse of the silver market Cripple Creek became of more importance than Creede, Colorado.

1894.

There was a second strike of the miners in the Coeur d'Alêne district.

An association of the principal smelters of Colorado was formed to limit prices to be paid for ores. The combination went to pieces early in 1895, and sharp competition was again inaugurated.

The Blue Bell drainage tunnel was began in the Cripple Creek district, Colorado.

The United States lost first place in the production of gold, its product being exceeded by $290,670 by Australia.

The Mount Pisgah excitement at Cripple Creek occurred in April.

There was a marked increase in the output of gold from Arizona, which was followed by a decline in the following year owing to the closing of the Harqua Hala mine.

The principal mines of New Mexico were the Grande, Bella and Apache.

1895.

Lead-zinc ores were successfully smelted at the Silver Valley mine, North Carolina, by Mr. Ninniger of Newark, New Jersey.

A patent electrolytic chlorination process was installed at the Clopton mine, Georgia, but achieved but little success.

A cyanide mill was built at Florence, Colorado, by the Metallic Extraction Company.

Unsuccessful attempts were made to employ the cyanide process at the Sawyer mine, North Carolina.

Colorado and Montana produced a steadily increasing output of silver up to this year, following which there was a decided decline.

The Pearce mine, Arizona, was discovered.

Gold mining was the most important single industry in California.

The Randsburg district, California, was discovered.

For the first time in one-quarter of a century the gold product of Colorado exceeded that of the silver.

A suction dredge was successfully operated on the Snake River, Idaho.

Gold was reported as found in the shale of western Kansas, on the Smoky Hill River, in Gove, Trego and Ellis counties.

A large dredging plant was installed on Grasshopper Creek, near Bannack, Montana.

Gold was discovered in glacial drift at Milford, Nebraska, during 1895–97.

No gold was produced in Texas, but there was a gain in the silver product especially from the Presidio mine at Shafter.

The Republic mine, Washington, was located on March 5, while fifteen days later the Mountain Lion claim was discovered.

There was a decrease in the production of gold from Washington.

1896.

The Fraction, Flat Iron and Last Chance claims, Washington, were located on September 7.

The first patent was secured on the Huntington-Heberlein process, important and revolutionary improvements in the metallurgy of lead.

There was a strike of miners at Leadville, Colorado, which practically stopped all production during the last six months of the year.

The Standard drainage tunnel at Cripple Creek, Colorado, was begun.

The Klondike district, British Territory, was discovered, and a mad rush commenced in August.

There was an increase in the gold and silver production in Oregon, due to the Baker City mines, which were also the chief producers during 1897.

The Lone Pine and Last Chance were among the first recorded locations in the Mercur district, Washington, being located on February 28 and 29, while the Pearl claim was discovered on November 5, the Surprise, July 18.

1897.

There was a revival of placer mining.

A modified caving method was employed in the Mercur mines, Utah.

Colorado attained first place, as a gold producer, among the states.

Gold was found on Gravina Island, Alaska, the Gold Standard property on Cleveland Peninsula being located in 1898.

The low-grade gold deposits of Ravillagigido Island, Alaska, were discovered.

The Eldora telluride district in the southwest corner of Boulder County, Colorado, was opened.

The Boise Basin, Idaho, produced most of the gold in the state.

The silver production of Butte, Montana, came largely from the copper-silver ores. Four dredges were operating at Grasshopper Creek and Alder.

The Daly West and Ontario were the most important mines in the Park City district, Utah; the latter was closed in 1897. There was a decrease in the gold production, owing to the fall in value of silver and increased railroad and smelter rates.

The northern one-half of the Colville Indian Reservation, Washington, was opened to mineral entries in February.

1898.

The Empire State-Idaho Mining and Development Company was organized, which was the beginning of consolidations of the Coeur d'Alêne interests.

The Theis process was operated successfully at the Isenhour mine, North Carolina, also at the Haile mine, South Carolina, and the Franklin and Royal mines, Georgia.

Gold was discovered on Anvil Creek, near Nome, Alaska, by Laplanders.

Dawson was built on the banks of the Yukon.

Several old mines were reopened in North and South Carolina.

Gold was claimed to have been found in the high terraces of the Platte River, Nebraska, during 1898–99, and Lincoln was the center of dry concentration apparatus manufacture.

Gold was found in sandstone at Bellville, Ohio.

The gold production of Oregon again fell off.

Hydraulicing was carried on in the Argonaut mine, Utah, at the mouth of Carr Fork.

The Camp Floyd district, Utah, was the chief producer, and the gold production steadily increased till 1902, although no new camps were opened. The Annie Laurie mine, Pinto County, was a good producer of gold and silver.

The largest producers in Washington were in Stevens County.

1899.

The American Smelting and Refining Company was organized, which acquired a large number of the silver-lead smelting and refining works of the United States, several of which were promptly dismantled.

The third strike of the miners of the Coeur d'Alêne district occurred this year; the Bunker Hill and Sullivan mill was dynamited on April 29; and martial law was proclaimed. The mines were finally opened on a non-union basis.

There was a strike of the smelter workmen in Colorado early in June, which hindered operations for many weeks.

Four cyanide plants were operating at Cripple Creek, Colorado.

The hydraulic jet-lift for draining the deep-levels of the Comstock lode was installed at the C. & C. shaft.

The tundra in the neighborhood of Nome, Alaska, was prospected by drill and shafts during 1899–02.

This was the record year in gold production for Colorado, Cripple Creek leading.

Steam operated gold dredges were working on Baboon Creek in the Florence district, also on Snake River, Idaho.

The De Lamar district continued to lead in the production of gold in Nevada.

An important strike was made at the Chainman mine, White Pine County, Nevada.

The Cochite district, New Mexico, began development work.

The Republic district, Washington, was very actively developed, but the Republic mine being closed kept the output low.

1900.

Electrical installations were made at the C. & C. shaft on the Comstock lode.

Relics of gravel-mining were found at Gold Run, Alaska.

The high bench-gravels on Anvil Creek, Alaska, were discovered during 1900–02.

Teller County stood first in gold production in Colorado.

There was a revival of mining in Georgia.

The Ramshorn and Bayhorse, Custer County, Idaho, were the deepest and best developed copper-silver mines in the state.

The Tonopah district, Nevada, was discovered by James Butler.

Electrical power was introduced into the Tonopah district, and the development of the Tonopah Lake district was stimulated by a system of small leases.

There was great activity in the construction of cyanide mills in South Dakota, although the mining of gold was confined largely to the Black Hills.

Gold was discovered in Box Elder County, Park Valley, Utah, during 1900–01.

1901.

The smelting interests of the Guggenheim's Sons were absorbed by the American Smelting and Refining Company, the former becoming, however, the dominating factor in the amalgamated company. The American S. & R. Company assumed control of the lead market, fixing the price both for the producer and consumer, and regulating the output by agreement with the large producers, and by adjustment of its smelting charges in connection with small producers.

There were eleven cyanide plants operating in South Dakota.

The mining interests of Tombstone, Arizona, were consolidated, following which the district again became an important mining center.

Gold was found on Thunder Mountain, Idaho.

The Oregon King mine, Oregon, was opened.

1902.

There was considerable activity in mill construction in Nevada, especially at the De La Mar mine.

The Sierra de Mogollon properties, in New Mexico, were developed.

Dredging was successfully carried on in the Moreno Placers, Colfax County; also at Grant, Sierra, Santa Fé, Taos, Lincoln and Socorro, New Mexico.

Practically all of the Republic mines, Washington, were operating.

There was considerable excitement in the Wichita Mountains, Oklahoma, during 1902–03.

Gold was found in glacial drift at St. Croix Falls, Wisconsin.

The output of the Coeur d'Alêne district was limited by arrangement between the leading producers and the Am. S. & R. Company. Further steps were taken by the smelting combine to centralize the smelting operations, the Philadelphia plant, at Pueblo, Colorado, being closed, and the famous smelter and refinery at Argentine, Kansas, was abandoned and dismantled.

A cyanide plant was installed at the Smuggler-Union mine.

Colorado produced more than one-third of the gold and one-fourth of the silver product of the United States. Alaska followed with one-ninth of the total gold output, while she contributed more than one-half the placer gold of the United States. Montana held second place as a producer of silver, having produced nearly one-fourth of the silver in the states. Utah stood third in rank as a silver producer.

Australia held first place in the gold production of the world; the United States came second, Russia fourth, and Canada fifth.

Mexico led in the production of silver, the United States being a close second.

There was a serious depression in the mining industry of Colorado, owing to the decline in silver and exhaustion of a number of large gold mines.

The Parks and Columbia mines of Georgia were the largest producers.

J. T. Lovewell reported finding from $2 to $10 in gold and silver per ton in the ores of Western Kansas; officials of the United States Geological Survey examined the district, but found only traces of gold and very small amounts of silver.

The gold deposits of Columbia Mountain, Tonopah, Nevada, were discovered.

1903.

The Federal Mining and Smelting Company effected a consolidation of many of the large mines of the Coeur d'Alêne district.

The Western Mining Company was organized as a subsidiary company of the Guggenheim Exploration Company, and acquired several of the large lead-producing mines at Leadville, Colorado.

In July there was a strike of the smelter-men at the Grant works of the American Smelting and Refining Company, and as a result the plant was closed and abandoned.

The first shipment of gold was made from the Combination mine, Nevada, which was discovered the same year.

There was considerable active development in the Bradshaw Mountain district, Arizona.

The passage of the eight-hour law was an important event in mining circles, Arizona.

The Cripple Creek drainage adit was started and completed, connection being made with the El Paso mine on September 6.

The Old Gold mine on Beacon Hill, Colorado, was discovered.

The extension of the Montana railroad from Harlowton to Lewistown was completed and stimulated the gold mining industry of Fergus County, Montana.

There was a falling off in the gold production of the Mercur camp, Utah.

1904.

Probably the first successful application of the cyanide process to low-grade Southern gold ores was made at the Colossus Gold Mining and Milling Company's plant.

Australia still led in the production of gold; South Africa came second and the United States third.

Owing to the lowering of the water-level in the Cripple Creek mines, Colorado, new discoveries were made.

The Harlson County placers of Georgia were worked.

Silver was still the most important product in Idaho.

Telluride ores were discovered at the Iron Spring mine on Rapid River, Idaho.

The Whitlace mine, Montana, was reopened after lying idle for 27 years.

Interest centered chiefly in the Cornucopia camp, sixty miles south of Baker City, Oregon.

There was a marked increase in the gold and silver production chiefly from the Bingham district, Utah. Increased railroad facilities stimulated the districts in the southern part of the state. Connection was made with the Pacific coast.

Both the gold and silver product of Washington had increased; the Sherman district began to attract attention.

1905.

Most of the gold produced in Utah came from the smelting of copper ores.

The Huntington-Heberlein process was adopted by the Am. S. & R. Co.

Many old mining camps, including Cerro Gordo, California, and Eureka, Nevada, began to attract attention again. The Eureka and Richmond companies were consolidated.

The Selby works at San Francisco was purchased by the Am. S. & Securities Company, a subsidiary company of the Am. S. & R. Co.

The United States Smelting and Refining Company was organized which took over several independent works, with plans to enter into competition with the Am. S. & R. Co.

During this year nine states and territories produced 99.5 per cent of the gold ouput of the United States, the more important being: Colorado, California, Alaska, South Dakota. Montana led in silver production, being followed closely by Colorado and Utah. Idaho was beginning to be an important factor in the production of silver which came chiefly from silver-lead ores.

The United States led in the production of silver, Mexico being second.

The principal source of gold in Arizona was from the copper ores.

There was a pronounced increase in the gold output of California.

The gold production of Idaho decreased somewhat.

Four-fifths of the silver came from the Butte copper mines, Montana. Fergus County led as a gold producer, Kendall being the chief center.

The only placers worked in Montana were those on Grasshopper and Rattlesnake creeks.

The Tonopah district was the most important in southern Nevada, the Tonopah mine being first and the Montana second in importance.

Gold dredging had become a fixed and profitable industry in California.

1906.

An electrolytic lead refining plant was erected by the U. S. S. & R. Co., near Chicago, which was the first work of this kind in the United States. The Guggenheims had practically secured control of the National Lead Company, thus bringing the larger part of the lead-consuming industry of the United States into direct affiliation with the Am. S. & R. Co.

Steam shovels were employed in the Boston Consolidated Mining Company's mines, at Bingham, Utah.

The Idaho mine, Clay County, Alabama, was opened, and dredging was done on the Chestatee River.

CHAPTER III.

OCCURRENCE AND ASSOCIATION OF GOLD AND SILVER.

No attempt at an exhaustive discussion of the theory of ore-deposits is undertaken in this connection; however, it would seem to be both necessary and desirable that so much of the generally accepted theories should be given as to render the following information more intelligible to the reader. Extracts from various papers on the theory of vein structure and deposition of minerals are quoted freely, references being given in order that the reader may be able to refer to the full text should he so desire.

Theory of Ore Formation and Occurrence of Gold in Gravel. — In J. F. Kemp's paper[1] on the Formation of Veins is an excellent discussion and summary of the principles involved, from which the following extracts are taken.

"All problems of ore deposition resolve themselves into three main parts. The first is the geological structure of the immediate country. The second includes the solvent or introductory medium and its prime mover. The third relates to the chemical reactions involved.

"Under the first we raise the question, Why has the particular spot been selected by the depositing agents? Granted, as is usually the case, that some fluid has been the vehicle of introduction, this phase of the problem becomes one of explaining cavities and waterways." The usual receptacles for mineralized solutions and the minerals subsequently deposited from them are porous rock and openings produced in rock masses by folding and faulting and often by the natural process of cooling of molten or heated bodies of mineral matter.

"Inasmuch as the greater number of ore bodies have been obviously precipitated in cavities and by the medium of some solvent, all careful observers have at once pitched upon water as the necessary vehicle. However widely one writer may differ from another in the emphasis laid on the condition of the water, whether hot or cold, whether derived from the vapors held by the igneous and molten

[1] The Formation of Veins, J. F. Kemp, Mining Magazine, Vol. 10, p. 89.

rocks deep within the earth or whether fallen from the clouds as rain; whether in the form of the ocean standing above the crevices or as lakes in the same relation; water in some form has appealed to all as the chief agent. . . . Try as one may, cast about among all conceivable agents and processes to the extreme of knowledge, we come inevitably back to this conclusion for the greater number of ore deposits."

A paper by Franz Posepny, the distinguished Austrian mining geologist, brought out two points, namely; the deposition of ores and gangues from solution in water and a clearer and more definite notion of the underground waters. Practical mining men had for many years recognized the existence of zones of water in relation to the sulphide ores below and the oxidized above. "It remained for Posepny to sharply differentiate the deep-seated water or those below the permanent water level, from the overlying ones, which by contrast he called the 'Vadose.' The deep-seated waters are relatively still and very slow in their movements if they move at all; whereas the vadose are constantly migrating as they trickle downward after rain-storms until they meet the ground-water, or until they are tapped off in springs and vents at some lower point, having perhaps gone deeper than the vent by a syphonic movement around an impervious barrier. With increasing depth within the earth the deep waters meet zones of slowly increasing temperature, and hence conditions of unstable equilibrium. . . .

"By a mathematical treatment of the increasing load supported by deeper and deeper layers of the earth's crust, and by a consideration of the resistance of the materials involved, Van Hise was able to establish the impossibility of cavities at an extreme depth greater than about 30,000 feet, or say, 10,000 meters, for the most resistant rocks, such as granite. For softer rocks, such as shales, it might be less than a tenth of this. . . . From these considerations it follows that as regards movement and cavities, there were three zones in the earth's crust, an outer or upper one of small load, where fractures would be possible and the natural result of movements; a lower one of flowage, where fractures and cavities would be impossible, and an intermediate one wherein from the varying resistance of the different rocks present, there would be both fracture and flowage.

"These conceptions are fundamental and far-reaching. At once, so far as the consideration of the circulation of underground waters is concerned, and therefore of ore deposition, they limit the discussion to the depth of possible fractures, and in the extreme therefore and amid the most resistant rocks, the ' ewige Teufe ' of the old German miners is 10,000 meters."

Van Hise also contends that the chemical changes taking place in the zone of vadose circulation might effect a healing or closing up of the fractures by precipitation, thus producing what may be called the zone of cementation. Further, he favors the idea that the more universal, moderate and long-continued agencies would be the most logical factors in affecting results than the more localized and temporary processes.

Kemp further contends that: " First, the point was made that all very deep mines penetrate through a water-bearing zone which may be quite shallow, and rarely goes as low as 2,000 feet unless in regions of expiring volcanic activity. Veins, however, extend much deeper; hence some other source than the meteoric must be found for the water which has in large part deposited the vein fillings. This point about the comparatively shallow penetration of the meteoric water has been fully substantiated by extended data subsequently collected by T. A. Rickard, and it may be considered quite firmly established." He further, " made the point that the increase of temperature with depth was so slight as to be of small ejective moment, and that at 10,000 feet it would practically disappear, when quantitatively expressed. While it is evident that some instability of equilibrium would be produced, yet, if we leave out of consideration localized, intruded masses of highly heated igneous rock, it limits the efficient motive power of the meteoric ground-waters to the head produced by higher points of entry, transmitted with constant loss from friction through the underground passages."

" The result of the above two main contentions is that waters deep-seated enough to yield known veins must come from some other source than the meteoric. The source which meets the above objections is in the deep-seated igneous rocks, which volcanic outbreaks show to be richly charged with steam, which are almost always visibly associated with veins, and which are vast and localized stores of heat and energy."

However, we must exclude from this class those ore-bodies usually basic and often composed of igneous segregations. "But for veins and kindred ore bodies in whose production underground and circulating water has so largely shared, the general disposition is to connect them in most cases with expiring igneous phenomena operating alike with emissions from the cooling magmas, and with meteoric waters. Since veins, moreover, are themselves comparatively rare phenomena, it is the more probable that they have been caused by some briefly operating, but exceptionally efficient agencies, rather than by universal and continuously operating ones."

It is probable that the circulating waters, especially of the zone of vadose circulation, derive their mineral content from the sparsely disseminated elements[1] of the rock mass through which they pass, and probably most actively during their downward movement. "Since, except in the case of iron and manganese, the greater number of metals are originally found as sulphides, they are oxidized with the attendant production of sulphuric acid, and thus go readily into solution. Several, however, such as zinc and copper, are apparently redeposited at or not far below the line of the permanent water level, giving rise to enriched ore bodies at these points." The effect of vadose waters is probably more largely exerted in producing changes in existing ore-bodies, producing the rearrangement and secondary enrichment of veins than in forming them in the first place.

"A third and concluding phase of the general process deals with the chemical reactions which are involved in the solution and precipitation of the ores and gangue. For the deep-seated reactions and those which take place under the influence of highly heated eruptive rocks, with the exalted temperatures, and the great pressures involved, we may not be always able to write exact reactions or suggest accurate expressions. But for those which take place under conditions familiar and normal at the surface we may formulate equations which are doubtless very near the truth."

If, as is generally believed, the elements are universally disseminated throughout the rocks of the earth, then considering the intimate relationship between sea and land with the constant exchange of products from one to the other, it is but reasonable to expect to find gold, silver, and in fact all elements in the waters of the ocean but in small amounts. The presence of gold in sea water has been proven by Sonstadt, who after careful experiments on water taken from Ramsey Bay, Isle of Man, stated that the water contained a little under a grain of gold per ton. From which it has been estimated that allowing £8,500,000,000 sterling as the whole gold production of the world, and assuming that the weight of the sea water is 560,000,000,000,000,000 tons according to Professor Wurtz, it would contain 5,000,000, times as much gold as has been mined;

[1] Eng. and Min. Jour., Vol. 84, p. 1067.

the conclusion being that the sea itself contained an ample supply to have yielded that which the rocks contain.[1]

According to Kemp in his Ore Deposits of the United States and Canada, the metallic contents of the ore forming minerals must have been derived either from the ocean or igneous rocks:[2] from the former through the agency of living organisms the metals were deposited in sedimentary deposits, from which temporary lodgment they were extracted by circulating waters, and finally concentrated into the present metalliferous deposits. In the case of igneous rocks their degradation and transportation are largely responsible for sedimentary strata, so that if they were the origin of the metals the sedimentary rocks would ultimately become their resting place, while further changes under favorable conditions would effect their transformation into metalliferous aggregations.[3]

In discussing the possible origin of the gold deposits of the Southern States, George F. Becker says: "The indications of the occurrence do not seem favorable to the hypothesis of such an origin (the assumption that the gneissic rocks are the source of the gold), for there is no such prevalence of solfataric decomposition of the wall rocks below water line as would possibly accompany a gathering together into the veins of small quantities of gold from great masses of rock."[4]

As to how mineralized solutions are formed and why their mineral contents are redeposited forming the various combinations found in in veins and other deposits, a few extracts from Mr. Lindgren's report on The Gold-quartz veins of Nevada City and Grass Valley districts, California[5] will help to explain.

"According to Fuchs,[6] amorphous freshly prepared silica is soluble in water to the extent of 130 grams per ton. The natural siliceous waters show, however, a far greater solubility; the Iceland geysers contain up to 606 grams per ton; Steamboat Springs, Nevada, 306, and the Yellowstone Park geysers up to 580. The silica in the latter is not precipitated by cooling, even to freezing

[1] Min. and Sci. Press, Vol. 69, p. 120 and Chemical News, 4th October, 1872.

[2] Eng. and Min. Jour., March 17, 1904, p. 440, Paper by W. H. Weed on Original Native Gold in Igneous Rocks; The Rôle of the Igneous Rocks in the Formation of Veins. T. A. I. M. E., Vol. 31, pp. 189 to 223.

[3] Ore Deposits of the United States and Canada, J. F. Kemp, p. 32.

[4] U. S. G. S. 16th Ann. Rept. Pt. 3, p. 288.

[5] U. S. G. S. 17th Ann. Rept. Pt. 2, pp. 176–181, 1896, and Ibid, 19th Ann. Rept. Pt. 3, pp. 716–718.

[6] Doelter, Chemische Mineralogie, Leipzig, 1890, p. 189.

point, when not exceeding 400 grams per ton, and, according to F. A. Gooch,[1] it is probable that the compound is not contained as alkaline silicates, but as free hydrated silica. Saturating the waters with H_2S (hydrogen sulphide) or CO_2 (carbon dioxide) did not produce precipitation.

"Deolter found that pyrite, galena, antimonite, sphalerite, chalcopyrite (in part) arsenopyrite, and bournonite are to some extent soluble in pure water when heated for almost four weeks in glass tubes to a temperature of 80° C. About one-eighth or one-tenth of the remaining undissolved, finely powdered mineral was in addition usually found to be recrystallized. Pyrite was soluble at the rate of 1,000 grams per ton of solution, or 0.10 per cent. The solution of galena contained 270 grams of PbS (lead sulphide) per ton.[2]

"According to the same authority galena and pyrite are also to some extent attacked by water containing carbon dioxide.

"Becker[3] found that pyrite is soluble in cold solutions of sodium sulphide. Ten cubic centimeters of solution containing 1.0955 grams of sodium sulphide dissolved 0.6 grams of pyrite, the solution thus containing about 60 grams of pyrite per ton, or 0.006 per cent. Pyrite is also soluble in hot sodic sulphydrate, but not in cold, and is relatively easily soluble in cold and hot solutions of sodium carbonate partly saturated with hydrogen sulphide.

"Similar results were obtained with the sulphides of mercury, copper, zinc, and, of course, arsenic and antimony. The sulphides of lead and silver could not be brought in solution, the former not even when heated to 100° C, in closed tube.

"Doelter's[4] later experiments show that pyrite, galena, zincblende, arsenopyrite, chalcopyrite, and bournonite are all soluble in sodic sulphide by treating the finely powdered minerals for twenty-four days of twelve hours at a temperature of 80° C. in glass tubes. Quantity of mineral used, about 1 gram; quantity of liquid, about 40 to 50 c.c. Of the pyrite, 10.6 per cent was dissolved, corresponding to an approximate content of 0.2 per cent of pyrite in the solution. Galena is even more soluble. In comparing these large amounts with Becker's results it would thus seem that time is a very important factor in the solution of these minerals. In

[1] Formation of travertine, etc., W. H. Weed: 9th Ann. Rept. U. S. G. S., p. 655, 1889.

[2] Tschermaks Mineral Mitteil., 1889, Vol. 2, p. 319.

[3] Mon. U. S. G. S., Vol. 13, p. 432, 1888.

[4] Tschermaks Mineral. Mitteil., 1889, Vol. 2, p. 323.

regard to the solubility of tellurium compounds, which evidently have a close relationship with the gold, there are no data available.

. . .

"It is a widely accepted view that in general the decrease of pressure and temperature forms an important factor in the formation of mineral deposits by ascending hot springs. In view of this it may be profitable to inquire how, as far as we know, the solutions of different substances are influenced by the increase of pressure and temperature.

"It is proper to draw attention at the outset to the fact that the question is extremely complicated, for the presence of other substances, as a rule, affects the solubility of any given salt; so that the rules obtained from simple solutions of certain compounds may not be applicable at all for solutions of the same in mineral waters.

"Pressure certainly affects the solubility of many substances, but the result may be either an increase or decrease. The investigation of Braun[1] shows that the rate of increase (positive or negative) is a function of the pressure, temperature, heat of solution, and change of volume taking place in the solution. If contraction takes place, which is the less common case, there is in general a decrease of solubility.

"Regarding silica, there are apparently no data available; deposition taking place from highly saturated solutions may be due to loss either of heat or of pressure. . . .

"The influence of temperature has been more extensively studied. It may be said that up to about 100° C. there is in general an increase in solubility, but recent experiments seem to prove that for many substances there is, in fact, after a certain point has been passed, a distinct decrease. . . . Assuming a mineral water emerging at the surface with a temperature near the boiling point, and a gradually rising pressure and temperature down to a depth of several thousand feet, it becomes clear that we are not in the least justified in assuming a gradual and indefinitely extended increased solubility in depth, or, reversed, that conditions for deposition will gradually become more favorable as upper levels are reached. It is in fact more probable that for temperatures rising high above 100° C. and under increasing pressures, there will be a decrease in the dissolving power of waters, at least as far as the principal constituents, of the water are concerned. In all probability the quartz veins here described were deposited from solutions at great depth

[1] Ostwald, Allgemeine Chemie, p. 1046.

below the surface, under strong pressure, and at temperatures ranging perhaps from 100° C. up to 250° C. It is true, and the fact agrees with results previously stated, that at the mouth of the crevice, deposits of many substances are formed by suddenly diminishing temperature, but it does not at all follow that a diminution from 200° C. to 100° C. will produce a result similar to that of cooling from 100° to 0°. Besides, the precipitation at the surface is very largely caused by the oxidizing influence of the air, escape of carbon dioxide, evaporation, reduction by organic matter, and algous growth. . . ."

"In regard to the influence of heat and pressure upon the solubility of gold and sulphides, there are but few definite data available, and, in fact, the problem is much more difficult than that offered by the ordinary easily soluble salts. The experiments of Becker and Doelter indicate that heat, and perhaps also pressure, increases the solubility, but how far this increase extends is almost entirely unknown. It is not unreasonable to suppose that, as with other salts, this increase is not indefinite, but reaches a maximum and then again declines."

"Opal or cryptocrystalline silica may be deposited at considerable depths, as its occurrence in several deep mines of Grass Valley indicates."

"The reaction by which the oxides of iron or other iron salts are converted to pyrite by the action of hydric sulphide or sodic sulphide is evidently of great importance. This reaction was shown by Dr. G. F. Becker to have taken place to great extent in the altered country rocks of the Comstock lode, the pyrite being principally, apparently, derived from the ferrous silicates; it was experimentally verified by Doelter[1] in case of oxides and carbonates of iron. It is clear that the ferro magnesian silicates and the magnetite in the wall rocks have furnished the greater part if not all of the iron for the pyrite in the altered rocks, while it is equally certain that comparatively little iron has been carried from the country rock in the vein.[2]"

Many tests on pyrite with nitric acid have shown the presence of gold, which usually occurs in the form of scales and grains and even laminated; this it is claimed could not be the case were the gold chemically combined with the sulphur.[3] It is well known that pyrite may be produced by the action of a reducing agent on sul-

[1] Chemische Mineralogie, p. 148.
[2] U. S. G. S. 19th Ann. Rept. Pt. 3, pp. 116–718, 1897–98.
[3] Am. Jour. Min., Vol. 7, p. 26.

phate of iron; all that would be necessary then to bring about the common occurrence of gold in pyrite would be to have a solution of sulphate of iron and gold, which when acted upon by the reducer would form pyrite with gold included [1] — both crystallizing at the same time, one forming a mineral, the other a metal.

The theory has been advanced by eminent authorities that under natural conditions of heat and pressure, gold and silica will unite forming silicate of gold, which would be slightly soluble in hot water. Therefore conditions favoring the solution and deposition of silica might also produce silicate of gold in siliceous auriferous rocks. Subsequent solution by heated waters would permit it to be transferred from its source in the country-rock to cavities, fissures or porous formations, where together with one or more other minerals it would be deposited as a filling. In the course of time the separation of gold would be affected, thus leaving it in its free metallic form.[2]

"In whatever direction we look for the cause of the original precipitation and re-solution for after-deposit in mineral veins, we must never lose sight of the fact that the first agent must have been potent to precipitate both gold and silver, and the second to redissolve the united precipitates, as no gold has yet been found in nature unalloyed with silver. That sulphur compounds have played an important part in the reactions is evidenced by the fact that scarcely ever has pyrites taken from the Silurian slates of Sandhurst, Maryborough, and other localites, failed to yield gold."[3]

Interesting experiments with solutions of gold, usually chloride of gold, from which the gold was precipitated by means of organic matter, have proven instructive — the gold was found to collect or be deposited upon metallic nuclei, and that besides the gold metallic sulphides as pyrite and galena were especially attractive. This action is analogous to the electro-plating process, the accretion being of practically uniform thickness all over the nucleus. Further, gold crystals have been found to contain or be nuclei of various metallic substances such as brown iron ore and pyrite, which would seem to corroborate the contention that gold can be deposited with or upon metallic sulphides.[4]

[1] Min. and Sci. Press., Vol. 85, p. 48.

[2] Eng. and Min. Jour., Vol. 58, p. 534, and Gold, Its Occurrence and Extraction, A. G. Lock, p. 766.

[3] Gold, Its Occurrence and Extraction, A. G. Lock, p. 757.

[4] Gold, Its Occurrence and Extraction, A. G. Lock, p. 759.

"From these experiments, it would appear that organic matter is the necessary chemical agent to decompose a solution of the chloride of gold, in order to precipitate the gold as a coherent coating around a nucleus presented to it; and that so far as we have yet tried, iron-, copper-, and arsenical pyrites, galena, antimony, molybdenite, blende, wolfram, and metallic gold, constitute especially favorable nuclei to demonstrate this chemical reaction."[1]

The association would appear to be more of adhesion than of an alloy, in either case maintaining that relation only so long as conditions were favorable, thus changing from the metallic state to a silicate and possibly a sulphide or *vice-versa*. However, the sulphide of gold (if it exists) is so unstable that it is not strange that it has not as yet been detected in nature, although it may be an important factor in the transition between different well-known mineral combinations.

According to Renwick, "Gold is, no doubt, in chemical combination with sulphur, as it is impossible, by mechanical means, to separate the gold from the sulphurets or sulphides — which is used as an argument for the occurrence of more gold in decomposed than undecomposed veins, the gold having been concentrated from the decomposed sulphides."[2]

Many theories have been advanced to account for the occurrence of gold grains and nuggets in gravels, the most obvious one being the disintegration of quartz-veins, which most authorities agree upon as the most probable source of the bulk of gold so found. However, there are a few facts which have led to considerable speculation and debate, and are still variously considered by different authorities. The fact that larger pieces of gold are often found in gravel deposits than are usual in veins, and further that it is usually purer has been a fruitful source of difference of opinion.

Although we may consider that the same agencies are acting in the superficial gravel deposits as in the deep-seated openings formed by fissuring, yet the extreme conditions existing in the latter are wanting in the former case therefore the results obtained for a given length of time would be proportionately less important. Nevertheless the solvent and precipitating actions might readily be augmented by the presence of elements and compounds, or increased amounts of the same, in superficial deposits not known to exist in the veins. "That the waters percolating our drifts have, in many

[1] Gold, Its Occurrence and Extraction, A.G. Lock, p. 760.

[2] American Jour. of Min., Vol. 1, p. 313.

instances, a strong solvent action on some metals and metallic oxides, we have constant evidence in seeing the blue slates of the hill slopes, where covered with drift in the valleys, converted into white pipe-clay. Was this solvent carbonic acid, or have we at times a stronger acid in operation capable of acting on silver, and so affording a reason for the fact that the alluvial gold of a district usually assays higher than the reef-gold of the same district?"[1]

It is known that weak solutions of gold chloride will dissolve pyrite, but not so fast as to hinder the deposition of metallic gold upon the crystal. Galena is probably the most readily acted upon of the sulphides and at the same time permits a rapid deposition of gold. Subsequently the enclosing film of gold bursts along the edges owing to the formation of salts, and in time may become detached or the nucleus may be entirely dissolved leaving the shell of gold. Further, the outside of this gold coating usually has a mammillary form while the inside is rough and irregular. Now, as placer gold often shows a crystalline form it is probable that some of it at least has been formed in this manner.[2]

However, after all evidence has been thrashed out, and when all known facts have been considered it seems unnecessary to look further than the natural and logical results obtainable from the disintegration of quartz-veins, and the subsequent purifying action of percolating surface waters through the containing gravels. The following well known and often observed facts are corroborative of the above conclusions: First, the closer to the source of the gold (the vein), the more impure is the gold, therefore, it may be generally stated that the higher the altitude the lower is the value of the gold; second, the smaller the piece of gold, the purer; third, the interior of a nugget of gold is more impure than the exterior; and fourth, the worn condition and rounded form of nuggets found in gravels and drifts.

Large masses of gold are found in veins, although such occurrences are not as common as in gravels.

As an illustration of the possible occurrence of large masses of gold in gravels the case of the Boly Fields gold-vein, Georgia, may be cited. It is stated that "thousands of dollars worth of metal were obtained in a few days by simply blasting it out of the rock, breaking it up with hammers and pounding the fragments in mor-

[1] Gold, Its Occurrence and Extraction, A. G. Lock, p. 558, 1882, and The Nature of Ore Deposits, R. Beck and W. H. Weed, 1907, pp. 651–656.

[2] Min. and Sci. Press, Vol. 17, p. 306; Ibid., Vol. 21, p. 228.

tars."[1] It is evident then that if this deposit had been subjected to excessive weathering and erosion it would have become decomposed and removed, ultimately to collect in some suitable place as a placer deposit of great value.

The product of the Red Point drift mine, Placer County, up to 1895 was $430,000 of which 85 per cent would pass a 10 mesh screen, but not a 40, while less than one-half of 1 per cent would pass a 40 mesh screen. Nuggets weighing from 1 to 2 ounces were occasionally found. At Bald Mountain Channel, Sierra County, 10 per cent of the product exceeded one ounce in weight and fully one-half weighed more than one-tenth of an ounce.[2]

The range in fineness of 800 placer and 200 quartz mines in California was: 650 to 988 and 550 to 980 respectively, while the average for the same was 899 and 820, showing a difference of 70 in favor of the placers. However, there are wide variations and only averages of a large number of cases bring out the difference. In this connection the following table is interesting:

Range in Fineness.	Per cent of Total Number of Mines.	
	Per cent Placer.	Per cent Quartz.
Less than 700	1	8
700 to 800	4	14
800 to 900	50	65
More than 900	45	13
Total	100	100

The average fineness of the total product of the Ruby gravel mine, California, was 898; 3 per cent of the product, weighing above 10 ounces, was 860, which is a close approach to that cited above for quartz mines; while the largest nugget, weight 200 ounces, had a fineness of 849. The fine gold averaged close to 910. The difference between coarse and fine gold was about 5 per cent. The thickness of the enveloping layer of purer gold in nuggets is probably independent of the size, but constitutes the larger part of a small than a large piece, and as has been pointed out: "The degree of purification thus appears to depend upon the ratio of the super-

[1] T. A. I. M. E., Vol. 25, p. 803, 1895.
[2] Eng. and Min. Jour., Vol. 59, p. 101.

ficial area to the volume, being largest in the small pieces and scales than in the nuggets. Further, in the Ruby mine the purity of the gold from the center of the mine was found to vary largely with the presence or absence of water, the variation being from 933 to 935, or as much as one-half of 1 per cent.[1]

Mr. George Hewitt observed that in the Black Hills, South Dakota, little gold occurred in the vicinity of dikes cutting the Potsdam formation, and what did occur had lost its rounded and worn appearance and showed evidences of the action of powerful solvents. The placer gold of this district is seldom worth less than $18.50.[2]

Along the upper Burnt River, Oregon, the flour gold in the bench gravels has a fineness of 970, while the coarser gold of the stream gravels is 922. At Canyon the placer gold is 900 fine, but a few miles below the mouth of Canyon Creek, in John Day River, the gold has a fineness of 990. At Rye Valley the upper benches yield gold 750 fine, while in the lower benches it has a fineness of 800.[3]

At California Gulch, Leadville, Colorado, the gulch gold was worth $17 to $19, while that from the veins was valued at $15.[4]

In the Warren district, Idaho the bullion from the quartz-veins ranges from 300 to 550 fine, the placer gold from the small creeks 650, that from the larger creeks 725, while that from the Salmon River runs from 800 to 825 fine.[5]

It is evident then that there is a progressive refining action caused by gradual dissolution of silver, lead, copper, etc., from the surface of the grains.[6]

For a brief and interesting summary of the possible influence chemical action might have upon the formation of gold in alluvial deposits, the reader is referred to the paper on the Geology of the Yukon Gold District, Alaska, by J. E. Spurr.[7]

The following summary may be given regarding the occurrence of gold and its probable origin.[8]

"First. Gold exists in the oldest known rocks, and has been thence distributed through all strata derived from them.

[1] Eng. and Min. Jour., Vol. 59, p. 102.
[2] T. A. I. M. E., Vol. 17, p. 573.
[3] U. S. G. S. 22d Ann. Rept., Pt. 2, p. 637, 1901.
[4] U. S. G. S., Monograph No. 12, p. 516.
[5] U. S. G. S., 20th Ann. Rept., Pt. 3, p. 242.
[6] U. S. G. S., 16th Ann. Rept., Pt. 3, pp. 292 and 293, 1894–1895.
[7] U. S. G. S., 18th Ann. Rept., Pt. 3, pp. 377–379, 1896–97.
[8] Gold, Its Occurrence and Extraction, A. G. Lock, p. 803.

"Second. In the metamorphosis of these derived rocks it has been concentrated into segregated quartz veins by some process not yet understood.

"Third. It is a constitutent of fissure-veins of all geological ages, where it has been deposited from hot chemical solutions, which have leached deeply-buried rocks of various kinds, gathering from them gold with other metallic minerals.

"Fourth. By the erosion of strata containing auriferous veins, segregated or fissure, gold has been accumulated by mechanical agents in placer deposits, economically the most important of all the sources of gold."

General Discussion. — Gold is not confined to veins of definite limits and well defined outlines, but is often found in massive rocks and zones of impregnation where there is no pronounced vein formation. However, when auriferous deposits in massive rocks are thoroughly explored they are usually found to have fairly well defined limits though extremely irregular, and in certain cases depending largely upon the question of economic working. Further, massive rocks when gold-bearing usually have suffered alteration by mechanical movement, although the resulting fracturing may be incipient in character and not noticeable except under the microscope. On either side of the line of faulting or movement the intensity of the fracturing force diminishes until even the incipient fracturing ceases which varies largely with both kind and character of formations present. Therefore the zone of fracture will be within definite limits, which may, however, be so wide as to eliminate all resemblance to that of a vein. A few cases will serve to illustrate this point: At Hedges, San Diego County, California, the deposits are really impregnated zones of hornblende schist, very siliceous, being blue, green and gray in color, the auriferous portion usually being colored. The zones are quite irregular and were probably influenced by the power of penetration of the mineralized currents, which brought in gold and silica. In the Black Hawk Mountains, San Bernardino County, California, a heavy stratum has been extensively broken up by step-faults and thrusts now existing as terraces on the mountain side. So severe has been the fracturing action that in many places the rock-mass is in granular form. The whole mass is stained with hematite, which lines the faces of the fractures and in which gold occurs in varying quantities. Often the rock is cemented into a solid mass of ore. At Gold Mountain, San Bernardino County, California, there are gold-bearing bedded quartzites, the quartzites having suffered considerable fracturing. Elsewhere in California there are broad zones of amphibolite schists, often with little quartz. At the Blue Gouge Mine, El Dorado County, California, there is a zone of slaty rock upwards of 600 feet in width, which is occasionally cut by small quartz-veins. The whole zone is low-grade ore. The Alaska Treadwell mine, Alaska, is an altered mass of eruptive material and is gold-bearing throughout although low-grade. The Cripple Creek deposits of andesite-breccia and granite are auriferous, and often lack most of the characteristics of veins. The presence of silica is noticeable mainly for the reason that there is so little of it. The Homestake mines of South Dakota often attain a width of 500 feet or more, and is practically all gold-bearing though the values are largely localized in quartz. It consists of a hydro-mica schist cut by many veins and lenses of quartz. The granites of California are often gold-bearing, but owe their values to neighboring veins. In Calaveras County, California, gold has been found in beds of volcanic mud, gravels and tufa.[1]

Gold may be found in any formation and in fact in practically any geological age — it has been found in limestone, sandstone, andesite, diorite, rhyolite, granite, porphyry, schists, coal, etc.

The following interesting summary of the rocks in which gold and silver, especially the latter, occur has been given: "Gold, silver, copper, lead, etc., are found in all rocks. Silver ores occur in all kinds of rocks, as granites, porphyry, trap, limestone, sandstone and shales. The famous mine of Guanajuato, the most productive of Mexico, and which yields one-quarter of its product of silver, intersects shales and porphyry. In Zacatecas they occur in wacke, a sedimentary trap rock; while in Sombrete they are found in limestone, in which there are extensive deposits of antimonial sulphuret of silver, one of which yielded in the short space of six months 518,000 pounds troy of silver, over $6,000,000. The veins of the Real del Monte district pass through decomposed porphyry. The mines of Chili, lying on the western slope of the Cordilleras, are connected with stratified deposits of a shaly sandstone of conglomerate character. The mines of Buenos Ayres occur in a mountain of argillaceous shale. In Norway the silver ores of Kongsberg are found in gneiss and slate, in a gangue of calcspar. The deposits in the Hartz Mountains are usually intersected by argillaceous shale, a clayey slate, and the gangue is carbonate of lime, though it is some-

[1] Min. and Sci. Press, Vol. 80, p. 148.

times quartz. In the mountains of Siberia the veins of argentiferous galena occur in crystalline limestone. Other Russian mines, those of Altai, for instance, occur in a coarse clay-slate in the vicinity of porphyry, and contain besides silver ores, those of gold, copper and lead.[1]"

Gold may occur in such quantities or in such a state in the rocks as to be indistinguishable. The tellurium minerals of Cripple Creek, Colorado, and Ragged Top district, Black Hills, cannot be seen nor separated. The latter ores are highly siliceous carrying no perceptible free-gold nor other heavy mineral which could act as a vehicle for the gold.

Gold is known to exist in certain ores so united with a siliceous matrix that the resulting compound is apparently no heavier and may be lighter than the accompanying gangue.[2]

As previously pointed out the surface ores are rich and easily treated, and often occur in a more or less bunchy manner, while at some depth, depending upon prevailing conditions, the values become disseminated and more uniformly intermingled with the sulphides of the baser metals, and are then spoken of as being refractory or rebellious. With this general relation of minerals with depth and their consequent distribution in mind, it is not difficult to see the application to the economical extraction of the useful and valuable elements. For where it would be possible to work a narrow vein with profit as is often the case with outcrops, it becomes an entirely different proposition when the vein has expanded to a width of 40 or 60 feet, and in certain cases to 150 feet. Added to this the change in character of the ore as from a free-milling to a refractory or sulphide ore and a mine which has been able to be worked with profit must of necessity prove worthless when the new conditions are encountered at a depth.

In certain localities tellurium is the disturbing ingredient, while in other localities a selenium alloy may prove to be the obnoxious element. The elements combined either together or singly with iron pyrites or even pyrite by itself may very materially augment the difficulties experienced in making an economical extraction of the precious metal. "Though it be conceded that in many or all cases, auriferous veins become unproductive of commercial profit in proportion as they proceed in depth, it would be very unphilosophical to base on such assumed fact, anything respecting

[1] American Journal of Min. Vol. 2, p. 213.
[2] T. A. I. M. E., Vol. 29, p. 228.

the primary influences which have led to the formation of auriferous veins."[1] More will be said regarding the occurrence of mineral in depth under the discussion of permanence of mining with depth.

Sulphides occasionally occur alone in nature, but an occurrence which is by far the more common is where several are associated together. Galena, blende and copper pyrites; iron and arsenical pyrites, etc., are illustrations; all of which are common associates of gold. Iron and copper pyrites are often gold-bearing, while galena and blende are almost universally silver-bearing. The Chilean proverb is literally true which says: "If thou findest copper, thou hast gold."

The auriferous deposits of the Southern States, some in Colorado, according to Whitney, and in many other localities here and abroad lead in depth to copper; while the early silver mines of Butte turned to copper with some gold in depth. The placers of this district had as a source of their gold the silver and copper veins discovered later.

The common minerals of gold and silver and their associated minerals are as follows: Native silver occurs in scales, crystals, wires, and only rarely as float silver or nuggets. It is commonly alloyed with copper and gold, and is practically universally found in silver veins especially at the outcrops. Silver glance or argentite is a sulphide of silver, and contains about 85 per cent of silver. It is a soft mineral, dull in appearance and is readily cut. It is often found in high-grade ores, especially of the western states and territories. Horn silver or cerargyrite, a chloride, contains 75 per cent silver when pure. It is soft, heavy and of several shades of gray with a waxy luster. Owing to the ease with which it is cut it has received the name, horn silver. Although not especially rich yet, because it can be easily milled even though low-grade, it is considered a desirable find. It occurred at Silver Reef, Utah, with a value of only $5 to $10 per ton, and was profitably worked. In the West it occurs largely in the outcrops of silver veins, but has been found at depths of 300 to 500 feet, when it usually changes into other silver minerals. The mineral embolite is very similar to cerargyrite except it is green. Pyrolusite or ruby silver is a compound of arsenic, sulphur and silver and carries over 60 per cent of silver. It occurred in the famous Granite Mountain mine, Montana; in the Comstock lode; and in high-grade silver ores of various parts of the

[1] Min. and Sci. Press, Vol. 13, p. 50.

West. Brittle silver or stephanite is black, being a compound of antimony, silver and sulphur. In its occurrence, value and characteristics it resembles dark ruby silver.

Practically all gold ores, especially the brittle tellurides, carry more or less silver, which is, however, usually considered as a biproduct.

The various minerals of the base metals such as lead, copper, iron, zinc, and antimony are often silver-bearing. However, these minerals may carry gold and silver in one locality while in a district not far distant with conditions similar or but little different one or the other or both may be wanting. Many of the minerals of lead are argentiferous, the most important ones being the sulphide, carbonate and sulphate.

Gray copper, tetrahedrite, is usually a silver carrying mineral in silver regions, often running as high as 2000 ounces per ton, and is considered one of the most valuable of the silver-bearing minerals. It is quite common in the West. Yellow copper or chalcopyrite is seldom found without traces of silver, which can also be said of blende. Pyrite also carries silver in silver districts, while the other iron minerals seldom carry large amounts, noticeably marcasite also a sulphide.

Silver is almost universally distributed among all forms and kinds of ore-deposits, being even more universal in its occurrence than gold.

The bulk of the gold mined is in the free state, usually found in a gangue of quartz, calcite, siderite, fluorite and barite; the last mentioned being a rare occurrence, and the amount of gold present very small. Gold is found in barite at Big Bend Mountain, Butte County, California, in the Pinkstown ledge.[1]

Gold also occurs naturally in combination with the rare metals as tellurium and selenium, the former with silver forming sylvanite, and petzite. Sylvanite is the most characteristic, and was named after the place in which it was discovered, the gold field of Transylvania. It is a double telluride carrying both gold and silver, and having an average composition of 28 per cent gold, 16 per cent silver, and 56 per cent tellurium. It is called " graphic tellurium " from its system of crystallization and is a brilliant silvery-white mineral. Pure telluride of gold, calaverite, contains no silver, and has a composition of 44.5 per cent gold and 55.5 per cent tellurium. It was first found in the Stanislaus mine, Calaveras County, Cal-

[1] Min. and Sci. Press, Vol. 70, p. 344.

ifornia, and was named after the county; calaverite and pyrite bear a close resemblance, but can be distinguished between by trial with a knife, the calaverite being easily cut. Probably the best specimens of calaverite found in the Cripple Creek district if not the United States come from the Work mine.[1]

General beliefs, which may be designated as superstitions, are often held by prospectors, miners and many other persons, and have, to a much larger extent than is supposed, been responsible for many failures to discover ore-bodies and so delayed the development of districts. In the case of prospectors and miners, their ideas as to the occurrence of minerals and their association with rocks is usually a matter of personal experience, which for well-known districts is one of the best possible guides, but when an attempt is made to apply such information to other districts without due consideration of changed conditions and environments, most serious and illogical conclusions are almost sure to result. Again, much information regarding how to locate and trace mineral veins is handed down from one generation to another of practical miners and so constitutes the traditions of various districts and camps; and it may be said that taken as a whole, with respect to mining and milling practice, it is fairly reliable, but there are exceptions to be made, and to illustrate, a number of fallacious sayings and typical misconceptions are given herewith:

1. Local prejudice for and against certain formations — the Butte miner thinks granite an excellent foundation in general; the Cripple Creek miner prefers phonolite to prospect in; the discovery at Ragged Top, Black Hills, has raised "arrowhead flint" in the estimation of many practical miners; since the silver mines of Calico, California, were discovered, masses of pea-green breccia are diligently searched for as the abiding place of chloride; the California miner looks with favor on black slate and greenstone; the Leadville miners find pleasure in a contact of limestone and porphyry; the miners of Homestake want broad zones of quartz and schists, preferring those stained red by iron; in Silver Reef, Utah, there is nothing quite as favorable as white sandstone and drab clay shales, which there carry high-grade silver ores; the Comstock lode miner expected to find values in bonanzas only and for a formation prefers porphyry (propylite), found in the Comstock country.

2. Prejudice against the so-called "specimen" mines, or mines in which show specimens can be obtained.

[1] Inst. Min. and Metallurgy, Vol. 8, p. 73.

3. Prejudice in favor of certain strikes which involve numerous and elaborate systems of zones as the 9-, 10-, 11- and 12-o'clock zones.

4. Prejudice against veins of certain dips, especially those of slight dips, also bedded deposits.

5. Predilection for the so-called " true fissure " veins.

6. The appearance of an ore as indicative of its value.[1]

7. The idea that values always increase with depth, which being true in certain cases cannot be stated as a definite and established rule for all veins, as has been thoroughly demonstrated (?) in the mines of the United States.[2]

8. Preference to certain slopes of hill or mountain side, as in some districts the northern slope, in other the southern.

9. Choice of low ground, as a depression, which for certain localities may be a sensible thing to do while in others, not. Where veins have outcrops, composed of softer material than the country-rock its more rapid disintegration may result in a sink or depression which may become a surface or underground water-way.

Erroneous statements regarding the occurrence of minerals and their associations are not, however, confined to unwritten sayings, but there is much of a similar character that has been written, and as has been aptly said: " Some put forth a suggestion, it may be the sheerest piece of guesswork; but it finds its way into print, floats with the current literature of the subject, and by virtue of iteration becomes accepted as fact without perhaps ever having been seriously scrutinized."[3] Therefore not only is the practical miner, but also the mining geologist, hampered by prejudices, which have become established and thus have all the weight of precedents. The notion that a theory can be first formulated and then substantiated by facts is changing the natural sequence of things, and is obviously placing the cart before the horse.

In the following pages brief but more or less detailed descriptions of the ore-deposits of the various states and districts are given, although no attempt has been made to give an exhaustive account of all the districts, but rather to discuss the more important and typical mines. However, the material for such a discussion must of necessity be derived largely from the literature on the subject, which in many cases is far from complete and accurate, while in

[1] Eng. and Min. Jour., Vol. 37, p. 465, and Min. and Sci. Press, Vol. 78, p. 265.
[2] Colliery Engineer, Vol. 11, p. 246, and U. S. G. S., 4th Ann. Rept., p. 259.
[3] Eng. and Min. Jour., Vol. 37, p. 465.

other cases is several years old. Further, unimportant districts may be given apparently undue prominence, but have in this connection been chosen to illustrate some peculiarity of structure or occurrence which seemed to warrant recording.

In this discussion the states and territories are taken up in alphabetical order while the mines are grouped in districts, which are in a general way arranged in order of prominence.

Occurrence in Veins, by States and Territories.

Alabama. — The gold fields of Alabama have been divided into two belts, the north and south; the veins of Chilton, Coosa, Tallapoosa and Chambers counties are embraced in the southern belt, while Clay, Cleburne, Randolph and Talladega form the northern belt.[1]

There are four classes of ore in the schists as follows: first, micaceous; second, graphitic; third, manganiferous; and fourth, garnetiferous. The garnetiferous ore is probably of the most importance, being a decomposed gneissoid-schist filled with large garnets. In color it is a deep red. The decomposed garnets are gold-bearing, the cracks being filled with red ochre which is rich in gold.[2]

According to one of the latest geological maps of Alabama, the gold-bearing rocks are distinguished as follows: first, the semi-crystalline Talladega shales of Algonkian age, including argillaceous and hard, greenish, sandy shales (often graphitic); second, the crystalline schists of Archæan age, including mica-schists, which on the one hand, grade through gneisses into granite, and on the other, into siliceous schists; garnetiferous hornblende-schists, probably of dioritic origin, also occur. The prevailing strike and dip are northeast and southeast respectively.[3]

The quartz-veins are parallel with the schistosity of the rocks coinciding exactly in both dip and strike. The vein-content is composed of quartz and other gangue minerals usually accompanying gold.

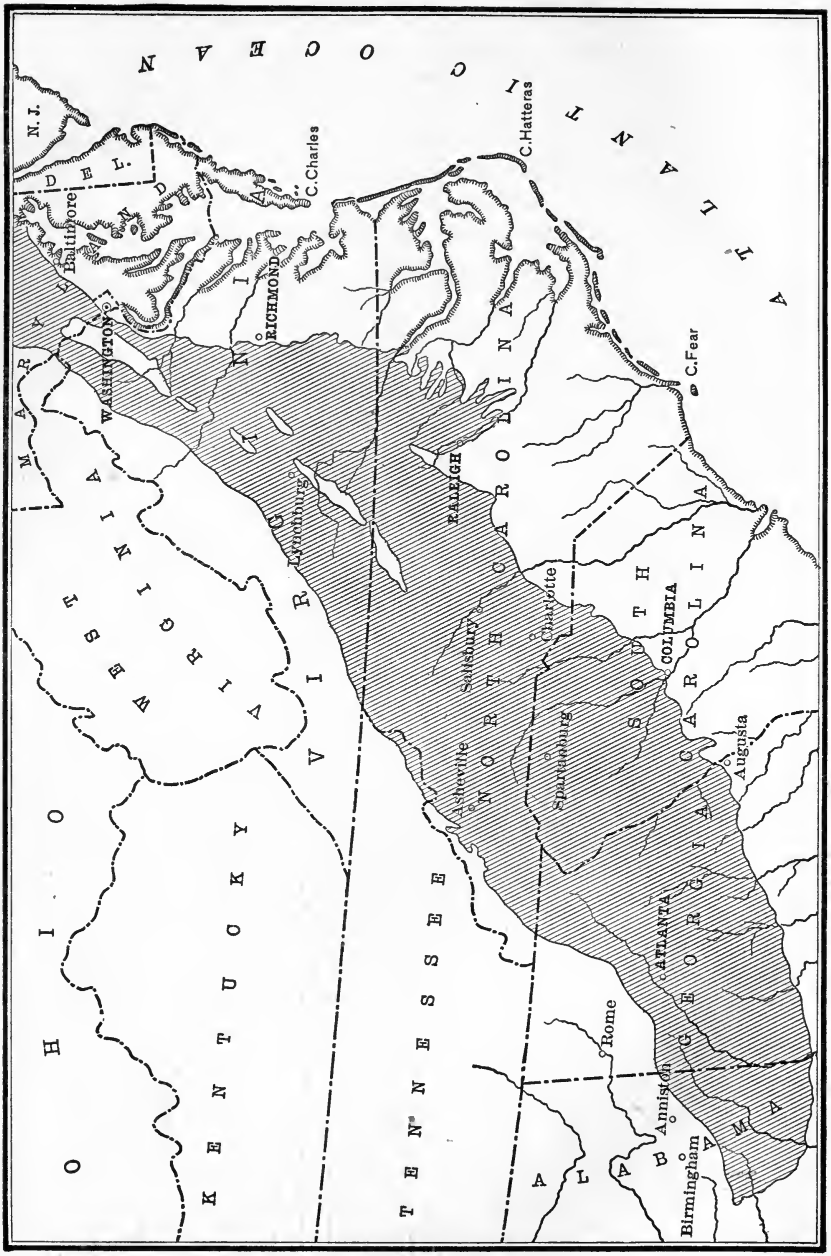
Pockets of quartz rich in gold are of quite common occurrence, in which are found grains of crystallized gold ranging in size from wheat grains to cherry stones. Their extreme irregularity both in strike and dip renders their exploitation expensive.

These irregular and lenticular "stringers" have been called "linked veins" by Dr. Becker.

[1] Eng. and Min. Jour., Vol. 55, p. 486, Bulletins Nos. 3 and 5 Geological Survey of Alabama, and the Mineral Resources of Alabama, 1904, p. 53.

[2] Federated Inst. Min. Engrs., Vol. 14, p. 96.

[3] T. A. I. M. E., Vol. 25, p. 678.



Gold Belt of the Southern States. Shaded portion shows area of Crystalline Schists. (From Trans. Am. Inst. Min. Engrs.)

The ore-bodies which have been mostly worked are found in the mica-schist formations or formations with a garnetiferous, semi-crystalline character. They are low-grade deposits, but of such size as to warrant successful exploitation in many instances.

The two mines which have been successfully operated on the narrow high-grade veins are the Creighton and Walker. The ore is as a rule very refractory, being usually associated with graphitic slate and graphite, through which the gold has been disseminated. Other ore is intermixed with talcoid micaceous schist.[1] In both cases but a very small part of the gold is free-milling. The so-called "saprolites" of this district consist of decomposed schist or gneiss.

At the surface the gold is practically all free-milling, but with depth when the undecomposed sulphides are encountered, the ratio of free-gold to that held in the sulphides is about one to three.[2]

The Arbacoochee district, Cleburne County, contains the more important mines. An area of nearly 100 acres is known to be auriferous in the Clear Creek Valley consisting principally of placer diggings, but later quartz-veins and pockets have been opened up. The deposits being very irregular and pockety, their value can only be determined by more or less extensive development work.

An ore known as "goober pea" is found in the Arbacoochee district, which is characterized by a peculiar speckled appearance being really a conglomerate of quartz and slate nodules cemented together with talc and stained with iron. This ore is moderately soft, and is not difficult to amalgamate. The ore of the Mossback mine averages $25 to $30 per ton, and is free-milling. It occurs in a decomposed vein-filling of sandstone and slate cut by quartz stringers.[3] The mines of most importance in this county are the Lucky Joe, on Turkey Heaven Mountain, the Annie Howe, Price, Red Rover, Eckles, Lee, Crown Point, Sutherland, Middle Brook, Bennie Field, Ballinger, Gold Eagle and Moss Back.

In Randolph County is only one mine of prominence, the Pinetuckey, which stands among the first in the state, and really belongs to the Arbacoochee district owing to its proximity to it. The vein has a north and south strike, with a dip of 20 degrees east. The average thickness is from eight to nine inches. The quartz is highly vitreous and of bluish color. It is said that about one-half of the gold is free-milling, the remainder being in sulphurets.

[1] T. A. I. M. E., Vol. 26, p. 466.
[2] Fed. Inst. Min. Engrs., Vol. 14, p. 93.
[3] Eng. and Min. Jour., Vol. 47, p. 458.

The veins lie more or less conformably in a very garnetiferous, hornblende-schist as a country-rock. At a depth of 60 feet the vein has been cut off or turned to one side by a mass of light-colored granite, which was located by prospect drilling.

The Idaho district of Clay County has two mines of some importance, namely, the Idaho and California. The Idaho mine ore-body is composed of quartz stringers intersecting decomposed hornblende and mica-schists, with well defined walls. The mine is more in the nature of a quarry having but little underground workings, the formation being taken out en masse for fully fifty feet.

Alaska. — As has been pointed out, the auriferous impregnation of this territory must have been strong and wide spread as is evidenced by the universal occurrence of gold both in the free state and in pyrites, often high in value — further, gold values in the tundra, creeks, gulches and benches attest its wide distribution.

Aside from the alluvial deposits, gold is found for the most part in small quartz-veins and stringers which occur in metamorphic rocks. Then too there are mineralized zones of these rocks, where the gangue material is largely wanting. Iron pyrite is not only the most common associate of gold in the parent rock, but occurs in the largest quantity. Gold occurs both in the free state and combined with pyrites, forming sulphurets. Quartz and calcite are the common gangues, while biotite, sericite and chlorite are less common. The minerals and metals associated with the gold are native copper, copper pyrites, galena, mispickel, pyrrhotite, siderite, silver, pyrargyrite and blende.

There are three broad belts in Alaska in which the principal gold-bearing deposits are found. The most important one parallels the Pacific coast line traversing the narrow strip of territory known as the "Panhandle" and terminates among the islands of southwestern Alaska. In this zone are practically all of the quartz mines of the territory and some small placer deposits. Another belt extends northward from the international boundary, near the Klondike, and includes a large part of the country lying between the Yukon and the Tanana, and probably turns to the southwest, entering the region drained by the Kantishna. Only placer gold is produced in this belt. The third belt is of the least importance, owing, probably, to its not being well known. It includes the placer district of the upper Koyukuk. However, the placers of the Kobuk River and Seward Peninsula may represent the southwesterly extension of this belt. Only placer gold has been obtained with the exception of a single quartz mine on Seward Peninsula.[1]

Probably the most important belt of gold-bearing quartz-veins yet discovered occurs along the southeastern coast. It has been worked at Berner's Bay, Douglas Island, Juneau, Silver Bow Basin and Cook's Inlet, of which the deposits on Douglas Island are of prime importance.

The veins occur in Tertiary rocks, slates, schists and granites and carry free-gold and auriferous pyrite.

Veins in igneous rocks have been found on the Skwentna and the Kuskokwim, as well as in the Tordrillo Mountains. The gold-deposits here are associated with intrusions of Eocene age. Further, gold-silver veins of considerable importance are found on Unga Island.[2]

Following directly upon the discovery of placer mines on Douglas Island the Paris claim, which site was subsequently occupied by a large surface pit or "Glory hole," was purchased by John Treadwill. On tracing the ore-body eastward the Mexican mine was located. The deposit as opened up was the upper or "feather edge" of an intrusion of sodium syenite or albite diorite, having been decomposed and silicified by solfataric or hydrothermal action, bringing about concentration of native gold and auriferous pyrites in sufficient quantities to make its extraction profitable.

The larger part of the country-rock is a carbonaceous slate of quite uniform texture, the origin of which was sedimentary. Later came the intrusion of syenite which formed an extremely irregular shaped dike. In the Alaska-Treadwell mine the dike is 420 feet wide, at the Mexican 150 feet and at the Ready Bullion it has again increased to 300 feet; these figures, however, include large horses, and in places a system of parallel slate divisions.

Following the intrusion of syenite came another of gabbro on the hanging-wall side, which is several hundred feet wide, and is considered to have been of prime importance in the formation of the ore. Following this in turn and extending over a considerable period of time, there occurred the mineralizing processes acting upon the syenite, and the ultimate deposition of the ore.

There was still another intrusion, but consisting of basalt, with a width of from four to six feet. It cut through slate, syenite and gabbro, and badly shattered the country-rock, the resulting openings being later filled with auriferous material. However, the basalt

[1] U. S. G. S., Bull. No. 284, p. 5, 1905. [2] T. A. I. M. E., Vol. 33, p. 812, 1903.

does not contain ore as no subsequent action has broken or fissured it forming receptacles for the deposition of ores.

The ores may be grouped into two classes: first, stringers of quartz and calcite filling fissures in the syenite; and second, a breccia, as it were, of syenite fragments and associated minerals which accompanied the auriferous solutions.[1] According to Professor Adams the ore is a mass of fractured rock filled with veinlets, and he says: " It may, therefore, be stated that the ore of the Treadwell mine is a granite, probably belonging to the class of the hornblende granites, much crushed, altered and impregnated with secondary quartz, calcite, and pyrite; that the ' kernels ' are portions of the rock in which alteration is less complete than in the mass of the granite, and that at least a considerable portion of the gold present in the ore is contained in the pyrite as free-gold."[2]

The gangue minerals of the Alaska-Treadwell mines are comparatively rare being chiefly quartz and calcite. In the impregnated portions the carbonates are usually found in larger quantities than the quartz. Of the metalliferous minerals pyrite is by far the most common. Chalcopyrite occurs more frequently in the Treadwell than in the Mexican mine, while mispickel occurs in the Mexican, but not in the Treadwell mine. Galena, blende and pyrrhotite are not common but are fairly uniformly distributed.[3]

Other deposits on Douglas Island are found in Silver Bow Basin, Sheep Creek Basin, Sumdum Bay, Berner's Bay, Funters Bay and Nyak Bay.

The county-rock of the Silver Bow Basin consists of micaceous schists of sedimentary origin — the strike is north, 60 degrees west, and dips about 60 degrees to the northeast. The rocks are cut by several nearly vertical dikes of about six feet width. Quartz often occurs in large quantities besides being a gangue associated with calcite. The metalliferous minerals are siderite, pyrite, mispickel, galena and blende. The ore sent to mills is worth about $4 to $5 per ton.

In Sheep Creek Basin the Silver Queen mine is of the most importance, and has been developed to a greater extent than the others. The rocks are carbonaceous and micaceous schists which are cut by dikes of gabbro similar to the Treadwell deposits. However, the gabbro is here a decomposed greenstone. The vein has a maximum

[1] Mines and Minerals, Vol. 24, p. 251.
[2] U. S. G. S., 18th Ann. Rept., Pt. 3, p. 65, 1896–97.
[3] U. S. G. S., 18th Ann. Rept., Pt. 3, p. 67.

width of five feet carrying quartz, pyrrhotite, blende, copper pyrites, galena, mispickel, a little pyrite and, as reported, native and ruby silver. The galena is argentiferous, and with that of the Glacier has produced the bulk of the silver of the district. The Silver Queen as well as the Glacier yields both gold and silver, but silver exceeds the gold in the ores of the latter. Besides the minerals given above the Glacier shows argentiferous tetrahedrite and pyrargyrite. Average tenor of ore is $40 per ton. Up to 1895, the Silver Queen had produced $100,000 in silver and $20,000 in gold.

The Bald Eagle mine of Sumdum Bay is a stringer-lead which follows the schistosity with great regularity. The main body of ore, a lens, is about five feet maximum width. The ore is quartz, pyrite, galena, blende and mispickel, and is usually richest on the foot-wall. Average of ore is $50 to $60 per ton.

Of Berner's Bay district the Comet and Bear mines are most prominent. The country-rock is diorite which bears veins of quartz, calcite, sericite, pyrite, chalcopyrite and mispickel.

The Tellurium and War Horse mines lead in the Funters Bay district. In the former are six parallel veins which fill cross fissures in the schists. The vein-filling is quartz, a little calcite, considerable pyrite and pyrrhotite with chlorite. Gold is found in the free state in both the chlorite and quartz. The pyrite is reported to be the chief bearer of gold, containing $150 per ton, while the pyrrhotite carries but $10 to $15.

The country-rock at the Apollo Consolidated mine, Island of Unga, is andesite and dacite; there is also a large amount of propylite or chloritic andesite. The ore is composed of free-gold, pyrite, galena, blende, chalcopyrite and native copper. Average yield of ores about $8 per ton, four-fifths of which is saved on plates. In 1896, the production was over $400,000 of which $40,000 was silver.[1]

In the Ketchikan district there are veins and mineralized zones, both of which bear gold in the free state, combined with pyrite and to a limited extent with tellurides. The silver occurs both in galena and tetrahedrite. The copper minerals are chalcopyrite, bornite, malachite, chalcocite and cuprite.

The Cleveland Peninsula and Tongan Narrows have deposits of gold and silver in veins of mineralized zones; the gold being both free and in pyrite. The country-rock is greenstone-schists. Thorne Arm has ore-bodies in true fissures usually associated with dikes of porphyry, the country-rock being greenstone-schists. Gold occurs

[1] U. S. G. S., 18th Ann. Rept., Pt. 3, pp. 70–78, 1896–97.

both free and with pyrite. As a usual thing the ores are low-grade. At George Inlet the same veins bear gold, others galena and blende. At Seal Bay and Dall Head the ores are chiefly chalcopyrite bearing gold and silver. Large mineralized zones of copper ores bearing gold occur at Niblack Anchorage. Gold-bearing quartz veins occur in diorite and granite at the North Arm of Moira Sound on the west side, while on the northeast portion of Arm blende and galena are found in crystalline limestone. At Dolomi are true fissure-veins in white crystalline limestone bearing gold and silver. The Twelve-mile Arm has true-fissure veins, the gold being in part free-milling. Irregular masses of copper sulphide occur in greenstone at Skowl Arm, Kasaan Peninsula and Tolstoi Bay.[1]

The country-rock of Gravina Island is siliceous and chloritic schists and limestones. In the schists are found gold-quartz veins carrying a little pyrite. The gold is readily amalgamated; the sulphurets consisting of pyrite and blende are caught on vanners. Average value of ore $4 to $6 per ton. The ores in the limestone are copper, gold, silver, and lead. The veins range from 20 to 60 feet wide.

On Annette Island silver is found with gold in tetrahedrite in quartz-veins. Silver values run from 600 to 2000 ounces per ton, and although the gold values are high they are not as high as the silver.[2]

In the Yukon region the quartz-veins are numerous, especially in the schistose rocks of the Forty-mile and Birch Creek districts; they also occur, but less frequently, in the granites. Further, the veins seem to be closely connected with dikes and were apparently formed at different periods, corresponding with the igneous injections. The result is that the older veins, dikes and country-rocks have been faulted and distorted thus making the veins very irregular, narrow and difficult to follow. The latest formed veins are unsheared and unfaulted, and are therefore wider and more persistent than the former. Practically all of the veins carry gold, and are probably the source of the widespread placer gold of the district.[3]

In the Nome district the veins are usually small and pockety. The contents of the veins are white quartz, carrying gold which is almost entirely free and often coarse. There are, however, lodes

[1] U. S. G. S., Professional Paper No. 1, 1902, pp. 53–54.

[2] Min. and Sci. Press, Vol. 83, p. 98.

[3] U. S. G. S., 18th Ann. Rept., Pt. 3, pp. 290, 375 and 383.

carrying gold in arsenical pyrite associated with blende and antimony. More calcite is found in the latter veins, which are often found 40 feet wide. Auriferous copper and magnetite with some cinnabar are encountered. The average value of the ores ranges from $20 to $40 per ton.[1]

According to Waldemar Lindgren: "The lodes along the southwestern coast will probably hold their own or increase for many years, as the most important ones contain great low-grade ore-bodies, the assay value of the ores on Douglas Island being often less than $2.50 per ton. Many veins with high-grade ore are likewise found in this coast belt which also promise well for the future."[2]

Arizona. — The southwestern half of the Territory contains the gold-bearing deposits, the northern part being a plateau region. The southwestern portion of the Territory consists of short desert ranges alternating with broad sandy valleys. The mountains are largely granites and schists of pre-Cambrian age upon which lie Paleozoic limestones and quartzites, the whole being occasionally cut by dikes of Cretaceous or pre-Tertiary porphyries. Overflows of rhyolite are in places broken by veins of propylitic character.[3]

The gold veins are found largely in crystalline rocks, either massive or schistose, the ore being iron pyrites and blende which is comparatively free from silver. However there are exceptions, notably the Harqua Hala, Mammoth of Goldfield and Mammoth of Pinal. In several mines the presence of free-gold in very base sulphides has been observed to increase with depth.[4]

The extensive limestone formation extending across the Territory from northwest to southeast contains or has associated with it many ore-deposits. The basic formations to the limestone are granites and gneisses. Beds of conglomerate and quartzite, formerly sandstone, occasionally occur associated with the limestone. Intersecting the stratified rocks are many dikes and masses of trachyte, diorite, porphyritic rock, and quartz-porphyry. In this area are deposits of gold, silver and copper.

Gold is found in at least four districts: first, in Cochise County, near Tombstone — the Pearce, now the Commonwealth mine, is the most prominent; second, the district about Tucson—the mines are, however, some thirty miles north and south of that place;

[1] Inst. Min. and Metallurgy, Vol. 9, p. 181.
[2] T. A. I. M. E., Vol. 33, pp. 813 and 814, 1903.
[3] T. A. I. M. E., Vol. 33, p. 814, 1903.
[4] Eng. and Min. Jour., Vol. 58, p. 366.

third, the Weaver Mountain district — the principal mines are the Congress, Octave and Vulture which with others reach from Weaver Mountain to Vulture Mountain; and fourth, the Harqua Hala district. Gold is found elsewhere, but has been developed but little anywhere except possibly the Silver King mine.[1]

Free-milling ores having been exhausted from the upper levels have transformed several districts from milling to shipping or smelting districts.

In the Pinal Mountains are found granites and schists which are gold, silver, copper and iron-bearing. The ores are quite rich in gold, while further north in the feldspathic granites, gneiss and talcose schists, they carry silver with considerably less gold. The veins in the latter locality carry galena in nodules and segregations, pyrites of iron and copper, wulfenite and the carbonates of lead and copper. The galena is argentiferous. Gold occurs free, and in a finely divided state, being readily amalgamated. Hornsilver and occasionally iodide of silver is found.[2]

In Yavapai County the gold district of the Lonesome valley comes first and is situated on the west foot of the Black Hills, the next following being the Agua Fria Mountains, then the district about Richenbar and Squaw Creek Cañon or the lower Agua Fria, and the high ridge between Richenbar and Black Cañon. Gold, silver and copper veins occur in the Agua Fria and Copper Mountains and owing to their occurrence practically no distinction can be made between them. The Chaparral district produces gold and copper, the east end of Big Bug yielding gold, while the west end produces lead; the Walker has a mixture of several metals, although gold is most valuable; and in the Slate Creek district both gold and silver veins occur in close proximity yet separate and distinct.[3]

The Silver King mine is situated near the base of the Pinal Mountain range in Pinal County, and on the southwest side. The country-rock is altered crystalline porphyry, the silica from which may have been the source of the vein-filling. The ore-body consists of a central mass or chimney 200 feet in diameter of quartz, both compact and white; brown iron-spar occurs with disseminated pyrites, and there is also a centrally filled compact ore, consisting principally of blende, but containing besides, galena and native silver. Gray copper is also found in the solid white quartz of the upper levels,

[1] Eng. and Min. Jour., Vol. 73, p. 795.
[2] Eng. and Min. Jour., Vol. 31, p. 248.
[3] Eng. and Min. Jour., Vol. 63, p. 633.

which is often bunched and quite rich, and is usually silver-bearing. From the central mass radiate many interlacing veinlets, varying from a mere crevice to one-quarter of an inch in width forming a "stockwork," which bears a great variety of rich silver minerals. The ore-body occurs in a dike of porphyry. The ore milled as high as $200 per ton, but gradually decreased in richness with depth. The surface ores are more or less oxidized and decomposed, being stained green or blue by copper minerals, and have therefore lost much of the metallic appearance of the original ore as shown in depth. Sulphides rarely occurred above, but with depth the mass of the ore consists of the sulphides of silver, lead, zinc and copper. Native silver also occurs in the quartz-veinlets, and at the surface, sheets, filaments and nuggets of snow-white silver are found.

The minerals found here are: native silver, stromeyrite, argentite, galena, blende, bornite, chalcopyrite, pyrite, tetrahedrite and near the surface hornsilver, malachite, azurite, native copper, cuprite and black masses of argentite. The gangues are quartz, calcite, siderite and barite.[1]

The Tombstone district is situated in Cochise County. The country-rock consists of limestone, quartzite and shale overlying granite. Dikes of igneous rock traverse the sedimentary formations, the ore-deposits occurring in the limestones, shales and probably to a less extent the porphyry.

The Tombstone mines are remarkable in extent and value of the deposits, which occur in pipes and sheets penetrating the country-rock, and therefore lying entirely without the vein, connection being made by cross-courses and channels. Often by far the richest portions of the deposits are the outlying masses, especially when the pay ore in the vein has decreased to two or three feet in width. The ores are replacement products occurring both in fissures and in anticlinals, in the latter especially, and similar to those usually found in the limestone. Gold and silver occurs in a comparatively free state although the silver is chiefly chloride especially near the surface. The chloride or hornsilver occurs in films and crusts, and in minute crystals upon cleavage surfaces. The gangue is principally quartz carrying carbonate of lead. At a depth of about 600 feet, or the permanent water-level, the sulphides of silver, lead and zinc are encountered, thus necessitating a change in method of treatment.[2]

[1] Eng. and Min. Journal., Vol. 35, pp. 238, 254 and 270.

[2] Eng. and Min. Jour., Vol. 49, p. 361, T. A. I. M. E., Vol. 33, p. 26, and Min. and Sci. Press, Vol. 90, p. 189.

The average value of the ore in gold and silver is $70 per ton, the gold having increased in later developments to 20 or 25 per cent of the total value. Gold occurs in seams and cracks in thin subcrystalline flakes and scales.[1]

Alabandite or manganese sulphide occurs in the Lucky Cuss mine associated with galena and pyrite, and carries gold but in small quantities.[2]

The Pearce district is located on the foothills east of the Dragoon Mountains. The core of the mountains is metamorphic rock which is flanked by copper-bearing carboniferous limestones intersected by dikes of porphyritic material, while the outlying hills, especially to the eastward, probably belong to the trachyte and rhyolite series. Rich shoots of ore of 16 to 60 feet in thickness have been opened to a depth of 300 feet and over.

The ore carries both gold and silver, is quartzitic and occasionally ferruginized. The silver occurs as chloride, bromide, sulphide and iodide, while gold is principally native (in broad splotches and in leaf form), and possibly in tellurides. The proportion of gold to silver in the upper and lower levels is 2.5 to 1 and 1 to 1 respectively. The hanging-wall side of the vein shows the highest values, along which streaks, veinlets and inclusions yield high values.[3]

The Fortuna mine of Yavapai County is situated in the Gila range. The vein lies between the strata of a limestone formation which has a schistose structure, both vein and limestone dip to the southeast. The vein is filled with ore composed of hard white quartz bearing free-gold, but no sulphides. The vein is about 12 feet wide and contains a shoot of ore which extends downward somewhat irregularly. Vein-filling other than the gold-bearing quartz, is quartz considerably broken up by the decomposition of pyritic minerals.[4]

The Hillside vein, Yavapai County, occurs in gray phyllite which changes to mica-schist. It is a fissure-vein. The ores first worked at the surface were highly oxidized, varying from light brown to a yellowish color and yielding high values in gold and the chloride of silver — ore is said to have been produced running as high as $1,000 per ton. With depth the sulphides are encountered of which iron,

[1] Min and Sci. Press, Vol. 91, p. 190.

[2] T. A. I. M. E., Vol. 33, p. 29.

[3] Eng. and Min. Jour., Vol. 63, p. 571.

[4] Min. and Sci. Press, Vol. 84, p. 34, and the Eng. and Min. Jour., Vol. 63, p. 664.

copper, lead, and zinc are common; however, arsenical pyrite predominates. Pure native silver occurs intimately intermingled with quartz crystals. Gold is visible in the quartz and varies little if any throughout the vertical extent worked.[1]

The Crown King mine, Yavapai County, is on a vein which varies from 5 to 30 feet in width, dipping at an angle of 26 degrees. The ore is gold and silver in quartz and clay gangue.[2]

The Silver Bell district is in northern Pima County. The Imperial, Poland-Lynx Creek and Big Bug mines are of most prominence. The principal minerals are the oxides and carbonates of copper, chalcocite, chalcopyrite and bornite. The change from oxides to sulphides is usually quite abrupt and without the occurrence of intervening bodies of chalcopyrite which is the most important sulphide ore. The surface ores are oxides and carbonates, chiefly cuprite, azurite and malachite. Silver has been found in quantities only in the surface ores although it occurs with gold in the iron, copper, lead and zinc sulphides.[3]

The United Verde district is situated on the eastern slope of the Black Hills. The United Verde ore-body occurs in great fault-fissures extending north and south. Masses of altered, laminated and mineralized rock composed of sandstones, shales, thin bedded limestones, schists and slates as well as porphyries occur along the line of the fissures. Within the fissured zone is a body of low-grade ore covering a surface area of 2000 feet north and south by 450 feet east and west. This ore belt extends for a distance of 12 to 18 miles and is considerably cut up by intrusions of volcanic rock. Small orebodies occur at intervals along the belt.

The ores have probably been formed by replacement. There are two separate ore-shoots in the United Verde mine which have an average length along the zone of mineralization of some 300 feet, traversing the intervening barren zone for a distance of 450 feet. They have been worked to the 700-foot level. The ores are bornite, chalcopyrite, cuprite, melaconite, and copper sulphate. The surface ores have been removed in large quantities by quarrying methods along the outcrop, where oxidized gold and silver-bearing minerals are found.[4]

The Congress district is situated about 55 miles south of Prescott

[1] Eng. and Min. Jour., Vol. 50, p. 162.

[2] Ibid., Vol. 78, p. 832.

[3] Eng. and Min. Jour., Vol. 77, p. 639. Ibid., Vol. 74, p. 622.

[4] Eng. and Min. Jour., Vol. 86, p. 70.

and is one of the few mining districts of Arizona engaged exclusively in gold mining. The country-rock of the district is a coarse biotite-granite, and forms the mass of the mountains to the west of the mines. The lodes are quartz-veins, closely associated with intrusions of igneous rocks. The Congress and Niagra lodes have been worked to the greatest extent. The Congress lode is closely associated with a strong dike, usually on the foot-wall side, but sometimes on the hanging. The dike is not mineralized except where cut by stringers. Other dikes, as in the Queen lode, are heavily charged with sulphides, and form ore-bodies of considerable value.

The veins carry massive white quartz, the values being in sulphides, both pyrite and marcasite. The value of the concentrates runs as high as $300 per ton.[1]

The Commonwealth mine, Cochise County, is a vein in rhyolite which carries gold and silver in a quartzose gangue. About one-third of the value is in gold, the remaining two-thirds in silver. This has proven to be one of the most important producers of gold in Arizona during recent years.

The Mammoth mine of Pinal County is also associated with a rhyolite dike. The original deposit has suffered great alteration, having changed from a smelting to a milling ore by oxidation. This mine is also a large producer.[2]

The last ten years has witnessed great advancement in the mining industry of this Territory. However, it is doubtful whether a proportionate increase in production will be made during the following decade, although there is no apparent reason why the present output should not be maintained and even exceeded.

California. — The gold deposits of the state are closely associated with the metamorphic rocks or slates, which has been brought out by Whitney in his various works. However, gold occurs in granites and schists, although few gold-quartz veins are found in exclusively granitic areas, and when they do occur are usually near contacts or fissured areas of schists and other formations. Within the gold-bearing regions the veins are distributed irrespective of kind of formation, occurring in almost any of the metamorphic rocks. Gold is found in quartz-porphyrite, augite or hornblende-porphyrite, diabase, granite, diorite, granodiorite, gabbro, serpentine, amphibolite and in sedimentary rocks as slates somewhat altered, sandstones and limestones.

[1] Eng. and Min. Jour., Vol. 77, p. 999.
[2] T. A. I. M. E., Vol. 33, pp. 814 and 815, 1903.

The normal quartz-veins are fissure-veins, *i.e.*, they are fissures and fractures in which are found quartz as a gangue and native gold and sulphides as the metalliferous part. According to good authority the clean quartz of the veins cannot be accounted for except by the filling of cavities, the replacement of the ferro-magnesian silicates and other minerals being practically impossible without the occurrence of chloritic stains and other accompanying signs. The veins of clean quartz vary from a few inches to several feet in width. Widths of from 10 to 15 feet are found in the veins of Mariposa and Tuolumne counties, but they are rather limited in horizontal extent and probably do not extend deeper than 10,000 feet. The common form of gangue is massive quartz although combed structure is not infrequent, while barite and fluorite are conspicuously absent. Other gangue materials, such as white mica with pearl luster and a green potassium mica stained with chromium, are found. Native gold in microscopic grains or coarse enough to be readily seen and occurring in scales and threads is quite irregularly distributed through the quartz. Masses of gold and quartz often with a large per cent of gold and weighing as high as 50 pounds are found. As a rule the usual run of ore does not contain gold that is visible to the naked eye. Gold and silver are usually alloyed, and occasionally occur in the proportion of 3.33 to 1. From 1 to 5 and 6 per cent of the vein-filling may be metallic sulphides, with which are found compounds of arsenic, antimony and tellurium.

The character of the country-rock has undoubtedly had more or less influence in determining the character and condition of the mineral associations. Granodiorite probably contains more gold than the other formations, and pyrrhotite is probably confined to occurrences in this rock, while veins in augite-porphyrite and diabase are poor in sulphurets. The contents of veins in black slates and contacts between slate and greenstone contain a variety of minerals besides pyrite and the arsenical forms. Copper is common to veins in gabbro.

As a rule the richer ores occur in masses more or less irregular, but taken as a whole the outlines may be fairly regular. These masses are commonly called shoots or chimneys, with dips, ranging from 45 degrees and up. The shoots may be flat or thickish; those of the Idaho mine, Grass Valley, are flat, with widths ranging from a few up to several hundred feet and lengths of 2000 feet or more. The so-called "pocket mines" are interesting in that the ore does not occur in masses but has the gold-content, usually coarse, concentrated at certain points. The smaller veins often carry surprisingly large values in gold and silver, which may even occur in the form of shoots or pockets at the intersection of one or more veins.[1]

The ores of the Tioga district and Mono Pass occur in schists, and are largely sulphides, being rather difficult to reduce. Besides the gold and silver are found cobaltite, pyrrhotite and the sulphides of iron, copper, lead, zinc and antimony. Chalcopyrite, pyrite, pyrrhotite and blende are abundant in the granite veins of Soulsbyville district, besides the occurrence of a peculiar galena-like material giving blow-pipe reactions for lead and antimony — the ore is free-milling. The West Point district yields ores of iron and copper sulphides and pyrrhotite. Gold occurs in albite at the Shaw mine, El Dorado County. Barite is one of the gangue minerals of Pine Hill, being associated with the ore in a zone of decomposed and kaolinized diabase. Quartz and calcite form the bond for an altered diabase at the Yellowstone mine, Bear Valley, Mariposa County. Free-gold occurs in a decomposed rhyolite dike in auriferous slate at Onion Valley, Plumas County. This particular occurrence is interesting as the rhyolite is probably of Tertiary age. Gold is associated with cinnabar in several localities: in the Blue Wing vein near Coulterville in diabase; in the Manzanita mine, Colusa County, and in the Coast Range in metamorphic strata.[2]

The following are the minerals associated together in the quartz-veins of the state: the most common minerals are iron and copper pyrites, galena, blende, pyrrhotite, mispickel, hessite, altaite, calaverite, sylvanite, petzite, melonite; those less common are molybdenite, marcasite, and tetrahedrite, and the rare minerals are compounds of nickel and cobalt and antimonial lead sulphides.[3]

The occurrence of tellurides is as follows: sylvanite has been found in the Melones mine, Carson Hill; at the Golden Rule mine, Mother lode near Poverty Hill, Tuolumne County, and in the Raw Hide mine. The telluride of silver was found according to Professor Silliman at the Reist mine, Mother lode, Whiskey Hill, Tuolumne County, and foliated tellurium was found in the ores in Angel's Camp, Calaveras County.[4]

The precious metals are widely distributed throughout the state

[1] Min. and Sci. Press, Vol. 70, pp. 181 and 213.
[2] Min. and Sci. Press, Vol. 69, p. 36.
[3] Min. and Sci. Press, Vol. 70, p. 213.
[4] Min. and Sci. Press, Vol. 16, p. 9.

and most of the deposits are so favorably located that mining can be advantageously carried on. The principal gold field is fully 700 miles in length, extending in a north and south direction from Siskiyou to San Diego, but confined to the western slope, and is remarkable for its regularity and continuity. Lying outside this field are other gold and silver-bearing districts, the most important being in the eastern part of the state in the Colorado River basin. The veins occur in andesites and rhyolites, the ores being gold and silver-bearing. The ore-deposits of Alpine, Mono, Inyo, and San Bernardino counties belong to this belt, but possibly not to the same period — some may be of Cretaceous age.[1] As late as 1898 the mining of gold was successfully carried on in thirty-one out of the fifty-seven counties, the majority being situated in the mountains, foothills and desert regions and only a few in the valley counties or the Coast Range.[2]

The Mother lode is composed of a series of black slates, generally designated as the Mariposa slate, which runs in a north and south direction through the country of the western slope of the Sierra Nevada being exceedingly persistent. This belt of slate varies in width from several hundred feet to over a mile, and is readily traceable through four or five counties. Occurring in this mass of slate are many quartz-veins which are often parallel, and in some instances follow the contact of slate and diabase. Closely associated with the quartz is a soft black gouge. Bodies of high-grade ores have been found in these veins, but by far the greater part is low-grade, varying from $4 to $6 per ton.[3]

In the central part of the southern portion of the Mother lode is a large vein of dolomite, which is most prominent in the vicinity of Coulterville. At an exposure where the vein crosses a creek a width of fully 300 feet is shown; the body of the vein consists of a great mass of ankerite through which is disseminated the green, scaly mineral known as mariposite. Lenses of quartz occur mainly along the hanging-wall and center of the vein, but are also irregularly distributed, and stand out boldly from the ankerite. Interposed between the quartz-lenses are large zones of dolomite, completely cut up by interlacing quartz-veins of varying size transforming the whole mass into a mineralized zone. One quartz-lens is nearly 20 feet wide, 300 feet long and stands at a height of 25

[1] T. A. I. M. E., Vol. 33, p. 817, 1903.

[2] California Mines and Minerals, T. A. I. M. E., p. 7.

[3] Eng. and Min. Jour., Vol. 75, p. 148.

feet, as an outcrop. Several, at least two, gold-quartz veins intersect the lode. Gold also occurs in the ankerite and mariposite when cut by quartz-veins, and the more fissured the rock is, the higher are the gold values. However, without quartz present the ankerite is barren of gold, otherwise the whole mass is low-grade ore.[1]

The gold-content is fairly uniformly distributed along the length of ore-shoots, which cannot be said, however, regarding its occurrence across the ore-bodies. Fine gold is the rule although some coarse gold is found, especially in southern Calaveras County where considerable quantities have been mined.

An auriferous conglomerate of the Jurassic age occurs in the Sierra Nevada, its exposure lying chiefly between the North and Middle forks of the American River. Presumably the gold-content was delivered from pre-existing quartz-veins, which with the quartz-filling found the conglomerate as a littoral deposit of the Jurassic sea.[2]

Nevada County. — This county had produced $212,000,000 in gold, or nearly one-sixth total production of the state up to 1899, and led in the production of minerals during 1898. In the early days it was a great placer-mining district, and consequently was seriously affected by the cessation of placer-mining in the early eighties. In 1899 it had within its borders 234 quartz mines besides many placer and drift-mines. The first quartz-mining district was organized here, and the first mining established in 1850. There seems to be no direct connection with the Mother lode to the south. Ground-sluicing was first employed here in 1851–2 in the "coyote" claims of Nevada City. The discovery of gold quartz on Gold Hill attracted great attention, and was the beginning of gold mining in the state. In 1855 there were seven producing quartz mines.

There are three distinct gold belts in the county, namely: Washington, Grass Valley and Meadow Lake, all west of the Sierra Nevada. The gold-bearing formations are slates, schists, serpentine, gabbro and syenite, which are cut by dikes of diorite and diabase, including veins of gold-quartz. The Washington belt consists of auriferous black slate, mica, talc and chloride-schists with quartzite containing dikes of diorite-diabase. The Meadow Lake belt is composed chiefly of syenite. The principal mines which have been worked in this country are: the Idaho, Eureka, Gold Hill and

[1] Min. and Sci. Press, Vol. 78, p. 589.
[2] Eng. and Min. Jour., Vol. 59, p. 389.

Massachusetts Hill, the Maryland, North Star, Empire, W. Y. O. D., Providence and Champion.[1]

Butte County. — The entire east side of this county consists of spurs and foothills of the Sierra Nevada Mountains, which lie between the North, Middle and South forks of the Feather River. These rivers debouch into the Valley of the Sacramento, having cut their way through a country rich in quartz-veins. Much gold has been taken from the placer mines, and they still continue to be worked.

The principal quartz-mining districts are: Forbestown, Enterprise, Yankee Hill, Oroville, etc. The Forbestown district is one of the most prominent. The ores are high-grade, most of the values existing in sulphurets. The ledges are large consisting of hard, white quartz bearing a little free-gold. The principal mines are: the Denver, Forbestown district; Murray, Lydia, Slater and Crystal Peak of the Enterprise district, and the Spring Valley mine of the Oroville district.[2]

Placer County. — This county extends from the summit of the Sierra Nevada Mountains to within 12 miles of the Sacramento River, thus having a difference in elevation of nearly 8,000 feet. It lies between the Yuba and Bear rivers on the north, and the Middle fork of the American River on the south. Shallow placers extend from the lowest to the highest portion and owing to the large area and prominence of the placer ground the name was aptly chosen.

Ravine, river and hydraulic-mining followed one another in rapid succession and at the time of the enforced stoppage of hydraulic-mining, gravel-mining was both extensively and profitably carried on.

Such wide distribution of placer gold could scarcely mean anything else than the close proximity of many and rich gold-bearing veins, which later developments amply verified — the whole eastern slope of the Sierras is traversed by veins of gold-quartz. The first quartz-mining was begun at or near Ophir, and was done by Mexicans who reduced the ore by mortars and arrastras. The first quartz mill was erected in 1851 at Secret Diggings. The deepest quartz mine in 1899 was near Towle. Other important mines are: the Herman, near Westville; the Golden West, five miles south of Blue Cañon; and Bellevue at Ophir.[3]

[1] California Mines and Minerals, T. A. I. M. E., p. 263.

[2] California Mines and Minerals, T. A. I. M. E., p. 279.

[3] California Mines and Minerals, T. A. I. M. E., p. 298.

El Dorado County. Placer-mining in 1848 to 1856 was carried on extensively, and as a direct result led to the discovery of numerous mineral belts and districts, the one of most importance being the Mother lode. The Calaveras formation, consisting of the older, coarser and more crystalline states, quartzites and limestones, occurs both to the east and west of the Mother lode formation — the Mariposa slates. Ore-bodies occurring in the fissures of this belt are as valuable as those of the Mother lode.

The Nashville quartz-vein was the first to be opened in 1851. The surface ores were very rich but with depth the value fell to $3 and $5 per ton. The principal mines of the Mother lode are the Springfield and Church, Larkin, Gentle Annie, Big Sandy and Gray Eagle. The Grand Victory, six miles southeast of Placerville, was an important mine.[1]

Amador County. — The deepest and probably most profitable mines of the state are found in this county. There are three well-defined mineral belts, namely, the western, central and eastern. In the western belt the ore occurs in diorite or diabase, altered by shearing and compression to amphibolite-schist. Gold veins occur here, but have not been much developed as yet. The central belt includes the Mother lode. The eastern belt lies in the granite area — the mines are not extensively developed. The most important mines of the various belts are as follows: Zeila, Kennedy, Oneida, South Eureka, Central Eureka, Amador Consolidated, Wildman-Mahoney, Keystone, Bunker Hill, Mayflower, Treasure, Plymouth, etc.[2]

Calaveras County. — The region of the Mother lode lies to the east of Bear Mountain having a width of two to four miles. Mariposa slate predominates with an accompanying belt of amphibolite-schist on the east. Dikes of serpentine and lenses of limestone are of frequent occurrence. Gold is found in quartz-veins in the Mariposa slate and in the amphibolite-schists. There are other localities without this region where gold is found, which are known as the Comanche-Milton, the Campo Seco-Copperopolis, the East Point and West Point, making five sections with the Mother lode. Although the Campo Seco-Copperopolis belt is strictly a copper producer, yet enough gold and silver are obtained to pay for cost of mining and treatment. The ores are the sulphides and carbonates of copper. The East belt is made up of Calaveras slates in which

[1] California Mines and Minerals, T. A. I. M. E., p. 310, etc.

[2] California Mines and Minerals, T. A. I. M. E., p. 319.

are quartz-veins, igneous dikes and lenses of limestone. In the West Point area the country-rock is diorite-granite, changing to the eastward into a hornblende rock. The mines of prominence in the Mother lode district are the Given, Utica, Fellowcraft, Troupe, Demorest, Lightner, Stickles, Madison, Gold Cliff; in the West Point belt, the Paragon, Keltz; in the East belt, Sheep Ranch, Taylor and Collyerville, and in the Campo Seco- Copperopolis belt, the Satellite, Campo-Seco and Royal.[1]

Tuolumne County. — This county is on the western slope of the Sierra Nevada Mountains. It also contains the Mother lode which enters it from the south at Moccasin Creek and leaves it at Robinson's Ferry. The vein dips 40 to 80 degrees, and conforms with the stratification of the enclosing rocks — the black Mariposa slates are also present here. The East belt includes a granite area. Some distance east of, and paralleling the Mother lode, is the Eureka or main fissure belt. The country-rocks of the East belt are states, mica-schist, quartzite and other metamorphic rocks in which the veins occur and frequently also in grano-diorite. The ore runs high in sulphurets; galena and blende are often good indications of value. The tellurides of gold are also found here. The veins are very irregular in both horizontal and vertical extent.

This county is especially famous for the number and richness of its pocket mines, which have been found and worked to the best advantage at Bald Mountain and near the Bonanza mine.

The Tioga district is situated on the summit of the Sierras, the mines being in slate. The ore is high-grade of which from 5 to 6 per cent is in sulphurets. The principal mines of this district are the Great Sienna, Sheepherder and Crown Point.[2]

Mariposa County. — The Mother lode probably terminates in this county. The principal formations are clay-slates, diabase, diorite and serpentine which accompany the main lode, all of which are abruptly cut off by a mass of granite. The width of the Mother lode is close to 300 feet made up largely of dolomite and stained with mariposite. There are two quartz-veins within the lode, the larger being 10 to 20 feet wide, the other smaller. The Hite vein of the East lode is of considerable importance. The following mines have been good producers: Princeton, Mariposa, Pine Tree and Josephine, Oso and Mount Ophir.[3]

[1] California Mines and Minerals, T. A. I. M. E., p. 330.
[2] California Mines and Minerals, T. A. I. M. E., p. 345.
[3] California Mines and Minerals, T. A. I. M. E., p. 360.

Plumas and Sierra Counties. — After the exhaustion of the placer mines quartz-mining was begun, and a number of rich mines have been developed. The Plumas-Eureka of Gold Mountain is one of the oldest and most important mines of Plumas County; the most noted mine in Sierra County is the Sierra Buttes.[1]

Fresno and Madera Counties. — Within these counties lies a portion of the great gold belt of the Sierra Nevada. Two arms of the auriferous slate belt extend southward into these two counties in granite and other formations, and contain mineralized veins. There are small, low-grade veins in the Grub Gulch district which are profitable to mine — they occur principally in mica-schist. There is, however, one of the largest gold-bearing quartz-veins in the state in this district which extends southward into Fresno County. Upon the vein are the following prominent mines: Mammoth, Starlight-Riverside and Savanna.[2]

Inyo County. — At one time this county led in the production of silver, and had produced up to 1899 fully two-thirds of the silver product of the state. It has produced lead and gold as well as silver.[3]

The Randsburg district, Kern County, discovered in 1895, has materially increased the gold production of the state. The country-rock is diorite through which quartz-veins run in every direction, and in which large shoots of ore often occur. The district has proven to be a " deep " ore region. The most important mine is the Yellow Aster, which yields ore worth $40 per ton. Other prominent mines are the Wedge, Little Butte and Kinyon. The Johannesburg is another district north of the Randsburg which is being developed rapidly. The Golden Cross group of mines is operating on low-grade ores. The gold being found in country-rock cut by granite dikes. The ore averages $2 to $5 per ton.[4]

The ore-deposits of eastern California can be divided into two general classes; gold and silver-lead. The silver-bearing veins may also be grouped into two classes: first, the argentiferous galena chamber deposits, and second, the silver-bearing sulphides such as antimony, arsenic and copper. These deposits occur in quartz-veins. The gold deposits usually contain silver also, and in many cases the value of the two metals is equal, while the silver deposits

[1] California Mines and Minerals, T. A. I. M. E., p. 383.
[2] California Mines and Minerals, T. A. I. M. E., p. 391.
[3] California Mines and Minerals, T. A. I. M. E., p. 404.
[4] California Mines and Minerals, T. A. I. M. E., p. 399.

rarely ever contain gold in any appreciable quantity. Gold-bearing veins are common in the southern part of the Argus Mountains, and occur in granite. In depth the gold will probably be found in sulphides, for in many veins chalcopyrite and galena occur and carry considerable silver.

The argentiferous galena is usually found in irregular chamber-like deposits in limestone, but occasionally occurs in other sedimentary rocks and granite. In the granite veins calcite and iron oxides form a large part of the gangue.[1]

Colusa County. — Gold is found in the Sulphur Creek district in dikes, joints, and bedding-planes, also in the honey-combed quartz seams of the dikes. Pyrite and pyrrhotite are abundant, and carry varying amounts of gold. However, the richest rock does not carry the sulphides. The formations are quartz and slate carrying the gold and sulphurets. Associated with this formation is a streak of cinnabar carrying fully 80 per cent quicksilver. The ore is first retorted for quicksilver then milled for gold.[2]

The Calico silver mines are of two kinds: first, deposits directly connected with fractures and faults; and second, those deposits of irregular form and pockety in character usually found in beds of tufa, and are nearly always more or less superficial in character, *i.e.*, lie close to the surface. The deposits occur in fissure-veins, and although irregular often follow the dip of the strata. The more important mines are: the King system, Bismark and Humburg, the Garfield group, Blackfoot mines, Waterloo, Waterman, etc.

The accumulations of gold are usually at or near the surface, the richest portions of the deposits being in the outcrops. The gangue is barite with jasper, while the ores are chloride of silver, hydrosilicates and carbonate of copper.[3]

The mining district of Angels is one of the oldest and most noted of the state. The gold-quartz veins were opened shortly after placer-mining began to wane. The country-rock is schist in which the large quartz-veins occur which have yielded numerous rich pockets of gold, especially in the outcrops. The principal mines are: Sickel, Angels, Bovee, Gold, Cliff, Utica and Lightner.[4]

At the Rathgeb mine, near San Andreas, there was found a most peculiar occurrence of gold. A mass of red clay intermixed with

[1] Min. and Sci. Press, Vol. 73, p. 480.

[2] Min. and Sci. Press, Vol. 34, p. 280 and the Eng. and Min. Jour., Vol. 42, p. 186.

[3] T. A. I. M. E., Vol. 15, p. 720.

[4] Min. and Sci. Press, Vol. 89, p. 358.

wire gold (more gold than clay, it is claimed) was found at a point where the enclosing vein had faulted. The vein is about ten feet wide, and has suffered a displacement of about ten feet. The gold was in a spongy state, while filling interstices were particles of quartz associated with which was pitch blende, or uraninite, in needle-like crystals; around and through this mineral mass occurred the clay, although uranium ochre often surrounded the uraninite. This occurrence of gold and uranium is somewhat out of the ordinary.[1]

Although it is probable that placer-mining will decrease in the future, yet the operation of dredges will prevent any sudden falling off. The old mining counties in which deep-mining has been carried on for years will continue to maintain the output, and new discoveries together with improved facilities in the properties already developed may result in a very material increase in production.

Canada, the Silver Islet Mine. — This mine is noted for the size and richness of its ore-bodies, and as it has already been referred to historically the mineral occurrence and association will also be given.

The workable portion of the vein on which this mine was located occurred on an island about 70 by 80 feet in extent, and some three-quarters of a mile from shore. Unfortunately for its development the island is exposed to the full sweep of the wind and storms off Lake Superior.

The country-rock is a very siliceous black slate, which dips slightly to the east, and is cut by several dikes of diorite trending in a north-easterly direction. The phenomenon of ledges of diorite standing above the surface of the lake is due to its being harder than the enclosing slates, thus often forming islands. A large fissure-vein intersects the dikes at approximately right angles, and is known to reach to a depth of 1000 feet, varying in width from 4 to 30 feet. Further, the vein stands nearly vertical thereby reducing the necessity of supporting timbers to a minimum. The main fissure split or bifurcated, one branch running eastward and the other westward, besides which there are numerous stringers and leaders which are continually returning to and reuniting with the vein. The diorite of the dikes is often charged with graphite giving it a black, coarsely granular and friable character, while small nodules of pure plumbago occur next to the walls. The walls of the vein in the diorite are usually smooth and fairly well defined.

The gangue is white and salmon colored crystalline calcite carrying carbonate of manganese and some rhodochrosite, while some-

[1] Min. and Sci. Press., Vol. 67, p. 180.

what irregularly distributed throughout the calcite are patches and scattering crystals of quartz. Vuggs occur in which are found crystals of calcite, quartz, pyrite, galena, blende, argentite and occasionally clay.

The silver occurs mostly in the native state in the form of grains and threads or in the massive form but rarely in crystals or crystalline. Massive crystalline silver sulphide was found, which occasionally assumed a lenticular shape. Other minerals associated with the silver are: pyrite, chalcopyrite, galena, blende, niccolite, smaltine, stephanite and pyrargyrite. The bulk of the bonanza ore was arborescent silver considerably mixed with macfarlanite, a rich silver ore carrying 78 per cent of metallic silver together with arsenic, cobalt and nickel. In physical appearance the macfarlanite resembles niccolite. All of the ores were associated with cobalt and nickel as arsenides or black oxide, but in small quantities.

The silver was distributed in streaks and patches, varying from 1 to 24 inches in thickness and from a few inches to 20 and 30 feet in length. However, the occurrence of these masses was very irregular occasionally being arranged continuously for 50 to 60 feet or stopping abruptly. Many of the pockets were composed of massive silver throughout, in which small quantities of rock occurred, and often so bound together by the pure native silver as to resist breaking apart or blasting.

It was claimed that a connection was noticeable between the graphite impregnations and the silver bodies.

The first bonanza was completely exhausted in 1874 after about four years of work. The second bonanza was discovered in 1878, its approach being indicated by the occurrence of graphitic impregnations. The ore-body showed a width of five feet of solid ore consisting of animikite and huntilite. In shape it was an inverted cone with its base 50 feet wide on the third level and its apex on the fifth level. A winze sunk in the middle of the bonanza to the fourth level for a distance of 60 feet is said to have been wholly in practically solid silver, the metal standing out bodily from the four walls. The deposit occurred near the junction of the two veins and had a width of about ten feet.[1]

The Duncan mine, also in Thunder Bay, is located on a calcite vein which is traceable for several miles. Its mineralization is very irregular — native silver occurs in bunches on the south wall.

[1] **Eng. and Min. Jour., Vol. 23, p. 54, Ibid., Vol. 34, pp. 321 and 322, and Ibid., Vol. 26, p. 388.**

Fully 8 per cent of the ore is very rich, the native silver occurring mostly as threads in blende and calcite. This vein is 15 to 22 feet wide, carrying quartz, barite, blende, pyrite and chalcopyrite — the sulphurets putting in an appearance in depth. The pyrite is somewhat argentiferous. Leaders or veinlets of calcite, about one-half inch in width, penetrate the slate walls and in one of them at least nickel ore occurs, which forms on the slate walls.[1] The vein cuts the black slate of the copper formation which belongs to the Lower Silurian.[2]

On Pie Island are other veins which are very similar to those of Silver Islet, the ores containing native silver and niccolite.[3]

The Carolina Gold Belt. — The most extensive and important area in the Southern States is the great zone of metamorphic schists and slates extending from the Virginia line in a southwesterly direction through central North Carolina into the northern part of South Carolina. In North Carolina it includes portions of the following counties: Granville, Person, Durham, Orange, Alamance, Chatham, Randolph, Davidson, Rowan, Moore, Montgomery, Stanley, Cabarrus, Anson and Union, while in South Carolina, Chesterfield and Lancaster counties, the rock formations are: first, metamorphic argillaceous, sericitic and chloritic slates and schists; second, devitrified ancient volcanics (rhyolite, quartz-porphyry, breccias, etc.); third, igneous plutonic rocks (granite, diorite, diabase, etc.); fourth, siliceous magnesian limestone, and fifth, sedimentary slates.

The ore-deposits occur in two principal forms, as quartz fissure-veins and impregnations in schists and slates. The veins are apparently interlaminated with the schists and are largely irregular, yet being more or less lenticular in form. Conforming with the schistosity of the enclosing rock in a general way, they nevertheless intersect the schistose planes at small angles. The impregnations are irregular in shape and consist of fine gold and sulphurets fairly uniformly disseminated throughout the rock mass, accompanying which are stringers and lenses of quartz.[4]

The minerals found in the veins are: calcite, dolomite, fluorite, quartz, pyrrhotite, pyrites, chalcopyrite, mispickel, tetrahedrite, blende, galena and altaite (telluride of gold with small percent-

[1] Eng. and Min. Jour., Vol. 20, p. 28.
[2] Eng. and Min. Jour., Vol. 20, p. 7.
[3] Ibid., Vol. 20, p. 28.
[4] Eng. and Min. Jour., Vol. 63, p. 629, and T. A. I. M. E., Vol. 25, p. 667.

ages of gold and silver) and native gold. When the gold occurs free it is usually bright and clean, and can readily be saved by milling; however, most of the gold occurs as a fine coating along the cleavage planes of the slate and associated with the pyrite.[1] Tellurides seem to be a good index for gold. The galena is often argentiferous.

Mining has been carried on more systematically and extensively in North Carolina than in any other section of the South. Nevertheless, comparatively few mines are being worked steadily. The mines are found in three belts, namely: the Eastern Carolina, the Carolina and South Mountain belts. The principal mines of the Eastern Carolina belt are: The Thomas, Kearney, Taylor, Mann, Davis, Nick-Arrington, Mann-Arrington and Portis. The Mann-Arrington mine has quartz-lenses of varying sizes up to 12 inches thick, which cut the schists in which they are enclosed. The country-rock at the Portis mine is diorite, and the ore-bodies occur in two intersecting belts of quartz-veins, with a total width of nine feet.[2]

In the Carolina belt most of the work has been done, and is for convenience described by counties.

Guilford County. — The Fisher Hill and Willis Hill mines have two systems of parallel veins, the first extending north and south, the second northeast and southwest. They vary in thickness from ten inches to four feet. One mile to the north is the Hodges Hill mine, in which the ore is quartz and chalcopyrite in a flat vein 6 inches to 12 feet wide. The Fentress mine has ore consisting of chalcopyrite in quartz, gold-bearing. It has been worked for copper. The thickness of the vein varies from 34 inches to 13 feet. The Gardner Hill mine has three veins (probably), with thickness of main vein of about three feet. The vein carries gold-quartz, pyrite, and chalcopyrite. The country-rock is granite. The North State mine yields similar ores.[3]

Randolph County. — The .rock is argillaceous and chloritic-schist sheared by eruptives, while at Hoover Hill is a massive porphyrite. The Hoover Hill mine is in a brecciated basic eruptive country-rock, the included fragments of which are hornstone. The rock is partly schistose. The ore-bodies are pyritic, and filled with quartz-veins lying in belts in the porphyrite. Intersecting the veins are pyroxenic dikes. The ore averages $8 to $10 per ton.

[1] Eng. and Min. Jour., Vol. 31, p. 39.
[2] T. A. I. M. E., Vol. 25, p. 693.
[3] T. A. I. M. E., Vol. 25, p. 694.

At the Jones or Keystone mine the country-rock is a brecciated porphyrite, strongly schistose. The ore-bodies are made up of separate zones of schist of from 12 to 15 feet in width, which are impregnated with gold-bearing pyrite. The width of the ore-bearing ground is between 50 and 110 feet. Ore runs according to assay values from $2 to $7 per ton.[1]

Davidson County. — The Silver Hill or Washington mine has an ore composed of slate and quartz which bears pyrite, galena, blende and chalcopyrite. The galena is highly argentiferous. The country-rock is chloritic schist in which are two parallel veins, known as the East and the West, standing some 28 feet apart at the surface, and uniting at the 60-foot level, while at the 160-foot level they are 32 feet apart.

The Silver Valley mine has a country similar to that at Silver Hill. The hanging-wall is siliceous argillaceous schist, and the foot-wall a hard hornstone. The sulphurets are encountered at a depth of 60 feet. The lode is from 5 to 12 feet wide, being made up of bands of quartz, slate and sulphides.[2]

Montgomery County. — The Russell mine near Eldorado is in an argillaceous slate, both soft and silicified, country-rock. Calcite occurs plentifully, especially in veinlets. The slates are probably sedimentary in which the bedding-planes and cleavage usually coincide. The ore-bodies are parallel bands in the slate carrying pyrite and free-gold, and are accompanied by quartz stringers. The Coggins mine also near Eldorado is similar to the Russell. In the Steel mine are ore-bodies 9 to 12 feet thick, composed of schists charged with galena, blende, chalcopyrite and pyrite and associated with quartz stringers. The country-formation is silicified schist. The ores yield gold and silver. The country-rock at the Moratock mine is a massive, devitrified quartz-porphyry and volcanic breccia.

Telluride of gold is said to occur in this county.[3]

Stanley County. — The Haithcock and Hearne mines are on quartz-veins from two to six feet wide in a country-formation of clay-slate associated with eruptives. The Parker mine has slates which have been intruded by flows of greenstone-porphyry and more basic eruptives — it has suffered partial brecciation. Intersecting the slates are a large number of quartz stringers and a few large veins, all of which are auriferous.

Moore County. — At the Bell mine the country-rock is garnet-

[1] T. A. I. M. E., Vol. 25, p. 696. [2] T. A. I. M. E., Vol. 25, p. 697.
[3] T. A. I. M. E., Vol. 25, p. 699.

iferous chloritic schist, in which is the ore-body, consisting of a four-foot belt carrying finely disseminated pyrite and intercalcations of siliceous seams of one-eighth to four inches wide. The ore averages about $12 per ton. The Burns mine is in sericitic and chloritic schist partially silicified. Certain belts of this rock are impregnated with pyrite and quartz in lenticular stringers. Value of ore in free-gold is said to be $2.50 to $3 per ton.

Rowan County. — There are three groups of mines in this county in which are found the following mines: first group, Hartman, Yadkin, Negus, Harrison, Hill, Southern, Bell, Goodman, Randleman and Roseman; second group, New Discovery, Bullion, and Reimer; and third, Gold Hill, Dutch Creek, Gold Knob, Holtshauser, Atlas and Bame.

Gold Hill has been one of the most important mining centers in the state. The country-formations are chloritic and argillaceous schists, while the ore belts are impregnations of schist and quartz stringers. The Randolph shaft at Gold Hill is the deepest in the South, being over 750 feet.

Carrabus County. — The Reed mine is famous in that gold was first discovered here. The chloritic schists are associated with greenstone, which are cut by a large number of quartz-veins varying from four inches to three feet in thickness, some of which are gold-bearing. At the Phoenix mine the gold-bearing quartz-veins occur in schists and diabase. The Phoenix is the main vein and varies in thickness from twelve inches to three feet.

Union County. — The mines are situated principally in the metamorphic slates of the western portion of the county. The Bonnie Bell or Washington mine consists of an ore-body of pyritic and quartz impregnations in schists, occurring in argillaceous schists somewhat silicified. The width of the belt is 14 feet. The ore averages from $4 to $5 per ton.

The Howie mine is in slates which are ore-bearing for a width of some 400 feet, and in which zone there are 8 parallel veins of from 18 inches to 16 feet in width. Gold occurs mainly as films on cleavage planes in the slates. It is claimed that the last ore milled yielded $13 to $14 per ton.

Mecklenburg County. — Gold mining has been carried on fully as actively here as in any county of the state. The mines that have been producers are: St. Catherine, Rudisil, Clark, Stephen Wilson, Smith and Palmer, Howell, Parks, Taylor and Trotter, Brawley, Arlington, Capps, McGinn, Alexander, Dunn, Ferris, etc.

The Rudisil mine has two parallel veins close together and separated by slate — they vary in thickness from two to six feet. The upper part of the mine has as a country-rock a silicified, chloritic and argillaceous slate, while at a depth of 200 feet it changes to a crystalline rock. The ores are rich, but mainly sulphides bearing gold. The largest body or shoot had a length of 100 feet, and was 15 feet wide. The Ferris mine has a country composed of hydro-mica-schist. The vein carries white quartz bearing free-gold and pyrite. Within the mine occurs a granite dike which intersects it.

Caston County. — The mines of this section are the Oliver and Farrar, the Rhyne and Derr, the Duffie and Robinson, the Smith and Sam Beattie, McLean, Long Creek and King's Mountain.

The King's Mountain or Catawba mine is located in mica-schist, cut by lenses of siliceous magnesian limestone, probably sedimentary. The ore-bodies are lenticular shoots of limestone carrying pyrite, chalcopyrite and galena. Tellurides are also found in small quantities. The shoots vary in length, but reach as much as 100 feet, and are probably 20 feet thick. The gold is difficult to mill.

The South Mountain belt is of comparatively little importance although considerable work has been done. The Miller, Scott Hill, Pax Hill, and Baker mines are located near a wide dike of olivine diabase. However, most of the gold obtained from the county has come from placers.

The gold fields of South Carolina are arranged in groups with the same names as those in North Carolina, but as late as 1895 the Haile mine was practically the only producer.[1]

In the Carolina belt, Chesterfield County, the Brewer mine is the most important. The country-rock is a hard acid volcanic, probably quartz-porphyry, which has been partly changed into silicified, sericitic schists. The schists are cut by numerous coarse-grained granite dikes. The ore-bodies are pyritic impregnations of the schists, and are largely lenticular in form. Gold appears as films and coatings in cleavage and joint planes. Some of the lenses are richer than the others, but there does not seem to be any determining characteristic. The average run of the mine ore is close to $3 per ton. The depth of the ore-bearing ground is estimated at 800 feet. Pyrite is the principal sulphide. Enargite is also found, but not widely distributed. Tin-stone occasionally directly associated with gold is found in hydraulicing. No vein-quartz is present.

Lancaster County. — At the Haile mine the mining and treatment

[1] T. A. I. M. E., Vol. 25, pp. 705–715.

of low-grade sulphide ores is shown to better advantage than anywhere else in the South. The formation is siliceous hydromuscovite and argillaceous schist, which is impregnated with gold-bearing pyrite and free-gold, with which are quartz stringers. Such impregnated masses usually lenticular in shape form the ore-bodies. Dikes up to 150 feet in width cut the country-rocks and at the points of intersection with the ore-bodies seem to have caused an enrichment.

It is claimed that the Silver Hill mine (silver) of Davidson County, North Carolina, was probably the first mine of that metal worked in the United States prior to the discovery of the Comstock lode. The ore is carbonate of lead, and other products of the alteration of galena occurring in the upper part of the lode.[1]

The following is an early description of the ore:[2]

"The ore which this company worked has yielded from 200 ounces to 300 ounces of silver to the ton of lead. It contains on the average, 8 per cent of lead. . . . The silver has been worth $1.80 the ounce, because it was alloyed with a large portion of gold."

Colorado. — According to Emmons, "the geological structure of its (Colorado's) numerous high mountain ranges, showing the results of repeated and powerful orographic movements, accompanied by plentiful outbursts of eruptive rocks, indicate conditions peculiarly favorable to the concentration of metallic minerals into ore-deposits. It is in the older crystalline and eruptive rocks that gold-bearing ores are mainly found."[3] Although considerable gold has been derived from placers, by far the greater part has come from vein-mining. At first silver predominated, gold being a by-product of its treatment, but ultimately the mining of gold-bearing ores constituted the principal feature of the mineral industry.

Regarding the distribution of the gold and silver ores Emmons says: "The mountain masses of Colorado are divided into two north and south uplifts — the Colorado or Front Range and the Sawatch uplift, with a third uplift, the San Juan group, at the south. The two first-named uplifts consist of a nucleus of ancient crystalline rocks surrounded by a fringe of upturned Paleozoic and Mesozoic

[1] T. A. I. M. E., Vol. 25, pp. 804 and 805, 1895, Mining Magazine, Vol. 2, p. 605, June, 1854, and Mining Magazine and Journal of Geology, 2nd series, Vol. 1, pp. 368, 428, 435, April–July, 1860.

[2] Mining Magazine, Vol. 1, pp. 360–370, October, 1853.

[3] Mineral Resources of the U. S., Calendar year, 1892, U. S. G. S., pp. 63, 64, 1893.

sediments, the whole cut through by dikes and intrusive sheets of eruptive rocks. Here the silver-bearing ores are mostly found in the Paleozoic limestone, while the crystalline rocks afford both gold and silver." The Mesozoic sediments are covered by flows of igneous rocks in which are rich veins of gold and silver.

In the early days of mining at Leadville primary deposits of silver-bearing ores were found in limestone along the contacts of intrusions of porphyry. Low-grade gold deposits were developed later, and greatly increased the gold production. These deposits are probably Cretaceous or possibly of Jurassic age.[1]

The development of veins in Tertiary volcanic rocks or the propylitic deposits is not exceeded in any other part of the United States. The deposits of Gilpin, Clear Creek, and Boulder counties are of this class. The ores are both gold- and silver-bearing, although the gold value exceeds that of the silver. Boulder County is a producer of telluride ores in which gold predominates, the silver value being only one-fourth the total. Complex smelting ores containing silver are produced in Clear Creek County. Free-milling ores are produced in large quantities in Gilpin County.

In the Cripple Creek district zones, cut by numerous narrow veins, often extremely rich, intersect Archæan granite and also occur in andesite and phonolite. The ores are principally gold tellurides, and are not free-milling, being treated by smelting, chlorination or cyaniding.

The San Juan region, lying in the southwestern part of the state, includes San Juan, San Miguel and Ouray counties. The ores are both gold- and silver-bearing or in certain instances silver alone, while much less frequently gold alone. The large veins as a rule have cut through the thick beds of andesite and rhyolite, the upper portions containing the deposits worked.

South of the San Juan district is the La Plata gold district. Extensive erosion has brought to the surface large bodies of igneous rocks as intrusive diorites and monzonites, which are probably more recent than the enclosing surface volcanics. The diorites and monzonites are cut by veins carrying both gold and silver ores of which the former predominates. The age of the deposits is late Tertiary or certainly post-Miocene.[2]

Of the comparatively large number of minerals found associated with gold in Colorado only a few of them are widely distributed.

[1] U. S. G. S., Atlas U. S., Folio 48, Ten-Mile District.

[2] T. A. I. M. E., Vol. 33, pp. 818 to 822, 1903.

Iron pyrites, galena and blende are probably the most common minerals to be found. Copper pyrites, although occurring in considerable quantities in a number of localities, is not generally found throughout the state. It is found at Central City, Georgetown, Idaho Springs, La Plata, The Needles, Gunnison, in the San Juan district and in the Boulder County mines. The telluride ores are still more limited in occurrence, being found in but four camps: Boulder, Cripple Creek, the La Plata and in the Golden Fleece mine at Lake City. Further, the telluride ores are seldom found associated with other and more common minerals, the most common associate being pyrite. There are two mineral belts at Boulder which are characterized by the presence of one class and the absence of the other class of minerals, namely, tellurides and pyrites. Even though these two belts intersect, yet there is no interchange of minerals, which may be accounted for by one belt being of later origin than the other. Moreover, the tellurides especially will be found confined to some particular formation in a district as in the La Plata Mountains, where the tellurides are restricted to veins in the diorite intrusions, while the adjacent sedimentary rocks contain large quantities of pyrites. The same peculiarity in occurrence is observed to a certain extent at Cripple Creek and Boulder, where the tellurides are confined to phonolitic dikes cutting andesitic breccia in the former place, and occurring in veins in gneiss cut by eruptive porphyries in the latter.

Galena and blende are partial two limestone formations as at Aspen and Leadville, but are not confined to that formation, occurring also in granite and eruptives. Tellurides have not as yet been found in sedimentary rocks.[1]

Cripple Creek District. — The principal deposits of this district are in the contacts between granite and phonolite, and andesitic breccia and phonolite areas. The characteristic rocks of the district are the three mentioned above. Massive deposits also contribute considerably to the production of the district, and in 1892 yielded one-third of total output, the deposits of Globe Hill being of the most importance.[2]

Gold occurs in the massive deposits associated with pyrite, being widely and fairly uniformly disseminated, the values ranging from $2 to $5 per ton. Silver also occurs with the gold.

The tellurides of gold are associated with fluorspar in this dis-

[1] Mines and Minerals, Vol. 18, p. 225.

[2] Eng. and Min. Jour., Vol 59, p. 151.

trict. According to T. A. Rickard, the gold occurs in this district both in the native state and as a telluride, being distributed in the interstices of the rocks and as linings of fractures, or as impregnations in the form of minute threads in the rock-mass. In granite the gold or tellurides are scattered in cavities produced by solution; in phonolite the values lie principally along fractures; while in andesite-breccia the distribution is quite irregular due to the heterogeneous character of the rock and other variable physical characteristics. Tellurides constitute the distinguishing characteristic of the ores of the district, and consist of the following forms: sylvanite, calaverite and petzite, the first mentioned being the most characteristic, although calaverite is of the most importance, while the tellurides of gold, silver and lead are present in varying amounts. The Work mine has probably produced the best specimens of tellurides in the district.[1]

The general trend of the dikes occurring in the district is north and south, while they vary in width from 2 to 20 feet.

The occurrence of the ores as filling for narrow fissures and crevices gives them the approximate composition of the country-rock, thus rendering them difficult of estimation. The tellurides are also associated with auriferous and highly argentiferous tetrahedrite with some molybdenite and stibnite, but the combination is mechanical and not chemical. Pyrite, while occurring in the country-rock, and to some extent in the fissures, is in such small quantities as to be negligible when considering the composition of ores. The same can also be said regarding the occurrence of galena and blende. Native gold is largely absent from the telluride ores except where it has been set free by oxidation. The gangues found in this district are quartz, dolomite and fluorite, while calcite is an interstitial component of the breccia especially near the ore-bodies. Rhodochrosite and roscoelite are also occasionally found. The proportion of gold to silver is about 10 to 1.[2]

The productive area in the Cripple Creek district may be roughly enclosed by a circle with a diameter of 3½ miles, the center being located about midway between Raven and Bull hills, with the towns of Cripple Creek, Cameron and Victor situated in the periphery. Cripple Creek, Squaw Gulch, Arequa Gulch, and Wilson Creek are formed by three southward projecting spurs, which are designated

[1] Inst. Min. and Met., Vol. 8, p. 73.

[2] Min. and Sci. Press, Vol. 91, p. 36, and U. S. G. S., Professional Paper 54, 1906, p. 4.

by the following names: Gold Hill, to the east of Cripple Creek; Raven Hill, a continuation of the lower spur of Guyot and Beacon hills; and Battle Mountain, a projection of Squaw Mountain. These hills lie practically within the Cripple Creek volcanic area, and upon them are situated the important mines of the district. The following brief description regarding the distribution of the mines is taken from the excellent paper of the Cripple Creek district by Waldemar Lindgren and F. L. Ransome.[1]

"The productive district, as previously stated, is practically covered by the area of a circle 3½ miles in diameter. The center of this circle would be located half-way between Raven Hill and Bull Hill, and the towns of Cripple Creek, Victor, and Cameron would be situated on its periphery. A very few mines — notably the Galena and the Fluorine — and many prospects lie outside of this area.

"The culminating points of the district are found in a ridge of high and bare hills that extends in a northwest-southeast direction and divides the waters flowing into Cripple Creek and Wilson Creek on the southwest from those joining Spring Creek and Grassy Creek on the north. From northwest to southeast the following hills mark this divide: Mineral Hill, Carbonate Hill, and Tenderfoot Hill, north or northeast of Cripple Creek; Globe Hill, Ironclad Hill, and Bull Hill, the latter being near the center of the district and equidistant from Cripple Creek and Victor. The ridge is continued by Bull Cliff and Big Bull Mountain, the latter, really outside of the productive area, being the highest point in this dividing range of hills. Its elevation is 10,826 feet. Three long spurs project to the southwest from the dividing range separating the deep trenches of Cripple Creek, Squaw Gulch, Arequa Gulch, and Wilson Creek; the first, called Gold Hill, rises directly east of Cripple Creek; the second is Raven Hill, being continued to the southwest by the lower spur of Guyot and Beacon hills; the third is Battle Mountain, continued by the almost equally high salient of Squaw Mountain.

"The important mines are situated in this region of sharply accentuated topography. As has been several times emphasized, the volcanic area practically coincides with the hills and ridges just described, and is surrounded on all sides by granitic rocks.

"Globe and Ironclad hills and Gold and Raven hills consist chiefly of heavy masses of breccia, and were scenes of great activity

[1] Min. and Sci. Press, Vol. 90, p. 36, and U. S. G. S., Professional Paper No. 54, pp. 147–150.

during the early years of the district. Near Poverty Gulch, just northeast of Cripple Creek, is the Abe Lincoln, not a large mine, but still actively worked with satisfactory results. Higher up are the Gold King, with dividend records of $150,000, and the C. O. D., with a reported production of $600,000 and dividends of $150,000. Both were idle in 1904, and have attained their eighth or ninth levels.

"On the summit of Globe Hill are the Stratton properties of Plymouth Rock and Globe mines, in which extensive low-grade mineralization without many sharply defined veins seems to be the rule. Adjoining is the property of the Homestake Company, including the Ironclad mine, where direct cyaniding of oxidized surface ores is now carried on in a mill erected on the property.

"Gold Hill is crowned by the Anchoria-Leland mine, with a production of over $1,000,000, and dividends of $198,000. The shaft is 1,100 feet deep. The adjoining Moon-Anchor has paid dividends of $261,000 and the Half Moon (Matoa Gold Mining Company) has a gross production of $650,000 to its credit, but is reported to have paid only a small amount in dividends. None of these mines is being worked at present, except on a small scale by lessees.

"On the western slope is the Midget mine, actively worked at present, with a depth of 800 feet, a total production of $662,000, and dividends of $195,000. The Conundrum, in the same vicinity, is likewise worked with good results to a depth of 600 feet. The Midget, like the mines described above, follows a vein in breccia, while the Conundrum is mining on a "basalt" dike in granite, close to the contact of the breccia.

"In the deep gulch between Gold Hill and Raven Hill are situated the Anaconda, Doctor-Jackpot, and Mary McKinney mines, all working on sheeted zones forming lodes in the breccia. The Anaconda produced about $1,000,000, chiefly from upper levels, and is now being worked by lessees. The Mary McKinney is one of the most successful mines worked at present in the district. Its depth is 600 feet. The Doctor-Jackpot has $4,000,000 to its credit, and likewise a handsome dividend record. The shaft is only 700 feet deep, water having until now prohibited deeper sinking.

"The breccia-granite contact is found on Guyot Hill a short distance south of the Mary McKinney. The extreme spur of Raven Hill, called Beacon Hill, is formed of an intrusion of phonolite in granite, and about this outlying volcanic center cluster a group of veins of great production and promise. On the eastern side of the hill are located the Prince Albert, Gold Dollar, and others, which are worked on a small scale by lessees. On the western side lie the El Paso, C. K. & N., and Old Gold mines, with their narrow, but extremely rich fissure veins in granite, now actively and successfully worked.

"A great number of smaller mines have been worked on veins cutting the breccia of Raven Hill. The famous Elkton mine is situated in the deep hollow between Raven Hill and Battle Mountain. It has been working on an exceptionally long vein, partly contained in breccia, partly in granite, and generally following a "basalt" dike. The production approaches $6,000,000, and the depth attained is about 900 feet, excessive water having formed a serious obstacle to deeper sinking. Dividends amount to $1,200,000. The Moose mine, situated higher up on the slope of Raven Hill, had a good ore shoot, from which $500,000 was obtained.

"Continuing northwest, we soon attain the summit of Bull Hill, which affords a magnificent panorama, not only of the whole camp, but of a large part of the state of Colorado. Toward the east, and 5,000 feet lower, spread the great plains at the foot of the Rocky Mountains; westward the Sange de Cristo, Collegiate and Mosquito ranges — a snowy and jagged line of ramparts — define the distant horizon.

"A multitude of small mines occupy the southwestern slope of Bull Hill. On the northwestern side an area of brecciated granite appears among the volanic rocks, and in this formation is situated the Wild Horse mine. This lode, which has been worked to a depth of 1,250 feet, has produced over $1,000,000, but is now operated only by lessees. A number of smaller producers may be found on the northern slope, toward Cameron, among them the Damon, Jerry Johnson, W. P. H., and Pinnacle.

"Those who have followed this description on a map will have noticed that the mines are chiefly situated on the periphery of a circular area, the central part of which, comprising the upper part of Squaw Gulch, has thus far yielded very little. Few strong veins have been met with in this part of the breccia, but, on the other hand, the developments in depth are not extensive.

"On the east and southeast sides of Bull Hill begins that most important belt of lodes which extends southward to Victor, and includes the richest group of producers in the camp. A characteristic feature of this belt is the intrusion into the breccia of thick masses of latite-phonolite and syenitic rocks.

"With few exceptions the veins of this belt strike north-northwest. We may begin the description with the system of linked veins 3,000 feet long, covered by the Isabella and Victor mines. The last-named mine, on the southern end of the system, is situated just below the western slope of Bull Cliff. It has been worked to a depth of over 1,000 feet, has produced about $2,200,000, and has paid dividends amounting to $1,150,000. The Isabella has attained a depth of 1,127 feet, produced $3,200,000, and paid dividends of $600,000. Both mines lost their pay shoot in depth, but are still worked by lessees.

"The small but rich cross veins of the Empire State, Burns, Pharmacist, and Zenobia connect this vein system with that of the Stratton mines on Bull Hill. South of the Burns begins the great Vindicator vein system traced southeastward for a mile through the Findley, Hull City, Vindicator, Lillie, and Golden Cycle mines. The Hull City and the Lillie have each produced over $1,000,000, the Vindicator and Golden Cycle over $2,000,000 each, all with corresponding dividends records. The Lillie is deepest, having attained 1,500 feet. Next in depth is the Vindicator, 1,200 feet. All of them, except the Lillie, are still actively worked. In the whole system water has been, and still is, a source of trouble. The deepest mine evidently drains all the others in this vicinity.

"The Stratton properties on Bull Hill, with the Logan, Orpha May, and Pikes Peak veins, on which maximum depths of 1,200 and 1,500 feet have been attained, are now worked only to a slight extent, whereas in the early days of the camp they were highly productive.

"This system is continued southward in the Last Dollar mine, now working at a depth of 1,270 feet. The production exceeds $1,000,000. South of the Last Dollar the veins enter the Modoc ground, a mine worked for a long time with gratifying success. The Blue Bird, an old-time producer, is situated a short distance west of the Last Dollar.

"South of the Modoc is the Battle Mountain vein system, crossing from the granite into the breccia, with general northerly or north-northwesterly directions, and distinguished by heavy production and ore bodies of imposing size. None of the veins is of great length, and the whole system extends scarcely a mile along the strike of the veins. The veins cannot be directly connected with others already described, though, in its general trend, the system heads toward the Dexter, Blue Bird, and Moose veins.

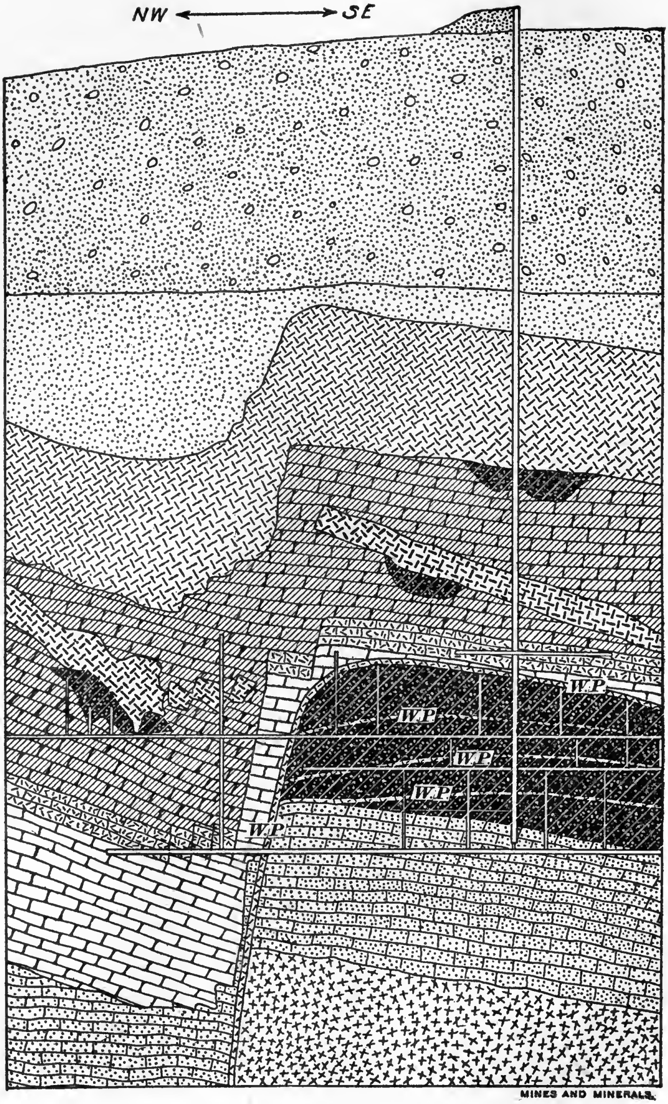
"Beginning on the southwestern side, we first come to the Gold Coin mine, the veins of which are in granite; one of them is successfully worked at present at a depth of 1,200 feet. The total production approaches $6,000,000; the dividends paid exceed $1,000,000. North of the Gold Coin is the Ajax, working partly in the veins, partly in large, irregular ore bodies in the granite. The total production is very considerable. The depth attained is 1,200 feet.

"Between this and the Portland vein system, almost within the town of Victor, are the Granite, Dillon, and Dead Pine veins. They are worked at present at depths of 800 to 1,000 feet.

"The Portland vein system begins on the south at the Strong mine, now worked at a maximum depth of 900 feet, on a vein in granite that follows a "basalt" dike, which is in places accompanied by a phonolite dike. The mine is an unusually regular and profitable producer, the total dividends since 1892 amounting to $2,500,000.

"The veins of Stratton's Independence run about parallel to those of the Strong, a few hundred feet eastward. They extend from the granite into the breccia, following for some distance a phonolite dike. The production of this mine amounts to over $11,000,000, with a dividend record of $4,000,000 since 1899. At present the company is leasing the various levels to tributers. From the two properties last described the vein systems continue into the Portland mine, but in the northern part of that great property are replaced by another and still richer aggregate of veins, the Captain system. The Portland is, beyond question, the most prominent mine of the Cripple Creek district. Its total production from 1894 to the end of 1903 amounted to $18,000,000, derived from 466,000 tons of ore (both in round figures), from which $4,600,000 has been paid in dividends, the remainder going to acquirement of territory, extensive milling and mining plants, and operating expenses.

Leadville District. — There are seven distinct formations in the district which may be outlined as follows: first, the lower-most, consists of Archæan granite and carries no ore; second, a Cambrian quartzite which contains seams and stringers of ore, but in small quantities; third, Silurian limestone, which at the contact with the quartzite below bears ore-bodies of fair size; fourth, a sheet of "parting quartzite" overlying the ore-bodies in the limestone; fifth, a blue Carboniferous limestone, designated as the "Blue," which is the principal ore-bearing formation of the district; sixth,



Section at Conorado Shaft, Leadville, Colorado.

an overflow of porphyry, which comes in contact with the ore-bodies below; and seventh, a deposit of glacial wash also containing ore.[1]

The ore-bodies occurring in the blue-gray dolomitic limestone of the Lower Carboniferous and lying near or at the contact with the porphyry above constitutes a sort of contact sheet, the upper surface of which is fairly regular and well defined, the lower surface being exceedingly irregular. The thickness of the deposit in this limestone varies from a few feet to the whole depth of the enclosing stratum, the transition between the limestone and ore-body being gradual.[2]

The ore-bodies are often separated from one another by rolls of barren rock and dikes of intervening porphyry, the ore being found at the contact plane of the blue limestone and porphyry, in the lower limestone horizons and in the dikes. At a depth of 600 feet, below the oxidation zone the ores are largely siliceous in character, being stained with oxides and often carrying silver and lead. Considerable of the gold occurs free, especially in the porphyry as at the Antioch mine, but the greater portion of it is in highly siliceous ore carrying silver — fully 80 per cent of the value is gold.[3]

The normal condition of the ore is sulphide, consisting of sulphides of iron, copper, zinc, and silver, with some native gold and silver. However, the most common and important ore is argentiferous galena with cerussite, carbonate of lead with cerargyrite. Gold occurs in the galena in the filiform state and in the ores ordinarily in small flakes and leaflets. The gangues are quartz, hydrous silicates of alumina, heavy spar, pyrite, carbonate of iron and sulphate of lime.[4] The district is usually considered as a silver producer. The silver-lead ores were first discovered in 1879 on Fryer, Carbonate and Iron hills. The principal mines are the R. E. Lee, Little Pittsburgh, Iron, Crysolite, New Discovery, Little Chief, A. Y. and Minnie, Crown Point, Maid of Erin, Adams, Henrietta, Morning and Evening Star, Matchless and Catalpa.[5]

A body of porphyry lying between the Pilot and Mike faults on the northwestern slope of Printer Boy Hill is unlike the other porphyry of the district. It is of considerable importance in that it contains the Printer Boy and Five-Twenty gold-bearing lodes. The lodes,

[1] Min. and Sci. Press, Vol. 86, p. 168.
[2] U. S. G. S., Monograph No. 12, p. 375.
[3] Eng. and Min. Jour., Vol. 59, p. 77.
[4] U. S. G. S., Monograph No. 12, p. 376.
[5] Mining Magazine, Vol. 11, p. 430.

especially the Printer Boy, were discovered before the carbonate ore was known of, and yield considerable gold. It consists of a deposit along a jointing or fracture plane in the porphyry having a strike of east of north. The gangue is decomposed porphyry, the gold and other metallic contents being mostly invisible. Formerly, free-gold occurred in noticeable quantities with chalcopyrite, galena and tennantite.[1]

The "Down Town" mines first produced carbonate of lead near the surface, which changed, however, to sulphides in depth. When the depression, due to financial conditions following the depreciation of silver, was felt the mines adapted themselves to the new conditions by becoming gold producers. It was found that at a certain depth practically coincident with the silver belt, gold and auriferous sulphides occurred in a zone of decomposed porphyry, which was first discovered in the "Little Johnny" or Ibex.[2]

Mines similar to those at Leadville are found at: Carbonate Camp (Iron Hill and Wilkinson mines), Dakota; Aspen, Colorado; Eureka Hill, Nevada; Little Cottonwood and the Bingham and Dry Cañon mines, Utah; the Sierra Mojada, Mexico; North Park mines, Colorado, etc.[3]

San Juan County. — According to T. B. Comstock [4] there are six geographical zones into which the mineral districts of the county can be divided, namely:

1. The Engineer Mountain area, arsenical zone, with a width at the ten-mile circle [5] of 4½ miles, including Mineral Point and adjacent territory.

2. The Handies' Peak area, bismuth zone, 10 miles wide at the ten-mile circle, including Capitol, Sherman, Animas Forks, Eureka, Middleton and Gladstone.

3. The Continental area, galena-gray copper zone, so-called, 11 miles in width at the ten-mile circle, including the towns of Howardsville and Silverton.

4. The Lost Peak area, antimonial zone, 9 miles wide at the ten-mile circle, with Chattanooga as the only existing town.

5. The Glacier Peak area, argentiferous zone, 3 miles wide at the ten-mile circle, including the towns of Ophir and Ames.

[1] U. S. G. S., Monograph No. 12, p. 513.

[2] Mines and Minerals, Vol. 21, p. 147.

[3] Min. and Sci. Press, Vol. 57, p. 106.

[4] Eng. and Min. Jour., Vol. 38., pp. 208 and 298.

[5] The ten-mile circle has as a center Red Peak, such a circle passes through Ouray, Rose's Cabin, Highland Mary and Ames.

6. The Mount Sneffels area, 17 miles wide at the ten-mile circle, including San Miguel, Telluride, Red Mountain Town, Ironton and Ouray.

At the Congress mine, Engineers Mountain area, enargite predominates, and is accompanied by galena. Arsenic occurs with the rich silver ores of Mineral Point. In the Inez mine arsenopyrite and mispickel are common, while ruby silver is found in limited amounts. At the Red Cloud mine blende and galena occur together, while in the arsenical zone blende is associated with both pyrite and galena. Bornite and chalcopyrite also are found with galena. Further, tellurium is found in the ores.[1]

In the Handies' Peak area a vertical fissure carrying free-gold extends from Red Peak crossing the divide near the head of Dry Gulch, passing north of Gladstone, across the head of the north Fork of Eureka Creek along the divide between Eureka Creek and Picayune Gulch, and across the Animas River, then traversing the ridge between the American Basin, and the source of Cottonwood Creek in Hinsdale County. The supposed order of occurrence is as follows: first, gold-bearing quartz, merging into; second, quartz and pyrite; third, bornite and chalcopyrite occurring between layers of barren quartz; fourth, galena often accompanied by blende; and fifth, bismuthinite occurring in flakes irregularly scattered through quartz.[2]

The Continental Divide area lies between Maggie Gulch and Mineral Creek. The most important veins follow the ridges, and constitute the tetrahedrite belt, although galena is present in considerable quantities, while free-gold is not so plentiful as in some of the other veins. Free-gold accompanied by galena and pyrite are found some eight miles from Red Peak. Blende bears more silver than the pyrite, copper and lead, although this condition is sometimes reversed.[3]

Lost Peak area includes the veins lying between south 2 degrees west and south 68 degrees west of Red Peak. A vertical fissure traverses the ridge of Red Mountain at the head of the United States Basin. Bournonite is characteristic of the area, although arsenic is also characteristic at least of several mines. Antimonial copper glance also occurs.[4]

[1] Eng. and Min. Jour., Vol. 38, p. 229.
[2] Eng. and Min. Jour., Vol. 38, p. 245.
[3] Eng. and Min. Jour., Vol. 38, pp. 299 and 315.
[4] Eng. and Min. Jour., Vol. 38, p. 315.

The Glacier Peak area includes the veins lying between south 66 degrees west and south 87 degrees west. The highest ridges are cut by vertical veins bearing free-gold. The vein-filling is argentiferous ore in which freibergite is one of the most characteristic silver-bearing minerals, usually associated with galena. No silver, free or combined, is found in the gold veins. Hornsilver is present, but not in any quantity. Galena occurs in two- to four-inch streaks, while blende is absent. The gangue is mainly quartz and ocherous material.[1]

The ore of this country belongs to the variety known as hübnerite, the concentrate assaying: tungstic acid, 75 per cent; manganese, 22 per cent; iron, 2 per cent, and oxide of calcium, 1 per cent. As high as 60 per cent of tungstic acid occurs in some of the sorted ores, but ordinarily it is disseminated through the quartz in small quantities. As the minerals occur in a quartz gangue they are easily concentrated. As a rule the ores show good values of gold and silver in depth. The mineral scheelite is occasionally found in the district.[2]

The Bear Creek district is located in a country-formation of Cambrian schists, slates and quartzites, overlying which in part is the San Juan andesitic tuffs and later flows. Veins of quartz, commonly known as "bull quartz," being barren, occur with widths of three to four inches. The ore-bodies are found in fissure-veins filled with white quartz in which occur masses or pockets of mineral. Other gangue minerals are: calcite, barite and kaolinite. The metallic minerals are tetrahedrite, pyrite, chalcopyrite, bornite, galena, blende, arsenopyrite, limonite, hematite, azurite, malachite and telluride of gold, probably petzite. The values lie in the telluride and gray copper. The veins vary in width from a mere fissure to two and three feet, while the Gold Bug attains a width of six feet. Horses of country-rock occur in the veins. The veins are often barren in precious metal values for considerable distances, but it often happens that high-grade ores may come in suddenly after the termination of such a barren portion. Such irregular and erratic occurrence of pay-rock discourages development.[3]

Ouray County. — The Camp Bird mine in the Imogene Basin is in a vein the average width of which is six to seven feet. The country-rocks are andesites and rhyolites.[4] The veins are probably fissures or

[1] Eng. Min. Jour., Vol. 38, p. 328.
[2] Eng. and Min. Jour., Vol. 67, p. 499.
[3] U. S. G. S., Bull. No. 285, p. 25, 1905.
[4] T. A. I. M. E., Vol. 33, p. 504, etc.

filled fissure zones, which reoccur in systems with intervals of varying widths intervening. The wide belts or zones of crushed rock have probably resulted from the intersection at small angles of the comparatively narrow fissured zones, thus providing a repository for the minerals which now constitute the larger ore-deposits. The width of the veins varies but little with passage from the San Juan series into the intermediate andesites, or *vice versa.* White massive quartz occurs along the edges of the main vein, which is interlaminated with country-rock, and occasionally sprinkled with pyrite, galena in crystals, and flakes of chalcopyrite, while within the vein the quartz gangue richest in gold has a dull luster. It is made up of closely packed crystals, and often having spherical aggregates. The vein-filling consists of gold, both free and combined, galena, silver, chlorite, rhodonite-magnetite, pyrite, chalcopyrite and quartz. Fully 90 per cent of the values is gold. Tellurium is known to exist as shown by tests. Open cavities often occur in which are found calcite, siderite and the oxides of iron and manganese, besides large quartz crystals. Silver is usually associated with galena and magnetite, and to some extent with pyrite. An alloy of gold and silver occurs in galena. Gold occurs in pure white quartz apparently without other minerals. It is finely divided, and is usually invisible.[1]

It is evident both from observation within this and neighboring mines that the veins vary but little in depth, even to a depth of 2000 feet — the deposits being young, and therefore have not suffered materially from erosion. The ore-bodies occur in shoots, but without any definite pitch in the plane of the vein, nor regularity in outline. They have been worked to a depth of 800 feet. The values of the ore are in gold, silver, lead and zinc of which the gold has a value of fully 96 per cent.[2]

In the American Nettie mine, the ore occurs in Dakota sandstone, both in cavities and as an impregnation. In the cavities it is a sintery mixture of oxidized material with ocherous ironstone, while in the impregnated rock it occurs as sulphides — iron, copper, lead and zinc with gray copper. Probably the best ores occur at the contact with the overlying shales, where the ore is in the form of pockets, produced by fissuring, and accompanied by some gypsum. Aside from the above are also found peacock copper, native copper, telluride ores (petzite principally), bismuth and copperas.

[1] T. A. I. M. E., Vol. 33, pp. 509–511.
[2] T. A. I. M. E., Vol. 33, pp. 499 and 509.

Dikes of igneous rock cut the sandstone country-rock, in which are fragments of the sandstone.[1]

The Virginius mine is a deposit of galena and gray copper, which is evidently a replacement of a part of the contiguous andesite dike and the country-rock adjoining. The ore occurs with or without a quartz gangue; however, the fissure ore is usually free from quartz. Both the galena and gray copper are argentiferous; the former, when free from gray copper, assays about 50 ounces of silver. Practically no gold is found in the surface ores, but with depth has increased to a value of two ounces per ton.

At Red Mountain, low-grade lead ores occur at the surface which in depth show an increasing per cent of copper and the ultimate disappearance of lead. The deeper ores consist of rich silver, copper and bismuth combinations.

The occurrence of enargite in higher ground to the south would seem to indicate that it exists in the upper portions of the veins.

Dolores County. — Newman Hill is situated on the east fork of the Dolores River. The ore-deposits occur in a series of nearly vertical and parallel fissures which are cut by other fissures at practically all angles. There are other deposits at the contacts of limestone and shale. The former are of the most importance, being known as the " vertical pay veins," while the ore-bodies of the " cross veins " are smaller and richer.

The veins usually split up on passing from the black shale underlying the contact-limestone and continue with widths ranging from one-sixteenth to one inch. The horizontal deposits have the form of pipes varying in width from 2 to 30 feet, and from a few inches to two feet in thickness, and following for considerable distance along the side of the vein to which they are connected. Close connections apparently exist between the contact pipes and the underlying veins, for they increase and decrease in size with remarkable regularity. Considerable local disturbance is shown at the point of intersection of the vertical and cross veins, many stringers occurring. The cross veins are probably the more recent.

The vein-filling is white quartz in which are many cavities. The principal minerals are pyrite, chalcopyrite, sphalerite, galena, tetrahedrite and gold and silver. At the contact zone the ore-deposit becomes nearly a solid mass of metallic minerals carrying both gold and silver. The minerals seem to increase quite perceptibly as the surface is approached, rhodochrosite also appearing. The

[1] Eng. Min. Jour., Vol. 76, p. 7.

principal veins are: the Swansea, Enterprise, Hiawatha, Jumbo and Eureka.[1]

The silver minerals are: argentite, polybasite and stephanite, all of which occur with galena and blende. Pyrargyrite and proustite and native silver are also found, but in small quantities.

The three mining centers at Rico are situated on three mountains; namely, the Dolores, Telescope and Expectation. Among the first workings on Dolores Mountain were the Enterprise and the Rico-Aspen, and the C. H. C. on Telescope Mountain. The ore occurs in practically vertical fissures and contact-deposits, probably fissures, besides which there are numerous other veins. There are three main veins traversing Telescope Mountain; namely, the Logan, Leap Year and Bourbon, of which the first named is the most important. This vein carries galena, chalcopyrite, with values in gold, silver and lead. The ores change from sulphides to carbonates in passing from the fissures to the horizontal contact-deposits. Overflows from the fissures formed the contact-deposits which lie between a capping of iron above and limestone below. The contact-deposits occur in benches or terraces, which position has been assumed by portions having been broken off the main formation, and sliding downward. The horizontal portions contain ore, while those that are tilted are low-grade. The high-grade ores of the contacts on Telescope Mountain, occurring above the horizontal bedding-planes, carry silver and lead, while the fissures of the northwestern slope have walls somewhat broken, and yield low values in silver, gold and lead. The Sambo mine on the north portion of Expectation Mountain, is on a contact-vein between limestone and sandstone formations above, and a bed of limestone (" short lime ") below. The ore is galena and blende.[2]

Boulder County. — Among the mines of this area the Golden Age is one of the most important, of which there are six claims: the Golden Age, Sentinal, Rambler, Boston, Terrible and Hurricane. The ore of the Golden Age lode is free-milling, occurring in a contact-vein; however, with depth, sulphide ores are encountered in the form of pyrite, galena, blende and chalcopyrite. The Sentinal is also a contact-vein in which are found free-gold and high-grade telluride ores.

The Golden Age ore-body occurs largely in shoots on the contact of a quartz-porphyry dike and a country-rock of granite and

[1] Eng. and Min. Jour., Vol. 54, p. 174.

[2] Min. and Sci. Press, Vol. 81, p. 341.

gneiss. The vein bifurcates at a depth of 100 feet, the two branches being known as the hanging-wall and foot-wall streaks. The dike also becomes mineralized, forming a low-grade ore. Of the two branches the foot-wall bears the most sulphides. The gangue is a hard, vitreous, white quartz, the gold occurring near the surface in the free state, and is often found in nuggets of several ounces. In fact the mine is famous for its specimen ore. The richest portion of the vein is in the granite and schistose rocks and poorest in the porphyry. No telluride ores are found in this vein.

The ores of this county may be grouped into two classes; free-milling ores at the surface, changing to sulphides in depth, and the telluride ores. With the oxidized ores are associated native copper and green carbonate. The telluride ores are: calaverite, sylvanite and petzite.[1]

Summit County. — The country-rock of the ridge consists of clay, slate and porphyry, the porphyry occurring as dikes and sheet intrusions overlaying the slate. The slate is cut at right angles by a system of parallel veins, which have a content of oxides and sulphides of iron and copper, galena, gold and silver, with a gangue of calcite and quartz. Gold is found with all the minerals mentioned except quartz, which contains no gold when it predominates in the veins. The calcite bears gold in the form of threads and wires and occasionally as crystals. Thread and wire gold also occur in the iron and copper minerals often so dense as to resemble a bunch of moss. Nuggets are also found weighing from a fraction up to several ounces. The free-gold is found near the surface, but decreases with the other metallic minerals with depth, being replaced by calcite and barren quartz. These veins have been the source of the placer gold in the Georgia, Humbug and American gulches.[2]

Clear Creek County. — The country consists largely of dark gneiss, composed of quartz, feldspar and black mica. This gneiss is well stratified, but considerably disturbed and often metamorphosed. Intersecting this formation are veins of porphyry, compactly crystalline and of light green and rose colors. The veins bearing the silver ores are found in the porphyry dikes. The ores are: argentiferous galena, gray copper, brittle silver (with ruby and glance), pyrite, chalcopyrite, blende and native silver, in wires and nodules. The gangues are: fine quartz crystals, barite and fluorspar. The porphyry dikes range in width from 10 to 100 feet, although the chim-

[1] T. A. I. M. E., Vol. 19, p. 323.
[2] Eng. and Min. Jour., Vol. 51, p. 516.

Ruby Mountain, Gray's Peak and Argentine Pass, near Montezuma, Colorado.
(From Engineering and Mining Journal.)

neys and shoots of ore seldom exceed 12 inches, and are often as narrow as one inch.

Galena carries the highest values, being fully 50 per cent in nine-tenths of the veins, and is very prominent in all. Pyrite is very common, while zinc and copper minerals are practically always present, arsenic and antimony only occasionally so. The Snow Drift vein is preëminently a silver sulphuret producer; its content having suffered decomposition, and in places the walls are difficult to follow. Between the walls pure silver glance occurs in some seams; in others are found galena and glance combined, while in still others the sulphuret; oxides of iron and lead, are present — the sulphuret predominating in depth.[1]

At the Stanley mine, Idaho Springs, the country-rock is Archæan gneiss and schist cut up by masses of coarsely crystalline granite. The veins vary considerably in shape and character, having widths of from a few inches to 50 feet. The vein upon which this mine is located has a width of five to ten feet. The ores (1894) were chiefly pyrite, chalcopyrite, purple copper or bornite and peacock copper. The value of the free-gold content is small.

Custer County. — A sheet of andesite, commonly called the "Bassic" andesite, occurs at the Bassic mine, which is situated about five miles from Silver Cliff. There are two ore-bodies in this mine, one reaching to the surface, the other extending slightly above the 600-foot level. In horizontal section the bodies are elliptical, varying between 25 to 50 feet on the minor and 50 to 75 feet or more on the major axes. These ore-bodies, which may be considered as channels or pipes, stand practically vertical. The ore apparently occupies the duct of an extinct hot spring or geyser, and occurs as thin incrustations on boulders and pebbles which fill the inverted conical opening. The shape of the fragments is subangular and rounded, composed of volcanic rock, similar to the walls of the duct; granite is also present in small pieces. The voids between this mass of boulders are filled with a plastic, granulated mass of decomposed rock fragments. The minerals constituting the ore are: the sulphide, carbonate and hydrous silicate of zinc, sulphides of iron and lead, gray copper, tellurium and gold and silver. Quartz also occurs as a filling. The ore is very rich, being principally tellurides, no free-gold having been found. The ore assays from $200 to $5000 per ton.[2]

[1] Eng. and Min. Jour., Vol. 27, p. 73; Vol. 13, p. 260, and U. S. G. S., Bull. No. 285, p. 38, 1905.

[2] Colliery Engineer, Vol. 12, p. 73, and Mines and Minerals, Vol. 23, p. 489.

The Racine Boy is the first mine which attracted attention to the district. The King of the Valley and the Horn Silver are two other well-known mines. The occurrence of ore is not unlike that in the Bassic, the ore-bodies being agglomerated masses of porphyry boulders and breccia cemented together with a trachyte mud, which has been kaolinized. Near Silver Cliff two large dikes of feldspathic glass or obsidian have intersected the ore-bodies. The metallic contents are derived almost entirely from the trachyte mud or sand. The silver is largely silver chloride, which varies in richness from 1 to 15 ounces.[1]

Pitkin County. — The mines of Aspen Mountain are among the richest of the county. The ore-deposits are found near the junction of the dolomite and blue limestone. It has been suggested that the ore-bodies occur at the contact between the dolomite and blue limestone, the former being of Silurian age, the latter of Carboniferous. The vein is not disturbed on either wall at the surface, but in depth the ore-body becomes somewhat irregular. The gangue is dolomite, limestone and heavy spar, while the characteristic minerals are zinc and copper, although galena, blende, polybasite, stephanite, carbonate of copper and lead carbonate are found in varying amounts. Silver and lead bear no special relation to each other in these ores. The richest ores occur in the most altered limestone; when heavy spar occurs in the ore-body the amount of silver present is small. Some of the richest mines in the district are: the Spar, Washington, Vallejo, Emma, Aspen, Visino, Connamara, Bonnybel, Chloride, and Silver Star.[2]

Telluride, San Miguel County. — There are three large mines in this county, namely: the Smuggler-Union, Liberty Bell and Tomboy.

The principal minerals occurring are pyrite, chalcopyrite, galena, blende and arsenical pyrites, such as proustite polybasite, etc. Native silver is rare, while native gold, though more frequent, is also rare.[3] The Smuggler-Union vein is probably a fault-fissure, the walls showing much evidence of movement such as striations, polished surfaces and gouge-material. The width varies from about two feet up to five feet. Horses of country-rock are of common occurrence. The occurrence of the ore in the vein is very regular and uniform, but shows a preference for the foot-wall. Shipping ore of a few inches in width is usual, while milling ore occupies a much greater width, as one or two feet.

[1] Eng. and Min. Jour., Vol. 27, p. 57.
[2] T. A. I. M. E., Vol. 17, p. 156, and Eng. and Min. Jour., Vol. 39, p. 277.
[3] T. A. I. M. E., Vol. 26, p. 455.

The common minerals are pyrite, chalcopyrite, galena, sphalerite and the arsenical silver minerals. Polybasite and proustite are known to be present; tetrahedrite has not been recognized. Metallic gold and silver, although present, are not common, but when present the gold predominates. At the extreme north end, where the vein crosses the divide, the gold value does not exceed one-fourth that of the silver, while a mile further south it exceeds that of the silver, and virtually becomes a gold vein.[1] The Sheridan mine, which is the northerly extension of the Smuggler mine, has a country-rock porphyritic and dioritic in character. The gangue is quartz, or the so-called horse-porphyry, filling a vein which averages 10 to 20 feet in width. A gouge of clay occurs separating the vein from the walls. The metallic minerals are the sulphides of iron, copper, lead and zinc, with which is associated free-gold.[2]

The country-rock at the Liberty Bell mine is bluish-gray breccia, angular and subangular fragments of andesite with a matrix of the

Gold-quartz, Smuggler Union Mine, San Miguel County, Colorado. (From Mines and Minerals.)

same material. The veins are large and strong, varying in width from five to six feet. The walls are well-defined, although showing

[1] T. A. I M. E., Vol. 26, p. 453.
[2] Eng. and Min. Jour., Vol. 30, p. 185.

some movement. The vein-filling is quartz and silicified earthy matter occurring in bands often separated by gouge or clay. Calcite is occasionally found in masses and a greenish slaty gangue is quite persistent in its occurrence. Pyrite is common in the vein-rock, also iron and manganese oxides. Gold-bearing quartz predominates, the gold being occasionally visible. The gouge also often runs high into both gold and silver values. Gold also is associated with pyrite. The silver, especially in the unaltered zone, is probably a sulphide being combined with arsenic and antimony.[1]

Gilpin County. — In 1892 this was one of the most important gold mining districts in the state.

The veins are two mineralized zones of altered quartzose rock with walls of banded gneiss. These zones or veins occur one on either side of the main vein, and are known as the hanging and foot-wall veins — the former is from three to six feet wide, the latter averages four feet, although it has a maximum width of 16 feet. The gangue is quartz, throughout which the metallic minerals pyrite and blende are found. Grains of free-gold often occur in crystalline form and are readily visible to the naked eye.[2]

Gunnison County. — The ore-body of the Vulcan and Mammoth mines consists of a coarse breccia of quartz fragments, which is both white and stained with oxide of iron. The quartz is considerably honeycombed and associated with red and yellow jasper, the mixture being cemented together by oxide of iron and sand. A zone of pure granulated sulphur occurs just below the 100-foot level and reaches to a depth of 125 feet, i.e., varies from 15 to 25 feet in vertical thickness. Following this is a zone of loose pyrite and below that massive iron pyrites which is low-grade ore, carrying from $4 to $14 per ton in gold. The presence of telluride of gold is suspected. The country is composed of schists and masses of granite and eruptives, although at the mines the schist seems to predominate. The principal mines here are the Vulcan and Mammoth.[3]

La Plata County. — The La Plata mines, some 15 miles northwest of Durango, occur in sedimentary rock cut by intrusions of diorite, which form the core of the mountains. The sedimentary rock has been very much disturbed and subsequently cut by nearly vertical dikes of diorite. The veins are large and well defined and contain

[1] T. A. I. M. E., Vol. 29, pp. 291 and 292.
[2] Mines and Minerals, Vol. 20, p. 82.
[3] Mines and Minerals, Vol. 18, p. 562.

sulphides low in gold and silver values. Sylvanite occurs between the elevations of ten and twelve thousand feet, being well disseminated. The Columbus mine in the Silver Lake basin shows at a depth of 200 feet considerable bodies of black quartz, averaging about $15 per ton, which is associated with an exceedingly rich streak of sylvanite.[1]

The output of the Cripple Creek mines has been increased most remarkably and will undoubtedly continue to be the principal source of the gold-supply of the United States. The size and persistence of the deposits of the San Juan region ensures a steady production if not an increase, while from present indications the production of the Gilpin region will be maintained for many years.

Connecticut. — Although the argentiferous lead mines of Connecticut and especially those of Middletown have become famous as being the first to receive attention in the United States, practically no ore of commercial importance has been obtained from them.

According to Whitney indications of galena are abundant in the state, the more important locations being at Monroe, Plymouth and Middletown. The Lane mine at Monroe yields rich argentiferous galena disseminated in a bed of quartz, but not in workable quantities. Probably the most important geologically is that at Middletown. The galena occurs in a thin vein of quartz in mica-slate, having a thickness of 10 to 20 inches.

The ore is associated with blende, iron pyrite, and rarely chalcopyrite. Aside from the quartz, mica-slate often occurs as a vein-filling. The galena contains, according to Mr. Pattinson's assays, from 25 to 75 ounces of silver per ton of lead.[2]

Georgia. — The occurrence of gold in this state is next to that in the Carolina belt. The area of auriferous rock begins with Rabun and Habersham counties in the northeastern part of the state and extends southwestward to the Alabama line, in the vicinity of Tallapoosa, including the mining town of Dahlonega. The country-rock is mica- and hornblende-gneisses and schists of Archaen Age probably derived from granite and diorite. Diabase dikes are common, while granite dikes are less common.

The ore-bodies consist of gneisses and schists cut by fissures and bearing gold-quartz and base minerals. The fissures conform quite closely to the schistosity of the rock, but in some cases cut the

[1] Eng. and Min. Jour., Vol. 66, p. 667.

[2] Report on the Geology of Conn., p. 52; Whitney's Metallic Wealth of the United States, 1854, pp. 392–394; and T. A. I. M. E., Vol. 5, p. 169.

same at small angles. The veins vary from 3 to 20 feet in width and are often close together being separated by barren bands of gneiss. At the Shingleton mine, Dahlonega, the total width of the ore-bearing zone is 200 feet. According to the homogeneity of the rock various forms of ore-bodies are produced — the rock may be completely shattered, which when filled with auriferous pyrite forms sort of a stockwork, while if the rock is more homogeneous and the forces of varying intensity, one or a few large fissures may result, which when filled forms a solid mass of auriferous and pyritic quartz. The pitch of the ore-bodies is usually to the northeast.

The vein-content is quartz, calcite, pyrite and chalcopyrite. Garnets and tourmaline are also present as gangues, but in small quantities.[1]

The rocks are usually weathered to considerable depths and in many instances solid rock is not encountered within 100 feet from the surface. This weathered material has been called saprolite by Becker, in which the gold occurs in the free state, the whole mass being suitable for treatment by the hydraulicing process. Mica-schist is usually encountered in depth in which gold-bearing quartz occurs.[2]

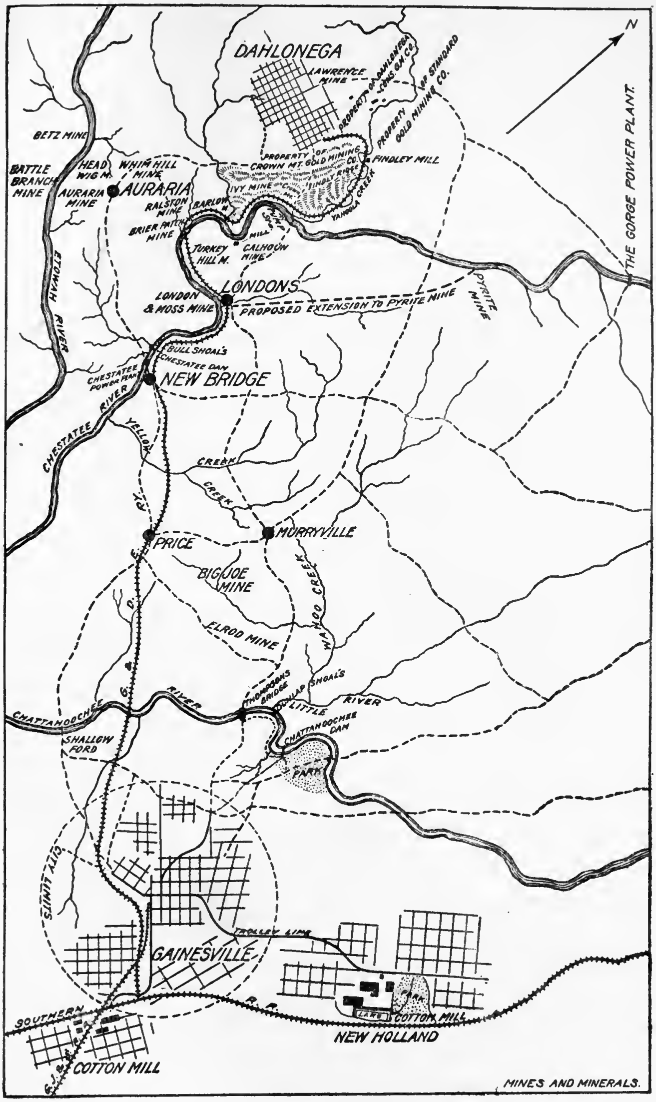
Besides the quartz-veins gold also occurs in slate-veins, although they are few and usually low in values unless accompanied by one or more quartz-veins, the two deposits being worked together. Itacolumyte is occasionally found in quartz-veins.[3]

The property of the Chestatee Pyrites Company some six miles from Dahlonega illustrates the occurrence of gold-bearing pyrite in this district and is important in that it is a high-grade ore-body. The deposit is comformable with the quartzose mica-schists occurring on the west while the adjoining rock on the east is hornblende-schist — it is then a contact deposit between sedimentary (probably) and metamorphosed igneous rock.[4]

For a description of the peculiar lode-deposit near Dahlonega see Georgia under the head of gravels.

Probably one of the most noted occurrences in the Southern States, of gold and tellurium closely associated is that at the Boly Fields gold mine on the Chestatee. The vein is in a compact hornblende-gneiss or slate in which no surface alteration is observable.

[1] T. A. I. M. E., Vol. 25, pp. 673–677.
[2] U. S. G. S., Bull. 213, p. 60.
[3] Eng. and Min. Jour., Vol. 24, p. 258.
[4] U. S. G. S., Bull. 213, p. 63.



Dahlonega and Vicinity (1903).

The gold occurs in coarse grains both free and combined with tellurium.[1]

Idaho. — The southern part of Idaho is characterized by intrusive granites and overlying Tertiary lavas together with isolated desert ranges of stratified rocks. In Owyhee County ore-deposits occur in the southern part only. Extending north of the Snake River Valley is the great central mountain mass consisting of intrusive granite surrounded by sedimentaries of a great range in age.

There are two classes of gold-deposits: first, the gold-quartz veins found in the granite area, in which auriferous pyrites occur and often considerable silver, and second, the veins occurring in basalt and rhyolite which carry both gold and silver. Some of the more important of these mines are the Custer, Rocky Bar, Atlanta and the Thunder Mountain discoveries.[2]

There is a continuous gold belt in this state from the Panhandle on the north to the southern boundary, with a width extending from the summit of the Bitter Root Mountain on the east to the Snake River on the west, thus including an area 40 to 175 miles wide to 400 miles long. Gold is found in the outcrops of all veins, but in small amounts, rarely ever exceeding $2 per ton, and usually disappears in depth.

Coeur d'Alêne County is rich in metals, especially lead and silver, although it was opened up as a gold district.[3]

In western central Idaho the veins north of the Snake River have a general strike of east and west. There are four classes of veins: first, silver-bearing veins in which are found some pyrargyrite, argentite, blende, tetrahedrite, a little galena and only a trace of gold; second, gold and silver-bearing veins, which are well defined and contain pyrargyrite, stephanite, argentite, pyrite, a little galena and blende, gold and silver; third, gold-bearing veins, chiefly gold with a little silver, galena and pyrite; and fourth, contact deposits in which are found silver-lead ores. The argentiferous galena and blende occur in calcareous strata accompanied by calcite, quartz, actinolite and ilvaite. The silver veins are found principally at Banner, Elmore County; Silver King and Vienna, Alturas County, and at Flint, Owyhee County. The ores of the second class contain

[1] T. A. I. M. E., Vol. 25, pp. 802 and 803; Am. Jour. Sci., 2nd series, Vol. 27, p. 366, May, 1859, and Mining Magazine and Journal of Geology, 2nd series, Vol. 1, p. 83, Nov., 1859, also p. 358, March, 1860.

[2] T. A. I. M. E., Vol. 33, pp. 823 and 824, 1903.

[3] Eng. and Min. Jour., Vol. 60, p. 172, and Mines and Minerals, Vol. 20, p. 563.

gold and silver in the proportion of 1 to 25 by weight, and are found at Atlanta and Rocky Bar, Elmore County. The gold veins contain gold and silver in the proportion of 1 to 2 by weight, being found at Florence, Idaho County. The contact deposits are found in South

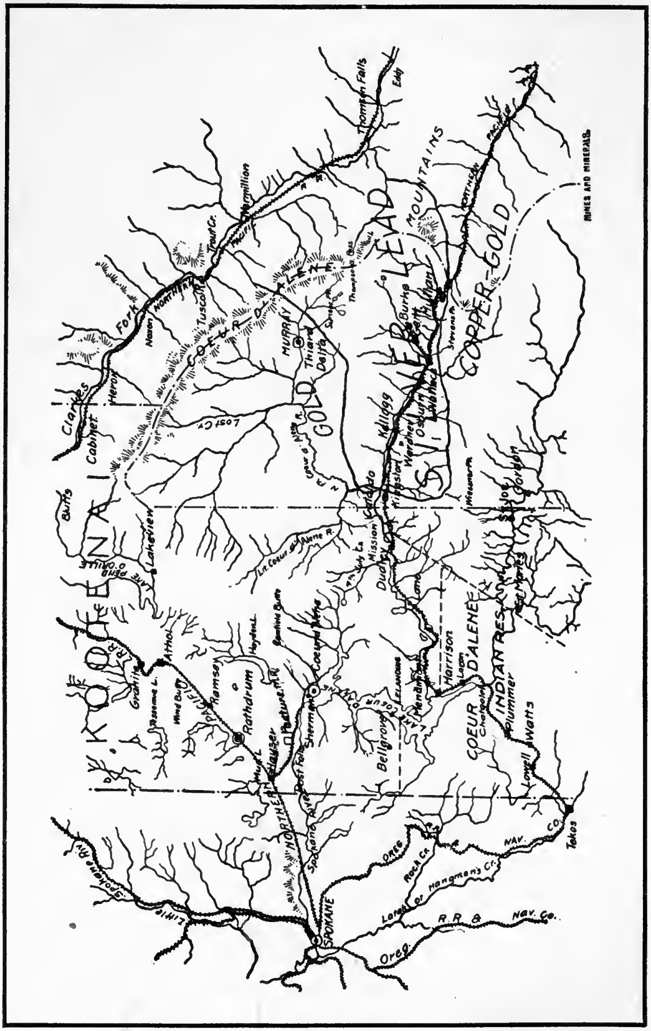
Central Idaho Gold-Fields (1899). (From Mines and Minerals.)

Mountain, Owyhee County, and probably in Sheep Mountain, Custer County.[1]

The Coeur d'Alêne District. — The country-rock consists of a formation of slates, quartzites and graywacke, which has been folded

[1] U. S. G. S., 20 Ann. Rept., pt. 3, p. 75, 1898–99.

with axes running east and west. The graywacke, or something between slate and quartzite, contains the lead-veins. A few intrusions of syenite and quartzless granite are known to occur, besides



The Coeur d'Alêne Mining Region (1900).

which there are a number of narrow basic dikes, probably basalt. The fissure-veins are the chief producers yielding galena and siderite.[1] Other associated minerals are blende, pyrite and quartz. In the

[1] T. A. I. M. E., Vol 33, p. 235.

zone of oxidation other minerals occur such as lead carbonate, oxides of iron and manganese and native silver. The proportion of silver to lead varies greatly in different mines and even in the same mine, as from 0.25 to 2 ounces to 1 per cent of lead. The variation may be noted either with regard to horizontal or vertical directions, while a wide variation in position with respect to the horizontal of ore-bodies is also noted. The deposits are often large, containing millions of tons of concentrating ore. The yield of most of the workable deposits as mined is from 5 to 25 per cent lead, while the average of the whole district in both silver and lead is 7 ounces to 10 per cent.[1]

Mineralization is more extensive in those veins which have suffered the greatest disturbance, the hanging-wall usually being most seriously affected; however, the largest deposits of lead-silver ores occur near the foot-wall fissure. Occasionally the fissuring has produced a number of nearly parallel veins which, when filled with ore and close together, form a broad zone of mineralized ground. The ore-bodies of the Bunker Hill and Sullivan mines are often 20 feet wide; in the Stemwinder, the average width is probably 12 to 15 feet; while in the Last Chance, one seam has a width of five feet and others near-by 3 to 10 inches.[2]

The principal lodes in this district are: the Bunker Hill, Sierra Nevada, Canyon City and Frisco.

Silver City District. — This district lies in the Owyhee Mountians which are composed of granite with intrusions of basalt and rhyolite. One of the first veins developed was the Golden Chariot (1864), west of which and paralleling it is the Poorman, while still further to the westward are found the Addie and Calaveras, all being practically parallel. The ore-bodies are composed of series of shoots which vary in width from 1 to 30 feet, but usually from 1 to 16 feet, and average probably 200 feet in length. The ore-bodies lie within the veins and are usually low-grade, as from $12 to $20 per ton. However, considerable ore is found running much lower in value and probably not exceeding $10 per ton. In the De Lamar mine the surface ores were largely sulphides of silver and hornsilver, the silver being extracted by pan amalgamation. With depth the ore became gold-quartz accompanied by silver. In 1903, 40,000 tons of ore were milled of an average value of $11 per ton, 85 per cent being extracted. Evidences found within the vein would seem to indicate that the original vein-filling was calcite and barite

[1] T. A. I. M. E., Vol. 33, p. 241.

[2] Eng. and Min. Jour., Vol. 45, p. 108.

which were later replaced by quartz. The principal mines in the district are: the Silver City, Dewy and De Lamar.[1]

Boise Basin. — This district includes the headwaters of Moore Creek and tributaries and is situated about 30 miles northeast of Boise. Granite is the principal formation which is soft and micaceous, disintegrating rapidly under the action of air and water. Porphyry dikes occur cutting the country-rock. The veins are found in the granite and usually in connection with the porphyry dikes, being zones of sheeted granite and porphyry carrying seams of quartz in which occur pyrite, arsenopyrite, blende and free-gold. The surface ores are free-milling, but change to sulphides below, and owing to the absence of sufficient lead and copper, smelting is rendered practically impossible. The walls of the veins often show considerable disturbance, being altered for some distance.[2]

The Washington mine is one of the oldest gold-quartz producers in the district. The gold vein is 8 feet wide and yields high-grade, free-milling ore. Another ledge on the property 30 feet from and parallel with the same carries gold and silver. Both the Lucky Boy and Mountain Queen mines produce $8 ore, although in the lower levels some $5 ore is mined. In the gold and silver vein the other minerals found are pyrite, native ruby, and antimonial silver.[3]

The Thunder Mountain District. — The formation of this district is largely igneous rocks which occur in beds, dikes and overflows of porphyry and rhyolite with large accumulations of brecciated material. Basaltic domes and vents are occasionally observed. To the northeast are crystalline schists and gneisses, cut by dikes of diorite, syenite and porphyry in which are large deposits of chalcopyrite bearing gold. Cross-cutting and radiating dikes are absent as well as quartz-veins, while secondary mineralization has evidently not acted to any great extent in the formation of the ore-deposits.

Free-gold occurs in the rhyolite, with which is associated a small amount of pyrite and considerable silver, the total value of the ore averaging probably $8 per ton.

The White Knob vein is a contact between blue limestone and porphyry, the former being the hanging, the latter the foot-wall. It varies from 10 to 300 feet in width. The ores are copper, but carry sufficient gold and silver values to cover cost of mining and smelting.

[1] Eng. and Min. Jour., Vol. 77, p. 885, and U. S. G. S., 20 Annual Rept. Pt. 3, p. 127.

[2] Min. and Sci. Press, Vol. 81, p. 400.

[3] Min. and Sci. Press, Vol. 79, p. 149 and Eng. and Min. Jour., Vol. 78, p. 297.

Other dikes yield auriferous pyrite assaying several ounces of gold per ton.[1]

Pearl District. — South of the Payette River some twenty miles northwest of Boise is situated a district bearing the sulphides of iron, lead, zinc. Antimony also occurs. The values lie principally in gold, silver and lead. Free-gold is present in the oxidized surface ores, but the bulk of the ore is especially adapted to concentration and smelting.[2]

Warren District. — This district is sometimes spoken of as the Washington district. The country-formation is granite, which has suffered alteration for a distance of a foot or more on either wall; the feldspar and biotite have thus been changed into sericite, calcite and pyrite. The ore-body proper consists of quartz varying in thickness from a few inches to one or two feet, averaging probably eight inches. This quartz is high in gold values, yielding from $20 to $100 per ton.

The Little Giant is probably the largest producer in the district. The ore consists of tetrahedrite, galena, blende, pyrite, arsenopyrite and gold. Other minerals found in smaller quantities are: tellurides, argentite, native silver and bromide of silver. The gangue is exclusively quartz.[3]

Wood River District. — In this district are found fissure-veins which carry silver and lead in sedimentary rocks. There may be said to be two types: the Wood River and Croesus; the former yields galena, principally with a gangue of siderite, while the latter, also fissure-vein, carries chalcopyrite, pyrrhotite and gold, with a gangue of quartz and carbonates.[4]

Florence District. — This district is situated in Idaho County north of the Salmon River and some 80 miles southwest of Lewiston. The veins are quite regular and well defined, usually simple, and consisting of altered granite separated by small quartz-veins. The gold occurs in quartz being wholly free-milling. Some veins carry more silver than gold by weight, but the value of the gold-content always exceeds that of the silver. Practically no sulphides occur. A comb-structure of the quartz-filling is common.

Blane County. — The country-formation is mostly granite cut by porphyry dikes. The Red Cloud mine is probably the principal

[1] Min. and Sci. Press, Vol. 84, p. 62, and Eng. and Min. Jour., Vol, 74, p. 273.

[2] Eng. and Min. Jour. Vol. 77, p. 1042.

[3] U. S. G. S., 20 Ann. Rept., Pt. 3, pp. 237, 245 and 246.

[4] U. S. G. S., 20 Ann. Rept., Pt. 3, p. 190.

property of the gold-belt. The vein varies from 30 to 70 feet in width, and yields pyrite, chalcopyrite and gold, the ore being quite siliceous. The Jumbo mines are on a vein lying between a hanging-wall of porphyry and a foot-wall of granite. The vein-filling is quartz, granite and decomposed talc. The gold occurs in streaks of quartz bearing free-gold and the sulphides of iron and lead. The average value of the ore is about $10 in gold with 3 to 4 ounces of silver per ton.[1]

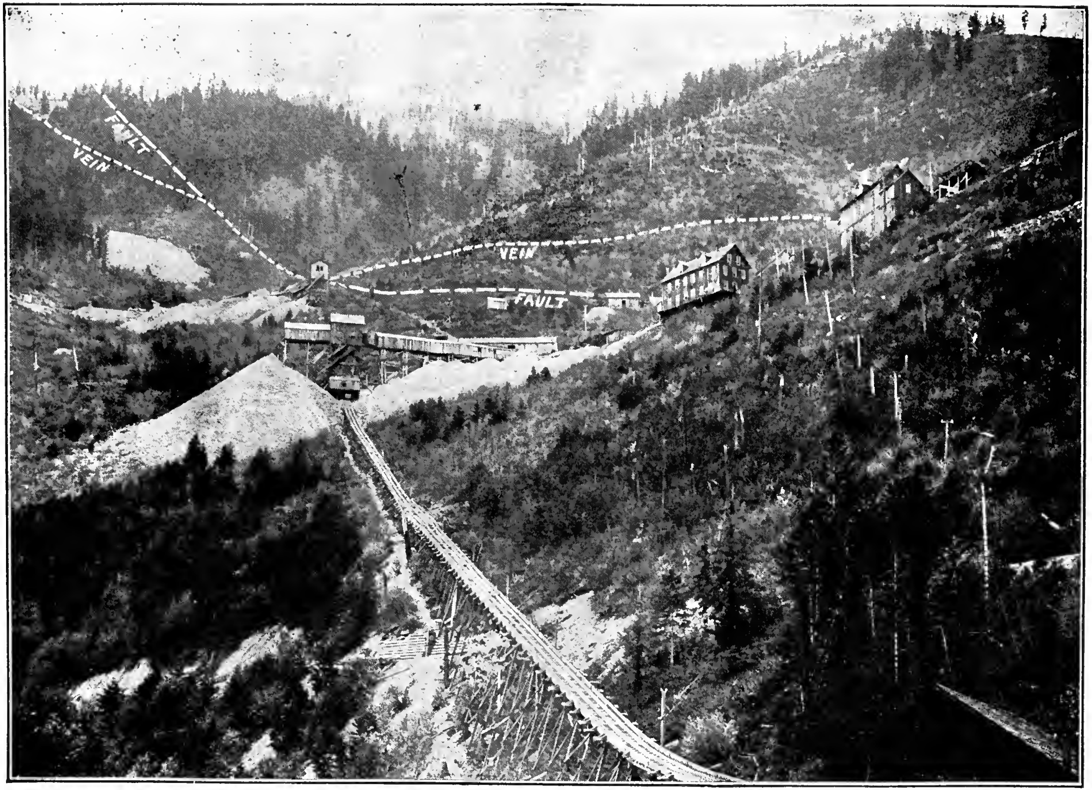
The principal lead-silver mines are at Hailey, Ketchum and Bellevue. At Hailey the ores occur in vertical or steeply inclined veins cutting slates and limestones which have been tilted by intrusions of granite. The zone of altered rock is from 30 to 40 feet wide and carries more or less gold throughout.[2]

The Seven Devils District. — This district comprises a group of peaks and spurs in northern Washington and southern Idaho counties. Auriferous and argentiferous copper ores occur here in a contact between diorite and porphyry. The metallic minerals occur in a gangue of iron garnet, silicates of alumina, iron and lime, and specular iron. Lenses of limestone occur in the contact-vein, while the ore-shoots are irregular, much broken and occasionally cut off by masses of limestone and diorite. The ores are both blue and green carbonates of copper, bornite and chalcopyrite. The ore at the Blue Jacket mines is largely bornite; the chalcopyrite ore has not been developed very extensively as yet. The bornite ore carries about 8 ounces silver and $15 in gold per ton.[3]

Buffalo Hump District. — This region lies to the west of the Bitter Root Range and is made up largely of metamorphic and igneous rocks, such as schists, gneiss, coarse-grained granular marbles and hornblende. Stringers and irregular masses of epidote, garnet and iron occur. The ore is gold and auriferous sulphides in a gangue of quartz. There are four principal veins cutting the country-rocks and dipping toward the east. The Big Buffalo vein varies from 6 to 30 feet in width carrying ore worth $8.50 per ton. The Mother lode is 22 feet wide, 15 feet sampling $12.60 per ton. The Jumbo five feet wide and carries $20 ore. The gold is free-milling.[4]

The Atlantic lode, situated on Atlantic Hill of the Sawtooth Range, has an average width of 40 feet. It is found in Archæan granite.

[1] Min. and Sci. Press, Vol. 82, p. 293.
[2] Mines and Minerals, Vol. 22, p. 204.
[3] Min. and Sci. Press, Vol. 83, p. 4.
[4] Min. and Sci. Press, Vol. 82, p. 105.



The Mammoth-Standard Mines, Idaho. Outcrops of faults and veins shown by broken lines. (From Mines and Minerals).

The vein-filling is friable, white, crystalline quartz containing stephanite, pyrargyrite, argentite and some native silver. From one-third to one-half the total value is gold. The ore-streak occupies a space of from one to ten feet in the vein. The Buffalo and Monarch mines are probably situated on the same lode.[1]

At Gibbonsville gold-bearing ores are found in veins cutting siliceous schists, with widths of 18 inches to 3 feet. The value of the ore lies in the sulphides, although fully one-third is recovered by amalgamation. The pyrite contains gold in values from $30 to $130 per ton. The gangue is chiefly quartz and schist. Silver is only occasionally found and where it occurs with the gold the value of the gold is low, ranging from $14 to $18 per ounce. Palladium is said to be present.[2]

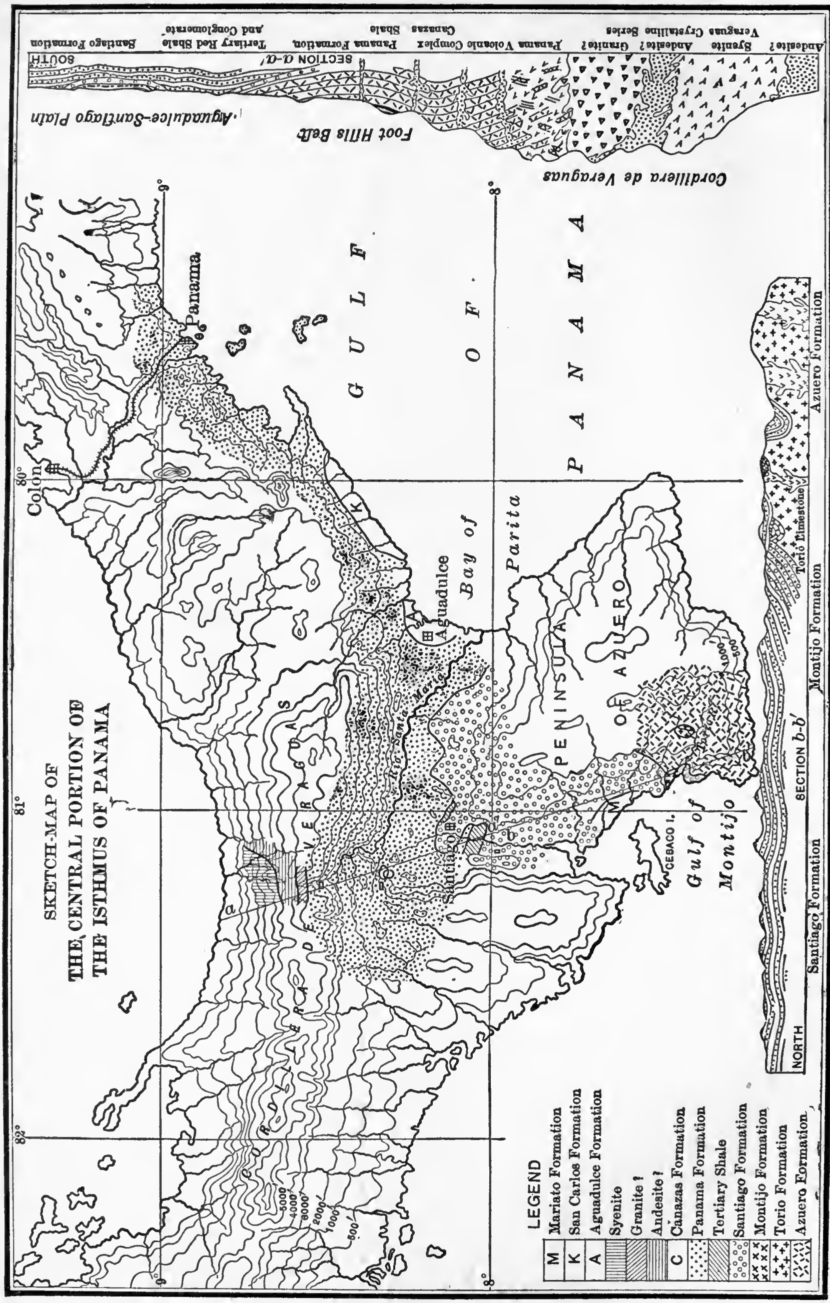
Isthmus of Panama. — There are numerous gold mines, both gravel and vein workings, in this territory, but comparatively little work has been done by way of development. The gold mines near Emperador may be chosen as a type. The country-rock is porphyry considerably decomposed and traversed by innumerable veins of ferruginous quartz, the gold occurring in the thin seams and crevices. The so-called "red ores" are usually very rich and owe their color to large quantities of peroxide of iron. The veins of the Pacific coast are generally characterized by containing a smaller percentage of sulphides.

The bulk of the ores of the Emperador mine range from $5 to $10 per ton, while those on the Pacific side usually run higher, as from $30 to $60 in gold per ton. The gangue is chiefly porphyry and quartz.[3]

Kansas. — Aside from the finding of gold in glacial drift and wash from the mountains on the west, but one authentic occurrence of gold and silver *in situ* has been reported. Both gold and silver have been found in small quantities in the shales of the Benton group of the Cretaceous in the western central portion of the state, especially in Gove, Trego and Ellis counties.[4]

Kentucky. — Silver ore has at various times been claimed to have been found in the shale underlying a conglomerate below the falls of the Cumberland in Whitley County. However, chemical analysis does not corroborate such claims.[5]

[1] Eng. and Min. Jour., Vol. 59, p. 128.
[2] Mines and Minerals, Vol. 19, p. 277.
[3] Eng. and Min. Jour., Vol. 34, p. 173, 1882, and Ibid., Vol. 6, p. 377.
[4] Eng. and Min. Jour., Vol. 74, p. 111.
[5] Report of the Kentucky Geol. Survey, 1856, p. 235.



Central Portion of Isthmus of Panama. (From Mining and Scientific Press.)

Maine. — Gold is found in quartz-veins in mica-schists at Baileyville. It is claimed that there are other similar occurrences in the state, but little attention is paid to such rumors owing to the small amount of values in the deposits. Pyrites occur with the gold especially in depth.[1]

In 1880 there were fully fifty incorporated mining companies in the state. The chief centers of silver mining were Hancock, York and Knox counties. The leading camps were the Sullivan, Gouldsboro, Cherryfield, Hampden, Franklin, Rockland, Dexter, Blue Hill, Acton, Sedgwick and Carmel.[2]

To illustrate the extent of the operations the following data of the Sullivan district is given:[3]

THE SILVER MINES OF THE SULLIVAN DISTRICT.

We give below a list of the prominent mines of the Sullivan district, Hancock County, upon which active developments are now going forward:

	Number of men employed.	Supt.	Present depth of Shaft.	Capital.	No. of Shares.
Franklin Mining Co.	4	P. Mullan..	22 feet	$400,000	40,000
Hancock Mining Co. (a)	7	F. W. Doughty	95 feet	400,000	40,000
Grant	4	B. Mullan.	16 feet	400,000	40,000
Waukeag S. M. Co. (b)	13	C. W. Kempton, M.E.	27 feet	500,000	50,000
Sullivan S. M. Co. (c)	25	B. C. Tilden	150 feet	500,000	50,000
Pine Tree S. M. Co.	15	J. Cameron	100 feet	Unorganized	
Milton M. & M. Co. (d)............	17	J. Shoenbar......	(No. 1, 25 ft) (No. 2, 16 ft)	500,000	50,000
Clapham Shaft....	5	....	22 feet	Unorganized	
Millbrook " (e)	5	....	45 feet	"	
Ashley S. M. Co....	7	W. Horne..	62 feet	400,000	40,000
Tugwassa Shaft...	8	A. Wilson .	36 feet	....	....
Gouldsboro' S. M. Co (f)...........	17	....	15 feet	400,000	40,000
Home S. M. Co. (g)	6	....	28 feet	Unorganized	
H. M. Sowle and J. H. West......	4	....	10 feet		
Eureka Mine (h)..	4	....	20 feet	Unorganized	

(a) Ore brittle silver in quartz. (b) This company will put in steam-power immediately; vein well defined and promising. (c) Shaft 104 feet down; 130 tons of ore on the dump; steam-machinery and pump. (d) This company has a 5-stamp mill and steam hoisting machinery. (e) The vein is well defined, and carries gold. (f) This company has 100 tons of smelting ore out, one-half of which is high-grade; preparing for steam power. (g) This company has 100 tons of ore out, ready for concentration. (h) This ore shows silver.

[1] U. S. G. S., 16 Ann. Rept., Pt. 3, p. 328.

[2] Special Correspondence to the Eng. and Min. Jour., 1880.

[3] Ibid., Aug. 9, 1879.

The Mount Glines mine, Oxford County, gave, as reported by assay, \$7.50 to \$49.68 gold. However, the officials of the United States Geological Survey were not able to obtain any trace of gold (see Bull. 225, 1904). (For analysis see Recent History, Maine.)

The country-rock is largely granite, the gangue mineral is quartz while the metalliferous minerals constituting the ore are sulphides of iron and lead. In 1879 the Canna silver mine is said to have yielded ore worth \$9 in gold; 37 ounces in silver, with varying amounts of copper and lead. The Home mine on an 18-inch vein yielded, as reported, \$22 silver and 20 per cent lead. It was further claimed that there were 1000 tons of \$50 ore on the dump. Other more or less important mines considered from the standpoint of the district were: the Golden Circle, the Fort Knox, Gouldsboro, etc.

The minerals usually found are galena, gray copper, antimonial silver, pyrite, chalcopyrite, stephanite and arsenical pyrite, which are found in quartz-veins, also veins of pegmatyte, and in contact deposits between limestone and trap dikes.[1]

Maryland. — Gold occurs in veins of quartz on the north side of the Potomac River in Montgomery County. Assays of specimens from this locality are said to have shown values ranging from \$168 to \$787 per ton.

The country-rock is fine-grained micaceous schists, probably more massive than schistose in structure. Some of the quartz-filling of the veins shows free-gold, but the greater part does not. Epidote and chlorite are found associated with the schists as basic silicates. Some pyrite is found in the oxidized zone, below which the sulphides occur as in the mines of the Southern states. It is evident from the work done that the quartz-veins are very irregular in both vertical and horizontal directions.[2]

Massachusetts. — The mines at Newburyport are spoken of as silver mines, although considerable quantities of gold are found in the ores. The ore-bodies are found in veins which vary in width from three to six feet, although the mineral does not occupy more than 15 inches in width across the vein. The minerals are galena, gray copper, siderite and quartz. An assay made on a sample taken from borings across the vein showed a gross value of \$154.14 per ton, of which \$69.84 was lead, \$72.87 silver and \$11.43 gold.[3]

Besides the Newburyport mines the following were among the

[1] Special Correspondence to the Eng. and Min. Jour. during the Eighties.

[2] T. A. I. M. E., Vol. 18, p. 391, etc.

[3] T. A. I. M. E., Vol. 3, p. 442.

more important: the Northampton, Merrimac, Four Rock, Cedar, Bartlett, Gorges and Davis, most of which yielded ore, largely argentiferous galena. Probably the most important of these mines was the Merrimac, which in a report by F. L. Vinton was accredited with 40,000 tons of ore of a value of $94 per ton. The Davis mine at Charlemont produced ore which sold at the mine for $4 and at tide water for $5 per ton.[1]

At the Merrimac mine the following conditions obtain: The country-rock is granite grading into gneiss and quartzite. The width of the lode is approximately 200 feet, consisting of trap, with masses of quartz and stringers of calcareous clay. The minerals are argentiferous galena and tetrahedrite; the gangue is quartz, fluor-spar, pyrite, blende and chalcopyrite. The ore occurs in a more or less vertical position resembling a chimney of ore.[2]

Michigan. — The presence of native silver associated with the copper of the Lake Superior Copper region has been known from the earliest times. Only a comparatively few of the copper mines of this region show no silver, while the majority yield varying amounts, some in quantities to warrant its separation from the copper, which is seldom or never attempted at the present time.

The belt of trap of the extreme northern portion of Keweenaw Point is composed of a variety of igneous rocks known as amygdaloid and granular trap. The amygdaloid is full of vasicles which in turn are filled with carbonate of lime, chlorite, agates, carnelians and amethysts, also minerals of the zeolite family. With depth the vesicular structure disappears and the rock becomes a dark brown granular trap.

The belt is traversed by veins containing native copper and silver. Mining has not, however, proven very successful, the more important attempts having been made at Eagle Harbor and Hawe's Island.

At the Cliff mine the gangue at the outcrop was prehnite with copper and silver associated, all incrusted with beautiful crystals of red oxide. Above, the width of vein was scarcely over two inches, but with depth a width of several feet is attained, the veinstone consisting of reticulations of laumonite.

The silver and copper are not alloyed as would be the case had they been in a state of fusion. Silver and copper often occur intermixed but in such a manner as to be entirely free from alloy

[1] Special Correspondence to the Eng. and Min. Jour. and Geol. of New Hampshire, Hitchcock, Vol. 3, Pt. 5, p. 35.

[2] Report on the Merrimac mine by F. L. Vinton.

one with the other, although intimately joined. The native silver occurrence is in connection with a soft, greenish, magnesian mineral, also with calcite and prehnite, and seldom if ever distinctly crystallized as is the copper.[1]

Silver occurs on the Iron River not far from Ontonagon in a stratum of gray sub-crystalline quartz lying between a fine-grained black slate roof and a red sandstone floor, the latter of Potsdam age. The silver is in the native state. Considerable money was squandered in an attempt to develop the mines at this place.[2]

The occurrence of gold-bearing veins near Ishpeming were discovered in developing argentiferous galena deposits. The gold occurs in a series of gash-veins in which are lenses of quartz. The country-rock is serpentine-dolomite which has been considerably cut by dikes and intrusions of diorite. The quartz-bodies are small but very compact. Pyrite, galena, blende, chalcopyrite and black antimonial silver are found in small quantities in the quartz gangue. Free-gold is visible in the ore of the Beaver mine. The vein of this mine has a granite hanging-wall and a talcoid-slate foot-wall, the granite reoccurring again beneath the slate. The Beaver ore is said to have assayed $502 per ton of which $12 was silver.

According to W. C. Hall[4] the gold deposits lie between greenstone on the north and serpentine on the south, and that an average of eleven assays gave $20.80 in gold and $9.50 in silver per ton.

Other deposits occur in granite in the form of quartz stringers; in diorite cut by a segregated vein of quartz; in felsite with a vein composed of layers of country-rock enclosed and of a merolitic structure formed by dolomite, chlorite and quartz; in a vein in diorite cut by felsite dikes; and in quartz-veins with diorite and serpentine as country-rocks.[5]

Minnesota. — Gold occurs in Benton County in narrow quartz-veins in eruptive granite and as a contact-vein between the granite and basic crystalline rock. The Delhi mine in Redwood County is situated on quartz-veins and segregations in Archæan gneissic and gabbroid rock. Quartz-veins are found in Archæan garnetiferous

[1] Foster and Whitney's Report, 1850, pp. 60, 128 and 178.

[2] Eng. and Min. Jour., Vol. 20, p. 575.

[3] Eng. and Min. Jour., Vol. 46, p. 238, and Vol. 52, p. 119.

[4] Lake Superior Inst. Min. Engrs., Vol. 5, p. 53, and Ann. Rept. Comr. Mineral Statistics, 1883, pp. 98–99.

[5] Lake Superior Inst. Min. Engrs., Vol. 5, p. 54, and a sketch of the iron, gold and copper districts of Michigan, M. E. Wadsworth, Rept. State Board of Geol. Survey for the years of 1891 and 1892, Lansing 1893, Exhibit K., pp. 152–155.

gabbro, but show hardly more than a trace of gold. The quartz-veins existing in a belt of hornblende-biotite schists and slates, extend southwestward from Thomson and Carlton to and beyond Little Falls and yield traces of gold, but not in paying quantities, judging from present developments.[1]

The Rainy Lake region seems to be the most promising portion of the state for the occurrence of gold in paying quantities. The country-rocks are granites, granitoid-gneiss, mica-schists, conglomerates and graywackes. Diabase dikes cut the other formations in various directions. The region has been thoroughly metamorphosed. Quartz-veins are numerous and their parallelism is quite marked. The veins are bedded rather than fissures. When trap comes in over the schist the veins also disappear, showing that they are of earlier date than the overflow of trap. The quartz-veins are usually heavily mineralized with iron sulphide, chiefly marcasite. Only a comparatively few of the veins are gold-bearing. The Little American was in 1893 one of the most important properties.[2] Some veins in the district are as much as five feet wide. Fissure-veins are not common.

Missouri. — According to Waldemar Lindgren the lead ores from the southeastern part of the state contain from 1 ounce to 1¾ ounces of silver per ton.[3] The lead-zinc ores of the Joplin district are also reported as carrying traces of silver.

Montana. — There is a marked similarity between the gold-deposits of Montana and those of the Pacific coast in that there are extensive placers and small low-grade gold-quartz veins. The veins usually occur in Archæan terranes or intrusions of granite. The veins occurring in the granite of the Butte district have produced considerable gold and silver.

In the Judith Mountains gold-bearing replacement deposits in limestone and porphyry occur and seem to be somewhat propylitic in character.[4] The gold and silver deposits of Montana occur in veins and impregnations in both sedimentary and eruptive rocks. They are found free, as tellurides, and associated with sulphides, the last usually occurring at some depth. The more common minerals are

[1] Lake Superior Inst. Min. Engrs, Vol. 5, pp. 55 and 56.

[2] Lake Superior Inst. Min. Engrs., Vol. 5, p. 56, Eng. and Min. Jour., Vol. 58, pp. 509 and 581, and Preliminary Report on the Rainy Lake Gold Region by H. V. Winchell and U. S. Grant, 23 Ann. Rept. Geol. and Nat. Hist. Survey, Minn., 1895, pp. 36–105.

[3] U. S. G. S., Mineral Resources, 1905, p. 117.

[4] T. A. I. M. E., Vol. 33, pp. 826 and 827, 1903.

galena, bornite, tetrahedrite, pyrite, blende, chalcocite, chalcopyrite, enargite and the sulphantimonides of silver.

Butte District. — The valuable ores are found almost exclusively in the older rocks, such as granite and aplite or quartz-porphyry. The silver ores occur in granite and the very acid porphyry, while the copper ores are found only in the very basic granite. The quartz-porphyry is found locally in the dikes of the copper area. Gold occurs in both the silver and copper deposits but more especially the silver; however, the copper deposits always carry some gold. In the western portion of the district the copper values decrease, while the gold and silver values increase, rendering them more valuable as producers of gold and silver than of copper.

The silver deposits have been developed north of the west end of the copper region, especially in the Moulton, Alice and Lexington mines. Rich silver ores have been obtained from the east bank of Missoula Gulch in an area lying between two copper-bearing belts. Gold was an important constituent of the ores of the Missoula mines and was probably the source of the placer gold found there, but as a usual thing its occurrence in the silver ores is so slight in amount that it is not determined in commercial assays.

The usual proportion of gold to silver in the silver ores is by weight 1 to 40 as shown by mill tests of ore, while in the copper bullion obtained from the copper ores the value of gold is about 3 per cent, the average proportion of gold to silver by weight being 1 to 2 hundredths to 1 to 3 hundredths. In the copper area the ores are too quartzose and poor in silver to warrant working them for silver and gold.[1]

The principal minerals occurring in this silver district are pyrite, chalcopyrite, bornite, chalcocite, enargite, blende, rhodochrosite, rhodonite, besides these there are covellite, argentite, pyrargyrite, hübnerite; gypsum, sericite and native silver. The oxidized ores contain cuprite, melaconite, chrysocolla, malachite, azurite, chalcanthite, goslarite, pyrolusite and native copper.[2]

The Judith Mountain District. — The rich gold ores are found in limestone near porphyry contacts and occur in masses instead of veins and shoots. The ore-deposits connected with the igneous intrusions may be grouped as follows: first, occurring in fissures in masses of porphyry; second, along the contacts of phonolite dikes;

[1] Mines and Minerals, Vol. 20, pp. 348, 350, and Eng. and Min. Jour., Vol 39, p. 261.

[2] Mines and Minerals, Vol. 20, p. 350.

and third, in the limestone at the contact with sheets of porphyry. The characteristic ore is a crushed and decomposed limestone containing angular masses of purple fluorite and quartz intimately intermixed; however, in some of the mines the fluorite and quartz are wanting. Gold occurs in all ores but especially in the quartz and fluorite. The richest ores carry gold in particles and cuboidal masses often of a platy, open texture, or spongy; occasionally a size of one-twelfth of an inch thick and one-eighth wide is found. The gold is usually more or less colored being covered by a film of oxide of iron and other material. Tellurides also occur and it is probably that they are the source of the free-gold. Calaverite is probably the telluride mineral. Pyrite in the unaltered form is rare in the gold ores. Silver is found in small quantities.[1]

The Judith Basin District. — This district is surrounded by various mountains, as the Snowy Range on the south, the Belt Mountains on the west, and the Judith and Moccasin on the east and north. The Kendall and Barnes-King mines are in this district, but lie in the North Moccasin Range. At the Kendall mine is a vein which strikes northeast and southwest along a foot-wall of limestone and a hanging-wall of shale and sandstone. The vein is cut by a dike of porphyry, the richest ore occurring at the contact of the walls with the porphyry. The ore is quartz-porphyry bearing values in gold and silver, especially the former. The Barnes-King mine occurs wholly within the limestone, the ore being composed of altered limestone and sandstone, and carries gold and silver to the value of $9 per ton.[2]

The Marysville District. — This is the most important district in the state as a precious metal producer. The district is situated some 18 miles from Helena in a northeasterly direction. The development of the veins followed the exhaustion of the placers. The richness of the ore-shoots has made the district famous, although they have not been conducive to permanent and extensive developments, as the mines are usually abandoned following the exhaustion of the shoots. The Drumlummon mine is one of the most famous and has produced more gold than any other mine in the state, following which is the Bald Butte.

The country-rock is granite surrounded by slates and thin-bedded argillaceous sandstones. The granite is technically known as a quartz-diorite which has been intruded into the sandstones and slates. Near the contact with the granite the surrounding rocks

[1] U. S. G. S., 18 Ann. Rept., Pt. 3, pp. 589, 592.
[2] Eng. and Min. Jour., Vol. 78, p. 96.

have been altered to hard and dense hornstone, while at a greater distance they have a slaty fracture. Dikes of acidic porphyry and trap rocks traverse both the granite and sedimentary rocks, occurring in the greatest number near Bald Butte.

There are three vein systems, namely: the Northeast, cutting both the granite and sedimentary rocks; the North-south parallel with the granite contact; and the Northwest, in the granite. The North Star vein is in the first, the Drumlummon vein in the second and the third has produced no ore-deposits of importance.

The ore occurs in fissure-veins with quartz-filling containing fragments of the country-rock. The ore consists of sulphides and sulphantimonides of silver with a gold-content aggregating 60 per cent of the total value. The oxidized ores are often very rich, while the ore-shoots of the Drumlummon mine run high in values. In this mine the fragments of wall-rock have been completely replaced by quartz, while in the Bald Butte mine there has been but little replacement.[1]

Ore-Deposits of the Bitterroot Range and Clearwater Mountains. — The country-formations are gneiss, granite, quartzites, slates and limestones. The granite is intrusive in the gneiss in the Clearwater Mountains, in the quartzites and slates in the Bitterroot Mountains, and in the slates and limestones along the western foot of the Clearwater Mountains.

The valuable deposits occur in fissure-veins carrying gold, and in a few isolated places deposits of lead and copper occur, being usually argentiferous.[2]

The Elkhorn District. — The ore-bodies do not occur in veins, although commonly spoken of as such, but lie along a bedding plane between hornstone (indurated shale) and dolomitic marble. Only the steeply inclined portions of the contact are mineralized. The ore-bodies are irregular although more or less lenticular in form being situated near or against the hanging-wall as separate masses or " chambers " of ore.

The principal minerals are galena, bournonite, tetrahedrite, pyrite and blende, with indeterminable rich silver sulphides. The oxidized ores contain native silver, cerussite, calamine, some minium, malachite, limonite, hornsilver, etc. The gangue is composed of quartz, dolomite, calcite, garnet, pyroxene and fragments of the country-rock.[3]

[1] U. S. G. S., Bull. 213, pp. 66, 89, 1902.
[2] Ibid., Bull. 213, pp. 67, 68, 1902.
[3] U. S. G. S., 22 Ann. Rept., Pt. 2, pp. 459, 470, 1901.

Black Pine. Granite County. — The Granite Mountain lode is a blanket-vein lying between hard quartzite walls. The vein has a quartz-filling with an average width of three to five feet, in which the ore occurs in irregular seams and patches. The minerals are malachite and tetrahedrite carrying silver, the average of the milling ore being about 25 ounces of silver to the ton.[1]

The Ammon mines, Fergus County, are located on a ledge of porphyry intruded into a shaly limestone and clay-band between walls of solid limestone. The intrusion has disturbed to some extent the limestone walls or ledges, forcing them forward into the vein in places where they are surrounded by ore, thus giving the limestone the appearance of " horses " in the vein. When no dislocation has taken place a thin but regular and laminated limestone lies next under the porphyry which often constitutes a good ore, ranging in value from $16 to $40 per ton. The gold occurs in the joints of the limestone which usually has a thickness of 18 to 24 inches.[2]

The Big Indian mine is situated about four and one-half miles southeast of Helena, on an ore zone traversing a granite country, but near or on the contact between granite and limestone. The ore is free-gold occurring in quartz and granitic material and associated with hornblende. The ore-body is really a bedded-deposit and not a vein, the ore being extracted largely by quarrying methods. The ores range in value from $2 to $2.50 per ton.[3]

In the northwestern part of the state, in the Fisher district, auriferous pyrites carry the values — pyrite and galena are the principal minerals. However, considerable of the gold-content is free-gold and can be treated by the free-milling process. The gangue is mainly white and decomposed quartz in which coarse flakes and particles of gold are visible.[4]

Although some of the free-milling ore-deposits have been practically exhausted, yet there will probably be a sufficient number of new discoveries and developments to keep up the supply of the precious metals from this source. With regard to the Butte district the output of the smelting ores will of necessity vary with the rise and fall in price of copper and silver and thus affect the production of gold depending upon them.

Nevada. — There are numerous forms of mineral deposits and a

[1] Mines and Minerals, Vol. 26, p. 492.
[2] Eng. and Min. Jour., Vol. 59, p. 416.
[3] Eng. and Min. Jour., Vol. 78, 225.
[4] Min. and Sci. Press, Vol. 83, p. 78.

great variety of ores found in the state. Gold-quartz mines similar to those in California, although not common, are represented by the Silver Peak mines of Esmeralda County and others.

Gold-bearing argentiferous lead deposits with other smelting-ores occur in limestone near intrusions of igneous rock. The Eureka mine belongs to this class and yields considerable gold — one-third of the total value of the ore being in gold.

But by far the most important deposits are the veins in recent volcanic rocks or the propylitic deposits. The most important mines of this class are the Comstock lode, the Tuscarora and the De Lamar, all of which yield both gold and silver.[1]

This state is important when considered from the standpoint of precious metal production, as it is not only one of the first of the Western States to become actively engaged in mining but more especially since it contains the famous Comstock lode, without the stimulating influence of which the mining industry of the United States would be far behind what it is at present.

Gold and silver occur in veins, both contact and fissure, and in sedimentary and igneous rocks. The principal minerals associated with gold and silver are galena, blende, bornite, chalcopyrite, pyrite, tetrahedrite, chalcocite, stephanite, sulphides and chlorides of silver and antimony minerals, while in the oxidized ores are oxides, carbonates and phosphates of lead, carbonates of copper and iron, chloride of silver and native silver, free-gold and probably the tellurides of both gold and silver, etc. The usual gangue minerals are quartz, porphyry, hydrous oxides of iron and manganese, etc.

The Comstock Lode. — This famous lode is situated in Storey County and extends along the eastern slope of the Washoe Mountains at the foot of Mount Davidson. The outcrop consists of parallel quartz ledges running east and west and often having an extent of 1000 feet or more. The length of the lode is probably about three and one-half miles, being composed of bonanzas or ore-bodies and great areas of barren ground. Its strike is approximately north and south.

The entire east wall of the lode is propylite or porphyry, while on the west the wall varies considerably in character: on the slopes of Mount Davidson and Mount Butler it is syenite, north of this both walls are propylite, while in southern Gold Hill the west wall is composed of various metamorphic rocks. A well defined clay-selvage

[1] T. A. I. M. E., Vol. 33, pp. 829 and 830, 1903.

separates the west wall from the country-rock. The west wall has a fairly uniform dip of 38 to 40 degrees to the east which increases gradually to 45 degrees, continuing so to considerable depths. The east wall first dips to the west but gradually assuming verticality and at a depth of 400 to 500 feet reverses and follows the direction of the foot-wall, maintaining a fairly uniform width of vein.

At the surface the width of the lode varies from 500 to 1000 feet, but owing to the convergence of the walls this is reduced to a width of 150 feet in a few hundred feet, vertical distance. However, the width is quite irregular owing to the hanging-wall which is full of sinuosities, rolling and pinching both in horizontal and vertical directions — the depressions and expansions conform remarkably well with the streams and spurs of the mountains.

The lode is filled with great masses, " horses," of country-rock, surrounding which is a selvage of clay, the whole being enclosed in a brecciated mass of porphyry, quartz and clay. The aggregate thickness of the quartz-seams at the surface is often not more than five-sixths of the total width of the lode, yet there are places where fully 150 feet of quartz occurs without interruption. Probably two-thirds of the lode-filling is barren country-rock. It would seem to be not improbable that the lode was formed not by one but a series of practically parallel fissures.

The ore-bodies or bonanzas lie mainly within the swells of the vein with their upper extensions adjacent to the eastern wall and their lower extensions near the foot-wall on the west. They are then of necessity practically vertical in their longer dimensions, except as they may pitch in the plane of the vein. Space is thus left between the ore-bodies and the east wall for the formation of still others. However, all of the bonanzas do not conform to this general arrangement, but dip at various angles toward one wall or the other, or may run parallel with one of the walls and pitch at varying angles.

The bonanza in the Ophir-Mexican mines was 330 feet in depth, 200 feet long and 45 feet thick, tapering both above and below to two or three feet. The Gould and Curry bonanza was 500 feet in depth, nearly 650 feet long and 100 feet wide at the widest point. The Savage and Hale and Norcross bonanza was 250 feet deep and followed the east wall with remarkable uniformity, having a width of 10 to 50 feet. Its total length was over 800 feet. A lenticular mass of red ore was found in the Chollar mine which was 200 feet long, 300 deep and 25 wide.[1] The largest single bonanza in the whole lode was found at Gold Hill. Its horizontal dimension was 1,100 feet and reached from the surface to the 700-foot level.[2]

The minerals of value are: native gold, native silver, argentite, polybasite (silver glance) and stephanite. Occasionally rich galena and pyrargyrite are encountered. Besides these pyrite, chalcopyrite, oxide of iron, manganese, sulphates of lime and magnesia, and carbonates of magnesia, lime, lead and copper. The zone of oxidation is confined to the upper 500 feet of the lode, when pyrite and all of the carbonates of lead and manganese are changed to oxides which account for the prevailing reddish color of the ore.[3] The gangue is chiefly quartz, which, with the exception of small quantities of silver minerals occurring in the clays, carries all of the silver values. From the position of the clays and their relation to the quartz, the walls and the horses, they were evidently formed subsequent to the quartz. The ore itself is composed of native gold and silver, silver glance, stephanite, polybasite, galena, some pyrargyrite, hornsilver and rarely sternbergite, with which are associated pyrite, chalcopyrite and blende.[4]

After the rich surface ores were extracted the yield rarely exceeded $50 per ton and $15 is probably nearer an average. Twelve of the principal mines in 1872 produced $13,569,724 and the average value of the ores that yielded $12,000,000 of this was $19.60 per ton. The Utah mine produced ore worth $3 to $12 per ton, value principally in gold; the Sierra Nevada ore averaged $5.50 per ton. The Virginia Consolidated and California mines in 1875 produced ore worth $150 as an average, although picked ore ran from $300 to $500 per ton. The Savage ore ranged from $1 to $20 per ton, while in 1874 the Hale and Norcross ore yielded from $14 to $17 per ton and the Bullion $10 to $15. The Belcher ore ran from $25 to $35 per ton.

The ratio of gold to silver was about one-third to two-thirds, although the deepest ore-body in the Chollar carried three-fifths gold to two-fifths silver.[5] A native alloy of gold and silver occurs quite

[1] Mineral Resources of the United States, J. Ross Browne, 1868, pp. 341, 342, 343.

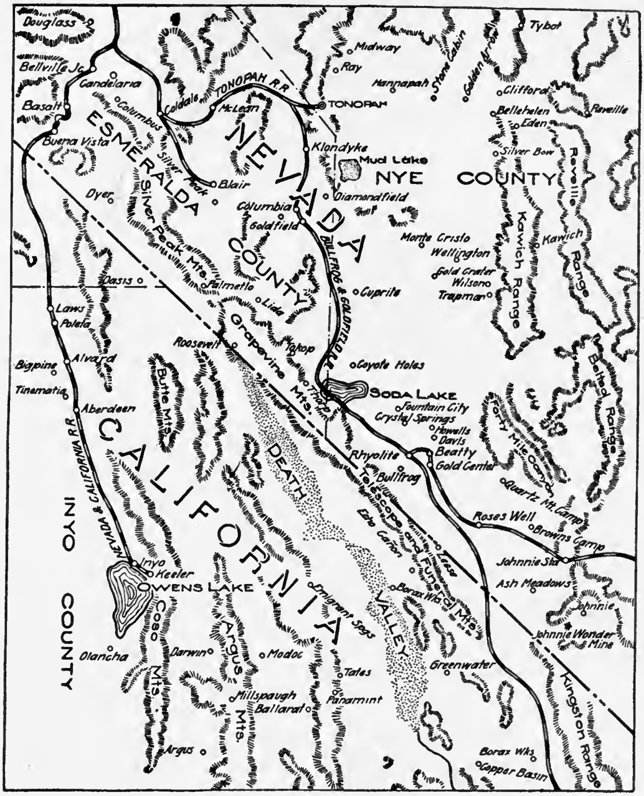
[2] Mineral Resources of the United States, J. Ross Browne, 1868, p. 343 and The Comstock Lode, its Formation and History, J. A. Church, 1879, pp. 100 and 101, and Min. and Sci. Press., Vol. 33, p. 418.

[3] Mining Industry, Rept. Geol. Exploration Fortieth Parallel, Clarence King, p. 75, 1870.

[4] Mineral Resources of the United States, J. Ross Browne, 1868, p. 343, and Mining Industry, Clarence King, 1870, p. 79.

[5] Eng. and Min. Jour., Vol. 18, p. 404.

generally in the ores of the Comstock lode which contains 55.37 per cent gold, 42.87 per cent silver, and the remainder some unknown substance, which is commonly known as electrum.[1]



Death Valley and Adjacent Mining Districts.
(From Mining and Scientific Press.)

Eureka District. — This district is situated in Eureka County, on the western side of the Diamond Range and in the eastern part of the state. The principal ore-deposits are found in the Prospect Mountain and Hamburg limestones. The massive rocks found in the metalliferous zone are: granites, quartz-porphyry, rhyolite, hornblende-andesite and basalt. The limestones with accompanying strata of shale have suffered extensive folding, which produced many fissures in the hard and compact limestone. In places the pressure

[1] Min. and Sci. Press, Vol. 28, p. 232.

was so great as to reduce much of the limestone to a fine state of subdivision. Subsequent to the folding there occurred eruptions of rhyolite and hornblende-andesite, often occurring in dikes and masses. Among the first locations in the district were the Champion and Buckeye claims on the southwest side of Ruby Hill, and later the Richmond and Tip-top claims were located.

The ores of Ruby Hill are argentiferous-auriferous lead ores, of which there are the oxidized and unoxidized forms. Sulphurets have been found in a few places, both above and below water level. The galena ore is usually changed to the sulphate and carbonate of lead near the surface. The galena contains small quantities of arsenic, antimony and molybdenum. In 1884 the ores carried from $100 to $150 per ton in silver and from $1 to $10 in gold. Anglesite (sulphate of lead) is an important mineral constituent of the Eureka ores. Other minerals found are: cerussite, mimetite, wulfenite, pyrite, limonite, blende, calamine, smithsonite, calcite, argonite, siderite and quartz. The ore-deposits resemble a number of different classes such as: fissure, contact, and stockwork types; they are often lenticular, occupying great chambers in the limestone, often more than 50 feet in each dimension, which are completely filled with ore. The ore-bodies do not appear to follow any general direction either as regards strike or dip, yet they are not wholly without system. On Ruby Hill the ore is usually found near the contact of limestone and quartzite. The ore-bodies are almost invariably connected with fissures through which the mineralized solutions largely came.[1]

White Pine District. — This district lies in White Pine County, at the east end of the White Pine Mountains. The principal mines are located on Treasure Hill. The predominating formation is Devonian limestone, being composed of stratified dolomites and calcareous schists. The veins extend from base to summit of the mountains, the sides of which are formed of huge benches of limestone.

The ore-bodies occur as contact-deposits between limestones and shales, in fissures, in beds or chambers in limestone, and in vertical and oblique seams across the bedding. They are exceedingly variable in size, strike and dip, cutting the mountain in all directions. In width they vary from mere stringers of spar and quartz to channels having a breadth of several hundred feet. The more important minerals constituting the ores are: green and gray silver chlorides

[1] The Silver-Lead Deposits of Eureka, Nevada, U. S. G. S., Monograph No. 7, pp. 1–75.

and hornsilver often carrying high percentages of lead and copper, the latter occurring at higher altitudes. The ores range in value from $120 to $10,000 per ton, an average being perhaps $600. Gold is scarce and when it does occur is found principally in the gangues and in limited amounts.[1]

Esmeralda County. — High-grade gold and silver ores are mined in this county, the principal camps being Aurora, Candelaria and Silver Peak. In the Candelaria the ores are mainly silver, containing hornsilver, malachite, galena and tetrahedrite in quartz-veins. The Silver Peak district is situated on the east spur of the Silver Peak Range, which is composed of a complex formation of granite, gneiss and schist, upon which is superimposed dolomite, limestone of Lower Carboniferous age and Olenellus slate. The quartz-vein traverses this formation in which also occur dikes of diorite. Ore not exceeding $10 per ton cannot be worked with profit. The gold is free-milling. Ores from the Great Gulch vein average about $20 per ton. The Montezuma district lying to the east of Clayton Valley produces lead-silver ores, consisting mainly of the sulphides and chlorides of silver and galena which are found in small shoots and pockets.[2]

Lincoln County. — The Pioche, Pahranagat and Tem Pahute districts are situated in this county. The country-rock is quartzite and limestone, the latter overlying the former. A large dike of porphyry, varying from 25 to 35 feet in width at the surface and 60 to 70 feet below, cuts the formations. The fissures are well defined and easily followed with a strike of east and west and a dip of 50 to 80 degrees to the south. When the veins lie wholly in porphyry they contain a mass of decomposed porphyry; at the contact of quartz and porphyry they become more siliceous, and when wholly in the quartzite, silica predominates. At the Zero mine the vein-filling is almost entirely hydrous oxides of iron and manganese. The ores are the oxide, carbonate and phosphate of lead carrying silver values, that were originally galena, which is still to be found in large masses above the water-level. Other minerals are: blende, which increases with depth and is often rich in silver and silver sulphides, occasionally with hornsilver scattered through the vein, and with small quantities of lead. The last mentioned silver mineral and gold were the values first sought, the sulphide being left. The Day fissure is one of the largest in the district, having a maximum

[1] Min. and Sci. Press, Vol. 18, pp. 18 and 226.

[2] Min. and Sci. Press., Vol. 82, p. 73.

width of 130 feet. Here bodies of carbonate and oxide of lead occur of varying width and rich in silver. The gangue when not ore-bearing is mostly crystalline calcite. It is claimed that the values in copper formerly thrown on the dumps exceed in value per ton that recovered in gold and silver. It is claimed that the ore carries from 50 to 100 ounces of silver, 30 to 50 per cent lead and 5 to 10 per cent copper per ton, while certain ores run as high as $7.60 in gold.[1]

Tonapah District. — This district is situated in the central part of the state, in a range of low volcanic mountains, being a southern extension of the San Antonio Range. The pass to the Ralston desert lies in these mountains. The district has been known for some time, but owing to the arid condition of the country both prospecting and development were seriously handicapped. Cambrian limestones occur both to the north and south of the igneous rocks of this district, which consist of flows, breccias, derived tuffs and ash accumulations, probably of Tertiary age. There were evidently several successive flows with intervals during which there were showers of ash and breccia, erosion acting in the meanwhile. The following sequence of the igneous rocks has been given: first, earlier andesite; second, earlier rhyolite and breccias; third, later andesite; fourth, volcanic breccias and flows; and fifth, water-laid tuffs. The oldest volcanic rock is called the " lode-porphyry " which is now largely decomposed into fibrous muscovite, pyrite, chlorite, iron carbonate, quartz, etc.

The more important veins occur in the lode-porphyry only and not in the later rock, although it is not improbable that they may be found there. However, as only the earlier rocks contain mineralized veins, so far as is known, it is possible that mineralization followed the first eruption. Moreover, the later flows cover the veins existing in the earlier andesite, and they must therefore be pierced in order to reach the veins. In a width of 1500 feet there are fifteen known veins ranging in width from 18 inches to 8 feet. They stand nearly vertically and contain a hard, compact, close-grained quartz with a little calcite carrying gold and silver, the mineral occurring in sheets and ribbons in the vein-matter. The veins resemble fissures, but are probably zones of fracturing and sheeting in the porphyry, the gangue varying from a pure quartz to a highly silicified porphyry. The ore-bodies are somewhat irregular, occurring in lenticular and detached forms, occasionally being connected by stringers, but more often without any connection. The values are very finely disseminated so as to be barely visible to the naked eye.

[1] Eng. and Min. Jour., Vol. 51, p. 171, and Min. and Sci. Press, Vol. 83, p. 164.

Silver occurs as chloride, sulphide and as ruby silver with pyrite; no lead and zinc are present. However, the ores have changed in part near the surface to sulphates, oxides, carbonates and chlorides.[1] The ratio of gold to silver is 1 to 100; average samples of all outcrops gave 100 ounces in silver and $20 in gold per ton. The second-class ore thrown on the dumps in 1901 averaged 50 to 80 ounces in silver and $12 to $15 gold per ton. In 1904 the average of the ores sent to the smelters was about $150 per ton.

Goldfield District. — Goldfield is situated in southwestern Nevada and was originally known as the Grandpa district. The district to the westward is overlain with basalt, beneath which is a brown, sandy-appearing rock, being a rhyolite glass-flow. Quartz-reefs cut the rhyolite formation, which, having resisted wear, now stand above the surface in the form of ridges. The veins are neither persistent nor well defined, as is shown by irregular, branching outcrops, and show no definite system.

The quartz vein-filling is usually gray and jaspery, being derived from the igneous rocks by silicification. Pyrite occurs in the quartz gangue, but in the majority of cases the veins are low-grade or barren. However, occasional lenticular masses of quartz occur in the veins which are very rich, but are not easily distinguished from the barren portions. These mineralized reefs constitute the true ore-bodies, while the bulk of the reefs or veins is merely a siliceous jacket, which may range from 25 to 30 feet in thickness, while the enclosed shoot may be only one or two feet wide.

The pyrite occurring in the quartz or siliceous gangue is probably indigenous, i.e., has had its origin in the immediate vicinity. Tetrahedrite and free-gold are also present, and probably, although not definitely known, tellurides occur.

The values are all in gold, silver being practically absent, although the ores from the Combination mine yield 1 to 3 ounces of silver per ton.[2]

Bullfrog District. — This district is in Ney County, some 80 miles from Goldfield. The country-rock is rhyolite and andesite with bodies of porphyry and limestone. The original Bullfrog mine is about three miles west of the town of Rhyolite and is on the outcrop of a quartz-ledge occurring between limestone and porphyry. The

[1] Min. and Sci. Press, Vol. 86, p. 338; Ibid., Vol. 88, p. 364; Ibid., Vol. 82, pp. 230 and 231, and Ibid., Vol. 86, p. 20.

[2] Mines and Minerals, Vol. 25, p. 332; Min. and Sci. Press, Vol. 90, pp. 394 and 393.

gold can readily be seen with the naked eye. The Montgomery-Shoshone property is on a talcose vein on a rhyolite hill. The ores of the mine run as high as $200 to $300 per ton in both gold and silver values. The proportion of gold to silver is two-thirds to one-third. The silver occurs as ruby silver and as a chloride; the gold is free.[1]

Gold Mountain District. — The district is about 35 miles south and 26 miles east of Silver Peak. The " State line lode " is situated in this district and at the west end of a belt of slate not far from its junction with granite. The walls of the vein are well defined, being separated by clay seams. The vein varies from 8 to 12 feet in width and is composed largely of a friable, granular quartz, stained with iron, manganese and phosphate and oxide of lead. Iron sulphides and oxides occur in considerable quantities and bear the gold, which is fairly well disseminated throughout the mass of the vein-filling. However, the gold-content seems to favor two special bands: one follows the foot-wall, while the other starts in the middle of the vein and seeks the hanging-wall above. Aside from these two enriched bands which do not exceed two feet in thickness, the bulk of the ore is low-grade, ranging from $5 to $15 per ton.[2]

Lander County. — Lander Hill, a western spur of Mount Prometheus, has mines rich in silver ores. The spur is composed of granite which is traversed by narrow fissure-veins trending northwest and southeast, which show a banded-structure and have suffered considerable faulting. Besides rich ruby silver ores are found gray copper, galena, blende and antimony with a gangue of quartz.[3]

Elko County. — This county lies north of White Pine and Eureka counties, and in it is situated the Tuscarora district which contains deposits of silver ores of high-grade, occurring in veins cutting a decomposed hornblende andesite.[4]

Nevada has produced a number of famous bonanzas, the most important having been found at Virginia City, Reese River, Aurora, Eureka, White Pine, Pioche and Tuscarora, while smaller ones have been worked at Cornucopia and Candelaria.

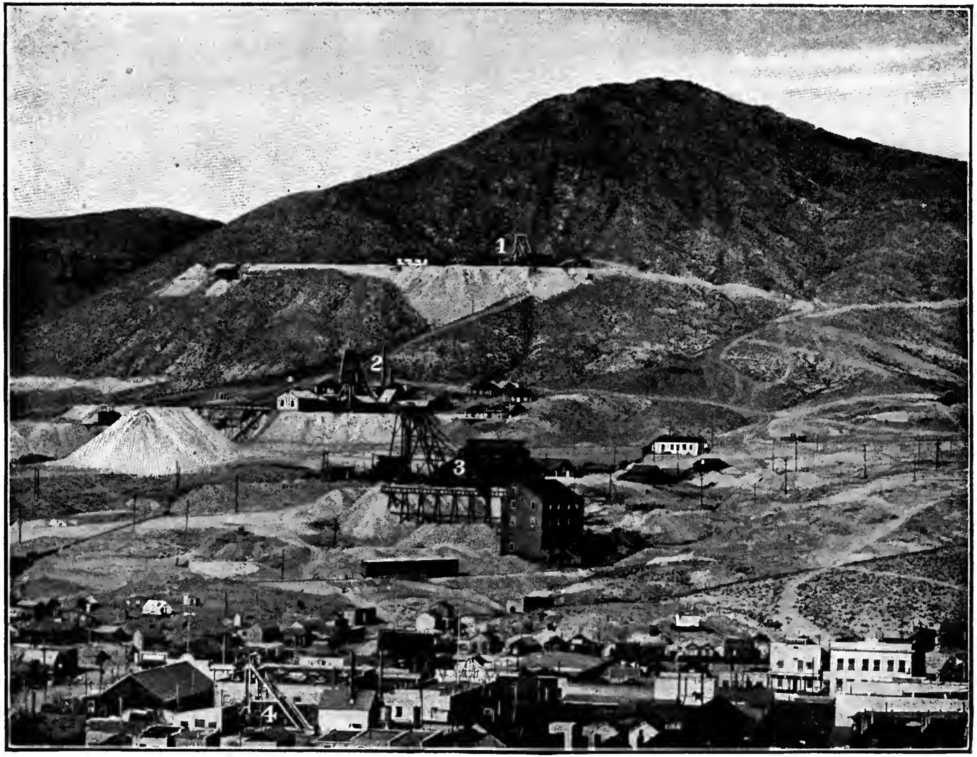
The occurrence of bonanzas is a characteristic of propylitic deposits which, as the majority of them are comparatively small, are not con-

[1] Eng. and Min. Jour., Vol. 80, p. 12, and Min. and Sci. Press, Vol. 90, p. 273.

[2] Min. and Sci. Press, Vol. 18, p. 62.

[3] Fortieth Parallel Survey, G. F. Emmons, Vol. 3, p. 349.

[4] Tenth Census, G. F. Becker, Vol. 13, p. 34.



Tonopah, Nevada.

1. North Star Mine. 2. Montana. 3. Mizpah. 4. West End.

(From Mines and Minerals.)

ducive to extensive and permanent operations. However, judging from the experience of the past, it is reasonable to expect that new discoveries of such rich deposits will maintain the output of the state — Tonopah is a case in point.

New Hampshire. — The Ammonoosuc gold field, as described by Professor C. H. Hitchcock,[1] consists of auriferous slates and schists. The schistose rocks belong probably to the Huronian and Cambrian systems. The gold-bearing quartz-veins traverse talcose slates and schists in which are found pyrite and chalcopyrite, together with seams of magnetic iron ore. The Dodge vein at Lyman has a width of 16 feet; it dips to the northeast and contains ore shoots pitching to the northwest. Besides the quartz gangue and slate fragments, pyrite, galena, and ankerite occur bearing free-gold. The pyrite carries but little gold. The ore carries from $3 to $19 in gold per ton.

At the Lisbon mine, not far from the Dodge, pyrrhotite, chalcopyrite and mispickel occur in quartz bearing gold — probably 5 per cent of the vein-content is pyrrhotite.[2]

In the Milan mine the metalliferous products are gray copper chalcopyrite, and blende, with which are associated gold and silver. This ore is said to have produced a matte valued at $60 per ton. The Shelburne mine produced galena which, according to reported assay, contained 36 to 84 ounces of silver — a five-ton lot is claimed to have yielded $80 per ton. This mine was worked during 1846–49.[3]

In the Ammonoosuc gold field the Bedell mine produced ore which was claimed to yield according to assay $12 per ton free-gold. The vein is two feet wide. The Hartford and Moulton mine was on a quartz-vein, which yielded $30 in gold and $10 in silver per ton, according to reports. A bed of conglomerate, ranging in thickness from 40 to 60 feet, shows values ranging from 75 cents to $10 per ton in gold.[4]

Ores from the Eaton and Shelburne mines yielded 2 and 3 pounds of silver per ton.[5]

New Jersey. — The Bridgewater copper mine, long since closed, has

[1] Ammonoosuc Gold Field, Geol. of New Hampshire, Pt. 5, p. 7, 1878.

[2] American Jour. of Min., Vol. 2, p. 390, and U. S. G. S., 16 Ann. Rept., Pt. 3, pp. 329 and 330, 1894–95.

[3] Special correspondence to the Eng. and Min. Jour. during the early Eighties.

[4] Hitchcock, Geology of New Hampshire, Vol. 3, Pt. 5, pp. 7–31.

[5] Geol. of New Hampshire, 1844, p. 216.

produced some silver and enough in fact to warrant coining, which was done in England. (See also "Recent History.")[1]

New Mexico. — According to Professor Herrick the gold occurs mainly in volcanic rocks and principally in andesites, rhyolites and trachytes — the basalts are barren. Probably the andesite is the most productive. There is a great similarity between the deposits of Colorado and New Mexico and it is not unlikely that similar deposits may be found in the latter territory.

Gold-bearing veins occur in the granites of Pinos Altos, Grant County, most of which are connected with dikes of igneous rock. Further, quartz-veins occur in the diorite of the Shakespeare district. These veins carry auriferous pyrite.[2]

One of the earliest records, in recent times, of the occurrence of gold in New Mexico is that by Dr. Wislizenus.[3] He describes the old "Placer" and the "New Placer," stating that the predominating rocks of the country are yellow and white quartzose sandstone, quartz, hornblende rock, syenite and diorite. The veins occur in syenite and greenstone and have a quartzose and ferruginous gangue. Both washings and mines were worked here, which at various times are said to have yielded from $30,000 to $250,000 per year.

The ore-deposits of this territory consist of lead-silver and silver-gold ores which occur in sedimentary and igneous rocks, both as contact-deposits and in veins. The ores consist of minerals of copper, lead, gold and silver, while the gangue is largely quartz and altered igneous rocks.

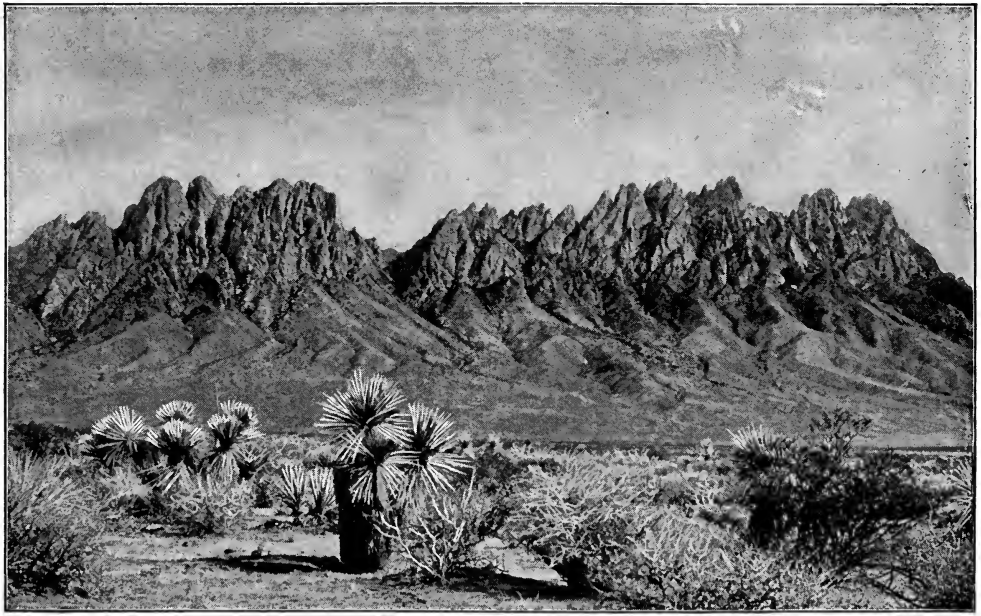
Lake Valley District. — This district is situated in Doña Aña County some 15 miles from the Rio Grande and six miles from the Old Santa Fé trail. These deposits bear a striking resemblance to those of Leadville and although they are lead-silver ores the silver predominates. The country-formations are shales, quartzites, limestones and porphyrite, the last mentioned probably being of the most importance owing to the close proximity of the ore-bodies to it. Further, the porphyrite often carries from a trace to 1 ounce of silver per ton.

The ore-bodies are practically always connected with blue limestone and occur either in contact with it and the crinoidal limestone or porphyrite; in form they are chambers and shoots. Probably the

[1] Eng. and Min. Jour., Vol. 33, p. 90.

[2] T. A. I. M. E., Vol. 33, pp. 831 and 832, 1903.

[3] Memoir of a Tour to Northern Mexico, 1846–7, published by Congress, p. 24, and Whitney's Metallic Wealth of the United States, 1854, p. 134.



The Organ Mountains, New Mexico.
(From Mines and Minerals.)

two most important deposits so far worked are the Bridal Chamber in the Grande and the Bunkhouse in the Bella, although there are several others of considerable importance.

The character of the ore varies much with the different mines; the Twenty-five Cut, Thirty Stope, and Bridal Chamber yield siliceous ores; the Emporia Incline yields neutral ores; while the Bunkhouse, Columbia and Apache yield ores basic in character. The ores of the Thirty Stope workings are variously colored flint. Pyrolusite occurs here. The ore from the Bridal Chamber consists largely of cerargyrite. Galena is an accessory mineral in the Emporia. The Bunkhouse workings yield several distinct kinds of ore: that from the central portion contained from 200 to 500 ounces of silver and was basic bearing considerable cerargyrite, while later workings produced manganiferous ore. The silver-content varies with that of the silica, increasing and decreasing with it and averages about 5 ounces to the ton.[1]

Kelley Lode. — This ore-deposit is situated in the Magdalena Mountains, some 30 miles west of Socorro. It is a contact-deposit between slates and porphyry. The ores are the usual minerals of lead produced by oxidation, blende and zinc silicate.[2]

Organ District. — This district is in the Organ Mountains, from 14 to 17 miles east of Las Cruces and extends southward for a distance of some eight miles. The country-formations are largely Archæan granite, Cambrian quartzite and Trenton limestone, overlying which is Carboniferous limestone with intrusions and overflows of porphyry. Lead-silver and copper-silver ores occur in contact-deposits between porphyry and limestone. Ores found in the Bennett-Stephenson mine are argentiferous galena associated with carbonates, sulphides and chlorides. Molybdenite and other allied minerals also occur.[3]

The Hopewell and Bromide districts in Rio Arriba County have veins in altered amphibolite, in which occur copper and silver minerals bearing gold. The gangue is usually quartz. The veins are narrow but strong and well defined. Some values are also found in the wall rocks.[4]

In the southwest corner of Socorro County, in the Mogollon Range,

[1] T. A. I. M. E., Vol. 24, pp. 148 and 149, and Rept. of Director of the Mint, 1882, p. 341.

[2] Rept. Director of Mint, 1882, p. 376.

[3] Mines and Minerals, Vol. 24, p. 1.

[4] U. S. G. S., Bull. No. 285, p. 81, 1905.

are deposits of considerable size containing sulphides bearing gold and silver in a gangue of quartz and calcite.[1]

There has been a steady increase in production in this territory during the past decade and there is every likelihood of a still further increase in the future, due to new discoveries being made in many of the districts.

New York. — Gold is known to occur in Dutchess County and on Manhattan Island. At Wassaic, Dutchess County, gold-bearing quartz-veins are found in mica-schists of post-Archæan age.[2]

The auriferous area has been divided into four portions; first, beginning near Plattsburg and extending into Hamilton, Fulton and Saratoga counties to the south, thence branching west into Herkimer and east into Washington County; second, in Dutchess County; third, in Westchester and Rockland counties; and a fourth, in Erie and Alleghany counties. A gold-quartz vein varying from 6 to 12 inches in width occurs at Clinton. Assays of samples of the ore showed $15.45 per ton in gold. Other quartz-veins containing gold have been found at various localities.[3]

Lead veins of some importance occur near Rossie, St. Lawrence County. They are well known for their specimen ore, consisting of galena and calcite. The country-rocks are gneiss, hornblende and mica-slates. The Coal Hill vein is probably the most prominent, being two to four feet wide and standing almost perpendicular. The silver-content is variable, but is seldom more than a trace in these ores.[4]

Oklahoma. — The region in which gold is reported to have been found includes the Wichita Mountains, located within Coddo, Comanche, Kiowa and Greer counties of Oklahoma. This area formerly occupied the section known as the Kiowa-Comanche Reservation which was opened for settlement in 1901.

The core of the mountains consists of crystalline rocks including granite, gabbro, porphyry and greenstone dikes, partially surrounded by Paleozoic limestones. The gabbro and porphyry are pre-Cambrian.

[1] U. S. G. S., Bull. No. 285, p. 85, 1905.

[2] U. S. G. S., 16 Ann. Rept., Pt. 3, p. 330, 1894–95.

[3] Gold, Its Occurrence and Extractions, A. G. Locke, 1882, p. 180 and Ann. Rept. Amer. Inst. City N. Y., Vol. 25, p. 827.

[4] Whitney's Metallic Wealth of the United States, 1854, pp. 382–387, and Mineralogy of New York, p. 48.

There are five modes of occurrence which have been prospected:

1. Well-defined quartz-veins cutting both gabbro and granite.
2. Greenstone dikes cutting all crystalline rocks indiscriminately.
3. Contacts of granite and gabbro.
4. Disintegration products of gabbro.
5. Occasional simple shear-zones.

Notwithstanding many and varied reports regarding the values of the ore found, it is probable that but little more than a trace of the precious metals are to be found. According to assays made by the United States Geological Survey on 300 pounds of samples carefully selected no gold was revealed.[1]

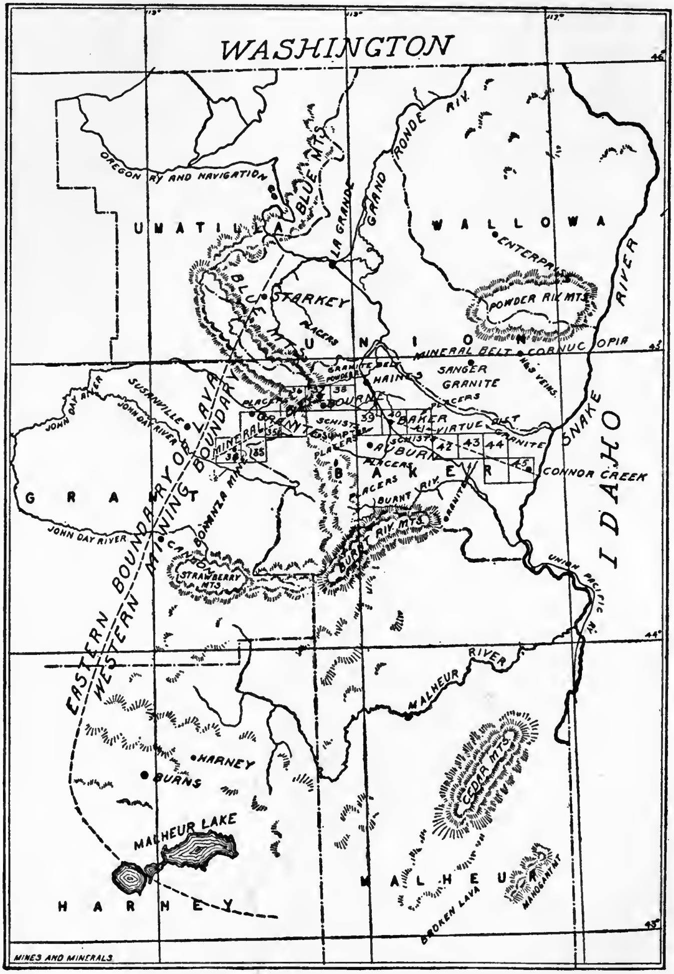
Oregon. — The gold fields of this state are located principally in the mountain ranges, such as the Coast and Cascade ranges, and the Blue, Siskiyou, Umpqua, Calapooya, Snow and Puebla mountains. The Cascade Range consists of granite and metamorphic rocks while Baker County is largely granite and slates.

The principal gold-bearing deposits of Oregon are found both in the southwestern and northeastern corners of the state. The former are closely allied to the California gold-belt, while the latter are also similar and probably belong to the same geological age — Cretaceous. In the deposits of the northeastern part of the state the occurrence of silver is more marked, and occasionally sulphide ores carrying a little free-gold are found. Veins carrying gold and silver in andesite are found in the Bohemia district of the Cascade Mountains and are probably post-Miocene deposits.[2]

Bohemia District, Lane and Douglas Counties. — The country-rock is andesite which is traversed by numerous mineral veins of great strength and continuity. The veins stand nearly vertically and strike northeast and southwest. Brecciated areas occur filled with quartz, which is the usual interstitial-filling for all brecciation. The whole brecciated mass is usually mineralized, bearing auriferous and argentiferous sulphides. Lenses and other forms assumed by the ore-bodies are strikingly parallel. The ores seldom fall below a value of $10, while $16 may be considered a fair average. Ores shipped from the Musick and Helena bodies average about $70 and $125 in gold per ton.[3]

[1] U. S. G. S., Bull. No. 225, pp. 120, 122.
[2] T. A. I. M. E., Vol. 33, pp. 833 and 834, 1903.
[3] Eng. and Min. Jour., Vol. 73, p. 889.

In the Blue Mountains the primary gold and silver deposits are usually normal fissure-veins. The gangue minerals are quartz, calcite, and dolomite. Occasionally the gold deposits contain notice-



Gold Mining Region of Eastern Oregon (1898).

able quantities of lead, zinc and copper, while the copper deposits usually contain small quantities of gold and silver; otherwise maintaining their distinct and separate characteristics. The zone occupied by the gold and silver veins is about 30 or 40 miles wide and 100 miles long — extending from the state line along Snake River and westward. Narrow and irregular mineralized belts constitute the veins which have suffered considerable brecciation. Both veins and walls are impregnated with pyrite. The veins are both simple and complex, the former exemplified in the Champion, the latter in the Musick lodes. The simple veins are usually much narrower than the more complex forms, with an average ratio of probably 4 to 12 feet.[1]

The minerals occurring in the district are: pyrite, arsenopyrite, blende, galena, chalcopyrite, cinnabar, stibnite, tetrahedrite, pyrargyrite and tellurides, of which pyrite predominates, while arsenopyrite is second in quantity.[2]

Elkhorn and Rock Creek District. — The mineral-bearing veins of this district may be grouped into two classes: first, in the massive granite formation as a series of parallel veins running north and south; and second, south of the granite in gneiss, schists and quartzites in a series of veins parallel with the stratification and running east and west.[3]

This district is also in the Blue Mountains. The ores are gold-bearing sulphides, which at the surface in the oxidized zone yield free-gold, that decreases with depth. In the Chloride mine the ores are chiefly silver chloride above, changing into ruby silver and argentiferous galena and blende below. With the exception of this mine the ores have been exclusively gold.[4]

Southern Oregon. — The vein-filling in this region is quartz which is hard, white and compact, in which are found the gold and silver-bearing sulphides. The gold is largely free, although variable in quantity. The more common minerals are: pyrite, chalcopyrite, mispickel and galena, all gold and silver-bearing.. The veins are rich in specimen-rock, which often occurs at the intersections. Remarkable specimens of flake native gold, occasionally as large as the palm of the hand, are found in the lower levels. The free-gold usually occurs in hard, snow-white quartz.[5]

It is claimed that silver in the form of chloride is found in saline mud or sediments at Silver Springs, Wasco County. It is evident

[1] U. S. G. S., 22 Ann. Rept., Pt. 2, p. 599.
[2] U. S. G. S., 22 Ann. Rept., Pt. 2, p. 604.
[3] Mines and Minerals, Vol. 19, p. 12.
[4] Eng. and Min. Jour., Vol. 62, p. 128.
[5] Min. and Sci. Press, Vol. 87, p. 391.

that little reliance is to be put in this report, as tests by reliable parties have not shown the existence of silver.[1]

The Philippines. — Gold is known to occur in practically every large island in the Philippine archipelago, being first worked as placers and later the quartz-veins were discovered and developed. Gold-bearing quartz-veins are found in Benguet, Lepanto and Surigao provinces, the most prominent and well-defined occurring in the older crystalline rocks, especially of Camarines and Masbate. There are several deposits of low-grade and refractory ores in the provinces of Lepanto and Benguet.

The placers of Camarines, Bulacan, Pigholugan, Arroroy and Pigtao have been large producers. It is proposed to begin dredging operations in the placers of Camarines, Masbate and Mindanao.

Transportation facilities are such that supplies can be obtained in a fairly reasonable time and conditions are constantly improving.[2]

Pennsylvania. — According to Whitney the lead veins of Montgomery and Chester counties yield some silver, although they have been worked for lead and copper chiefly. There are ten to twelve veins lying close to the junction of the New Red sandstone and gneiss, some of which traverse gneiss while others lie wholly in red shale, the latter being characterized by yielding copper ores. The principal gangue is quartz and heavy spar. The following mines have been worked for lead and silver: Chester County, Wheatley, Brookdale and Charlestown.[3]

Porto Rico. — As previously given (under the head of Recent History) the gold obtained from this territory is chiefly placer product. Veins of quartz and iron pyrites bearing gold occur in euritic and porphyritic rocks of the watershed of the Mameyes River. Near the source of the Congos River pieces of quartz have been taken from its bed which contained from 8 to 10 grams (123 to 154 grains) of pure gold. Numerous nuggets have been found in Mayaguez, San German, Yauco and Coamo.

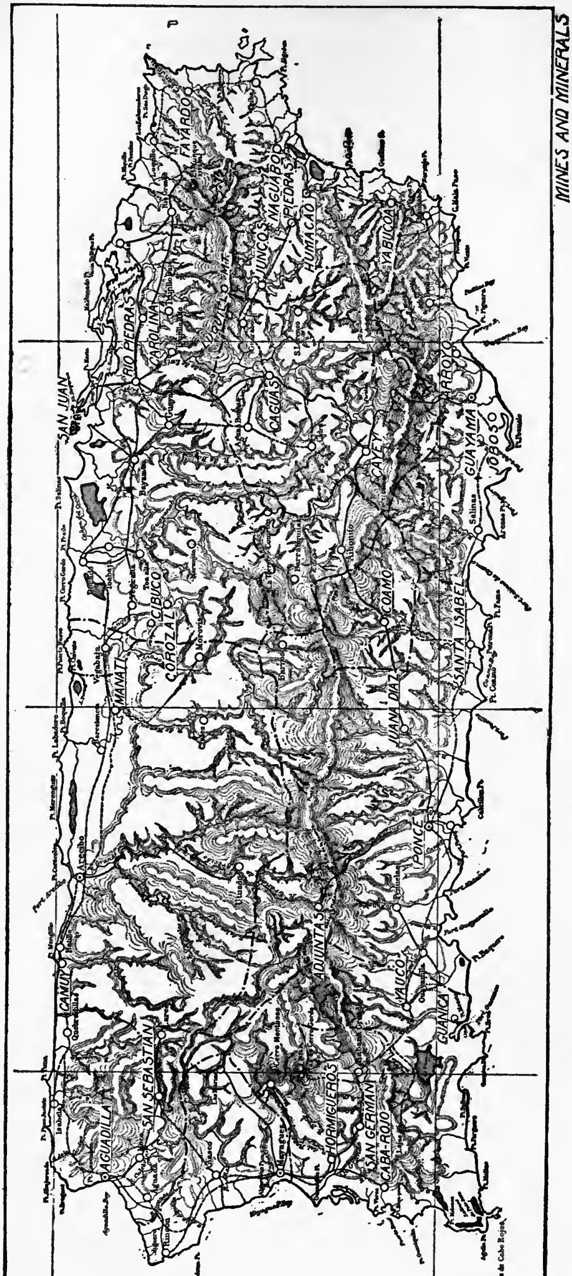
Although silver mines have been known to exist as early as 1538, yet little authentic information regarding them is available. Concessions for working silver mines have been granted in Naguabo, Corozal, Rio Grande, Fajardo, Lajas and Las Piedras.[4]

[1] Min. and Sci. Press, Vol. 34, p. 415.

[2] Annual Report of Mining Bureau of the Philippines, 1904, and the Mineral Industry, 1904, pp. 178 and 179.

[3] Whitney's Metallic Wealth of the United States, 1854, pp. 397–398.

[4] Second Annual Report of Governor of Porto Rico to the President of the U. S. and Special Report Census Office, Mines and Quarries, 1902, pp. 1076, 1077, 1902.



Map of Porto Rico (1899).

South Dakota. — The ore-deposits of this state consist of two distinct classes: first, the great lodes occurring in Algonkian and Archæan rocks, the Homestake being a type. The deposits consist of closely-massed stringers of free-gold and auriferous pyrites and are known to extend to considerable depth. These deposits are probably of pre-Cambrian and post-Archæan age. The second class comprises the siliceous ore-belt, in which the ore-deposits occur as irregular masses or horizontal shoots lying between Cambrian quartzites and the superimposed lime-shales. These deposits being genetically connected with phonolite dikes are considered as belonging to the Tertiary age.[1]

Mining in South Dakota is largely confined to the Black Hills and the adjacent territory. The Black Hills occupy an elevated area roughly elliptical in form, which consists of a mass of metamorphic crystalline rocks as a core, around which are grouped sedimentary strata of later geologic age.

The so-called basement formation, consisting of schists, slates, amphibolite-schists and various other crystalline rocks of Archæan age, was evidently an island in the Cambrian sea, the erosion of which produced material which was deposited along the shore line thus completely enveloping that portion lying below the level of the sea. This deposit of shingle sloped gradually away in all directions from the central ridge and was later cemented into a conglomerate. Successive subsidences permitted other deposits to be formed upon this conglomerate, which in order of their deposition are: sands and alternating beds of calcareous and argillaceous materials, another sand deposit, then successive deposits of limestone and sandstone, which continued to the close of the Cretaceous period, etc. The deposits of sand were ultimately consolidated into quartzite. At the end of the Cretaceous an uplift occurred, when the whole area of the Black Hills was elevated, accompanying which were intrusions of igneous rock, as rhyolite, trachyte and phonolite. In the northern hills laccolites were formed, thus elevating the sedimentary rock, the higher portions of which being eroded away exposed the underlying igneous formation. Surrounding these cores of igneous rock and sloping away in all directions are the sedimentary formations, the sequence of their deposition being readily observable.

The ore-deposits occur principally in the sedimentary rocks, particularly in the Cambrian, although other ore such as lead-silver is found in the Carboniferous. Placer-gold occurs in the conglomerate

[1] T. A. I. M. E., Vol. 33, pp. 834 and 835, 1903.

beds at the base of the sedimentary formations, having been derived from the erosion of the crystalline rocks below. Gold ores, particularly tellurides, occur in the quartzite overlying the conglomerate. So extensive has been the erosive action that large areas of ore-deposits are exposed thus permitting of their easy extraction by quarrying.[1]

Deposits of iron, copper and tin as well as gold and silver are found in this area. However, auriferous pyrite is of the most importance, although lead and zinc ores are also mined. The ore-bodies are irregular in shape, varying from thin sheets to 20 feet in thickness, but also occasionally assume a lenticular form and are often associated with dikes, having a width of a few to 100 feet on either side. They usually have the columnar cleavage coincident with the bedding-planes, that is noticed in the slates and schists. The pyritic impregnations occurring in the slates and schists which constitute the ore-bodies are seldom or never very large, rarely yielding above 20 per cent and averaging about 7 per cent. There are, however, solid bodies of pyrite. The igneous rock in the Homestake mine, although porous and much altered, shows no gold on analysis.

The function of the porphyry has been two-fold, it is claimed, namely, it has rendered the ore free-milling and caused a concentration of the gold by enrichment from the neighboring rocks. The cross sectional dimensions of the ore-bodies in the Golden Star and Terra claims were 150 by 130 feet and 150 by 250 feet respectively, while it is claimed that widths of 300 feet are attained. Other ore-bodies besides those at the Homestake occur in the Black Hills which show values by assay ranging from $2 to $12 per ton. Most of them are somewhat smaller than those mentioned.[2]

There are two belts of free-milling gold ores occurring in the Algonkian schists, namely, the Homestake and the Clover Leaf, or Uncle Sam, to the southeast. The Homestake ores occur in mica-schists and are not true fissure-veins, but broad zones of impregnations in the schists, with a strike of north 34 degrees west and dipping to the south. The ore first mined at the surface was in irregular lenticular masses lying almost entirely within the dikes of porphyry, but in depth a gradual divergence has taken place, the two separating until in the lower levels they appear to be independent. Pyrite is an index of the ore, but often quartz is also present. The usual character of the ores is quartz and pyrite, although calcite, dolomite and arsenopyrite also occur.

[1] Min. and Sci. Press, Vol. 87, p. 166, and Vol. 86, p. 212.
[2] T. A. I. M. E., Vol. 17, p. 571.

The gold-bearing cement deposits have a thickness of about 30 feet and are grouped about the Homestake mine. The enclosed pyrite is probably a replacement of the original quartzose bond. The refractory siliceous ores are found at Bald Mountain, Yellow Creek, Lead City, Garden City and Squaw Mountain, while the lead-silver ores of Galena resemble in form and occurrence the refractory gold ores. Further, both gold and silver and lead and silver ores are found in the Carboniferous rocks although they have not been large producers. Tellurium has also been found here. The lead-silver ores occur in limestone traversed by dikes and masses of porphyry in which are found two classes of deposits: large irregular masses of lead carbonate and partially filled crevices. Crystals of cerussite and wulfenite are occasionally found.

The siliceous gold ores have been successfully treated by the chlorination and cyanide processes and by smelting.[1]

Although there may not be any material increase in the production from the mines of the Black Hills, yet a steady output is assured for many years to come — enormous ore reserves have been proven.

Tennessee. — The discovery of gold on Coca Creek in Monroe County as early as 1831 created quite a stir and was responsible for a not inconsiderable rush to this and other localities. Aside from these placer diggings gold-bearing quartz-veins have been discovered on the Whippoorwill branch of the Tellico River. They are small and have never been worked and it is not probable that any more extensive deposits will be located.[2]

Most of the gold so far produced in this state has come from the Ocoee shales along Coca Creek, Monroe County, which contain numerous lenticular, conformable veins of quartz in which the values occur very scatteringly.[3]

A mass of silver sulphide ore was found in eastern Tennessee in 1857, but to our knowledge no further discoveries have been made, either of other detached pieces or the source of the original find.[4]

Texas. — Both gold and silver are found in this state, but, up to the present time developments have not shown any very extensive deposits. Probably the most pretentious workings are near Shafter,

[1] Min. and Sci. Press, Vol. 87, p. 187.

[2] Resources of Tennessee, J. B. Killebrew, 1874, p. 265, and T. A. I. M. E., Vol. 25, p. 717.

[3] Geology of Tennessee, James M. Safferd, 1869, pp. 489, 490.

[4] T. A. I. M. E., Vol. 25, p. 805, 1895.

Presidio County, where silver has been mined since 1884. The Presidio mine has produced over $300,000 for quite a number of years.

The country-rock is dolomitic limestone which has been considerably disturbed by the intrusion of igneous matter, the center of the disturbance being the Chinatti Mountains. Two dikes traverse the property of the Presidio mine which have probably influenced the mineralization, as the ore-bodies are more or less intimately associated with such occurrences, although not always in actual contact.

The ore of the Presidio mine is free-milling silver chloride, bearing traces of gold, and argentiferous galena. Indications of copper are present. The line separating these two classes of ore is about one-half mile west of the Presidio mine. The ore occurs both as pockets and impregnations in limestone strata, often being as much as 50 to 60 feet in both vertical and horizontal dimensions. However, the impregnations form the principal source of the ore.[1]

Gold occurs in small quantities in Llano and Gillespie counties. Veins carrying traces of gold are quite common in the Quitman Mountains. Gold also is found in the Burnetan system of rocks of central Texas, but according to the Texas Geological Survey "do not give much promise of profit."[2]

The Bonanza and Alice Ray mines of the Quitman mountains have produced some fairly good ore containing 30 per cent lead, 25 to 30 per cent zinc, and from 20 to 30 ounces of silver, with traces of gold. An average value of the ore is probably close to $60 or $65 per ton.

Gold and silver associated with pyrite, marcasite and various copper and lead minerals occur in the Burnetan system, usually as infiltrated masses, streaks, pockets, etc.[3] The Trans-Pecos region also produces gold and silver, especially the latter — the Presidio and Cibolo mines are the main silver producers. The copper ores of the Carrizo Mountains show traces of gold.[4]

The Silver Mine Creek, southeast of Enchanted Rock, Gillespie County, was the scene of operations in 1889 the object of which was the search for gold. The ore found consisted of schists and quartz-seams carrying pyrite, which in part was altered to hematite and limonite. However, the only district in the Central Mineral region

[1] Eng. and Min. Jour., Vol. 74, p. 150.

[2] Geol. Survey of Texas, 1 Ann. Rept., E. T. Dumble, p. 331.

[3] First Ann. Rept. Geol. Surv. of Texas, 1889, pp. 223, 260.

[4] Lake Superior Inst. Min. Engrs. Vol. 5, p. 59, 1898.

which has produced gold is the country about the headwaters of the Little Llano Creek and Babyhead Creek, in Llano County. Here the gold is invariably associated with silver and copper-bearing minerals.

The auriferous deposits of Big Sandy Creek have been known for some time, but have never been profitably worked.

The "Mexican Diggings" on a branch of Babyhead Creek have probably been the most productive of silver.[1]

There is, however, little literature on the subject of the occurrence of gold and silver in this state and the information available is therefore entirely out of proportion with the importance of the industry.

Utah. — The productive districts of Utah occur in the desert-ranges at the foot of the great Wasatch fault and also in the Wasatch Mountains, the latter being mainly silver-lead deposits. Very few deposits are found in which gold predominates. The Horn Silver mine, at Frisco, and the Tintic district contain veins of the propylitic type. The typical deposits are veins and irregular masses of ore, following contacts of sheets and masses of porphyry. The ores are chiefly of lead and copper carrying considerable silver and little gold and are usually base. The age of these deposits is probably Cretaceous.

Gold-deposits in limestone are found in the Mercur district; silver-bearing deposits are also found here. The former are probably of Tertiary age while the latter are Cretaceous.[2]

The gold and silver deposits of this state occur in veins, bedded deposits and impregnations in sedimentary and igneous rocks. The minerals forming the ores are: chalcopyrite, pyrite, manganese oxide, polybasite, blende, orpiment, realgar, cinnabar, black copper sulphide, galena, enargite, cerussite, anglesite, calamine, cerargyrite, pyrargyrite, stibnite, while some of the oxidized products are horn-silver, malachite, azurite, lead carbonate, etc. The gangues are: quartz, tremolite, calcite, barite, gypsum, rhodochrosite, magnetite, shale, limestone, quartzites and igneous rocks.

The Camp Floyd or Mercur District. — This district began its existence as a silver producer. The country-rocks are limestones and shales, which have been interstratified by a sheet of quartz-porphyry, known as the Eagle Hill porphyry. This intrusion in the neighborhood of the productive mine has separated into three sheets which

[1] First Ann. Rept. Geol. Surv. of Texas, 1889, pp. 260, 331, 332 and 333.

[2] T.A. I. M. E., Vol. 33, pp. 836 and 837, 1903.

lie some 150 feet apart, forming one gold ledge and two silver ledges. Following the intrusion and consequent disturbance mineralized currents impregnated the limestone, forming a zone of 10 to 20 feet in thickness.

In the Mercur mines there are two distinct horizons which carry ore: the lower or "Mercur" vein and the upper or "Ruby" vein, being separated by from 50 to 70 feet of limestone. Pay ore is obtained from both, but the upper is smaller and of lower-grade. The lime has been largely replaced by quartz which carries high values in gold, being often associated with cinnabar in considerable quantities. However, the limestone may carry the values, little silica being present; in which case the limestone is usually porous and cellular. The values are often very irregularly distributed. The amount of gold in the ores, never very great, rarely exceeds 2 or 3 ounces per ton, while silver is entirely absent from the gold ledge. Iron and sulphur, although present in quantities, do not unite as pyrite; however, pyrite was formerly a constituent of the rock as shown by the cubical cavities. The base ores carry from 1 to 5½ per cent of arsenical sulphides — orpiment and realgar. It is probable that the gold occurs in the original sulphide ores as tellurides, which having been oxidized, yielded free-gold. Cinnabar does not occur throughout the Mercur vein except at intervals, but is usually an index of good values. When arsenic occurs the ore is usually dark but fresh fractures show layers of realgar. Large masses of this base or arsenical ore occur, or it may be in small quantities, yet will coat the gold to such an extent as to render its extraction difficult.

The silver ledge is characterized by the complete silicification of the limestone and by the presence of barite in masses accompanied by small amounts of stibnite, some copper and silver. The copper occurs as carbonate, while the silver is principally chloride and probably some sulphide also.

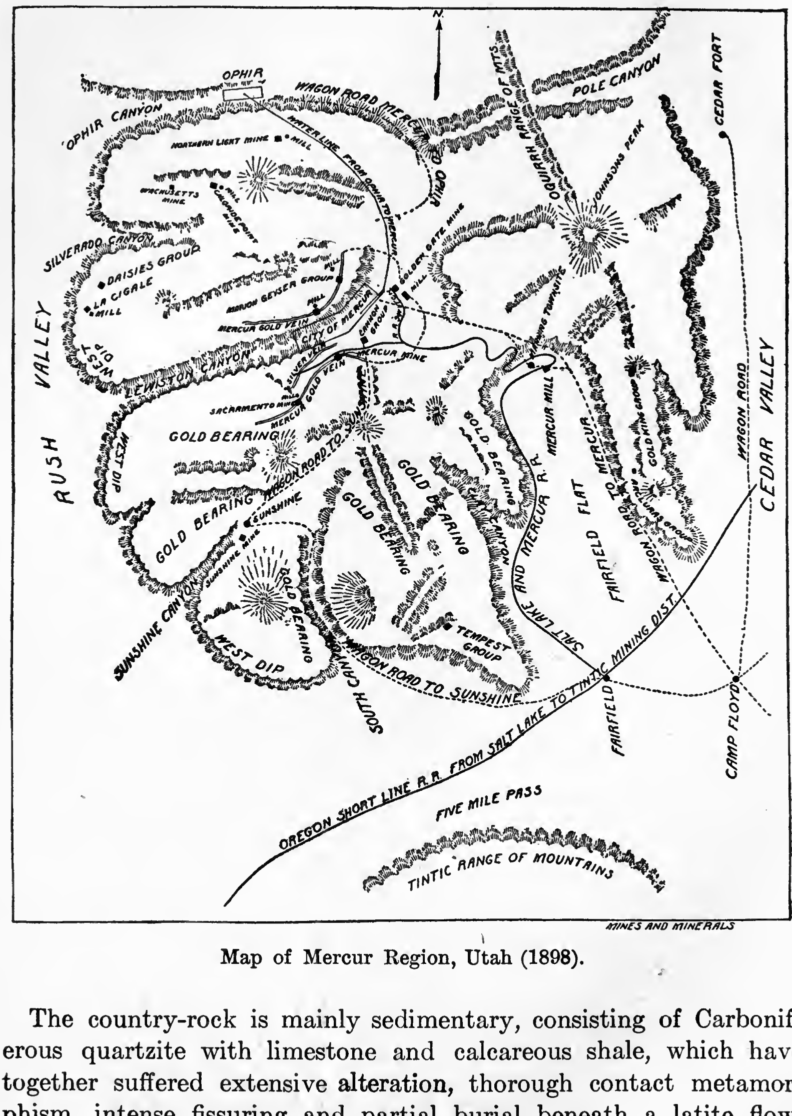
The values of the gold ores range from $2 to $60 per ton, the base ore carrying the higher value — the average run of ore is between $3 and $12 per ton.[1] There are, however, large areas in which the gold values run from $1.20 to $1.70 per ton.[2]

Bingham District. — Bingham and Big and Little Cottonwood Cañons constitute the oldest district in the state. It is situated

[1] Eng. and Min. Jour., Vol. 68, p. 754; Ibid., Vol. 63, p. 403; Ibid., Vol. 61, p. 86; Mines and Minerals, Vol. 19, p. 82, and U. S. G. S., 16 Ann. Rept., Pt. 2, pp. 368, 455.

[2] Mines and Minerals, Vol. 19, p. 130.

in the northern central part of the state on the eastern slope of the Oquirrh Mountains, some 20 miles southwest of Salt Lake City. The district originally produced lead-copper ores; then carbonate and argentiferous lead ores and oxidized gold ores, and finally an increased production of copper ore.



Map of Mercur Region, Utah (1898).

The country-rock is mainly sedimentary, consisting of Carboniferous quartzite with limestone and calcareous shale, which have together suffered extensive alteration, thorough contact metamorphism, intense fissuring and partial burial beneath a latite flow.

The characteristic formations of the region which have proven productive are the intrusives. The largest ore-bodies are found in metamorphosed limestone in close proximity to fissures and intrusives, while outside of such areas no deposits are found.

Argentiferous lead ores occur in single and composite veins throughout the extent of the camp, but usually favor the presence of intrusives. All formations are cut by the mineral veins which show the greatest width in the limestones and shales. Much of the ore mined at present is derived from the bedded-deposits in limestone, and consists of copper and iron sulphides. Chalcocite, tetrahedrite and tenorite occur as alteration products with sulphides. In some of the ores tellurium is associated with black sulphide, often in considerable amounts, with which the values in gold and silver are increased. The ores produced in 1905 were composed largely of low-grade pyritous copper sulphides, with comparatively small amounts of enriched high-grade black copper sulphide and rich argentiferous lead ores.

The average copper-content in the sulphide ores is low, running from 2.5 to 5 per cent, and averaging about 3.5 to 4 per cent. The accessory gold averages from $.10 to $1 per ton, while the silver-content is 2 to 5 ounces per ton, making a total value of $11 to $15 per ton. It is not improbable that both gold and silver occur in part as tellurides.

The auriferous copper ores, which form the milling-ores, occur in monzonite and are composed of chalcopyrite and pyrite with some bornite, magnetite and a highly siliceous gangue. Gray copper seems to be the silver carrier in the lead-bearing ores; galena and blende are also argentiferous. Pyrargyrite, galena, cerussite, anglesite, blende, calamine, native silver, silver sulphide, pyrite, realgar, gold and cerargyrite also occur occasionally. The gangue minerals are: quartz, calcite, barite and rhodochrosite.

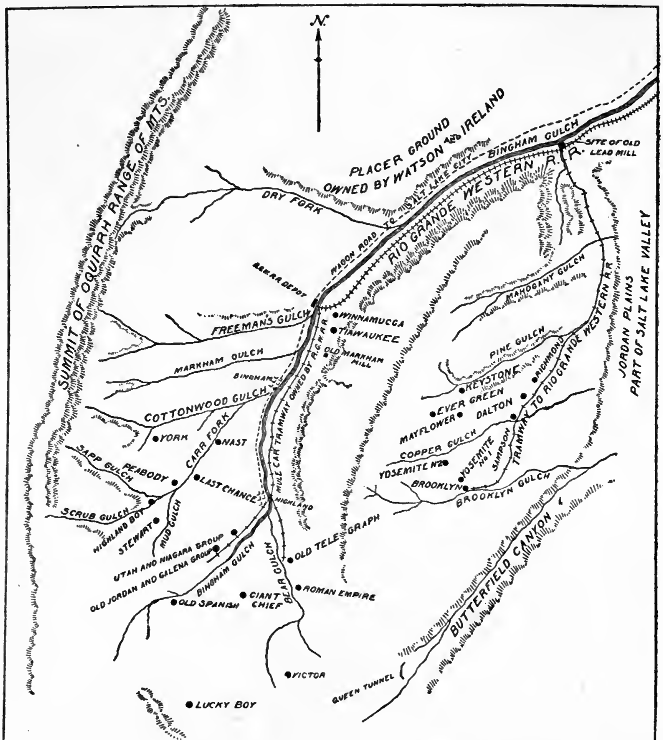
The early silver-lead properties in this district were the Winnemucca, Tiawaukee, Telegraph, Galena, Nast, Giant, Roman Empire, Spanish, Stewart and Jordan.[1]

There is probably no district in the state where such large quantities of ore have been mined so close to the surface as at Bingham. The work is largely done by lessees.

The Old Telegraph mine has large irregular bodies of more or less siliceous pyrites which in the zone of oxidation are altered into

[1] Eng. and Min. Jour., Vol. 79, pp. 1176–1178; U. S. G. S., Bull. No. 213, p. 118, 1905; Mines and Minerals, Vol. 19, pp. 377 and 378.

ochreous, spongy and brittle quartz and into siliceous ochres of various colors. Other bodies of galena with blende and pyrite occur and correspond to the bodies of lead carbonate ore within the zone of oxidation which have produced most of the ore mined. These oxidized lead ores or carbonates carry as high as 16 ounces of silver, 60 per cent lead and a little gold. The distribution of the



MINES AND MINERALS.

Bingham Cañon Region, Utah (1899).

gold and silver is very irregular, the larger part of the ore being low-grade, while pockets run considerably higher. The pyrite ores are low-grade and those parts that are free from quartz contain from 5 to 6 ounces of silver and less than $1 in gold per ton. The carbonate ore carries about 10 to 12 ounces in silver and about $1 in gold per ton. The quartz ore may carry as much gold and silver as the carbonate. The ores are wholly sulphide in depth. The gangue is usually quartz, especially of the pyrite and galena ores, and is in the crystalline form.[1]

Tintic District. — The country-rock is both sedimentary and igneous; in the former the ore-bodies occur in very irregular forms, being in the shape of chambers, chimneys, pipes and pockets, and not infrequently of considerable size. They extend on both sides of the planes of fracture and are not separated from the country-rock by walls and selvages. In the igneous rocks the veins are narrow and regular, the walls being well defined. The mineralized zones in the sedimentary rocks are sometimes from 100 to 200 feet in width and extend to depths of 100 to 400 feet. Their size and persistency would seem to indicate that these deposits are of greater permanence than those in the igneous rocks. The zone in which the mines are located does not usually show its greatest values close to the surface, nor is there a continuous body of ore along the foot-wall, but for a width of about 1000 feet its mineralization consitutes an independent zone in which the large ore-bodies are found.

Gold is confined almost entirely to the sedimentary rocks in which it is only distinguishable as free-gold. Native gold is found in small quantities in the Mammoth, Grand Central and Eagle mines. Tellurium is known to occur in the ores, but has not been found associated with the gold. Owing to the complete oxidation of the ores it is next to impossible to determine its original condition, but was probably auriferous pyrite.

Silver is common to both sedimentary and igneous rocks, its usual associate being galena, although in the sedimentary rock cerargyrite forms the most important mineral. Silver is also associated with the unaltered copper minerals, but only rarely so found. Lead seems to be the predominating mineral in the northerly mines of each zone except the Mammoth. Sulphides and sulpharsenides occur in both kinds of rocks, but sparingly in the sedimentary and as residual bodies in the upper workings. On the other hand enargite, accompanied by chalcopyrite and tennanite are more common in the sedimentary than in the igneous rocks. Blende is also found occasionally.[2]

The Mammoth mine leads in the production of gold. Gold, copper, silver, lead and bismuth are also found in the mine. The ores often run exceedingly high in value — it is claimed that occasionally

[1] T. A. I. M. E., Vol. 16, p. 26, and School of Mines Quarterly, Vol. 14, p. 354.

[2] U. S. G. S., 19 Ann. Rept., Pt. 3, pp. 685, 713, 1898, and Mines and Minerals, Vol. 19, p. 154.

$80,000 in gold per ton is obtained and similarly equally high values in silver.[1]

Tooele County. — The Chloride Point mine is situated on Lion Hill and is really a part of the Camp Floyd district. The vein formation consists of altered cherty and shattered limestone in which are bunches and stringers of quartz, calcite, barite and gypsum. The veins are bedded-veins lying between limestone and quartzite, or wholly in limestone. The ores are lead-silver occurring in shoots. Fissure-veins also occur but are of comparatively little importance. The metalliferous minerals are: galena, cerussite, stibnite, malachite, azurite and cuprite. Lead is found in the richer ores. Copper stains are considered as an index of good ore. The chlorides and bromides of silver occur in cracks in the vein-filling. The ore yields from 15 to 40 ounces of silver and from $.50 to $1.50 in gold per ton.[2]

State Line District. — This district is located in Iron County, close to the Nevada line. Quartz-veins occur in a dike of porphyry which has been formed by a succession of flows and intrusions of igneous rock. This dike is fully a mile wide and can be traced for several miles. The underlying portions consist of hard, iron-stained quartz-porphyry or rhyolite, while the overlying portions are less siliceous and more feldspathic. Fluorspar occurs in considerable quantities, also black oxide of manganese in practically all of the veins, but neither are gold-bearing. The strike of the veins is usually north and south and east and west, the former corresponding to the fractures in the porphyry. The veins vary in width from stringers to 30 feet. The country-rock is porphyry.

The ore occurs in well-defined shoots in the north and south veins, while in the other series of veins running east and west the ore has displaced the country-rock, there being no well-defined limits. A characteristic feature of the east and west veins is the occurrence of silver, equalling the gold value, while the north and south veins carry but little. The vein-filling is quartz which carries the values. The ore is free-milling but low-grade, although ore is mined which runs as high as $1000 and $2000 per ton.[3]

Park City. — Park City is situated on the eastern slope of the Wasatch Mountains in the northern central part of the state and some 25 miles southeast of Salt Lake City. The ore-bodies occur in fissure-veins, replacements and as contact ores. The fissures carry

[1] Mines and Minerals, Vol. 19, p. 154.

[2] Eng. and Min. Jour., Vol. 66, p. 605, and Min. and Sci. Press, Vol. 77, p. 451.

[3] Min. and Sci. Press, Vol. 84, p. 101.

silver or lead, with or without zinc, gray copper, or gold. In the impregnations the ores are largely silver and lead occurring as elongated lenses in limestone and being approximately parallel with the bedding-planes. In the contact deposits the ore contains copper and gold, with or without silver and lead. The ore-bodies are in the form of irregular masses, pockets, lenses and pencils in metamorphic limestones adjacent to intrusive masses.[1]

The Ontario mine was the most important mine in the district during the early days, but was closed in 1897 when the Silver King was the only reliable producer; however, in 1899, the Ontario took on new life and has produced smelting ore ever since. The ores are lead carbonate and silver, carrying some copper and gold. In 1901 a fair-grade sulphide and carbonate ore was found on the fifteenth level.[2] The ore of the Silver King mine is free from zinc which has been the source of much trouble in the Cresent, Anchor and Daly West mines. The ore also contains some gold, but the mine is not considered as a gold producer. The mine produces large amounts of low-grade concentrating ore, composed largely of galena and lead carbonate.[3]

The Horn Silver mine, at Frisco, Beaver County, is located on a contact deposit. A great contact vein with a hanging wall of trachyte and a foot-wall of limestone and quartzite carries almost a solid body of lead-silver ore. The ore is hornsilver and sulphate of copper. Barite and other minerals occur. Although the fissure can be traced for several miles it is only at the Horn Silver mine that values are found. The average thickness of the ore-body is 50 feet, range 20 to 150 feet, which is all removed as pay-rock, but of varying degrees of richness. The ore carries from 40 to 50 ounces of silver and from 30 to 40 per cent of lead per ton.[4]

Silver Reef District. — This district is situated in the southern part of the state, the town of Silver Reef being on the upper Leeds Creek. The silver occurs in Triassic sandstones which are traversed by dikes of igneous rock. There are two strata of sandstone which carry the silver minerals, being separated by beds of shale; they are red and white and are associated with carbon and clays. Other beds of clayey rock carry considerable copper as blue or green carbonate and rich argentiferous iron in nodular form. Values show along the

[1] U. S. G. S., Bull. No. 213, pp. 39, 52, 1905.
[2] Eng. and Min. Jour., Vol. 68, p. 455, and Min. and Sci. Press, Vol. 82, p. 242.
[3] Eng. and Min. Jour., Vol. 68, p. 545.
[4] Eng. and Min. Jour., Vol. 27, p. 219, and Colliery Engineer, Vol. 12, p. 50.

bedding-planes, while the mineralization extends from a few inches to one and two feet into the adjacent strata. Probably the highest values occur along the contacts in the form of extensive lenses. Although there is no vein formation the silver values follow certain channels and seams which are connected with the neighboring intrusions. The best values lie close to the surface, the silver existing as black sulphurets, chlorides, hornsilver and native silver in thin sheets. The silver occurs almost entirely as sulphide below the water-level and the values average rather low. The light sandstone stratum contains the silver mineral in streaks and thin layers carrying from $50 to $100 in silver per ton, although a more usual range is from $5 to $30 per ton.

The hornsilver is often invisible and occasionally replaces the stems and leaves of plants.[1]

Deep Creek District. — The district lies along the western border of the state and southwest of the Great Salt Lake. Gold occurs in limestone associated with tremolite and pyrite. The limestones and other sedimentary rocks have been considerably broken by overflows of igneous rocks, such as granite, andesite, etc. The ore-bodies usually occur near the contacts between limestone and igneous rocks. The gold is in coarse grains and stringers, is free and in considerable quantity.[2]

Box Elder County. — In Park Valley near the base of the Sierra Madre Mountains are strong quartz-veins between well-defined walls of granite, gneiss and porphyry, and near the surface in slates. Midway up the mountain is a belt of Cambrian or Weber quartzite on the upper contact of which is clay-slate. The slate caps Carboniferous limestone, which in turn is overlain with chloritic schist and later quartzites. The ores contain gold, silver, copper, lead, zinc, antimony, iron, nickel, cobalt, molybdenite and uranium. The gold-bearing fissures occur in the gneiss, while the silver-bearing lead ores are in the Carboniferous limestone and clay-slate near the summit of the mountain.

The Eldorado vein is a gold- and silver-bearing lead vein lying between blue limestone and clay-slate, the limestone often containing large bodies of ore. The ore usually has a value of from 20 to 85 per cent lead, 30 ounces in silver and from 2 to 6 pennyweights in gold per ton.[3]

[1] Colliery Engineer, Vol. 12, p. 73; Mines and Minerals, Vol. 20, p. 323, and Eng. and Min. Jour., Vol. 23, p. 317.

[2] Eng. and Min. Jour., Vol. 53, p. 253.

[3] Min. and Sci. Press, Vol. 82, p. 93.

From present indications it is probable that the production of gold from smelting ores will increase. However, nothing definite is known regarding the ore-reserves of the large districts, as for instance the Mercur, but with the opening of new mines, as is constantly being done, the prospects are encouraging.

Vermont. — Gold has been found in the extreme northern part of the state next to Massachusetts. Search for gold-veins began with the discovery of a small nugget at Readsboro. The first work was probably done about 1884. Ore was mined yielding, according to report, from $30 to $40 per ton, of which $25 was gold.

The Taggart vein at Bridgewater was opened in 1859 and produced 10 tons of ore which yielded 374 pennyweights of 21.5 carat gold.

The following assay by the United States Geological Survey gives an idea of the value: [1]

Gold	none.
Silver	1.27 oz.
Copper	6.19 per cent.
Lead	6.26 " "

Two nuggets found at the Plymouth mine, in 1855 and 1861, were worth $9 and $14 respectively.

According to Hitchcock [2] in 1861, "We trust that too much is known of the subject at the present day to leave any to indulge in extravagant speculation, or to make investments without reason."

The Virginias. — The gold belt consists of an accumulation of veins of iron pyrite associated with chalcopyrite. The veins have a quartz-filling in which the gold occurs as spangles, plates, grains and well-developed crystals. Pyrite is evidently the matrix of the gold and silver.[3]

The principal gold-region is the Virginia belt, which extends from Montgomery County, Maryland, to the North Carolina line, paralleling and lying on the east side of the Blue Ridge. Mining is carried on principally in Fauquier, Stafford, Culpepper, Orange and Spottsylvania counties, being in a belt some 15 miles wide at the junction of the Rappahannock and Rapidan rivers, although Louisa, Fluvanna and Goochland counties have been the seat of active operations.

In Louisa County are large bodies of pyrite occurring in lenses, often 60 feet thick and over 600 feet long. Traces of gold are found in the

[1] U. S. G. S., Bull. No. 225, pp. 85, 87, 1904.
[2] Vermont Geol. Survey, Final Report, Vol. 1, p. 533.
[3] American Jour. of Min., Vol. 2, p. 389.

pyrite deposits, which also contain small quartz-veins bearing gold. The State Hill mine of this county contains quartz-veins which yield ore averaging $4 per ton.

According to Professor Silliman the average values of the Busby and Moss mines of Fluvanna and Goochland counties are $160 and $140 per ton, while the Fisher mine has $60 ore.

Gold is also found in Patrick, Carroll and Grayson counties but in small quantities and associated with copper.[1]

Gold and silver are occasionally reported as being found in the Panhandle of West Virginia. It is supposed to occur in beds of shale contiguous to coal strata. It is claimed that the precious metals are associated with pyrite. According to J. D. Whitham $5,000,000 worth of the precious metals were taken out of the Lake Valley mines, while at another place $340,000 were obtained.[2]

Washington. — The country has been subjected to extensive lava-flows which overlie folded sedimentary rocks of a considerable range in age. The Monte Cristo in the Cascade Range and the Republic districts are the two most important sources of gold in Washington. From the limited amount of information available the precious metal deposits are found in fissure-veins, contacts and impregnations. The ore forming minerals are: chalcopyrite, pyrite, bornite, pyrrhotite, marcasite, arsenopyrite, galena, cuprite, bende, magnetite, stibnite, argentite, millerite, realgar, etc., while the gangue is quartz, tonalite, andesite, dolomite and limestone.

The Republic District. — This district contains the Republic mine and is composed largely of sandstones of the Cretaceous and possibly Tertiary ages. Archaen granites and syenites and Silurian syenite occur, while between the granite and sandstones are thin beds of gneiss and mica-schists. The fissures of the vein systems follow the lines of contact and structure, while others run transversely. Further, the veins are considerably faulted and cut by intrusions of porphyry and vary in width from a few inches to 60 and 70 feet, average between 4 and 20 feet or probably eight feet.

The foot-wall is andesite-porphyry and the hanging-wall porphyritic conglomerate overlain with argillaceous sandstone somewhat metamorphosed.

The vein-filling is country-rock and quartz of a variety of colors, usually containing only gold and silver; however, pyrite occurs either finely disseminated or in aggregations, but seldom carries any values,

[1] T. A. I. M. E., Vol. 25, pp. 689-693.

[2] Eng. and Min. Jour., Vol. 48, p. 71.

although it is considered as an index of ore-bodies. The ores are highly siliceous, containing as much as 93 per cent of silica. The gold is usually very finely subdivided, although it is found in fine grains in the rich ores. The quartz occasionally carries black sulphurets of silver which are also gold-bearing.[1] The district is essentially a gold region, although some mines yield considerable silver. The general average of a large number of mines is $12 to $16 per ton, although occasional enriched portions run as high as $50 and $1000. Large quantities of ore run as low as $10 and more yet of a value of $6, but are not worked. The proportion of silver to gold is, for ore milled, 3.2 to 1 ounce, which does not, however, represent the true value. About twenty-five mines produce ores more valuable in silver than gold. The average of the district is 5 ounces silver to 1 ounce of gold.

The ore is difficult to treat, necessitating unusually fine crushing to liberate the gold so it can be leached out.[2]

The Mountain Lion mine probably ranks second or next to the Republic as a producer in this district; it consists of the following claims: Mountain Lion, Flat Iron, Lost Chance, Navahoe, Zeta and Mountain Lion Fraction.

Monte Cristo District. — The country-rock is black slate overlying a metamorphic granite. A system of east and west veins carry argentiferous galena in the slates, with which are associated arsenopyrite and blende, with silver in excess of the gold values; but when the veins enter the granite below, the amount of galena decreases and even disappears altogether. The ore then becomes an arsenical pyrite in which the gold value is in excess of the silver value. Probably two-thirds of the ore of this district is suitable for concentration.[3]

The ores occur mainly in the joints and fractures, often being localized at the intersection of fractures; therefore wherever the rock has been most fractured is the seat of the greatest mineralization. In passing from above downward the minerals occur roughly in the following order: galena, blende, chalcopyrite, pyrite and arsenopyrite; the upper zone containing galena, blende and chalcopyrite, with more gold and silver than the lower zone in which pyrite and arsenopyrite predominate.[4]

[1] Eng. and Min. Jour., Vol. 68, p. 636.
[2] Eng. and Min. Jour., Vol. 74, p. 74.
[3] Eng. and Min. Jour., Vol. 55, p. 343.
[4] U. S. G. S., 22 Ann. Rept., Pt. 2, p. 865, 1901.

Silverton District. — This district lies in Snohomish County and produces both gold and silver. The characteristic ore is chalcopyrite, which is associated with bornite in the Index region and with pyrrhotite and pyrite at Silverton. Galena is also present, accompanied by ruby silver.

The Independent mine carries its ore in quartz-veins and also in the interlaminated schists. The ore is pyrite, löllingite (an arsenopyrite low in sulphur), galena and traces of blende. Realgar is found with the gold, but occurs sparingly. The löllingite seems to be the principal gold-bearer for the district. Other veins parallel with the Independent produce ores which differ mainly in the galena and blende-content. Small amounts of chalcopyrite and ruby silver are found, while bornite is notably absent.[1]

Stevens County. — The silver mines of this region are probably the largest producers in the state. The ore is composed of silver sulphide and galena in limestone, and ranges in value from 25 to 100 ounces silver and 40 to 70 per cent lead per ton. The Chewelah, Alice, Copper King, Jay Gould and Golden Crown are the principal mines.[2]

Wisconsin. — "Gold might naturally be expected to occur, in small quantities at least, anywhere within the region of crystalline rocks in the northern part of the state; and it has in fact been reported from that region at a number of points. So far as my own tests are concerned, however, — and I have no other reliable information — these reports have always failed of proof save in one instance. In some samples of a quartz carrying pyrite and arsenopyrite brought me from the northern part of Clark County, I found minute quantities of both gold and silver. It is not to be expected that gold in quantity will ever be found in Wisconsin." [3]

Gold also occurs in veins of diabase in Douglas County and in the Chippawa mine, assays of the ore have shown a value of $9 per ton.

Native gold and silver have been found alone and in the native copper occurring in the drift from the copper region of Lake Superior, also in the Keweenawan system of rocks which is silver-bearing near Ontonagon on the Iron River in Michigan and extends westward across the Montreal River into Wisconsin. Both silver and copper are found in this formation, but owing to the lack of success in work-

[1] Eng. and Min. Jour., Vol. 72, p. 105, and Ibid., Vol. 73, p. 832.

[2] Mines and Minerals, Vol. 18, p. 313.

[3] Trans. Wis. Acad. Sci., Arts and Letters, Vol. 1, Geol. of Wis., 1873–79, Vol. 1, p. 310, and Geol. Wis. Vol. 1, p. 661.

ing this silver-bearing stratum in Michigan little or no work has been done upon it in this state. Silver also occurs in the lead ores of southwestern Wisconsin, but in minute quantities only. According to the Geological Reports of the state: " there is no justification for fostering an expectation of rich results, or for incurring an expense beyond what the satisfaction of knowing, or the possibilities, rather than the probabilities, may warrant.[1]

Wyoming. — Granite and gneiss constitute the formations of the central portion of some of the larger mountain ranges. The Cretaceous and Tertiary rocks form the plains and plateaus. The National Park of the northwest is largely volcanic, while in the northeastern portion of the state is a part of the Black Hills. The precious metals are found in both sedimentary and igneous rocks and usually in quartz-veins.

The Grand Encampment and Saratoga Districts. — In 1899 the principal mines of this region were: the Rambler or Doane, Rudefeha, Chatterton-Kurtz, Haskins, Bohemian, Charter Oak, Meta, Alma, Puzzler, Spring Creek, Badger, Cox, Evans, etc., all of which were largely in the prospect stage. However, some ore has been mined and assays made on a sample from the Cox mine are said to show 48.8 per cent copper, $17.16 in gold and $3.87 in silver per ton.[2]

Weston County. — This district is situated about 65 miles from Deadwood, South Dakota. The gold occurs in portions of a coal seam, silver is also present but in smaller amounts. Pyrite is associated with the gold, certain specimens contain as much as 3 pennyweight of gold per ton of coke, although the average is between 1 and 2 pennyweight per ton.[3]

Sweetwater County. — Gold and silver occur in quartz-veins traversing granites, gneisses and schists.

The mining industry of this state is handicapped by lack of capital, transportation facilities and severe climatic conditions — capital and railroads will come in time and with the consequent development the disadvantage of a rigorous climate will be largely alleviated.

To supplement the foregoing discussion a table on the occurrence and mineralogical association of ores has been prepared, see tables following Chapter VII. (Appendix of Tables.)

[1] T. A. I. M. E., Vol. 8, p. 488; Geol. Wis. Vol. 1, 1873–79, p. 661; Ibid., Vol. 2, p. 27; Vol. 3, pp. 201, 206, 358, and 669; Vol. 4, pp. 382–383, and Eng. and Min. Jour., Vol. 74, p. 248.

[2] Mines and Minerals, Vol. 20, p. 28.

[3] Min. and Sci. Press, Vol. 90, p. 184.

Permanence in Depth. — The occurrence of workable ores in depth is a subject, the discussion of which is of peculiar interest to the mining engineer and mining geologist. Much is known regarding the genesis of ore-deposits of moderate depth, but as yet our knowledge of the occurrence of ores at greater depth is very meagre and most uncertain and unreliable at best, and is based upon only a comparatively few disconnected and isolated cases. However, we may hope that in time the system, if such exists, of the occurrence of metalliferous minerals in depth will be revealed under the intelligent and painstaking search of those whose business it is to direct the mining industry of the world. It is not unlikely that facts already known, or such fortified by information subsequently obtained, will ultimately be correlated and crystallized into an orderly system of occurrence in a manner similar to the law of vadose or ground-water and permanent water-levels, and the oxidized and unoxidized zones, together with the zone of secondary enrichment.

Although the depth to which fissures may extend and remain open sufficiently long to permit the formation of bodies of mineral matter is largely conjectural, yet it has been estimated with some degree of certainty. According to the old German miners the "*ewige Teufe,*" the extreme depth at which fissures may remain open in the most resistant rocks, is 10,000 meters.[1] Professor Van Hise's "zone of flowage" begins at a depth of 5,000 to 12,000 meters.[2] Thirty thousand feet then for rocks such as granite and 10,000 feet for softer rocks as shales may be considered the probable depth to which veins remain open and, if other conditions do not prevent, the depth to which mining operations may be carried.

The origin of fissures is probably largely due to the intrusions of igneous rocks, such as granite, porphyry, etc., and we may therefore expect to find the widest, deepest and richest veins flanking mountain ranges and in general in the centers of greatest disturbance. The common occurrence of mineral-bearing veins in or adjacent to areas of igneous rocks is generally recognized at the present time, as has been pointed out, in the case of gold deposits, by Lindgren.[3] In contra-distinction to the association of metalliferous mineral veins with igneous rocks are the fissures occurring at a distance from

[1] Mining Magazine, Vol. 10, p. 91.

The limit set by Professor Heim, at which fissures or open spaces cannot exist, is 16,000 feet. U. S. G. S., 17 Ann. Rept., Pt. 2, p. 162.

[2] T. A. I. M. E., New York Meeting, Apr., 1907, p. 502.

[3] T. A. I. M. E., Vol. 33, p. 790, 1903.

mountain masses as in plains and valleys, which are usually barren or only slightly metalliferous.

As a rule veins contain ores of workable value to comparatively shallow depth only, and therefore mines located thereon are soon exhausted. However, care should be taken that too broad and sweeping generalizations are not made without due consideration as to the nature of the deposit in question, as well as that of the neighboring country-rock and the geological age of both. It may be that erosion has removed the greater part of a vein in its vertical dimensions leaving only the root as it were as the part with which we have to do. Facts obtained and conclusions drawn from such fragmentary evidence are obviously unreliable. Further, other veins protected from erosion by an overflow of igneous material and therefore left intact may represent an unbroken record throughout their vertical length. But in this case the record, although unbroken, is incomplete owing to the elimination of the after effects of the secondary action of percolating waters, having been effectually sealed by the lava cap, and conclusions drawn therefrom may be as illy applicable to ore-deposits in general as in the former instance.

The processes of oxidation and leaching of the sulphides of the primary deposits in the upper portion of veins may disguise the true nature of the deposit, and, as has been previously stated, not until the permanent water-level has been reached and passed can the true character of the deposit be determined. Such, indeed, was the case at Leadville, Colorado; Bingham, Utah; Ely, Nevada; and in many other localities both in the United States and abroad — one of the most prominent cases outside of the States is that of the Mount Morgan mine, Australia, where a gold mine has proven to be a great copper mine.

In other cases the metallic-content of the oxidized portions of a vein may be wholly wanting, owing either to scant primary occurrence of the sulphides or to their more or less complete removal. And as has been remarked, " In such cases the discovery of the subterranean treasures is purely fortuitous " — Butte is a case in point.[1]

The natural concentration often effected in the oxidized portions of a vein, together with the metallic state of the values, may render those portions sufficiently valuable to warrant mining, while the unaltered portions with the widely disseminated values combined with sulphide minerals may be unworkable.[2] This condition of

[1] Eng. and Min. Jour., Vol. 84, p. 1068.

[2] U. S. G. S., 17 Ann. Rept., Pt. 2, p. 161.

affairs may exist in narrow and wide veins alike, but under similar conditions of dissemination it may be said that a vein of considerable width can be worked more profitably than a narrow one — the Alaska-Treadwell and Homestake mines may be cited as instances where low-grade deposits are worked with profit, which condition of affairs is rendered possible only through a large output. It is claimed that certain veins in California with a width of only three feet have been worked very profitably at or near the surface, which, with depths of 600 to 700 feet, have proven unprofitable to work owing to the scattering of values and that, too, when the width has increased to 40, 60 and even up to 120 feet.[1]

Sir Frederick McCoy speaking of the probable occurrence of gold with depth says: "I believe, as a rule, the upper portion of gold veins is richer than the lower, but that there is no limit to the depth at which traces of gold may be found."[2]

Uniform dissemination of values in vein-rock, both vertically and horizontally, is the exception rather than the rule, both primary and secondary occurrences favoring unequal and irregular distribution, and owing to the irregularities it is extremely difficult to determine when the limits of an ore-body have been reached. However, ore-shoots, bonanzas, etc., although broken in their continuity, often show a pronounced tendency to maintain more or less vertical, rarely horizontal, lines, which condition, when once established with certainty, is of considerable importance in the development and operation of a mining property.

Regarding the influence of width on the comparative richness of veins no definite conclusions can be stated, except in special instances; both wide and narrow veins have produced extremely rich ores, and in fact the same general locality may contain such occurrences. Probably the narrow veins of Grass Valley, California, and Colorado may be classed among the most productive in the United States.

The following specific instances are cited illustrative of the actual conditions existing in some of the most prominent mines and districts of the States: In the gold belt of the Sierra Nevadas, Lindgren[3] states that it is "an incontestable fact that many small veins close up in depth." In Amador County, California, at the Kennedy mine,

[1] Min. and Sci. Press, Vol. 13, p. 50.

[2] Ibid., Vol. 78, p. 258.

[3] U. S. G. S., 17 Ann. Rept., Pt. 2, p. 162, 1895–96, and T. A. I. M. E., Genesis of Ore-Deposits, 1901, p. 290.

after working in medium and low-grade ores a barren zone was encountered at a depth of 400 to 500 feet, but on proceeding to a depth of 900 feet a body of high-grade ore was struck which extended to a depth of 1000 feet more and yielded several millions of dollars worth of ore. Later another body of high-grade ore was encountered at a depth of 2200 feet, which so encouraged the management of the Argonaut, a neighboring property, that a deep shaft was sunk to a depth of 1000 feet when a valuable discovery was made.[1]

The depth of a number of the prominent mines on the Mother lode, California, especially in Amador and Calaveras counties, are approximately as follows:[2]

	Incline Feet.	Vertical Feet.
Lincoln	2000	1766
Baliol		1800
South Eureka		1800
Central Eureka	2300	2030
Oneida		2300
Kennedy		2863
Argonaut		2100
Zeila		1200
Gwin		2380

In 1906 the Kennedy, Central Eureka, Oneida and Gwin mines were stoping on or below the 2700, 2000, 1900 and 2000-foot levels, which condition of affairs shows that free-gold ores do occur in depth, although the bonanzas are of less frequent occurrence in the lower than in the upper levels. Hopes are entertained that paying values may be found at much greater depths, which cannot, however, probably exceed 5,000 feet, owing to the increasing temperature of the workings.

It has been estimated that fully 3000 feet of the veins have been removed by erosion, which, if so, would indicate a depth of some 6000 feet as that of deposition of gold ores in this locality. In Calaveras County, the Utica mine showed a decided improvement in value of ore with depth and the same has been the case with other properties. However, other important mines of the Mother lode have not been so fortunate and, although developed to a depth of 1200 to 1500 feet, the results have been much less satisfactory than at a more moderate depth of 800 or 900 feet. Furthermore, the cases given were located at the most favorable portions of the surface.[3] Speaking of the

[1] Proceedings Royal Society of New South Wales, Vol. 9, p. 75, 1875.
[2] Min. and Sci. Press, Vol. 92, p. 41.
[3] Min. and Sci. Press, Vol. 76, p. 106.

veins of the Grass Valley district, Lindgren says, "It can be confidently stated that there is no gradual diminution of the tenor of the ore in the pay shoots below the zone of surface decomposition; within the same shoot there may be many and great variations of the tenor, but there is certainly no gradual decrease of it from the surface down."[1] Such facts have been previously brought out by Professor Silliman and Mr. J. A. Phillips, while statements to the contrary have been made by Mr. Laur or Mr. Reyer.[2] Mr. Lindgren, however, states that from the standpoint of production, in tons and value, this district has undeniably shown a decided decrease. This statement also includes the average value of the ore. He explains the decrease as follows: "The cost of treatment and mining has decreased greatly by reason of the modern methods introduced, and more low-grade ores are now milled than formerly; nor are there any rich surface ores left to swell the grade.[3]

With reference to the occurrence of the ores in the Cripple Creek district, Messrs. Lindgren and Ransome state that "The position of this carbonaceous material (the materials now filling the volcanic neck) affords material support to the view . . . that the Cripple Creek ores were deposited at a very moderate depth."[4] However, Mr. T. A. Rickard,[5] argues as follows regarding the probable continuance of the ore in depth in the mines of this district. "What of the deep? Will increasing depth be accompanied by impoverishment? This is not asked with the timidity of a few years ago, when the lodes had only been followed two or three hundred feet in vertical descent, and it was foreseen that they would eventually cut into the granite under the breccia. At that time the future of the district was uncertain, and many cautious men held back in fear of unfavorable developments. It is obvious that the mines near the edge of the depression occupied by the breccia will penetrate into granite. . . . This has occurred notably in the case of the Independence and Portland mines, which reach the granite on the southern and western sides of the territory owned by them. It is very satisfactory to be able to record the fact that magnificent ore-bodies have been found in these two properties upon veins which have been followed downward into the underlying granite. If good ore is found in the granite

[1] U. S. G. S., 17 Ann. Rept., Pt. 2, p. 163.
[2] Hütten- und Salienenwesen im preuss, Staate, Vol. 34, pp. 1–28, 1886.
[3] U. S. G. S., 17 Ann. Rept., Pt. 2, p. 163.
[4] U. S. G. S., Professional Paper, No. 54, p. 32, 1906.
[5] Trans. Inst. Min. and Met., Vol. 8, p. 93, 1899–1900.

at a horizontal distance of 2,000 feet from the mass of breccia, why should it not be also found at a similar vertical distance below the same formation?"

The following facts regarding the occurrence of ore in the Cripple Creek mines, during 1903, is of interest in this connection.[1] The Portland shaft had a depth of 1,200 feet, and the ore-bodies encountered, as a rule, showed no signs of playing out. The Hidden Treasure, one of the larger ore-bodies, first opened up on the 10th level, is 500 feet long with an average stoping width of ten feet. The average value of the shipping ore was $35 per ton. The Stratton's Independence shaft had a depth of 1,400 feet and showed little ore in the lower levels. The Gold Coin shaft was 1,200 feet deep. The vein contains low-grade ore and is rather irregular. It was last cut on the 10th level, where it was poor. The shaft of the Golden Cycle was down 1,000 feet. There has been a marked improvement from the 7th level downward. Two ore-shoots were encountered on the 10th level, which had a combined length of 400 feet with an average thickness of ten feet. The average value of the shipping ore was $35 per ton. The Vindicator shaft had a depth of 1,200 feet. The lower levels showed high-grade ores. A 400-foot ore-body was struck on the 10th level with an average thickness of nine feet. The ore averaged $50 per ton. The Eagles shaft was 1,500 feet deep. The main ore-body has been encountered at the 5th, 8th, 11th, and 15th levels, the 11th being the best opened. The ore-body was 120 feet long with a width of five feet yielding ore valued at $60 per ton. The 15th level showed high-grade ore. The Doctor-Jackpot mine was 700 feet deep. Winzes sunk below the 7th level showed high-grade ore which increased in richness with depth. Average shipments from the winzes have averaged $40 per ton. The Gold King shaft had a depth of 920 feet. The 6th and 7th levels were poor, while raises and winzes driven from the 8th developed rich ore, which was especially found in the winzes. Assays showed four feet of $80 ore and 12 feet of lower-grade. The Shurtloff shaft was 920 feet deep and had developed no ore in quantity above the 7th level. On the 8th level an ore-body 160 feet long and five feet wide was opened up, which yielded shipping ores worth $45 per ton. Even better showings were found on the 9th level. The Findley shaft was down 1,300 feet. No ore-body of importance was found above the 7th level. At 750 feet a body of fair ore was found which continued to a depth of 1,300 feet. The 12th level was the best in the mine, where the ore-body

[1] Eng. and Min. Jour., Vol. 76, pp. 86–88.

was 350 feet long by four feet wide, averaging $35 per ton. The Blue Bird shaft had a depth of 1,350 feet. Considerable ore was found on the 6th, 7th and 8th levels. Ore was again encountered on the 9th and 11th levels, where a space from 300 to 400 feet in length by five feet in width was occupied by ore. The Last Dollar shaft had a depth of 1,220 feet and is claimed to have the most remarkable showing in depth of any mine in the camp, the bottom level being the best. Two veins occur running parallel which with the included rock constitute a mass 75 feet wide which can be regarded as low-grade ore. The Princess Alice shaft was down 1,000 feet, which was still further extended by a winze to a depth of 1,320 feet. A rich ore-body was struck at the 1,220-foot level. The Wild Horse was 1,250 feet deep. The largest and probably the best stope in the mine was between the 8th and 10th levels. It was 100 feet long and 15 feet wide, and yielded $90 ore. The Isabella and Victor yielded the best ore above the 500-foot level, although some rich ore was encountered on the 10th level. The Elkton shaft was 800 feet deep and carried its best ore at the bottom. The Hull City shaft was 1,180 feet deep. An ore-body 450 feet long by eight feet wide with $40 ore occurred at the bottom. The Ajax shaft was down 1,200 feet. Work had not been carried below the 10th level but the ore was evidently just as good there as elsewhere in the mine. There were four other deep shafts in which no ore occurred at the bottom. Out of 23 deep shafts which yielded ore 19 showed good ore at the bottom levels, a remarkably good showing and one which augurs well for the future of the camp.

According to Lindgren:[1] " A review of the veins which cut through surface lavas will show that many of them have been followed down for over a thousand feet from a point which was undoubtedly near the original surface. In the Silver City district a depth of over 2,000 feet has been attained, in Cripple Creek 1,500 feet, and in the San Juan country, Colorado, at least one of the veins has actually been proved payable within a vertical range of 3,000 feet. But in most cases the ore — which generally is of higher value than in the deep gold-quartz mines of California — seems to decrease somewhat in quantity and value as the lowest levels are reached, and in many cases the decrease is marked and conspicuous."

The occurrence of the rich ore and bonanzas seemed to favor the upper levels, which were still further enriched in many cases by secondary action.

[1] Min. and Sci. Press, Vol. 92, p. 41.

With regard to the Southern Appalachian gold fields the limit of pay-ore is usually only several hundred feet in depth; a depth of 1,000 feet has, however, been attained, but the probable depth at which values terminate, and indeed even the veins themselves, is largely or wholly conjectural. However, the formation of the veins of this region is known to be of remote date and consequently erosion has had a much longer time to act than in many other localities — thousands of feet have thus been removed and yet there still remain low-grade ores and small pockets of rich ores at considerable depths.[1]

What has been said of gold is also to a certain extent applicable to the occurrence of silver, as they are usually associated. Probably the largest and richest bodies of silver ore were those of the Comstock lode, some of which were found at considerable depth although they favored the upper levels of the great vein in which they occurred.

Abroad one of the most prominent instances of continuance of gold in depth is that of the Victoria mine at Bendigo, Victoria, Australia. In 1904 a depth of 4,029 feet had been reached, at which point a quartz feeder some four inches thick was cut in which free-gold was found.[2] However, gold was found at still greater depth in a neighboring mine, the New Chum Railway mine, Bendigo; where at a depth of 4,224 feet, gold in the free state was found associated with quartz and slate.[3] This is probably the greatest depth at which gold has been discovered.

According to the Australian geologist and others, a conservative estimate of the rock removed by erosion has amounted to 3,000 feet, which gives a depth of at least 7,000 feet as that at which gold was probably originally deposited.

A decrease, although comparatively slight, is noticeable in the ores of the quartz mines of Ballarat, Australia, which are in the neighborhood of 2,000 feet deep.[4]

In the Dutch East Indies, especially in West Borneo, a large amount of exploratory work has been done with the discovery of the source of the gold in the alluvial deposits as the object in view. The results have been far from satisfactory, however, the veins encountered showing little persistency in depth.[5]

[1] Min. and Sci. Press, Vol. 92, p. 41.
[2] Eng. and Min. Jour., Vol. 78, p. 618.
[3] Min. and Sci. Press, Vol. 91, p. 360.
[4] Min. and Sci. Press, Vol. 92, p. 41.
[5] The Mineral Industry, 1901, p. 319.

The following statement by G. A. Denny regarding the permanency of the gold reefs of the Witwatersrand is of interest in this connection: " The incontestable truths that for 42 miles on the line of strike there is a practical continuity of the reef that in all probability the existing line of outcrop forms to the original detrital edge the relationship of an immensely deep level; that the reefs and quartzites form inseparable parts of a whole, which as such must be regarded as above any suspicion of doubt of continuity; that the present line of outcrop is only accidental on the plane it represents, and might easily, if acted upon by the same forces in another axial direction, have occupied a position corresponding to portions now very remote from the outcrop; all these premises form strong links in a chain of evidence favoring the assumption of the permanency of average conditions in the reefs themselves, which cannot be controverted.[1]"

According to Truscott[2] " it would appear that on an average the deep levels . . . are working 10 inches less than the outcrop mines, though the assay value is slightly higher."

However, the gold reefs of the Witwatersrand are peculiar and can hardly be compared with the lode mines with which this discussion is particularly concerned.

Observations in Nova Scotia by Mr. Faribault and W. H. Prest seem to confirm the fact that paying gold mines occur throughout a thickness of formation of 17,500 feet, the Moose River mine being one of the lowest geologically and the Caribou the highest in the neighborhood. Further, it seems evident that the gold-bearing rocks have suffered denudation to a depth of 26,000 feet, and as the Moose River district lies at the bottom of this 26,000 feet, deep-mining would have been necessary to have reached the ores here had not erosion brought them to or near the surface. Similarly with the Caribou mines which are, however, 17,000 feet higher. To cite a specific case to substantiate the theory of permanency, that of the Libby mine at North Brookfield may be taken. This mine at a depth of 200 feet yielded 2,419 tons of ore with a gold-content of 2,232 ounces. A pinch closed the vein and it was abandoned. Several years later the mine was reopened and on cutting through the pinch the vein was found as good as ever and has continued for years to produce paying ore.

The North Star vein was followed for 1,000 feet at least, yielding

[1] Eng. and Min. Jour., Vol. 76, pp. 80–81.

[2] The Witwatersrand Gold Fields Banket and Mining Practice, 1902, p. 461.

an average of 6 ounces of gold to the ton.[1] Other instances might be cited to the same effect.

Although the information cited is far from conclusive even for a given locality, yet it is only through the collection and correlation of such data that anything definite as to theory can be arrived at regarding the occurrence of mineral, in paying quantities, with depth. The lack of extended and published records of observation is largely responsible for the lack of more detailed discussion in this connection.

In conclusion the relation of gold values to depth may be summarized as follows: first, the contention that workable values are not co-extensive with depth is fairly well established;[2] second, the change in values takes place comparatively slowly; third, the distribution of values seems to be more uniform in depth, at least masses and bonanzas are of less frequent occurrence; and fourth, the relation of value to depth depends largely upon economic mining and extraction. The reduction of cost of operations is then the working basis of permanency of values in depth which combined with any natural, local advantage of occurrence makes for higher profits, and larger production.

Occurrence of Gold in Gravels, by States and Territories.

Introductory Remarks. — Gold always occurs in gravels in the metallic state and when so found has various physical characteristics — in the deep placers it usually has no luster, often having no appearance of gold whatever, and resembles the associated iron sands. In the shallow placers, however, the gold usually has more marked characteristics, although varying considerably in color. Dark-colored gold is found to become clearer on exposure to atmospheric agencies and is more amenable to amalgamation. This is shown to advantage in the case of the Red Gulch mine, El Dorado County, California, where it has been found both possible and profitable to rework the gravels at least six times, which fact has led to a belief among miners that the gold is constantly being renewed, i.e., that it "grows again."[3]

There are three classes of gravel deposits, namely; 1st, bar, ravine and cañon placers; 2d, bench or hillside placers; and 3d, extinct river-channel deposits usually overlain with lava.

[1] Eng. and Min. Jour., Vol. 67, p. 495.
[2] Min. and Sci. Press, Vol. 92, p. 41.
[3] Min. & Sci. Press, Vol. 60, p. 297.

The grade of most streams traversing auriferous areas is usually considerable and it is therefore only the coarser pieces of rock which find their way into them that find lodgment, the finer and lighter particles being carried down-stream to a point where the current velocity is less, unless they are checked by some especially favorable condition. The tendency then is to sort the materials entering the streams, each particular stream varying that action with its varying conditions of grade, width, depth and character of channel. Such variations are constantly happening at any particular place owing to changes in shape of channel and seasons. It is evident then that there will be a considerable overlapping of the grades of sorted products, including the accumulations of gold and associated minerals.

Disintegrated fragments of quartz-veins entering a stream may be comparatively large fragments, pebbles or sands, which continue to be reduced in size by abrasion, thus gradually approaching the normal specific gravity of the gold. The movement then of such a fragment under the action of running water becomes more and more retarded until freed of all adhering gangue it attains a maximum specific gravity, and a minimum volume, when it stops and is added to the accumulation in the bed of the stream, while the gangue passes on.

It has been observed that coarse gold tends to be concentrated on soft bed-rock in preference to hard. The reason for such ocurrence is that the soft bed-rock wears away much more rapidly than the hard and therefore the disintegration of the quartz-veins is more rapid at such points and consequently more gold is freed and in larger pieces than would be the case were the wear less rapid. Further, the base-level of a stream in a soft country-rock is more quickly attained and the deposits of gravel are therefore more uniform.

" In the larger streams, when the current which transports gold along with other detrital material suffers a decrease of velocity, and hence of carrying power, some material may be dropped to the bottom, while the water flows on more slowly and gradually becomes comparatively clear. The rate of cutting and consequently the load carried by a stream has much to do with the deposition of the gold carried. A greatly over-loaded current will deposit too rapidly to admit of the concentration of the gold and especially the fine gold. Evidently then there is a certain relation between the velocity of current and the load of débris carried that is of considerable importance in determining the character and location of the pay streak. Further, this condition of affairs varies considerably with the position of deposit with respect to the banks — there may be an unloading on the outer rim and an overloading on the inner.[1]

It thus happens that in long rivers which flow through auriferous formations or whose feeders cut auriferous rocks there are at intervals deposits of fine gold in gravelly accumulations. Such accumulations of detrital material are known among the miners as bars, and when sufficiently rich in gold to repay working, these are called 'bar diggings.' Bars are formed wherever the curves of the channel are such that the current flows off at a tangent to the bank, thus producing slack water and often back water or an eddy in the immediate vicinity of the bank. Thus the most common loci for bars are points immediately below where a pronounced curve changes suddenly for another. Slightly concave irregularities in an otherwise straight channel also produce the conditions necessary for these deposits, since such concavities will not ordinarily influence the course of a moderately swift current."[2]

The character of the bed-rock when not covered with gravel is largely responsible for the nature of the deposits and may contain within itself the larger part of the gold. In comparatively soft bed-rock the gold may be found in paying and often large quantities for a depth of 18 to 24 inches, while hard bed-rock, especially when fissured and cut by cleavage planes, may hold the largest values. Subsequent deposition of gravel may form a deposit of many feet depth throughout which much gold may occur, thus forming an exceedingly rich gravel bed. When a stream crosses a formation consisting of stratified rock more or less tilted so that the upturned edges of the strata form riffles on a large scale, or when under similar conditions hard and soft strata alternate one with the other, exceptionally favorable conditions exist for the collection of both coarse and fine gold.

The position of such riffles with respect to the stream has much to do with the collection of gold on the bed-rock and in the overlying gravels. To illustrate this point the bend of a stream cutting upturned strata may be taken. If the case is chosen where the course of the stream directly at the bends is at right angles with the stratification, there will be no other point in the stream's course except at the bends where the same conditions exist. Now, the effect of riffles placed normal to the current of a sluice (the same being applicable to streams) causes a uniform settlement of the transported gold, but

[1] Min. and Sci. Press, Vol. 77, p. 108.

[2] U. S. G. S., 18 Ann. Rept., Pt. 3, pp. 360, 361, 1896.

on changing the direction of the riffles with respect to the current it is found that there is a deflection of the sorted material, which occurs on the side of the larger or obtuse angle. It is evident then that on approaching such a bend, with the current, the pay streak of gravel beginning on the left hand side approaches the middle of the stream at the bend, after which it shifts to the right side and ultimately hugs the bank only to be again thrown across the stream by a reverse bend.[1] With streams of variable cross-section the above-described method of deposition of gold may be somewhat modified.

The bed-rock may be soft and decomposed, or hard, as granite and slate, but in nearly all cases it is usually uneven and full of crevices which form the riffles that have caught and held the gold. In most of the largest and most prominent camps the richest spots are generally those on hard rough bottoms, where the gold has been picked out by hand from the crevices and with small tools, as knives and spoons. Montana Bar, Confederate Gulch, near Helena, Montana, is said to have yielded four men $1,200,000 from three-quarters of an acre in 100 days, the bed-rock being tough, hard and ragged.[2]

The extensive distribution of gravels in benches on hill and mountain sides may be partially due to river action but not entirely so in some cases at least. Where there are evidences of recent submergence, as in Alaska, it is probable that the origin of the deposits of gravel is marine, or that they have been redistributed by marine action. However, the lower terraces or benches are probably remnants of older river-beds left by the down-cutting of the present streams.

The Summit Diggings of the Mojave desert have derived their gold from the flat mesa lands, the concentration having been effected by winds, and as might be expected the surface sands are richer than those at a depth.

Placers have also been formed by slides which, however, come from older gravel beds and must, therefore, be considered to have a water origin. An excellent example of such an occurrence was observed at Morris Ravine, where a mass of auriferous material several miles in extent was found to be gradually moving forward into the workings as hydraulicing proceeded from below, clearing

[1] Min. and Sci. Press, Vol. 68, p. 165.

[2] Min. and Sci. Press, Vol. 79, p. 60, and U. S. G. S., 18 Ann. Rept., Pt. 3, pp. 375 and 376, 1896–97.

away the deposit to bed-rock. There is no doubt but that landslides contribute in many instances to the accumulation of auriferous materials and possibly to a much greater extent than is usually suspected.

As a rule gold occurs on or close to bed-rock. However, many large bodies of gravel have been found in which the gold has been uniformly distributed from surface to bed-rock. The coarser gold is usually found in the lower portion of the deposit unless the stream has built up from a lower base-level with comparatively long intervals of activity followed by others of inactivity when no change in level occurred. Under such circumstances different levels or zones of gravels can readily be traced out, in which considerable variation in size of gold grains is noted and there may be several successive layers of coarse gold with quite a distance, vertically, intervening.

It is claimed that the concentration of gold, iron sands and other heavy minerals is also brought about by gravity — "thus effecting a concentration variously perfect in different places, and that in this process the passage of the gold particles is mechanical."[1] However, without some movement, although comparatively slight, such action could not take place. In ordinary placers the only cause for such movement would be the circulation of drainage water which in itself would be slight and probably accounts for the imperfect concentration noted, but in regions, as Alaska and Siberia, where alternating freezing and thawing is of daily occurrence the resulting expansion and contraction would suffice to produce a decided downward movement of the gold grains. The retention and concentration of the gold at the bottom of the gravel or on the bed-rock would then depend upon the existing conditions — if rough, it would tend to remain at or near the point where it came in contact with the bed-rock, if smooth it might travel for some distance before coming to rest. It is evident then that in the former case the tendency would be to form a fairly uniform deposit on the bed-rock, while in the latter case the distribution would be very irregular, but exceedingly rich.

The occurrence of gold in gravel deposits may be still further complicated by the crossing of rivers, the gravel deposits formerly built up being washed out and redistributed by the subsequent action of another river running in a somewhat different direction, which action may be repeated a number of times, with added confusion as to occurrence of gold-content and thickness and character

[1] U. S. G. S., 18 Ann. Rept., Pt. 3, pp. 375–377, 1896–97.

of the gravel deposit. Again the course of a stream may be changed or it may be split up into two or more parts by landslides, glacial action, flows of lava and the choking up of the channel owing to excessive wash from above without sufficient grade to bear the débris away and thus preventing its accumulation. The splitting up or spreading of rivers brought about by the accumulation of débris in the channels may result in the formation of a gravel deposit extending over large areas, in which case they resemble to a marked degree lacustrine deposits.

The cemented gravels commonly known as "cement gravel" may consist of volcanic materials of brecciated or conglomerated character or may be a quartz conglomerate cemented by ferrous oxide or iron pyrite, lime or siliceous materials, but is a term of variable signification.

Ferrous oxide results from the oxidation of pyrite through contact with a continuous flow of surface waters percolating through the deposits — blue is the characteristic color. With an intermittent movement of the surface water and where oxidation is rendered more complete by the action of atmospheric agencies, ferric oxides result which are seldom effective bonds — such gravels are red. The so-called "pyritic cementation" is probably produced by uprising sub-surface currents, while siliceous and calcareous cementation is caused by surface waters. Here too cementation is seldom complete, the deposits being an agglomerate rather than a conglomerate — the distinction if any being that the first distintegrates into its original constituents, while the latter does not.[1]

Pipe clay, a more or less indurated clay, is usually a characteristic formation accompanying gravel deposits and especially the "deep" gravel.

The deep gravels are usually composed of layers of gravel, sand, volcanic ash or clay and lava usually in the order given from the bottom up. About the only regularity in occurrence is in the position of the gravel and lava, the former being at the bottom and the latter at the top of the deposit. The layers of sand and ash are flat and lenticular, varying in thickness from 6 to 8 and 12 yards, while their lateral extent is considerably greater. The volcanic materials consist of scoria, sand, mud or basalt, and owing to their extreme hardness have resisted wear — they now stand as mesas. The lava may have flowed into the river channels or been washed in as rounded, water-worn boulders. The most common form of material comes

[1] Min. and Sci. Press Vol. 84, p. 59.

from the consolidation of volcanic mud and ash and occurs in light-colored, fine-grained, homogeneous beds. Occasionally lava occurs interstratified with the gravel.[1]

The minerals and metals occurring in gravel deposits naturally consist of those found in the rock traversed by the streams forming the placers, but there are certain minerals almost always present and as an illustration those found in the California auriferous deposits are given; zircon, magnetic iron-sand and garnets are the most common, while platinum, iridosmine, rutile, epidote, chlorite, topaz, cassiterite, diamonds, etc., are often present.

Gold is found varying in size from the smallest particles to large nuggets. That of the size of flax and melon seed being considered coarse, while all under that is fine.

The top gravels usually carry fine gold of high-grade, the coarser being nearer bed-rock as previously indicated. The gold grains are usually more or less flattened with rounded edges, but at times rough and showing but little evidence of abrasion — they often occur attached to the original matrix thus showing their proximity to the parent vein. The gold of the upper gravels often has a crystalline form. Occasionally placer gold resists amalgamation owing to a coating of silica and sesquioxide of iron covering the grains, when it is saved by its specific gravity alone.[2]

The difference in character of gold according to its position with respect to bed-rock is shown to good advantage in the River Cauca of Colombia, Central America, although the usual order as to value is reversed. The deposit is some 20 feet thick and contains gold varying in size from dust to nuggets the size of pigeon eggs. Near the surface or the "playa" the composition is gold, 67.06; silver, 32.94. Ten feet below the surface the composition is gold, 75.97; silver, 24.03. While the composition on bed-rock is gold, 78.70; to 90.40; silver 9.60 to 21.30.[3]

Ocean placers or beach gravels occur along the Pacific coast at various points extending from Klamath County, California, northward into Oregon. There are several theories as to the origin of the gold in the sands, of which the following have been given some prominence:

1. Sub-ocean quartz ledges may furnish the gold. In fact it is well known that a gold-bearing formation exists, and extends beneath

[1] T. A. I. M. E., California Mines and Minerals, p. 20, 1899.

[2] T. A. I. M. E., California Mines and Minerals, p. 24.

[3] Min. and Sci. Press, Vol. 53, p. 151.

the ocean from Point San Pedro to Point Reyes. However, the theory is hardly tenable.

2. The gold may be brought down with the silt as a deposit from the waters of the Sacramento River, which are subject to redistribution by the tidal currents.

3. That the source of the gold is the adjacent bluffs, which are known to contain gold, and further the beaches are noticeably enriched after a storm that has broken away large masses of the bluffs. However, it is rather odd that less coarse gold is found with the source so near at hand, yet the bluffs themselves may have been built up from similar materials.[1]

4. Deposition of gold from solution in the sea water has been suggested, especially in connection with the beach gravels of Cape Nome, Alaska.[2]

Alabama. — There are three general forms of placer deposits that have been worked in the Southern states, namely: 1, ordinary stream deposits; 2, hill-side and gulch deposits produced by the action of gravity and frost, and, 3, the decomposed but not disturbed country-rocks commonly known as "saprolites." The character of these three forms of deposits are very dissimilar, the first being a true gravel deposit with rounded water-worn pebbles; the second consists of angular fragments, the deposits varying from a few inches to several feet in thickness, while the third is in no sense gravel, being the decomposed rock in place, its gold-content having been derived from the quartz-veins.[3] Although the above characteristics are especially applicable to the South Mountain gold belt yet they will apply fully as well to the whole gold-bearing region of the South.

In the early days placer-mining was carried on rather extensively about three-quarters of a mile southwest of Arbacoochee and principally in the Clear Creek valley. Fully 100 acres of auriferous gravel was found at this point.

The only hydraulic-mining done in the state prior to 1900 was conducted by the Arbacoochee Hydraulic Company near Arbacoochee. A deficient water supply and poor management caused the abandonment of the enterprise.[4]

As late as 1904 quite extensive preparations were made to

[1] Min. and Sci. Press, Vol. 37, p. 210.
[2] Min. and Sci. Press, Feb. 10, 1906, p. 89.
[3] T. A. I. M. E., Vol. 25, p. 673, 1895.
[4] T. A. I. M. E., Vol. 25, pp. 64 and 65, 1895.

hydraulic gravels at Kemp Creek post office, Cleburne County, which if successful will probably lead to the establishment of other similar plants in the state.[1]

Gold is obtained both from gravel deposits and zones of decayed rock or saprolite.[2]

Alaska. — There are four forms of gravel deposits in Alaska, namely: gulch diggings, bar diggings, ancient and fossil placers, and old lake beds, of which the first two mentioned have up to the present time proven of the most importance. These conditions obtain especially along the Yukon.

Placer gold has a very wide distribution in Alaska, having been found as far south as the southern boundary and at various points northward to the 60th parallel and westward to Bering Strait. The area of workable gravels has a width of about 200 to 300 miles and trends in a northwest and southeast direction, beginning at the south Pacific coast running thence north and west to the Strait.

The source of the gold is mainly quartz-veins and stringers traversing the metamorphic rocks consisting of schists, phyllites, limestones, quartzites and altered igneous rocks. Gold, however, occurs in the country-rocks of the mineralized zone. It is evident from the appearance of the gold and its associations that it has not traveled far from its source, which is usually within the basin in which it is found. Change in drainage areas may in some cases have brought about an interchange of products from different basins. It is very likely, however, that the rich placers have been produced by secondary concentration — erosion acting on placers and causing a redistribution. It is evident that under anything like favorable conditions the perfection of concentration increases with the frequency of sorting, but with a decided tendency toward irregular distribution. Further, the repeated sorting effected on the coastal plains has produced marvelously rich placers, as at Nome.[3]

Probably the richest placers, as a rule, are the gulch and bar placers of the interior. Low-grade deposits occur at higher elevations, especially in the Klondike, having an elevation of 300 feet or more at Dawson — these are known as "bench gravels." Bench gravels have been found elsewhere in Alaska but have not been worked to such an extent as in the Klondike.[4]

[1] The Mineral Resources of Alabama, 1904, p. 56.

[2] Index to the Mineral Resources of Ala., Geol. Survey of Ala., p. 54, 1904.

[3] U. S. G. S., Bull 213, p. 41.

[4] Eng. and Min. Jour. 76, p. 807.

The Forty Mile placer district in the Yukon gold region contains gulches which drain into Forty Mile Creek and Sixty Mile Creek; however, the line of the international boundary traverses the district, so dividing it as to throw several of the gulches of Sixty Mile Creek, as the Miller and Glacier into British territory; nevertheless the greater part of the district is American.[1]

The bar-diggings are productive of comparatively fine gold only, or that which is light enough to be transported to considerable distance by the rather rapid gulch streams; however, owing to the rather high grade of these tributary streams some of the gold grains are of fair size. "Most of these accumulations of gold are extremely recent, as is shown by their coincidence with the channel of the present stream and their evident relation to the present currents. Moreover, the gold-bearing gravel is nearly always confined to the actual surface and varies in thickness from 20 inches to half an inch."[2] It is found that after the lapse of a number of years these bars can be reworked, showing that there is a gradual enrichment in progress.

Besides the gulch and bar-deposits are many others of much earlier age occurring at various heights above the level of the present streams. They are even found covering large areas on plateaus. An extensive study of these deposits has led to the conclusion that their formation cannot be attributed entirely to river action, but that they have been formed wholly or in part by marine action. In some cases it is evident that there has been simply a redistribution of river gravels, while the deposits occupying the lower terraces were undoubtedly formed by the down-cutting of the present streams. So far these deposits have not been exploited to any great extent.[3]

Deep or fossil gravels are found especially on Napoleon Creek and along the Koyukuk, and consist of a coarse basal conglomerate made up of fragments of quartzite, vein-quartz, gray and green slate, aplite, porphyry, and other rock derived from the country-rock of the adjacent region. From the occurrence of gold in the streams it is evident that it has come from this conglomerate.[4]

The remarkably uniform and practically horizontal deposits of gravels consisting of schists, gneisses, granite and vein-quartz as

[1] U. S. G. S., 18 Ann. Rept., Pt. 3, p. 317, 1896–97.
[2] U. S. G. S., 18 Ann. Rept., Pt. 3, pp. 360, 363, 1896–97.
[3] U. S. G. S., 18 Ann. Rept., Pt. 3, p. 364.
[4] U. S. G. S., 18 Ann. Rept., Pt. 3, p. 365, 1896–97.

observed in the broad valley of Crooked Creek seem to indicate the presence of a large body of water such as a lake in which this accumulation took place.[1]

That portion of the Yukon region which lies in American territory is divided into a number of districts, namely: the Forty Mile, Mission Creek, Birch Creek, etc. Tributary to these are a large number of gulches which make up the districts.

In southern Alaska gold-bearing beach sands are especially abundant from Lituya Bay to Yakutat Bay. These sands do not occur in masses but in patches varying from one inch in thickness to a mere trace, and when such patches are found they are collected and carried out of reach of the waves. The Kadiak sands consist of magnetite, garnet, slate, serpentinoid material and very light, scaly gold, which tends to float and does not amalgamate well.[2]

Placers have been found on Turnagain Arm at the head of Cook Inlet along Resurrection, Bear and Six-mile creeks. The pebbles are mostly diorite and the gold is usually in flattened but coarse and somewhat worn grains — its color is light.[3]

In Silver Bow Basin the lake-beds are gold-bearing and often to a considerable extent. The deposit consists of a fine muddy sand of about a foot in thickness, upon which is a few inches of vegetable mold and upon that in turn large boulders ranging up to two and three yards in diameter, with which are sands and gravel. Many of the pebbles are gold-bearing quartz. In the locality are considerable areas of decomposed rock or saprolite, similar to the occurrences in the southern Appalachians, which is gold-bearing and has for some reason escaped destruction by glaciation. It is probably the wash from such deposits that has filled the lake-beds.[4]

Placers also occur on Douglas Island and it was while working one such that the low-grade quartz deposit of the Alaska-Treadwell mine was laid bare.

Gold-bearing gravels are found in the Ketchikan district on the Kassan Penninsula but they are not extensive and do not form an important source of gold.

Cape Nome is a point of the southwest coast of the Seward Peninsula which is the western extremity of northern Alaska. Extending inland from Nome is a gently sloping tundra which at a distance of

[1] U. S. G. S., 18 Ann. Rept., Pt. 3, p. 343, 1896–97.
[2] U. S. G. S., 18 Ann. Rept., Pt. 3, p. 85.
[3] U. S. G. S., 18 Ann. Rept., Pt. 3, p. 81.
[4] U. S. G. S., 18 Ann. Rept., Pt. 3, pp. 71 and 72, 1896–97.

203 miles breaks abruptly into hills with an elevation of 1000 feet, being totally void of any vegetation except a covering of moss and Arctic shrubs. Anvil Creek, upon which gold was originally found, rises in these hills and probably has been most productive; however, gold in considerable quantities has been obtained from Glacier, Dexter and Dry creeks. The supply of gold in the beach-sands has been largely exhausted although portions of it have been reworked at least three times, the gold-content apparently renewing itself.

Beyond the Nome district but still in the Seward Peninsula gold occurs in the Bluff district, on Daniels Creek, the Solomon River and at Topkok beach. Ophir Creek, in the Council district and Dahl Creek, in the Kougruk district have both yielded considerable gold. Further, gold has been found still to the northeast in streams flowing into the head of Kotzebue Sound among which are the Inmachuk River, the Kewalik River and its tributaries, Candle and Shumnak creeks. Gold also occurs in the streams of Cape York, the western point of Seward Peninsula. Anvil, Ophir and Daniels creeks stand first in production in the Seward Peninsula.[1]

Beach-mining has been carried on in the Bering Sea by digging through the ice where the water was shallow and freezing took place to the sea bottom. In certain localities such mining was possible for a distance of one-quarter of a mile from the shore. There is no water to contend with in this work.[2]

Prospecting by bore-hole and shafts in the tundra lying between the Bering Sea and the inlying hills, has revealed the character of these deposits. It is claimed that the results obtained were very satisfactory and have proven the presence of layers or zones of pay gravel varying in thickness from six inches to three feet, and in a few instances of 30 feet. The shafts sunk have seldom exceeded a depth of over 120 feet, the average being between 60 and 75 feet. However, owing to the irregularity of distribution and the distance apart of the shafts no definite idea as to occurrence of the gravel or its gold-content could be arrived at, only local conditions being shown. The deposits of gravel and clay alternate one with the other and often with layers of beach-sand between. It is thus evident that the action of the sea has been the cause of concentration and that the same conditions now prevail on the beaches.[3]

Ground frozen to a depth of 150 feet is reported from Siberia, but

[1] Eng. and Min. Jour., Vol. 76, pp. 852 and 853.
[2] Min. and Sci. Press, Vol. 83, p. 51.
[3] Min. and Sci. Press, Vol. 86, p. 132.

it is doubtful if, except in extreme cases, frozen ground occurs to that depth in Alaska; however, shafts have been sunk in gravel deposits frozen for a depth of 65 and even 100 feet, and that frost may be found at greater depths is not unlikely. Contrary to the generally accepted idea, these deposits have not been frozen from the surface downward, but rather from the bottom upward, or the reverse from the usual order of things. The facts are that in those localities favorable for the accumulation of débris and wash by slides and freshets, comparatively great depths of frozen ground are observed, while in other localities not so situated the ground is frozen only to moderate depth, i.e., only a few feet. It is therefore evident that each year, during the winter months, the accumulations of the preceding summer are frozen, which are covered by slides and sediments during the following spring and summer from the higher ground, and that, too, before the ground is thawed very deep, and this is frozen during the next winter; thus year by year the accumulation grows, a frozen layer of deposit being added each year — in other words, the deposits freeze as they form. Further, there is little doubt but that periods of subsidences and elevations added to and increased the importance of such action.[1]

It is a well-known fact that the tundra is not frozen, or if so, to slight depth only in the neighborhood of growing trees, especially willows.[2]

High benches were discovered in the Nome district in 1900, which are situated on the divide between Anvil and Dexter creeks. The following locations are among the more important: Bowery, Molasses, Honey, Sugar, Snow Flake, Mattie F., Daisy and Madeleine.[3]

The principal creeks in the Fairbanks placer district are: Pedro, Cleary, Chatham and Wolf, all of which are tributaries of the Tanana River. In 1905, the Cleary, Pedro and Fairbanks creeks were probably of the most importance.[4]

Arizona. — Extensive auriferous gravel deposits are found in various parts of the state, but especially east of La Paz, and on both banks of the Gila River in the vicinity of Gila City, Las Flores and Oroville. As a usual thing the gravel is composed largely of slates and often contains some earthy material. The rock fragments show but little wear, being rather angular and sharp. The

[1] Min. and Sci. Press, Vol. 79, p. 379.
[2] Min. and Sci. Press, Vol. 86, p. 132.
[3] Min. and Sci. Press, Vol. 86, p. 182.
[4] Eng. and Min. Jour., Vol. 78, p. 216, and Ibid., Vol. 80, p. 1013.

deposits are found in ravines or gulches, and are usually continuous to the open mesas above. As a rule the gold is very pure, averaging probably $19.75 per ounce. Owing to the lack of water practically all the gold obtained comes from dry-washing, and therefore only the coarse gold is saved. The Papago Indians for years sold gold to the merchants of Tucson.

Probably the best placers were found in Yavapai County, about 1863. Large quantities of gold were taken from the upper Hassayampa, Lynx and Big Bug creeks, but it differed quite materially from that of the Gila. It is considerably finer, and not so pure, ranging in value from $15 to $17 per ounce. The placers of Ehrenburg, Yuma County, cover an area of 40 miles long by 15 miles wide. Nuggets ranging in value from $2 to $10 have been taken from the gravels. The Mexican system of dry-washing is that usually practiced.[1]

Gold was obtained for a time from the small streams of the Bradshaw Range, but they were soon worked out, and the search for veins began. In 1894 two steam shovels and washers were in operation.

California. — The detrital deposits of the Sierra Nevada are not only of considerable extent both vertically and laterally, but are also of great interest, and are probably of more importance than any other similar deposits in North America. Their formation has occupied a geological period of considerable length, even extending into recent or post-Tertiary times. They consist largely of volcanic and derived materials, and are usually sufficiently auriferous to warrant working. The bed-rock is granitic and metamorphic, and as a comparatively large part has a slaty structure, the term "auriferous slate series" has been applied to it. However, the "auriferous slates" or non-granitic rocks are only slightly gold-bearing, but bear the gold quartz-veins, the disintegration and demolition of which has freed the gold found in the gravels. Superimposed upon this mass of detrital material is a covering of volcanic materials, which with the gravels constitute the superficial covering of the western slope of the Sierras.

Those portions of the Mother lode composed of dolomitic and magnesitic materials disintegrate readily, forming a loose ferruginous mass or gossan traversed by a network of quartz-veins and stringers together with slate and clay bands, the whole mass often being

[1] Eng. and Min. Jour., Vol. 11, p. 58 and Gold, Its Occurrence and Extraction, A. G. Lock, pp. 128 and 129.

auriferous. The quartz-veins are probably the source of the gold found in the enclosing materials. Such decayed materials resemble somewhat the saprolites of the southern Appalachians.

Besides the auriferous gravel deposits of the western slope of the Sierras other extensive deposits are found in the Coast Ranges, but have been worked only to a limited extent.

Gold-bearing gravels are also found in the northern and southern parts of the state and in the cañons and valleys of the San Gabriel and San Bernardino mountains.

Of the auriferous gravel deposits lying on the western slope of the Sierra Nevada Mountains only certain portions are of sufficient richness to be profitably worked, the richer portions being identified with the "auriferous slates." Beginning with the northern part of the productive area and proceeding southward, the principal deposits lie within and between the following counties. Tuolumne to Calaveras and thence to Amador, of which El Dorado, Placer, Nevada and Sierra are of the most importance, while Butte and Plumas counties are of somewhat less importance.[1]

The original source of the gold was the auriferous slates or the metamorphic rocks, either from the enclosed quartz-veins alone or both the veins and the slaty rock. According to Whitney the gold might readily have been derived from the country-rock as the occurrence of gold is widespread throughout these rocks. However, the quartz-veins themselves would be amply sufficient to furnish the gold for the placers. Whitney further considers that the materials from which the older gravel beds were formed were richer in gold than the source of the recent gravels.[2]

The westerly slope of the Sierra Nevada at the beginning of the formation of the gravel beds was a broad, gently undulating and

[1] Gold, Its Occurrence and Extraction, A. G. Lock, pp. 135–137, 1882.

[2] That the gold found in the gravel was derived from the disintegration of auriferous veins was held to be the only logical explanation by the two eminent authorities — Professors J. D. Dana and W. P. Blake.

Professor Blake gives the following classification of the auriferous deposits:

"First. We find great boulder like drifts, the result of great abrasion and powerful currents in a great body of water.

Second. A river drift, or coarse alluvium, ancient and modern.

Third. Alluvial deposits on flats and over broad surfaces. Not confined to river channels.

Fourth. Lacustrine deposits — at the bottom of former ponds or lakes."

Notes on California, Silliman's Journal, Vol. 7, 1849, and Twelve years in the mines of California, pp. 57–60, 1862.

moderately hilly country having a slope not unlike that which exists to-day, the average pitch being from 100 to 130 feet per mile. Streams having their source among the peaks several thousand feet above the sea level found their way to the valley below, traversing considerable areas before finally debouching into the plains at the foot of the mountains. The greater the distance traversed by these streams, the greater would be the accumulations of débris and the greater the area covered by the same. Very probably this condition of affairs continued until the advent of the volcanic era, when the whole western slope of the Sierras was covered by overflows of lava and showers of volcanic ash, thus entirely changing the appearance and condition of the surface of the country. Not only were the streams obliterated but the rocks from which the gold was derived were buried, thus effectively bringing to an end the first great gravel-producing period.[1]

At the close of the volcanic period new streams began to form and work their way seaward. At first they ran more or less at random over the comparatively smooth plains of volcanic materials, often hard and resisting but probably more often loose. However, their general course was in a southwesterly direction, and it was not long before they began to cut channels. In the course of time channels were cut deep enough to restrain the largest floods, and thus concentrated the down-cutting action to the course of the stream. Subject always to heavy floods and confined to deep V-shaped cañons of steep grade coupled with the intensified cutting action of rapidly moving débris, the rapidity with which these streams cut through the overlying lavas, then through the gravels, and lastly into the bed-rock, is astounding, and would scarcely be believable if evidence of such were not present in the form of cañons ranging from 1500 to 2000 feet deep, of which depth from two-thirds to three-fourths and even more is in solid bed-rock beneath the gravel.

At points where the volcanic cap was thin or had been worn away, the hydraulic mines operated, while where considerable thickness of cover still remains were located the drift mines.[2]

The following interesting summary of the events incident to the formation of the gravel deposits has been given:

1. The Pliocene or ancient eroding period, during which the deep "dead" river channels were cut into the bed-rock.

[1] Gold, Its Occurrence and Extraction, A. G. Lock, pp. 139 and 140, 1882.

[2] Eng. and Min. Jour., Vol. 28, p. 300.

2. The Pliocene channels filling up with gravel, or the choking or damming period.

3. The active volcanic period of the Sierra, when the gravels were capped with lava and volcanic ash.

4. The cold or glacial period, when the mountain slopes were covered with living, moving glaciers.

5. The modern erosive, or recent, period during which the present river channels were formed, crossing the old channels at various angles.

The filling of the ancient river channels with gravel may have been produced by several conditions, such as: 1, change in quantity of rainfall, and 2, change in gradient of rivers. It is not probable, however, that there was any material change in gradient, as the course of the present rivers corresponds closely with the ancient or buried channels.

It is not difficult then to imagine how the gold-bearing gravel deposits were formed, having some idea of the vast geological periods during which erosion acted prior and subsequent to the volcanic periods which intervened, the amount of débris which filled the channels of the rivers, and the character of the formations which contributed to the formation of the gravel beds.[1]

The thickness of gravel deposits in the state varies considerably with the location; the following figures give a general idea:[2]

Clinton mine, Grizzly Cañon	20 feet.
Todds' Valley	35 "
Smiths' Point	50 "
Vaughns' claim, Wisconsin Hill	55 "
Gopher Hill	240 "
Magara, Slate Creek	300 "
Indiana Hill	400 "
Cherokee Flat	430 "
Gold Run, Blue gravel	150 "
Blue Tent	650 "

Many and varied have been the theories as to the "blue lead," the one most persistently held to being that the blue gravels filled the channel of an extinct river of great size, but with the development of the gravel deposits it was found that blue gravels were widely and irregularly distributed, and therefore could not have been deposited by a single river. Ideas as to its origin then began to change, until now it is generally conceded that blue gravel may occur in any deposit, provided that the conditions are favorable. It usually

[1] Min. and Sci. Press, Vol. 26, p. 56.
[2] Min. and Sci. Press, Vol. 60, p. 264.

occurs near or next to bed-rock, and is composed of boulders of serpentine rock, talcose slate (in fact all metamorphic rocks), quartz boulders, gravel and sand, all more or less associated with clay, the latter usually being considered a good sign as to richness. The color varies from blackish green to indigo blue; even the quartz has a bluish tinge, which resists both washing and exposure.

The blue lead varies in thickness from a few inches to 100 feet, and is generally considered to be not only the richest but the most important and reliable gold-bearing gravel deposit in the state. As a rule the blue lead deposits are readily worked, seldom being cemented; however, exceedingly hard blue cement gravel is occasionally encountered, and has to be drilled and blasted and milled similar to gold-quartz. With such occurrences hydraulicing serves simply to clear away the over-burden, and prepare the way for work upon the hard cement below. Further, the blue cement is usually very rich. Next above the blue lead comes a deposit of yellowish or reddish gravel ranging from 5 to 25 feet in thickness, which is readily worked by hydraulicing. It is composed of "rotten boulders" of quartz and clay-slate. The upper gravels occupy a position directly above the yellowish gravels and decayed boulders, and consist of deposits of quartz, gravel and sand of considerable thickness and extent. This last layer of gravel contains the greater part of the fine or flour gold, often in such quantities as to make it profitable to work.

Great bodies of quicksand occur on the bed-rock which, when charged with water, constitute one of the most serious obstacles to development. The presence of iron cement and pipe-clay are also characteristic occurrences of the dead river gravels. The former occurs in thin layers of very hard, brownish cement of one to two inches in thickness separating the different deposits of gravel. Pipe clay is found in all deep gravels, usually occurring near the bed-rock, and is in reality a mud deposit. It also becomes quick under the influence of water, turning into a muck.[1]

Springs are usually considered good indications of deep channels or basins, especially when found within the rim-rock. Such channels are usually difficult and expensive to mine, owing to the large quantities of water encountered. The Old Woman's Gulch channel of Indian Gulch, south of the Mokelumne Hill is one such, and contains "blue lead" gravel.

The character of the lava capping of the deep gravels differs

[1] Min. and Sci. Press, Vol. 29, p. 369.

widely in various localities. Some deposits consist of snow-white rhyolite, above which may be a breccia of andesitic materials, or the first covering may be volcanic mud upon which lie tufa and breccia. Occasionally a capping of black basalt is found, although it is usually hornblende or augite-andesite. The covering may have been deposited as an overflow, as a shower of ash or deposited by water as a wash. The material deposited other than by overflows of lava may be loose or consolidated into a hard mass, while the lavas are often of columnar structure.[1]

It is a well-known fact that there are a number of gravel-filled channels paralleling, intersecting (usually at small angles) and often superimposed one upon the other. In those localities where the erosion of a river has exposed the deposit of a former river, the gravel may be deposited upon the earlier deposits; thus different layers or zones of pay gravel are found, the upper being designated as the "upper lead." The same conditions may obtain from a river following in the channel of an older course, a not uncommon occurrence, especially when the rims of the older river channel are prominent — both upper and lower leads are then found within the rims of the superimposed channels.[2]

Where the capping of volcanic materials is of such a thickness and character as not to warrant removing it preparatory to working the underlying gravels, various systems of underground workings are resorted to, the most common being drift-mining. The area in the state in which drift-mining has proved practicable and profitable lies on the western slope of the Sierra Nevada, extending from Mariposa to Siskiyou counties. The richest ground is probably found in Nevada, Placer and Sierra counties, although extensive operations have been carried on in Plumas, Butte, El Dorado, Amador, Calaveras and Tuolumne counties.[3]

The ocean beaches of California which have proved profitable to work are situated between Ocean Side House and Point San Pedro. On digging through the sands the deposits are found to be composed of alternating layers of black and white sands, which vary in thickness from a knife-edge to three and six inches, while at a depth of two to four feet hard-pan is reached. The gold is fine or "float" and in some cases may have been carried some distance by the waves and currents. The maximum and minimum sizes of the beach gold are,

[1] Min. and Sci. Press, Vol. 79, p. 544.
[2] Min. and Sci. Press, Vol. 78, p. 290.
[3] Min. and Sci. Press, Vol. 69, p. 34.

.0065 to .0070 and .0030 to .0035 inches respectively.[1] Other beach deposits have been found, but have proven of little value.

In the preceding pages an attempt has been made to give a general, but brief and concise account of the character and occurrence of the gravel deposits of the state. No exhaustive description of the various deposits is given in this connection as it would be a tedious narrative, and of little profit in a work of this character. However, the reader is referred to the following works for a more detailed account: Gold, Its Occurrence and Extraction, and The Auriferous Gravels of the Sierra Nevada of California.

A few typical cases of the occurrence of gold in gravels are given to illustrate certain phases of the general statements made.

The Red Point drift mine yielded the largest and richest portion of the gold from the gravels directly upon the bed-rock, and in many cases directly from the bed-rock itself. The gold was found in joints and cleavage planes in the bed-rock and around quartz-veins cutting the bed-rock. Such crevices and other depressions yielded gold to such an extent that often a foot or more of the bed-rock could be removed with profit. The greater part of the gold was found to lie on the sides of the channel, only coarse gold and comparatively little of that occurring in the deepest portion of the channel. Gold was also found in abundance on the down-stream side of islands and boulders.[2]

The ancient river gravels of Nevada County have a depth of 200 feet in places with from 300 to 400 feet of volcanic material as a covering. The bed-rock is granite, but soft and decomposed and contains hard boulders varying in size from a few feet up to 40 and 50 feet in diameter. Drift-mining is employed here, in which operation only the gravel lying upon the bed-rock is taken. The gravel is usually loose and readily disintegrates in sluicing, but occasionally a hard cemented gravel is encountered which is difficult to work with profit.

High-grade gravel ranging in value from $2.50 to $13 per ton is found in the channel proper. The gold occurs in coarse grains which imbed themselves in the soft bed-rock. The usual thickness of the workable gravel is two to five feet.

In Placer and El Dorado counties the bed-rock of the gravel deposits is often very rough as at Iowa Hill and the Morning Star mine, at Startown, while it is very smooth and much water-worn at Nahor's

[1] Eng. and Min. Jour., Vol. 26, p. 279, and Min. and Sci. Press, Vol. 37, p. 210.

[2] Min. and Sci. Press, Vol. 68, p. 165.

Claim, in Green Valley Gorge and near Damascus. Between these two extremes there are many variations. At Indiana Hill and Smith's Point furrows and channels have been cut in the bed-rock. Pot-holes occasionally occur, and in some cases yield considerable gold. Crevices also occur in the bed-rock, and are usually rich in gold, even more so than the gravels. The gravels are both cemented and uncemented, and are often interstratified with sands and pipe clay. The quartz gravel and boulders are quite variable in amount, the latter often attaining considerable size and usually near bed-rock. Occurrences of lenticular masses of clay, more or less consolidated, and of a chocolate-brown color, and varying from nothing to five feet in thickness, are occasionally met in the gravels, being locally known as "chocolate." The finer gravels or pebbles consist of quartz and metamorphic rocks, while angular fragments of igneous rocks often lie on or close to bed-rock. The thickness of the volcanic capping ranges from a few hundred to a thousand feet, and consists of black and white lava and volcanic ash and breccia. The channels vary in width from a few feet up to 100 and occasionally to 600 feet.[1]

At Mokelumne Hill, Calaveras County, the gravels are thin, but very rich. They have a capping of some 200 feet of sedimentary volcanic material. The gravel is fine-grained and homogeneous, but somewhat variable in character. Above the gravel is a layer of angular andesitic boulders.[2]

The gravel deposit of Dutch Flat, Tuolumne County, consists of coarse gravel with many boulders five to six feet in diameter. The lower gravel is usually blue, owing, it is claimed, to the big slate boulders. Above the blue gravel is a red gravel consisting largely of red and white quartz. The gold in the blue is coarser than that in the red gravel, the latter being flat and scaly and often fine.[3]

The so-called seam-diggings consist of decomposed bed-rock filled with seams and stringers of gold. Such deposits occur at the Illinois Cañon, Georgia Slide, Young's Dry Diggings, the Spanish Dry Diggings, etc. This material is not unlike the saprolite of the Southern Appalachian gold fields, and similar occurrences in Alaska. The country-rock is slate and sandstone which in some cases, as in the Spanish Dry Diggings, is filled with pyrites and traversed by

[1] Auriferous Gravels of the Sierra Nevada of California, pp. 89–112.

[2] Ibid., p. 128.

[3] Ibid., p. 151.

numerous quartz-seams. Occasionally the deposits are very pockety pinching out when the quartz-seams run into hard rock.[1]

Colorado. — In Colorado, as elsewhere, auriferous gravels were the first form of mines worked, and through their exploitation many of the veins were discovered. Among the first placers discovered and worked were those on Chicago Creek, just above the junction of Clear Creek. These deposits were known as the "Deadwood Diggings" and yielded considerable gold. Further, the decomposed rock or surface ores of veins (which might possibly be called saprolite) were sluiced to some extent. These placers were worked to the best advantage and profitably between 1859 and 1863.

In the Idaho Springs district, as elsewhere in the state, auriferous gravels may be grouped into three classes, namely: River bars, stream gravels and bench deposits. The river gravels and bars lie in or adjacent to the stream beds and consist of gravels, sands and boulders lying on the bed-rock and forming the bed of the streams. The bench deposits are in most cases remnants of ancient river beds, and have probably been added to by wash and slides from the mountain sides above. They have for convenience been divided into three classes: first, those 25 feet above the present stream level consisting largely of glacial material worked over by the present stream; second, gravel terraces situated some 55 feet above the beds of the creeks and, as has been suggested, are possibly of preglacial origin; and third, other deposits fully 180 feet above the stream channels, being composed of indurated river gravels probably of late Tertiary origin. The elevations given here are for the Idaho Springs deposits, and will vary somewhat with other locations.

These deposits were in certain places remarkably rich, the best values being found either in the deep gravels in the channels or directly on bed-rock. Mining was carried on here by tunnels and shafts, in this respect following the California practice.[2]

On the south side of Hahns Peak gravel bars have been worked in two places, namely; Ways Gulch and Poverty Bar. These gravels are probably reconcentrations from the conglomerate underlying the Red Beds, which are loosely consolidated.[3]

The placer deposits of Leadville furnished the bulk of the gold and were the principal source of the precious metals prior to the dis-

[1] Gold, Its Occurrence and Extraction, A. G. Lock, pp. 142–144 and Auriferous Gravels of the Sierra Nevada of California p. 115.

[2] U. S. G. S., Bul. 285, p. 36.

[3] U. S. G. S., Bull. 285, p. 31.

covery of silver. California Gulch was probably of the most importance, while the Iowa and Evans gulches adjoining it on either side and containing more extensive deposits have yielded comparatively little gold. The bend of the California Gulch below Oro, at the Mouth of Nugget Gulch, was probably the richest portion, the next in point of yield was the bend at the La Plata mine, while the next in importance was below Graham Gulch. The gulch gold varied from $17 to $19 in value per ounce, while that from the veins averaged about $15.[1]

The Fourmile placers are situated about 75 miles south of Rawlins in Routt County, Colorado, and Carbon counties, Wyoming, on the Snake River. They cover an area of some 1200 square miles and range from 2 to 20 feet thick, average probably nine feet. The gravels occur on the uplands or mesas, the bed-rock having an elevation of 100 to 150 feet above the valley. As a rule the gravel is free from cement, pipe clay or boulders and is readily broken down and washed. The gold is quite uniformly distributed throughout the gravel and is easily saved. It is claimed that the yield of the gravel is 20 cents and upwards per cubic yard. The principal creeks in the district which yield gold are: Fourmile, Timberlake, Thornburgh, Dry Gulch, Scandinavian and Big Hole. Gold is also found for a distance of ten miles along the Snake River, beginning south of Big Hole Creek.[2]

At Fairplay and for some distance below, the bed-rock in places is fully 35 feet below the stream bed, showing a depth of deposit of 100 feet. About ten miles from Fairplay are the Alma placer workings. Here the bed-rock is a coarse sandstone known as Weber-grit, upon and in the crevices of which most of the gold occurs. To save the gold often several feet of bed-rock are removed. The gravels vary from 50 to 75 feet in thickness being made up of sand, gravel and boulders, the latter of porphyry and of a considerable range in size. Besides the porphyry, granite and quartzites are present in varying quantities. The gold varies in size from dust to quite coarse grains and nuggets, the former extending even to the grass-roots.[3]

On Swan River are the Fuller placer mines. There are three forks of the Swan River, namely; the North, South and Middle forks — the South Fork is in a country of porphyritic overflow and carries gold, while the Middle and North forks are barren of gold,

[1] U. S. G. S., Monograph No. 12, p. 515.
[2] Eng. and Min. Jour., Vol. 60, p. 102.
[3] Mines and Minerals, Vol. 21, p. 128.

the former lying wholly in slates and sandstones, the latter has its source in a granite-country. The gold-bearing gulches of this district are: the Georgia, Brewery, Brown, French, Mayo, Illinois, Boston, Dry and Negro. The first or Georgia Gulch was worked as early as 1859.

Some placer-mining has been done at Cripple Creek and vicinity, but owing to the peculiar condition of the gold which has been derived from the oxidation of tellurides, being light and powdery or spongy, no very rich placers have been formed. Limited operations have been conducted at Hull City, along Beaver Creek, in Squaw Gulch, Arequa Gulch and on Wilson Creek. Gophering has been attempted on the southern slope of Mineral Hill, the gravels being washed in rockers, and dry-washing has also been tried.[1]

The Carolinas. — There are two gold-bearing districts or belts in the Carolinas and Georgia, namely: the western goldfield of North and South Carolina and Georgia, and the field of central North Carolina and Georgia. The former being close to the Blue Ridge lies in the highlands where the valleys are deep. The gravels being nearer their source are coarser and, as a rule, the deposits are more abundant and thicker than in the central field.

The following streams cross the gold-belt in their downward course from the Blue Ridge; the Catawba, Etowah, Chestatee, Yahoola and Cane Creeks. These streams and their branches are auriferous and as they have cut downward have left hill-deposits and old channels filled with gravel.[2]

The character of the auriferous deposits which are worked as placers in these states are similar to those of Alabama, consisting of gravels and saprolites.[3] (See Alabama). Small scale placer-mining has been carried on in various parts of North Carolina. At the Portis mine, Franklin County, auriferous saprolites are worked by surface-sluicing and hydraulicing to a depth of 15 to 30 feet. The country-rock is diorite which is intersected by quartz-stringers. The Sam Christian mine near Troy is a gravel deposit varying in thickness from one to three feet. The gold was mostly coarse and many nuggets weighing from 5 to 1000 pennyweight were obtained. The Crawford mine, Stanley County, is a true gravel deposit in which the gold is coarse and nuggety. The bed-rock is slate upon which lie angular fragments of quartz and country-rock in a clay matrix,

[1] U. S. G. S., Professional Paper No. 54, p. 152, 1906.
[2] T. A. I. M. E., Vol. 25, p. 798, 1895.
[3] U. S. G. S. 16th Ann. Rept., Pt. 3, pp. 289–293, 1894–95.

and is often spoken of as cement. The nuggets show but little wear, being rough and irregular. Hydraulicing has been carried on at the Parker mine, at New London, for a number of years. The gold is coarse and nuggety. Auriferous saprolites are also worked here by a combination sluicing and milling process. Placer-mining has also been the principal source of the gold from Burke, McDowell and Rutherford counties.[1]

The auriferous gravel deposits are often spoken of as grits being composed of loose beds of disintegrated veins, the gravel being both rounded and angular. The origin of these deposits is recent time, even the present. They vary in thickness from a few inches to many feet and vary fully as much in richness as in thickness.[2]

Small scale placer workings have been carried on at various points throughout the state and the first work done at the Haile mine consisted of branch washing, later changing to open-cutting and still later to underground mining. The gold from Spartanburg, Greenville, and Pickens counties comes largely from placers.[3]

According to Tuomey the gold occurs in South Carolina in " deposit " or " branch " and " vein " mines; the former having been formed at two different times or periods. The first constitute the most extensive mines of the state and consist of much worn pebbles and gravel none of which is much larger than six inches in diameter and has undoubtedly been transported from a great distance as it cannot be traced to its source. Such deposits are found in the Tomassic Valley, on the Tyger near the summit of Blue Ridge, at the foot of Poor Mountain and at Rankin's, on Little River. The second and more recent deposits consist largely of angular fragments of quartz which can be readily traced to their source in the veins in the neighborhood. In fact most of the veins were found by following up the placer deposits. Such deposits have proved remunerative at Estatoe, in Abbeville; on Lawson's Fork, in Spartanburg; and in Cherokee Valley. The gold, especially the larger pieces, is somewhat water-worn and is purer than the vein-gold.[4]

Georgia. — (For distribution of gold-fields see the Carolinas.) Surface washing of gold began in Georgia and North Carolina in 1829, and extended from the Rappahannock River, in Virginia, to the Coosa, in Alabama. Gold occurs in this state as elsewhere in the

[1] T. A. I. M. E., Vol. 25, pp. 693–717 and Ibid. Vol. 25, p. 728.

[2] Gold, Its Occurrence and Extraction, A. G. Lock, p. 155, 1882.

[3] T. A. I. M. E., Vol. 25, pp. 717–718.

[4] Gold, Its Occurrence and Extraction, A. G. Lock, pp. 154–159, 1882.

South in two general forms of deposits, namely: true placers and deposits of decomposed auriferous rock *in situ* or saprolite. In this decomposed material the gold is free-milling, the pyrite of the veins and country-rocks having been altered to limonite and the gold released. Further, the deposit being loose can be worked in a manner similar to a deep placer. The gold found in the deposits of saprolite is rough, occasionally in the form of wires and often in masses as at the Loud mine, north of Dahlonega. Probably the most extensive deposits of stream or " branch " gravels are on Duke's Creek, near Nacooche, also on Yahoolah Creek, at Dahlonega, while smaller ones are found near Brindletown.[1]

The Loud deposit of Loudville is one of the most celebrated and extensive in the southern gold region. The gravel deposit occurs in a basin-like area and consists of water-worn quartz fragments. The gold is semi-crystalline and is remarkably free from evidences of attrition, from which it is judged that its source is not far distant. This deposit has been worked over a number of times with fair results. Unfortunately owing to their location and lack of extensiveness the high deposits scarcely warrant an attempt at hydraulicing.

The placers of White County have yielded considerable gold in the form of nuggets weighing several ounces, which are usually much worn by stream-action.

The " Pigeon-Roost Streak " is a peculiar lode deposit near Dahlonega, consisting of micaceous schists or slates in which quartz-veins occur, but owing to their extreme smallness (usually not over one-eighth inch, or two to three millimeters in thickness) and their occurrence interleaved with the micaceous layers, it is often next to impossible to distinguish them. This assemblage of " knife-blade " veins has suffered considerable alteration by the decomposition of the included pyrite and has been worked by sluicing like the saprolite deposits; with depth auriferous pyrites associated with tellurium occur.[2]

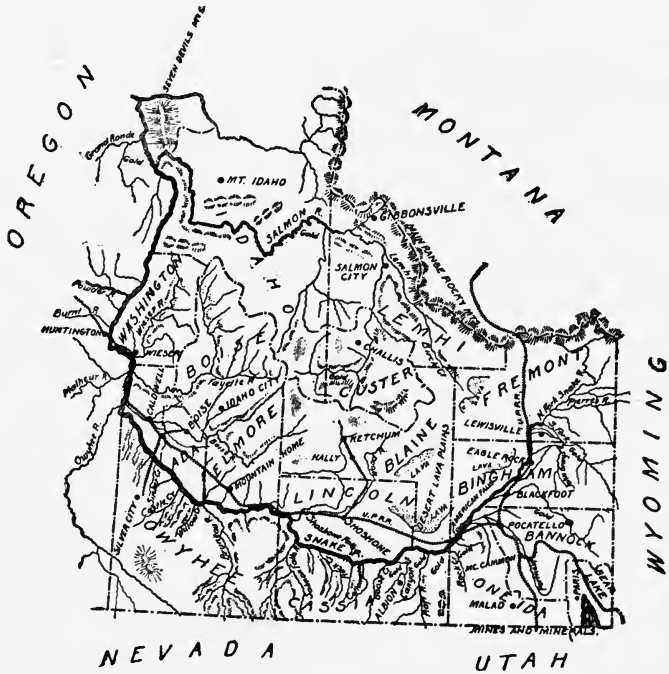
The placer deposits have been gone over so many times that profitable working by ordinary methods is next to impossible; however, river dredging is still profitably carried on. Placer-working with an hydraulic elevator was carried on in the bottom-land of Duke's Creek in 1895. Old gravel piles were also being worked by a giant. Wire-gold is found at this locality. Small placer-workings have been the main source of gold in Forsythe County.

[1] Mines and Minerals, Vol. 23, p. 493 and U. S. G. S., 18th Ann. Rept., Pt. 3, p. 289.

[2] T. A. I. M. E., Vol. 25, pp. 800–802, 1895.

Some ten miles south of Dahlonega, gravels varying from nothing to four feet in thickness are found. As a rule they are covered with a layer from 2 to 20 feet of dirt which carries no gold. Coarse gold, often crystallized and arborescent, is found here.[1] In many cases, gold is found uniformly distributed throughout the soil and drift on hills and hillsides, also in the dry ravines and bottoms of Lumpkin County.

Idaho. — Profitable placers have been found in practically every county in the state. The gold is usually very fine and is associated



Snake River Gold Fields, Idaho (1899).

with black sands. Many of the auriferous gravel deposits of the Rocky Mountains are glacial overwash or both overwash and moraines together. The former are often of considerable importance especially in Idaho and neighboring states. In Idaho overwash glacial deposits are found in the Boise Basin, Warren Meadows, Red River Meadows, at Bull of the Woods, and near Leesburg. Occasionally the overwash was deposited in lakes. South of Elk City a gravel plain

[1] Eng. and Min. Jour., Vol. 26, p. 243.

about one-fourth of a mile wide and seven miles long and often 80 feet deep extends from the valley of Red Horse River over hills fully 100 feet high; the American Hill placer is a part of this system. The materials of this deposit are very much water-worn and rounded, while the bed-rock is also smooth and polished, yet is quite uneven. Depressions and pot-holes with a depth of five feet are common. From appearances it would seem that a river of slow current had traversed a glacier which had become covered with vegetation like the Alaskian glaciers.[1]

The source of the Snake River gold seems to be the Caribou, Snake River and Pierre's Hole mountains. The gold is very fine, and has its source in quartz-veins. Some of the bars carry an average value of 30 cents per cubic yard for a depth of ten feet, while comparatively large areas yield but 5 to 15 cents per cubic yard, and are especially adapted to dredging. Above the mouth of the Boise River it takes 1200 colors, on an average, to make a cent, while below, there are about 900 colors to a cent.[2]

Rich gravels were worked near Centerville, Idaho City, Placerville and Granite Creek as early as 1862. The deposits occur with an extreme range from two to six feet in depth, and contain sand, cobbles and boulders of granite, porphyry and quartz. As a rule the boulders are small, seldom exceeding eight inches in diameter and the greater part less than four inches. At an elevation of 10 to 60 feet above the stream are bench gravels varying but little in character. It is not unusual to find a number of these benches occurring one above the other. There is a remarkable uniformity in richness in the gravels.

The bed-rock of the stream gravels is usually granite, although on Moore Creek, extending for some distance below Idaho City the bed-rock is a mixture of sand and clay called "false bed-rock." Little or no gold is found in the false bed-rock.

Monazite sand occurs with the gold in the gravels, and is caught with it in the sluices. The source of the gold is numerous small quartz-veins. An ample water supply together with the absence of clay and large boulders and a soft and easily cleaned bed-rock render the district especially adapted to dredging.[3]

The gravel deposits of the Warren district have a depth of about

[1] Mines and Minerals, Vol. 20, p. 494.

[2] Eng. and Min. Jour. Vol. 73, p. 241; Min. and Sci. Press, Vol. 81, p. 610, and Mines and Minerals, Vol. 20, p. 57.

[3] Min. and Sci. Press, Vol. 81, p. 400 and Eng. and Min. Jour., Vol. 68, p. 395.

18 feet in the Valley of Meadow Creek. Overlying the gravel and sand a black loamy soil is usually found. Subangular pebbles and cobbles of quartz and granite form the main portion of the deposit. The bed-rock is granite, somewhat decomposed. The gold is fairly coarse and occurs in streaks, usually on the concave side of the streams. There is a gold-bearing area lying between Warren and Florence extending from the northeast to the southwest; in fact, all the streams rising in the Grouse Mountains are more or less auriferous. Beside the present stream gravels there are lake-bed deposits and others which are subordinate gravels lying on the disturbed surfaces of the auriferous fluviatile gravels. It is doubtful whether these latter deposits could have been formed by the comparatively small streams of the present time.[1]

In the Florence Basin many of the creeks contain rich gravel deposits. These gravels have no great thickness, but are remarkably rich in places. The gravel is subangular as is much of the gold. Magnetite and ilmenite are associated with the gold together with considerable zircon, commonly known as "white sand." Baboon Creek has probably been the most productive.[2]

The placers of Silver City and the De Lamar district are neither extensive nor deep, and have been practically exhausted for some years, which is especially true of Jordan Creek, it having been worked from below De Lamar to its head. The northern slope of Florida Mountain near Silver City, has produced some rather extensive workings, the principal workings being in Long, Blue and Jacobs gulches. The gravels in Jacobs Gulch were in placers 30 feet thick, while Blue Creek yielded many nuggets.[3]

The Ramey mine on Silver Creek in the Thunder Mountain district is noteworthy on account of the low-grade gold found in the gravels. The value of the gold is about $12 per ounce, but the placers on Panther Creek, two miles distant, yield $18 gold.[4]

Robinson bar at the mouth of Warm Creek, in Custer County, is an extremely rich placer. Mining by drifting into the high bars and back channels, and wing-dam stream work was done with good results.

Auriferous gravels yielding from 15 to 70 cents per cubic yard and having a depth of 15 to 17 feet have been worked on Sheep

[1] U. S. G. S., 20th Ann. Rept., Pt. 3, p. 240.
[2] U. S. G. S., 20th Ann. Rept., Pt. 3, p. 234.
[3] U. S. G. S., 20th Ann. Rept., Pt., 3, p. 163.
[4] Min. and Sci. Press, Vol. 84, p. 62.

Creek. The values are uniformly distributed from top to bottom of the deposits.[1]

Fairly rich placers are also found at Salmon Falls and Gibbonsville; in the latter the gold is fairly coarse and nuggets ranging in value from $3 to $10 have been found.

Illinois. — According to the reports of the Geological Survey: "In a few instances minute particles of gold have been found in the drift, and sometimes charlatans, professing to be geologists, have availed themselves of this fact to proclaim to the world wonderful and valuable discoveries of gold and silver."

Indiana. — Gold occurs in the glacial drift and occasionally small particles are washed from the creeks and rivers; however, its source is in all cases the glacial débris brought down from the north. Gold has been found in Brown, Franklin, Jennings, Morgan, Northington and Warren counties. It is reported that $2,900 worth of gold was taken from Beanblosssom Creek. Gold was also found in the bed of the Muscatatuck River.[2]

Iowa. — According to White, of the Geological Survey of Iowa, "whatever gold may be found in the glacial drift of Iowa may be supposed to have originated in northern Minnesota. There is no reason to hope it will be found in paying quantities."[3] W. J. McGee in the Pleistocene History of Northeastern Iowa says: "An element of the glacial drift, generally throughout the entire basin, which is almost insignificant in volume, but sometimes important in value, is triturated gold. This element occurs in Iowa, as elsewhere, commonly in exceedingly small quantities; but there is a considerable area in which the local conditions of deposition of the upper till have led to such concentration that it may prove of ecomomic value. . . . About, Fayette, at Maynard, and elsewhere in in the northwestern part of the basin, indeed, more or less gold has been found, and even in the gap cut by the Volga in the basin rim, at Wadena, gold has been obtained in nearly paying quantities."[4]

Isthmus of Panama. — The auriferous gravels of this region are shallow, limited in extent and of moderate richness, although that

[1] Eng. and Min. Jour., Vol. 69, p. 441 and Ibid., Vol. 68, p. 395.

[2] First Ann. Rept. State Geologist of Indiana, Folio 190, 1869; Sixth Ann. Rept., Folio 107, 1875; Seventh Ann. Rept., 1876; Eight, Ninth and Tenth Repts.; Thirteenth Ann. Rept., 1883, and Trans. Lake Superior Inst. Min. Engrs., Vol. 5, pp. 51 and 52.

[3] Geological Survey of Iowa, Vol. 1, p. 97, 1870.

[4] The Pleistocene History of Northeastern Iowa, 11 Ann. Rept. Director, U. S. G. S., p. 486, 1891.

lying next to bed-rock may carry from $20 to $40 per cubic yard in gold. Associated with the gold are found amalgam, native quicksilver and cinnabar. Unsuccessful attempts to hydraulic the gulches have been made.[1]

Kansas. — No gold has been found in the state except in exceedingly small quantities in the glacial drift and wash from the Rocky Mountains and traces in the shales of Gove, Trego and Ellis counties.

Minnesota. — Gold has been found in various localities in the state in the Glacial drift, reported finds from the following counties having been made: in Fillmore County, at Spring Valley and Jordan; in Olmsted County, near the Zumbro River and extending from Rochester to the Wabasha County line; and in Scott, Kandiyohi, Itasca and Saint Louis counties. Of these localities Olmsted probably stands first and Itasca and Saint Louis are next in importance; however, none of them yield gold in commercial quantities.[2]

Mississippi. — "Unmistakable signs" of gold were reported from Jackson County in 1854. If gold is found in the state its source will have been the glacial drift distributed along the course of the Mississippi River.[3]

Missouri. — According to C. P. Williams glacial drift covers a large area extending from the Iowa line into Macon County. It is exposed along the great Chariton River. It was also found at Kirksville in Adair County. The gold occurs in fine particles in the drift, which is composed of three layers of gravel all panning colors. Boulders of granite, syenite, hornblende, greenstone, trap and quartz occur intimately mixed together and forming a bed some 64 feet thick.[4]

Montana. — This state has been a large producer of gold, especially from placers during the sixties. When the principal gulches such as the Last Chance, Grizzly and Prickley Pear were exhausted placer-mining began to lose its prestige. The principal diggings were in the vicinity of Helena, and the yield per cubic yard seldom fell below 20 cents, usually being considerably more. The Montana Central, the Penn and Cataract placers of Jefferson County yielded about 50 cents per cubic yard. The usual thickness of the deposits is 12 to 50 feet. The bed-rock is decomposed granite, the

[1] Eng. and Min. Jour., Vol. 34, p. 173, 1882.

[2] Trans. Lake Superior Inst. of Min. Engrs., Vol. 5, p. 55 and Geology of Minnesota, 1st Ann. Rept., 1866.

[3] Rept. on the Agriculture and Geology of Mississippi, Wailes, 1854.

[4] Min. and Sci. Press. Vol. 31, p. 338.

upper six to eight inches being gold-bearing. As a rule the gravels are fine with occasional patches of cement.[1]

A placer deposit in the form of a lake bed is situated some ten miles south of Drummond, on Flint Creek. It consists largely of clay and marl, and has a thickness of 150 feet; upon this is a deposit of gravel with a depth of about 75 feet in which the gold is found. The gold-content is about 2 cents per cubic yard, and it is only owing to the particularly favorable conditions of operation that it is possible to work the deposit with profit. The gold is very fine, but is caught readily by block riffles. Nuggets worth 50 cents and less are occasionally found.[2]

The Bannack placers of Beaver Head County were discovered in the sixties and produced over $20,000,000 in gold, and that too by simple methods of washing. Gold was obtained from bars. Hillside placers were worked in Deer Lodge County, but were soon exhausted.[3]

Other placers which have produced large amounts of gold are: the Alder Gulch, Madison County; Bear Gulch, Granite County; and Cedar Creek, in Missoula County. The Cedar Creek placers have a bed-rock of shaly slate which is easily cleaned. The gravels yield about 50 cents per cubic yard.[4]

The quartz ledges of Butte were located subsequent to the working of the placer deposits in the Missoula Gulch.

Nebraska. — Gold has been found from time to time in the glacial drift in the southeastern part of the state, and the drift or wash from the Rocky Mountains to the westward. An occasional quartz pebble is found to show traces of gold. The centers of the excitements over the finding of gold were Seward, Stanton and Franklin counties. Gold has actually been obtained from the gravels at Milford and Crete, and it is claimed that the high terraces of the Platte, especially at Scott's Bluff, contain gold.[5]

The Milford gold was obtained from a decomposed ferruginous granite, found in the drift along the Blue River.[6]

Nevada. — In the early days some placer-mining was done in the state and the operation on Carson River, in Gold Cañon, led to the discovery of the Comstock lode, but the magnitude of the lode mines

[1] Eng. and Min. Jour. Vol. 44, p. 167.

[2] Eng. and Min. Jour. Vol. 68, p. 575.

[3] Min. and Sci. Press, Vol. 83, p. 183, and Gold, Its Occurrence and Extraction, A. G. Lock, p. 172, 1882.

[4] Eng. and Min. Jour. Vol. 67, p. 143.

[5] Eng. and Min. Jour. Vol., 67, p. 408.

[6] Trans. Lake Superior, Inst. Min. Engrs. Vol. 5, p. 57.

so overshadowed the comparatively small and superficial deposits of auriferous gravel that little work has been done upon them, and practically nothing has been written regarding such operations.

New Mexico. — According to Dr. Wislizenus there were two localities in the Territory where gold was obtained from gravels in 1846 and 1847. The " Old Placer " was situated 27 miles from Santa Fé, the " New Placer " some nine miles distant. It is claimed by the same authority that both the washings and mines had at various times yielded from $30,000 to $250,000 per annum.[1]

Auriferous gravels are found on both the east and the west sides of the Rio Grande in Sierra County. Those on the west bank were not found to be rich enough to work with profit. In 1904 the deposits on the east side of the river were discovered and are being worked. Cemented gravel occurs here and occasionally has a thickness of 200 feet, which thickness is exposed. The bottom is composed of sand and boulders and contains gold for a distance of 14 feet. Gold is found on the surface of the cemented gravels. In working these deposits the boulders are picked out after which the top layers of gravel and sand are removed, that next to the bed-rock being carefully brushed back and collected from the hard cement. It is finally panned and blown until all of the sand is removed and the gold remains. So far the cement has not been found to be of sufficient value to warrant working.[2]

Ohio. — Gold is found in this state, as in most of the states of the Mississippi Valley, in the glacial drift. " In 1868, $17 worth of gold were taken from Boling Green township, 1 mile north of Brownville, from glacial drift; the largest pieces were the size of grains of wheat. In Licking County, Prof. Andrews reports the quantity of gold small, but in my experiments nearly every panful showed the color. There is a range of terraces about 50 feet above the bed of Licking River. They are cut through by small streams from the south and in the narrow ravines gold is obtained from the sands and clay. A jeweler in Newark found gold in small fragments in quartz." Gold is also found in Clermont County of which occurrence Professor Orton says: " This formation should be called the drift gold-field rather than the Clermont gold-field."[3] The gold is usually found in the boulder-clay and gravels.

[1] Memoir of a Tour to Northern Mexico 1846–7 published by Congress, p. 24.

[2] Min. and Sci. Press, Vol. 88, p. 61.

[3] Geol. Rept. of Ohio, Vol. 1, Folio, 462, Ibid., Folio, 70, 1874, and Folio, 71, and Ibid., Vol. 3, p. 314, 1878.

Oregon. — The auriferous gravels of this state are often extensive and are confined to the areas of the older rocks, at least they have been the source of the gold. In southwestern Oregon the formations are pre-Tertiary while in the Blue Mountain district they are pre-Jurassic. The absence of auriferous gravels in the areas known to be gold-bearing is accounted for by the comparatively slight erosion of the country. While in those districts where lavas and tuffs predominate the accumulation of such materials exceeded in amount that lost through wear by erosion, thus many at least of the gold-bearing veins were covered up and protected against disintegration and transportation to the water courses. However, in the Blue, Klamath and part of the Rogue River mountains, in Oregon, and the Salmon and Trinity, in California, there has been excessive erosion since the deposition of the ores, thus forming auriferous gravel deposits in the streams. In the Blue Mountains the wear of the disturbed pre-Jurassic rock has probably been several thousand feet in vertical height, while the wear in the Klamath Mountains has evidently been fully as great. The gold freed by this erosion has in most cases been deposited and concentrated at no great distance from its source.[1]

The gold is usually close to bed-rock in the Blue Mountains, although occasionally gravel beds in which the gold is distributed evenly throughout a height of 10 to 20 feet are found — the Nelson placers of Pocahontas, are examples. The Burnt River gravels yield pay gravel in the two or three feet adjacent to the bed-rock, the upper portion being practically barren. However, the average of the whole bank is between 10 and 35 cents per cubic yard. Large scale operation can handle gravels averaging 2 cents, although 5 cents is usually considered the lower limit. Gravels yielding from 2 to 7 cents per cubic yard can be worked with profit by dredges. The size of the gold varies between wide limits: the finest grains (colors) require several thousand to make a cent, while many slugs and small nuggets have been found.

The placer-mining districts of the Blue Mountains are as follows; bars on the Snake River; Eagle Creek Mountains; Sparta; and an area extending from Connor Creek by Weatherby, Chicken Creek, Rye Valley, Humbolt, Clark's Creek and Malheur; the camps of Auburn, Pocahontas and Minersville, west of Baker City; and the headwaters of Powder and Burnt rivers and Granite Creek, which

[1] Min. and Sci. Press, Vol. 88, p. 299.

include the districts of Sumpter, Granite, Robinsville, Bonanza and Gimlet.[1]

In the Susanville district in Elk Creek the gold occurs in two or three channels or gutters which have a depth of one to three feet, the channel proper being nearly level and fully 100 feet wide.[2]

In Josephine County placer-mining was inaugurated shortly after similar work was begun in California. The principal localities being on the Applegate, Illinois, Josephine and Galice rivers. Here as in California, the richest deposits occur in the dead river channels. As late as 1902 there were 150 hydraulicing operations in the county. The gold is fairly coarse and numerous nuggets ranging in value from $1 to $50 have been obtained. Waldo, Althouse, Galice and Grave, areas in the four corners of the county, have proven most productive.[3]

The gravel deposits of the old river channels in southern Oregon, and especially in Josephine County, lie in channels varying from one-half to one mile in width and have a depth of 10 to 230 feet. All of such gravels carry gold, the coarsest occurring next to bed-rock, thence decreasing in size to the top of the deposits. Boulders and coarse sand and gravel lie on bed-rock above which is a layer of pipe clay and above that in turn is a capping of red clay. The red clay yields flour gold which is largely caught in the undercurrents placed along the sluices. The gravel carries from 6 to 8 cents per cubic yard in gold.[4]

The beach mines of the state, especially at the mouth of the Rogue River, were at one time among the richest of all the placers. The mouth of the Coquille River in southwestern Oregon also produced auriferous deposits. The sands were well and distinctly stratified and contained many remains of trees. Both gold and platinum were found in the black sands which had a depth of a few inches up to 12 feet. The gold occurred in scales and flakes often too fine to be saved, and on an average it took 600 colors to make a cent. The yield of the gravel was 50 to 57 cents per ton.[5]

Pennsylvania. — The only occurrence of gold in the state is that reported from Philadelphia where gold was found in a stratum or bed of clay some three square miles in superficial area and about 15

[1] U. S. G. S., 22 Ann. Rept., Pt. 2, pp. 634, 636 and 637, 1901.
[2] U. S. G. S., 22 Ann. Rept., Pt. 2, p. 708, 1901.
[3] Eng. and Min. Jour., Vol. 74, p. 582.
[4] Min. and Sci. Press, Vol. 81, p 216.
[5] Min. and Sci. Press, Vol. 88, p. 299, and Ibid., Vol. 71. p. 121.

feet in thickness. Assays made by Eckfeldt, principal assayer of the Philadelphia Mint, in 1861, gave a value of 3 cents in gold per cubic foot of clay.[1] As this deposit of clay lies beneath the streets of the city and especially owing to its poorness in value, no attempt toward extracting the gold has been seriously considered.

Philippines. — Gold-bearing gravels often of considerable extent are found on practically every large island in the Philippine Archapelago. The placers of Camarines, Bulacan, Pigholugan, Arroroy and Pigtao have yielded considerable gold in times past. Dredging operations are to be begun in the gravels of Camarines, Masbate and Mindanao.[2]

Porto Rico. — Official statistics show that as early as 1509, and up to 1536, 2,700 pounds of gold were sent to Spain, which probably represents only one-fifth of the total output. This was obtained largely or wholly from placer-mining operations as there are no evidences, of vein-mining to be found. Further, Fray Iñigo Abad[3] describing the effects of the great hurricane of 1530 says: "They turned their eyes to the mines, but found them all submerged by the overflow of the rivers."

One of the tributaries of the Mameyes, the Anon, has been worked, the auriferous alluvia yielding from one to two pounds of fine gold per day. Alluvial deposits occur over large areas of the middle and lower parts of watershed of the Mameyes River and are composed of clay, sand and boulders. In the valley of the Anon these deposits have a depth of 20 to 26 feet. Other auriferous deposits occur in the watersheds of the Corozal, Negros, Congos, Cibuco, Mavilla, and Manatí rivers.

Numerous nuggets of pure gold and gold with quartz attached have been found on the Congos River. Operations on the Corozal have yielded $2.17 to $4.30 per ton of sand treated. A nugget worth $200 was found on the Corozal.

Gold placers also occur in Mayaguez, San German, Yanco and Coamo, where nuggets of a value of $2 to $3 have been found.

Native "lavadores," washmen, work irregularly and collect small quantities of gold by means of a batea locally called a "gaveta."[4]

[1] Sci. American, U. S. V. 247, and Gold, Its Occurrence and Extraction, A. G. Lock, 1882, p. 181.

[2] Ann. Rept. Min. Bureau, Philippines, 1904.

[3] History of Porto Rico, Fray, Iñigo Abad, 1788

[4] Special Rept. Census Office, Mines and Quarries, 1902, pp. 1075–1076, and Second Ann. Rept. of Governor of Port Rico to the President of the United States.

South Dakota. — There are two classes of auriferous gravel deposits, those of the Quaternary period and the ancient placers at the base of the Potsdam. The former yields gold but in small quantities up to the present time, although the richest part as Deadwood Gulch has been practically exhausted.

The "cement deposits" are undoubtedly gold-bearing gravel deposits which have been consolidated and cemented into conglomerates. They are easy to mine and yield rich ore. The principal mines are situated near Central City. In some of the mines "ledge-matter" consisting of gold-bearing slates and quartz occur in place. These mines were first worked for the "cement," which lies unconformably upon the bed-rock slates, but on removing the slates it was discovered that the bed-rock carried gold.[1]

At French Creek in the southern hills the deposits show a higher range of values on the outer edge of the bed-rock than at points some distance from the rim-rock. Further, the pay streaks are usually 10 to 20 inches above the bed-rock, and form the upper surface of a layer of compact clay and gravel intermixed. Fragments of decomposed bed-rock, rich in gold, also occur at this point. The gold is in small scales and grains fairly uniform in size and occurs with a small amount of fine dust and little or no magnetic sand.

At Spring Creek a streak of pay-gravel, 35 feet in width was found to cross the stream and extend into the bank on either side. This proved to be a stratum of decomposed soft clay-slate in the bed-rock which acting as a riffle had caught and held the gold. In this zone occurs a compact gravel composed to a large extent of small red garnet crystals quite rich in gold.

Other localities where gold has been found in paying quantities are; Whiskey Creek, Castle Creek, Rapid Creek, Box Elder and Elk creeks, Spearfish and Bear Butte creeks, Bear Lodge, etc.

Auriferous gravels also occur in the foot-hills, resting on the Red beds near the edge of the plains. These gravels are apparently river deposits although often found on hills fully 300 feet high, and the widest divides have the thickest deposits. It is believed that these gravels have been formed since the elevation of the Black Hills. The gravel consists of limestone and sandstone resulting from the erosion of the Potsdam, Carboniferous and Red Beds, together with pebbles and boulders of granite, trachyte, schist, slate, quartzite and quartz.[2]

[1] T. A. I. M. E., Vol. 17, p. 571 and Eng. and Min. Jour. Vol. 30, p. 4.

[2] Gold, Its Occurrence and Extraction, A. G. Lock, pp. 163–168, 1882.

Tennessee. — The only source of gold in this state is the placer mines and they have been of practically no economic importance. (See Tennessee under heading Occurrence and Association of ores.)

Texas. — Where there are gold-bearing rocks there must occur deposits of auriferous gravel and therefore such deposits must exist in this state as it contains gold veins. However, owing to the comparative scarcity of gold-bearing lodes and their low-values it is not surprising that no placers of importance have been located.

Utah. — Mining began in Bingham Cañon about 1866 on the discovery of free-gold in the stream gravels. Placer-mining was actively carried on until 1871; since then there has been a steady decline in the output of placer gold. Hydraulicing was done in the Argonaut at the mouth of Carr Fork as late as 1898. Auriferous gravels of various ages are found in the Bingham Cañon as is shown by their position, deposits occurring at points from bed-rock to several hundred feet above on the slopes. The down-cutting and widening of the channels have evidently removed the larger part of previously formed deposits, thus the gravel-covered terraces mark the successive stages in the cutting of the streams to their present level. The gravels of Bingham Cañon have yielded 18 to 20 cents per cubic yard, while those of West Mountain are reported to carry 8 to 10 cents per pan, which is probably considerably above the average. The Argonaut cut, showed on sampling, 6 cents for the lower 30 feet, and 18 cents per cubic yard for the lowest six feet. As a rule the gold is coarse ranging in weight from one-half an ounce downward.[1]

The placers of Bear Gulch yielded large returns during the late sixties and early seventies, — the deposits being found in extinct waterways.[2]

Vermont. — Washings of a small body of gravel at Plymouth Five Corners are said to have yielded from $9,000 to $13,000. Aside from this no other workable gravel deposits have been located.[3]

Virginia. — Both lode and placer-mining operations are carried on in this state, but at present little work of importance is being done. Considerable placer-mining has been done in the past, especially in Spottsylvania and Louisa counties. Placers were worked at Pigeon Run in the former county and at the Tinder Flats in the latter; both of these localities have produced considerable gold. Other localities

[1] U. S. G. S., Bull. 213, p. 119.

[2] Mines and Minerals, Vol. 19, p. 377.

[3] Rept. Vermont State Geologist, G. H. Perkins, 1903–4, pp. 56–57.

in which gravel deposits have been worked are: the Rattle Snake mine in Stafford County, and various points in Fluvanna and Goochland counties.[1] The alluvium at certain localities in Spottsylvania County is 20 feet thick, carrying gold in coarse grains and nuggets. One worth $35 was found in 1868 and many others ranging from $1 to $3 have been found.[2]

Washington. — Placer gold has been found at quite a number of points in the state, but no very extensive operations have been begun.

In Kittitas County on Peshastin Creek a little gold was produced in 1862. Placers were also worked on Swauk, William and Baker creeks, for fully 20 years, but in a very desultory fashion. From reports the Black Bigny and Delig are among the most important locations. The gold is usually rather coarse and is often found in nuggets of 14 ounces or more, 50 and 75 cent pieces are common.[3]

Wisconsin. — Gold is found in the glacial drift at a number of points. There was a fairly large basin in the bed of the St. Croix River extending from St. Croix Falls upstream for a distance of three or four miles prior to the erosion of the intersecting trap-ridge. The bed rock of this basin is Potsdam shale of a sandy character. The river has cut through this shale, now forming the banks on either side, which have a covering of drift ranging from 10 to 25 feet in thickness at the river and thinning out toward the trap-ridges. The river bed is now trap upon which the concentration of the gold in the gravel has taken place. During periods of low-water considerable gold has been obtained from the cracks in the trap. The gold occurs mainly as flakes and scales, but can be quite readily saved by ordinary means.[4]

Native silver has also been found in small quantities in the drift, but is found by mere chance only, and not by systematic search.

Wyoming. — Placer-mining never has been carried on very extensively in the state, and it is doubtful that it ever will be, although in certain localities the yield may be considerable. In the southern part of Wyoming and northern Colorado, on Douglas Creek, some placer-mining has been done. The gold is coarse and jagged and often attached to the vein-quartz. Nuggets weighing from 15 to 68 pennyweight are found. The gravels range from three to ten feet in thickness, and are free from clay and cement. The bed-rock is a

[1] T. A. I. M. E. Vol. 25, pp. 689–693, 1895.
[2] Eng. and Min. Jour., Vol. 6, p. 377.
[3] Eng. and Min. Jour., Vol. 54, p. 608.
[4] Eng. and Min. Jour., Vol. 74, 248, 1902.

decomposed granite and very uneven, upon which the gold is usually found. Diggings on Lake Creek, just below the mouth of Ingalls Gulch, and just above the mouth of Douglas Gulch, yield $1 and $2 respectively per cubic yard.[1]

Gravel on Spring Creek is reported to average $1 per cubic yard.

An attempt has been made in recent years to work the dry placers in several localities by steam shovels.

[1] Eng. and Min. Jour., Vol. 60, p. 539.

CHAPTER IV.

THE GEOLOGICAL DISTRIBUTION OF GOLD AND SILVER.

Introductory Remarks.

In the preceding pages the geological occurrence and geographical distribution of gold and silver deposits have been given in considerable detail. However, a discussion of the geological distribution of the precious metals with respect to the time of their origin in geological periods involves to a certain extent the consideration of their occurrence and distribution and, therefore, in order to simplify matters, a table has been prepared (see table of Geological Occurrence of Gold and Silver), by means of which the importance of the various periods as precious metal producers and their relation to the different districts can more readily be seen.

After an exhaustive study of the mineral deposits of the West, Clarence King deduced the following interesting generalization:

"The Pacific Coast ranges upon the west carry quicksilver, tin, and chromic iron. The next belt is that of the Sierra Nevada and Oregon Cascades, which, upon their west slope, bear two zones, a foot-hill chain of copper mines, and a middle line of gold deposits. These gold veins, and the resultant placer mines extend far into Alaska, characterized by the occurrence of gold in quartz, by a small amount of that metal which is entangled in iron sulphurets, and by occupying splits in the upturned metamorphic strata of the Jurassic age. Lying to the east of this zone, along the east base of the Sierras, and stretching southward into Mexico, is a chain of silver mines, containing comparatively little base metal, and frequently included in volcanic rocks. Through Middle Mexico, Arizona, Middle Nevada, and Central Idaho is another line of silver mines, mineralized with complicated association of the base metals, and more often occurring in older rocks. Through New Mexico, Utah, and Western Montana lies another zone of argentiferous galena lodes. To the east, again, the New Mexico, Colorado, Wyoming, and Montana gold belt is an extremely well-defined and continuous chain of deposits." [1]

[1] T. A. I. M. E., vol. 1, p. 33.

That this classification is correct in every detail or complete is open to question, but is valuable as an outline of the general occurrence, of the mineral deposits, and can be further elaborated by adding to it on the east, the slightly argentiferous zone of galena of the Mississippi Valley, and the gold belt of the Southern and Eastern states, besides which are the zones of iron ores, both magnetites and hematites, and the extensive coal measures.

As early as 1859 Sir Roderick Murchison said, in the third edition of "Siluria," "My chief article of belief has now proved to be true — that is, that the rocks which are most auriferous are of Silurian age." And again, "The Paleozoic accumulations — particularly the Lower Silurian — are the chief source whence gold has been or is derived."[1] Nor was this wholly without corroborative evidence as gold had been discovered in considerable quantities in both the Ural Mountains and in Australia; however, it was the former which led him to propound the theory in the first place.

In 1864 the work of the Geological Survey of California, conducted by Whitney, disproved once for all the theory that the Silurian was pre-eminently the gold-bearing formation, and since that time similar evidence from other districts has been accumulating. According to Rickard: "The following tabulated statement shows at a glance that the chief gold fields of the world are scattered through the entire sequence of geological strata, from the Archean to the Tertiary:

GEOLOGICAL DISTRIBUTION OF GOLD AS ILLUSTRATED BY THE PRINCIPAL MINING DISTRICTS OF THE WORLD.

Period.	Rock.	District.	Region.
Quaternary	Andesite	Monte Cristo	Washington.
Tertiary	Eruptive	Cripple Creek	Colorado.
Cretaceous	Sandstone	Verespatak	Transylvania.
Jurassic	Amphibolite Schist	Mariposa	California.
Triassic	Limestone	Raibl	Carinthia.
Permian	Conglomerate	Stupna	Bohemia.
Carboniferous	Shale	Gympie	Queensland.
Devonian	Conglomerate	Witwatersrand	Transvaal.
Silurian	Slate and Sandstone	Bendigo	Victoria.
Cambrian	Slate and Quartzite	Waverley	Nova Scotia.
Algonkian	Schist	Homestake	South Dakota.
Archean	Granite and Schist	Lake of the Wood	Ontario.

[1] "Siluria," 3rd Edition, p. 474.

"The Lower Silurian of the Urals is now scarcely worth mentioning, the gold production of that region having dwindled to insignificance. Since Murchison's day the geographical center of Russia's gold production has shifted steadily eastward. It was once at Ekaterinburg, in the Urals; it passed to the Yenesei, and then to the Olekma. To-day the chief gold region is that drained by the Amoor and its tributaries. The gold fields of Victoria, in Australia, also refuse, now, to be indentified any longer with Murchison's blunder, several of the best districts in that colony having been developed in the Upper Silurian, as distinguished from the prevailing Lower Silurian of the first discovered gold-veins at Ballarat and Bendigo. Newer mining regions, scattered all over the globe, afford testimony which denies the supposed relation between gold-deposits and the age of the rocks enclosing them. Although numerous rich districts occur in igneous formations of the Tertiary period, no important gold field of the present day is indentified with sedimentary rocks later than the Cretaceous; nevertheless to make the testimony complete, it can be stated that a conglomerate (the San Miguel formation of the Telluride district) of undoubted Tertiary age, covering an extensive area in southwestern Colorado contains gold-veins, which have been mined at a profit. If eruptive rocks be included, we have the testimony of J. E. Spurr that the gold veins of Monte Cristo, in the State of Washington, occur in andesite and tonalite of Pleistocene or Quaternary age,[1] and at Steamboat Springs, Nevada, gold has been detected in cracks traversing the sinter around a thermal vent; this rock can therefore be labeled Recent. The Laurentian granitoid gneiss of western Ontario is traversed by important gold-bearing lodes. Therefore, the record of the rocks, in regard to their association with the occurrence of gold, is unbroken throughout the main divisions of geological time.[2]

"Deposits of gold ore occur in rocks of every age, and in rock of every kind. The metal was deposited later than the encasing rock and it is likely that since it was so deposited it has been subject to constant solution and precipitation, by which it has been redistributed and concentrated. The first deposition, the time when it was brought from below the zone of rock fracture to the place of precipitation, was associated with a thermal activity following upon regional movements and volcanic eruptions; that time of first for-

[1] The Ore Deposits of Monte Cristo, Washington, 1902, U. S. G. S. 22 Ann. Rept., Pt. 2, p. 864.

[2] Min. and Sci. Press, Vol. 93, pp. 477–478.

mation may have been late or early, in the Cambrian or the Cretaceous of geological history. But once so deposited, it became at once the sport of the chemical waters that find a passage both from the surface and from the deep. These may have effected no noteworthy redistribution of the gold along the rock-fractures where the ore lies.[1] . . .

"Gold bearing veins cluster in certain localities. A critical examination will reveal the fact that many vein-systems are massed about the contacts of intrusive masses, which consolidated far below the original surface of the earth at the time of the igneous activity, and which have been exposed by subsequent erosion. Most commonly, perhaps, these intrusive rocks are diorite, monzonite, quartz-monzonite, granodiorite, or their porphyries, more rarely typical granites. Under favorable conditions it can often be proved, and in other cases established with probability, that the upper part of the vein has been removed by the same erosion which laid bare the intruded rock masses. In other words the top of the vein has been removed, the root remains. . . . The age of these veins must, in general, be considerable, for the great erosion involved has usually required a long time-interval.

"Another large class of vein-systems cut the recent or comparatively recent lavas, which cover the surface of the older, eroded rocks in the form of successive volcanic flows. Frequently the age of these lavas may be established with accuracy."[2] When it is possible to determine approximately the position of the earth's surface at the time of an eruption or flow of lava, any vein cutting the formations may be said to have a certain age, assuming that the vein-deposition was coincident with the lava flow, and that the portion of the vein near the original surface may be considered as the true apex of the vein.

By far the larger number of gold-bearing districts of the United States occur in or contiguous to igneous rock either in the form of dikes or intruded masses. Further, probably the majority of the intrusions did not reach the surface at the time of the volcanic flow, but formed bodies of consolidated, granular or coarsely porphyritic rocks, which were laid bare by subsequent erosion.

There is no doubt but that gold-bearing fissure-veins have been formed throughout the geological history of the continent. "Cambrian conglomerates bear witness to pre-Cambrian gold-veins, and

[1] Min. and Sci. Press, Vol. 93, p. 480.
[2] T. A. I. M. E., Vol. 33, p. 794, 1903.

very recent thermal deposits at Steamboat Springs, Nevada (according to Becker), and at Boulder, Montana (according to Weed), prove that gold is deposited by thermal waters to-day. But the process has evidently not been a continuous one. Cambrian, Silurian, Devonian and Carboniferous gold-deposits are not definitely known to exist in North America. Continuous sedimentation, absence of dynamic movements and relatively slight igneous activity characterized these periods."[1]

"The great eruptions of the Cordilleran belt of North America began during the Triassic period of the Mesozoic age, and igneous activity has continued almost without interruption from that date to recent time. Each eruption has probably been accompanied by more or less extensive deposition of gold in fractures near the igneous focus. On the Pacific coast the eruptions began at an earlier date than in the region of the Rocky Mountains; and, likewise, many of the gold-deposits of the Pacific coast antedate those of the Rocky Mountains. In the latter province the igneous rocks began to break out at the close of the Cretaceous period, and have continued at least up to the beginning of the Pleistocene. Certain periods of deposition, however, stand out prominently, and we may, with good reason separate the distinctly Cretaceous or late Mesozoic gold-belt of the Sierra Nevada and the Pacific coast in general from the Tertiary, mostly post-Miocene, veins so extensively developed in Mexico, Nevada and Colorado. The former are genetically connected with great intrusions of granitic and dioritic rocks, the latter with big flows of surface-lavas which erosion has not, as yet, removed. But both in the Great Basin and in the Rocky Mountains there are also many deposits of late Cretaceous or early Tertiary age genetically connected with intrusions of granitic rocks and very commonly, porphyries. In very many cases the age of these deposits is doubtful. If erosion has been exceptionally active in the particular district in which they occur, they may well, though occurring in connection with deep-seated intrusions, be of Tertiary age. To this class of doubtful age belong, for instance, many of the gold-veins of Montana. Miocene and later igneous rocks are often lacking in this region, so that an accurate determination of age becomes very difficult.

"Still another complication to be borne in mind consists in possible, though probably rarely occurring, reopening of veins and superimposition of deposits of two or several epochs. All this being

[1] T. A. I. M. E. Vol. 33, p. 795, 1903.

admitted, there still exists, in my opinion, sufficient reason for attempting a division of the deposits according to age.[1]

"Looking over the field, it is undeniable that within many belts of gold-deposits of contemporaneous origin the veins are very similar in mineral composition and metasomatic development. The Appalachian belt of gold-quartz veins contains deposits striking similarity from one end to the other. The Mesozoic gold-quartz veins of the Pacific coast are practically identical in character from Lower California to Alaska, and, moreover, closely related in character to the far older Appalachian belt. . . . On the other hand, scarcely one of the veins, which in so many parts of the Cordilleran region cut volcanic flows of Tertiary age, can be classed as identical with the Pacific coast type of gold-quartz veins. While it is, perhaps, not permissible to say that they represent one type, yet most of them have certain common, peculiar features, constituting a relationship.[2]

"In conclusion, it may be said that gold-veins of the same age and province usually have the same characteristics. Belts of different age may differ greatly in general features. This is probably due to varying composition of the mineral waters following different periods of eruption." [3]

That class of mineral occurrences known as contact metamorphic deposits are found in the United States, British Columbia and Mexico. The principal ore-bearing minerals are copper sulphides and magnetite, which may, however, occasionally carry gold in small quantities. This is especially true of the United States and British Columbia, while in Mexico these deposits are much more common and valuable.

In the following pages a brief summary is given of the distribution of gold and silver in rock of the different geological periods.

The Older Crystalline Rocks. — The crystalline formations of the Appalachians contain gold-bearing veins in an area extending from Maine on the north, to Georgia on the south. Where erosion and glaciation have not removed the decomposed surface rocks, gold is often found in paying quantities either in gossans or placers. The country-rocks are usually schistose or foliated, the gold occurring in lenses of quartz and pyrites. Dikes or igneous rocks seem to have exerted considerable influence in effecting a concentration of the

[1] T. A. I. M. E., Vol. 33, p. 796, 1903.
[2] T. A. I. M. E., Vol. 33, p. 797, 1903.
[3] T. A. I. M. E., Vol. 33, p. 798, 1903.

values. The gold-bearing formations probably belong to some of the Algonkian series.

The principal localities in which gold-bearing veins occur in the older rocks are: the Carolinas, Georgia, Maryland, Tennessee and Virginia. Poorer deposits of similar character are found to the northward close to the Canadian line, while still further to the north, in Ontario, Quebec and Nova Scotia quite rich gold-veins occur.[1]

The Huronian rocks of Lake Superior yield both gold and silver in small amounts, especially when associated with igneous formations. Silver occurs in larger quantities here than in the Appalachians.

The crystalline rocks of the Black Hills, Colorado and Wyoming and the granites of Idaho, Montana and Nevada have yielded a large proportion of the precious metals of the older rocks. The Black Hills are Algonkian, while the rocks of Wyoming and Colorado are usually considered as Archæan, although according to Rickard the eruptive rocks of Colorado are early Tertiary.[2] Here too the deposits are associated with igneous rocks.

In the northern Rocky Mountain region the age of the granites is probably largely pre-Cambrian.

The granite is eruptive and is traversed by dikes of later igneous material.

The unaltered deposits of the districts outlined are largely quartz-veins yielding free-gold and auriferous sulphides. According to available evidence the veins are probably pre-Cambrian, and may, therefore, be considered as being the oldest deposits of the North American continent. The following facts are corroborative of such a conclusion: "The Triassic sandstones of the Atlantic coast contain no placer gold; no important gold deposits are found in the Paleozoic rocks of the Appalachian region; Carboniferous conglomerates in Nova Scotia are said to contain water-worn gold of older veins; in the Black Hills the Cambrian conglomerates yield placers of the precious metal."[3]

Of all the pre-Cambrian gold-bearing deposits in North America, those of the Black Hills, South Dakota, are undoubtedly of the most economic importance.

So extensive has erosion acted upon these veins that it may be said that in most cases, only the lower portions or roots remain.

Paleozoic Rocks.— Silver-bearing deposits in sedimentary rocks

[1] T. A. I. M. E., Vol. 33, p. 800, 1903.
[2] Min. and Sci. Press, Vol. 93, p. 478.
[3] T. A. I. M. E., Vol. 33, p. 800, 1903.

of the Paleozoic formations are of more common occurrence and of greater value than the gold deposits.

In the eastern part of the United States and Canada no valuable deposits of the precious metals have been found in the rocks of this formation, unless some of the gold-bearing schists and the rocks of Nova Scotia prove to be Cambrian.

In the Western States the Paleozoic formations are of considerable importance in the production of gold and silver, but usually are most productive when associated with eruptive rocks. Important deposits of silver ores are found in Paleozoic rocks at Eureka, Nevada, where about one-third the value of the ores was gold; at Leadville, Aspen and various districts, where the values are mainly silver in carboniferous limestones; and in several districts in New Mexico, Arizona, Utah, Montana, Idaho and Nevada where silver and lead ores are found in Paleozoic limestones. The Carboniferous quartzites of Ontario; the Wahsatch Mountains, at Bingham; the Oquirrh Mountains of Utah, are all important producers of silver ore, also some lead ores, but little or no values in gold. On the other hand the Cambrian sandstones below the silver-bearing limestones are often gold-bearing. A few gold-bearing deposits occur in siliceous rocks in California, which have been considered as Carboniferous or earlier formations, but are probably Mesozoic.

Mesozoic Rocks. — The East has no deposits of the precious metals in the Mesozoic sedimentaries. In the West these rocks have yielded the greatest part of the gold output, and in certain localities considerable silver. The western slope of the Sierra Nevada consists of both Paleozoic and Mesozoic rock, but the gold-bearing veins probably predominate in the latter, which are considered as Jurassic and early Cretaceous. Numerous intrusive masses and dikes of diabase and diorite occur in these formations, which have suffered excessive dislocation, being upturned and are covered by uncomformable beds of late Cretaceous. These latter strata are nearly horizontal, and carry some detrital gold, but are free from gold veins.

Here, too, so excessive has been the erosive action that only the lower portion of the veins remains. There is no doubt but that thousands of feet of the country-rock have been removed since the veins were formed.

" Beginning in Lower California, Mexico, a hundred miles or more south of the boundary line, this great belt continues through San Diego, Los Angeles and Kern counties; through the central part of California, where it is developed in great strength; then on to Northern California, southwestern and northwestern Oregon and Idaho. In the latter states it is modified by the appearance of many silver-gold deposits, and veins carrying auriferous sulphides without free-gold. Covered for a distance by the lava-flows of the Cascades, it again appears in southern British Columbia on Vancouver Island, among other places. Strong development is again attained in the Cariboo district, in Central British Columbia, and it continues through the Omenica, Cassiar and Atlin districts to the Klondike region. Thence, bending westward, it follows the Yukon to the western end of the continent at Nome, on the Seward Peninsula.

"The Cretaceous age of this belt is clearly established in California. In Oregon and Idaho a late Mesozoic age is extremely probable. In British Columbia and Alaska the evidence is not positive, and the deposits may possibly, in part, be older."[1]

In California, Oregon, and Alaska the veins are often characterized by their smallness and irregularity in occurrence of values, but owing to the excessive erosive action to which they have been subjected, immense and widely distributed auriferous detrital deposits have resulted, and from which a large part of the gold product has been derived.

High-grade silver-bearing rocks of Triassic age occur in Western Nevada, while in Utah the silver sandstones are probably of the same age. No intrusives are found in connection with these deposits. Gold and silver ores occur in Cretaceous rock, the veins being closely associated with eruptive rock of various types. Gold-bearing veins are found in igneous rocks at Leadville, in which native gold occasionally occurs with galena ores.

In the central and eastern part of the Cordilleran region is an extensive area which contains numerous gold-bearing deposits. It is not definitely known to which geological age these veins belong, but it is probable that many of them were formed subsequent to the California quartz-veins, therefore at the close of the Cretaceous or in the early Tertiary period.

This area may be traced from the states of Sonora and Sinaloa, Mexico, in which many gold deposits occur in pre-Cretaceous sedimentary rocks, crystalline schists and granites, through the southwestern part of Arizona, and probably further northward.

In Utah the gold-deposits of the Mercur district occur in limestone, in close proximity to intrusions of igneous rock which are probably Cretaceous porphyries.

[1] T. A. I. M. E., Vol. 33, pp. 801–2, 1903.

At Leadville, Colorado, the gold-bearing formations are sedimentary rocks and porphyry of the Paleozoic age, containing deposits of Cretaceous origin. The same is true of many of the gold-veins of Idaho and Montana, being connected with the intrusion of granites of the Cretaceous period.[1]

Tertiary Rocks. No gold or silver deposits have been found in workable quantities in the sedimentary rocks of the United States. However the igneous rocks of the Tertiary age as they occur in the West, excepting granites, yield large deposits of rich gold and silver ores, and probably those deposits occurring in earlier eruptives did not receive their precious metal content until Tertiary times.

The veins of the Tertiary lavas are so common and persistent in certain characteristics that they are usually known as propylitic veins, which refers to the peculiar alteration of the adjacent rock associated with them. These veins carry both gold and silver usually in about equal proportions, although occasionally either metal may occur alone, a more usual occurrence for silver than for gold. The ores are largely siliceous.

To these deposits and the occurrence of very rich ore-bodies within them the term " bonanza " has been applied. The bonanzas of the Comstock lode are types.

Although not all of these veins are distinctly propylitic, but vary considerably from the characteristic veins of that type, yet they are markedly different from those of the Pacific coast — the typical gold-quartz veins.

The great silver veins, also gold-bearing to a certain extent, of the central plateau belong to the Tertiary period. The gold-silver veins in the andesites of the western slope of the Sierra Madre in Chihuahua, Zacatecas and Sinaloa have proven to be of great extent and value.

In Arizona and New Mexico both Tertiary and Cretaceous veins occur, and it is not always easy to distinguish between them. As an illustration of a Tertiary vein the Commonwealth mine of Cochise County, Arizona, may be cited. It occurs in rhyolite and carries about one-third of its value in gold and the remainder in silver.

Tertiary veins occur in Oregon, especially in the Bohemia district of the Cascade Mountains, where the gold-bearing veins are found in igneous rocks. The veins of Monte Cristo, Washington, occur in diorite and andesite.

[1] T. A. I. M. E., Vol. 33, pp. 802 and 803, 1903.

The Apollo mine of Alaska, Unga Island, is in andesite, and other similar occurrences are met with in the Alaskan peninsula.[1]

The Comstock lode is the most important of these deposits, carrying both gold and silver, about 40 per cent of the bullion being gold.

The ore-deposits of Tuscarora, Eureka, Tonopah and the De Lamar districts are propylitic in character and all except the last mentioned occur in igneous rocks.

A large part of the silver product of San Bernardino County, California, comes from rhyolites of the Tertiary age. Further, the rich silver deposits of western Nevada, eastern Oregon and Idaho are found in granites which are so intimately associated with intrusions of rhyolite, that they are in reality of Tertiary age. The Horn Silver mine of Utah is a contact deposit between limestone and recent igneous rocks. In Colorado the silver veins of the San Juan region, also of Creede and Cripple Creek are in eruptives probably of Tertiary age.[2]

[1] T. A. I. M. E., Vol. 33, pp. 804 to 806, 1903.

[2] T. A. I. M. E.. Vol. 22, pp. 87–92, 1893, and Ibid., Vol. 33, p. 808, 903.

CHAPTER V.

MINING GOLD AND SILVER ORES AND GRAVELS.

Gold and silver are won from gravels and veins and the methods employed in their extraction have through common usage been designated as placer-mining and lode or quartz-mining. Various other terms are employed in designating the modifications of these two general methods of mining found to be both necessary and desirable owing to varying conditions and previous experience.

A classification of mines from the physical standpoint may be given as follows: Gravel mining, which according to the method of working is hydraulic-, drift-, branch- and river-mining, booming, shovel-sluicing, and dry washing. Lode- or deep-mining may in like manner be subdivided into open-cut work and tunnel- or shaft-mining. The latter may be resolved into methods of stoping and support of excavations. Such terms as the " Glory Hole " and " square-set-mining " are now commonly employed in connection with two kinds of lode-mining, namely, open-cut and stoping. Further, a classification of mines may be made, based upon the character of ores extracted rather than upon the methods of extraction; as mines of free-gold, with or without small quantities of silver; mines of silver, containing only traces of gold; mines of gold and silver, both occurring in paying quantities; and mines yielding base bullion from smelting ores, in which the precious metals are associated with considerable quantities of copper, lead and zinc.[1]

No attempt is made in this connection to give an exhaustive discussion of the methods of mining employed, but rather to consider mining historically and practically, showing the process of evolution from the simpler methods of small output and high costs with the modern complicated, but highly perfected and efficient methods, involving large outputs at low working costs.

Historical Sketch of Development of Mining Industry. One of the earliest accounts of collecting gold within the present confines of the United States is found in Lemoyne's Brevis Narratio of the journey

[1] Min. and Sci. Press, Vol. 44, p. 216.

made by Laudonnière in 1564.[1] Speaking of the Indians he says "That chief sent me a sheet of copper dug from those mountains (Appalachian), from the base of which flows a torrent rich in gold, or, as the Indians think, in copper; for from this stream they draw up sand in a hollow cane-like reed until it is full, then by shaking and jarring it they find grains of silver and copper mingled with the sand." A drawing accompanies the description and bears a legend which reads as follows: "Manner of gathering gold in the rivers flowing from the Apalatcy Mountains." He then speaks of three great rivers which have their source in the mountains and which bear down gold, silver and copper, and then continues: "On this account the inhabitants of the region dig pits in the river so that the sand swept along by the water may fall into them by gravity. This, diligently extracted, is carried to a certain spot, and after some time, having removed the sand which had again fallen into the pits, they collect it and convey it in boats down the great river, called by us the Mai, which empties into the sea. Now, the Spaniards know how to convert to their own use the treasures thence obtained."

Commenting upon these statements Mr. George T. Becker says: "The French certainly did not see the washing of gold in canes. It is possible, as Mr. Packard thinks, that the description of the process is a distorted account of panning as practiced by or learned from the Spaniards. It is conceivable, however, that separation of gold dust should have been carried on in tubes instead of dishes. While panning is a process known throughout the Eastern Hemisphere, with minor modifications, and is no doubt of pre-historic origin, I have met with no clear and authoritative statement of the means originally employed by the American Indians in gathering gold from sands."[2]

As early as the seventeenth century gold was obtained from gravels and veins in that portion of the United States now bordering on Mexico. However, little is said in the early records regarding the methods employed, the statement usually made being that gold was mined. The remains of underground workings such as partially filled pits, windlasses and tools found in this Southwestern country, and in the Southern states would seem to indicate that mining by shafts was

[1] A famous work published by De Bry in 1591, and U. S. G. S., 16th Ann. Rept., Pt. 3, p. 254, 1894–95.

[2] U. S. G. S., 16th Ann. Rept., Pt. 3, p. 256, 1894–95.

It is claimed that the Indians of Arizona worked the dry diggings of that country by winnowing the gold sands in moderately high wind, and that the early prospectors learned from them.

the method preferred by the early Spanish miners. Understanding the relation between placers and veins, they, in their haste, sought the store-houses of wealth, rather than the scattered remnants of demolished treasures. From the scant records we have it is evident that their efforts were well repaid and vast deposits of gold and silver were opened up in the country, now lying within the States and Territories of California, Texas, Arizona and New Mexico. While in the Southern states much extremely arduous and useless labor was expended in underground work, which would have proven much more remunerative had it been employed in the working of gravels.

The first work of importance was done in the Southern states following the discovery of gold in 1829. Very extensive operations, for the times, were carried on in the easily worked placers and the decomposed outcrops, the period between 1829 and 1836 being that of greatest activity. There was then a falling off in the output, which was followed in turn by another period of renewed activity from 1839 to 1849, due probably to more systematic development of the veins. Here as in practically all newly-discovered gold fields the first work was done by hand in pans, which was followed later by the simple and inexpensive rocker, long-tom and sluice-box. These devices are still used in small scale work by men whose only capital is their muscle and endurance. The following description of the gold saving devices which constitute the so-called placer-mining methods is given in a paper entitled the Present Condition of Gold-Mining in the Southern Applachian States:[1]

"The rockers in use to-day are of two types. The first is essentially a panning process, using a minimum amount of water, the operation being an intermittent one. This type of rocker is closed at both ends, the discharge being over the side. . . . The second type consists of a hollow segment of a log closed at the upper end. It is set on a slight inclination, about 6 inches in 10 feet, and is provided at the lower end with grooves or strips that act as mecury-pockets or riffles. When used on gravel, it is provided at the upper end with a shallow box having a round punched or slotted iron bottom. The length of this type of rocker is about 5 feet. The gravel and clay are thrown into the box, where a constant stream of water, together with the rocking motion and stirring with fork or shovel, disintegrates the material. The pebbles and bowlders are thrown out with the fork, while the fine portions are washed down the bottom.

[1] T. A. I. M. E., Vol. 25, pp. 680 and 681, 1895.

The rocking facilitates the settling and amalgamation of the gold, and the discharge of the tailings. Two men work at one rocker. One throws the gravel from the pit into the box, and the other sits above the rocker moving it with his feet, disintegrating the gravel with a fork, and discharging the coarse material. Rockers of a similar type are at present in use at several mills for handling pulp and blanket-washings.

"Where sufficient flowing water is at hand, the sluice-box and long-tom are used, as they handle larger quantities with less labor. The sluice-box, generally 8 to 10 feet long, 20 inches wide and 12 inches deep, provided with riffles and a perforated charging-plate at the head, fulfills the same purpose as the rocker; being stationary, however, it requires a large amount of water to carry off the tailings."

In the early days of gold-mining in the South, farming and placer-mining went hand in hand, that occupation which proved most remunerative being most persistently followed, the other being worked upon as opportunity afforded. In a report on the Tinder Flats placer, Louisa County, Virginia, Prof. Silliman says: "Jenkins is in the habit of substituting a fall working in the gold, for which he obtains $1000 annually, as a compensation for his tobacco crop, which he relinquishes in favor of the gold."[1]

The long-tom was introduced into California from Georgia, in 1848 (1860?), and with it the sluice by means of which it was claimed that two men could wash from 10 to 20 cubic yards of gravel daily.[2]

There is some doubt regarding the locality in the United States in which ground-sluicing [3] was first employed.

According to Tuomey,[4] the hillside deposits, at Arbacoochee, Alabama, were ground-sluiced as early as 1854 — a ditch and a series of

[1] Report to the President and Directors of the Walton Mining Company. By Prof. B. Silliman, Jr., Fredericksburg, Va., and T. A. I. M. E., Vol. 25, p. 681, 1895.

[2] Mines and Minerals, Vol. 18, p. 539. Twelve Years in the Mines of California, p. 70, 1862.

[3] The primitive washing of gold gravels as employed here in the United States was practiced by the ancients. Pliny describes similar operations on the shores of the Mediterranean — water was ditched, and material was run through bed-rock sluices after it had been broken down from the bank. (Natural History, Bohn's Edition, Vol. vi, p. 99) While in De Re Metallica Agricola in 1621 (p. 270) the use of pan, rocker and riffles together with ground-sluicing, are shown.

[4] Second Biennial Report on the Geology of Alabama, p. 70, Montgomery, 1858.

trenches being employed into which quicksilver was poured. However, it is claimed that ground-sluicing came into general use in 1851-1852 in the "coyote" claims near Virginia City, Nevada.[1]

Low banks of gravel were worked to advantage in the early days of placer-mining in California by ground-sluicing. Large areas of ground could be rapidly worked over when the lay of the ground provided sufficient grade and when considerable water was available. The sluices consisted of trenches cut in the ground and lined with rock walls or timber, the bottom being provided with riffles to hold the quicksilver and catch the gold. The earth and gravel were thrown into the sluice and worked along by means of a heavy stream of water. This method proved too slow for the miner and was soon superseded by the hydraulic giant.

While working a claim on American Hill in 1853, E. E. Matteson conceived the idea of using a nozzle on a hose to throw a stream against a bank of clayey gravel in order to facilitate its disintegration and removal. Danger to the workmen from caving banks led him to think of it he claimed. It is reported that a hose had previously been used in similar work by A. Chabot in his claim at Buckeye Hill in 1852. By the use of the nozzle it was found that one man could do the work that formerly required several, and that too with no great effort on his part.[2] There are a number of statements on record as to the construction of the first nozzle. According to one authority the hose was made of raw-hide with the hair on the outside, and was four inches in diameter. The nozzle was of brass, three-quarters of an inch in diameter, and inclosed in a wooden jacket. For a pressure-box a keg was placed on a stump, being replaced later by a pork barrel.[3] According to others the pressure-box was made of two lengths of sluice-boxes fastened together thus forming a box which was placed vertically, water being admitted into the upper end and the hose attached to the lower, while the nozzle is claimed to have been made entirely of wood.

During the same year J. F. Tabbott claims to have made and used a similar device in his claim on Indiana Hill. In handling a hose through which water was running to the bank, the end was compressed thereby giving greater force to the stream of water. He made a tapering box of wood to the larger end of which he attached the hose, and by this improvised nozzle was able to double the effective work pre-

[1] T. A. I. M. E., California Mines and Minerals, p. 266, 1899.

[2] T. A. I. M. E., California Mines and Minerals, p. 266.

[3] Min. and Sci. Press, Vol. 68, p. 7.

viously done. Later he had a sheet iron nozzle made, which was four feet long and had a two-inch discharge opening.[1]

Following the introduction of hose and nozzle in placer-mining, the desire for greater service led first of all to an increase in pressure, which in turn required greater strength of material to contain and control the disintegrating agent, namely, water. The limit of common duck hose, made of No. 1 and No. 2 duck, through which the water was brought to the pit, and thence to the bank, was soon reached, while the sheet iron nozzles although made of two thicknesses of iron failed to withstand even moderate pressures. To reinforce the canvas and duck hose they were placed within pipes made of No. 22 sheet iron, securely riveted and the whole staked securely to the ground. But owing to the rapid decay of the hose and the rusting of the enclosing pipe, such makeshifts were soon found to be inadequate for the purpose. Sheet iron pipes without hose were used, often having a diameter of 11 inches and were put together in sections of 16 feet in length. They were joined by slip-joints which were provided with hooks by which they could be wired together. Further, strips of old hose were often riveted on at the joints to prevent leakage.

In 1856, some three years after the introduction of water under pressure into placer-mining or the beginning of hydraulic-mining, the canvas hose with nozzle attached was often held and operated by a nozzleman (usually a short stocky man), who stood from 20 to 30 feet from the bank and directed the stream against it. The hose was attached to the lower end of a wrought iron pipe, some eight inches in diameter, which ran to the pit from the pressure-box, and to prevent the hose bursting it was wrapped with three-quarter inch manila rope. The rope-wound hose was usually tapered gradually to 4 inches at the small end, to which was attached a rubber-lined woven canvas hose, while at the end of this was placed a brass nozzle. The discharge opening in the nozzle was from $1\frac{1}{2}$ to $1\frac{1}{4}$ inches in diameter, depending upon the amount of water to be handled.

The development was, however, much more rapid in the centers of greatest activity for as early as 1856 a few 40-inch iron pipes had been installed, while the first ditch for carrying large quantities of water was built in 1850, and in 1860, 6,000 miles of canals were constructed at a cost of $15,000,000. In 1852 the first riffle was patented and in 1864 the goose-neck nozzle with a flexible iron joint was introduced. About this time the first pipe-bridge was erected, and in 1870 the first inverted syphon was constructed.

[1] Min. and Sci. Press., Vol. 64, p. 74.

J. M. Allenwood of Timbuctoo, Yuba County, patented in 1864, the so-called "goose-neck machine," which had two joints, a lower horizontal one and an upper one made of a short section of hose. By means of this device the stream of water could be directed against any portion of the bank desired, but it was found that the canvas joint known as a "Dutch sleeve" was apt to become kinked, when the nozzle would fly around in a circle, knocking over everything within its reach — this the miners called "bucking." J. W. Richards of Michigan Bluff, Placer County, devised a double-jointed machine, eliminating the hose-joint, but it proved about as unreliable as the form with hose-joint, and was but little used. The great difficulty experienced with the early forms of nozzles was to effect a change in direction of the stream without bending the connecting hose. In 1869 a single-jointed ball-and-socket machine was patented by the Craig Brothers, but it was not until the following year that the first successful double-jointed machine was invented. This machine was known as the "Hydraulic Chief" and was devised by F. H. Fisher of Nevada City. The element of success in this machine was the upper joint which was pivoted on both sides, thus permitting the nozzle to be moved up and down without interfering with the passage of the water. The side motion was obtained through the horizontal joint. This machine proved a great success and was widely used, which was the immediate cause of the institution of a number of suits by other manufacturers claiming infringement. Various interests combined against Fisher, among whom was the Craig and Hoskin combination, which concern at once began the manufacture of the Little Giant, a bold duplication of Fisher's Hydraulic Chief. To still further drive out competition the Macy and Martin patent riffle was purchased outright, without which no machine could operate,[1] and suit was instituted against Fisher to prevent its use in his machines. Suit followed suit interspersed with arrests and fines imposed upon the principals involved, until in 1880 Fisher reissued his patent, instituted a successful suit against the Craigs and Hoskin, and then began the active manufacture of hydraulic machines.[2] At various times and places the hydraulic machines or giants have been given the following names: "goose-neck," "globe monitor," "dictator," "deflector," "knuckle," "joint," "little giant," etc.

[1] The object of the riffle which is placed in the discharge pipe, is to prevent the stream of water issuing from the nozzle from spreading, and thus becoming ineffective.

[2] Min. and Sci. Press, Vol. 44, p. 264.

From the beginning of hydraulic operations in 1853 to about 1875, when the greatest activity prevailed, it is estimated that an aggregate sum of $100,000,000 had been invested. Ditches, flumes, pipes and inverted syphons with a length of fully 6,000 miles were in use, which had been constructed over such rough ground as to call for great ingenuity and enterprise — the boldness and initiative exhibited in the undertaking and successful solution of the stupendous problems which confronted the early hydraulic-mining engineer have not been excelled in any profession. By 1880 hydraulic-mining had been put nearly out of commission by the injunctions of State and Federal courts, and although many and strenuous efforts have been made to revive it by the removal or limitation of adverse legislation, the proper conditions do not and probably will never again prevail for more than a partial resumption of the operations.[1]

As the use of the ditch and flume led to the employment of sluices and hydraulic water in mining, so the introduction of hydraulic-mining led to the working of higher gravels, which opened up large areas of ground hitherto unavailable, owing to the lack of water. This was opportune as the more available portions of the river bars and beds had been pretty thoroughly worked over. However, owing to the change in methods and location there was a corresponding change in the status of the miners — formerly the work was done largely by individuals, but with the change to hydraulic-mining it was of necessity confined to large companies.

From 1850 to 1856 river-mining was one of the most important factors in the production of gold in California, but owing to the necessity of turning the streams from their courses, and the comparatively short period of operation possible the work was both expensive and uncertain. Since the operations on the Feather River at Oroville in 1857 and 1858, no extensive fluming enterprises have been undertaken. This then marks the decline of river-mining.[2]

In 1855 the ancient river channels of Tuolumne County, California, were discovered, and later similar occurrences of gravels were found at various localities in the state. As a usual thing these dead river gravel deposits were located by the following up of rich surface deposits, which had their origin in the buried beds. Probably the largest and most noted of such deposits is the so-called Blue lead, which traverses Sierra and Nevada counties, and has a width of from

[1] Annual Report, Chief of Engineers, U. S. A., 1882, and Eng. and Min. Jour., Vol. 81, pp. 939 and 940.

[2] Mineral Resources of the West, p. 23, 1867.

one hundred to three hundred yards — its course is at right angles to that of the present streams.[1]

After the true nature of these newly discovered deposits of rich auriferous gravel became known, the attention of mining men was directed toward their exploitation, which was later accomplished by means of a system of tunnels and shafts, thus inaugurating drift-mining. The first systematic attempt at drift-mining was made on Table Mountain, Tuolumne County.

As early as the sixties (exact date not known) a dredging machine was sent by a New York Company to dig for gold in the Yuba River. It is needless to say that it was a failure, as have been many others since that day.[2]

In 1892 two negroes occupied themselves in scooping up sand and gravel from the bed of the Sacramento River at a point about a mile east of Redding. It was slow and uncomfortable work but is said to have netted them from $18 to $20 per week. During the following year a crude home-made dredge was built and operated on the Sacramento, near Redding, the idea being obtained probably from the work of the negroes previously mentioned.[3]

Dredgers of the single-bucket type are supposed to have originated in New Zealand in the early sixties, the first built being operated by hand. One operated by steam was built in 1870; however, of 188 used at a later date the majority were driven by current wheels. The first endless chain bucket dredger, steam operated, was introduced there in 1882, while the first of this type operated in the United States was built at Grasshopper Creek, Montana, in 1894. The first modern dredger operated in California was built in 1897.[4]

Following the successful operation of dredgers in rivers, auriferous deposits in valleys were next worked, which necessitated the flooding of the valley sufficient to float the dredgers or they were operated in self-made excavations, water being pumped in to float the dredgers.

Since Alaska has been discovered and rendered accessible by railways quite extensive hydraulicing operations have been established there, which have, however, been handicapped by the shortness of the season and the difficulty of having to operate upon frozen ground. By systematic work over a considerable area of ground, the shallow placers are readily worked, but with the deeper deposits as the tundra,

[1] Mineral Resources of the West, pp. 24, 25, 1867.
[2] Ibid, 1867, p. 20.
[3] Min. and Sci. Press, Vol. 66, p. 308.
[4] Min. and Sci. Press, Vol. 91, p. 125.

and certain other localities where hydraulicing is not possible or advisable, the frozen gravels must be worked by shaft. At the beginning of such operations thawing was done by burning wood piled against the walls of the underground galleries. This method proved both slow and disagreeable, owing to the small amount of gravel thawed, and the smoke filled mine. It was not long, however, before a method of thawing the frozen sands and gravels by means of steam was devised, when practically all of the disadvantages of the former method were eliminated.

The Dahlonega or Georgia method of mining was originated in 1868. It is in fact neither a method of gravel-mining nor vein-mining, although it is a hydraulic method applied to a vein formation. It consists in transporting decomposed vein and country-rock materials (saprolites) to a mill where they are treated. The material may be loosened by hand and flushed to the mill, or may be both broken down and washed to the mill by water furnished by hydraulicing.[1]

The earliest records mention mining of gold and silver by means of pits and shafts, or when possible by open-cuts. Remains of such operations have been found in the Southern Appalachian states, and in Texas, Arizona, New Mexico, and California. All of this work was undoubtedly done by the Spaniards or carried on under their supervision, and was, therefore, practically identical with the present methods of mining employed by the natives in Mexico.

Furthermore, the same crude methods of vein mining were employed in the Southern Appalachian states as late as 1854, where after the shallow placers were exhausted quartz-mining was begun. Both deep gravel deposits and quartz-veins were worked by open-cuts for some time. Probably the first incorporated mining company of any kind was chartered in 1709; this was at the Simsbury mines, Granby, Connecticut. Vein mining was carried on in Montgomery County, North Carolina, in 1825, and at the Tellurium Mine, Virginia, in 1832. The free-milling brown ores of the outcrops were worked, being broken down by hand and raised by horse-whim and hand-windlass, while in certain instances portage was resorted to, the ore being carried in baskets on men's backs.[2]

The present method of mining employed in the large and systematically worked mines consists in sinking shafts and driving levels in or near the vein, and then by stoping, removing the workable portions of the veins and adjacent wall-rocks.

[1] T. A. I. M. E., Vol. 25, p. 742, 1895.

[2] T. A. I. M. E., Vol. 25, p. 682, 1895.

The first quartz miners in the west were Mexicans, who both mined and treated the gold-bearing quartz in a manner similar to that in common use in their home country. With such examples to pattern after together with the shallow mining necessitated by lack of equipment, it is not to be wondered at that the progress of gold mining in the early days following gravel mining was slow. However, the American miner and capitalist did not lack confidence, with the result that many costly failures were made in beginning extensive operations with inadequate knowledge of existing conditions. After making a trip through the country Horace Greeley made the remark that: "I am confident that fully three out of every four quartz mining enterprises have proved failures, or have at best achieved no positive success."[1] This state of affairs was soon to be materially changed (although the success of a few is always largely off-set by the failure of the many) by the remarkably rich and extensive ore-bodies discovered in the Comstock lode in 1859. Other extensive deposits of the precious metals were discovered in Nevada, as in the Esmeralda, Potosi, Coso, and Humboldt districts and the Bodie district, California. However, the Comstock mines were the most important and led in magnitude and extent of operations and workings. The Comstock lode has been called the mining school of the world and so it seemed, for the training acquired there was considered a fitting equipment for foremen, superintendents and managers, who were called all over the world to take charge of similar extensive operations.

The primitive Mexican methods predominated at the Comstock lode for some time after its discovery. Defining was a common term applied to the proving of the lode and consisted in running an open-cut or trench across the outcrop and extending to a depth of 5 to 20 feet (according to the pitch of the land), thus showing the character of the vein and walls at some distance below the surface. Following this preliminary work an incline would be driven in the vein, starting on the outcrop or in some instances the miner preferred to work by tunneling, when work would begin at a point some distance below the outcrop on the hillside. However, many such tunnels failed to strike the lode owing to lack of means and too great distance, the starting point having been chosen at too low a level. The idea was to intersect the lode at a depth of some 100 to 200 feet. As a general rule tunnels were preferred when the lode was known or supposed to have a slight pitch, while shafts were often resorted to with the steeper pitches, thus permitting the material to be raised more readily.

[1] Mineral Resources of the West, 1867, p. 22.

The first shafts or pits sunk were of the nature of wells, being small and round, following the example of the early quartz-mining practice of California. Hundreds of such pits were sunk along the line of the lode and varied in depth from 20 to 100 feet, but such methods of prospecting were usually abandoned for the simpler, more convenient, and less expensive method of tunneling. These tunnels ranged from 40 to 2000 feet in length, and were often connected with shafts reaching to the surface and to greater depths. Following this early, and to a certain extent preliminary and temporary work, the work of development became more systematic and permanent in character. The shafts were then made with two compartments, a hoisting and pumping compartment, and were given some support in the shape of wooden linings. Later the number of compartments was increased from two to five, with permanent timber linings. The first steam hoist was installed at the Ophir mine, and in 1861 a requisition was made by Superintendent Deidesheimer, of the Ophir, for a 45 horse-power engine and an 8-inch pump, which unheard of extravagance startled the officials and brought forth the query "if all that came out of it was to go for machinery."[1]

Prior to the proving of the position and character of the lode by actual work, the false pitch of the eastern wall and the slight westerly pitch of several of the ore-bodies led to the belief that the general dip of the lode was to the west. However, development showed that the western or footwall had an easterly dip, and that with depth the eastern wall conformed with it. Therefore those shafts sunk on the outcrop on reaching the west wall at a depth of some 400 or 500 feet, penetrated the hard syenite below the lode, and as these shafts increased in depth, their divergence from the lode became more marked. This led to the location of deep shafts some 800 to 1000 feet from the outcrop, and to the eastward. This plan was further rendered advisable, owing to the weak and unstable condition of the vein material. It was first adopted by the Gould and Curry, and afterward by nearly all of the principal mines.[2] The depths attained by these shafts varied from 700 to 1400 feet. As work progressed and greater depth was reached, other shafts were sunk at still greater distances from the outcrop.

Ultimately four lines of shafts were established, each so placed that it required from 600 to 1000 feet further sinking to reach the lode. The fourth line was expected to intersect the lode at depths varying

[1] Eng. and Min. Jour., Vol. 54, p. 152.

[2] Mineral Industry, 1870, pp. 101 and 102.

from 2500 to 3500 feet, after which they were to be prolonged as inclines conforming with the pitch of the lode.[1]

From stations established in these shafts drifts or tunnels were run for the purpose of extracting the ore and for exploratory work. The lode on being reached was attacked, the ore being removed by an overhead system of mining commonly known as overhand stoping. Owing to the extreme unstable character of the lode material, the excavations required immediate support, which was first accomplished by timbering, and later by a combination system of timbering and filling with waste rock. However, extensive caving occurred before the idea of rock-filling was hit upon, and considerable ground was lost, as well as lines of development closed.

The almost insurmountable difficulties experienced in supporting the large excavations in the weak rock masses, led to the invention of a system of timbering, which at first met with considerable opposition, owing to the expense, but was ultimately, generally adopted in all of the mines of the lode, and has since found wide application in practically all kinds of metal mines the world over. This method of timbering is known as square-setting, owing to the manner in which the timbers are framed together into square or rectangular sets. This form of timber support is said to have been devised by Mr. P. Deidesheimer of the Ophir mine in 1860.[2]

This invention and the introduction of higher explosives and power drills may be said to have revolutionized the mining industry, and made it possible to work at great depth.[3]

In the haste to get out mineral and to reach a depth where richer ore-bodies were confidently expected to occur the rich bonanzas of the upper levels were ruthlessly gouged out, with little regard for close and clean work, and when the best portions were taken, the downward progress was again resumed. The idea of roughly sorting the

[1] Eng. and Min. Jour., Vol. 28, p. 35.

[2] Mineral Industry, 1870, p. 112, and Min. and Sci. Press, Vol. 34, p. 184.

It is thought that the idea of using the square-set form of timbers originated in the German mines, but if used there was exceedingly crude in form. Min. and Sci. Press, Vol. 62, p. 377.

[3] According to Werner gunpowder was first employed in metal mines in 1613, although it had previously been applied to quarrying and military operations. It was first used in the mines of Hungary or Germany in 1620, and during the same year was introduced into the copper mines of Eaton, Staffordshire. Plot, however, gives the date of first use in Staffordshire as 1686. Chemical Essays, 1781, Vol. 1, p. 332; Natural History of Staffordshire; and Eng. and Min. Jour., Vol. 57, p. 123.

ore underground, in order that low-grade ores might be concentrated to one-half or one-fourth their former bulk, and thus have their values increased was hardly thought of, most of it being left behind, and forgotten.[1] It is claimed on good authority that much good ore still remains in the solid ground above the 200 and 300 foot levels, especially in the Ophir and Mexican and California mines. Former Mexican miners evidently knew of such rich pickings, probably left purposely, when they could return and mine on their own account, and they have long evinced a desire to return.[2]

The next event of interest not only in connection with the Comstock lode, but to the mining world, was the inception and building of the Sutro tunnel.

It had become evident by 1865 that if mining was to be continued in the Comstock mines a radical change in the systems of drainage and ventilation would be necessary, and apparently the only solution of the problem lay in the construction of a tunnel, that would lower the water level by a thousand or more feet.

In 1866, July 25, A. Sutro was granted by act of Congress the right of way and other privileges to aid in the construction of a drainage and exploratory tunnel to the Comstock lode in the State of Nevada. On February 4, 1875, the Nevada legislature also granted Sutro a franchise, giving him the right of way. Work was begun on the tunnel on October 19, 1869. In 1898 there were two miles of branches of the Sutro tunnel along the lode, which with its many air connections through shafts and winzes had established a new base of operations, at a depth of 1700 feet below the surface and from which a further depth of 3000 feet could readily be reached.[3]

The general practice of mining in the Comstock mines was also employed in the mines of the Mother lode, where similar conditions exist, while in certain extreme cases the problem of support of excavations is even worse.

The great advance made in mining practice in the mines of the Comstock lode was by no means local, but was first made manifest in the character and extent of operations in the California metal mines and later throughout the United States and the world. Undoubtedly greater progress was made in mining in all its depart-

[1] Min. and Sci. Press, Vol. 40. p. 278.

[2] Ibid., Vol. 41, p. 98.

[3] Eng. and Min. Jour., Vol. 6, p. 385, Ibid., Vol. 26, p. 384, and Min. and Sci. Press, Vol. 76, p. 155.

ments during the period of 30 years beginning with 1860 than had been made during the preceding 500 years.[1]

The Homestake mine has always been worked by shafts and stoping with square-sets. However, in the summer of 1878 it was decided to remove the large ore-bodies lying close to the surface by means of an open-cut. This was accomplished by running long drifts into the deposit from the hillside and connecting them with the surface by raises. Work of breaking down the ore is then begun at the surface, the ore being run down the raises, caught in cars and hauled through the drifts to the surface on the drift-level. When the level of the drifts is reached other drifts are run at a lower level thus opening up a new level or block of ground. This system of open-cut working is in reality a milling method and is practically identical with the milling methods employed in the iron mines of Lake Superior. The resulting open pits are called " Glory Holes."[2]

Mining began on Douglas Island about 1881 and as late as 1904 it was estimated that fully 75 per cent of all the ore mined had come from the open pits or " Glory Holes " of the Treadwell mines. One such Glory Hole at the Alaska-Treadwell mine had reached a depth of 220 feet below the adit-level and about 450 feet from the surface with a maximum width of 420 feet and length of 1,700 feet. The method of procedure here is similar to that at the Homestake mine and it is in fact becoming the usual method employed with the proximity of large deposits to the surface.[3] A similar method is employed in the Mercur mines, Utah,[4] and at the Combination mine, Goldfield district, Esmeralda County, Nevada.[5]

A modified caving system was employed in mining the gold ores of Mercur, Utah, as early as 1897 and has been successfully operated up to the present time.[6] The peculiar conditions obtaining here renders this method applicable, a method that has been used extensively for many years especially in the iron deposits of the Lake Superior region, but was not, to our knowledge, applied to gold and silver deposits prior to its use in these mines.

In those localities where there is lack of water to carry on hydraulic-mining operations successfully, also where the grade is

[1] Min. and Sci. Press, Vol. 76, p. 109.
[2] Min. and Sci. Press, Vol. 90, pp. 392 and 404.
[3] T. A. I. M. E., Vol. 34, p. 351, 1904.
[4] Mines and Minerals, Vol. 25, p. 3.
[5] Min. and Sci. Press, Vol. 95, p. 435.
[6] Eng. and Min. Jour., Vol. 68, p. 755.

not sufficient for sluices and dumping of gravels, the working of auriferous deposits has always been a serious problem. The first attempt to overcome these difficulties was the introduction of a hydraulic nozzle into the lower end of a section of straight wooden box or spout which was leaned against the pit bank, thus delivering the gravel with sufficient water for sluicing at a considerably higher level. However, it was found that to thoroughly mix the water and gravel, and make a mobile mass the lower end of the box needed to be given a curve, when the gravel could be elevated with little difficulty. The first hydraulic elevator, built on the proper lines, is claimed to have been used in California by the Yreka Creek Gold Mining Company, Siskiyou County, in 1880. This was a Cranston elevator and was operated under a head of 266 feet, using about 800 miner's inches of water and raised the gravel 40 feet. In 1889 the Joshua Hendy works erected a hydraulic plant at the North Bloomfield mine. This elevator raised the gravel 96 feet with a head of 540 feet and used 1500 miner's inches of water.[1]

Hydraulic elevators were not generally used until comparatively recent times but are now in common use in most of the Western states and to a limited extent in the Southern goldfields.

The first hydraulic elevator was used in the South at Brindletown, North Carolina, in 1883, also at Dahlonega, Georgia. A Crandall elevator was installed at the Chestatee mine, Georgia, in 1895.[2]

As early as 1893 electric power for the operation of mine plants was installed at Bodie, California, and since that time many other installations have been made in the gold and silver mines of the West. About 1900 the electrical equipment of the C. and C. shaft at Virginia City, Nevada, was begun. Power is generated on the Truckee River not far from Floriston. Extensive hydraulicing operations along the Truckee River are also furnished with power from the same plant.[3]

The hydraulic system of raising water was adopted by the California and Consolidated Virginia Company of the Comstock lode, in 1899 and proved very successful.

Many mines are now being operated by electric power in whole or in part in the Cripple Creek district as well as in numerous mining camps throughout the United States.

[1] Min. and Sci. Press, Vol. 34, p. 24, and Ibid., Vol. 72, p. 261.

[2] U. S. G. S., 20 Ann. Rept., Pt. 6, p. 116, 1898–99, and T. A. I. M. E., Feb., 1896.

[3] Eng. and Min. Jour. Vol. 74, p. 243.

The discovery of dynamite by Nobel, in 1866, furnished the mining industry with one of its most important and powerful agencies which may be considered as standing second to none in its influence on the advancement of mining. Exactly when dynamite was introduced into the United States as an explosive for mining purposes is not known, but an early mention of it occurs in the Mineral Resources of the States and Territories for the year 1869, about three years after its discovery.[1] In this connection the following statement is made: "Now since the small holes with giant powder do as much execution as the larger ones with common powder, the comparative cost of using the two materials is as 51 to 92 in favor of the former. . . . The miners foresee that this change reduces the necessity for skill on their part, and will lead to the introduction of unskilled labor."

Power or the so-called machine drills were first used in the mines of this country, about 1850, although the "drop drill," a hand operated machine, was first used in 1838. A German engineer, Sommeiller, operated the first air drill in the Mt. Cenis tunnel, which was being driven through the Alps. Steam or air operated drills were used in 1848, but it was not until several years later that they were introduced into the mines of the United States, when all such drills went by the name of Burleigh.[2]

The improvements made in methods of reducing ores together with the processes of extraction of values were largely responsible for the rapid advancement in mining made during the sixties and seventies. The invention of the Blake crusher and the gravity stamp, and the application of the lixiviation methods to the treatment of ores must be considered of vital importance in the building up of the mining industry to its present status. However, a discussion of the methods of treating ore in the extraction of values is given in another chapter, under the heading of Milling.

DESCRIPTION OF METHODS OF MINING.

In the following pages are given descriptions of the methods of mining employed at various times in the mines of the United States. Gravel-mining is first considered in its varied and multiform phases, following which is a discussion of vein-mining. When available, extracts are given of descriptions of typical operations; otherwise

[1] Mineral Resources of the States and Territories West of the Rocky Mountains, 1869, pp. 33–36.

[2] Min. and Sci. Press, Vol. 87, p. 19.

descriptions, incorporating the best practice, are used instead. Numerous references are appended in order that the reader may verify statements made and enlarge upon the information given should he so desire.

Gravel Mining.

Prospecting. — The prospecting of auriferous gravel deposits is more readily accomplished than similar work in veins owing to the comparative shallowness of the deposits, and the greater regularity and uniformity of occurrence of the gold-content.

The first work of this character is done by pits which are sunk to bed-rock, but where water occurs in considerable quantities such work is impossible, except in special localities, as in Alaska, where, during the winter months, the miners even prospect the beach of Bering Sea, by sinking pits through the ice and underlying sands. Such work has been carried on at a distance of one-quarter of a mile from the shore, where the water was shallow and consequently froze solid to the bottom.

Prospecting of the tundra of the Cape Nome goldfields was first accomplished by shafts, but owing to the expense is now done almost entirely by drills. Both drilling and shaft sinking are readily accomplished as the tundra is frozen except in open spots, which usually occurs near growing trees.

The testing of gravel deposits, especially those of considerable depth, is now almost universally done by churn drills. Such work is now successfully carried on in all of the large hydraulicing and dredging fields, that at Oroville being typical of such operations. Here a 7½-inch drill is employed, the casing of the hole being driven as far in advance of the drill as possible, the core being cut out by the bit. The volume and contents are thus readily determined as measured, when raised by the sand-pump. This material is rocked and panned, and from the results the value per cubic yard of the deposit for that particular locality is determined.[1]

Ground-Sluicing and Booming. — Detailed descriptions of the early methods of working gravels, while interesting are not of sufficient importance to warrant elaboration in this connection. However, as ground-sluicing and booming, or hushing, especially the former are still used, and will probably continue to be employed by individuals with small capital and in new districts, brief mention is made regarding them.

[1] Min. and Sci. Press, Vol. 90, p. 266.

Ground-sluicing consists in digging a ditch, either by hand or by the use of a stream of water, which is cut down to bed-rock. If the bed-rock is smooth, boulders and stones are thrown in, often very irregularly, while in other cases they are carefully placed on edge with the upper edge inclined slightly upstream; but if the bed-rock is rough it may serve to arrest the gold, from which irregular depressions it is removed at certain intervals. After the ditch or ground-sluice has been made and prepared with riffles, the work of washing is begun; all of the water and gravel passing through the sluice to the waste bank. As the face of the bank recedes the sluice is advanced thus maintaining the same relative position between the two. Many of these sluices may be in close proximity, each having an independent discharge, or several and possibly all may feed one large sluice, which may be a ground-sluice or wooden sluice, in either case provided with some sort of riffles. Ground-sluicing is, however, pre-eminently a poor man's method, and the equipment is usually of the roughest sort.

In the early days in California ground-sluicing yielded the greater part of the gold produced, but was soon superseded by hydraulicing and other improved methods by which it was possible to obtain larger returns at small cost. Nevertheless ground-sluicing did not cease as a source of gold production, for the Chinese still persisted in the work, even working over many times ground long since abandoned by the white man. Furthermore, the Chinaman excelled the white miner in saving gold, and especially fine gold, under difficult conditions. In fact the Chinese became adepts in collecting gold from clayey gravels, black sands, etc., and were thereby able to work profitably ground considered too low-grade for the American miner to spend his time upon. Taking the case of black sands, the Chinese so arranged their sluices that all materials passing through them dropped into a large shallow box floored with perforated iron. All material too large to pass this screen was shoveled out, while that passing through the screen was carried by a stream of water into a wide sluice provided with blanket riffles, and is practically identical with the operation known as "blanket sluicing." By this means it is evident that the bulk of the material in the sluices is considerably reduced, the coarser being thrown out by shovels, while the finer and lighter earthy material is permitted to escape with the water. The black sand, gold, quicksilver and amalgam are thus concentrated into a comparatively small bulk.[1]

[1] Min. and Sci. Press, Vol. 43, p. 6.

A modification of the blanket-sluices is used at Salmon Falls, on the Snake River, Idaho, where the gold is quite fine and difficult to catch. Here the finer materials are separated from the coarser and passed over burlap placed in sluices, the gold and fine sands adhering being run over amalagamating plates, which readily catch the gold.[1]

Booming has had quite extended application in a number of localities in the United States, especially in California and at a later date in Oregon. It was used before the discovery of America, being described by Pliny as a process extensively employed in Spain before the Christian era. It is now used to a limited extent in Alaska owing to comparatively slight grades and the disposition of tailing. Booming originated from the method of prospecting known as "hushing," and so-called in Yorkshire where it was resorted to in the search for lead-veins.

Booming consists in impounding water at some convenient level above the ground to be worked, either by means of ditches or pipes. The impounding dam is provided with a gate which can be suddenly thrown open, permitting a large volume of water to rush down the slope washing out and carrying along with it all loose material. The character of the gate varies largely with the scale of the operation. In California sheets of canvas were occasionally used, being stretched across the opening in the dam and allowed to collapse when a rush of water was desired. However, automatic gates are now generally employed in the larger operations, the actuating device being a water-box which when full dumps and frees the gate. When the water has drained from the dam the gate closes, raising the water-box, which in the course of time becomes filled and the operation is repeated.

When gold is to be collected from the materials thus washed down, some means of catching the gravels must be provided. For this purpose a strongly built flume is constructed at the foot of the slope so arranged as to catch all the water and gravel descending from above. Flumes several thousands of feet in length are often employed in order to ensure the saving of all of the gold.[2]

Speaking of an instance where booming was employed in Alaska, C. W. Purington says:[3] "During a period of three weeks a block of overburden, consisting of muck and barren gravel 5 feet thick by 25

[1] Min. and Sci. Press, Vol. 58, p. 297.

[2] Gold, Its Occurrence and Extraction, A. G. Lock, p. 992, 1882.

[3] U. S. G. S., Bull. No. 263, pp. 56 and 57, 1905.

feet wide by 900 feet in length, had been removed by the booming process before the shoveling operations commenced. . . ."

The booming process is very similar to the Georgia or Dahlonega method of mining decomposed materials in the Southern states, which is described under the head Hydraulic-Mining.

"Rocking" or "cradling" and "long-tom" work is in reality sluicing in wooden sluices of various lengths. With the rocker one or two men may be employed—one rocks while the other feeds water and gravel. The tom usually consists of two lengths of sluice, the lower being provided with riffles and catches the gold while in the upper the gravel is disintegrated and mixed with water. Mercury may or may not be employed in these two pieces of apparatus.

Hydraulic-Mining. — Three principal conditions control the choice of a hydraulic property, namely: First, the amount of gold in the deposit, which must be sufficient to cover cost of purchase, equipment and maintenance and further pay interest on capital invested; second, an ample water supply, accessible and under sufficient head to ensure effective washing of gravel to and through the sluices; and third, sufficient fall to permit proper treatment of gravels and disposition of tailing. Besides these, other important considerations are: the presence of timber, and in such quantities as to furnish lumber for sluices, flumes, trestles, sluice blocks, etc., not too high-priced labor, and transportation facilities.

With regard to the amount of gold which warrants the undertaking of such operations we can do no better than to refer to other similar operations. The Blue Tent yielded, 15 cents per cubic yard; Gold Run, $4\frac{3}{4}$ cents per cubic yard; Quaker Hill, $6\frac{2}{3}$ cents per cubic yard; American Hill, 30 cents per cubic yard; and the Cement Mining Company's mine on North Fork, $4\frac{3}{4}$ cents per cubic yard. It is doubtful whether other districts can show higher averages, although certain localities may run higher or lower during their most productive periods. Probably the lowest value of gravels successfully worked are those of Drummond, Montana, which yield an average of 2 cents per cubic yard.

In California gravels not yielding more than 4 to 6 cents per cubic yard are considered low-grade.

In 1899 there were eleven principal reservoirs constructed almost exclusively for hydraulic-mining operations and were situated on the Yuba, Bear, Feather and American rivers. They varied in area from ten to four hundred and eighty-seven and one-half acres each (high water) and had a capacity of 2.5 to 796.7 million cubic feet. The aggregate capacity was about two billion one hundred and ninety-five million gallons. The total area of these reservoirs, at high water, was eleven thousand six hundred acres. Other mining reservoirs swelled the capacity to about fifty billion gallons. These reservoirs were fed chiefly by rains and melting snows, and by means of the water thus impounded it was often possible to continue the operations throughout the dry season, while without such a reserve supply the hydraulicing season was co-extensive with the rainy reason.[1]

Water was drawn from the reservoirs and often conducted for miles in order to bring it to the desired point and to obtain sufficient head or pressure for the work in hand. As the mining operations and supplies of water lay at the two extremes in point of altitude, considerable engineering skill was required to surmount the intervening obstacles of a rugged topography.

Ditches and flumes were employed principally in conducting the water from the reservoir to the gravel pit, although occasionally considerable lengths of pipe and tunnel were necessary where particularly difficult sections of the country had to be traversed. The following companies had artificial water-ways in the shape of ditches, flumes, pipes and tunnels: The La Grange Ditch and Mining Company had 25 miles of ditch; The Mokelumne and Campo Seco Company had several hundred miles of ditches; The California Water and Mining Company had 250 miles of ditches; the Park Canal and Mining Company had 290 miles of ditches, eight miles of pipe etc., with 2,200 miner's inches capacity; the North Bloomfield Mining Company had, including reservoirs, 157 miles of ditches; the Excelsior mines at Smartsville, on the Yuba, had 115 miles of ditches, carrying 6,000 inches of water; the North Fork Company had a ditch 25½ miles in length, with eight miles of pipe; the Maxwell ditch, in Plumas County, carried 2,000 inches of water, while the El Dorado Deep Gravel Company's canal carried 12,000 inches; at Cherokee Flat, Butte County, there were ten miles of ditch and four miles of pipe; etc., etc. The Amador canal had a capacity of 5,000 inches of water, which was supplied by a reservoir at the New York ranch having an area of 140 acres. The ditch was 45 miles long and had a three-fold purpose, namely; 1st, the driving of mills; 2nd, furnishing water for gravel mines; and 3rd, for irrigation purposes.[2]

[1] T. A. I. M. E., California Mines and Minerals, p. 27, 1899.

[2] T. A. I. M. E., California Mines and Minerals, pp. 27 and 28, Min. and Sci. Press., Vol. 30, p. 57, and Eng. and Min. Jour., Vol. 78, p. 589.

The tunnels ranged from a few hundred feet to several thousand in length. The north Bloomfield tunnel was 7,874 feet long with a rock-section of 7 × 8 feet, while the Excelsior mine had six bed-rock tunnels with a total length of 13,300 feet.[1]

The Spring Valley mine at Cherokee Flat brought its water from the high Sierras some 63 miles distant through 122 miles of ditches and crossed the Feather River, over a deep gorge, in an inverted syphon pipe 30 inches in diameter. This pipe was 14,000 feet long and made of riveted steel. It stood a pressure of 404 pounds per square inch and at the lowest point of the syphon the water had a head of 856 feet.[2]

Data regarding a number of the large ditches used in California are given in the following table:[3]

Name.	Length of Ditch.	Width of Top of Ditch.	Width of Bottom of Ditch.	Depth of Ditch.	Cost of Ditch.	Average Grade per Mile.	Discharge in Miner's In.
	Miles.	Feet.	Feet.	Feet.	£	Feet.	
Milton	100	6	4	3.5	52,000	14.5	3000
North Bloomfield	55	8.65	5	3.5	84,000	14	3200
North Bloomfield	60	8	6	4	....	......	2200
Spring Valley	52	6	4	3.5	....	......	2000
Hendricks	46.5	6	4	2	27,000	9.6	
San Juan	45	......	......	......	59,000	......	1300
South Yuba	35	8	4	4	....	......	
Excelsior	33	8	5	4	....	9	1700
La Grange	20	9	6	4	90,000	7.5	3000
Eureka Lake	18	......	......	......	86,000	......	2800
Union	15	8	4	3.5	....	13	1200
Boyer	15	8	4	3.5	....	13	1200
....	......	6.5	4	3	....	11.2	3000
....	......	......	3	3	....	......	2000

For list and description of ditches in the Canyon district, Blue Mountains, Oregon, and the Seward Peninsula, see references.[4] A more extended list of water ditches in Alaska and the Northern goldfields may be found in C. W. Purington's paper on Methods and Costs of Gravel and Placer Mining in Alaska.[5]

The first cost of a flume is often less than that of a ditch and the

[1] T. A. I. M. E., California Mines and Minerals, p. 31, and Eng. and Min. Jour., Vol. 78, p. 589.

[2] Eng. and Min. Jour. Vol. 78, pp. 588 and 589.

[3] Gold, Its Occurrence and Extraction, A. G. Lock, p. 962.

[4] U. S. G. S., 22 Ann. Rept., Pt. 2, p. 717, and Ibid., Bull. 284, p. 141.

[5] U. S. G. S., Bull. No. 263, pp. 104, 110, 1905.

repair is considerably less; further, a flume presents less resistance to the flow of water than does a ditch. However, the building of flumes, especially if they must be supported on trestles, should be avoided as they are liable to be destroyed by fire. Pipes are also occasionally mounted on trestles when depressions have to be crossed, but when gorges cross the proposed line, the pipes are usually supported on bridges either horizontally or as an inverted syphon. The ditch should be high enough at the point of delivery into the pipe line to give a sufficient head both to overcome friction and to ensure a rapid discharge of water from the pipe, which is of necessity of smaller dimension than the ditch. The resistance due to friction in the pipe of the Spring Valley Canal Company which crossed the North Fork of the Feather River was estimated to be equivalent to 20 feet of head.[1]

The pipes employed with ditches and flumes in conveying water are usually made of No. 12 to No. 16 sheet iron, with lengths varying from 12 to 20 feet. They should be buried in the earth when possible and to a sufficient depth to escape the expansion and contraction to which they would be subjected if exposed to the weather.

It is, however, considered better practice to carry a ditch around rather than attempt to cross a depression by flume or pipe.

The capacity of ditches in California varied from 600 to 800 up to 7000 miner's inches with grades of 4 to 30 feet per mile, average probably 12 feet.[2]

Timber flumes ranging up to 150 feet in height were occasionally constructed, and when timber for trestles was not available the flumes were built along the faces of steep cliffs, being supported by iron brackets.

Water for hydraulic-mining is almost universally measured by the miner's inch, which is an arbitrary unit of measurement based on the amount of water that will flow through a given opening in a given interval of time. Varying quantities of water were adopted as the unit in the various camps with little or no regard for uniformity. The usual method of estimating the " inch " consists in determining the flow through an orifice one inch square in a two-inch plank, with a head of water of six inches above the top of the orifice. Formerly the miner's inch used in California was put at 100 cubic feet per hour, or 1000 cubic feet per day of 10 hours, which amounted to

[1] Eng and Min. Jour., Vol. 19, p. 183.

[2] Min. and Sci. Press, Vol. 75, p. 572.

1.66 cubic feet per minute. However, the legislature of California, on March 23, 1901, established the miner's inch as: "The standard miner's inch of water shall be equivalent or equal to one and a half ($1\frac{1}{2}$) cubic feet of water per minute, measured through any aperture or orifice."[1]

Raymond gives the following table of the standard miner's inch:[2]

Pressure from Surface to Top or Middle of Orifice.	Miner's Inch.	Cubic Feet (each 6.23 Gallons)				Authority.
		Per Second.	Per Minute.	Per Hour.	Per 24 Hours.	
6 inches	1	0.039	2.33	140	3,360	Hittell.
Do	1	0.026	1.57	94.7	2,274	Carpenter.
Do	38	1.000	60.00	3600.0	86,400	do.
Do	1000	26.125	1580	94,700	2,274,000	do.
10 inches	1	0.03	1.8	109.1	2,618	do.
6 to 10 inches	1	0.027	1.6	100	2,400	Standard
Do	10	0.27	16	1,000	24,000	experi-
Do	100	2.7	166	10,000	240,000	mental
Do	1000	27	1666	100,000	2,400,000	Miner's inch.

Water measurement in the Yukon is given in the following table:[3]

Dimensions of Orifice in Inches.		Head in Inches Over Center.	Discharge in Cubic Feet per Minute.	Number of Miner's Inches of $1\frac{1}{2}$ Cubic Feet per Minute.
Width.	Depth.			
6	2	6.25	17.98	11.99
12	2	6.25	36.38	24.25
18	2	6.25	54.59	36.39
24	2	6.25	73.05	48.70
4	4	6.25	23.56	15.71
6	4	6.25	35.35	23.57
12	4	6.25	70.95	47.30
18	4	6.25	107.48	71.65
$25\frac{1}{2}$	4	6.25	152.37	101.58

According to Egleston the theoretical horse-power of a miner's inch of water is as follows:[4]

[1] Mines and Minerals, July 1901, p. 549.
[2] Gold, Its Occurrence and Extraction, A. G. Lock, p. 953, 1882.
[3] Min. and Sci. Press, Sept. 27, 1902, p. 177.
[4] Gold, Its Occurrence and Extraction, A. G. Lock, p. 955, 1882.

Heads, in Feet.

100 30	90 20	80 15	70 10	60 5	50 3	40 1

Inches to Horse-Power.

3.25 10.8	3.61 16.2	4.06 21.6	4.64 32.5	5.41 65	6.50 108	8.12 325

It is roughly estimated that the amount of gravel moved is, in cubic yards, three times the quantity of water used in miner's inches.

ESTIMATED QUANTITY OF WATER, DUTY AND NUMBER CUBIC YARDS GRAVEL MOVED.

Mine.	Water Used in 24 Hours, Miner's Inches.	Cubic Yards Gravel Washed in 24 Hours.	Amount Gravel in Cubic Yards per Miner's Inch.
La Grange	375,155	683,000	1.82
North Bloomfield	710,987	3,250,000	4.6
Southern Cross	299,144	598,000	2.02
Polar Star	412,000	618,000	1.49
Franklin	91,409	326,000	3.40
Cedar Claim	247,000	2,057,000	7.50
Hill Top	456,000	1,140,000	2.5
Irish Hill	162,000	405,000	2.5
Various Small Placers & Hydraulic	54,750	54,750	1.
Volcano, Hydraulic	365,000	912,500	2.5
Campo, Seco and Stockton Ridge.	61,000	122,000	2.
Railroad Flat	45,000	90,000	2.
Jenny Lind	365,000	730,000	2.
Chili Gulch	200,750	501,875	2.5
Table Mt.	833,250	2,916,000	3.5
Butte Creek	24,000	84,000	3.5
Feather River	1,259,363	4,407,770	3.5
Yuba River	5,458,171	19,103,598	3.5
Bear River	1,117,082	3,351,246	3.
Dry Creek No. 2	44,229	132,687	3.
American River	1,914,500	8,615,250	4.5
Total	14;495,290	50,108,676	Av. 3.4

As a rule the lower or delivery end of the water-way terminates in a length of flume sufficiently long to discharge into the bulk-head or pressure-box, and is usually supported on a trestle owing to the height of the latter, which stands from 10 to 30 feet above the ground. However, with an inclined pressure-box the flume may not need to be elevated. The pressure-box is a long box of rectangular section strongly built and rigidly supported in a vertical or inclined position, depending largely upon the lay of the ground. It receives the water from the flume or pipe line, and discharges the same through a pipe set into its foot. Above the pressure-box or to one side of it in the flume is a sand-box, the object of which is to catch any sand and fine gravel carried along by the water in the flume, and thus prevent it from entering the supply-pipe for the giants in the pit. By means of a gate the accumulations of sands and gravels may be discharged from the sand-box. Further, a grate is set in the upper end of the pressure-box to prevent any floating material passing through it. The supply of water should be sufficient to cover the mouth of the supply pipe to a depth of several feet, in order that no air, or as little as possible, be carried into it. To safe-guard against the entrance of air into the pipe the pressure-box is usually divided into two compartments, thus permitting the water to become quiet before entering the supply-pipe compartment. A waste gate is also placed in the flume above the pressure-box in order that the supply and discharge may be maintained equal.

From the pressure-box the supply-pipe should descend to the pit with as few irregularities, such as rises and depressions, as possible, which tend to both retard the flow of water and permit air to collect and thus increase the danger of rupturing the pipe. Air valves are also employed to release any air that may become entrapped. When the bank down which the pipe is carried has considerable pitch, it is advisable to construct a wooden frame-work as a foundation for the pipe, to which it is attached, the whole being securely braced and staked down, and as a further precaution against movement should be weighted down with boulders. Beginning with the pressure-box the supply-pipe for the first few lengths is given a greater diameter, gradually decreasing in size until the normal diameter of the pipe line has been reached. The pipe is also provided with a heavy cast iron gate operated by a screw, thus letting in or shutting off the water at the entrance of the main feed or supply-pipe.

The size of the pipe depends primarily upon the quantity of water to be transmitted through it. As a rough estimate a 22-inch pipe will carry from 1500 to 2000 miner's inches, while for quantities ranging from 3000 to 4000 inches a 30-inch pipe should be chosen.[1]

[1] Min. and Sci. Press, Vol. 75, p. 572, Ibid., Vol. 76, pp. 5 and 34.

The following data has been given for the ordinary feed-pipes:[1]

Diameter of Pipe in Inches.	Pressure in Feet.	Number of Iron.	Thickness of Iron in Decimals of an Inch.
22	150	16	0.060
22	150 to 250	14	0.078
22	250 to 310	12	0.098
30	150	14	0.078
30	150 to 275	12	0.098
40	160	....	0.236

The iron used in these pipes must vary with the pressure, the range being from No. 16 to No. 11. In general for a 22-inch pipe, with a pressure of 150 feet, No. 16 iron is used; while Nos. 14 and 12 are employed with pressures from 150 to 200 and 200 to 300 up to 400 feet, respectively. With a 30-inch pipe Nos. 14 and 12 have been found sufficient under heads of 150 to 275 feet. The pipes should be thoroughly treated with liquid asphalt before being placed.

It was the practice formerly to employ a distributor which was a large cast iron box, placed in the washing pit, from which the branch feed pipes were led off, but owing to its weight and the danger of bursting it was abandoned.[2]

There are two types of giants or nozzles in general use, namely: the single- and double-jointed forms. The double-jointed form is claimed to be more efficient with respect to the action on the bank, while the single-jointed form can be more readily manipulated since lubrication is possible without turning off the water. However, the former is considered safer under high heads, as 200 feet or more. The double-jointed machine is made with or without a king-bolt — with the king-bolt the construction is simple and strong, but the passage of the water is obstructed; without the king-bolt a free water-way is obtained, and the machine is more efficient, but the ball-bearings employed get clogged with sand and dirt and often crush. There are eight sizes of giants which use nozzles varying from 1½ to 10 inches in diameter, and weigh from 390 to 2300 pounds.

Formerly the direction of the stream of water was changed by pushing or pulling the giant around, which often required the efforts of three men to accomplish it, but with the use of the deflector the

[1] Gold, Its Occurrence and Extraction, A. G. Lock, p. 966, 1882.

[2] Min. and Sci. Press, Vol. 76, p. 34.

largest machine can be controlled perfectly by a child. The deflector consists of a short section of pipe attached by two pivots vertically placed at the end of the nozzle of the giant, and in fact constitutes the true nozzle. A handle fastened to this adjustable nozzle permits a horizontal movement of it, thus changing the direction of the issuing stream of water, and causes the giant to rotate about its vertical axis. Great care must be taken in adjusting and handling the deflector, otherwise the giant may get beyond the control of the operator and do great damage.

The giant is bolted to one or more heavy timbers, which in turn are securely braced and staked at the bottom of the pit, or at the point chosen for its operation.[1]

As many as half a dozen giants (in a few instances 10 to 15) have been used at one time in some of the largest hydraulic mines, each throwing a powerful stream against the mountain side. As much as 1500 miner's inches of water (per minute) have been discharged by a single machine, giving a capacity of 25,000,000 gallons per 24 hours. The Spring Valley mine, at Cherokee Flat, used 36,000,000 gallons daily, which was three times the quantity of water used by the city of San Francisco (about 1880), while in the winter months this was increased to 70,000,000 gallons.[2]

These giants can throw an effective stream of water fully 200 feet. However, notwithstanding the terrific force of such a jet of water the gravel banks are often so indurated and tenaceous that they cannot be economically broken by means of the jet alone, but blasting must be resorted to, to shatter them preparatory to the use of the giant. In order to get the full effect of the force of the stream the giant must be placed as close to the bank as is safe — it is evident then that the distance of the giant from the bank varies directly as the height of the latter. With banks of 100 feet or more in height bench working should be employed, the benches ranging from 50 to 60 feet in height. Speaking in a general way a large giant can do the work of 1000 men.[3]

When the gravel bank cannot be effectively broken down by a stream of water, recourse is had to powder. Powder is also used when the bank is dangerously high. The preliminary work of bank blasting consists in drifting or tunnelling into the bank at its foot, and forming receptacles for large charges of powder. After the

[1] Min. and Sci. Press, Vol. 91, p. 94.
[2] Eng. and Min. Jour., Vol. 78, p. 588, 1904.
[3] Min. and Sci. Press, Vol. 76, p. 57.

charges are placed with the necessary fuse or firing-wires leading to the surface, tamping is placed and finally the charges are fired.

The length of the drifts depends upon the height of the bank, and the nature of the material to be broken up. The quantity of powder used also depends on similar conditions. The rule usually followed is to make the length of the main drift about three-quarters the height of the bank, if this is considerable. One or more cross-cuts are driven from the main drift, one being always driven at the extreme end and running in both directions, thus forming a T. Each arm of the cross-cut should have a length of 40 to 50 feet. Again other short drifts or secondary cross-cuts are run at right angles from the latter, the ends of which are extended toward the face of the bank. The secondary cross-cuts are called "lifters" and form the receptacles for the powder, which is often placed in shallow pits sunk at the extreme inner ends. Shallow banks and blocks of ground are occasionally broken up by charges of powder placed in drifts driven at the bottom of shafts.

The quantity of powder employed should be carefully determined, but varies from 16 to 20 pounds for every 1000 cubic feet of ground covered by the drift. It is estimated that a successful blast will loosen twice the area covered by the drifts. Further, two-thirds of the powder should, it is claimed, be placed in the terminal cross-cuts, the remainder in the other cross-drift or drifts.

Formerly fuse was used in firing the charges, and to make sure that the powder would be ignited, as many as two and even three lines of fuse were laid to the surface in gas pipes. Later, electrical firing was employed, the wires after being attached to the primers in the cartridges were placed along on top the paper covering the boxes and kegs containing the powder. Sand and gravel is used as tamping, being placed on top of a line of large stones and boulders which are laid along the center of the drifts forming a basis for the tamping. The tamping should not be allowed to stand so long that it will settle before the charges are fired, which may, however, result in a very short time if placed loosely. Occasionally a timber bulkhead or barrier is set into the drift at or near the intersection of the cross-cuts.

Black powder has now been superseded by low-grade dynamite in the work of bank blasting.[1] The Smartsville Company, in October, 1869, exploded in their mine 1500 kegs of powder in one blast. There were 1800 feet of drifts and the bank broken up had the

[1] Min. and Sci. Press, Vol. 76, p. 57.

following dimensions: height, 35 to 110 feet; length, 600 feet; and width, 350 feet.[1]

The common practice in the use of giants in California is to employ four of them in breaking down the bank, which are operated as follows: one giant at the front, with a head of about 400 feet and nozzle ranging from 7 to 9 inches, according to requirements; two giants operating on the left side, with a head of 150 to 250 feet; and one giant on the right side, with a head of 500 feet to break up hard portions of the gravel as " cement." The bank broken by the side giants is prevented from sliding forward too far by the giant acting in front.[2]

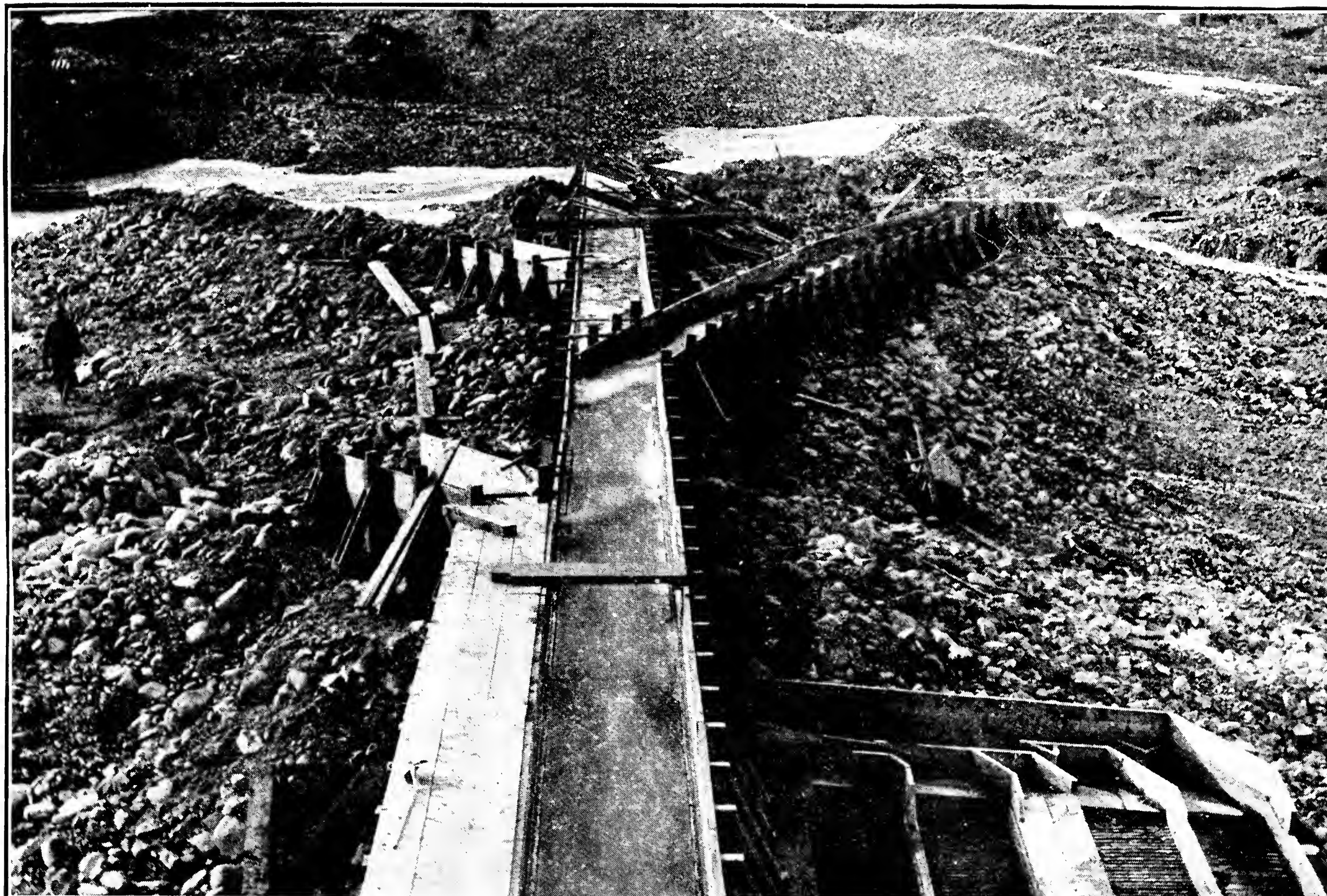
Often the hydraulic giants do not furnish sufficient water for properly handling the gravel broken down and washed away from the bank, when extra water is provided by allowing a certain amount to escape from the flume above, through a gate and run over the bank nearly directly above the point being operated upon by the giants below.

Aside from the giants the sluices are the most important part of the equipment of an hydraulic enterprise. Sluices are for conveying the water and gravel and are located within the washing pit, and according to their position with respect to the bank are designated by the following terms: that portion lying close to the bank is called the " rock-cut " being cut in the bed-rock, of which there may be a number. The function of the rock-cut is to convey the wash from the bank into the " rock-sluices " or " sluice-boxes," which may be separate ditches or boxes in which riffles and blocks are placed for catching the gold washed down from above. Rock-sluices differ from rock-cuts in that they are provided with means of catching gold. A rock-cut may then be changed into a rock-sluice by simply placing blocks along the bottom, but it is usually considered better practice to place a wooden box within it, in which the blocks and riffles are secured to better advantage.

Great care should be exercised in the location and construction of the rock-sluice or as is sometimes called the " bed-rock " sluice. The water supply, character of gravel and topography of the ground largely control their length, position and grade. Sluices for handling sands require steep grades, and may be shallow. Gravel with many moderately large boulders should have narrow and deep sluices, especially if the dump is poor. The usual grade is six inches for a box

[1] Min. and Sci. Press, Vol. 19, p. 250.

[2] Ibid., Vol. 86, p. 244.



Arrangement of Sluices, Discharge End, in Hydraulic Mining. (From Engineering and Mining Journal.)

of 12 feet in length, but in special cases may vary from 1 to 12 inches per length of box. The head boxes are usually given a lower grade, which is increased slightly toward the dump. As the tail-sluices are usually old and often in poor condition, they are given more grade. Light deposits with slight grades and low dumps require wide and shallow sluices. A prime requisite of sluices is that they be straight, which is not always possible, however. Sluices should be placed in the lowest part of the channel, to accomplish which it is often necessary to make deep cuts and even drive tunnels for their accommodation. However, open bed-rock cuts and sluices are preferred when practicable, and may be quickly and cheaply excavated by drilling and blasting the bed-rock, and washing (piping) it out with a giant.

When wooden boxes are put in the cuts, they must be anchored down. The riffles or blocks are then placed, the sluice obstructed temporarily, and run full of sand or gravel to wedge in the blocks, then the obstacle is removed and the material is run out of the sluice with a giant or a strong stream of water. Sluices should not be less than 240 feet in length, owing to loss of fine gold, especially when clay is present. Blocks should never be wedged into a wooden sluice or flume as they will spread the box on swelling. They may be prevented from floating, by nailing a scantling on top of the blocks, and against the side of the sluice.[1]

Along the side of the sluice-boxes and at various intervals, large shallow sluices are placed, which are called " under-currents." They vary from 20 to 50 feet in width, 40 to 50 feet in length, and have sides some 16 inches high. These under-currents are set at a fairly heavy grade, being placed to one side of and a little below the main sluice, the object of which is to relieve the latter of the finer material, and thus permit a more effective collection of the gold.

The coarse stuff passing the grating through which the fine passes to the under-current, may be picked up by a sluice at a lower level, or be permanently disposed of by being thrown on the dump. The fine material entering the under-current, which is set at a grade of 8 to 10 per cent, passes over cobblestones and block riffles, and may then be returned to the sluice at a lower level.

Riffles or some similar means of holding the quicksilver, when used, and catching the gold are indispensable for hydraulic-mining.[2]

[1] Min. and Sci. Press, Vol. 91, pp. 94 and 111.

[2] Catching gold by means of rough surfaces is of ancient origin. Van Humboldt mentions the use of sheep-skins by the placer workers of Colchis and attributes to that practice the possible origin of the legend of the " Golden Fleece."

There are pole, rail, block, angle steel and expanded metal riffles. While the expense is greater the iron riffles are claimed to be better gold savers than the wooden forms. However, with short sluices metal is usually employed in the larger operations, but for the longer ones timber is generally chosen.[1]

Pole riffles made of green saplings often armored with strap iron, nailed to the upper surface are frequently employed in small-scale placer operations, and at present are used quite extensively in the Northern Territory. When clayey gravels are encountered, sharp projecting pieces of metal are provided in place of the flat straps — two-inch square plates of iron being driven cornerwise into the poles. Iron and steel rails placed longitudinally in the sluice-boxes are occasionally used, especially in the Seward Peninsula. Although rail riffles give excellent service in large-scale hydraulicing operations they are considered most too expensive for creek placers.[2] Expanded metal and cocoa matting are usually employed on dredgers and similar gold-saving apparatus, and they are described under Dredging.

Preparatory to heavy piping of gravel into the sluices quicksilver is charged to them. This is done after several days run of gravel, preferably light gravel, by pouring (not sprinkling) it into the sluice in a zig-zag manner lengthwise of the sluice. From one to four pounds of mercury constitute a charge for about 50 feet of sluice and alternate sections are charged daily. In order to obtain unamalgamated specimens the first, one or more, boxes are not charged with mercury.[3]

In the washing of heavy gravels the action of running water can be materially increased by so placing the giants that the force of the stream will be utilized in moving the materials. While if the material is light and tends to move forward readily, or with slight assistance, it can be handled with little trouble by a judicious use of water and operation of the stream of water, thus drawing it directly away from the bank. Gravel may be driven or drawn from 100 to 150 feet to the sluices or rock-cuts, which is often an economical method, since the construction of sluices is reduced to a minimum.

Further, it is known that the kings of Imeret used wool in catching gold in the Tskinitskali and Abacha rivers of the Caucasus and the Turkish gipsies used goat skins for a similar purpose in the Belichta River. Mining and Scientific Press, Vol. 49, p. 148.

[1] Min. and Sci. Press., Vol. 91, p. 111.

[2] Mining Magazine, Vol. 11, p. 125, 1905.

[3] Mining Magazine, Vol. 91, p. 11. Other authorities say mercury must be scattered in a light spray from a sprinkling pot. Eng. and Min. Jour., Vol. 19, p. 243.

With light deposits it is preferable to first remove the covering of dirt and sand preparatory to working the gravels below, which usually effects a higher saving in values, while with heavy deposits, both top and bottom are worked together since the light top material aids in moving the heavier bottom gravels.

In washing cement deposits where the gravels are compact and tough and where difficulty is experienced in properly disintegrating the material for gold-saving, the method of backing the gravel up against the bank is occasionally resorted to, by which means it can be effectively broken up, while other giants are driving the disintegrated material toward the sluices. By this method of procedure more time can be given to under-cutting the bank and keeping the face free from boulders, stumps, logs, etc., which are kept at such a distance from the bank that they can readily be attacked and handled by the rock "rustlers," instead as is often done kept held close to the bank.

Boulders, stumps, etc., are after being reduced to the proper size, handled by derricks, operated by water power, thus clearing away obstacles which obstruct the washing operations.

In shallow workings as in creeks and gulches the ground is usually worked toward the sluices, which is accomplished by cutting a race up through the middle of the block, and setting the giant on the surface of the ground in behind the block, then by inclining the stream down to bed-rock, either side can be broken down and washed to the sluices as desired. With deep deposits this method is not applicable, as it is practically impossible to work to advantage between high banks.[1]

Little trouble is experienced with dumps of 60 to 70 feet in height, but those of less height require much attention and considerable water to spread the material; however, spreading is materially facilitated by the use of Y or branch sluices. Often extensive bed-rock tunnels have been driven in order to provide sufficient grade for the disposition of tailing from the sluices. A change in grade of the washing pit or channel may in a short time render useless such expensive constructions.[2]

Finally at the end of a run, which may last for a month or two, the bed-rock is cleaned by piping into the rock-cuts, and the latter into the sluice. Bed-rock too rough and full of crevices and seams to be cleaned in this wise, is often cleaned by hand.

[1] Min. and Sci. Press, Vol. 84, p. 204.

[2] Min. and Sci. Press, Vol. 91, p. 111, and T. A. I. M. E., California Mines and Minerals, p. 25, 1899.

After water has run through the sluice for some time, it is shut off, the lining cleats ripped off and washed, and finally the riffles are removed, being carefully cleansed and laid to one side of the sluice. The material in the sluice is then loosened by shovel, and is worked down the sluice, aided by a slight flow of water, usually about two inches in depth. The mercury and amalgam being heavier, move slower than the sand and gravel, and can readily be separated from them, and collected with an iron scaper.

Long sluices, usually four to six feet wide, and four and one-half feet deep are economical gold savers while short ones with moderately high grades and clayey materials may cause a loss of 10 to 40 per cent of the gold. The following are common causes of loss of mercury, which may amount to 12½ to 15 per cent: velocity of current, length of sluice and time of run, temperature of water, character of material washed and method of charging mercury. Pipe clay and leaky flumes are claimed to be the greatest sources of loss of both gold and mercury. When properly operated well devised sluices should save from 90 to 98 per cent of the gold, and from 98 to 100 per cent of the coarse gold.[1]

The occurrence of gold in sluices is given as follows:[2]

First recovery, 1st 15 boxes	73.5 per cent.
Second recovery, next 30 boxes	13.4 " "
Under-currents	11.5 " "
Recovery below under-currents	1.6 " "

A general clean up takes place only once or twice a year, when the sluices are thoroughly over-hauled and repaired preparatory to making another long run.

Hydraulic-mining under a head of water obtained by pumping has been successfully accomplished in various districts as in the Western states, Alaska and in the Klondike region. However, it is rather expensive and can hardly be employed except with rich gravels.[3]

The three conditions formerly considered essential to the operation of an hydraulic mine, namely; rich ground, plenty of water and ample dumping room for tailing, are not now considered indispensable. With scarcity of water has come a demand for economy of water in such work, which has resulted in the modification of former methods and the adoption of power-driven machines and appliances whereby economics may be effected in labor and other attendant expenses.

[1] Min. and Sci. Press, Vol. 91, p. 111, and Ibid., Vol. 86 p. 244.
[2] Ibid. Vol. 86, p. 244.
[3] Eng. Min. Jour., Vol. 76, p. 809.

Small nozzles or tips are used in breaking down the ground, obstacles as boulders are promptly and quickly removed and separated from the finer materials, small quantities of water are used in washing, short sluices of little grade are employed, and a number of faces are worked simultaneously. The faces are carefully prepared in order that a minimum amount of water need be used and is used only so long as effective work can be done. Such a method can be used to advantage in connection with hydraulic elevators when dumping room cannot be had. It does away with long and expensive rock-cuts and sluices and can be operated at moderate expense.[1]

The deposits of frozen gravel in Alaska present special difficulties to hydraulicing operations. A further obstacle to be contended with is an inadequate water supply. Quite extensive hydraulicing operations are, however, being carried on in the Nome Region, where the overburden of barren ground is as a rule thinner than in the Klondike. On Anvil Creek the overburden is only two or three feet thick, below which are from three to six feet of pay gravel, the whole of which can readily be run through the sluices. Placer operations ranging from panning to hydraulicing are employed; rocking, small-scale sluicing and the use of dredgers and steam shovels are common.

No great difficulty is experienced in breaking down the frozen ground but to disintegrate it preparatory to entering the sluices, it must be kept under water sufficiently long to thaw out.[2]

In working frozen gravel the sun is depended upon to thaw several inches of the surface which is then washed off by the giants. It is therefore evident that in a mine of any considerable capacity, such that several giants can be kept busy, a large area must be operated upon, which is systematically worked from one end to the other and back again. However, when the gravels are dry frost troubles but little and thawing by solar heat is unnecessary.[3]

For hydraulic equipment in the Seward Peninsula in 1905 the reader is referred to Bull. 284 of the U. S. Geological Survey, p. 141.

The following description of the method of working frozen ground in the Yukon placer fields is taken from a paper by L. M. Prindle,[4] occurring in Bull. 284 of the U. S. Geological Survey: "The deposits vary from a few feet to over 120 feet in thickness. . . . In the Fairbanks region till within the last two years thawing was accom-

[1] Min. and Sci. Press, Vol. 78, p. 480.
[2] Eng. and Min. Jour., Vol. 76, p. 853.
[3] Min. and Sci. Press, Vol. 89, p. 342.
[4] U. S. G. S., Bull. 284, pp. 120–122.

plished by the crude methods, . . . and the equipments for thawing by steam, which has been found so effective, in the Klondike region, were not plentiful. Since then extensive steam plants have been introduced, capable of thawing and handling daily, large quantities of gravel.

"The process in general includes the following operations: (1) The sinking of a shaft to bed rock, ranging in depth from 20 to 120 or more feet; (2) the timbering of the shaft and portion of the drifts near the shaft; (3) the opening up of the ground by drifts which are run either parallel to or across the pay streak and from which cross-cuts are driven; (4) the extraction of the gravel from the cross-cuts, beginning at the farther limits of the drifts and working toward the shaft; (5) the hoisting of the pay gravel with as little waste as possible to the surface, and (6) the recovery of the gold by ordinary sluicing. The main drift is usually carried to a maximum distance of about 200 feet in each direction from the shaft, and the ground is blocked off by cross-cuts having a variable length up to about 100 feet. Fortunately but little timbering is generally required. Where the ground is weak, pillars are left at intervals of about 25 feet when working back the faces. Ordinarily, as mining commences at the extreme limit of the area to be worked, the ground from which the pay dirt has been removed is allowed to settle if it will. Experience has shown that settling is generally so gradual that the work can be carried away from the settling ground with sufficient speed to avoid trouble.

"The steam-point method of thawing is the one most commonly in use. The steam point is a piece of one-half or three-eighths inch hydraulic pipe, 5 to 8 feet or more in length, with a blunt, hollow point of tool steel for piercing the ground and a solid head of tool steel or machine steel, sufficiently strong to withstand the impact of a mallet or sledge. Steam is admitted through a pipe fitted laterally in a small aperture near the head. The points are placed about 2½ feet apart and from a dozen to twenty or more are used in a plant of average size. The power needed is 1 to 2 horsepower per point and the duty of a point is 3 to 4 or more cubic yards per day of ten hours. In use the point is driven in gradually as the ground becomes thawed. It is customary in most cases to use either hot water at a temperature of about 140 degrees F. or a mixture of hot water and steam while driving the points, and then to complete the thaw by means of steam alone, since by employing hot water in a part of the operation the atmosphere of the mine does not become so vitiated through the condensation of the steam and the conditions for working are consequently better.

"Hot-water hydraulicing by means of the pulsometer or other steam pump has been found very successful in some cases. Pulsometers were in use which were reported to do the work of 20 points, and as by this method a jet of hot water is thrown forcefully against the frozen face, the conditions are more favorable for the release of the gold particles from adhesive material in which they may be embedded than by the use of points. Pulsometers are generally suspended in a sump at the bottom of the shaft and the hot water is supplied by siphon from the boiler. Surplus water is generally removed by centrifugal pumps. It seems probable that hot-water hydraulicing will meet with an increasing use.

"After thawing, the gravel is removed with pick and shovel and carried by wheelbarrows to the shafts, whence it is hoisted to the surface by buckets attached generally to an automatic trolley. In summer it is conveyed directly to the sluice boxes, or, when the water for sluicing is available for only part of the shift, to a hopper connected with the set of boxes. In winter the gravel is conveyed to a dump under which sets of boxes have been arranged and later, in the spring, it is passed through the sluices. Ground which stands well without timbering is worked both winter and summer, but summer work is cheaper. Ground having a tendency to cave is often left for winter exploitation, as it is found that the expense of rehandling in the spring is more than counterbalanced by the greater facility with which the gravel can be extracted."

A steam shovel plant operating in the Klondike in 1901 illustrates the versatility of the placer miner. According to C. W. Purington,[1] "The plant figured used 125 miner's inches of water, led by a ditch from Bear Creek; the capacity was said to be 500 cubic yards in ten hours. The material elevated to the platform at the upper end of the trommel was dumped into a hopper feeding the trommel. The water was led into the lower end of the trommel, and fed through a perforated pipe. The largest holes in the revolving screen were one inch in diameter and all oversize passed through and into the hopper below the lower end, whence the tailings were hoisted in a self-dumping carrier, on a cable, a horizontal distance of 200 feet, and a vertical distance of 60 feet. The fines passed over 80 square feet of riffle-tables, floored with expanded metal and cocoa matting, on a grade of twelve inches to twelve feet, followed by sluices

[1] Mining Magazine, Vol. 11, 124 and 125, 1905.

with iron Hungarian riffles. . . . The fines, after passing out of the 96 feet of sluice-boxes following the tables were elevated by a steam scraper to a pile 200 feet distant and 15 feet high. The expense of installation of such a plant will be not less than $5,000, and will more likely be $10,000 in any part of the interior of Alaska."

The Dahlonega method of hydraulicing which originated in the Dahlonega district, Georgia, in 1868, is a combination mining and milling method not applied to the working of gravels but to the peculiar decomposed deposits of vein and country-rock commonly met with in the Southern states and known as saprolites. The following graphic description occurs in Harper's Magazine for September, 1879. "What a natural freshet would accomplish by accident is precisely what the miners do by artifice. They dig away all day at the loose soil and easily disintegrated rock, break up the larger fragments into small pieces and strew everything, good, bad, and indifferent, in a careless pile on the floor of the cut. Then at sundown they gather up their tools, climb out of the diggings, and open the gates of the reservoir. A torrent of water sweeps through the mine, cleans out every loose rock and fragment of dust and hurls it down into the mill, where a rack catches all the coarse material and lets the water drain through. The whole product of the days' excavating has been deposited on the floor of the mill, one-half mile away, ready to be shoveled under the stamps, which chew on it all night, and it has not cost a cent for transportation." To be more specific the material is sluiced from the mine to the stamp mill into bins provided with perforated bottoms, which stand from four to five feet above and back of the mortars. Beneath the bins are settling boxes, in which the coarser sands settle and the slimes overflow. While in other plants the material is flushed back of the stamps, which space is arranged as a large bin with a slat screen at one end, the slats being spaced one-half inch apart. Again the material may be collected in V-shaped storage-tanks without the mill, and from which it is flushed to the mill as desired. More recent practice consists in hydraulicing the material broken down either by hand, by blasts or by giants, through ground-sluices to the mill. Often tunnels and sections of wooden-sluices, provided with riffles, are employed. For this method of breaking down and sluicing, giants have been operated under heads of 50 to 150 feet.[1]

In 1903 the Crown Mountain Mining Company, in the Dahlonega

[1] T. A. I. M. E., Vol. 25, pp. 742–745, 1895.

district, hydrauliced the material in sluices to a 60-stamp mill, situated at the base of the mountain. The coarser ore was stamped while the finer and softer portions went to Huntington mills. About one-half of the gold was caught in the sluices the remainder being saved in the mill.[1]

River-Mining. — River-mining is a branch of placer-mining although the method of procedure is quite different. It is carried on in the beds and channels of streams both large and small, but is not confined to the actual channel in which water is flowing; it is applicable to the working of deep bars the greater part of which lies below the water-level. This form of mining is not confined to any particular locality or country, having been used the world over and not only for the collection of gold, but precious stones also. However, in those streams where the banks are high and steep and where room for building a diverting flume is lacking as well as space for handling the gravels, taken from the bed of the stream, the method is not applicable. Probably in no part of the country or world, in fact, has river-mining been carried on so extensively as in the State of California, and many of her rivers, such as the American, Yuba and Feather, have yielded enormous sums to those who had the means and enterprise to undertake such work.

River-mining is pre-eminently dry season work, being practicable only when the streams are in their low-water stages and resolves itself into a problem of restraint and handling large volumes of water. The mountain streams in which the work is largely confined being fed mainly by melting snows do not materially lessen in volume until June, and restraining dams cannot be built until July, while in November the streams often become swollen again. However, the season varies considerably with different localities but may be said to begin with the receding of the spring floods and continues until the rise of water with the beginning of the fall rains. Occasionally the early fall rains do not affect the streams to such an extent as to seriously interfere with or destroy the mine equipment in the river-bed, while with a period of low-water following, the operations may be prolonged till the winter storms set in. It is evident then that the season is an uncertain quantity varying not only from year to year but for different streams. In California on the Klamath River and its tributaries an eight month season is usual, beginning with the middle of March or the first of April and closing about the first of December. On the Middle Fork of the American River the sea-

[1] Mines and Minerals, Vol. 23, p. 497, 1903.

son begins with the first of May and ends with the first of November, but varies from early in October to late in December. While on the Feather River the season is even shorter, operations beginning about the middle of May and closing at the first of November.

River-mining involves the construction of dams and the extensive use of pumps in order to control the water that the river-bed may be exposed and the gold collected. From the nature of the appliances then and their location in the river-bed they cannot be maintained from season to season but must be taken down if possible on the occurrence of a rise of water and assembled again for each season's work. Furthermore, it is not infrequently the case that the work of preparing a plant for operation leaves only a few days for actual mining, before a sudden rise of water wrecks or entirely sweeps away in a few hours the work of months.

Operators often consider themselves fortunate if an uninterrupted period of 20 to 30 days is had, but an output of $500 to $5,000 per day is not uncommon and usually well repays the labor and expense of fitting up.

The work of river-mining may for convenience of consideration be subdivided as follows:

1. The use of temporary wing-dams, an upper and lower, built from the same side of the stream and connected at their outer extremities by means of another dam running parallel with the stream. The enclosed portion of the river-bed may then be pumped out and mined. The obstruction to the stream effected by this method of procedure is so comparatively small as not to materially raise the level of the stream.

2. A section of a stream-bed may be exposed by building two dams across the channel and conducting the water over them by means of a large flume which is laid as near the low-water level of the stream as is practicable. The water-level above the upper dam is by this method seldom raised more than three or four feet above the normal.

3. The water of a stream may be diverted into a flume or tunnel in a manner similar to that described above, by the use of one dam only, i.e., an upper dam, which may or may not be permanent in character. The water-level is then raised above the ordinary high-water line, and a portion of the bed of the stream below the dam is rendered dry.

4. River-mining may be carried on by means of shafts with their

accompaniment of hoisting and pumping plants situated on the bank of the stream. Drifts are run along bed-rock under the channel. This method resembles drift rather than river-mining.

5. Mining in streams by means of elevators, dredges, vacuum pumps and similar devices, which are usually installed on barges, being self-contained; all work is done beneath the surface of the water. This method is considered under the heads of Dredging and Hydraulic Elevators.

6. Deep-bar mining by shafts and drifts, is also a drift-mining method.

7. Deep-bar mining by a system of open-cut work in which power elevators and hydraulic lifts are employed.

Wing-dams are of necessity temporary structures, being made at a cost exceeding but little that of the labor employed. They were used almost exclusively on the Feather, Yuba and American rivers in California, in 1854. A riffle is usually chosen as the starting point for the upper dam, two parallel walls of boulders being built at its upper end. These walls are usually about six feet apart, the space between being filled with gravel and sand, the coarser material occupying a position next the walls. After extending these walls as far as it is desired to work the stream-bed, they are turned down stream, and continued to the lower limit of the ground to be enclosed. They are finally turned on to another riffle if possible, and the lower dam is constructed, making connection with the bank. The mining ground is then completely walled in, and the work of freeing the enclosure from water is begun.

Belt pumps working through wooden column pipes, commonly known as Chinese pumps, are usually employed, and are situated at the lowest point in the ground. These pumps are driven by current wheels, placed along side of the dam, paralleling the stream. Piles driven in the bed of the stream support the bearings of the wheel shaft, being protected and reinforced by large boulders piled around them. To permit the wheels to be kept in the same relative position with respect to the water-level the bearings or pillow blocks are placed in vertically grooved supports, which are adjusted by levers. In order to more effectively control the current of the stream and keep it directed against the wheel another wing-dam may be built extending from the opposite side or bank of the river. These wheels are made as cheaply as possible, as they are especially liable to sustain damage by floods. Aside from the dams, wheels and pumps, the only appliances necessary for working a river mine are: Picks, shovels, wheelbarrows, sluice-boxes and derricks. The derricks may also be operated by water wheels.

As the washing of the gravel taken from the river-bed is done in the pit it is necessary to provide water for the operation, but the water so used as well as the tailing produced must not be discharged into the pit, as it would necessitate a second handling. Water for washing is let in through the head dam, but if the grade is not sufficient for the discharge of the tailing over the tail dam, the sluices must be raised and additional water provided by a so-called dip wheel also mounted without the dam and driven by the current. These wheels vary from 20 to 26 feet in diameter and 4 to 6 feet in width.

The gold almost invariably occurs on the bed-rock and in its irregularities and crevices, although the overlying gravels may contain gold for a distance of a few inches to 15 to 20 feet above bed-rock. Above the pay gravel there usually occurs a mass of boulders and gravel containing little or no gold. The boulders are removed by derricks while the gravel and sands are wheeled out by wheelbarrows. When pay gravel is reached it is taken out to bed-rock and washed in sluices, the bed-rock also receiving careful attention being washed and creviced with spoons and knives.

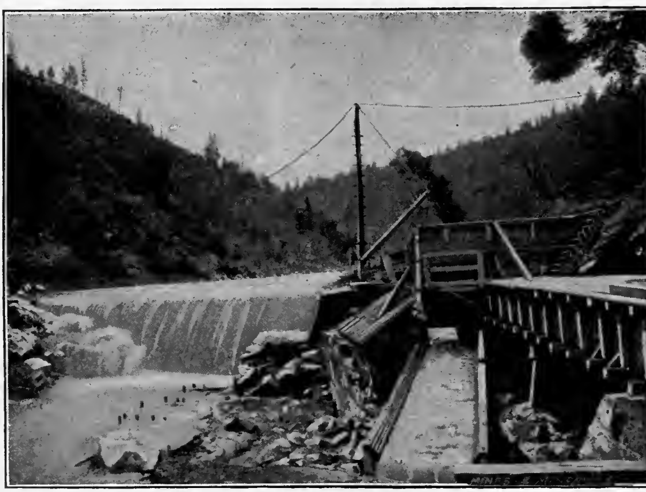
As fast as the bed-rock is cleared it is utilized as a storage place for boulders, and a dump for the overburden taken from new ground.

As a rule the riffles contain the highest values while the deep holes are usually barren of gold, the crevices in the bed-rock being often extremely rich.

The work of river-mining when once begun is rushed forward both night and day, with all possible haste, owing to the shortness of the season. When rising water threatens the operations the derricks are first secured, following which the pumps, wheels, etc.

River-mining by fluming, although more expensive and uncertain than the use of wing-dams, is applicable to more extensive operations, but must of necessity be confined to the shorter seasons and smaller streams, while wingdam-mining may be employed in streams of any size, and is an inexpensive and rapid operation. To gain time the construction of the flume is begun first of all, and as it cannot be built under water, operations cannot begin until moderately low-water is obtained. The flume is built on the bank of the river, often right in the water, in order that it may be as low as possible. The dimensions and grade must vary with the quantity of water to be handled. However, sufficient grade should be provided for to give enough power to drive current wheels, and to keep down weight in flumes by reducing height of water.

As soon as the flume is completed, work upon the head dam is begun. Various forms of dams are built depending upon the character of the materials available, and the permanency of the structure desired. They are occasionally built in sections which are floated out into the stream and sunk, being loaded with boulders. Finally sand and gravel is dumped above the dam until water ceases to flow. A tail dam may not be necessary, as a riffle may protect the pit from being filled by back-water. As the gravel is mined from under the line of the flume the latter is supported by posts which may have boulders piled around them.[1]



A Yuba River Dam and Flume, Grass Valley, California.
(From Mines and Minerals.)

During 1852, 1853 and 1854 river-mining yielded a large part of the gold mined in California, during which time all of the large rivers were extensively worked, but with the discovery and exploitation of the dead river gravels, the industry began a steady decline until in 1857–58 such work practically came to an end, owing to the filling of the river channels with tailing.

Drift-Mining. — Felix Chappellet of the Mayflower mine is believed to have been the first to demonstrate by development work the character of the deep-lead channel gravels. The discovery of new

[1] Min. and Sci. Press, Vol. 76, pp. 312 and 313.

and workable deposits of auriferous gravels gave new life to the gold mining industry, which was seriously feeling the effect of the débris agitation. The cemented portion of the gravel deposits had been generally considered as the bed-rock, and all operations had terminated on encountering it. Reasoning that slate ought to be the bed-rock instead of the cemented gravel Mr. Chappellet decided to sink a shaft through the latter, and by a combination of shafts, drifts and winzes he finally reached the bottom of the channel, thus corroborating his theory of an extinct river channel.[1]

Other deep channels buried beneath lava and various volcanic materials were discovered, and the first attempt at mining was by shafts sunk through the volcanic capping, but owing to the presence of water in considerable quantities, and the expense entailed in its removal, the method was abandoned.

When possible the following information should be obtained regarding an extinct river channel in which it is proposed to inaugurate drift-mining operations:[2]

1. The location of the line of the channel.
2. The grade of the channel or at least its elevation at a number of points some distance apart.
3. The location of various parts of the channel as inlets, outlets or break-outs, with a reasonable certainty as to which is which.
4. With regard to the workable portion of the channel, the possible length of a tunnel necessary to develop it, with its elevation with respect to the channel, should be ascertained.
5. If no outlet or inlet can be discovered the nearest point of the channel to the surface for tunnel or shaft opening should be determined.
6. Location of the pay-lead and its probable extent should be made in order to ascertain whether the channel can be worked with profit.

The driving of tunnels or drifts, often called "bed-rock" tunnels, to reach and develop auriferous deposits occurring in channels having rocky sides, is one of the initial operations in drift-mining. The channel sides called "rim-rock" consist of the same material as the bed-rock or floor of the channel, and it is through the rims and often even below the level of the channels, that the tunnels must be driven in order to properly develop the contained deposits of gravel. However, before driving the tunnel it is con-

[1] Min. and Sci. Press, Vol. 77, p. 108.

[2] Min. and Sci. Press, Vol. 68 p. 18.

sidered advisable to sink one or more shafts to bed-rock in order that the level or altitude of its entrance may be determined, otherwise there is danger of its being too high or too low. If too low a connecting passage must be made with its inner extremity and the channel above.

There are two general classes of drift-mining operations, namely; first, the construction of a bed-rock tunnel as an outlet for the channel above and as a means of saving the gold hydrauliced from above, sluices being placed throughout its length; and second, actual underground mining of gravel which is hauled in cars through the tunnel and milled or sluiced in a plant outside the mine proper.

In the former method after connection is made between the channel and tunnel, which may be an inclined or vertical shaft (a "chimney" in the first instance and a shaft in the latter) and thence to the surface, and after the tunnel has been provided with a line of sluice-boxes, hydraulicing may begin in the channel above. Often no shaft connecting the surface with the opening in the bed-rock is employed, the material in the channel if loose running through the chimney into the tunnel, while if cemented and hard it may be broken down by blasting.

Too great care cannot be taken to ensure against mud and sand rushes when breaking through between the tunnel and channel. The accumulations of water and gravel in the basin-like channels may exist under great pressure and may by lack of care in completing the connection fill and choke up the tunnel in a few minutes time. Test holes should be drill, through which the character of the material may be ascertained by a small iron rod. The presence of sand and water indicates that the deepest portion of the channel has not been reached, and that danger from mud and sand rushes is imminent.

When a connection to the surface has been made, by whatever means employed, a steady stream of gravel can be maintained through the sluices in the tunnel by a judicious operation of the giants in the pit above. However, the first washing often consists in removing the upper sections of the shaft-timbering and permitting the material to cave into the shaft, taking care that the shaft and chimney are not choked. This process is continued downward, the surrounding gravels being washed down in successive steps in order that caving may not result. Little or no water under pressure should be employed in the opening of such a mine and in fact until bed-rock has been reached, a free and uninterrupted discharge of the sluice-boxes must be secured, and therefore, no irregularity of feeding them must be allowed. Space should be left beyond the sluice-boxes, provided the line of the tunnel is to be extended. Further, a means of escape should be provided as a safeguard against any possible choking of the tunnel.

Certain portions of ancient channel deposits may be so situated that they can be operated without expensive bed-rock tunnels, i.e., when they stand above the rim-rock; such portions when worked separately are known as "upper" workings, and through their exploitation the expense of driving the tunnel, by means of which the lower portions are to be worked, may be met. Bench-working of banks especially when 125 to 150 feet high is resorted to, which with removal of considerable material from the point where drift-mining operations are to begin at a later date, serves a three-fold purpose:

1. Provides means for subsequent equipment.
2. Reduces the length of the connecting passages between surface and tunnel.
3. Leaves a bench, which is considered essential to the proper working of deep gravel deposits.

A slight modification of the above described method is occasionally made when considerable depth of bed-rock intervenes between the end of the tunnel and the bottom of the channel. This consists in cutting the lower side of the inclined chimney (when used) in step-form or terraces. The height of the respective steps should vary from above, downward, the upper having the greatest height, while the lowest one has a height of two to three feet. The following figures are given for a chimney of about 100 feet in height: First step, 30 feet; second, 25 feet; third, 20 feet; fourth, 15 feet; fifth, 7½ feet; and sixth, 2½ feet.

It is claimed for such an arrangement that the harder gravels are more readily disintegrated by the falls to which they are subjected, and further, that there is less danger of blockades in the chimney, and consequently in the tunnel.

Branch-drifts leading to any part of the channel may be driven from the bed-rock tunnel, all of which feed into the main sluice-boxes in the tunnel. Occasionally drifts are run into the gravel-banks to facilitate the handling of gravels, but are of course ultimately washed into, and their mouths closed by the advancement of the mining operations.

The face of the bank is widened as rapidly as possible in order that a number of giants can be employed. The subsequent working of the "upper" gravel banks does not differ materially from that of ordinary hydraulic-mining, and but for occasional difficulty experienced in obtaining sufficient head of water, the exploitation of the higher, deep-leads is as readily accomplished as the lower stream deposits.[1]

As an illustration of the extent of drift-mining operations the Bald Mountain mine may be cited, which was located in 1864, and worked out during the seventies. As many as 250 tunnels were employed, varying in length from 150 to 500 feet. In 10 years this mine is said to have produced $2,000,000.[2]

Often no quicksilver is used in drift-mining, otherwise the method employed in collecting the gold in the sluices is similar to that in common use in hydraulic-mining. A set of blocks has a life of about 10 months, during which time they are reversed for greater efficiency.[3]

From the stand-point of cost the development of a drift-mine by vertical shafts is advisable, but as drainage is of necessity a serious problem, in this kind of mining, and as it is practically as expensive to haul the gravel to the foot of the hoisting shaft and load it preparatory to raising to the surface as to run it to the surface through a tunnel without change, vertical shafts are seldom used. Further, a mine operating through a vertical shaft must have richer gravel than when a tunnel is employed. However, shafts are indispensable for exploratory work.

When the quantity of water encountered is small, and readily handled by hydraulic jet-pumps, or ordinary steam-pumps, the deep-leads may be worked by inclined shafts or slopes, rather than vertical shafts, which was the usual practice in Nevada County, California. However, when the bed-rock or the bottom of the channel is reached, the methods employed in developing the mine and extracting the pay gravels, varies but little regardless of the kind of opening made. The location, grade and course of the channel having been determined, a tunnel is driven from a point nearest the outlet of the channel, and after entering the channel is continued up the approximate center of the same, being kept as close to the bed-rock as the grade will permit. When driven wholly or partially within the gravel, timbering must be resorted to besides which pillars of unmined ground are left on either side for a distance of 30 feet or more. These pillars of gravel are ultimately robbed when the bulk of the gravel has been extracted. When the gravel is difficult to support, it is customary to run a bed-

[1] Eng. and Min. Jour., Vol. 19, p. 181.

[2] T. A. I. M. E., California Mines and Minerals, p. 382, 1899.

[3] Min. and Sci. Press, Vol. 29, p. 312.

rock tunnel as previously described, the development of the gravel being accomplished through inclined chutes or chimneys, extending upwards from the tunnel. Obviously it is better to have the tunnel too low than too high, and therefore its entrance must be considerably below the bed of the channel as previously ascertained. The dimensions of the main or bed-rock tunnels are $6\frac{1}{2}$ feet high, and $5\frac{1}{2}$ feet wide untimbered, while the largest are 7×9 feet, narrowing somewhat above.

The grade of such tunnels varies from a quarter to half an inch to 16 feet in length, and thence up to three and four inches for the same length.

When the tunnel has entered pay-ground, cross-drifts are run, extending from rim to rim of the channel, the driving of the tunnel proceeding in the meanwhile. The distance between the cross-drifts is usually 60 feet, which is considered an economical limit for length of breast to accommodate two miners and for handling material, laying tracks and moving loading platforms.

After connecting the ends of the cross-drifts the actual work of removing the gravel is begun on the rectangular pillars thus formed. Often gangways are run parallel with the tunnel, still further subdividing the ground and increasing the points of attack. The miner may work from a cross-drift to the center and back again, or from gangway to gangway, which method is employed depending on condition of deposit. The gravel is broken down and separated from the enclosed boulders, the pay gravel being thrown on loading platforms, from which it is shoveled into cars by the car man, who still further sorts out the cobble stones and takes such material only as will probably readily pass the grizzly employed.

The gravel is often worked out for considerable height, as five or six feet, which is especially the case when the roof is self-supporting, or when the boulders usually encountered next to the bed-rock are piled into the excavations formed by the removal of gravel. Systematic exploitation of such deposits is absolutely essential to their complete and economical working.

Hammers and hand drills were first employed in preparing holes for blasting down gravels, but were abandoned owing to the fact that many of the holes so started, were lost by encountering boulders. The " gopher " bar was next tried and was largely used. By its use a hole could be turned slightly thus giving a means of determining the size of a boulder, after which a drill could be used to drill a hole through, or past the obstruction according to its size.

When considerable gold is found to occur in the bed-rock, large sharp augers are often used to form holes, more rapid progress being possible by them than other means. Powder and dynamite are employed to break down the gravel and loosen the bed-rock.

The greater part of the gold is found on bed-rock, although in some localities it occurs mainly in the gravels above. At the Red Point mine, Forrest Hill Divide, the richest portion was in a layer of gravel from 6 to 12 inches above bed-rock; however, the bed-rock at this point was hard and smooth, and the channel fairly straight.

Occasionally the channel is faulted, thus complicating the methods usually employed in mining the gravels. This was the case at the Magalia mine, which underlies the Magalia ridge, between big Butte and Little Butte creeks, California, where underground inclines and hoists were employed in handling the gravels. Here, too, a portion of the channel was worked by a tunnel on bed-rock, with cross-drifts turned off from it, but on encountering a fault the tunnel was continued on the same level as before, and the channel above was worked by chutes or raises from the tunnel, being connected by a bed-rock gangway in the channel. The raises were double, containing a manway and gravel chute. They were driven at an angle of 75 degrees and securely timbered with square-sets. This mine was opened by vertical shafts, the depth of the main one being 510 feet.

The gravel mined was loaded into cars and hauled by mules to the surface and thence to the mill in trains of 12 to 25 cars.[1]

The following tabulation of data regarding drift-mining operations at Dogtown, Calaveras County, California, is interesting in this connection.[2]

Dredging. The exhaustion of the richer placers was directly responsible for the introduction of dredging and the consequent rapid advance made in that industry in a comparatively short time. The assembling of a dredger and its subsequent operations correspond to the development of a mine and the building of a mill, and their successive operation, i.e., a dredging outfit is a mining and milling institution all in one.

Dredgers can be operated successfully in rivers, with channels of varying grade, in shallow water, and in valleys where the

[1] School of Mines Quarterly, Vol. 8, pp. 213–218; Min. and Sci. Press, Vol. 86, p. 7; Ibid., Vol. 77, p. 108; T. A. I. M. E., California Mines and Minerals, p. 276, 1899; Ibid., p. 382; Min. and Sci. Press, Vol. 68, p. 165, and Ibid., Vol. 78, p. 373.

[2] Mining Commissioners Report, 1872, p. 72, and School of Mines Quarterly, Vol. 8, p. 298.

TUNNEL CLAIMS NEAR DOGTOWN, CALAVERAS COUNTY, CALIFORNIA (1872).

	Hammerschmidt, Hensel & Co.	Barney, Hurle & Co.	Bully Co.	Buckeye Co.	Deitrich & Co.
Inches of water used in sluice washing	25 to 30	30	30	30	30
Inches of water used in hydraulic washing	20	...	...	...	...
Height of fall	100 feet	...	...	...	...
Supply of water lasting in the year	6 to 7 months	6 to 8 months	6 to 8 mo.	6 to 8 mo.	6 to 8 mo.
Cost of water (sluicing) per day	$4	$4	$4	$4	$4
Cost of water (hydraulic) per week	$20	...	...	...	...
Air-shafts	One of 70 feet; one of 148 ft.	One of 105 feet.	4	4	10
Length of tunnel at present	1500 feet	One of 200, one of 400, and one of 300 feet.	700 feet	1000 feet	1200 feet
Height of drift (all pay-dirt)	6 feet	4½ to 5½ feet	4 feet	...	...
When this claim commenced	In 1865	In 1862	1870	1870	1870
Area of ground drifted out and worked	9166 superficial square yards	5600 superficial square yards	...	...	...
Number of cubic yards drifted out	18,332	7,500 square yards	3000	...	...
Length of ground unworked	400 feet	600 feet	1000 feet	...	...
Average of cement-gravel extracted per day	20 to 25 carloads; about 25 square yards.	15 to 20 square yards	Over one-half	...	...
Quantity of refuse left in the stope	Over one-half	Over one-half	2000 sq. yds.	...	...
Quantity of gravel-cement washed during last year and extracted.	2200 square yards	Not washed	$700	...	...
Yield of cement-gravel washed	$4 to $5 per square yard	$4	$700	...	...
Total yield last year	Over $8000	Not washed out	...	...	...
Total yield since commencement of this claim	$70,000	$30,000	...	...	...
Gold, description	Small flat particles	Both coarse and fine	...	...	...
Wages paid to underground-drifters	$2.50	$2.50	$2.50	...	...
Number of men hired	4	...	...	...	...
Number of men working	8	4	4	4	4
Composition of deposit	Red soil, small and large white and blue quartz, boulders, pieces of dark blue slate, quartz, and mica slate, cemented granite gravel.	Red soil, quartz, gravel, slate, granite, sand-all cemented.	gravel, cemented	gravel, cemented	gravel, cemented
Bed-rock	Dark blue slate, full of cubical pyrites.	Dark blue slate, veins of quartz.	Blue slate	Blue slate	Blue slate
Direction of tunnel and course of deposit-channel	E. N. E.	E.	S. E.	S. E.	S. E.

auriferous deposits lie at some distance from any considerable body of water or stream. Roughly speaking, dredging operations may, according to the location, be divided into river and interior work.

Of these two methods practically all advantages favor the latter. The advantage of making and controlling the water-level is considerable; further, the operations are entirely independent of floods, which are not always dangerous but interfere with the work.

The greater part of the Western states are well adapted to dredging owing to a plentiful water supply, and although many of the gravel deposits have been worked over by the earlier miners operating with rockers, ground-sluices and hydraulicing, yet either owing to hasty and inefficient work done or to the replenishing of previously exhausted ground, it is now found possible to rework them profitably by dredging. Other deposits not worked by the pioneers, owing to the light grades and presence of boulders, are now available for the dredgers and are yielding large returns.

Too much was expected of dredging during the first few years of its application which resulted somewhat disastrously to its normal and healthy growth. There was too much generalization and too little experimentation; too little knowledge of actual conditions; too little attention paid to details; too little preliminary testing of deposits, and too much haste in entering into investments.

Gold dredging is largely a mechanical problem as is hydraulic-mining, but judging from the kinds of machines first used and the character of the ground operated upon it would hardly seem that it was realized. Fully 90 per cent of the early attempts at dredging were deplorable failures, the causes of which were; incompetency; dishonest methods; reckless business management; and careless speculative investment.[1]

The following conditions should obtain in a property suited to gold-dredging operations:[2] paying values in gravels; moderately soft bed-rock which can be readily cut and handled by buckets; moderate depth to bed-rock should not exceed 60 feet below water-level; easy digging ground; plenty of fuel at moderate cost or proximity to electrical power plant; good water supply; long working season; a favorable topography; transportation facilities; and reasonable cost of plant and general equipment. Although the first condition is paramount in importance still it is not the controlling

[1] Min. and Sci. Press, Vol. 80, p. 94.

[2] Ibid., Vol. 90, p. 265.

factor as conditions resulting from the failure of any of those named may prove prohibitive.

Supplementary to the above the following statements may be made: Placer ground well suited to dredging, or what may be called ideal ground, may be said to fulfill the following conditions: 1st, depth of deposit not to exceed 25 feet and overlying a soft bed-rock; 2nd, a supply of flowing water equal to at least 20 miner's inches; 3rd, the absence of timber or brush on the ground to be operated on; 4th, not over 5 per cent of boulders in gravel, the largest not weighing over 400 pounds; 5th, gold-content averaging 25 cents or more per cubic yard, being fairly coarse and evenly distributed from top to bottom of the deposit; and 6th, cheap fuel or electrical power.[1]

The presence of cemented gravel and clay in considerable quantities may reduce both output and profit, and has often necessitated radical changes in operation and management.

Any gravel that can be broken by pick can be dug with a dredger with the ocasional use of powder; however, if it is so hard as to require regular and systematic blasting, the cost per cubic yard will be materially increased. The presence of clay in quantities interferes with the operation of the dredger in that the gravel is held in the buckets and much of it is carried back, thus reducing the capacity, besides when introduced into the sluices, it entails a loss by carrying off fine gold and amalgam. Frozen gravel cannot be worked, consequently the season is considerably shortened in certain localities, as in Montana, Alaska, etc. Very large boulders cannot be handled by dredgers, hence in not being able to handle and dispose of them much gravel may be left around and underneath them. With bed-rock that is hard and irregular or full of crevices the gold occurring in the crevices and hollows is lost. The bed-rock must be level enough to permit the movement of the dredger over the whole ground; further, the surface of the gravel bank should be moderately level in order that the head lines may be used to advantage.[2]

Swiftly flowing streams, especially when subject to floods, in which there is considerable depth of gravel intermixed with boulders and interstratified with mud, are considered unfavorable to dredging.

Testing of a dredging property can be done by shafts or pits in

[1] Min. and Sci. Press, Vol. 83, p. 183.
[2] Min. and Sci. Press, Vol. 91, p. 179.

shallow deposits of five to ten feet deep. However, drilling is preferred, besides being cheaper and quicker. The size of drills employed vary from 3 to 18 inches in diameter. By this means the probable depth of cut and approximate value of the ground can be ascertained.[1]

In dredging as in other lines of work, large scale operations are more conducive to economy than are small scale individual efforts, which is especially true when low-grade deposits are worked. The choice of a dredger is affected by both the first cost and its capacity, there being a certain ratio existing between the two. Other conditions being equal, one dredger of 4000 cubic yards capacity costs less than two of 2000 cubic feet each, besides which the operating expense per cubic yard would be less in the former than the latter case.[2]

A gold dredger consists of a boat or scow equipped with appliances for handling the boat, digging and elevating the material in front or below it, disintegrating and washing it, collecting the gold contained in it, and finally discharging the waste or tailing to the rear of the boat in such a manner as not to interfere with the subsequent movement.

There are three forms of dredging machines commonly known as dredgers: first, the suction dredger; second, the dipper dredger; and third, the endless chain bucket form. As the first dredgers used in general work as deepening harbors, rivers, and canals, were of the suction type, so the first mining dredgers were constructed along the same lines. They do not work well, however, and have a small field of application, even at the present time, although they are occasionally used successfully. Suction dredgers work satisfactorily where there is plenty of water, and a small percentage of boulders of moderate size, say three or four inches in diameter. They have proven suitable for working the gravels on the Snake River, where boulders are notably lacking, but have proven failures, when operated on the Klamath and Rogue rivers of California. In general they may be said to be suitable for those deposits laid down in comparatively quiet water, but not for mountain stream deposits. The character of the bed affects the working of a suction dredger, the smoother the better — micaceous granite bed-rock can be cleaned fairly well, but slate, serpentine, porphyry or feldspathic granite beds present conditions unfavorable to the employment of the suction type of dredger.

[1] Min. and Sci. Press, Vol. 80, p. 94.
[2] Min. and Sci. Press, Vol. 83, p. 183.

Shovel dredgers are not applicable to deep deposits, and not being tightly closed, much gold is lost by leakage. Further, they cannot clean bed-rock to advantage, and by agitation in taking loads, disturb and scatter the gold in the gravel, thus causing a loss. On the other hand they take large loads and elevate the material to a height sufficient to permit its being washed to advantage.

The objection to shovel and clam-shell dredgers, namely, that gold is lost, does not hold, when clayey and cemented gravels are worked.

In cleaning bed-rock, especially if hard and uneven, the relatively narrow, endless chain bucket dredger can operate to greater advantage than the wide-mouthed shovel form. Again the bucket dredger can work to considerably greater depth than a shovel dredger, that, too, both above and below water-level. Another consideration is the continuous feed, which is especially important when close gold saving is attempted.

The endless chain type of dredger (large size) can handle stones of considerable size, as three feet in length by 18 inches in width and one foot thick.[1]

The speed of the line of buckets is from 42 to 52 feet per minute, the rate of cutting, and therefore, the capacity varies with the arrangement of the buckets on the chain; if there is a bucket on each link, which is called the "closed-chain," the capacity will be larger than with the "open-chain" arrangement, i.e., where the buckets are placed on every other link. The latter arrangement has the advantage over the former that larger boulders can be picked up and carried. The shape of the buckets is also important, and should be so arranged as not to return any material to the pit, but discharge it freely. To accomplish this the bucket hood is rounded somewhat.

The shape of the tumblers or polygonal wheels, supporting the chain at both ends, especially the upper of the bucket ladder, should for quick and efficient dumping be as nearly square as possible, i.e., should be few-sided. The result is a sharp blow as each bucket seats itself on the tumbler, which blow decreases in force with the decrease in number of sides of the tumbler. However, it is seldom that more than six sides are given to the tumblers, and five sides are common.[2]

There is an art in the operation of a dredger or "winching," which is acquired only through considerable application and experience with various kinds and conditions of ground. In ground that caves

[1] T. A. I. M. E., California Mines and Minerals, pp. 88, 94, 1899; Min. and Sci. Press, Vol. 80, p. 120, and Ibid., Vol. 75, p. 456.

[2] Min. and Sci. Press, Vol. 90, p. 232.

well the winchman keeps the ladder in constant action, always low enough and sufficiently buried to ensure taking a full load, and not so deeply buried as to make the buckets drag. As soon as he sees or feels the bank caving, the ladder is raised, thus keeping the buckets free, and preventing undue wear and loss of power — a full bucket is all that is desired, more is impossible. In hard ground the work of the operator consists in getting a load rather than in preventing the taking of too large a load as in soft ground. If the bank cannot be worked from the top, the dredger should be backed off and the bank approached from the bottom along bed-rock. By such a method of procedure, the bank may be undermined and caused to cave, thus giving a "run" of buckets. In hard and clayey ground, therefore, the work should be confined largely to or near bed-rock, and then working upward as occasion permits. In fact it is claimed that all ground can be worked to advantage from the bottom for the reason that following the digging of a certain quantity a much larger quantity will be obtained by caving, making easy digging, with minimum expenditure of power and minimum wear. Further, the delivery of material elevated is attended with some inconvenience if the bucket ladder is too flat, as when digging at the upper part of the bank, or the working of shallow deposits. Therefore, to keep the buckets close to the point of delivery, and thus prevent loss, dig as deep as possible or convenient.

A bank can also be worked to advantage by beginning some six to ten feet above bed-rock, and working downward; when bed-rock is reached, the ladder is raised, and the dredger moved over four feet or more and bed-rock is worked to again. This is repeated until 20 to 30 feet of face has been worked over, but there will remain a series of small mounds on the bed-rock, which are removed, by keeping the buckets on the bed-rock and side-feeding back and forth, thus thoroughly cleaning the bottom. The whole face may be worked before an attempt is made to clean up the bed-rock, but there is probably greater danger of missing ground, if cleaning up is not done as the work progresses.[1]

The bank can be worked either parallel with the face or at right angles to it, which method is employed depends largely on the condition of the gravel and the disposition of the tailing.

Cemented gravel cannot be worked to advantage with dredgers, but the so-called "tight" gravel can be readily handled especially with a little preparation. The latter may consist of a solid mass of

[1] Min. and Sci. Press, Vol. 83, p. 36.

gravel; cobbles and sand, filling the voids of the coarser materials. Such material is extremely difficult to dig causing frequent breakages, and as repairs are expensive, the capacity and profit are materially reduced. In certain cases the capacity of a dredger has been reduced fully one-fourth, many of the buckets running empty, while shut-downs often amount to one-half of the time. Blasting can be employed to good effect in such ground, and often puts it in good shape for handling by dredger. In one particular case a 6-inch churn drill was used, holes being drilled to bed-rock. The first row of holes were 20 feet back from the face of the bank, while the remainder varied from 50 to 100 feet from the existing bank faces. These holes were staggered, so as to distribute the effect of the explosions. Charges of 30 pounds of 80 per cent dynamite proved sufficient for the work, and were put up in cans three feet long by four and one-half inches in diameter. Charges were fired by electricity. As the holes caved, the casing could not be removed before placing the charge, but was first raised about four feet, and after the charge was placed, wholly withdrawn. The holes were finally filled with sand for tamping. The resulting explosion did not break down the bank, but thoroughly loosened the cobbles, and permitted the buckets to take full loads.[1]

The handling of the dredger is accomplished in two ways, namely, by the use of lines and spuds, and lines alone. In the former case there are two spuds, i.e., long vertical members capable of being raised and lowered, and in reality forming feet for the boat, being placed at the stern of the boat. These spuds may be wood or steel, often one of each, the wooden one being used when the steel spud is raised in the process of " walking " the boat ahead. Two steel lines are provided at the forward end of the boat, which are fastened to the bank, and by means of them the boat is moved from right to left, being swung in an arc about the spuds at the stern. In the latter case the spuds are entirely replaced by lines of which there are five — two in front and two in the rear, at the corners, and one directly head-on connecting the front of the boat with the bank. This is called the " guy " method, and for light and soft ground is often preferred to the spud and line method. At Oroville, California, both methods are employed. In general it may be said that with level surfaces and soft and shallow ground, lines are preferred, while with uneven surfaces, hard and deep-lying gravels, the spud method is preferable. Further, bed-rock digging is advisable with guy lines, while high banks

[1] Eng. and Min. Jour., Vol. 78, p. 9, 1904.

to be worked in terraces practically require spuds. In working deep-ground in terraces from the top down or the bottom up, it is claimed that there is less danger of injury to the bucket line and cleaner work done if spuds are used. However, with lines a dredger can be handled more readily, and moved quicker than with spuds, so that under similar conditions of deep-ground working heavy caves can be avoided. It is also claimed that by means of the head-line tailing can be disposed of to greater advantage, and more evenly and that the sand pump is unnecessary.[1] There have been failures of both spuds and lines, but it is probable in working hard ground, that spuds hold the dredger to its work better than do lines, there being more resilience or give in the lines, which, however, relieves the buckets from much unnecessary strain.

Shovel dredgers are of necessity operated by spuds owing to ever changing center of mass, and must sacrifice quickness of movement to stability.

In the interior work where the dredger is to operate in an artificial excavation or in an artificial body of water there are two methods of procedure. When some distance from a stream the dredger is assembled in a slight excavation made sufficiently large to float the scow or boat. Water is pumped in or if possible, run through a ditch from some source of water supply. The excavation is then enlarged by operating the dredger, the tailing being conducted clear of the excavation by a long sluice-way. This process continues until the pit has been extended to or nearly to bed-rock, which is cleaned and as work is continued serves as dumping ground for the boulders and tailing. The method employed varies considerably with kind of dredger and manner of handling the same, but following the floating of the dredger and selection of a proper place for the disposal of the tailing there is little difference between it and ordinary river-working.

Interior work may be carried on in a valley which can be flooded by the construction of a dam across the stream traversing it. The dredger is assembled at the same time that the dam is being built, and when all has been made ready the dam is closed. Ultimately the dredger will float and begin operations, having the advantages of quiet water, and a means of controlling the water-level, and consequently the height of the dredger above the surface of the gravel and the bed-rock.

Tailing banks formed by suction and dipper or shovel dredgers

[1] Min. and Sci. Press, Vol. 91, p. 160.

occupy more space than with the bucket type owing to the manner in which they are placed in the bank. When the coarse material and boulders are put upon the bottom of the pit, the fine material being deposited later there is a tendency for a more or less thorough mixing during settlement; but when the process is reversed, the boulders being placed on top of the finer materials, the unfilled space between the boulders causes an increased height of the resulting bank, which in turn necessitates raising the dumping point of the tailing. Care should always be taken to keep a full boats' length between the face of the gravel bank and the tailing bank.[1]

When the channel in river dredging has a fair grade, say 25 feet or more to the mile, tailing can be readily disposed of by working upstream, but when this is impossible or inconvenient, considerable trouble may result. However, downstream work is not infrequently resorted to, and with moderately swift currents may cause no serious inconvenience for short distances. Occasionally brush dams are employed in impounding and controlling the débris, especially if there is a large proportion of sand present.[2]

When large quantities of sand are encountered in the gravel, occurring both above and below water-level, it may be taken from the sluices and discharged by means of a centrifugal pump behind the bank of tailing. This method of disposing of the sand has been found to be very satisfactory.[3]

The gravel on being excavated and elevated is discharged into a revolving screen, within and extending its whole length is a large perforated pipe, by which means and by other jets playing on the in- and out-side of the screen, the gravel is thoroughly washed, the finer material passing through the perforations while the larger gravel and boulders are discharged at the outer and lower end of the screen, and fall overboard. In some dredgers all undersize material passes directly into a tank or sump, from which it is raised by a centrifugal pump and delivered to the sluices. In this arrangement the upper end of the sluice-box rests on a turn-table, the base of which sets on the dredger. Connection is made between the pump and sluice-box by means of a short length of hose. The sluice-box is adjustable so that the tailing may be evenly distributed on the waste bank.[4]

[1] Min. and Sci. Press, Vol. 83, p. 216; Ibid., Vol. 81, p. 582.
[2] Min. and Sci. Press, Vol 80, p. 120.
[3] Ibid., Vol. 82, p. 36.
[4] Min. and Sci. Press, Vol. 83, p. 194.

Occasionally shaking screens are employed instead of the revolving forms; which should be used, is determined by the hardness of the gravel and the presence of clay.

Definite information regarding the condition of the gold contained in the gravels to be dredged should be obtained in order that the proper appliances may be chosen for its collection. The principal considerations are: First, shape of particles, whether in grains or flakes; second, size of grains or particles; third, presence of clay; fourth, presence of materials which interfere with amalgamation, such as arsenic, etc.; fifth, amount of platinum in sands; and sixth, character of gravel whether hard or soft.[1]

When tables are used on dredgers the gravel from the screens usually passes directly to them. These tables are arranged on either side of the screen, especially if it is of the revolving type, and are covered with cocoa matting alone or with cocoa matting and expanded metal. From the tables the gravel is run through sluices, placed longitudinally with the dredger, which are also provided with riffles, usually of the expanded metal forms. So-called "beehive" riffles are often used next to the screen, and consist of a nest of riffles in layers placed under the upper portion of the screen. In certain dredgers the sluices discharge into a sump from which the material is elevated and discharged overboard by a centrifugal pump, but a gravity disposal is more usual.

Experience shows that most of the gold is saved at the upper end of the tables, in some cases even the first six inches.

Hungarian or ordinary cross-riffles are also used with mercury on the tables, which in dredgers are made of iron to prevent warping.[2]

Tailing is handled by various contrivances which must, however, extend far enough over the stern of the boat to discharge it so that it will not interfere with the dredging operations. The tailing stacker, now commonly used, works very satisfactorily, and consists of an endless belt conveyor of some description, but preferably the rubber belt form.

The capacity of a dredger is regulated largely by its ability to save gold, and in order to insure this the tables should be as wide as possible and have frequent drops in their surfaces. It is claimed that the capacity of a dredger can be increased fully 6 per cent, by using

[1] Min. and Sci. Press, Vol. 91, p. 160.

[2] Min. and Sci. Press, Vol. 83, p. 229; Ibid., Vol. 90, p. 252, and Ibid., Vol. 91, p. 160.

closed-linked chains. Further, by their use the load on the motor or engine is steadier, and the feed to the screen is more regular.[1]

Boulders exceeding 200 pounds in weight should not be allowed to enter the screen.

The range in capacity of buckets in endless chain dredgers is from three to five cubic feet or from 25,000 to 45,000 cubic yards per month. What was claimed to be the largest dredger in the United States as late as 1905 was that of the Folsom Development Company, at Folsom, California, which has a capacity of 125,000 to 140,000 cubic yards per month. The ordinary life of a well constructed boat should not be less than 12 to 15 years.[2]

The buckets on dredgers at Folsom, Oroville and the Yuba River vary in capacity from three to eight and one-half cubic feet, while a 13 cubic foot machine is contempated.[3]

The acreage of ground estimated to be available for dredging in California in 1905 was as follows: [4]

District.	Acreage.	Average Value per Cubic Yard, in Cents.	District.	Acreage.	Average Value per Cubic Yard, in Cents.
Oroville	7,500	17	Stanislaus	1,200	15 to 30
Yuba River	5,000	25 to 30	Trinity	1,000	
Bear River	1,000	18 to 30	Shasta	1,500	
Folsom	5,000	15 to 25	Siskiyou	1,000	
Calaveras	350	16 to 22	Plumas	1,500	
			Total	25,050	

California leads in number and extent of dredging operations, while the Oroville district, as indicated above, is of the most importance among the districts of the state. In April, 1905, there were 28 dredgers operating in the district, and at least four more were either being built or their construction contemplated. Beginning in 1899 electrically driven dredgers were introduced into the Oroville district, and since that time all boats previously steam operated have been changed and fitted with electrical equipment.

Electrically operated dredgers are now employed in the Boise Basin, Idaho; many of them having a capacity of 2500 cubic yards

[1] Min. and Sci. Press, Vol. 83, p. 204.

[2] Min. and Sci. Press, Vol. 90, p. 252, and Ibid.,Vol. 90, p. 283.

[3] Ibid., Vol. 91, p. 160.

[4] Min. and Sci. Press, Vol. 91, p. 125.

Arrangement of Sluices on Gold Dredger. (From Engineering and Mining Journal.)

in 24 hours.[1] The actual width of channel in the streams of this region ranges from 15 to 30 feet, although the alluvial deposits vary from one-half to one mile in width, and in depth to bed-rock from 20 to 40 feet. This large body of gravel together with an abundant underflow of water constitute very favorable conditions for the operation of dredgers. Further, the values, especially in the stream deposits are quite uniformly distributed.[2]

In 1905 a suction dredger was installed on the Snake River, Idaho, and in 1899 a bucket dredger, with buckets of 5 cubic feet capacity, was built by the same company.

According to F. Powell the difficulties encountered by dredgers on the Snake River are: the occurrence of values in a few inches of surface gravel, thus necessitating the handling of considerable barren material; the fineness of the gold and its association with magnetic iron sands; and finally the flat and cup-shaped scales and flakes of gold.[3]

The nozzle first used with the suction dredger on the Snake River, was six inches in diameter, but was later changed to ten inches, which worked successfully. The gravel on being elevated was discharged into a sluice-box which was set in a horizontal position to retard the flow before it passed onto two shaking screens. The length of the first screen was 12 and the latter 17½ feet. The shaking screens had a pitch of one and one-half inches to the foot, were five feet wide and were given a longitudinal movement of three inches. The riffles in the shaking screens consisted of perforated steel plates, No. 10 gauge, with holes one-eighth inch in diameter and placed three-eighths inch apart, center to center. From the screens the coarser material passed to a rubber belt tailing stacker while the fine material entered a distributing box from which it was fed to burlap tables, after which it was discharged over the side of the boat.[4]

Dredging has not been successfully carried on in Colorado, due to a number of reasons of which the more important are: tight ground, rough bed-rock, large boulders, spotty distribution of values and low values. Dredging has been attempted on the Swan River, a branch of the Blue; near Breckenridge; French gulch; at the head of the South Platte, as at Fairplay and Alma; at the Granite placer; in the Durango district on the San Jaun River; in Northwestern

[1] Min. and Sci. Press, Vol. 79, p. 149.
[2] Min. and Sci. Press, Vol. 79, p. 149.
[3] Mineral Industry, 1901, p. 324.
[4] Eng. Min. Jour., Vol. 73, p. 241.

Colorado; and in the Clear Creek district between Denver and Golden. The last locality is probably the most favorable to dredging operations.[1]

Dredging operations have been carried on at Bannack, Montana, for a number of years. A mistake was made, however, at the beginning of operations in figuring on the depth to bed-rock as 25 feet, but it was found to exceed that being nearer 35 feet.[2]

Dredgers are employed in a number of localities in the Southern gold fields, which in most cases operate upon gravels formerly worked over by the early miners with their crude methods. In 1903 there were four dredgers in the Dahlonega district having a capacity of one to one and one-fourth cubic yards.[3] Dredging operations are carried on at a number of other localities but none of the work is very extensive.

The crude and wasteful methods employed in working the placers in the beginning of mining operations in Alaska and the Klondike prepared the way for a more skillful and systematic treatment of the gravels at a later date. A prominent feature of the new operations is dredging. Dredging is now a permanent industry and is gradually overcoming such obstacles as lack of facilities in transportation, high cost of installation and operation, short seasons and frozen ground. By the extensive application of dredging large areas of low-grade ground are being opened up. The capacity of the average dredger is 3000 cubic yards per 24 hours. In 1906 there were nearly a dozen dredgers operating in the Klondike region.[4]

The Hydraulic Elevator. — As previously pointed out there are two conditions considered essential to hydraulic-mining operations, namely, sufficient height of intake of gravels into the sluices and ample room for the storage of the tailing. The use of the hydraulic gravel elevator overcomes these two difficulties at minimum cost. An hydraulic elevator is in reality a jet pump in which the motive force is hydraulic water. A large mouthed suction connects with the sump in the pit, or a sluice which conducts gravel and water to it. Naturally the height of the lift depends upon the head of water employed. The Evans and Cranston were the first two makes of hydraulic elevators placed on the market. The following descrip-

[1] Min. and Sci. Press, Vol. 91, p. 398.
[2] Ibid. Vol. 83, p. 183.
[3] Mines and Minerals, Vol. 23, p. 497.
[4] Mines and Minerals, Vol. 27, p. 182.

tion of an Evans' elevator is taken from a paper by T. J. Barbour:[1] "Its principal features are the three suctions. The patent was on an elevator with more than one suction inlet. It is now built, for most of the gravel claims, with three openings, one of which is called the main suction, the other two, auxiliaries. The auxiliaries are principally used to balance the intake, reducing the wear and tear of the machine. They also increase the efficiency of the elevator by allowing the proper proportions of air to enter when the water and material in the main opening might, from any cause, become choked. The auxiliaries can be extended with any size pipe to a distance beyond the elevator proper, and are frequently used for draining places in the bed-rock below the line of the sluices connecting with the elevator. This is a great advantage and can be carried on without interfering with the sluicing of the material through the main opening on the elevator seat."

Hydraulic elevators may be employed in opening up the washing pits in which they are later installed. There are various sizes of elevators which may be designated according to the capacity of the nozzle employed — Nos. 1, 2, 3 and 4 of the Evans make have capacities of three-, four-, eight-, and ten-inch nozzles, while the size of the throats is 3 to 20 inches. In the largest size an 18-inch boulder can be raised to a height of 60 feet, with a head of water of 400 feet.

In operating an hydraulic elevator plant the elevator is placed at the lowest point of the mine a sump being formed in the bed-rock in order that it can be readily fed by the sluices extending into the various parts of the pit. In order that repairs may be made upon the elevator it is customary to install an hydraulic water lift or jet pump to control the rise of water in the pit. However, probably a better arrangement is the use of two elevators, which may work together or in relays. Plenty of air is essential to the proper working of an elevator, since the material raised may pack and will not enter the up-cast if air is not admitted. A further advantage in the use of air is that after passing the throat it becomes compressed, thus materially assisting by its expansive force in raising the gravel. From the up-cast or main discharge pipe the gravel strikes against a plate by which it is deflected downward into the sluice. A grate of curved steel bars is usually preferred to the deflecting plate, especially when large stones and boulders are elevated, wear is less and is it more readily repaired. This grate is securely anchored

[1] T. A. I. M. E., California Mines and Minerals, pp. 434–436, 1899.

in the top of the sluice-box which is covered over for some distance, often being weighed down with boulders.

The first box of the sluice-way seldom has any grade owing to the force with which the boulders enter it, often being carried from 10 to 40 feet down the sluice. The second box has a grade of about one to two inches per length of box; the third two to four inches, etc., until the maximum desired grade is obtained. The construction and operation of the sluice is similar to that in ordinary hydraulic working.

It is claimed that the best results are obtained when the elevator is fed by a bed-rock flume, which should be kept within a short distance of the bank, thus permitting a more prompt and positive supply of gravel. As about two-thirds of the water used in such operations is employed in lifting the gravel and only one-third in piping by giants, it is evident that care should be taken in regulating the gravel supply, provided the best results are desired.

Grizzlies are often arranged in the bed-rock flumes which feed the elevator in order that materials tending to choke the feed may be removed from the gravels.[1]

Occasionally an auxiliary nozzle is employed to assist in lifting the gravel to the proper height. A description of such a double-acting elevator used in the Columbia placer, Oregon is as follows:[2] "At the lower end (of the elevator) is a cylinder 31 inches in diameter. Sixteen feet vertically up from the bottom this cross-section is increased 12 inches on the under side, making a total depth of 43 inches, to admit of an auxiliary three and one-half inch nozzle, the stream from which acts as a helper and counteracts the already very material retardation in the ascending current due to gravity, friction and atmospheric influence. This nozzle is protected against injury from rocks by a cylindrical collar surrounding and projecting beyond it. The initial impulse is derived from a six-inch nozzle, 16 inches below the mouth of the elevator, so placed that its stream shall be accurately centered in the cylindrical pipe. There is no contraction forcing a throat as in most elevators."

The quantity of water used with this elevator is twice that used in piping.

Boulders 15 by 17 by 27 inches, and a tree stump 31 by 33 inches were observed to pass through the elevator, which had a lift of 36 feet, while a rock weighing 800 pounds was known to have been

[1] Min. and Sci. Press, Vol. 91, pp. 111 and 112.
[2] Eng. and Min. Jour., Vol. 65, pp. 431 and 432.

elevated. Other interesting details of this plant may be obtained from the original paper.

Hydraulic elevators are now employed in practically all of the gold producing states, although their principal application is in California, Oregon, Idaho, Colorado, Alaska, Wyoming, etc.

The operating conditions of hydraulic elevators, may be illustrated by the following cases: the Yreka Creek Gold Mining Company operating in Siskiyou County, California, in 1880 with a Cranston elevator elevated the gravel 40 feet, with 800 miner's inches of water under a head of 266 feet. This elevator took care of the gravel piped by two giants with nozzles of two and one-half and three inches in diameter. In 1889 the North Bloomfield mine installed an elevator with a lift of 96 feet, depositing and impounding the tailing in an old pit. Fifteen hundred miner's inches of water were used under a head of 540 feet. The nozzle employed was six inches in diameter, which elevated the gravel in an upcast 20 inches in diameter and 113 feet long. The giant supplying this elevator used 800 miner's inches of water.[1]

Hydraulic elevators are successfully operated in many localities with lifts ranging from 50 to 70 feet, although probably the larger number lies between 50 and 60 feet. It is claimed that gravel does not materially influence the height of lift, but it is rather the water itself which controls it.[2]

The Débris Controversy. — The development of placer-mining from hand work with cradles and long toms to the use of hydraulic giants that could do the work of a thousand men each, was accomplished in but a few years in a manner little short of the marvelous.

So profitable was the work that capital was readily induced to invest with the result that at one time no less than $100,000,000 were invested in property consisting of lands and equipment — canals, ditches, reservoirs, etc., and as it has been aptly remarked "the extent of their operations proved their undoing."

It was but natural that two things should result, namely: through the very nature of their operations they must infringe on the rights of others, and that in turn they should be preyed upon by other interests. The development and maintenance of such gigantic enterprises created other industries upon which they ultimately became largely dependent for supplies, the most important of which were the agricultural and grazing interests, and strange as it may

[1] Min. and Sci. Press, Vol. 72, p. 261.
[2] Min. and Sci. Press, Vol. 72, p. 265.

seem these two industries were largely instrumental in almost completely driving out the former industry from the state.

The detritus, commonly known as "tailing," "débris" and "slickens," resulting directly from hydraulicing operations was at first disposed of as best it could be, and without regard to anything except the convenience of the mining operations. It was not long, however, before the gulches and cañons of the mountains and foot hills, the direct recipients of the débris, became filled and choked, and, with the periodic seasons of high water, discharged immense quantities of sand and slimes into the tributaries of the larger rivers which emptied into the ocean. Serious blockades to the rivers were obviated to a large extent by the removal by floods generally occurring during the winter months, and culminating at least once in 10 years. The final disposition of the débris was then the bay of San Francisco, which was extensively shoaled in its upper portions.

With regard to the amount of débris deposited in the beds of the rivers, it is estimated that there were 120,000,000 cubic yards in the Bear, and 70,000,000 in the Yuba by 1880.[1] While in the bed of the lower Yuba, where the gradient was less than 15 feet to the mile there had accumulated débris to the amount of 300,000,000 cubic yards.[2] Further, when hydraulic operations were most actively carried on, on the Yuba, between 1880 and 1890, the annual discharge of débris into the streams was 22,000,000 cubic yards, while the material moved each year was approximately 46,000,000 cubic yards. The quantity of débris discharged into the Yuba alone each year has been graphically described as being sufficient to fill a street 11 miles long and 120 feet wide to a depth of 75 feet, or to fill the Erie canal in 18 months.[3]

In 1894 it was estimated by the Débris Commission that the amount of detritus then in the Yuba River from De Guerre Point to Marysville, was 308,000,000 cubic yards, while a rough estimate of that between Smartsville and De Guerre Point was 100,000,000 cubic yards, making a total of 408,000,000 cubic yards then in that river. It was claimed, however, that it could be proven that only one-fourth of the débris in the rivers came from the mines, which was roughly shown from the figures given above — 408,000,000

[1] Eng. and Min. Jour., Vol. 81, p. 940.

[2] Proc. Soc. Civil Engrs., Vol. 32, p. 104, and Eng. and Min. Jour., Vol. 81, p. 941.

[3] Eng. and Min. Jour., Vol. 78, p. 588.

cubic yards in the Yuba River in 1894 as a result of washing approximately 100,000,000 cubic yards of gravel.[1]

The coarse gravel and cobbles remained in the upper portions of the tributary streams such as the Yuba, Bear, Feather and American rivers, while the sand and clay (" slickens ") were carried on and deposited in the valley of the Sacramento, also to a certain extent in the lower portions of the larger tributaries. It was estimated that at the rate of washing during 1880 the channel of the Sacramento would be raised 1 foot in every 38 years.[2] By this change in the level of the river beds 40,000 acres of rich bottom land along the Yuba, Bear, Feather, American and Sacramento rivers were inundated and ruined for cultivation, besides which there were 300,000 acres of valuable land more or less damaged. It was claimed that 43,546 acres of land suffered a depreciation of $2,597,000 in 36 years.[3] Where such damage was not permitted, owing to the building of levees, the expense incident thereto was equivalent to a depreciation of the property.

The citizens of Marysville were taxed 6 per cent of their property value to construct levees to hold back the waters of the Yuba River during floods.[4] Further, navigation in the bays of Suisun and San Pablo as well as on the Sacramento River was seriously impaired.[5]

The miners paid for damages obviously done, but this in time led to extensive blackmail. The purchase of lands damaged by débris worked no special hardship upon the miners when they were isolated cases only, but when a whole township had to be purchased and where agricultural and grazing land were acquired more for speculative purposes than for their professed use, then such proceedings became most offensive tyranny.[6]

The farmers first sought relief at the hands of the State Legislature, and although the matter was much discussed no definite action was taken. An Association, the Anti-Débris Association, was then formed, the object of which was to take charge of and conduct the proceedings against the miners. Forthwith a protective association was formed by the miners, and as a result the matter soon

[1] Min. and Sci. Press, Vol. 69, p. 354, and Ibid., Vol. 74, p. 28.
[2] Min. and Sci. Press, Vol. 74, p. 71.
[3] Eng. and Min. Jour., Vol. 81, p. 940.
[4] Min. and Sci. Press, Vol. 43, p. 378.
[5] Eng. and Min. Jour., Vol. 78, p. 588.
[6] Min. and Sci. Press, Vol. 29, p. 361.

became a political issue. Suit was brought against the Little New York Gold-Washing and Water Company, which was operating along the Bear River.[1]

Litigation followed litigation and the controversy waxed warm, and as was to be expected much injustice resulted to both parties concerned, until finally in the test suit of Woodruff *vs.* The North Bloomfield Mining Company, the miners suffered defeat. The decision of the United States Circuit Court resulted in the closing of all the principal hydraulic mines in the central northern portion of the state. "The mining company and its agents and employes were perpetually enjoined and restrained from discharging and dumping into the Yuba River or any of its forks, ravines, or branches, or any stream tributary to the river, any tailings, boulders, cobblestones, gravel, sand, clay, débris, or refuse matter from the track of mineral lands or mines, and also from allowing others to use the water supply of their mines for washing such material into the rivers or streams."[2]

The following summaries of contentions as to their rights offered by the two parties in the débris controversy are of interest in this connection: The miners claim that "We are engaged in a legitimate and lawful business, sanctioned by special laws of the United States, and by custom and usage for more than 30 years, whereby we have acquired an easement and prescriptive right. We have purchased our lands from the United States government as mineral lands, and paid for them double the price of agricultural lands, with full knowledge on the part of the government of the method to be pursued in extracting the gold, as is apparent by the inspection of the heading and vignetts of the United States mineral patents, representing hydraulic mining as at present prosecuted. Confiding in the validity of our title and easement or franchise, we have expended many millions of dollars in driving long tunnels to tap our auriferous deposits, and in building reservoirs and digging canals to convey water to our mineral lands. In the prosecution of these works, populous communities have grown up; and thousands are dependent upon our industry. We have added to the metallic wealth of the world nearly 1200 millions of dollars, and if undisturbed, will continue to add thereto at the average rate of $18,000,000 annually for an indefinite period, estimated at not less than 100 years. Gold is the great lubricator of commerce. In the present age of prog-

[1] Min. and Sci. Press, Vol. 38, p. 168.

[2] T. A. I. M. E., California Mines and Minerals, pp. 256, 257, 1899.

ress, it purchases all necessities; and the nation which produces it can want for nothing. The equity of our tenure of lands and public policy alike forbid suppression of our business. The breaking down of dirt by projecting water is an incident of our business, without which it cannot be pursued. The mountain cañons are the natural receptacles for the material washed from the mines. You have endangered your towns in periods of high water by a defective and unscientific system of levees, and you have obstructed the efforts of the government to protect the navigable rivers by measures recommended by the government engineers. The bay of San Francisco has in no manner been affected by our operations." [1]

On the other hand the claims of the opposition were: "(1) hydraulic mining is the exercising a right which prevents others enjoying their rights, a use of property which prevents others enjoying theirs; it is therefore a nuisance; (2) it thus interferes with and disturbs large numbers of citizens; it is therefore a nuisance; (3) there can be no prescriptive right granted in the maintenance of a nuisance; (4) the Statute of Limitations will not run as against a nuisance; (5) a public nuisance may be, and should be abated; (6) it is no answer to charge of nuisance to say it also produces benefits; (7) the United States guarantees the free use of the navigable streams to the public; (8) the state cannot, by law, or neglect, or permission, consent to any obstruction to such streams; hydraulic mining does obstruct streams, and prevents their free use and enjoyment; (9) therefore, it is a public nuisance and should be abated; (10) hydraulic mining proper did not begin till 1865, and it has not gone on without protest — custom is no defence, if the custom be a nuisance; (11) hydraulic mining, it is proven, it is not profitable, but agriculture is; (12) a court of equity will interfere to prevent the continuance of a nuisance." [2]

As a result of the closing of the mines by both State and Federal injunctions, hydraulic operations were suspended, and the costly plants and equipments were allowed to go to decay. Dams and pipe lines were blown up and destroyed. Thus were thousands of men thrown out of work, and many camps and towns depopulated. The decadence of hydraulic-mining culminated about 1880 when the mines were practically wholly closed.

[1] Eng. and Min. Jour., Vol. 36, p. 210.

[2] Min. and Sci. Press, Vol. 44, p. 137, and Ibid., Vol. 48, p. 28 (full text of Judges Sawyer and Deady's decision).

The losses to California following upon the closure of the hydraulic mining operations may be summarized as follows: There was —

1. A large reduction in gold production.
2. A depreciation in value of property and equipment of the mines from $100,000,000 to practically nothing.
3. A loss to other industries dependent more or less upon the mining industry, and among those affected were agriculture and grazing.

The decrease in gold production during 1880 to 1885, i.e., during the last few years of its struggle for existence, was $1,000,000, while during 1880–1889 the decrease in placer gold was $4,379,268. In 10 years mining property had depreciated 90 per cent, while the loss to sympathetic industries approximated $72,000,000. It has been estimated that the total loss to all industries affected by the closing of the mines, was close to $225,000,000, while the direct damage to property by the débris was $3,304,035.[1]

In the fall of 1891 a movement was set on foot to form a State miners' convention, and through it to memorialize Congress as to needed legislation for the hydraulic-mining industry of California. This led to the calling of a State convention, which was held at San Francisco, and included among the representatives, both farmers and miners. Mutual concessions on both sides resulted in the adoption of a common plan of procedure, the basis of which was the report of a government commission of engineers. Prior to this the Legislature had passed a joint resolution in order that the matter might be presented to the attention of Congress. An act was passed by Congress appointing a commission of engineers whose duty it was to examine into existing conditions, and devise means whereby the mining industry might be rehabilitated. The report of this Commission is that referred to above. It was reported that dams and other restraining works might be erected in many cañons, which would restrain the débris already in the streams and that subsequently made and thus prevent damage. Localities were specified together with the amounts of gravel that could be worked, the cost of dams, etc. Congress was petitioned by the convention of miners to accept and adopt the report and that steps be taken to put in practical and effective operation the means suggested.[2]

In March 1893, the Caminetti Act was passed by Congress, which

[1] Min. and Sci. Press, Vol. 74, p. 48, and Ibid., Vol. 74, p. 71

[2] T. A. I. M. E., California Mines and Minerals, 1899, pp. 258, 259.

permitted the operation of hydraulic-mining under certain restrictions and conditions.

"The essential features of the law are that all such mines, operated under this system, shall impound or restrain their débris or tailings, and prevent them from entering the navigable streams, or injuring the lands of other parties. Under the Act, the California Débris Commission, consisting of three officers of the Corps of Engineers, U.S.A., was appointed by the President. This Commission is empowered to issue licenses for mining by the hydraulic process under this Act, when it is satisfied that the débris dams or impounding works are sufficient to restrain the débris. The hydraulic miner must make application to the Commission for a license to mine, and submit his plans of the proposed restraining works, which are subject to the approval of the Commission. Each separate application is advertised for a specified time, and a hearing is held before the Commission, at which those who may be opposed to the issuance of a license may state their reasons. When the plans are approved, and the necessary works constructed, members of the Commission make a personal examination of them, and, if satisfied that the débris can be restrained, a license to mine by the hydraulic process is issued, and the mine may begin operations. If they see any reason to believe, however, that damage may be done to the rivers or to individuals by the operation of the mine, no license is granted, and the mine may not be legally worked. Moreover, even after the license is granted, if the débris, or water carrying too much of it, is for any reason permitted to enter the stream, the license may be recalled. Frequent examinations are made to see that the miners are complying with the laws." [1]

A serious objection raised is that too much time lapses between the application for and granting of the license — 113 days, not including the time necessary for constructing the works, is about the minimum time required under the most favorable circumstances, while often from six months to a year is needed before the necessary legal proceedings are properly carried through.[2] Furthermore, such a permit should ensure against molestation by opposing interests, but such has not always been the case, injunctions having been granted by the Courts of the valley districts. This uncertain and unfortunate condition of affairs has resulted in the discouragement of new enterprises, especially where considerable expense was necessary; however,

[1] T. A. I. M. E., California Mines and Minerals, pp. 260–261, 1899.

[2] Eng. and Min. Jour., Vol. 81, p. 942.

numerous old works have been repaired and refitted, and operations successfully carried on.

The Caminetti Act applies only to that section of the state which lies within the drainage areas of the Sacramento and San Joaquin rivers and their tributaries. In Siskiyou, Trinity, Humboldt and Del Norte counties, there is not and never has been, any restriction to hydraulic-mining. The mines of this section discharge their débris into the tributaries of the Klamath River, which is a non-navigable stream. The output of the mines of the Sacramento and San Joaquin rivers has constantly increased under the supervision and protection of the new law, and as a result the country has gained largely in population, a not unimportant factor in its development.[1]

There is no law against hydraulic-mining in California, either State or Federal. The numerous injunctions granted were directed against certain mines for damage done to individuals and not generally against the industry as a whole and in name.

The Civil Code of California makes clear the present status as follows:[2]

Section 1424. The business of hydraulic mining may be carried on within the State of California, wherever and whenever the same can be carried on without material injury to the navigable streams and the lands adjacent thereto.

Section 1425. Hydraulic mining, within the meaning of this title, is mining by means of the application of water, under pressure, through a nozzle, against a natural bank.

An unexpected and unusual condition of affairs was occasionally encountered in the controversy between miner and farmer, as for instance when, owing to the proximity of farming land to the mines, fine gold in considerable quantities was found to exist in the tailing deposited on the fields. Often the farmer lost sight of the actual damage done to his property, and threatened to institute suit if the mining company attempted to lay claim to such deposits. Furthermore, the question arose as to whether such lands could rightly be called agricultural lands — the General Land office withdrew from the market some of the land in question, having considered it mineral land.[3]

Another similar case occurred in South Dakota, where the tailing

[1] T. A. I. M. E., California Mines and Minerals, 1899, pp. 261, 262, and Eng. and Min. Jour., Vol. 81, p. 942.

[2] T. A. I. M. E., California Mines and Minerals, p. 262.

[3] Min. and Sci. Press, Vol. 29, p. 361.

from the mills about Lead and Central City overrun and destroyed gardens and ranches of nominal and uncertain value. Extravagant claims for damages were made against the Homestake Mining Company, until it was discovered that the tailing still contained gold in sufficient quantity to be profitably extracted by the cyanide process, when the land-owners at once proceeded to assert their ownership of it.[1]

Ore Mining.

The methods of working mines by shafts, slopes and tunnels have already been given in connection with the working of gravels, as in drift-mining and the working of the frozen alluvial deposits of Alaska. However, these deposits partake of the nature of stratified or water-lain formations, and may, therefore, be considered in a class apart by themselves, although certain auriferous and argentiferous occurrences are also bedded, but lie at a much steeper inclination than any auriferous gravel deposit ever worked in this country.

Veins or lodes are worked by horizontal and vertical openings, and by intermediate openings, which are usually designated by the terms slopes or inclines, according as they approach the horizontal or vertical positions. There is, however, no sharp line of separation between slopes and inclines, the terms often being used interchangeably. Further, such openings may be employed for all phases of mine working, namely: prospecting, development and extraction, varying mainly in extent for the various operations.

Prospecting. — Prospecting is pre-eminently a method of location, location of veins and values within them, and is therefore not confined to the surface. The method of procedure in underground prospecting or exploration is usually more definite and reliable than surface work for similar deposits. In those sections of the country where erosion is rapid, and the rainfall is great, the location of outcrops is a comparatively easy task, but when these conditions do not obtain the outcrops are usually hidden or obscured by a mantle of soil or wash, thus rendering their location extremely difficult.

The general considerations affecting the work of prospecting and the methods employed are as follows: Change in direction and grade of streams may be produced by their intersection with veins. Further, gold-bearing veins have been located above holes and depressions, which occurrences are occasionally observed in the extinct river channels of California. In general in the search for gold in streams, preparatory to the search for veins, the grade of the stream must first be taken into consideration. If the grade is heavy, the search

[1] Min. and Sci. Press, Vol. 89, p. 2.

for values should be made at wide portions of the channels, on the sides and the inner rims of curves. With moderate or light grades the long straight channels are more favorable to the collection of gold.

Gold having been found in the stream bed or bank and traced to a point where no more can be found or there is a marked diminution in that found, the search extends to higher ground; the accumulations of gravel often found in the form of terraces, or benches, on the slopes and occasionally at considerable altitude should be carefully examined. Thin hill-side deposits are often auriferous to a marked degree, which deposits may extend even into the valleys. All portions of such deposits should be tested for gold which, being composed largely of wash and formed on fairly high grades, may be a heterogeneous mass of gravel, sand, soil and clay.

The prospecting of wind-formed deposits and wash, especially when shallow, is rendered comparatively simple due to the fact that the values usually lie close to the surface, while water-lain deposits more often carry the values on or close to bed-rock, and the same may be partially true of wind-formed deposits if the country is rough.

A careful geological reconnaissance should be made of the surrounding country in order that the factors governing the present slopes may be ascertained. Underground work may be necessary to supplement such investigations. When shafts are employed they should be given the minimum size consistent with the work to be done — a shaft two and one-half by four feet is large enough for considerable depth.

Regarding the choice of location with respect to formation, the junction of various formations as the older sedimentary rock with metamorphic and igneous formations, as slates, schists, quartzites, shales, sandstones, and limestones with basalt, phonolites, andesites, etc. are favorable, while recent formations both stratified and igneous are usually considered of little importance. Where vegetation is poor or wanting there is evidently a thin covering of soil; however, more credit is given to the influence of mineral matter on vegetation than is actually known to exist.[1]

If considerable depth of soil is found in the locality prospected an examination of cuts by streams and exposures made by landslides may be of value.

In the actual work of prospecting a slope is usually chosen, although the more level portions are not wholly overlooked, and "surfacing" begins. This consists in digging small holes or

[1] T. A. I. M. E., Vol. 15, p. 645.

trenches; if the former, they are spaced some five to ten feet apart, along the base of the slope. The material excavated is washed separately, a record being kept of both location and results obtained.

As a rule the occurrences of gold are contiguous, the amount found decreasing in either direction from the productive portion on the line of search. The lateral extent of the gold-bearing area having been ascertained, another level some distance up the slope is chosen and is worked as before, except that the center of the area already determined is taken as a center for the new level. By this method of procedure the amount of work done is materially reduced. It is probable that each new level worked will show both a narrowing of the gold-bearing area and an increase in values obtained. On continuing the operation the deposit narrows to a point, which is the apex of a fan-shaped area produced by the downward movement of particles on a slope and under the influence of gravity.

The vein is thus located, but it is evident that there are many conditions tending to vitiate the conclusions thus arrived at. If the vein prospected for is "spotted" in values, as when the pay streak or body occurs at the intersection of veins, in isolated patches or pockets, etc., such a method of procedure may be reliable, provided that the even distribution or spread is not interfered with, but when the whole vein contains values, such extensive and systematic work is hardly necessary as the whole slope should show values. However, in either case the occurrence of ditches with the intervening ridges brings about a concentration of the values along the lines of depressions and if found in the lowest point of the depression it is impossible to determine from which slope it came. If the vein is spotted as in pocket mines, the work of the prospector often proves of no avail for on tracing the wash gold to its source he may find that the supply has been exhausted or only a remnant remains.

Other vitiating factors are: landslides, which may be old or new; great depth of cover formed subsequent to the erosion of the vein; the cutting of gulches; etc.

Having located the vein it is considered good practice to extend the work by trenching some distance above it in order to ascertain whether other sources of supply lie above. On testing the vein and finding gold the work of prospecting the vein is begun.

The work of prospecting as described is often rendered difficult owing to the presence of dense brush, and masses of decayed leaves, trees, etc., and often a covering of moss. With considerable depth of soil, trenches, shallow shafts and drives may have to be resorted to.

The occurrence and appearance of the gold itself may also be indicative of the presence of the vein from which it was derived. If attached to gangue and rough and porous it has not traveled far, while if flat and worn it is evident that it is far from its source. The float or "shoad" rock, often called "kindly" rock, consists of portions of the vein-filling, being quartz, calcite, fluorspar, heavy spar, etc. The color of the rock is also often an indication of the presence of veins and when stained red or brown, by iron oxide, it is known as gossan rock. The iron stone "blow-out" or "iron hat" of the Germans will always bear careful examination and testing.[1]

It is fully as important to know what minerals are commonly associated with gold and silver and their properties as to be acquainted with the properties and characteristics of the metals themselves. Further, simple blow-pipe tests are often of inestimable value to the prospector and should constitute an important part of his outfit.

The following summary of facts has been given as being of considerable importance in prospecting.[2]

1. The gold contained in the surface wash is the principal guide to the vein or the localized values therein.
2. The work of prospecting by shafts on veins unless values are obtainable from the outcrop, is not to be recommended.
3. If the gold found in tracing is smooth and rounded there is little chance of finding the source.
4. If a trace extends to a clay bed, begin immediately to search for the vein.
5. Serpentine traces usually show values but are unreliable.
6. Numerous fine colors with an occasional coarse one are preferable to a single nugget, even if rough.
7. A coarse gold district is to be preferred as the veins and pockets are apt to be larger and more readily found.
8. In prospecting it is well to bear in mind that the majority of gold-bearing veins do not reach the surface.

The prospecting of veins is as a rule more satisfactory than their location by methods previously described, for their position with regard to the surface is usually pretty well known, while the possible points of attack are limited. Nevertheless prospecting by shafts, tunnels and drifts is more difficult and expensive owing to the

[1] Min. and Sci. Press, Vol. 75, p. 242, and Ibid., Vol. 70, p. 164.
[2] Ibid., Vol. 81, p. 155.

hardness of the rock and in more extended work, the necessity of ventilating and draining the workings.

Formerly the work was done largely by driving tunnels and drifts and sinking shafts, but during recent years exploring by means of drills, both churn and core, has come into great favor and their use is being rapidly extended both above and below ground. The advantage of the former over the latter methods consists in the fact that a larger cross sectional area is exposed with the result that sampling can be carried on more advantageously and accurately.

Shafts for exploratory work are usually sunk in the vein and lie in a vertical plane cutting the vein transversely. Drifts are also driven in the vein but are horizontal openings or nearly so, being given sufficient grade for purposes of haulage and drainage. Tunnels as distinguished from drifts do not follow the vein but usually run normal to the stratification of the rocks and therefore cut the vein transversely. Shafts and drifts prove the vein-contents over a large area while tunneling is more in the nature of drilling in that respect. The special advantage of tunneling consists in exploring ground lying without the vein and locating the so-called "blind" deposits, i.e., those that do not come to the surface.

Drilling has all of the advantages of shafts, drifts and tunnels with respect to position as holes can be drilled in any direction, but the results obtained are lacking in definiteness and detail.

The following comparison between shalt sinking and drilling as means of prospecting has been given:[1] A shaft can be sunk 100 feet in four months at a cost of $3,000, while with the same expenditure 10 holes could be drilled with a diamond drill to the same depth and spaced 10 feet apart in about two and one-half months. In the latter case a block of ground 100 feet square and deep will have been fairly well explored, while in the former case only the cubical contents of the shaft will be positively known. Further, the disadvantage of limited area of hole is largely offset by drilling a number of holes normal to the vein in the same plane.

Although prospecting, which includes all systematic search for minerals, is absolutely necessary for the proper development of mineral properties, yet a large number of the largest gold and silver mines in the world owe their discovery to accident or chance. And the prospector although aided by the constantly increasing store of information regarding the association and occurrence of gold and

[1] Min. and Sci. Press, Vol. 82, p. 106.

silver knows little more than the philosopher of old who said: "Surely there is a vein for the silver and a place for the gold where they find it."

Development. Development work is prospecting extended, but is also considerably more. Besides being more extensive it is of necessity more systematically carried on as the various horizontal and vertical passages must serve as means of inlet and exit for men and an outlet for ore. Further, by such work the ore-bodies are rendered accessible to the miner, their extent and value are made known and economic handling is rendered possible.

Shafts and tunnels are almost universally employed in developing mines of gold and silver, as well as other minerals, and which method is employed depends largely upon existing conditions. If the outcrop of a vein is at considerable height on a mountain and the pitch of the vein is such that the distance from the base of the mountain to the vein is not unduly great, then a tunnel might be chosen to advantage in the development and working of the vein. Even then a shaft would be sunk to make connection with the tunnel in order that proper development, might be made at minimum expense and that effective ventilation might be secured.

In other cases where lines of transportation can be brought to or moderately close to the proposed site of a shaft, shafts are preferred as a means of opening up a vein or ore-body.

In the consideration of mine development are involved problems relating to the time and expense of hoisting and handling the ore, capacity of individual hoists and output of the mine, proper installation of machinery and capital to be invested.

Some of the more important considerations affecting the choice of kind of shaft to be employed are as follows: For steeply pitching veins and extenuated ore-bodies, vertical shafts may be employed to advantage and may be sunk in or to one side of the vein according to the character and strength of the vein-filling and wall-rock. However, inclined shafts are occasionally employed in such cases, but some difficulty is experienced in arranging for hoisting. The principal advantage of vertical shafts is convenience in hoisting which may be largely offset by the amount of dead work necessary to reach the vein, and with decrease in dip, this is proportionately greater until a point is reached where the expense of making frequent connections (cross-cutting) between shaft and vein together with that of handling the ore is prohibitive. Vertical shafts are then limited to pitches of about 36 to 90 degrees; the former being considered the lowest economical limit. Inclined shafts may, however, be readily employed between the limits of 16 to 85 degrees, although both limits merge into other methods of development that are preferred — the upper, especially above 65 degrees, into the field for vertical shafts, the lower into that of slopes and incline-planes.

The location of the shaft whether vertical or inclined, is also of considerable importance, and not only from the standpoint of ease of sinking and stability, but in regard to the methods of handling the mine product. When a vertical shaft is located on the outcrop of a pitching seam, it is evident that the line of the shaft will soon deviate from the course of the vein, thus necessitating the driving of cross-cuts, which with considerable depth will become unduly long. This difficulty can be largely obviated by sinking the shaft in the hanging-wall, and at such a distance from the vein as to properly proportion the length of cross-cuts, both above and below the intersection of the shaft with the vein. Further, with due regard for other controlling factors, the distance of the shaft from the vein outcrop, must bear a definite relation to the proposed depth of the shaft or development of the property.

Inclined shafts are usually sunk in the vein for various reasons, the more important being ease of sinking, as the vein-filling is usually softer and more easily worked than the country-rock, and the value as a means of ascertaining the extent and character of the deposit. However, when sunk in the vein, more care must usually be taken in the support of the excavation, which involves the leaving of pillars of mineral standing in the vein, and the consequent reduction of the percentage of extraction. The loss of mineral may be largely overcome by sinking the shaft in the foot-wall, although the advantage of sinking in the vein material is thus largely offset, but the inclined still has the advantage over the vertical shafts, in that the length of cross-cuts is considerably less.

Shafts should be located in the foot- rather than the hanging-wall owing to the fact that there is less danger of movement. Further, to prevent reversing the grade or direction of hoisting, when inclined shafts are employed, it is necessary to place the ore bins and surface work on the foot-wall side of the outcrop.

The considerations outlined above may be considerably modified by prevailing conditions, such as fissuring and faulting of the vein, and its intersection with one or more productive or non-productive veins.

Having made connection between the surface and vein by means of shafts and cross-cuts, levels are formed in the vein by driving drifts at the points of intersection of cross-cuts or shafts with the vein. The levels are in turn connected by other opening in the vein, which according to whether they are sunk or driven upward, are called winzes and raises. The secondary connecting passages are usually spaced at more or less regular intervals along the line of the levels, and on either side of the shafts.

Beginning with the levels, their roofs are attacked, which work is continued upward until the level above is reached. The process of removing the valuable portion of the vein lying between levels, is known as stoping, being designated as over- and under-hand stoping, according to whether the work is done by breaking down the roof, or heaving up the floor.

The following interesting summary was made regarding the development work in precious metal mining of the United States:[1] "There were in 1886, 920 mines in the various States and Territories, of which 195 were opened by shafts, 86 by inclines, 91 by shafts and inclines, 202 by shafts and tunnels, 40 by shafts, inclines and tunnels, 1 by shaft, incline and opencut, 12 by shaft, tunnel and opencut, 2 by shaft, incline, tunnel, and opencut, 151 by tunnel, 49 by tunnel and incline, 20 by tunnel and opencut, 6 by incline and opencut, 3 by incline, tunnel and opencut, and 50 by opencut alone. Of the 85 mines in California, 23 were opened by shaft, 17 by inclines, 9 by shaft and inclines, 7 by shaft and tunnels, 21 by tunnels, 7 by tunnels and inclines, and 1 by shaft, incline and tunnel. Of the 825 deep mines reported on, the total length of shafts and inclines aggregated 399,686 feet, total length of tunnels and galleries 1,992,191 feet, total length of winzes and raises 221,071 feet, while the greatest vertical depth of workings was 3027 feet, and the greatest horizontal development was 4000 feet. These distances expressed in miles, neglecting fractions, would be as follows: length of shafts and inclines, 76 miles, tunnels and galleries 377 miles, winzes and raises 42 miles, giving a total of 495 miles. In the above, tunnels and galleries include all horizontal openings. The development of mines in Nevada was of the most importance, having a length of shafts and inclines of 119,547 feet, of tunnels and galleries 794,914 feet, of winzes and raises 100,133 feet. The greatest vertical depth of shaft and horizontal development are also found in this state, the entire development work representing an aggregate length of 185 miles."

The remarkable progress in development of the mines of the Comstock lode is shown in the following list of depth of shafts for the year

[1] Min. and Sci. Press, Vol. 52, p. 224.

1881. The datum line for depths was the Gould and Curry croppings. On the 23rd of November, 1879, the incline of the Belcher mine had reached a depth of 3,000 feet, and had the distinction of being the deepest mine in the United States.[1]

	Depth
Utah, bottom of incline which ran south from vertical shaft	2250 feet
Sierra Nevada, bottom of joint Union Consolidated winze.	2700 "
Union Consolidated, bottom of joint Sierra Nevada winze.	2700 "
Mexican, Bottom of joint Ophir winze.	2860 "
Ophir, bottom of joint Mexican winze	2860 "
California and Consolidated Virginia, each	2500 "
Best and Belcher, bottom of Consolidated Virginia winze .	2300 "
Gould & Curry, Osbiston shaft	1980 "
Savage, Hale & Norcross, Chollar & Potosi, each	2400 "
Julia	2900 "
Bullion	2800 "
Imperial Consolidated	2800 "
Yellow Jacket	3000 "
Crown Point	2760 "
Belcher	3090 "
Overman	2275 "
Alta	2065 "
Foreman shaft	1980 "

Owing to the scarcity of published records it is difficult to give a comprehensive account of the development work in the various states and territories, for any given time or period; however, an occasional enumeration is given as the following for Utah:[2]

	Depth May 1, 1900,
Mammoth mine, Tintic district, Utah	2000 feet
Horn Silver mine, Frisco, Utah	1630 "
Ontario, Park City, Utah	1600 "
Centennial Eureka, Tintic	1600 "
Daly West, Park City	1400 "
Silver King, Park City	1300 "
Daly, Park City	1200 "
Grand Central, Tintic	900 "
Bullion Beck, Tintic	1350 "
Eureka Hill, Tintic	1500 "
Dixie copper mine, Washington County	400 "

Mining by tunnels is the usual and preferred method of development in the Coeur d'Alêne region, Idaho, and up to 1903, it was claimed that at least 70 per cent of the ores mined there had been extracted through tunnels, while of the remaining 30 per cent, two-fifths was raised in underground shafts, and thence hauled to the

[1] Min. and Sci. Press, Vol. 38, p. 249, and Ibid., Vol. 43, p. 76.
[2] Mines and Minerals, Vol. 20, p. 524.

surface through tunnels. The Tiger-Poorman was the only mine having employed surface shafts from the beginning of operations.

Below is given a list of the principal tunnels in this region:[1]

	Feet in Length
The Sweeney, Wardner, about	5000
The Reed, Wardner, about	5500
The Kellogg, Wardner, about	12000
The Frisco, Gem, about	1200
The Standard, Mace, about	3000
The Mammoth, No. 6, Black Bear, about	3600
The Hecla No. 3, Burke	2400
The Morning No. 5, Mullen	3000
The Morning No. 6, Mullen	10000

A list of shafts in the same district is in part as follows:

	Feet in Depth
Tiger-Poorman, from the surface	1700
Hecla, from surface	300
Standard, in Campbell tunnel, 3000 feet from the surface	850
Frisco, in Frisco tunnel, 1200 feet from surface	1400

As measured from the surface the mines of the Tiger-Poorman, Frisco and Standard are practically of the same depth, being about 2000 feet deep.

In the Cripple Creek district practically all of the shafts are vertical and sunk from the surface. The following list gives a fair idea of the development work that has been done (1903), especially in some of the larger mines:[2]

	Depth
Portland	1200 feet
Stratton's Independence	1400 "
Gold Coin	1200 "
Golden Cycle	1000 "
Vindicator	1200 "
Eagles	1500 "
Doctor-Jackpot	700 "
Gold Ring	920 "
Shurtloff	920 "
Findley	1300 "
Blue Bird	1350 "
Last Dollar	1220 "
Princess Alice	1000 "
Wild Horse	1250 "
Isabella, Victor & Empire State,	1000 " (?)
Elkton	800 "
Hull City	1180 "
Ajax	1200 "
Midget	750 "
C. O. D.	1000 "

[1] T. A. I. M. E., Vol. 33, pp. 250–251, 1903.

[2] Eng. and Min. Jour., Vol. 76, p. 86.

Methods of Extraction. — Special methods employed in breaking down and handling the ore, commonly known as stoping, are discussed in this connection. Such methods as have been successfully employed in the large gold and silver mines of the United States are given, no attempt being made to describe in detail all of the principal processes, but rather the more typical ones.

Further, the occurrence of the ore together with the methods of development are of necessity considered, but only in so far as to be of service in elucidating the methods of extraction or mining proper.

For convenience the methods are described as applied to narrow-veins, wide veins, bedded deposits and masses. Massive deposits may occur in stratified formations, in contacts and in wide veins. The principal conditions affecting the methods of working, are the lateral and vertical extent of the deposits, which in turn depend largely upon the pitch.

Narrow Veins. — *The Southern States: the Franklin and Cross Mines.* — Quartz-veins of variable width forming lenticular masses together with impregnations of the country-rock constitute the general type of ore-bodies worked in this region. Methods of mining employed in the Franklin mine, Cherokee County, Georgia, and the Cross mine, Lancaster County, South Carolina, are described as typical for this class of deposits.

"The (Franklin) mine is worked entirely through No. 2 shaft driven in the hanging-wall to a depth of 215 feet, at which point it strikes the vein. From this level work is carried on to a total depth of 430 feet by a slope on the dip of the vein and the pitch of the ore-shoot, resting on a small horse of poor ore.

"The method of mining the ore is as follows: Levels are run every 100 feet, and the ore-lenses are entirely stoped out, leaving the intervening bodies of low-grade material as pillars. The levels are connected by a series of raises, their number depending upon the length of the ore-shoots. The ore is then stoped by underhand work, the raises acting as ore-chutes (mill-holes), and the cars being loaded directly from pockets in the level below. No pillars are left below the levels, the track when necessary being carried over the worked-out stopes on stulls. Only such timbers as are necessary to assist the men in their work are used, the walls requiring no support. All the material stoped is hoisted and milled, leaving no waste filling in the mine. Air-drills are used almost exclusively; for stoping, a Baby Rand with $\frac{7}{8}$-inch steel is used, while drifting is done with $3\frac{1}{4}$-inch cylinder Sergeant machines. The ore is raised in cars of one-half ton capacity, first up the incline by underground hoisting engine, and then trammed to the bottom of the vertical shaft, from where they are hoisted to the surface on cages. No. 1 shaft is used for ventilation, and has a pipe-way. The mine is not a wet one, a small steam-pump, situated immediately below No. 2 shaft, taking care of the water. At the surface, the ore is run over a grizzly, and then through a crusher, the jaws of which are set 1½ inches apart. The crushed ore is hauled to the mill by mules in cars of 1½ tons capacity, which are loaded from a bin below the crusher.

"Besides the above deeper developments, exploratory work is being pushed at two other points along the outcrop of the vein known as No. 3 and No. 4 shafts, and located respectively ¼ and ¾ of a mile to the southwest of No. 2 shaft. At both points inclined shafts are being sunk on the dip of the vein with the object of developing in depth lenses which have been worked to some extent on the surface."[1]

"The method of working these (the Cross mine) deposits is the pillar system (Pfeilerbau). . . .

"The levels (8 by 7 feet) are run 70 to 100 feet apart, and nearer the hanging- than the foot-wall. At intervals of about 50 feet upraises are made, with a cross-section of 8 by 7 feet. These are carried forward at an inclination as near as possible to 45 degrees. If necessary, the upper portion through the chain pillar left under each level is carried up vertically. This raise serves afterwards as a chute (mill-hole). Drifts are then run below this pillar until the limit of the stope in length (about 30 to 40 feet in all) is reached, leaving a vertical pillar 15 to 20 feet in thickness between the stopes. The ground is then cut away between the foot- and hanging-wall, completely exposing as roof the bottom of the chain-pillar above, which is sprung in the shape of an arch, with its heavier toe in the foot-wall, and a minimum thickness of 15 feet. This, as well as all other work in tight ground, is done by air-drills. Stoping is then carried downward by hand-drilling in circular steps, arranged in such a manner as to allow the ore to drop into the chute on blasting, without further handling. The angle of 45 degrees given to the latter allows a steady flow of the material down the foot-wall without completely choking it. At the bottom of the chute is a rough grizzly made of logs, which holds back the larger boulders and prevents them from choking the smaller loading-pocket below. This grizzly is easily accessible from the drift, and the larger pieces of ore are here sledged.

[1] T. A. I. M. E., Vol. 25, p. 760.

The loading-chute and grizzly are kept up as long as possible until the stope is finally broken through to the drift-level below, the ore being shoveled into cars. As far as possible, the pillars are left in poor ore, the diabase dike fulfilling this purpose admirably. No timber whatever is used, and although chambers 100 by 100 by 40 feet have been cut out, there seems to be no danger of a fall, the country-slate being very tough and self supporting. The stopes from the 100 and 200 foot levels are connected with the surface by raises, so that at a future date the worked-out stopes can be filled from the surface and the ore in the pillars, i.e., what is left toward the hanging-wall, can be taken out.

"Blasting is done with 40 per cent Hercules powder. One-inch steel is used for both hand- and machine-work. The number of air-drills is limited by the size of the compressor — an Ingersoll machine, with 3-drill capacity. The ore is carried from the loading-chutes to the shafts in sheet-iron cars of ¾-ton capacity, running on 18-inch gauge track. At No. 2, shaft (7 by 12 feet, single compartment) they are hoisted by cage, with automatic safety catch. The new shaft is 6 by 14 feet, double compartment, and the ore is raised by a novel skip designed by Mr. Thies."[1]

Colorado: the Standley, Camp Bird, and Cripple Creek Mines. — An interesting description of a typical gold mine, the Standley Consolidated Mine at Idaho Springs, Colorado, is given by Professor Arthur Lakes.[2]

"Stoping is done as follows: An upraise is made by a power or air drill in the roof of the tunnel to a height of perhaps 50 feet. An opening upwards is thus made, the dirt from the excavation falling into the tunnel below. From this chute stoping is commenced; that is excavating along the vein on either side of this chute, beginning at the bottom. In doing this, the drills are directed in a slanting direction downwards so that water can be poured into the holes to assist drilling. In this stope, the gangue matter of the vein is blasted down first, away from the richer streak of ore, which in this mine almost invariaby lies close on to either foot-wall or hanging-wall, generally the foot-wall. Previously, however, as soon as stoping begins, thick stulls are laid across the upper part of the tunnel from wall to wall, each of them five feet apart from centers, and on these is laid a lagging of poles 15 feet long; forming a floor on top of these stulls. The cross stulls in this case were the width of the vein,

[1] T. A. I. M. E., Vol. 25, pp. 773, 775 and 777.

[2] The Colliery Engineer and Metal Miner, Vol. 14, pp. 282–283.

and two feet thick. The butt end of a stull is laid in a hitch or square notch, cut in the face of the foot-wall, and the other end is jammed down on to the head in the hanging wall at a nearly right-angle with both walls.

" These stulls in this mine, with inclined walls, have to be very thick and strong to support the enormous pressure of the hanging-wall, a pressure in this mine increased by the swelling of a body or dyke of porphyry behind the hanging-wall. So powerful was this pressure that I saw cross stulls two feet thick, and only five feet long; split, broken, bent and crushed at the butts like tow.

" The stulls and lagging having been laid as a floor, the work of stoping upwards progresses. The dirt falls on the lagging of the floor, but much of its pressure is distributed over the sloping surface of the foot-wall, instead of all on the floor of lagging and stulls.

" On top of the dirt that falls from his work upon the lagging floor, the miner stands to continue his attack on the vein in the roof of the stope with the power drill, whose pillar may be placed across the stope horizontally or else vertically.

" After the poorer rock of the gangue (i.e., the vein matter from wall to wall) has been blasted down, and scaled off from the streak of rich ore that in this case lay close to the foot-wall, the poor barren rock is broken up small to make a somewhat smooth floor to receive the precious ore as it is broken down. This, if soft, is either taken down with a pick or gad or else blasted down with a light charge of powder.

" Meanwhile to dispose of this ore, and get it down safely into the tunnel below, a chute or mill-hole has been kept open and carefully timbered with small cross-sets of timber to the level of the floor of the stope where it is as an open chimney down which to throw the ore into the tunnel below where a car stands ready to receive it, and carry it out on the dump, to be wheeled to the mill or sorting room or to the incline shaft for hoisting. As the dirt on the floor of the stope rises, additional cross pieces are added to keep the mill-hole or ore-chute free and clear from stones. The mill-hole is wider at the bottom, which is called a pocket, than at the top. This enlargement is done to prevent stones clogging, hence the mill-hole is in the form of an inverted funnel.

" Down this ore-chute, the ore is dumped into the car in the tramway at the bottom of the tunnel.

" Very rich ore is sometimes carefully broken down on a blanket spread on the floor of the stope.

" The result of driving the drill holes down in a slanting direction is finally to make one end of the stope higher than the other.

" On reaching near the upper level, if the ore is not very valuable, a pillar is left or else it is stoped clear up to the track and filled in. The vacant space is filled by stoping on one side and filling in, laying cross pieces from wall to wall to support the rails of the upper level whilst this is in progress. Commonly this part is filled up during the night shift, so that by the morning the cars can run on the rails of the upper level.

" Mill-holes or ore-chutes as they are called, are generally placed at every 40 or 50 feet apart. Men may be working at one end of a stope, and others at the further end, the drilling holes converging towards the cutter. The cross-section of the vein is well seen on the roof and end faces of these stopes."

The quartz veins of the San Juan region, as exemplified by those at the Camp Bird mine, are high-grade, averaging in width from three to eight feet, the range being 2 to 16 feet. Values are somewhat irregularly distributed throughout the vein, but when concentrated in certain areas constitute the so-called ore " shoots."

" The main cross-cut, 2200 feet long, at level No. 3, runs south to cut the vein. The two upper levels, also, are opened by cross-cuts. The total length of development-work, including cross-cuts, drifts on the vein, stopes, raises, mill-holes, shafts and winzes, is between 5 and 5½ miles. In the west end of the workings, over 1500 feet of depth beneath the top of the mountain has been gained.

" The main cross-cut at No. 3 level is 7 by 7 feet in the clear, and timbered for the first 420 feet from the entrance (that is, so long as the tunnel is in the " slide-rock "), with square sets (posts and caps 12 inches square). After entering the solid rock, no timbering is required. The upper cross-cuts, also, are timbered only in the slide-rock. In general, it may be said that, throughout the mine-workings, timbering is required only in the chutes or mill-holes, raises, winzes, and the floors of stopes. The ground in the mine stands remarkably well, several stopes from 10 to 20 feet wide having required no timbering.

" The main cross-cut is lighted with incandescent lights 100 feet apart. In the No. 2 and No. 3 levels and cross-cuts, the 30-pounds steel-rail track is 22 inches wide. Compressed air is conducted into the main cross-cut by a 6-inch pipe, the size of which is successively cut down as the air passes through the different workings to various parts of the mine. A 2 by 1 feet ditch for water is cut in the lower cross-cut; and there are smaller ditches in the levels.

"From the upper level, and stopes above, the ore is handled entirely by gravity, through chutes, to the lower level, then trammed by mules to the ore-bins at the mouth of the main adit, and dropped into the tram-buckets, which run by gravity over the aërial tram-line, 9000 feet long, to the mill. From all other parts of the mine the ore is similarly handled. No ore is trammed out to the surface at the No. 2 or No. 3 levels.

"From the lower level, 9 end-dumping cars, of a little over 1 ton capacity each, are run in a train. The installation of electric tramming is now under consideration. The average quantity of ore trammed out is a little over 200 tons per day. Shafts are now being sunk on the vein from the lower level, and one of these is already 200 feet deep. Part of the tonnage making up the daily mill-run is taken from this shaft.

"In chutes and raises, stulling with 5-feet centers is used. Mill-holes are put in at intervals of 50 feet; and as often as necessary for getting the ore from the upper levels, these are continued upward as raises. Every alternate chute is supplemented with a man-way and slide for steel.

"In stoping, it has been the custom to stull and lag over the top of the drift, forming a floor for the power-drills. Recently there has been put in practice, where ground is sufficiently solid to warrant it, a system introduced by Mr. Cronin, the mine-superintendent. When a new stope is to be started, a raise is put up from 6 to 10 feet, according to the solidity of the ground and timbered as usual. From the top, the vein is run on as if a drift were being started. The machine-men thus stand on a solid block of ore in place, instead of stulls and lagging. The pillar thus formed is lengthened as far as it is desired to carry the stope, say 50 feet, to the place of the next chute, and the broken ore falls on the solid pillar, the timbering being thus practically replaced. The pillar is, of course, always accessible as ore, when its extraction is desired.

"The mine is at present well off for timber, the lower level being situated below timber-line and there being, a fairly heavy growth of spruce on the side of the mountain near by. Spruce timber is plenty along the mountain sides from the mine-workings to the mill.

"It is the practice in all the mining operations to take out only about 40 per cent of the ore broken in stoping, allowing the rest to remain in the mine. It is found that this 60 per cent of broken ore very nearly fills the space occupied by the total original ore in place. An advantage of this system is that there is no necessity for going into the walls for waste to fill the stopes, since these are continually filled with broken ore. For the most part, levels, raises, chutes and winzes have been run in ore; and at present the percentage of waste trammed out is very small.

"Cross-cuts and main levels are carried 7 feet above the track, with a grade of 4 inches to 100 feet.

"All drifting and breaking is done by machine-drills, operated by compressed air from the compressor-plant at the mouth of the main cross-cut."[1]

The following supplementary description is taken from a paper on the Camp Bird Gold Mine, by H. A. Titcomb:[2] "Where a level has run through pay values a stope is commenced about six to eight feet in height being cut out above the level, which is then stulled and lagged. Openings are left at intervals of forty to fifty feet along the level for the chutes and man-ways which will give access to the coming stope. A second cut of six to eight feet of ore is next shot down on top of the lagging which now forms the roof of the drift, using light charges of explosives so as to avoid injury to the timbering, and subsequent cuts add successively to this broken ore, the excess being shoveled down the ore-shoots to the cars in the level below.

"As the stope is thus carried upwards in the pay ore, the timbermen keep pace with the machine-men and timber and lag the chutes and man-ways so that they are kept open to the top of the pile of broken ore, which acts as a footing on which the miners can work at the unbroken ground overhead. The writer has calculated that in stoping in the Camp Bird, from 50 per cent to 60 per cent of the ore by weight remains in the stopes, and from 50 per cent to 40 per cent is removed and milled.

"When the back of a stope becomes low-grade, if it be deemed advisable to abandon further stoping, the lagging of the chutes is removed beginning at the top, and the ore is run down and hauled out to the tramway. The ore finally remaining directly over the drift must be shoveled into the chutes in order entirely to clear the stope. In thus drawing a stope it is usual to put in numerous stulls as the level of the broken ore is lowered, the stulls being left to support the walls of the now open stope. Where waste rock is available

[1] T. A. I. M. E., Vol. 33, pp. 523–524.

[2] School of mines Quarterly, Vol. 24, pp. 61, 63.

it can be advantageously run into an open stope. . . . Sullivan, Ingersoll-Sergeant, and Rand air drills are used in mining, and all give satisfaction. In the wider stopes and in hard rock as well as in drift work, a 3¼ inch machine is employed, requiring two men for its operation. In raises and in softer ground or narrow stopes, a drill with 2-inch or 2¼-inch piston is used, one man alone operating such sizes. These small sized drills are known to the miners as "Babies" and "Chippies."

The following brief description of the practice in mining in the Cripple Creek district is taken from the Professional Paper on the Geology and Gold Deposits of the Cripple Creek District, Colorado, by Waldemar Lindgren, and F. L. Ransome:[1] "The methods of mining employed at Cripple Creek, are not materially different from those in use in other districts, where metalliferous veins are exploited. Overhand stoping with slightly differing variations is used. In narrow veins, short stulls comprise about the only timbering used and required, but when the stopes become over 12 feet wide, square sets become desirable. The rock is usually so hard that stopes will stand unsupported for a remarkable height and width. Examples of stopes up to 200 feet high and 30 feet wide, standing without any support may be seen at the Vindicator and Prince Albert mines. Still in many places the calcite seams cause a dangerous scaling off on the walls, and partial filling must be resorted to in conjunction with the square sets. In the big stopes up to 50 feet wide, as in the Portland mine, from 30 to 40 per cent of the amount broken can be left in the mine as filling.

"A favorite method of stoping is to break down the whole of the ore in place between two levels, leaving the loose rock to be drawn off through shoots as rapidly or slowly as may be required. This leaves the empty stope entirely unsupported. Sometimes the walls are partly secured by stulls while the ore is being drawn off. The ordinary half or three-fourths ton cars are used. The El Paso is the only mine in which 1-ton cars have been introduced and hoisted on cages. Buckets are also employed very extensively in the shafts and sometimes used to a depth of even 1,000 feet, a practice which is not to be recommended. Practically all of the shafts are perpendicular."

The problem of working very narrow high-grade veins is a difficult one and has led to the adoption of the system known as "resuing." There is, however, a question regarding the use of resuing and the

[1] U. S. G. S., Professional paper No. 54, pp. 135, 136, 1906.

Stope in Silver Wave Mine, Montezuma District, Colorado. (From Engineering and Mining Journal.)

working of the vein and adjoining rock walls together. According to F. C. Roberts[1] the two methods gave results that varied considerably when applied under the following conditions: "When resuing was applied, the vein was first stripped on the foot wall (which, in this case, was the more economical to handle) to a width of 30 inches. This waste rock used largely as filling, although a certain percentage was necessarily sent to the surface. When some 3,600 square feet of quartz had been stripped, this was broken down as a clean product so that no sorting was required.

"In the second case, the quartz and adjoining rock were broken together and the fineness to which this product was reduced allowed of sorting out only 5 per cent of the barren rock."

There was considerable difference in the profit and loss obtained in operating by these two methods, but the results favored resuing.

Wide Veins. — *California: the Utica Mine, Mother Lode.* — Mining practice on the Mother lode is given in a valuable paper by J. H. Collier[2] in which the particular conditions encountered there with the manner in which they have been met are given in detail.

"It might more properly be called a gold-bearing mineralized zone rather than a simple vein. The zone consists of a large mass of crushed diabase which, under pressure, has developed a slaty cleavage. The crushed mass has been more or less altered into a schist containing considerable mariposite and white mica. In this mass the ore occurs as large bodies of massive quartz of a brownish-grey color; as masses of quartz veins from 1 to 3 inches wide, interspersed with micaceous schists in a distinctly banded structure; as masses of more or less altered diabase, containing infiltrated silica often in reticulated veinlets; and as impregnations in massive diabase; all containing free gold and auriferous pyrites.

"In working upward on the ore-bodies, they sometimes change from massive quartz to a schistose character, and thin out toward the hanging-wall. Cross-cuts run into the foot-wall, then show the ore making next the foot-wall, and soon widen out to the original width on its upward course, thus proving that the ledge was cut off by a large horse of diabase split from the hanging-wall and fallen to the foot-wall. In this way, the ore-body is made up of several parallel lenses or masses, at different points dipping at a high angle to the eastward with a greater southerly pitch, ranging in all from 10 to over 100 feet in width.

[1] Eng. and Min. Jour., Vol. 76, p. 882, 1903.

[2] T. A. I. M. E., California Mines and Minerals, pp. 97, 98, 105–109, 1899.

" With this outline of the general nature of the deposit, the difficulties of mining, more particularly stoping, such a deposit will be better understood. Not only must the stopes be properly supported and economically worked, but the ground must be thoroughly prospected as the work proceeds.

" The prospecting must be thorough to ensure the most economical use of the long levels through which the ore is removed. These levels are often driven in extremely hard diabase, and are not only costly in driving and fitting with tracks and compressed-air pipes, but are often very expensive and difficult to keep open, on account of the settling and crushing of the rock.

"A stope is started by breasting-out the ore to the full width of the deposit. Cross-cuts are run into both walls, to be sure that all the ore has been removed. The opening is then timbered with 8-foot stope sets. If the ground is solid, no timbering is done, until the whole mass of the rock covering the area of the stope has been removed. The posts are then set in the solid rock, with 6-inch spreaders and 12-inch round brace-sprags between the posts at the bottom. A floor is then laid over the spreaders.

" If the rock is loose or soft, one set is put in at a time as fast as room is made for them. In the soft ground heavy sills are laid, to give a solid foundation for the posts. Sills are not, as is generally supposed, an advantage in working up under an old stope. Good floors laid across the spreaders, even though they have been in place so long as to be badly decayed, are found to be more serviceable than sills. The sills are seldom in place when reached, and have to be caught up securely, or they are liable, by their own movement, to start a serious run in the waste above them. After the sill floor is opened and timbered, a raise following the foot-wall is run up to the level above.

" This raise is necessary for the proper ventilation of the stope, as well as the economical introduction of timber and waste into the stope; the timber and waste being thrown down the raise into the stope. The raise is located in the most convenient part of the stope, and, if possible, where there is a seam of gouge on the foot-wall, which greatly lessens the cost of the work by lessening the difficulty of breaking the ground. If the rock is hard and solid, machines are used, and the raise is timbered with full-sized stope sets, if timbering is necessary; so that, as the stope is carried up, the timber of the stope is joined on to that of the raise. If the ground is loose, the work is all done by hand, and the raise is built up solid with round timber, halved together at the ends, making the raise 4 feet square in the clear.

" The second floor above the level is now started from the raise, the ore falling to the sill floors, where it is shoveled into cars. After this floor is excavated, a set for the full length of the stope is lagged on tops and sides with half-round slabs, made by cutting 12-inch logs, 8 feet long, in two lengthwise. This set is then kept open for the gangway, along the line of which the chutes and man-ways, leading up into the stope, are started. All the remaining space to the top of the sill floor set is now filled with waste. This waste is obtained from three sources within the mine: first, from the vein-rock, by hand-sorting in the mine; second, from cross-cuts run in the wall-rock from the different floors of the stope, for the double purpose of prospecting the ground and supplying the waste; and, third, from the dead-work in different parts of the mine, which is brought in through the raise from the level above.

" From this time the chutes and man-ways are carried up by means of cribbing, to within one set of the back of the stope. When the ground is heavy, similar cribbing is used to help support the ground. In wide and heavy stopes, a row of such cribbing is generally put in extending the full length of the middle of the stope, and is stowed with waste as rapidly as possible.

" The different floors are started successively from the raise. As soon as a floor has been advanced far enough from the raise to prevent the mixing of the quartz and waste, filling is commenced by throwing waste down the raise. When the floor is completed, the lower floor, remote from the raise, is stowed with waste from the cross-cuts. In order to supply sufficient material for this purpose, the cross-cuts, which start out with small dimensions, are widened out into large chambers. In this way no opening in the stope is kept open to a greater vertical height than 16 feet.

" When a level is being worked, a large mass of rock is left in place in the ledge, opposite the shaft, until the last thing before the level is abandoned. This precaution protects the shaft, which is already weakened by the cutting of the station.

" When the vein-matter is badly crushed and broken up, an ingenious system of lagging, called poling, is used. Poles are run out over a cap or sprag — depending on the direction of the work, whether with or across the vein — which supports the ground until the timber is in place. In some cases the poles are a necessity to prevent the ground from running, in others they are put in more for a protection to the miners working beneath them. In the latter case the trouble is caused by detached pieces which continually slack away, due to the presence of water and slight settling.

"In running ground, the poling has to be performed with great care. The ends of the poles are sharpened and worked in over cap all together by working the rock loose around the points with a bar, and driving the poles ahead with a hammer. As the poles are advanced over the cap, the broken rock is raked back from the points of the poles, and left standing on the natural slope to prevent its running. Also side-poles are put in, if necessary, beginning next the roof and working them in as the rock is removed, and the face breast boarded to prevent the loose rock running around the points of the poles. Proceeding in this way, room is made for one set at a time."

The most serious obstacle encountered in mining on the Mother lode is swelling ground and although it is difficult to combat yet the work of development and extraction is in many instances successfully carried on. Methods employed in overcoming swelling ground are given in a paper [1] appearing in the publications of the State Mining Bureau to which the reader is referred.

Alaska: the Alaska-Treadwell Mines. — Much interest is attached to the working of the Treadwell mines owing to the successful operation on low-grade ores. The following abstract is taken from a paper by Robert A. Kenzie: [2] "Formerly, it was the custom to open up a level every 110 feet; but below the 440-foot level the distance between levels in the Treadwell will be 150 feet from now on. By this method a large development-expense will be avoided.

"At each level a station is cut out, the width of the shaft, from 40 to 60 feet long and with an average height of 8 feet. In the Treadwell the main cross-cuts run parallel to the wall-plates of the shaft, and as far as possible it is aimed to have the station on the side opposite from that toward which the skips dump. . . In cutting out the station, a drift is run from the shaft a distance of 25 feet. . . The main cross-cut is then started at right-angles to the station-drift. . . At the hanging-wall end of the cross-cut, a station is cut for the winding-engines that operate the tail-rope haulage; and directly opposite the sinking-compartment, on alternate levels, a station is cut for the sinking-hoist. Beneath the floor of each station an ore-bin is cut

[1] Bulletin No. 18, Cal. State Mining Bureau and reprinted in the Min. and Sci. Press, Vol. 82, p. 37.

[2] T. A. I. M. E., Vol. 34, pp. 345, 347–350, 352–354.

out with a capacity of from 500 to 1,500 tons, according to the quantity of the ore to be handled. . . .

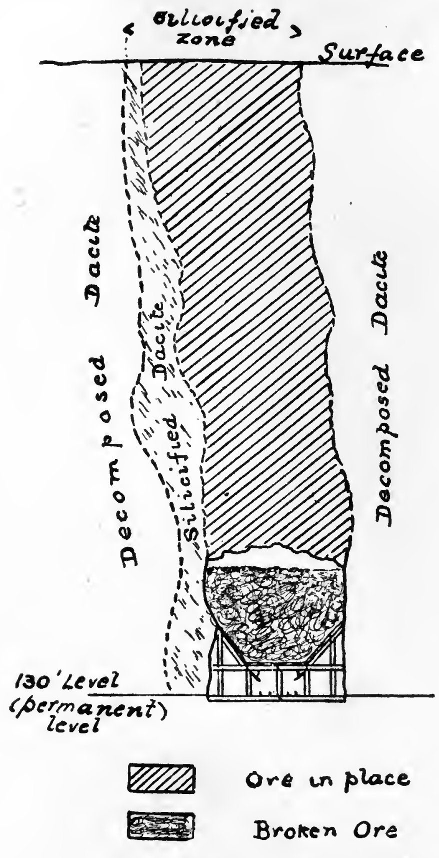
"In the Mexican and '700-foot' mines, the main cross-cuts start directly from the shaft, and, as a consequence, the station-cutting is much simplified. . . . When the ore bin and station are completed, the main cross-cut is driven to the foot-wall. It thus serves the double purpose of determining how the level can be developed in the most economical way and of permitting a thorough sampling of the ore, so that a fair idea of its value can be obtained. The following rule is almost axiomatic in its applicability to the ore bodies on the island: Start the first drift along the foot-wall, and keep it there. . . . It is imperative that the ore be drawn from the stopes by gravity, and this cannot be applied to the ore along the foot-wall unless the chutes, and, consequently, the drifts, are kept as close to it as possible. . . . At intervals of 25 feet, raises are put up on alternate sides of both the main cross-cuts and drifts. These raises are 15 feet high, and are designed to accommodate the chutes for drawing the ore from the stopes. They are put up while the drift is run, and given a slope of 60 degrees from the horizontal, so that the ore will run freely in them. In the Treadwell, Ready Bullion and '700-foot' mines, the drifts and chute-raisers are in ore; but in the Mexican, on account of the flatness of the vein, they are run in the foot-wall slate, and the chute-raises put up to the ore at an average height of 20 feet above the track. At the same time, as the main drift and the chute-raises are being run, a second drift, called the intermediate, is driven directly above the main drift and separated from its back by a pillar of rock 10 feet thick. This drift is the same in size as the lower one, and is so driven that it connects with the top of each chute-raise as it progresses.

"At the ends of the main cross-cuts, and at intervals varying from 200 to 500 feet along the deposit, the different levels are connected by winzes. These winzes are used as man-ways, and as a medium of ventilation. It might be well to add that they are always raised from the lower level, and not sunk from above unless circumstances absolutely require it. While running the main drifts and cross-cuts close attention is paid to the grade. The standard grade in all mines is 0.5 per cent. This grade favors the loaded car going to the station, while it does not retard it too much on its return trip. Cross-cuts are used for connecting the various drifts and for prospecting. They are the same in size as the drifts. When used for the first purpose they are at the level of the drift, but when the second object is the incentive, they are usually driven from the level of the intermediate, so that the broken rock can be stored and handled through chutes. The usual size for drifts, cross-cuts and intermediates is 10 by 7 feet in the clear, and for raises 6 by 8 feet in the clear, no timber being used. . . .

"The future economic workings of the mines depend on no one factor more than on the success attending the carrying of the present system of stoping to the lower levels of the mines. The surface pits are practically exhausted, and the value of the ore does not allow of timbering or any extensive method of filling. So far, the present method has proven applicable to the lowest levels, and I do not hesitate to say that it will be equally successful at any depth to which it may be desired to carry it.

"It was explained above that the object of the intermediate drift is to open communication with the ore-chutes and to furnish a large facial area for the machine drills to work upon, in cutting out or under-cutting the ground floor for the stopes. When the intermediate has advanced about 50 feet, the work of cutting out the stope is started. This consists of mining out a chamber 7 feet high, from 150 to 300 feet long, and with a width varying with the width of the ore-body. In the past it has been customary to cut out the stopes with a level floor, but experience has shown that it is more economical to cut the floor so that it slopes from the parallel lines of chutes at an angle of about 30 degrees. This does away with a large amount of shoveling, and the ore thus left is ultimately obtained through the stopes from the next lower level.

"When the ground-floor has been cut out, the work of stoping upon the ore is immediately begun. The roof of the stope is arched, thus serving the double purpose of supporting the back, and offering a better surface for the attack of the machine-drills. The ore is shot down in large, thin slabs, so that the shock of falling, combined with that of the blasting, breaks it up as much as possible. The pieces of rock too large to pass through the ore-chutes are broken by hand, and 'bull-dozed' with powder to the required size. When starting from the floor, the machine drills cut out a trench along the center of the back to form the arch, its height varying with the character of the rock. Two sizes of machine-drills are used: the 3¼-inch and 3⅝-inch Ingersoll-Sergeant, and the holes are drilled to an average depth of 8 feet. A machine-stoping will drill an average of 28.69 feet per shift of ten hours, and break 34.96 tons of ore with the consumption of 12.53 pounds of No. 2 dynamite. The cost of breaking up the rock after it has been blasted down, is a large item in the expense of stoping. One rock-breaker is usually required to each machine, and it takes 0.85 pounds of powder in ' bull-dozing ' for each ton of rock broken.



Method of Over-hand Stoping Employed at the Combination Mine, Nevada. (From Mining and Scientific Press.)

" As no timber is used, it is compulsory that a sufficient quantity of broken ore be left in the stopes to form a solid working-floor for miners. It has been found that one-third of the broken ore can be drawn off while the stope is being worked, and the surface of the broken ore kept within working distance of the back. In other words, by the above methods, two-thirds of the ore broken must be left in the stope, and cannot be drawn off until the stope is worked up to the next higher level and finished. In the Treadwell and Ready Bullion mines the slate-horse forms a natural division between the stopes of the north and the south ore-bodies. The walls of the ore-body are supported by vertical pillars, or ribs, 15 feet thick, and from 200 to 300 feet apart. For means of communication and ventilation, man-way raises are put up in these pillars and connected with the levels. At intervals of 25 feet, short drifts are run in opposite directions from the man-way raise; so that, as the working floor of the stope advances, each of them is used successively when the workings connect with the main raise, and in turn abandoned and closed up as connection is made with the next higher one. The levels are protected by horizontal pillars from 20 to 30 feet thick. Heretofore these pillars have been left at each level, but from now on only the pillars at every other level will be left in place; yet even with this saving, fully 20 per cent of the ore must remain in the mine in the shape of pillars and ribs to support the ground and prevent caving."

South Dakota: the Homestake Mines. — Not unlike the Alaska-Treadwell mines both in character and extent of deposit and magnitude of operations is the Homestake mine of South Dakota. A special method of mining has been evolved and successfully employed in this mine. It is known as the "Homestake System of Stoping."

Levels are formed in the lode which are laid out in squares or blocks, and sill timbers are placed. Three lines of track are then laid running in the direction of the lode, and are connected by such cross-tracks as are deemed necessary. Sets are then placed and securely lagged above, and on the sides of the car-ways in order to protect the tracks from materials loosened by the mining operations carried on above, while spaced lagging is placed on the sets between the car-ways. It is then evident that with the breaking down of ore the space not occupied by the car-ways will be filled, none of it is removed, however, until the filling has been completed. The lagging serves as a false floor upon which the miners work, and is removed on the completion of the filling of the sets. This filling of ore is not disturbed until during the next operation of cutting out the stope it may be necessary in order to make room for the miners.

This method is conducive to rapid work owing to the fact that little or no attention need be paid to the timbers, and therefore large charges may be fired knocking down large masses of rock and ore.

Two or more sets are placed next to each wall of the stope, keeping pace with or in advance of the stoping operations, which are kept open and serve as ladder and pipe-ways, also as a means of facilitating ventilation.

Ore-chutes may or may not be employed depending on the size of ore produced in blasting. With softer ores the size may be such as to warrant the use of chutes, but with hard ores the large masses broken down do not permit of the use of chutes. The ore is then usually shoveled from the floor on a level with the tracks in the car-ways, there being as many places to shovel from as there are spaces between the posts of the sets.

When a height of some 85 feet has been attained in stoping, the stope worked and the level above are connected by raises which are to serve as means of introducing filling into the stope. The work of removing the ore is begun, the walls being examined in the meanwhile in order that serious falls may not occur. Having emptied one end of the stope the floor is lagged, and the filling from the stope above is run in. As the work progresses a stope will be partially filled with broken ore and filling, but occupying opposite ends of the stope. The walls are thus well supported, and the miners are provided with support for drills and staging upon which to stand.

To effect a still further saving in timber the above described method has been modified by employing only two lines of track in the stopes, one being in the middle of the stope while the other is laid in a drift cut in the pillar to the side of the stope. No sets are used between these two lines of car-ways as was formerly the practice.[1]

Idaho: the Coeur d'Alêne Mines. — The lead-silver ores of the Coeur d'Alêne region occur in typical fissure-veins and are associated with considerable quantities of siderite. The fissures occupy fault-planes which have suffered more or less displacement. As a usual thing there is only one principal plane of fissuring in each vein which generally occurs near the middle of the vein, but often forms one of the walls.

The following brief description of the methods of mining is taken from a paper by J. R. Finlay.[2]

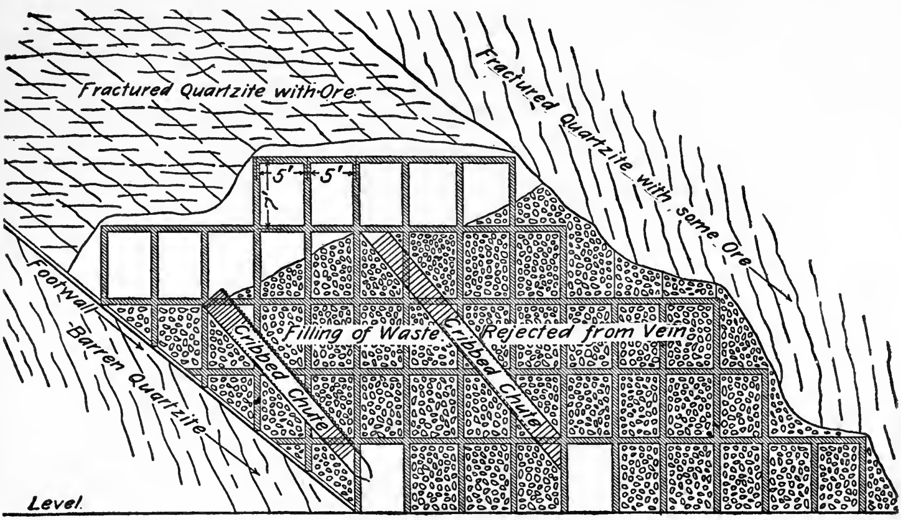
" At least 70 per cent of all the ore thus far mined in the Coeur d'Alênes has been extracted through tunnels without hoisting or

[1] Min. and Sci. Press, Vol. 88, pp. 177, 178, 1904. For details of stoping in the Homestake mine see pp. 165–166.

[2] T. A. I. M. E., Vol. 33, pp. 250–252, and 255.

pumping. Of the remaining 30 per cent, which has been hoisted, at least two-fifths has been hoisted through underground shafts, to be subsequently hauled out through tunnels. The Tiger-Poorman is the only mine which has always been operated by shafts from the surface. This large proportion of tunnel-work has been a great advantage to the district. . . .

"Three methods of mining are used in the district: (1) back-stoping and timbering; (2) back-stoping, timbering and filling; and (3) back-stoping and filling without timbering. . . . At the Bunker Hill and Sullivan, the most interesting feature of the underground mining is the extraction of wide bodies of low-grade ore by stopes which are filled, as the work progresses, with waste rock sorted from



Mining with Square Sets and Filling, Bunker Hill Lode, Coeur d'Alêne Region. (From Mines and Minerals.)

the broken ore. There is usually more than enough of such material to keep the stopes full, and provision has to be made for tramming the surplus waste away. Sometimes this back-stoping is done without any timbering, other than an occasional prop to support a suspicious-looking piece of ground in the roof; but more commonly the stopes are timbered with light square sets.

"In stoping the ore at the Standard it has been found necessary to fill up the stopes with barren material from the vein. This is done by the simple process of sorting out part of the waste rock from the barren streaks and from the walls, and throwing it down among the timbers below. It is quite easy, in most parts of the mine, to secure in this way enough filling to keep the stopes full within two or three floors of the back. As the levels are 200 feet apart, it is necessary to build massive cribbed chutes up through the timbers. . . . In the Mammoth mine, the ore almost invariably lies in a single streak in immediate contact with the fissure. The shear-zone is much narrower than elsewhere; and the mining is simpler, in that no filling on an extensive scale is required. . . .

"At the Tiger-Poorman, Hecla, Frisco and Morning mines, all the stoping is done with stull-sets, about as in the Mammoth. Very little effort is made to sort the ore before concentrating, or to fill the stopes systematically."

For a further detailed account of the mining practice in this region the reader is referred to a paper by R. N. Bell in the Seventh Annual Report of the Mining Industry of Idaho 1905.[1]

Bedded Deposits.— *Utah: the Mercur mines.* The essential features of the mining practice in the Mercur mines as given herein are taken from a paper by Geo. H. Dern:[2] "The ore-veins of Mercur, Utah, . . . consist of parallel blanket deposits, dipping at a slight angle from the horizontal. The upper vein is usually from 12 to 20 feet thick, though often much thicker. The middle vein is situated about 40 feet lower, and is from 12 to 30 feet thick. The mineralization sometimes extends throughout the entire intervening space, forming a continuous ore-body, from the floor of the middle vein to the roof of the upper vein. The dip varies from nearly horizontal to 25 degrees. . . . The veins outcrop on the sides of Mercur and Marion hills. Naturally, the original prospecting and development work consisted of driving tunnels on the veins, following the ore on its strike. The tunnels were close enough together to make it convenient to stope out the ore between them. . . .

"The original method of mining consisted of advancing large stopes, leaving pillars of ore to hold up the ground, and supporting the roof by means of stulls. The pillars were subsequently withdrawn, so far as practicable. Usually this method admitted of clean mining though sometimes cave-ins caused loss of a good deal of ore. As a general rule, it was "good ground" and there was little difficulty in holding the roof and keeping the stopes from caving, which was at that time not desired. In the Marion mine, which has not been

[1] Mining Magazine, Vol. 13, pp. 306–307.

[2] Mines and Minerals, Vol. 25, pp. 1–3.

operated for several years, and in the old workings of the Sacramento mine, there are still vast chambers from which the ore has been extracted, which show no signs of closing, and in which the timbers, when any are present, have taken very little weight. . . . With increased output, and enforced economies due to lower-grade ores, the mining methods were necessarily changed and improved."

The following description of methods is that of the Consolidated Mercur Gold Mines Company in the Mercur and Golden Gate mines.

"In the Mercur mine, the hanging-wall is usually very hard and firm, so that it does not cave readily.

"In fact, it is often difficult to make a stope cave in, even when such action is desired. Hence the method of mining hitherto employed in this mine differs somewhat from the more typical caving system worked in the Golden Gate mine. The latter system, however, is now being more generally adopted in the Mercur mine on account of its superiority.

"Let us assume that there is a certain body of ore to be stoped out with a definite boundary, caused by a fault, a lean streak, or an old stope. A drift is driven into this body until the boundary, or end of the values, is reached. Then stoping is commenced by 'swiping' on both sides of the drift. An open stope is thus formed. This is supported by stulls so long as necessary for the safety of the men. The stope is drawn backward toward the place where the drift started. The men work for the most part in the drift, and the 'back' is blasted down in front of them. Of course with the width of such a stope limited, and if the block of ore be large, the same operations must perforce be carried on in two or more drifts, so as to draw back all the ore. As the stope is drawn back a large chamber is left, which is expected to cave in.

"The advantages of this system are that the place where the ore is coming from is in plain view of the miner, and the ore is always mined clean up to the hanging-wall. A disadvantage is that, with an inclined vein, the drift cannot always be kept upon the foot-wall, hence there is danger of leaving a layer of ore in the floor of the stope. Also, a premature cave often causes the loss of valuable pillars of ore. This can hardly be called a true caving system, because the only caving about it is that the stopes are allowed to cave in after the ore has been extracted. In the Golden Gate mine, the ore itself is partly caved, at least enough to crush it and minimize the amount of explosives required to mine it.

"In working the latter system, the extent of the ore-shoot is first proven up by development-work, in the shape of an incline with its levels, or whatever method may be applicable. Then sublevels are driven through it, to block it out properly for economical extraction, and to make the country 'work.' This crushes the ore and gets it ready for mining, and it is then stoped out by men working in the faces of these various 'subs.'

"The ore-body has first been followed down by an incline. Such an incline is frequently run along the hanging-wall instead of on the foot-wall, and we will assume that this was done in the example given. The first South level from the incline followed the ore on the strike until it struck a fault, which definitely cut off the ore. The first North level, farther down the incline, followed the ore on the other side. Neither level was kept on the foot-wall, because in prospecting or development it is not always satisfactory to confine workings to a definite portion of the vein.

"We will assume that the workings above the level from which the incline was started are sufficiently advanced so that they will be all stoped out in a few months. It is therefore desirable to get a new block of ore, down the incline, ready for stoping. Accordingly, a point is selected in first North level, and a cross-cut is driven to the foot-wall. When the foot-wall is reached, an incline raise is started, kept strictly upon the foot-wall and continued to the upper level. From this incline, a series of 4-foot by 6-foot sublevels are run, about 15 feet apart, on the foot-wall to the south, until they reach the fault which terminates the ore. The 'subs' are numbered 1, 2, and 3, from the top down. They are timbered with tunnel sets, lagged over. These subs cut the ore-body up to such an extent that it begins to 'work,' and the pillars of ore left between the different subs begin to crack, and crush, and crumble. As the timbers begin to take weight, and a sub shows signs of caving in, it is often necessary to take out a set, relieve it by taking down some dirt above it, and put it back. This 'crushing' operation is usually slow, and often a 'country' has to be left alone for two or three months after the subs are driven before the ore is broken enough for easy mining. If necessary the long, narrow pillars may be further weakened and the crushing hastened by transverse cuttings.

"When at last it is ready, and the main level has been worked out and caved in, the incline is abandoned, chutes are provided to receive the ore from the subs, and stoping is begun in the face of sub No. 1. A set of timber is taken out and the ore begins to fall down in front of the miner. Standing in the drift, and protected by the timbers, he shovels the ore into a car, trams it out of the sub, and dumps it into a chute. He shovels as long as the ore keeps coming, though, of course, some blasting is necessary to shake the ore down at times, and the large boulders have to be drilled and blasted. Finally, waste begins to come, and the miner knows that all the ore is down and that the hanging-wall rock is coming. He therefore retreats, takes out the next set of timbers, and lets a fresh lot of ore down. This operation is repeated until the sub is drawn to the incline raise. When sub No. 1 is drawn back 10 or 12 feet from its original face, work is started in sub No. 2, and this level is kept a uniform distance behind the one above it. Sub No. 3 is started when sub No. 2 is a safe distance back, and so on until all the subs are being worked. It is always essential that an upper sub be kept safely behind the one below it, otherwise the lower level would cause the upper one to cave, and thus lose the ore. Also the man in the upper level would be working over caving ground and would be in constant danger of going through.

"The chief advantages of this system are the small amount of timber used, diminished quantity of powder required, assurance of getting practically all of the ore, and safety of the men. There is far less difficulty than might be expected to keep the ore free from waste. When the two veins are distinct, and both carry values, the upper vein is mined out first. When the vein is more than 15 or 20 feet thick, or where the two veins come together and form an ore-body of great thickness, the whole body cannot be mined at once. In such cases the ore is mined out in successive slices, first taking out a layer about 15 feet on top, next to the hanging-wall, then mining a second layer of the same thickness. In the Golden Gate mine there have been ore-bodies nearly 100 feet thick, and several levels were required to mine this out."

To supplement the above description another account [1] of the methods employed in these mines as outlined by H. L. J. Warren is herewith given in part.

"The main working artery is part shaft and part incline. . . vertical for 300 feet and then turning an angle of 29 degrees, passing under the leaching and roasting departments of the mill, where it makes an angle of 45 degrees, and comes to the surface; it then passes over a steel trestle to the top of the shaft house, where the crushers are placed. . . At the main level the shaft is 200 feet in the hanging-wall and encounters the upper lode at the Viking level. A cross-cut

[1] Eng. and Min. Jour., Vol. 68, p. 755.

is driven from the main level southwest 600 feet, encountering the upper lode at 200 feet from the main shaft, the middle lode at 500 feet, and the lower lode at 600 feet. At 200 feet from the shaft there is a drift on the strike of the upper lode, and at 500 feet from the shaft a drift on the strike of the middle lode. Raises are put up from this cross-cut and from the drifts to the top of the upper lode. These raises are connected, where it is practical to connect them, by drifts and the ore-body cut into blocks as near 50 feet square as it is practical to get them. When the ore is cut into blocks stoping is begun at the farthest point from the raises, or at the outside of the ore-body, and the ore drawn out toward the raise, cutting it into small blocks, and afterward drawing the pillars and the ore out of the back of the drift and the back of the pillars. While this is in operation another sublevel is being cut, 14 feet below the one being stoped. This sublevel is cut into blocks the same as the upper one while the upper one is being stoped. As soon as the upper sublevel is stoped out, stoping is begun on the second and the third is started to be opened up in the same manner as those above. The drifts are 4 feet wide by 6½ feet high, and are timbered with drift sets and lagged closely. The timbers used for drift sets average about 6 inches in diameter, while the lagging averages about 3½ inches in diameter.

"As the ore is stoped out the hanging-wall is allowed to fall in and take the place of the ore and on the second and following sublevels the broken ground falls in as the ore is taken out, so that after the first cut, or the first sublevel is worked out, all of the ground constituting the hanging-wall follows down as the ore is mined out.

"The above system works very satisfactorily indeed, excepting in a few places, where the hanging-wall is a blocky lime, which does not cave very readily, and to overcome this difficulty the first sublevel is taken out on stulls to support the hanging. When sufficient area is mined out, so that these stulls show distress, they are blasted and the hanging-wall allowed to cave in. After this the balance of the levels below are worked out on the regular caving system.

"To accommodate the requirements of the mill over 700 tons daily have to be mined, which necessitates breaking ore from 4 to 10 blocks at a time, and the constant blocking out of new squares for the stoping of different classes of ore. . . . This is one of the most interesting phases of this most interesting method of economic ore handling. The check on the work is so close and accurate that accidents, through the caving system proper, are no more frequent than in ordinary mining."

Masses. — *Nevada: the Comstock mines; Surface pits or Glory Holes.* — The following brief statement of conditions in the ore-bodies of the Comstock lode and the methods of mining employed in extracting the ores in 1870, is taken from a paper by J. D. Hague:[1] "The material inclosing the ore-bodies, or 'bonanzas,' is of a very unstable character and involves an immense cost in timbering. The great mass of vein-matter is composed of 'horses' of country-rock, chiefly propylite, associated with immense sheets of clay. . . . The ore-bodies frequently have selvages of clay of considerable thickness. The whole is soft, yielding, and owing to its clayey nature, swells on exposure to the air, exerting an enormous pressure. The extraction of such immense bodies of ore, and the opening of such extensive chambers with insufficient support of the country-rock or vein-matter, induces large movements of the surrounding masses. In early days, the immense stopes, though timbered at an extravagant cost of material and labor, were not filled with waste-rock, but allowed to remain open. Great caves of ground were, of course, the consequence, extending in some cases, from the surface to a great depth. It is now the custom to fill up exhausted stopes as soon as possible, after the extraction of the quartz, but the necessary outlay for maintaining the mine in proper condition for work is still very large. The means of obtaining waste-rock, as observed in the Savage, where the supply from the dead-work of the mine is insufficient, affords some indication of the character of the ground to be dealt with. For this purpose drifts, 30 or 40 feet long, are driven at convenient points into the country-rock, or, more properly speaking, the barren vein-matter. These drifts are securely timbered. At the end of any such drift a chamber is excavated, about 10 or 12 feet high, and 20 or 30 feet in diameter, the roof, during excavation, being sustained by a few posts and plank. When the chamber has attained the desired dimensions, these slight supports are removed. The roof and sides soon begin to swell and fall in, supplying the material which is wheeled out and dumped into the stopes. The loose material being removed from the chamber, the swelling and falling continues for an indefinite period, affording a supply for a long time."

Stoping is accomplished in the following manner: "The vein, or its ore-bearing portion, being reached by a drift or tunnel proceeding from the shaft, the work of extraction begins, and is almost invariably conducted by over-hand stoping. The first desideratum, under

[1] Mining Industry, J. D. Hague, pp. 109, 110 and 111, 1870.

ordinary circumstances, is to connect the new level or station with the one above it by a winze, usually passing through the ore-bearing ground, by which means a circulation of air is effected, and the necessary ventilation obtained. The stoping then commences, the work progressing from the level of the new station upwards towards the station next above; the ore, as fast as it is removed from the place, being thrown down to the track-level, and transported from the stope to the shaft by means of the drift-cars."

The methods of mining now employed on the Comstock lode do not differ materially from that above described, except that square-sets are almost universally employed, usually accompanied by filling.

As previously stated up to 1904, considerably more than 75 per cent of the ore mined at the Treadwell mines, had come from surface-workings, although the output from this source showed a falling off, while that from underground work was materially increased.

The following extract is taken from Mr. R. A. Kinzie's paper The Treadwell Mines:[1] The main open-pit, or " Glory Hole," has reached a depth of 220 feet below the adit level, and 450 feet from the surface, with a maximum width of 420 fet, and a length of 1,700 feet.

" Owing to the large slides of waste rock from the foot-wall, and the necessity of having a secure pillar of rock at the 220-foot level, to protect the underground workings from surface-water, it is impracticable to carry the pits to a greater depth. In the other mines, at present, very little ore is being taken from the surface, but at the beginning, all of them depended on the open-pits for ore on which to start their mills. When a pit is to be opened, a raise is put up from the nearest level, and connected with the surface. This raise is started from the intermediate drift, in general, directly over a chute-raise. The chutes on each side then serve as a man-way for the raise in course of erection, and the broken rock is drawn off through the middle chute-raise into cars. When the raise has been connected, machine-drills are put to work cutting out a small stope at the bottom. This raise when finished has the shape of an hour-glass, the top being formed by the open-pit, and the bottom by a stope, covering three chutes, and from 20 to 30 feet high, the two being joined by the raise. The object of cutting out the pit-raises in this manner is, first, to obtain chute-capacity in case of their being hung up by large pieces of rock, or by blasting; and, second, to afford an opportunity to break up any large piece of rock that may have been overlooked

[1] T. A. I. M. E., Vol. 34, pp. 351–352, 1904.

in the pit, which would stop up the chute unless it were broken to pieces small enough to pass through it.

"Machine-drilling is seen at its best in these pits. The $3\frac{1}{4}$ inch diameter Ingersoll-Sergeant drills, set on tripods, are used in all the pits at present. The average number of feet drilled per machine in 10 hours, is 36.35. The holes are drilled to an average depth of 12 feet, and each machine will break 69.69 tons of ore per shift of 10 hours. When the pits were smaller, and the difficulty of setting up was not so great as at present, the average number of feet drilled was much higher, and the breaking capacity of a machine-drill was from 150 to 200 tons of ore per shift of 10 hours. The pits are worked by drilling and blasting the ore from a series of benches or terraces around the chute-raise as a center, and when the ore is blasted the broken rock rolls down to the bottom. The small pieces are then broken by sledges, and the larger ones by placing sticks of powder on the surface of the rock, tamping with a little fine dirt, and blasting. For blasting holes, No. 2, or 40 per cent, dynamite is used, while for 'bull-dozing' No. 1, or 70 per cent, is the best.

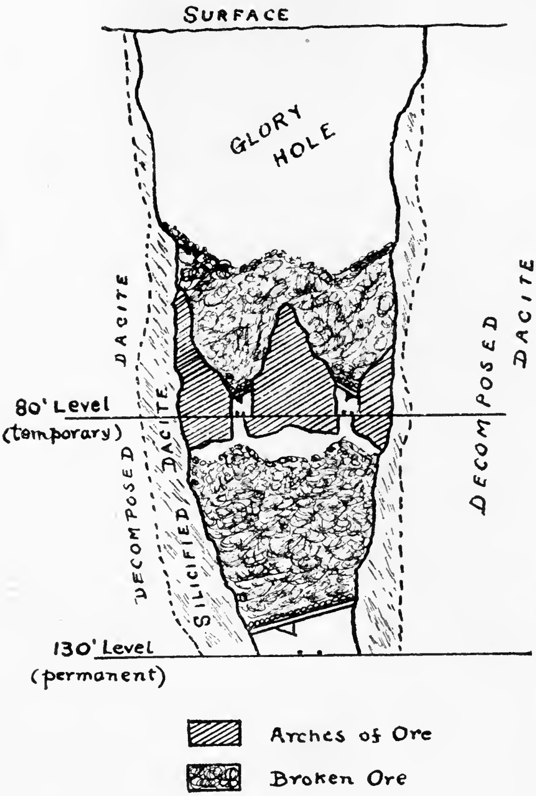
"When the rock has been broken to the required size, it is drawn off, through the raises and chutes described above, into cars. These cars are hauled to the station ore-bins by horses, or by endless-rope haulage, where they are dumped. The ore is then loaded into skips, hoisted to the surface, and handled in the usual manner."

Three other localities in which similar operations are carried on, may be mentioned, namely: the Homestake Mines, South Dakota, the Combination Mine, Nevada, and the Mercur Mines, Utah.

Supplementary Mining Methods. — Aside from the location, development and extraction of ore-bodies there are still other operations essential to the proper carrying out of a complete scheme of mining, and without which it is often found impossible to begin operations. The operations referred to are mine timbering or support, drainage and ventilation. In special cases all three of these operations must be more or less completely developed, while the other extreme would be the occurrence of conditions not necessitating the employment of any one of the three operations, as when the deposit requires for its exploitation neither support, drainage, nor ventilation.

The uncertainty of existing underground conditions is such as not to admit of speculation regarding the same unless based upon geological data and better still upon facts collected from a careful examination and study of mines in the same locality.

It is not our intention to enter into an exhaustive description of the operations, nor does the scope of this work warrant it; but, rather, brief descriptions of the work as carried on under ordinary conditions are given, which are supplemented by occasional specific applications.



Glory Hole Mining at the Combination Mine, Nevada.
(From Mining and Scientific Press.)

Mine Support. — *Kinds of Timber.* — Timber well adapted to use underground is somewhat scarce in the United States. On the Pacific coast oak is probably the best to be had although a number of cone-bearing or coniferous trees are widely used, and when these are not available cottonwood, ironwood, juniper and yuccas are resorted to. The rule usually followed in the choice of mine timber is, *use the cheapest* which is usually that most readily obtained.

Of the thirty six varieties of coniferous trees on the Pacific coast the most important are: The Oregon pine, spruce, yellow pine, tamarack, sugar pine, pinion pine (bull pine), besides several varieties of fir and redwood.

In Washington and Oregon the Oregon pine is extensively used for both mine and surface work and is known in different localities by various names, such as, Douglas fir, Douglas spruce, yellow fir or red fir, while in the parlance of the lumbermen it is known as Oregon pine and Puget Sound pine.

Yellow pine although of no great durability or strength is widely used.

Sawed timber is largely used especially when close work and tight or well fitting joints are desired; it is inferior to either hewn or split timber as it is more liable to split. However, for close work as in shaft-timbering squared-timber is necessary and as hewn timber is more expensive than sawed the latter is usually preferred. Cypress and Oregon pine are largely employed in lining shafts.

Among the more important considerations involved in the choice of mine timber, that of endurance or life stands first, being even more important than the cost — the expense of removing and renewing timbers is often greater than the original cost. The life of timber depends largely on its condition before and after being placed in the mine; seasoned timber will last one-half or as long again as green material, while timber with the bark on is not in the condition to resist decay. Bark holds moisture, favors the growth of fungi and is unfavorable for examination and inspection.

Moisture and heat are especially unfavorable to longevity of timbers, decay being especially accentuated when the former condition fluctuates between mere dampness and saturation.

Timber composed of alternating rings of growth of hard and soft material constitutes one of the poorest forms for mine support as the soft and spongy growth readily absorbs and holds the moisture. Such timber when used should be given only temporary duty, as when filling is employed, thus relieving it of strain in a comparatively short time.

Timber grown on southern exposures is claimed to be superior to that from northern exposures for the reason that variations in moisture cause varying rates of growth; the more rapid the growth the less firm the fibre. Further, timber cut when the sap is not flowing is preferable to that cut during the flowing season; therefore mine timber should be cut in the winter rather than the spring.

If the quantity of seasoned timber is limited it should be employed in those portions of the mine where the work of removal and repair would interfere most with the mine operations — it should then be used for the support of shafts, stations, drifts and, in fact, all permanent openings.[1]

Fir is quite strong, as is pine also, the softer woods having the advantage over the harder forms in that they crush more readily, thus taking up the load more uniformly. For this reason the soft woods are largely used for wedges.

Timbering.— *Posts, Stulls, Sets and Square-Sets.* Under this head the following forms of mine timbering are discussed; posts or props; stulls; sets and square-sets.

Posts are timbers, round or square, which are set normal to the roof and floor of the workings and have their widest range of usefulness in flat or slightly inclined deposits and are therefore especially applicable to bedded deposits. Occasionally posts are provided with caps, i.e., short lengths of plank placed between the ends of the posts and the roof and floor, thus enlarging the bearing surface of the support. Posts are often used in combination with other forms and arrangements of timbers and form the principal element in mine timbering.

Stulls are posts applied to inclined deposits and are universally employed in mining narrow veins, even up to 20 feet, and for inclinations up to 90 degrees, or the vertical. The application of the stull is, however, somewhat different than that of the post owing to conditions brought about by change in pitch of deposit. The stull like the post often has a cap used with it, but it is placed at the upper end only, the lower end being placed in a notch or " hitch " cut into the lower or foot-wall of the vein. The object of the hitch is to prevent the timber from slipping from its place. Further, stulls are not set normal to the walls but in such a position that their deviation from the normal, called " angle of underlie " is about one-fourth that of the angle of dip of the deposits, thus:[2]

Dip of Vein.	Angle of Underlie of Stull.	Dip of Vein.	Angle of Underlie of Stull.
10°	2½°	40°	10°
20	5	50	12½
30	7½	60	15

[1] Min. and Sci. Press, Vol. 90, p. 240.
[2] Mine Timbering, p. 43, 1907.

The reason for so setting the stull is that if normal to the walls a slight movement, especially of the hanging-wall, would cause the stull to become loose and fall, while if placed at an angle any downward movement of the hanging-wall serves only to set more firmly the stull in its place.

Conditions often occur such as weak foot-walls, excessive weight of hanging-wall and great width of vein necessitating the employment of secondary timbers to hold in place and supplement the original stulls, which must be maintained in position as they form the basis for the levels in the stopes. For a detailed description of the various forms of stulls the reader is referred to Mine Timbering.[1]

Extreme conditions in the use of props and stulls occur in the Elkhorn mine, Montana. As a rule the roof is solid and requires upright timbers only for support, but with increase in size of excavations, as is often the case as when the ore-bodies of the foot-wall come in contact with the quartz hanging-wall, the problem of support becomes more serious and the original timbers must be supplemented by others. It is not infrequently the case that the supporting timbers stand so close together that there is hardly room for a person to pass.[2]

Occasionally large stopes have crib-works of timber filled with waste placed in the center and carried upward with the timbering. These cribs vary from 10 to 20 feet square and aid materially in steadying the timbering in the stopes.[3]

Sets not otherwise specified are forms of timbering employed in supporting the roof and walls of passages cut in the rock or ore. The simplest form of set consists of a horizontal timber supported at either end by a post, which may stand vertically or be slightly inclined outward at the foot, the lower ends or feet of the posts standing on the bottom of the passage or drift. The roof is then supported by the cap which in turn is held in place by the two posts. When a number of sets are employed and the roof is weak it is customary to place on the caps, planks and other light timbers called lagging, extending longitudinally in the drift. If the walls are also weak the lagging may be extended to the sides of the sets, thus forming a passage enclosed on three sides by timbers. When the floor is weak and the wall pressure is considerable,

[1] Mine Timbering, pp. 44 and 45.
[2] U. S. G. S., 22 Ann. Rept., Pt. 2, pp. 474, 476.
[3] Min. and Sci. Press, Vol. 85, p. 369.

Chamber in 1,250-Foot Stope, Elkhorn Mine.
(From Mines and Minerals.)

timbers are placed on the floor, called sills, upon the upper sides of the ends of which the feet of the posts are placed. A portion of the still is cut away at each end forming shoulders against which the feet of the posts rest, thus spacing them. When conditions permit, one end of the cap may be set into one of the walls next to the roof, the other end being supported by a prop.

Sets may then consist of two, three or four members which forms are usually spoken of as two-piece, three-piece and four-piece sets or one-half, three-quarters, and full sets. The use of poles or spiles with sets constituting the so-called fore-poling method employed in drifting in soft or loose ground is not considered in this connection.

Square-sets were first employed in the United States, in the working of large ore-bodies as the bonanzas of the Comstock lode, but in later years their use has been extended to practically all forms of mining, nor is it confined to the working of any particular metal. It has had extensive use in the Homestake mines, South Dakota, in the lead-silver mines of the Coeur d'Alêne region, Idaho, and in the mines of the Cripple Creek district, Colorado, etc., etc.

The usual practice is to begin at the bottom of a stope and lay long sill timbers which are regularly spaced by other timbers, thus covering the floor of the open stope with a system of timbers arranged in squares. Upon these timbers are erected other timbers which consist of posts, caps and girts. The posts are placed upright at the intersection of the sills and cross-pieces, and upon the posts are placed caps, the ends of which rest on two adjacent posts in a direction transverse with the vein. The girts also rest upon the posts but run longitudinally with the vein. The caps and girts when placed form a new level or floor and by successive additions of posts, caps and girts the timbering can be kept within easy reach of the walls above. In like manner by adding to the sills the sets can be extended indefinitely in any direction, thus providing a staging for the miner to stand upon and, by bracing to the walls, support can be provided for any portion of the roof or sides of the stope. The stopes are thus filled with a cellular mass of timbering perfectly matched together and symmetrical in all directions.

When the ground is especially heavy diagonal braces are placed in the sets, and in line with the greatest pressure.

The length of the posts varies largely with the locality, but as a rule the first set of posts, and in fact the post at any level where hauling in cars is done, is sufficient to permit the passage of men without stooping. Other sets of posts may have the same length as the caps, thus forming actual square-sets. However, the posts may all be of the same length, giving a clear space between timbers of 6 to 7 feet, while the usual length of cap is 5 feet. The girts may be of the same length as the caps or less, never more — 4 feet 6 inches being common.

A drift may be the starting point of square-set timbering which is extended laterally and vertically therefrom.

Square-set timbers may be rough and round or sawed with a square cross-section, the latter is preferable owing to convenience in handling and forming the joints. Methods of framing are too elaborate to give in detail here, the reader being referred to Mine Timbering.[1]

As has been previously stated square-sets were first employed in the mines of the Comstock lode and probably received there their severest tests as a desirable form of mine support. Before this method of joining timbers was devised so as to give great strength with a comparatively small amount of timber used, an unsuccessful attempt was made to splice * the large timber props; then a filling of timber was employed, which occupied fully two-thirds of the stopes, and served quite effectively in preventing a collapse of the walls. This timber filling was called corduroy, which in many instances was compressed into a solid mass by the caving in of the walls. Twelve-inch timbers were in this manner reduced to 7 inches and even less and following this shrinkage there were more cave-ins, which ultimately reached the surface.

Stopes in the old bonanza mines were of enormous size, which in one case extended from the 1200 to 1950-foot levels, having a length along the vein of 1300 feet and a width of from 10 to 200 feet. Such

[1] Mine Timbering, pp. 50–52, 1907.

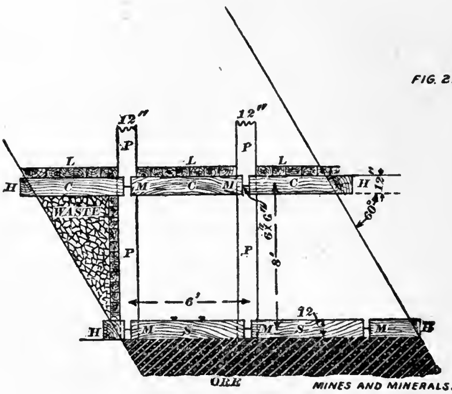
* " At the 50-foot level (of the Ophir mine) the vein of black sulphurets was only 3 or 4 feet thick, and could readily be extracted through a drift along its line, propping up the walls and roof, when necessary, by simple uprights and caps. As the ledge descended, the sulphuret vein grew broader, until at a depth of 175 feet it was 65 feet in width, and the miners were at a loss how to proceed, for the ore was so soft and crumbling that pillars could not be left to support the roof. They spliced timber together to hold up the caving ground, but these jointed props were too weak and illy supported to stand the pressure upon them, and were constantly broken and thrown out of place.

The dilemma was a curious one. Surrounded by riches, they were unable to carry them off.

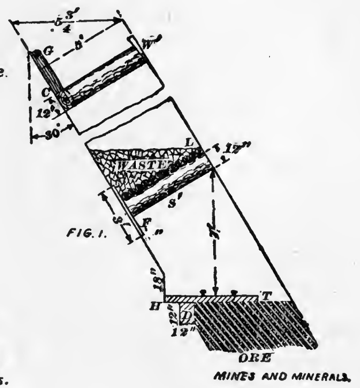
The company was at a loss what to do, but finally secured the services of Philip Deidesheimer, of Georgetown, California, who visited and inspected the treasure-lined stopes of the Ophir."

stopes were filled with square-sets, and in many cases also filled with waste, thus preventing the buckling of the timber frames.

These timbered stopes almost invariably caught fire, smouldering for years, and at intervals getting a draft of air from fresh caves would burst out into a terrible blaze, which would continue until smothered by subsequent falls of ground. The gases generated from this more or less incomplete combustion, were of the deadliest character, and were, therefore, carefully guarded against and confined by bulk-heads and stoppings of timber and earth often 60 feet or more in thickness.



Square-Set Timbering.



Stull Timbering.

The value of the ore was such, often being worth $126 per ton, that the operators were willing to go to almost any expense to permit its complete extraction. It is claimed that for every dollar taken from the Comstock mines, a foot of timber was put in; i.e., the mines yielded $120,000,000 and there were 120,000,000 feet of timber used in them at a cost of 2 cents a foot.[1]

The providing of wood for fuel and timber suitable for mine support was one of the most difficult problems that the operators of the Comstock mines had to solve, but was accomplished by the same indomitable spirit and enterprise as was exhibited in all phases of the work. The timber of the mountain above the mines, although excellent for fuel, was wholly unfit for mine work. However, it was soon exhausted, and attention was turned to the eastern slope of the Sierra Nevada, while as late as 1891 both lumber and wood for these mines came from the Lake Tahoe basin, on the California side.

In transit from the forest to the mines the timber was handled as many as

[1] Min. and Sci. Press. Vol. 48, p. 258, Ibid., Vol. 70, p. 172.

thirteen times, but so carefully had the system been worked out that it operated with mechanical regularity and precision.

From the mountain summit the logs were run through 14 miles of V-flume to the valley below. The flume carried logs of from 16 to 20 inches in diameter with ease, and bridged over that portion of the mountain which was inaccessible to every other known method of conveyance. The flume was extended both north and south along the summit of the mountains, and through it as much as 500,000 feet of timber and 750 cords of wood were delivered daily to Carson City. The Virginia and Truckee railway hauled a large part of the timber from Carson City to the mines.

It was estimated that in 1895 fully 120,000 acres of the choicest forest of the Sierras about Lake Tahoe, and 75,000 acres at the headwaters of the Carson River, had been carried to the mines. The region denuded represents an area of 305 square miles, and there is little wonder that the Comstock lode has been called "The Tomb of the Sierras." Min. and Sci. Press, Vol. 35, p. 182; Ibid., Vol. 70, p. 172.

The size of the mine timbers ranged from 16 to 24 inches in diameter and as many feet long. Cribbing was made of eight-inch round timbers. Yellow pine, fir and cedar were used, and in the proportion of two-thirds pine, one-third fir and less than 1 per cent cedar.

It is claimed that the heat and vapors of the mine had a preservative effect upon the timbers.[1]

The California Company first introduced square-sets into the Homestake mines which served as a check to the caving ground, thus lessening the losses and dangers incident thereto. However, square-setting when used alone, was found to have its limitations, and would support the stopes only when they were excavated rapidly, and often only small sections could be so worked. Subsequently, rock-filling was employed in conjunction with the square-sets, and has proven quite successful.

The timbering was done by expert Comstock timbermen and as the stopes were usually large, often being 100 to 150 feet long, 100 feet wide and 64 to 80 feet high, large timbers were necessary. The timbers usually put into the stopes ranged from 12 to 24 inches square.

Owing to placing too much faith in square-sets, disastrous caves have occurred in the Highland, De Smet, Golden Terra, and Caledonia mines, but warning of coming caves was always given by the yielding timbers.[2]

The economical limit in height to which square-sets can be used in the Homestake mines is 80 to 90 feet, beyond which the timbers crush under their own weight.[3]

[1] Min. and Sci. Press, Vol. 70, p. 172.

[2] Min. and Sci. Press, Vol. 90, p. 392.

[3] Ibid., Vol. 88, p. 177.

It is not the depth with the consequent increase in pressure so much as the strength and firmness of the foot- and hanging-walls that determines the safety of square-setting. This was demonstrated in

Square-Sets, Gold Coin Mine, Cripple Creek, Colorado.

the mines of the Comstock lode, where the support of the upper working was often fully as difficult as in other localities at greater depths.

The reader is referred to the following articles for descriptions of standard tunnel and stope-sets.[1]

DESCRIPTION OF TIMBERING (STULLS AND SQUARE-SETS) REFERENCE.

Homestake Mine, South Dakota.	Sets have 6′ centers and are 7¼′ high. Timbers are 12″ × 12″ in section. Number of feet B.M. in a set exclusive of sills, sprags and blocking, 275, or 14 feet per ton of ore extracted. First cost of timber 14 cents and when placed 25 cents per ton.	Min. and Sci. Press, Vol. 91, p. 4.
Utica Mine, California.	Stope-sets 8 feet, posts 12″ to 26″ in diameter, spreaders 6″ and brace-sprags 12″.	T. A. I. M. E., California Mines and Minerals, p. 106, 1899.

[1] Colliery Engineer and Metal-Miner, Vol. 16, pp. 100, 101, 102, 123, and 124, T. A. I. M. E., California Mines and Minerals, p. 106, 1899; Min. and Sci. Press, Vol. 85, p. 187; Ibid., Vol. 62, p. 377; U. S. G. S., Monograph 7, p. 153, and Min. and Sci. Press, Vol. 58, p. 181.

DESCRIPTION OF TIMBERING.—*Continued.*

Richmond and Eureka mines, Eureka, Nevada.	Posts 6′ between shoulders. Caps and ties 5′ and 4′ respectively. Timber Sierra Nevada pine, hewn to 12″ × 12″ or 10″ × 12″ or 10″ × 10″. Ties at the Richmond are 10″ × 10″ or 10″ × 12″. At the Eureka, 12″ × 12″ or 10″ × 12″, but 10″ × 10″ timbers are used when possible, although 12″ × 12″ caps and posts are preferred. The tenon of the Richmond post is 9″ × 6″ × 1⅛″; of the tie, 9½″ × 6″ × 1⅛″; the cap, 9″ × 7¼″ × 3″. Of the Eureka mine, post, 8″ × 8″ × 2″; cap 6″ × 8″ × 4″; tie, 12″ × 8″ × 2″.	U. S. G. S., Monograph No. 7, pp. 156–157.
The Coeur d'Alêne District, Idaho.	There are two forms of sets: square and stull. In the Standard mine the square-sets are 9′ × 5′ × 6′. Stull-sets are mere caps extending from wall to wall of the stope and are supported by two posts. Wherever the vein is over 15′ wide the cap of a stull-set is made of two pieces, being supported on a third post. In the Mammoth mine the stull-sets have 6′ posts.	T. A. I. M. E., Vol. 33, pp. 252, 255.
Camp Bird Mine, Ouray, Colorado.	Inclined chutes and raises, winzes, mill-holes and stope floors are practically the only portions of the mine workings that are timbered. Usually stulls with 5-foot centers are used.	T. A. I. M. E., Vol. 33, p. 524.
Maxwell Gold Mining Co., Blue Mt., Oregon.	Sets of stulls put in levels 6′ apart in wide veins 10′. Inside measurements of sets 4′ to 6′ in the clear. Timbers for sets and stulls 6″ to 12″ in diameter. Cost 2 cents per foot.	Mines and Minerals, Vol. 19, pp. 14, 15.
Horn Silver Mine, Utah.	Posts of square sets — 10″ × 10″ × 6′ 6″, which join with tenons 2″ × 6″ × 6″, leaving a shoulder 2″ wide. Ties are 8″ × 10″ × 4′ 2″. Plan of set 4′ one way and 5′ the other.	Mines and Minerals, Vol. 19, p. 425.
Rossland, British Columbia.	Sill timbers 10″ × 10″ × 16′. Height of set 9′, length of caps 5′ 4″, girts 4′ 4″, posts 8′ 2″. Each set occupies the space of 24 tons of ore or 240 cubic feet. Size of timbers 12″ to 20″, round. Cost of framing per set .553 cents, or 17 cents per ton. Tie-sill 4′ 4″ long.	Eng. and Min. Jour. Vol. 74, pp. 584–585.
Little Johnny Mine, Leadville, Colorado.	All timbers 10″ except ties. Set is 4′ 4″, cap-way, × 4′ 10″ × 6′10″ centers, and 3′6″, 4′ and 6′ in the clear. Posts are 6′ 4″ long, with 6″ × 6″ × 2″ tenons. Ties are plain 6″ × 10″ timbers 4′ 4″ long. Caps are 4′4″ long, with 6″ × 6″ × 3″ tenions. Sets are also used in drifts.	Colliery Engineer and Metal Miner, Vol. 16, p. 125.

DESCRIPTION OF TIMBERING.—*Continued.*

El Paso Mine, Leadville, Colorado.	Timbers are 10″ except ties. Set has 5′4″ × 5′ 4″×7′ 4″ centers and is 4′ 6″×4′ 6″×6′ 6″ in the clear. Posts are 6′ 8″ long, with 8″ × 8″ × 1″ tenons. Caps are 5′4″ long, with 8″ × 8″ × 4″ tenons. Ties are plain, 8″ × 10″ × 4′8″ long.	Colliery Engineer and Metal Miner, Vol. 16, p. 125.
Bingham, Utah.	Sills framed from 6″ × 10″ timber, cut 5′ long, dapered 1″ on each end and gained to receive end of post. Posts are 9″ × 9″ or 10″ × 10″ square and 6′ 8″ long, with tenons 1″ × 6″ × 7.5″. Caps are 10″ × 10″ square and 4′ 4½″ long.	Eng. and Min. Jour., Vol. 78, p. 300.
Comstock Mines, Nevada.	Sets 4′ to 5′ square, height 7′ to 8′. Timbers made of 12″ material, square-hewn or sawed. In the Savage mine the posts are 7′ 2″ over all, the tenons are 8″ × 8″ or 8″ × 10″ being 9″ long on upper end of post and 2″ on lower end. Caps and sills have ½-inch shoulders cut to fit posts. Sills and caps are 3′ 9″ in the clear, with short tenons on each end to receive the posts and girts or ties.	Mining Industry, Hague, 1870, pp. 112, 113.

The Timbering of Shafts. — Timbering for both vertical and inclined shafts varies considerably from that employed in drifts and slopes, although the forms of timbers used are not unlike in inclined shafts and slopes. For vertical shafts when the pressure of the walls comes on the two opposite sides of a shaft of large dimensions the full- or four-piece set is used, but is rectangular in form, the cap and sill being identical in all respects, as are the posts. The former are called wall-plates, while the latter are end-pieces.[1] When the pressure of the walls is practically uniform from all sides, the corners of the supporting frames are joined by notches, the cutting of which is proportioned to the amount and direction of the pressure. In this case a square-set system of timbering is commonly employed, which does not differ materially from that employed in stopes. However, the members known as posts, caps and girts or ties are here known as studdles, wall-plates and end-pieces.

The "horn-set" system of framing shaft timbering is well illustrated in the Utica mine of Angels, California, being one of a number of forms of joining the wall-plates and end-pieces previously referred to.[2]

[1] T. A. I. M. E., California Mines and Minerals, p. 102.
[2] T. A. I. M. E., California Mines and Minerals, pp. 100, and 101, 1899.

The following references are given to assist those interested in looking further into the subject of shaft timbering.[1]

The question of mine support has been tersely stated by Professor W. F. Blake,[2] who says: "This extensive caving and crushing is another example out of many of the futility of attempting to hold up a mountain with timbers. Even on the Comstock lode, at Virginia City, within sight almost of the superb pine forests of the Sierra Nevadas, the transfer of large portions of those forests to the interior of the mines in the shape of square sets, framed and set with geometrical precision, served only the temporary purpose of checking incipient caving of the walls and securing the safety of the miners for a time. But when heavy splitting off from the walls began, with crowding at one side or the other, the beautiful symmetry of the square set structure was impaired and the posts were thrown out of plumb. The structure had more the nature of a trap than a secure shield.

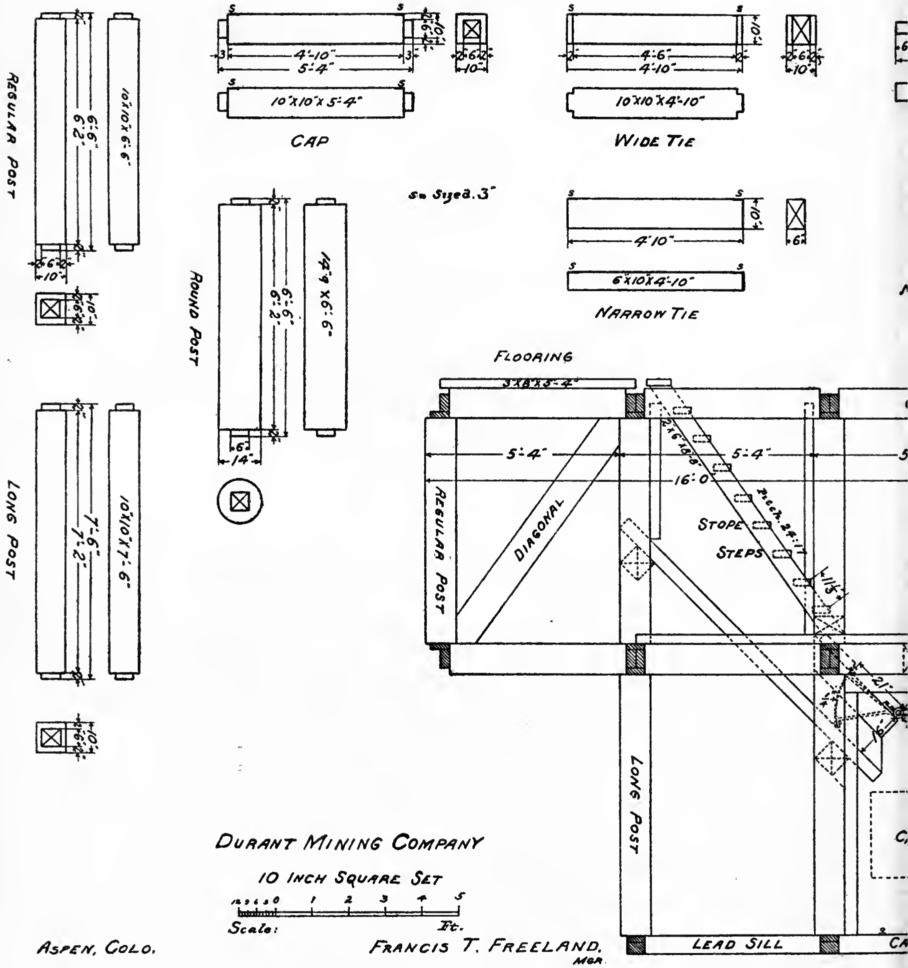
"So it was at the Emma, in Utah; at the Silver King and at the United Verde in Arizona, and ever will be in mines where there are large stoped spaces, with walls liable to split off and fall in. It is only a question of a few months or years in most cases, when a collapse must come, and generally with fatal suddenness, and great loss of property and life.

"How, then, shall we work such deposits? This is a question confronting the mining engineer, and requiring his best efforts for its solution. It is not a new problem, and each case has its peculiar conditions, so that no fixed rule or method can be insisted upon. There is, however, one general plan which may be adopted. If the walls are unstable and unsafe, caving should be regarded as advantageous. Let the ground cave in and follow the extraction. Do not try to build it up; remove the ore below the wreckage, in such a way that this wreckage shall follow slowly but surely, and fill the spaces from which the ore has been removed. Attack the unbroken ore in such a way as to remove it in blocks or slices of convenient width, as in the long-wall system of mining coal. Or drifts may be run at right angles just under the wreckage, so as to block out regular squares, one after the other being removed.

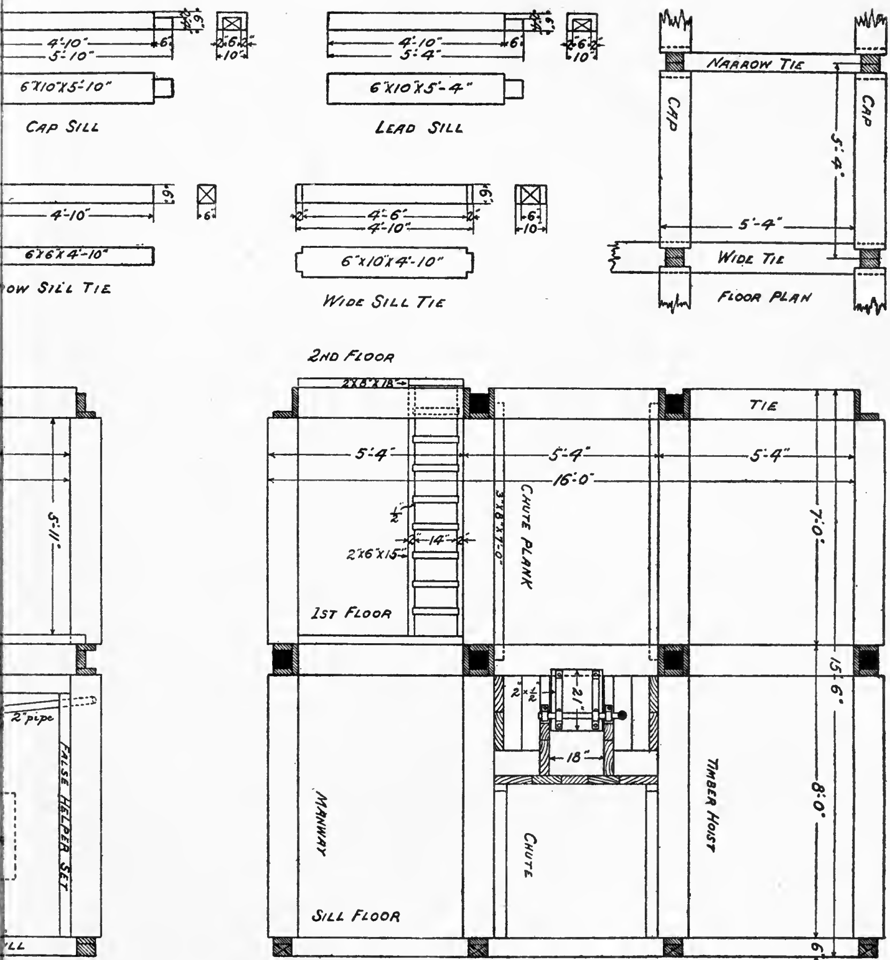
"Access may be had by side drifts or galleries in the firm ground. The stopes may be carried across the lode or parallel with the walls.

[1] Eng. and Min. Jour., Vol. 77, p. 396–398; Colliery Engineer and Metal Miner, Vol. 16, p. 123, and Mine Timbering, pp. 16–31, and 108.

[2] Eng. and Min. Jour., Vol. 73, p. 611.



Ten-Inch Square-Set at Durant Mine, Aspe



Colorado. (From Mines and Minerals.)

The removal of a small area of the solid lode does not precipitate a run or sudden cave. Usually the movement of the loose débris is gradual, and gives time for the removal of broken ore. If there are deads and waste these can be piled back, as in drift mining in gold gravel placers. This method of stoping out the ore in slices may be varied as regards the breadth of the slice and its height, according to the conditions. If the débris stands up well and does not crowd the miners, a broad opening can be made.

"Temporary protection from the falling of small fragments can be secured by a line of timbers or supports, covered by planks or steel plates, all of which may be withdrawn and moved forward as the extraction proceeds. Timbers or steel supports may be made tapering, so as to be easily withdrawn from the débris of rocks and timbers. Any timbers lost in the caving tend to form a mat or network, which is a protection against the rapid and sudden fall of earth and stones.

"The plan of filling in old stopes by loose waste or earth, stones or broken rock has the disadvantage that such stuff runs too freely, and cannot be subsequently underrun with the same security as a mass of coarse rock and timber wreckage, which moves slowly downward."

Drainage. — The cost of the drainage of mines constitutes one of the largest items of expense in their operation. Therefore every possible precaution should be taken to keep surface waters from entering the mines and to intercept and remove that occurring in the upper levels and thus prevent it passing downward to the bottom of the mine. The drainage of mines then resolves itself into excluding surface waters, intercepting the waters of the upper workings and ejecting by various means any and all water from the mines.

The occurrence of water in mines is exceedingly variable, often being confined to the superficial portions of the deposit as one extreme and the deepest workings as the other extreme, while in many cases water is encountered throughout the workings. However, it may be stated as a general rule that the quantity of water increases more or less in direct proportion to the depth attained, and calculations for its disposal are based upon such observed facts, unless definite information to the contrary is known.

The deep-seated waters are probably of the most importance as affecting the workings and when encountered in considerable quantities their expulsion from deep mines involves a large outlay of money in first cost and maintenance.

The means employed in freeing mines from water may be grouped under two heads, namely, the gravity and power systems. Both of these systems are as old as mining itself and are new only in the extent and ingenuity of their application. When the position of the ore-bodies is such that they can be reached and worked to advantage by drifts and tunnels, that portion of the workings lying above the level of the tunnel can be drained by gravity. Such openings when employed partially or exclusively for drainage purposes are properly known as adits or adit-levels, but are commonly miscalled drifts and tunnels in the United States, which misuse of the name probably results from the double use to which they are put, being employed both for haulage and drainage. When, however, the mine workings extend below the adit-level some other means of removing the water must be resorted to, to supplement the adit drainage. When adits are not available the power system must be employed, which has so many forms of application that a complete discussion is out of the question here and only a few typical forms are given.

Pumps are almost universally employed in freeing mines from water, being used wholly or in part. The common practice in the use of pumps consists in installing a large pump, at or near the bottom of a mine, the suction of which extends to and enters the main well or sump at the foot of the shaft. Waters collected in this sump from the lower levels of the mine are raised and discharged at the surface or into another sump located in an upper level. The upper or level-sump is a large reservoir cut in the floor of a level into which all water from the upper portion of the mine is caught and raised to the surface by a pump placed at that level. Often as many as three and four pumps are installed at various levels in order to save the expense of pumping, which may be considered as dead-work, as little or no advantage results from the work done other than ridding the mine of water

Pumps are driven by water, electricity, steam and air, which is employed depending largely upon its cheapness and availability. Water is, however, seldom used in driving pumps in the mines of the United States. Electricity is being extensively used in various localities and is rapidly growing in favor. Steam and air are widely employed as the motive power of pumps, the latter being preferred as the escaping air serves both to ventilate the workings and reduce the temperature, which are often important considerations. Further, air is employed to a limited extent in the so-called air-lift pumps, which have not, however, received much attention in this country.

Water-lift or jet pumps, although only occasionally used in the mines of the United States, have proven their efficiency and adaptability under most severe and extreme conditions.

To illustrate the manner in which the drainage of mines has been effected by the means outlined above, a few specific cases are given, which although peculiar and possibly extreme in character are interesting and instructive.

The drainage of the Comstock mines presented one of the most difficult problems that mining engineers have been called upon to solve, owing to the large volume of water that had to be handled and raised to the surface from great depths (which was still further complicated by the excessive heat encountered in the mines, especially in the lower levels). In 1879 the mines were raising approximately five million tons per year (a large amount for that time), to which should be added the immense but unknown quantity expelled in the form of vapor which was continuously given off by the heated water and wet walls and rose from the shafts to a height of 40 feet or more in dense clouds. The great lateral extent of the working, which in 1879 aggregated 200 miles in length and was increased by the amount of 12 miles yearly, together with depth and an abundant rainfall, was responsible for the apparently unlimited amount of water that entered the mines.[1]

The mines of the Comstock were flooded by the tapping of an immense pocket or reservoir of water by a drift at a point some 350 feet above the bottom of the Yellow Jacket shaft. This occurred on February 13, 1882, when a connecting passage was being driven on the 2700 foot-level from the Yellow Jacket to the Exchequer mine, and owing to the difference in level between the two workings, there was a tremendous flow of water from the latter into the former. All operations excepting pumping were at once suspended, and although pumping and bailing were energetically carried on for many days, the water steadily gained on them, eventually raising to the source of the supply, which was the 2700 foot-level of the Exchequer. The mines of the south end of the lode or the Gold Hill end were then flooded and abandoned, except for pumping, which was continued with the hope of ultimately exhausting the subterranean reservoirs of the Exchequer. On March 28, the water-level had been lowered to a point 950 feet above the 3000-foot

[1] Eng. and Min. Jour., Vol. 28, p. 36.

level of the Yellow Jacket shaft. However, as no arrangement whereby the expense of pumping could be distributed among the several companies affected, the Yellow Jacket Company stopped pumping * and abandoned the lower levels of their mine to the water. Thus it came about that the whole line of south-end mines had their operations limited to the level of the Sutro tunnel, which condition of affairs continued until 1898. It is needless to state that had proper precautions been taken by the Exchequer operators this great waste in time and effort might readily have been obviated.[1]

Prior to the flooding and abandonment of the lower levels of a number of the Comstock mines, the Sutro tunnel was projected to handle the water encountered. When this tunnel reached and made connection with the mine workings the water-level was lowered 100 feet during a period of 8 hours, thus conclusively demonstrating the success of the undertaking.[2]

An attempt was made to keep the water-level of the mines of the north end of the lode at the 3300-foot level by means of Cornish and hydraulic pumps, but owing to the great expense involved the mines were allowed to fill up to the 1600-foot level. The installation in 1899 of a large hydraulic jet or lift in the C. and C. shaft marked another epoch in the operation of these mines and was a bold and hazardous undertaking, only warranted by the magnitude of the work and future possibilities of the mines. By this system the water-level of the north end mines was maintained at a point 2150

[1] Min. and Sci. Press., Vol. 76, p. 155.

[2] Min. and Sci. Press, Vol. 39, p. 9.

* The pump of the Yellow Jacket mine may be described briefly as follows: The foundations of the pumping engines and walking-beam were 35 feet high, in and extending through which were 4-inch anchor-bolts. The engine was a duplex cross-compound, condensing form, the cylinders being water-jacketed. The high and low pressure cylinders were 32 and 64 inches in diameter, with a 12-foot stroke. Being cross-compounded the cylinders stood side by side, the pistons of which were connected by a cross-head. In order to equalize the movement of the engine the ends of the cross-head were connected with two large fly-wheels 30 feet in diameter, and of 36 tons weight each. The walking beam consisted of a single stick of timber, 38 by 48 inches in section by 42 feet long. It was claimed that this was the largest piece of timber ever brought to Comstock mines, and came from Oregon. It weighed 12 tons. The other timbers were proportionate in size to the walking-beam. The stroke of the pump was 10 feet, the water being lifted by a rod 16 by 16 inches, and put together in sections of 60 feet in length. The column pipe was 14 inches inside diameter. Min. and Sci. Press, Vol. 36, p. 6.

feet below the Sutro tunnel. Encouraged by the success attained, the work of still further lowering the water-level was begun. For which purpose three Reidler pumps were installed which are electrically driven, each having a 200-horsepower induction motor. These pumps receive the water from the 2150-foot level and deliver it to the Sutro tunnel. A volume of 4500 gallons per minute is thus discharged into the tunnel under a head of 430 feet. The hydraulic pumps serve as sinking pumps raising the water from below and discharging it into the sump from which the Reidler pumps draw their supply.

With an expenditure of less than $100,000 the hydraulic jet-lift system was discharging more water into the drainage tunnel than had ever been handled by the $5,000,000 equipment of former years.[1]

In the mines of the Comstock lode there has then been exemplified as extensive and varied practice as can be found in any other mining region in the world, for which reason it has been given in considerable detail. However, the practice in the Cripple Creek district, Colorado, illustrates remarkably well the use of tunnel-drainage in precious metal mining — the existing conditions and practice there are briefly given. Extracts from the paper[2] on the Geology and Gold Deposits of the Cripple Creek District, by Messrs. Lindgren and Ransome, are given: "Although the annual precipitation at Cripple Creek is not heavy and the conditions for rapid-run off are unusually favorable, standing water was originally encountered in the mines at moderate depths. At the beginning of mining operations the underground water surface stood at an elevation of about 9,500 feet in the western part of the district and, on an average, fully 100 feet higher in the eastern part. Several mines began pumping about the year 1895, but it was soon found that this mode of lowering the water was slow and costly. Attention was directed to tunneling, and the Ophelia tunnel was driven into Gold Hill at an elevation of 9,268 feet. This tunnel drained the western part of the district until 1898, when the Standard tunnel, over 200 feet lower, tapped the phonolite of Beacon Hill and became the chief effluent. Finally the El Paso tunnel, with its portal at an elevation of 8,783 feet, was driven under Beacon Hill in 1903 and has since been the main drainage outlet of the district. Prior to January 1, 1905, this

[1] Min. and Sci. Press, Vol. 90, p. 73, and Ibid., Vol. 78, p. 373.

[2] Geology and Ore Deposits of the Cripple Creek District, Colorado, U. S. G. S., Professional Paper, No. 54, p. 9, 1906.

tunnel is estimated to have discharged about 3,550,000,000 gallons or nearly 15,000,000 tons of water.

"The records of the pumping operations and tunnel projects show that the underground water is for the most part held within open fissures and cavities in the rocks of the volcanic neck. It is stored water, inclosed by the relatively impervious rim of granite and schistose rocks that form the general Cripple Creek plateau, and has been supplied by the rain and snow that fell upon the surface of the plateau.

"Drainage and pumping have both shown that the underground water does not flow freely through the rocks in all directions. Neighboring mines in some cases show marked differences in water level, and the drainage tunnels on the west side of the district have but slightly benefited the mines on the east side. The behavior of the water shows that the unfissured breccia is practically almost impervious and that artificial drainage affects only those parts of the district that are connected by fissures with the tunnel or shaft whence the water is drawn off."[1]

The new drainage tunnel projected and begun by the mine owners of Cripple Creek will cost approximately $800,000 and is expected to drain the whole productive area in the district. It will have a length of 27,140 feet, having as a starting point the bed of Cripple Creek some 3 miles below the El Paso shaft. From its mouth or portal its course will be northeast to the El Paso shaft, a distance of 14,000 feet, thence continuing in a direction slightly north of east to the Vindicator property, some 12,640 feet. Its approximate depth at the El Paso, Elkton, Portland and Vindicator mines will be 1325, 1680, 2000, and 2125 feet. The cost will be borne by the owners of the principal properties drained.[2]

Data regarding the drainage tunnels of Cripple Creek are given in the table on following page:[3]

The great advantage accruing from the organization of the owners of mines in a district into associations for the purpose of draining the properties of a district has been well illustrated by the work done in various localities.[4] The following statement regarding the

[1] Geology and Gold Deposits of the Cripple Creek District, Colorado, U. S. G. S., Professional Paper, No. 54, pp. 9 and 10, 1906.

[2] Mineral Industry, 1904, pp. 173–174.

[3] Geology and Gold Deposit of the Cripple Creek District, Colorado, U. S. G. S., Professional Paper, No. 54, p. 235, 1906.

[4] Mines and Minerals, Vol. 27, p. 219, and Am. Min. Congress, Denver, Colo., Oct., 1906.

operations of such an organization in the Leadville basin may serve as an example.[1]

Tunnel.	Date of beginning Work.	Elevation (in Feet).	Length (in Feet).	Discharge (in Gallons per Minute).	Remarks.
Blue Bell....	Prior to 1894.	9,335		200	
Ophelia......		9,268	(Dec., 1896) 2,600.	(Dec., 1896) 2,000 to 2,100.	Became dry in 1898.
Standard.....	January, 1896.	9,027	Work abandoned in June, 1899. 2,800.	Feb. 1896, 250; 1898, 1000; 1899, 12,000 to 18,000.	Became dry in 1901.
Newell.......		8,930			No important flow of water.
El Paso......	January, 1903.	8,783	Less than 1 mile.	Prior to Jan. 1, 1905, the estimated discharge was 3,550,000,000 gallons (total output).	Completed Sept. 6, 1903.

"This association includes nearly all the leasing companies, as well as the owners of territory embraced in the Leadville basin. All mines operating within the association territory bear the cost of pumping in proportion to their output, based on net smelter returns less cost of haulage. By means of counters on these pumps the amount pumped is computed in gallons and charged to the association at the rate of 10 cents per 1,000 gallons. Those mines which pump are credited with the amount of water they have raised. Taking the entire district, investigation shows that the flow of water which must be handled is not less than 15,000,000 gallons a day. Comparing this amount of water with the average daily tonnage of the district for the past year, we find that 28.6 tons of water are raised for every ton of ore raised. Careful estimates of the cost of pumping have been compiled and show that it costs 4 cents to pump each ton of water to the surface. Hence, the cost of pumping referred to the ore makes a charge of $1.14 per ton extracted."

Ventilation.— As a usual thing the ventilation of metal and especially precious metal mines is easily accomplished. There are special cases, however, where ventilation is exceedingly difficult, one of the most prominent cases in the history of mining in the

[1] Special Rept. Census Bureau, Mines and Quarries, 1902, p. 575, and Rept. Director of Mint on the Production of the Precious Metal, 1900, p. 118.

United States was that of the mines of the Comstock lode, but the conditions of excessive heat encountered there were exceptional and cannot be cited as other than unusual in practically every respect.

With the introduction of compressed air drills the problem of mine ventilation has been materially simplified, as the exhaust of a number of drills is often sufficient, especially when supplemented by natural ventilation. Under ordinary conditions, then, gold and silver mines may be ventilated by two shafts, preferably with the mouth of one elevated somewhat above the other, or by one shaft in which is placed a vertical partition or dividing extending from the surface to the workings below. When tunnels or drifts are employed in opening a deposit, ventilation can readily be maintained by running a wooden or metal pipe into the workings along the line of the drift and blowing air in with a blower or forcing it in with a jet of compressed air. Tunnel ventilation is most advantageously accomplished when the inner end of the tunnel or the workings are connected with the foot of a shaft sunk from the surface above. The one essential condition is that there must be a motive column of air, i.e., that one of the two columns of air necessary for a movement of air currents, must be heavier than the other, which may result from greater length or density of the column.

In mining districts where considerable development-work has been done the ventilation of the mines is disposed of as soon as connection is made with other workings in the immediate vicinity — a usual and legitimate method of procedure. However, when the atmosphere of the mine is close and warm or hot, owing to chemical change in the rock-walls or heat emanating from uncooled masses of igneous rocks, the problem of providing a sufficient volume of cool and fresh air becomes more difficult. The usual method of procedure under such circumstances is to install a blower at one of the mine openings thus aiding natural ventilation, or placing small fans, usually of the high speed type, at or near the localities where the greatest inconvenience is experienced. These fans are driven by air or electricity and have practically solved the difficulty of poor ventilation in metal mines. They are also used quite extensively in coal mines.

CHAPTER VI.

EXTRACTION OF VALUES.

THE extraction of values from gold and silver ores may be accomplished by mechanical or chemical means, the choice of the process depending largely upon the occurrence and condition of the ore. In general it may be said that free-gold and silver may be extracted by the former, while when chemically combined, chemical means must be resorted to.

Another important consideration in the extraction of values from ores is their reduction to a size suitable for the removal of the individual particles of useful metal or mineral. It is evident then that the size of the particles and their matrix are important factors in the economical working of a given ore.

The mechanical treatment of ores may be considered as milling, while the chemical treatment is usually spoken of as metallurgy. However, there is no sharp line dividing the two processes and they are probably more often used together, as supplementary processes, than separately, although in smelting there is often no connection, except in some instances a slight hand treatment, as sorting.

As between mining and milling the latter is probably of the most importance as a factor in the growth of the mineral industry. Means of winning ores from the earth naturally antedated the extraction of values therefrom, for which reason attention was first turned to improvements in mining the ores. Another important factor was the condition of the metal sought in the ore — little or no attention was at first paid to those deposits in which the metals occurred other than in the free or native state. The extraction of the values of such ores meant only a simple reduction, but, then as now, the methods of extracting the ores from the ground were largely independent of the after-treatment and were the immediate object of improvement. It is not surprising, then, that mining should have reached a comparatively high state of perfection at an early date, while the advance made in extraction of values has been by slow and devious ways, and even yet is wanting in many details. However, it has been largely through the overcoming of apparently impossible conditions in extraction of values that the remarkable and phenomenal growth of mining in all its phases has been due.

The reduction of working costs of the Comstock ores of from $50 to $30 was considered both remarkable and extraordinary. The cost has, however, been still further reduced to $10 and even $7 and $6 per ton, which under the present conditions of low-grade ore is considered high, but could it have been effected during the production of the high-grade ores it would have meant not millions but billions saved.

The economical working of low-grade ores is becoming of more and more importance and will continue to draw the attention of mill men and metallurgists until a point has been reached when ore containing values worth $1 and even less per ton can be worked with profit. Such a process would be tantamount to the discovery of new mines of the precious metals and would be a potent factor in maintaining if not materially increasing the production of gold and silver.

For convenience of discussion in this connection, extraction is considered under the two general heads of milling and metallurgy, but it is obviously impossible to treat of them exhaustively, and therefore typical examples are given of the various methods and processes which have proven to be especially suited to the classes of ores mined.

HISTORICAL SKETCH.

The washing of gravel for gold dust and nuggets constitutes probably the first attempt at extraction of values from their natural and crude surroundings. Further, this may be considered the first method employed in each new locality in which gold, especially, is discovered.

Where free-gold occurs in the upper oxidized portions of veins its extraction from the loosely associated matrix of weathered rock is a comparatively easy operation and does not involve extensive and costly appliances. Later, when considerable depth is reached and the free metal gives way to combined forms, as auriferous sulphides, in which the gold and silver occur in smaller quantities and from which it is more difficult to recover, the problem of extraction becomes more complicated. Improved methods both mechanical and chemical must be employed, thus elaborate and costly equipments are necessary, which are planned as much with an idea of preventing loss as ensuring rapid and economical work.

If, at the present time, auriferous deposits are found and give evidence of permanence, the crude methods are soon replaced by highly efficient and labor-saving devices. This was not, however, the case in the early days of the mining industry and that, too, even as late as the discovery of gold and silver in the United States, with which this treatise is particularly confined. Nevertheless the history of mining and milling and metallurgy of South America, Mexico, and the United States is so closely connected and intimately interwoven that casual mention of the two former countries is not out of place here.

The reduction of ore was first accomplished by hand mortars which were used in the Southern goldfields of the Appalachian region as early as 1825, or about the time that vein-mining began, and were employed in reducing the silver sulphurets of the Comstock lode in order that the gold might more readily be extracted. The hand mortar was replaced by the Mexican drag-stone mills and wooden stamps.

Another Mexican method of reducing ore, which in many instances was employed in place of hammers, was the use of a boulder attached to a balanced pole, the ore being placed upon a large stone and pounded by the spring-pole hammer.

The following interesting description is given of the early methods of reduction employed in 1835 by the United States Mining Company, at their mine on the Rappahannock River, Virginia:[1]

"The plant consists of a crushing-mill (rolls) and a vertical mill (stamp-mill) in a building 26 by 36 feet. Both mills are located on the ground floor, and are propelled by a water-wheel 11 feet in diameter, with a 11-foot face. The crushing mill has three sets of cylinders 2 feet in length and 15 inches in diameter, the first or upper set fluted, the other smooth. The ore is thrown into a hopper on the upper floor, from which it is conducted over an inclined shaking table to the fluted cylinders by which it is crushed to a size from ¼ to 1 inch in diameter. The crushed material is equally divided, and goes to the two sets of smooth cylinders. By them it is further greatly reduced, ranging from impalpable powder to grains as large as coarse hominy. From these cylinders it falls into a sifter having the fineness and motion of the common meal sifter, from whence the material which passes through is conducted to 12 amalgamators, constructed upon the principle of the Tyrolese bowls, making from 90 to 100 revolutions per minute. They perform the office of washing and amalgamating. The sand discarded

[1] T. A. I. M. E., Vol. 25, p. 682.

by them, after being washed, is conducted through troughs to the vertical mill, where, being reduced to an impalpable powder, it passes in the shape of turbid or muddy water to another set of amalgamators similar to those above mentioned, and thence to the river. The portion of the ore reduced by the cylinders, which passes over the sifters, is conducted to the vertical mill, and is treated in the same manner."

The drag-stone mills are probably the oldest form of reducing apparatus, power-driven, that was used in the United States. They probably originated in Mexico, at least were introduced into the States by Mexicans. Briefly, a drag-stone mill consists of a circular bed of stones some 8 to 12 feet in diameter, and enclosed within a vertical wall of stones, or timber standing on edge. In the center is a bearing for a vertical post, which is supported at the upper end by a second bearing, maintained some distance above the bed by a rude frame-work of timbers. A number of arms extend from the post a foot or more above the bed, to which are attached by ropes or chains drag-stones weighing from 200 to 800 and 1000 pounds. Other longer arms or sweeps are attached to the post by means of which it is rotated, and the stones attached to the arms caused to move around upon the bed or pavement of rock. In the earliest use of this apparatus it was occasionally operated by man-power, later by animals, and subsequently by water and steam-power; the latter method of driving is, however, comparatively rare.

It is essential that both the pavement and drag-stones be of hard material, in order that the expense of renewal may be small.

Ore and water fed in the proper proportion to the drag-stone mill or arrastra when in operation result in a reduction by slow attrition, thus effecting a separation of the values.

The arrastra was probably first used within the borders of the United States in the Southern Appalachian gold fields, although it is not improbable that it was employed at an earlier date even, in the states and territories bordering on old Mexico. It was found operating on the gold quartz-veins in the vicinity of the Comstock lode as early as 1848.

Its simplicity and cheapness make it pre-eminently a poor man's mill, for which reason it was largely used, and still continues in favor in those regions where mining operations are conducted on a small scale, and transportation facilities are wanting. Even as late as 1880 the arrastras outnumbered the stamp mills.[1]

[1] Tenth Census, Vol. 13, Report on Precious Metals, pp. 282, 283.

Stamps did not originate in America, but were used in Europe even before the discovery of gold in the United States. Probably the first stamp mill erected in the present borders of the United States was operated at the Tellurium mine, Virginia, in 1835 or 1836. It was a 6-stamp mill, the individual stamps weighing 50 pounds. During the following year a stamp mill was built at the Haile mine, South Carolina, by a Frenchman.

In general these early stamps were all wood, except the shoes and dies, i.e., the crushing parts. The stems were square, and the cams operated in slots in the stems.

Shortly after the close of the Civil War a regular California stamp mill was erected at King's Mountain mine, North Carolina, and in 1866 another was built at the Singleton mine, Georgia, by Dr. Hamilton.

Rotary pulverizers and pan amalgamators have been employed extensively in the Southern states, the more important forms of mills being, the Howland, a circular disk revolving in an iron shell; the Crawford, with revolving iron balls; the Huntington, with pendulum rollers; the Parson, with the interior grinding surfaces coated with lead amalgam; the Meech, in which the mercury was comminuted by superheated steam; the Wiswell, practically an iron Chilean mill in which was placed corrosive sublimate in connection with an electrical current; and the Nobles process in which a buhr stone mill was employed, the pulp being run over amalgamated slabs of zinc or lead.[1]

Two Germans are said to have built the first quartz-mill used in California, as early as 1850. This mill was patterned after the German form of stamp, and was erected in Grass Valley, being followed by another in the following year, both of which were practically failures.

These mills consisted of tree-trunks shod with iron, by the raising and dropping of which upon an iron or stone block or anvil, to which the ore was fed, its reduction was accomplished. These mills were but little removed from the wooden stamp mills of the Southern gold fields.[2]

An earlier report states that machinery for a small mill was sent to Mariposa County, California, for Colonel Fremont in 1849. The mill was an arrastra probably and not a stamp mill if the report is true — it has not been substantiated. However, in 1850, a 2- or

[1] U. S. G. S., 20 Ann. Rept., Pt. 6, p. 119, 1898–99.

[2] Min. and Sci. Press, Vol. 81, p. 120.

4-stamp mill was erected in Mariposa County for an operator named John Bennett. These stamps were of the Stockton make, consisting of a single stamp in a single mortar box.[1]

The Gold Hill mill, Grass Valley, California, contained 18 stamps and although not particularly successful, was purchased in 1852 by the Agua Fria, an English company, and was enlarged in 1853 to 21 stamps, with which were also employed Cornish rolls. The system of reduction employed in this mill consisted of breaking the ore by sledges, then passing it through the rolls, and finally through the stamps. The screens used in the stamps were punched copper plates and brass wire cloth of 24 mesh. After passing over blanket-covered tables, and through amalgamators the remaining pyrites were roasted, and still further reduced in a Chilean mill. This mill was in 1858 awarded the first premium (a gold cup) as being the best equipped and efficient stamp mill in the state. Further, an award of a silver medal was also given for the best amalgamator and gold saving devices.[2]

A 4-stamp mill was erected at Dayton* in the Washoe region, in 1859, and in the following year A. B. Paul of Nevada City, organized a company known as the Washoe Gold and Silver Mining Company, who erected a mill of 24 stamps in Gold Cañon, in which work was begun on August 11, 1860. The ore was crushed dry in this mill.[3]

Several years prior to 1860, Georgia miners had built numerous 3, 4 and 6 heads of stamps in Gilpin County, Colorado, which were, however, soon replaced by the improved California forms. In July, 1860, 60 mills were operating in Gilpin County, and in 1861 copper plates were first used there.[4]

The first stamp mill was built at the Wide West mine, in the Esmeralda district, Nevada, in 1861, and by the spring of 1864 there were fully 17 mills in the district although not all operating.[5]

By 1855 there was considerable change made in the character of the stamp mills of California; the most important improvements were an increased height of mortar box in order that the feed open-

[1] Min. and Sci. Press, Vol. 76, p. 108.

[2] Min. and Sci. Press, Vol. 70, p. 360.

[3] Eng. and Min. Jour., Vol. 51, p. 205.

[4] Eng. and Min. Jour., Vol. 54, p. 198.

[5] Min. and Sci. Press, Vol. 36, p. 409.

* It is possible that arrastras and stamps may have been confused by various writers. It appears that Judge James Walsh and his partner, Joseph Woodworth, built an arrastra mill at Dayton, in 1850, the power for driving which came from damming the Carson River. Min. and Sci. Press, Vol. 34, p. 81.

ing and screen frames might be contained within it, and an increase in the number of stamps to the unit or battery — four and five stamps being common. Five stamp units were grouped by twos into units of ten stamps each. Owing to the growing dissatisfaction of wooden stamps and mortar boxes, resulting from the unwieldy stamp stems, leaky boxes and square stamps, all-iron batteries were devised in 1853, and soon entirely replaced the wooden forms.[1] Square iron stems of the Cornish type were used. The first straight-frame battery was built for Joseph Moore in 1853.

The Howland circular battery had round iron stems, which were rotated when in operation. This is said to have been the first revolving stamp to stand the test of practical work, and was constructed in 1858 — Isaac Fisk is, however, credited with the idea of revolving stamps.[2]

Copper plates were introduced about 1850, and by 1853 were beginning to be generally used. The advantage of silver plating copper plates was not thought of until the silver ores of the Comstock were operated upon by stamps.[3]

An important labor saving device, in the shape of the automatic feeding apparatus, was invented and introduced into California, in 1855, by C. P. Stanford. As this feeder was operated by a lever actuated by the stamp tappet, it possessed the essential feature of all similar apparatus that followed.[4]

Aside from the invention of the stamp, probably no other single form of ore reducing apparatus has had such a far-reaching influence on the mining and milling industries as has the Blake crusher. It was invented in 1852 by Eli Whitney Blake, and was probably first employed in breaking ore in 1860.

The first mill built on the Blake system was for crushing iron ore, being erected for the Chateauga Ore and Iron Company, in 1882. It was also employed in crushing gold-quartz ores in the Southern states, and was installed at the Haile mine in 1884. The Blake crusher was introduced into California in 1861.[5] It has been changed in form a number of times, although the principle has remained the same. To increase the capacity the multiple-jaw form was

[1] Comstock Mining and Miners, U. S. G. S., Monograph No. 4, p. 82, 1883.

[2] Ibid., p. 82.

[3] Min. and Sci. Press, Vol. 76, p. 108.

[4] Ibid., Vol. 76, p. 109.

[5] T. A. I. M. E., Vol. 16, p. 755; U. S. G. S., 20 Ann. Rept., Pt. 6, pp. 118–119, and Eng. and Min. Jour., Vol. 11, p. 352.

devised, but did not prove a great success. Following the introduction of the Blake crusher, and owing to its great success, various other forms were invented in which were employed ingenious combinations of eccentrics and levers in order to obtain sufficient crushing force to reduce the ore.

Rolls were first used in Cornwall, in 1800, for which reason they were known as Cornish rolls until comparatively recent times.[1] Now only the simplest forms are so designated. Rolls were first introduced into gold milling practice in the Southern Appalachian states, and later in California about the same time as stamps. English buddles and jigs were also given a trial, but were not considered suitable, although they were quite extensively employed at a later date.[2] Stamps were replaced by Krom rolls at the Bertrand and Cory mills, Nevada, in 1883. The first tube mill employed in metallurgical work was operated at Butte, Montana, by the Moulton Mining Company in November, 1894, and was designed by R. F. Abbe.[3]

The next operation following the reduction of the ore, especially after passing the crushers and stamps, and in some cases tables and other concentrating apparatus was amalgamation.

It is claimed that an amalgamation process, in which gold and silver are collected by quicksilver and commonly known as the "patio" or "yard" process, was invented by Barthlome de Medina, a Mexican miner, about 1551.

The old town of Pachuca, State of Hidalgo, Mexico, is noted as the locality where the patio process was first applied (probably invented) by Medina in 1551 and applied in 1557.[4] During the next two centuries it was extensively employed throughout that country and subsequently was introduced into Europe where it was rather extensively used but was soon replaced by other more improved and modern methods. It is also known that the Incas of Peru were acquainted with the action of mercury on gold as they used it in riffles in the washing of gold gravel,[5] as early as 1557.

Probably the first application of the amalgamation process in the United States was at the Vaucluse mine, Virginia, where it was employed in 1847.

[1] Eng. and Min. Jour., Vol. 81, p. 813.
[2] Min. and Sci. Press, Vol. 76, p. 109.
[3] Eng. and Min. Jour., Vol. 81, p. 1010.
[4] Eng. and Min. Jour., Vol. 79, p. 564.
[5] Min. and Sci. Press, Vol. 59, p. 153, and Eng. and Min. Jour., Vol. 79, p. 564.

The patio process of amalgamating gold and silver ores has been practiced in Mexico from the earliest times and consists in mixing pulverized ore on a paved floor, called a patio, or a circa, when in a circular form. Salt, blue vitriol and quicksilver are added to the ore, which is thoroughly mixed and stirred by driving horses and cattle around in the patio. The Mexicans have become very expert in this work regardless of whether the operations are conducted on a large or small scale. The process is slow often extending over a period of 20 to 30 days before the final wash up and collection of amalgam is attempted. The constant treading of the ore charged with salt, blue vitriol and quicksilver soon causes the hair to come off and sores to form on the feet and legs of the animals. Absorption of quicksilver by the open sores soon reduces the poor beasts to walking skeletons and ultimately relegates them to the bone-yard. Therefore only poor and cheap animals are employed.[1]

The Freiberg, German barrel process was also used in California contemporaneously with the yard or patio process, and in the Southern states at an early date, exact date of introduction not known. Both of the processes are described briefly under their respective heads.

Amalgamation was also effected in the arrasta by adding quicksilver to the charge of mineral.

Amalgamating pans were first used in the United States in 1835, in the gold mills of the Southern Appalachian states, but as employed there resembled the Tyrolese bowls.[2]

The great disadvantages of the early methods of amalgamation were that too much time was consumed, with a consequent small capacity, and the expense was excessive especially in the barrel process.

The Washoe or pan process is in reality an Americanized Mexican patio process, employed in treating raw silver sulphurets, in which machinery has replaced animals in stirring and artificial heat that engendered by the sun, to hasten chemical action. The period of treatment was then reduced from 20 or 30 days to 5 or 6 hours. Further, the chemicals used, although many and varied at various times, were practically the same as those employed in the original patio process.[3]

In the Washoe process, however, there was no grinding attempted,

[1] Eng. and Min. Jour., Vol. 54, p. 80.
[2] U. S. G. S., 20 Ann. Rept., Pt. 6 p. 117, 1898–99.
[3] Min. and Sci. Press, Vol. 88, p. 180, Eng. and Min. Jour., Vol. 54, p. 80.

but a simple stirring action; in the California pan process there was both a grinding and stirring action, the stirring arms having shoes attached which rubbed on the bottom of the flat bottomed iron pan.

It is claimed on good authority that Almarin B. Paul of Nevada City, conceived the notion to employ the chemicals used in the patio process in the grinding pan, with the shoes detached. The first mill employing the process was erected in Gold Cañon on August 9th, 1860, by the Washoe Gold and Silver Mining Company and contained 24 stamps, the Knox pans being used for amalgamation.[1]

C. S. Goover and E. B. Harris erected an 8-stamp mill at the same time and began operation three hours after Mr. Paul's mill, a good-natured race having been run to see which mill would have the distinction of first beginning work.[2]

The pan employed in Mr. Paul's mill for amalgamation was designed by I. W. Knox of San Francisco in 1858. This pan was not intended to grind or otherwise reduce the ore, but simply to amalgamate.

Another pan was designed in 1860 by Mr. Brevoort, a mill man of Sonora, California, the object of this pan being to both grind and amalgamate.

It appears, however, that J. E. Clayton had previously hit upon the same idea and had employed a similar apparatus in reducing ores, at Tallahoosa, Alabama, as early as 1845.[3]

The first clean-up made by Mr. Paul in his mill amounted to several thousand dollars and was carried to Rhuling's assay office, in Virginia City, in iron kettles. The bullion produced from this clean-up is said to have been the first produced in this country.[4] This success in treating the Comstock ores gave a great impetus to mining silver-bearing ores.

According to another authority the Washoe process was first used, at Silver City, in 1860 being installed by Captain Hatch in the mill of Colonel Trench, where it was known as the " Hatch " process. It is possible, however, that the Washoe pan process has been confused with the German Barrel process.[5]

[1] Eng. and Min. Jour., Vol. 51, p. 205.

[2] Comstock Mining and Miners, U. S. G. S., Monograph No. 4 p. 86, 1883; The Big Bonanza, p. 69, and Nevada Directory, 1863.

[3] Comstock Mining and Miners, U. S. G. S., Monograph No. 4, pp. 82–83 1883.

[4] Min. and Sci. Press, Vol. 34, p. 73.

[5] Ibid., Vol. 18, p. 178.

Owing to the success of the Washoe pan process many mills were erected on the territory adjacent to the lode. In 1861 there were 76 mills erected for the treatment of the Comstock ores which had a daily capacity of 1,200 tons and employed 1,153 stamps. Besides these there were forty or fifty arrasta and patio yards. The building mania grew with the mining excitement but culminated in 1863, being followed by a panic in stock in 1864. In 1864 there were 700 mining companies incorporated to operate the Comstock mines of which 100 held prospected mines and only 14 paid dividends. The number of mills built for these mines was 150, far exceeding the capacity of the working mines.[1]

One of the first, if not the first, steam stamp invented and employed in the mines of California and Nevada for reducing gold and silver ores was devised by T. R. Wilson in 1870. Not long after this steam stamps were given a trial at Silver City, but were soon discarded.[2]

As an illustration of the extreme measure resorted to by the early miners to collect gold from gravels and ores, the attempt made to amalgamate gold with lead instead of mercury may be cited. The auriferous gravel or reduced ore was run through a bath of molten lead. The result was far from satisfactory, owing to an incomplete combination of the gold and lead and the great loss of lead by volatilization.

Following the reduction of ores by stamps, and the collection of values by amalgamation, both within and without the batteries, an attempt was made to reduce the losses resulting from escape of mercury and amalgam, and, probably to a greater extent, the gold enclosed by or attached to sulphides of the base metals. These sulphides comprise the so-called sulphurets which usually accompany gold in its various occurrences and often contain the largest part of the values. The free-milling ores of the upper or oxidized portion of a vein may be nearly free of sulphides, but with depth their occurrence is ensured. In fact the ores may become wholly sulphide in character, when they are known as rebellious ores as they resist all attempts at amalgamation.

At an early date the attention of mill men was directed to a solution of the problem of saving the rich auriferous and argentiferous sulphides, and at the same time the collection of fine gold escaping

[1] Eng. and Min. Jour., Vol. 51, p. 205.

[2] Silver and Gold Report for 1872, Raymond, p. 33, and Eng. and Min. Jour., Vol. 51, p. 205.

amalgamation in the mortars and on the outside amalgamating plates, together with amalgam that was not retained in the mortars or on the plates.

Owing to the crude methods of concentration employed in the early mills considerable trouble was experienced in saving the fine gold; often particles of gold as large as a pin's head were allowed to go to waste, thus materially reducing the capacity of the mills.

Concentration of sulphurets was probably first accomplished at the Vaucluse mine, in 1847, by the use of tables or strakes, which were followed by buddles, crude bumping tables and blanket tables and sluices; log rockers were also employed.[1]

The practice at the Vaucluse mine, Virginia, was as follows:[2]

"The machinery consists of a condensing Cornish mining-engine of 120-horsepower; the mill house contains six large Chilean mills; the cast-iron bed-plate of each is 5 feet 6 inches in diameter, and on it are two cast-iron runners of the same diameter, the total weight of the mill being 6,200 pounds. The ores on arriving at the surface, are divided into two classes:

"1. The coarse and hard ore for the stamps. 2. Slate and fine ore for the Chilean mills. This is done by means of a large screen. The very large pieces are first broken by a hammer before they are fed to the stamps. All of the ores are ground with water, each mill being supplied with hot and cold water at pleasure. Twelve inches from the top of the bed-plate there is a wide, open mouth, from which the turbid water escapes to tanks. On the south side of the steam-engine is the stamp-house and amalgamation-mill, containing six batteries of three stamps each; these stamps, with the iron head of 125 pounds, weigh 350 to 380 pounds each. Each battery is supplied with water, and at each blow of the stamp a portion of the fine ore passes out of the boxes through the grates to the amalgamation-room. Here are stationed 18 small amalgamation-bowls of cast-iron, 30 inches in diameter. The bowls are supplied with runners which move horizontally; in the center of these runners is an eye or opening like that in the runner of a corn mill. The ground or finely-stamped ore, gold, and water pass into this eye, and by the rotary motion of the same are brought into contact with the quicksilver deposited in the centre, forming amalgam. From the amal-

[1] U. S. G. S., 20 Ann. Rept., Pt. 6, p. 119, 1898–99.

[2] Plan and description of the Vaucluse mine, Orange County, Virginia, Philadelphia, 1847.

gamators the pulp passes through three dolly-tubs or catch-alls, acting as mercury and gold tubs. After this the whole mass passes to the strakes or inclined planes, where the sulphurets are deposited and the earthy matter washed away. These sulphurets were formerly treated in two heavy Mexican drags or arrastas; but not answering so good a purpose, they have been altered into three heavy Chilean mills."

The first attempt made in California to save the auriferous sulphurets was by the Chavanne brothers, together with William and Robert Watt, at Grass Valley, California, in 1857. Rockers were used here, while Mr. Soggs, at Nevada City, used the Bradford shaking table which was introduced by a Mr. Ferre, Shaking tables (copper plates) were used in Montana in 1878.[1]

The Frue Vanner was devised by Captain Frue in 1874 to treat the silver ores of the Silver Islet mine, Ontario. It is a modification of the old Brunton table.

Blankets were first employed in the mills of Grass Valley, in 1853, and were in general use in 1873, being used in troughs and on tables. The head blanket troughs were made in sections of six feet each, and were given an inclination of three to five degrees, with a drop of six inches between sections. Ordinary red bed blankets were first used, those with long nap being preferred. The expense in the use of these blankets was considerable, owing to the cutting to fit various sized surfaces, also to the wearing off of the nap. When the demand for blankets became great enough to warrant it woolen mills were established at San Francisco, and blankets were furnished in long lengths and standard widths to fit standard sizes of tables. These special blankets were made of very coarse wool, the nap being thrown to one side. Blankets were used with stamps with or without battery or outside plate amalgamation.

A number of the first operated stamp mills of California used blankets alone to save the gold, this being the practice in the French and Gold Hill mills. In this process the pulp from the stamps passed directly into a trough in front of the battery, and thence to the blankets. Every 20 to 30 minutes the blankets were changed and rinsed in order that their surfaces should remain in proper condition to catch the gold and sulphurets. When amalgamation either in or outside the batteries was practiced the work of the blankets was materially reduced. The practice at the Empire mill, Grass Valley,

[1] Gold Amalgamation and Concentration, McDermott and Duffield, 1890, p. 16.

was to discharge the batteries directly into tubs of quicksilver, after which it passed to the blanket tables. At the Mount Hope mill blanket troughs were employed in two sections placed in tandem, between which was a vessel of quicksilver. This was really the beginning of the use of mercury wells or traps in the milling practice of the United States.[1]

Blankets were used in the Homestake mill, South Dakota, the first mill built on the gold belt. This mill was erected during the summer of 1878 and had 80 stamps. It was enlarged shortly to 200 stamps and concentrators were added, but proving unsatisfactory a "blanket house" was built. In this house were series of shallow sluices, about 22 inches in width, in which were placed strips of Brussels carpet. The concentrates obtained from these sluices were principally iron oxide, metallic iron, from the wear of stamps and coarse sands. The carpets were washed from three to four times a day in tanks of water.[2]

A rule generally followed in the early use of blankets was not to amalgamate before running the pulp over the blankets for the reason that the angularity of the gold grains would be considerably reduced thereby, thus increasing the loss on the blanket tables. However, the Wiggam's mill at Nevada City amalgamated within the batteries in 1885.

The Cornish miners employed the tye (a form of hand buddle) and the ordinary stationary rectangular buddle. These were supplemented by kieves, which were introduced into California by a Mr. Houk, also a Cornish miner.

Convex buddles, mechanically driven, soon replaced the hand forms. They were in use in California as early as 1865 and probably earlier, although no definite record to such an effect is at hand. Buddles and tables were also used in Gilpin County, Colorado, in the pioneer gold mills. Concave buddles, with centrally placed riffles were also used with the convex form. The Hendy shaking table was introduced at the Keystone mine, Amador County, California, by Captain Faull in 1863. This table although quite extensively used for many years was ultimately succeeded by the Frue, Triumph, Woodbury and Johnson vanners, all of which were widely used in 1890–95.[3] At a later date the Frue, Embrey and Triumph concentrators were used in the Southern states.

[1] Min. and Sci. Press, Vol. 54, p. 20.
[2] Min. and Sci. Press, Vol. 90, p. 392.
[3] Eng. and Min. Jour., Vol. 58, p. 390.

Following the use of blankets as gold savers, reservoirs were employed in collecting slimes and tailings. The development of the process is due to Mr. Janin, who became metallurgist for the Mexican mill of the Comstock lode. The tailings were dried, roasted and amalgamated in barrels.[1]

Slime tables, usually stationary with wooden or canvas surfaces, were subsequently employed in handling slimes. As large quantities of slimes must of necessity be handled in the larger plants, floors are laid, upon which rectangular sheets of canvas are stretched which receive the slimes and concentrate the values. The use of canvas tables has been so satisfactory that they have been employed in handling slimes and fine sands in the treatment of all kinds of ores, both precious and base metals.

Sulphurets were at an early date treated by raw amalgamation, roasting and amalgamation and smelting. The Southern Appalachian states led in this work owing to the occurrence of gold in sulphides at comparatively shallow depths.

When it is considered that to leave a profit, the sulphurets so saved had to have a value of fully $200 per ton in order to bear shipment to Swansea, their separation became an important problem. It is said that Messrs. Chavanne and Watt, of the Rocky Bar mine, near Grass Valley, California, had at one time several hundred tons of sulphurets stored at the mill and were at a loss to know what to do with them.[2]

In 1874 the price of mercury more than doubled, rising from 60 cents to $1.30 per pound, which with the fall in the value of silver and troubles experienced by the tailing mills, in working low-grade materials, so crippled the milling industry that practically all of the mills in the Washoe region closed. The Lyon mill was the single exception; all of the others closed, some permanently, others temporarily. The Lyon mill, located at Dayton, was built in 1865, and was in charge of George Langtry, who was said to be the most successful tailing man of Washoe. The Omerga mill, erected in 1877, was probably the most successful mill on the Comstock.[3]

Of the mills built prior to 1870 for reducing the Comstock ores eight, carrying 114 stamps and costing $2,000,000, were located in Ormsby County, Nevada; six, carrying 106 stamps and costing

[1] Eng. and Min. Jour., Vol. 51, p. 231.
[2] Eng. and Min. Jour., Vol. 58, p. 390.
[3] Ibid., Vol. 51, p. 231.

$1,200,000, were in Washoe County; forty, carrying 573 stamps and costing $3,700,000, were in Storey County; twenty-two carrying 360 stamps and costing $1,000,000, were in Lyon County; and ten carrying 84 stamps and costing $300,000, were located in Esmeralda County.[1]

For an excellent historical account of milling operations on the Comstock see reference.[2]

In the early days of mining in the Tintic district, Utah, only the rich ores could bear transportation charges to San Francisco, California; Reno, Nevada; Baltimore, Maryland; and occasionally to Swansea, Wales. The ores of average and low values were then left in the mines or thrown on the dumps. As soon as it was practicable mills and smelters were established in the district.

The first mill was erected at Homansville, Utah, May, 1871. Another was built in the same locality during the same year. The Wyoming, Miller, and Shoebridge were built in 1873, the latter being at or near Diamond. The Copperopolis was erected in 1873, and the Mammoth, at Tintic, in 1879. The Roseville, located in southeast Mammoth, was put up the same year as the Mammoth. These early mills were crude, and were failures when economically considered.[3]

The following table gives the stamp mills erected on the gold belt of South Dakota between the years 1878–1894.[4]

Name.	Date of Erection.	Location.	Number of Stamps.		Owners.
			1888	1895	
Homestake....	1878	Lead City....	80..	..100	The Homestake M. Co.
Golden Star...	1879	....do.........	120..	..160	do.
Highland......	1880	....do........	120..	..140	The Highland M. Co.
Deadwood.....	1879	Terraville....	80 }	..160	The Deadwood Terra M. Co.
Golden Terra..	1880	....do........	80 }		do.
Father de Smet	1878	Central City	100..	..100	The Father de Smet M. Co.
Caledonia.....	1879	Terraville....	80..	...80	The Caledonia M. Co.
Columbus.....	1894	Central City..	......	...10	

[1] Min. and Sci. Press, Vol. 34, p. 81.
[2] T. A. I. M. E., Vol. 19, p. 204.
[3] U. S. G. S., 19 Geol. Rept., Pt. 3, p. 613, 1898.
[4] Eng. and Min. Jour., Vol. 60, p. 221.

The mills operating in a number of the districts of Arizona in 1872 are given in the following table:[1]

District.	Name of Mine.	Company.	Ore.	Mill.
Bradshaw	Tiger	Tiger	Galena and silver.	None.
Do	Del Pasco	Jackson	Gold	5 stamps.
Big Bug	Big Bug	Gray & Hitchcock.	Gold	10 do.
Hassyampa	Sterling	Sterling	Gold	10 do.
Do	Davis	C. C. Bean	Silver	
Do	Benjamin	Noyes & Curtis	do	
Lynx Creek	Vernon	C. Y. Shelton	Gold	Arrastra.
Do	Pointer	William Pointer	do	Do.

The stamp mills installed in the Cripple Creek district during the first three years of its existence as a mining camp have been given as follows:[2]

Name of Mill.	Locality.	Date of Erection.	Number of Stamps.
Lawrence	Lawrence	1892	20
Summit	Gillett	1892	30
Gold and Globe	Cripple Creek	1892	40
Beaver Park	Beaver Park	1893	20
Colorado Springs	do	1893	25
Denver	do	1893	20
Hartzell	Anaconda	1893	20
Gold Geiser	Cripple Creek	1892	15
Crammer	Arequa	1893	20
Rosebud	Mount City	1893	60

The first mill was built in Idaho, at the Oro Fino and War Eagle mines in 1864.

As previously pointed out the silver and gold in the sulphurets was saved by raw amalgamation, roasting and smelting, the choice of treatment depending largely upon the character of the ore to be treated, while in many instances no attempt was made at the extraction of the contained values, the concentrated sulphides being shipped to Europe for metallurgical treatment. However, the great expense involved in this long distance transportation and consequent handling and rehandling necessitated a relatively great reduction

[1] Silver and Gold Rept., 1872, Raymond, p. 333.

[2] Inst. Min. and Met., Vol. 8., p. 80, 1899–1900.

in volume, which in turn resulted in considerable loss. With the growth of the mining industry and a greatly increased output of refractory products came a demand for less expensive methods and more rapid disposal, which naturally resulted in the establishment of facilities for treatment closer home. With the growth of such facilities their application was extended to the treatment of lower-grade products as slimes and tailings. Janin was a pioneer among the workers who inaugurated such methods in the West.

The methods employed in extracting the values from the refractory ores or sulphurets were, in the order in which they were applied, smelting, chlorination and cyanidization.

Raw amalgamation as practiced in the Vaucluse mine, Virginia, in 1847, previously described, is probably the first application of the process in this country. However, a roasting process had been applied to the pyritic concentrates at Charlotte, North Carolina, by Dr. Holland, of Massachusetts, as early as 1852–53. He roasted a mixture of potassium or sodium nitrate and the sulphurets in a reverberatory furnace employing a low heat. While according to Lieber, Mr. C. Ringel roasted and amalgamated suphurets at a mine near Rutherford, North Carolina. It is also stated that the process was successfully employed elsewhere in the State.[1]

Heap roasting with salt was also early tried at Silver Hill, North Carolina, which was followed by wet-stamping. The ores treated were galena-blende carrying both gold and silver. The zinc oxide was dissolved and recovered separately, following which the residues were smelted in old-fashioned Scotch open-hearth lead furnaces, the precious metals being recovered from the lead by refining in a cupellation furnace.

Pyritic smelting was given a trial in 1847 at the Vaucluse mine by Commodore Stockton, but was abandoned. In 1881–82 matte smelting and refining in reverberatory furnaces was practiced on the ores of the Conrad Hill and the North State mines, in North Carolina. Mr. E. G. Spilsbury experimented on matting auriferous sulphides at the Haile mine, South Carolina, in 1886, but without success.

A successful method of smelting galena-blende ores was installed at the Silver Valley mine, North Carolina, in 1895, by Mr. Nininger of Newark, New Jersey, which consisted of a down-draft jacketed furnace, through which the lead and zinc fumes were carried into condensers, where saturated with water the lead oxide was deposited

[1] U. S. G. S., 20 Ann. Rept., Pt. 6, p. 120, 1898–99, and Report on the Survey of South Carolina for 1856, p. 47.

from the resulting liquor, having been run into tanks. The zinc oxide remaining insolution was subsequently precipitated out. The matte, carrying gold, silver and copper was drawn from the furnace and cast into ingots.[1]

G. F. Deetkin in 1858 attempted to smelt the sulphurets of Grass Valley in reverberatory and blast furnaces, but owing to the scarcity of lead ores and cheap fuel the results were not satisfactory. In 1866 a smelting furnace was built at Galena, Nevada, to treat the Comstock ores, but after a struggling existence of one or two years it was abandoned, the Washoe process becoming practically universal.[2]

The almost universal failure of milling enterprises due to the mill-building habit was largely responsible for a depression in mining in the early days of the Comstock lode. As an example of the credulity of the public and even the operators of properties and plants the case of the Bunker Hill mine, Nevada, can be cited. " A man who pretended to be an assayer and chemist, induced the company to build huge furnaces out of fire-brick, at a dollar and a half apiece. What for? To melt the quartz and find the gold at the bottom of the molten mass, when it had cooled. This was actually tried; the result, of course, zero, plus a heap of slug."[3]

The change from oxidized ores in the upper portions of the veins of Gilpin County, Colorado, to less quartzose and more sulphide ores, together with considerable country-rock caused a decided check to the mining industry there.

Amalgation by copper plates and the saving of sulphurets by buddles, tables and other concentrating apparatus, which formerly gave an extraction of 60 to 75 per cent, under the new conditions gave but 30 to 40 per cent extraction, therefore, none but the richest ores would pay for the treatment. It took two-thirds of the profits to operate the mills and the result was that many of them were forced to close.

In 1867 the Boston and Colorado Smelting Works were erected at Black Hawk, in which the Swansea process of copper smelting was employed. For a number of years this smelter took the place of the stamps mills, but as it operated on the richest ores mainly it did not solve the problem for the district.

By dint of much experimenting a milling method was worked out by which the ores of the district could be milled economically.

[1] U. S. G. S., 20 Ann. Rept., Pt. 6, pp. 122–123, 1898–99.

[2] Eng. and Min. Jour., Vol. 58, p. 390; Ibid., Vol. 51, p. 205.

[3] Twelve Years in the Gold Mines of California, 1862, p. 83.

The essential features of the new method consisted of slow drop of stamps and deep discharge of products. Inside plate amalgamation collected a large part of the free-gold in the mortar box, a further saving being effected by blankets and concentrators. Buddles and tyes were also used to supplement the work but were soon discarded.[1]

The exceeding fine condition of the gold necessitated fine crushing in order to separate the gangue, but as the discharge from the batteries was too rapid to permit the gold to settle to the bottom of the ordinary form of mortar, where the mercury was more plentiful, and owing to the presence of large quantities of sulphurets, increased depth of discharge from mortar box was adopted. Under these conditions the sulphurets although sufficiently fine to pass the screen, settled and became more thoroughly amalgamated, thus increasing the percentage extraction of the gold. Slow drop and roomy mortar box also contributed to the efficiency in extraction. Black Hawk lead in gold milling in Colorado in 1892, being pre-eminently a custom milling locality, which practice led to careful work and attention on the part of both mine operator and millman.[2]

In the following table is given a number of the smelters built in Colorado with the date of installation.[3]

Name of Company.	Location.	When built.	When closed.
Boston & Colorado Smelting.	Black Hawk	Jan. 1868	Removed in 1878.
Grant Smelting	Leadville	Sept. 1878	Burned in May, 1882.
Do	Denver	1883(?)	
Do	Durango	1883	
Philadelphia Smelting & Refining.	Pueblo	1888	
Pueblo Smelting & Refining.	Pueblo	1878	
Colorado Smelting	Pueblo	1883	
Arkansas Valley	Leadville	1897	Sold in 1882.
Bimetallic	Leadville	....	
American zinc-lead	Canon City	....	
Omaha & Grant	Durango	....	
....	Silverton	....	

Tailings of the Mexican mill, Comstock lode, were in 1862 dried and roasted in reverberatory furnaces after which they were amalgamated in barrels. In 1866 the Gould and Curry company built

[1] Eng. and Min. Jour., Vol. 54, p. 198.

[2] Ibid., Vol. 54, p. 246.

[3] Mines and Minerals, vol. 19, pp. 97, 99.

the Reservoir mill for the treatment of tailings, probably the first of its kind in the United States.[1]

An O'Harra mechanical furnace was erected in 1862–63 at Dayton, Nevada, to treat the Comstock ores. This was the first furnace of the kind to be erected in the West. Later three other similar furnaces were installed at Flint, Idaho. The O'Harra furnace was also employed in drying ores, a 40-ton plant was built for that purpose near Shasta, California, in 1880.

Bruckner furnaces were introduced into Colorado in 1867 and were successfully operated on gold and silver sulphurets.

A Stetefeldt furnace was installed and operated on argentiferous ores at the Ontario Mill, Utah, in 1877. The ores of the upper or oxidized portions of the mines ran high in silver which could be treated by raw amalgamation. With depth the ores became sulphide, necessitating roasting with salt before amalgamating.

A Stetefeldt furnace was used in treating the cupriferous ores of Panamint, California, at the Surprise mill and at Austin, Nevada, prior to 1880.[2]

A Pardee furnace was installed in the Algonquin mills, at Phillipsburg, Montana, in 1880.[3]

The Plattner chlorination process was first employed in Germany, in Silesia, in 1851, where it operated on auriferous arsenical residues. It was later introduced into Saxony, Hungary and Transylvania. In 1838 it made its appearance in California.[4]

The chlorination process was first successfully applied to the treatment of auriferous sulphurets in the Southern states in 1879. A Mears chlorination plant was installed at the Phoenix mine, North Carolina, by Mr. A. Thies and under his direction was improved and was subsequently known as the Thies process.

The Davis and Tyson Metallurgical Works was built near Salisbury, North Carolina, in 1880. This was a chlorination plant, the process employed being known as the Davis process, and differed from the Thies process only in the method of precipitation of gold — charcoal being employed instead of ferrous sulphate. Another Davis plant was installed at the Reimer mine, North Carolina, in 1881.

The Plattner chlorination process was employed at the Tucker

[1] Eng. and Min. Jour., Vol. 51, p. 231.
[2] Roasting of Gold and Silver Ores, G. Kustel, 1880, pp. 77, 84, 88, 97, 98, 99.
[3] T. A. I. M. E., Vol. 18, p. 242.
[4] Roasting of Gold and Silver Ores, G. Kustel, 1880, p. 140.

mine, North Carolina, in 1882, but without success, the Mears process being used in its stead, which, too, soon proved a failure.

Mr. P. G. Lidner experimented at the Brewer mine, South Carolina, also at Dahlonega, Georgia, on treating ores in bulk with the chlorination process. In 1895 a patent electrolytic chlorination process was installed at the Clopton mine, Villa Rica, Georgia. Little success was accomplished by the two last mentioned operations.

As late as 1898 the Thies process was successfully operated on the ores of the Isenhour mine, North Carolina; the Haile mine, South Carolina, and the Franklin and Royal mines, Georgia.[1]

According to Mr. Ottokar Hofmann, who first introduced the lixiviation process on this continent, the process was employed at the following localities at the dates given:[2] In 1868, at La Dura, Sonora, Mexico; in 1869, at Trinidad, Sonora, Mexico; in 1869, at San Marcial, Sonora, Mexico; and in 1871, at Bronzas, Sonora, Mexico. Further, it had been or was being employed at other localities in Mexico in 1884, some of the more important localities being, La Barranca, Sonora; Promontorio, near Alamos, Sonora; Cosihuiriachic, Chihuahua; at mines near Parral, Durango; Triunfo, Lower California; Las Yedas, Sinaloa; and Alameda and Tirito, Sonora.

"In the United States lixiviation was first introduced by Mr. G. Kuestel, in 1874, at Melrose, near Alameda, California. The works were built to do custom-work, and the supply of ore being limited and irregular, they did not prove a financial success, and had to be abandoned.*

"**1877.** At Galena, Nevada, ores containing zinc-blende and galena were concentrated by Krom's dry system. The galena concentrations were sold to smelting-works, and the silver-bearing zinc-blende treated by lixiviation. The mine has been abandoned.

"**1878.** O. Hofmann works concentrations containing $250 silver and $25 gold per ton at the Advance Mill, Monitor, California, where 85 per cent of the gold has been extracted by simple lixiviation.

"**1879.** Introduced at the Tarshish mine, Monitor, California, by O. Hofmann. Both of the last-named works had only a short existence.

[1] U. S. G. S., 20 Ann. Rept., Pt. 6, p. 121, 1898–99.

[2] T. A. I. M. E., Vol. 13, p. 113, 1884–85.

* According to Mr. T. A. Rickard, Dettkin first applied the chlorination process to ores in 1857 in California (Inst. Min. and Met., Vol. 8, p. 79.)

"**1880.** First successful introduction, on a large scale, at the Silver King mill, Arizona, by O. Hofmann. Average of ore $196.92 per ton; percentage of silver extracted 89.2 per cent.

"**1882.** Lixiviation works of 60-ton capacity are constructed at the Bertrand mine, Geddes, Nevada. Krom's rolls are successfully introduced for pulverizing the ore.

"**1883.** A lixiviation mill has been built for the Mt. Cory mine, Nevada, with Krom's rolls.

"At the Old Telegraph mine, Utah, chloride of silver has been extracted by lixiviation from oxidized lead-ores without roasting. The residues were subsequently concentrated for lead-minerals."

The O. Hofman chlorination process for treating gold and silver ores was applied to the sulphurets of the Tarshish mine, Monitor, Alpine County, California, prior to 1880.

The development of processes for treating the Cripple Creek ores is both interesting and instructive. In 1892–93 ten stamp mills of the Gilpin type, i.e., light stamps and slow drop, were installed, and in a comparatively short time mills aggregating 270 stamps were operating. The Rosebud and the Gold and Globe mills were the largest having 60 and 40 stamps, and were situated along Cripple Creek. Difficulties of amalgamation, supposedly a coating of tellurite of iron, so reduced the percentage of extraction that, notwithstanding the employment of various improved apparatus as percussion tables and blankets the milling method proved inadequate. Further, the appearance with depth of unoxidized tellurides caused the method to be abandoned.

Smelting of the ores was then turned to as the proper method of treatment, especially of the rich ores, and the smelters of Denver and Pueblo received increasing amounts of ore from year to year. In 1906 fully one-sixth of the tonnage or approximately 100,000 tons was thus treated. The smelting charges ranged from $6.50 upward, and therefore were prohibitive for ores running below four ounces of gold per ton. With an increase in the output of the district the production of the lower-grade ores became an important consideration and means of treating them economically engaged the attention of the mining men.

In 1893 the first chlorination plant was erected at Gillet a few miles northeast of Cripple Creek, by Edward Holden. This mill followed, and was based upon experiments made by W. S. Morse, in 1893, at the Russel Lixiviation Works at Aspen. The mill was completed by January, 1895, and had a capacity of 50 tons. The process employed was barrel chlorination similar to that employed in South Carolina and the Black Hills, South Dakota.

The cyanide process was introduced about the same time, the first mill having been built at Bodie in 1892. Another mill was built at Florence, in 1895, by the Metallic Extraction Company, which when completed had a capacity of 170 tons per day. From that time on there grew up a keen competition between the two processes, and from appearances the chlorination process seems to have gained the ascendency. Further, improved railroad facilities, connecting the mines with the low lands and valleys, where reduction works could be placed to an advantage, made it possible to build up large smelting centers, such as Colorado Springs and Florence, where the ores are treated under the most favorable circumstances. In 1899 there were four plants operating at Cripple Creek, while in 1903 there were three, which included two small mills for direct cyaniding.[1]

In 1904 the kind and distribution of the plants were as follows:

Locality.	Mill.	Process.	Capacity.
Cripple Creek	Economic	Chlorination	300 tons.
Do	Homestake	Cyanide (direct).	200 tons.
Do	Sioux Falls	Cyanide (direct).	100 tons.
Colorado Springs	Portland	Chlorination	300 tons.
Do	Telluride	Chlorination	300 tons.
Do	Standard	Chlorination	450 tons.
Florence	Dorcas	Cyanide	150 tons.
Do	U. S. Reduction & Refining Co.	Chlorination	400 tons.

The combined capacity of these mills is over 2,200 tons, or about 800,000 tons per year, and therefore represents a larger tonnage than is produced in the district.

Although the charge for the two processes varies somewhat with the grade of the ore yet for 1904 it did not exceed $9 per ton for 3 to 5-ounce ore, the range being $5.50 to $9 for ½ to 5-ounce ores, which also includes freight charges.[2]

The use of cynide of potassium as a solvent for gold had been known to chemists and metal workers for many years prior to its

[1] Geology and Gold Deposits of the Cripple Creek District, Colorado. U. S. G. S., Professional Paper No. 54, pp. 138–139, 1906.

[2] Geology and Gold Deposits of the Cripple Creek District, Colorado. U. S. G. S., Professional Paper No. 54, p. 39, 1906.

application to the extraction of values from ores. The adaptation of this solvent to the commercial treatment of ores was made by J. S. MacArthur in 1886.[1]

For an historical account of the cyanide process and its development the reader is referred to the following works.[2]

We are especially interested in this connection with the introduction and development of the process in the United States.

Probably the first use to which potassium cyanide was put in the treatment of ores in the United States was the removal of the coatings from rusty gold, especially in pan amalgamation. It was also used at an early date in dressing the outside amalgamating plates in stamp mill work.

The following summary of the early work in the development of the cyanide process is given by C. E. Munroe, in his paper on the Cyanide Process:[3] "The first instance of an attempt to apply this solvent action of the cyanides to the extraction of precious metals from their ores or other bodies containing them appears in United States Patents 61866 and 62776, issued to Dr. Julio H. Rae, of Syracuse, N. Y., on February 5 and March 12, 1867. Dr. Rae claimed the use not only of potassium cyanide as a solvent for the precious metals in the ore, but also of an electric current in precipitating them from the solution, and of rotatory or movable electrodes. This was followed by United States Patent 229586, of July 6, 1880, to Thomas C. Clark, of Oakland, Cal., who roasted his ore to a red heat, and placed it, in this condition, in a cold bath containing salt, prussiate of potash, and caustic soda; United States Patent 236424, of January 11, 1881, to H. W. Faucett, of St. Louis, Mo., who subjected hot crushed ores, under pressure, to the action of sodium cyanide in solution; and United States Patent 244080, of July 12, 1881, to John F. Sanders, of Ogden, Utah, who treated his ore with potassium cyanide and glacial phosphoric acid.

"In 1884 Astley P. Price applied for British Patent 5125 for the use of zinc in a state of fine division in precipitating gold or silver from solutions containing them. On July 28, 1885, United States Patent 323222 was issued to Jerome W. Simpson, of Newark, N.J.,

[1] Eng. and Min. Jour., Vol. 80, p. 241.

[2] Histoire de Chemie, Vol. 1, p. 226, The Metallurgy of Gold, 1896, p. 378; The Art of Electro-Metallurgy, 1877, pp. 19–20; California State Bureau, Bull. No. 5, 1894, p. 9, and Special Rept. of the Census Office, Mines and Quarries, 1902, p. 595; Min. and Sci. Press, Vol. 95, pp. 655–657.

[3] Special Rept. Census Office, Mines and Quarries, 1902, pp. 596–597.

covering the extraction of gold, silver, and copper from their ores by means of solutions containing potassium cyanide, ammonium carbonate, and sodium chloride, and the subsequent precipitation of the dissolved metals by means of pieces or plates of zinc suspended in the solution. A caveat for the use of cyanide was filed in the United States Patent Office by F. M. Endlich and N. W. Mühlenberger, during the same year, but was subsequently abandoned. At Park City, Utah, about the same time, Louis Janin, Jr., made experiments with cyanide in extracting silver and gold from ores, which led to his filing a caveat on May 1, 1886. He did not press this to an issue, but he published his results in the Engineering and Mining Journal, 1888. W. A. Dixon, also made experiments with cyanide on Australian ores, and recorded his results in a paper read before the Royal Society of New South Wales."

The development and application of the cyanide process in England and South Africa is given in the same paper as follows:[1]

"The cyanide process acquired commercial value in 1887, when John S. MacArthur and W. Forrest, of Glasgow, Scotland, applied, on October 19, for their English patent covering the use of dilute solutions of cyanides in the extraction of the precious metals. Later they obtained a patent for the use of zinc as a precipitant in a particular state of subdivision.

"The commercial value of the cyanide process was demonstrated by the tests made on a large scale, with ore from the New Zealand Crown mine, in June and July, 1888. Commercial success dates from the introduction of the MacArthur-Forrest process, in 1890, in the Witwatersrand gold fields in South Africa, the first cyanide plant in the world for treating tailings having been erected at Johannesburg in April, 1890. In the Witwatersrand alone, at the end of 1891, there were 6 companies treating tailings by the cyanide process; at the end of 1892 there were 22, and at the end of 1893 there were 32, with a record of 143,500 tons per month treated. By the use of this process there were recovered in the Rand 286 ounces of gold in 1890, 34,862 ounces in 1891, 178,688 ounces in 1892, 330,510 ounces in 1893, 714,122 ounces in 1894, 753,490 ounces in 1895, and 703,704 ounces in 1896; the output then increased up to September, 1898, when the commencement of active hostilities in the Boer War interfered with the active workings of the mines."

The cyanide process was first successfully and commercially employed in the United States in extracting gold from ores at the Mercur

[1] Special Rept. Census Office, Mines and Quarries, 1902, p. 596.

mines, Utah, about 1891. The process was introduced by Captain J. R. De La Mar, owner of the properties.[1]

Experiments on Gold Hill mine ores, North Carolina, by Mr. Richard Eames in May, 1892, gave an extraction of 60 per cent of the assay value. During the summer of 1893 a 10-ton cyanide plant was in operation at the Moratock mine, North Carolina, but owing to the leanness of the ore it was discontinued. In the same year another plant was operating at the Gilmer mines, Goochland County, Virginia, but with apparently little success. At the Franklin mine, Georgia, work with the cyanide process preceded that of chlorination, and was successful as applied to the more or less oxidized ore of the dumps, but failed of economical extraction when applied to the fresh sulphides.

The Sawyer mine, Randolph County, North Carolina, was the scene of further cyanide work in 1895, but the work soon stopped owing to lack of results. Two other plants were installed in North Carolina during 1896; one at the Russell mine, the other at the Cabin Creek mine, but they did not pass the experimental stage in their operations.

The Hunt and Douglas process was installed at the Conrad Hill mine, North Carolina, in 1880, which consisted of treating roasted sulphides with a ferrous chloride solution, by which the copper was rendered a soluble chloride, being precipitated by scrap iron as metallic cement.

The Designolle process, by which roasted ore was treated with corrosive sublimate in iron vessels, was only partially successful owing to the formation of base bullion, the iron of the containing vessel precipitating the soluble salts resulting from roasting. This process was applied to the ores of Charlotte, North Carolina, during 1882–83; also at the New Discovery mine, Rowan County, North Carolina, in 1883; and at the Haile mine, South Carolina, in 1883.

Another plant for extracting the gold from sulphurets (concentrates) together with the recovery of sulphuric acid was installed at Blacksburg, South Carolina. In connection with this process was a Walker-Carter muffle furnace and lead chambers. The oxidized ores being treated in turn by the Caloric Reduction Company's process, which consisted of volatilization of mercury through the mass of the ore followed by a condensation of the same. The process never attained any success and was abandoned. The so-called

[1] Eng. and Min. Jour., Vol. 68, p. 754.

Phelps process was similar to the last mentioned, being tried without success in 1877 at Philadelphia, on North Carolina ores.[1]

Probably the first successful application of the cyanide process to low-grade Southern ores was at the plant of the Colossus Gold Mining and Milling Company in 1904.[2]

The Cyanide process was established at Bodie and the Smuggler-Union mines, Colorado, in 1892 and 1902, respectively. A mill was built at Florence in 1895. There were four cyanide plants at Cripple Creek in 1899, similarly in 1903, three of the four in the latter case being direct acting.[3]

According to the Report of the Director of the Mint for the calendar year 1901, there were eleven cyanide plants in active operation in South Dakota which had a capacity aggregating over 1,500 tons daily.[4]

METHODS OF EXTRACTION.

It is obviously impossible in a work of this character and scope to more than outline the methods and processes employed in the treatment of ores and the extraction of the contained values. But, owing to the fine spirit of coöperation exhibited by the experienced and highly skilled engineers of all countries our technical literature has been enriched by elaborate and painstaking descriptions of the various operations of extraction, which may serve equally well as a guide to those who wish to follow after or deviate somewhat from the beaten path of practice. It is from such sources that much of the information found in the following pages has been derived. Extracts of papers descriptive of the various typical operations which have been successfully applied to certain ores under fixed conditions are given, the selection and arrangement of which have been made with an idea more for brevity and clearness than technical detail.

MILLING.

Reduction. In the treatment of certain ores, either owing to the fineness of dissemination of the useful mineral or metal, or to its being chemically combined, it is obviously necessary to reduce the

[1] U. S. G. S., 20 Ann. Rept., Pt. 6, pp. 121–122, 1898–99.

[2] Min. and Sci. Press, Vol. 88, p. 146.

[3] U. S. G. S., Professional paper No. 54, pp. 138–139, 1906.

[4] Special Rept. Office of the Census Bureau, Mines and Quarries, 1902, p. 602, and Production of the Precious Metals during 1901, p. 201, 1902.

ore to a fine state of subdivision preparatory to the extraction of all or a large part of its values. Authorities differ widely as to the desirable amount of reduction, when done either by stage-crushing or in one operation. The following may be considered as a reasonable degree of fineness for the various machines usually employed.[1]

Crushers reducing to 3 inches or 1 inch; the former for stamps the latter for rolls.

Stamps reducing to Nos. 6 and 9, perforated metal, or 30 to 40 mesh, wire cloth, or .027 to .020 inches for the former.

Rolls reducing to about ¼-inch.

Ball mills reducing to 30 down to 80 mesh and even lower.

Tube mills reducing to practically any degree of fineness.

In special cases where reduction must be carried to the extreme limit of sliming in order to release the values, the ball and tube mills should be employed, which for efficiency and low cost of operation have not been excelled.

As a rule finer crushing should be resorted to when a base silver or gold ore is treated which requires roasting as a preliminary operation to lixiviation.

Reduction is accomplished in modern gold and silver mills by crushers, stamps, rolls and mills, while small scale work may be successfully done in arrastras and crude edge-stone mills.

Breakers are employed for the preliminary work, the amount of reduction depending largely on the subsequent method of treatment, i.e., whether the ore passing the crusher goes to stamps, rolls, or mills. There are two general types of crushers used, namely, the reciprocating-jaw and spindle forms — the former has probably the widest range of application, although possibly not the largest capacity under similar conditions.

Stamps are especially suited to crushing the ores of the precious metals, although under special conditions their capacity may be unduly small. The California form of drop stamp, developed from the German and Cornish forms, is still in general use and has reached a high degree of perfection. However, steam stamps are now in common use and may in time practically replace the more cumbersome and less easily regulated drop or gravity forms.

Rolls may precede or take the place of stamps. The old Cornish forms are now seldom used, other improved forms especially those of high speed, being almost universally employed.

[1] Min. and Sci. Press, Vol. 79, p. 492, and California Gold Mill Practice, Preston, 1895, pp. 24, 227.

Mills, such as the Huntington, Bryan, ball and tube forms, are in many localities wholly replacing stamps, but are probably more largely used as supplementary reducers, as when employed in reducing sulphurets, tailings, etc.

Owing to the prominence of the tube mill at the present time, due to its application in connection with the cyanide process the following description by F. L. Basqui is given.[1] "It consists of a sheet steel cylinder with cast ends, varying in size (the largest mills are five feet in diameter by twenty-two feet long), and supported either upon trunnions or upon steel tires revolving on rollers like a chlorination barrel. The interior of the mill may be lined with cast iron, or a species of natural flint, known as 'Silex.' The latter is the more commonly used, and is sold in two sizes — blocks two and one-half inches and four inches thick. The Silex linings are laid in neat cement and will last from four to eight months, depending upon the ore. When ready to operate, the mill is charged about half full with flint pebbles. The product to be reground is fed into the mill either through a spiral feed or a feed of the stuffing-box type, and the reground material is discharged at the opposite end, being finely comminuted by attrition against the flint pebbles and the lining during the slow revolution of the cylinder. The average speed of the tube mill is from twenty-five to thirty-five revolutions per minute. The fineness to which the sand may be reduced will depend upon several factors, chief among which is the amount of water introduced with the sand. The best proportion has been found to be one part solids to one part water.

"As a machine for economical sliming, that is reducing ore to an extreme fineness, the tube mill has no equal. The cost of tube milling is variable. In this country and Mexico it will range between 20 and 40 cents per ton. The practice at El Oro, Mexico, and at Telluride, Colorado, is representative of the best practice on this continent, while the figures on tube milling at the Combination mine, Goldfield, Nevada, probably represent the maximum of cost, owing to high price of power and labor. A small 4 by 12-foot trunnion mill is installed at the latter property for sliming the forty-mesh product from a Bryan mill. The product of ten stamps, about thirty-five tons of ore per day, passes to the tube mill classifier, and of this product about seventy-five per cent goes to the tube mill, or 24.6 tons per day."

[1] Am. Min. Congress Papers, Vol. 9, p. 54, 1906.

The reader is referred to the following references for detailed information regarding reducing machines.[1]

As stamp mill practice is intimately associated with and is a part of battery and plate amalgamation, a description of the former will be reserved until similar practice in amalgamation is given.

Amalgamation. — The paper on Gold Amalgamation by C. G. W. Locke is an excellent summary of the occurrence of gold, some of its characteristics and the conditions under which it can be treated to the best advantage and with slight loss. Extracts of this paper are given below:[2]

"The natural affinity which exists between gold and mercury, and the ease with which their combination can be broken up again without appreciable loss of either metal, led in very early times to the adoption of mercurial amalgamation as a means of recovering gold from auriferous mineral; and, nothwithstanding the introduction in recent years of many other processes for extracting gold from so-called 'refractory ores,' it is probably no exaggeration to to say that nine-tenths of the gold now being won is obtained by amalgamation. The subject would, therefore, appear still to be worthy of some attention.

"At the outset we come to the question of the state in which gold occurs in nature. On this point there is some diversity of opinion, apparently due to different experimenters working on different ores. But if we admit that in some cases the gold is in chemical combination with tellurium, and, perhaps also with antimony; and that in other cases it may exist as a sulphide soluble in another sulphide (on the authority of Prof. Roberts-Austen); whilst in a third case it may be present as a chloride associated with silver chloride; yet the sum of all these cases will give but a very small figure in comparison with the enormous number of instances in which it is only mechanically associated with the other ingredients of the mineral. It is in this predominating case of the gold being in a metallic state that the amalgamation process is applicable.

[1] The arrastra — Min. and Sci. Press, Vol. 67, p. 277; Ibid., Vol. 74, p. 341, and Ibid., Vol. 78, p. 32. Stamps — T. A. I. M. E., Vol. 25, p. 906; Eng. and Min. Jour., Vol. 60, pp. 221–560; Min. and Sci. Press, Vol. 81, p. 556, and Ibid., Vol. 80, p. 668. Rolls — T. A. I. M. E., Vol. 9, p. 464; Min. and Sci. Press, Vol. 82, p. 250, and Eng. and Min. Jour., Vol. 79, p. 77. Mills — T. A. I. M. E., Vol. 29, p. 776; Mines and Minerals, Vol. 26, p. 488; Eng. and Min. Jour., Vol. 79, p. 511; Ibid., Vol. 81, p. 1010, and Mining Magazine, Vol. 11, p. 405.

[2] Institution of Mining and Metallurgy, Vol. 1, p. 205, 1892, and Gold Amalgamation and Concentration, McDermot and Duffield, 1890, p. 2.

"Before amalgamation can take place, the mineral, or that portion of it which contains gold, must be reduced to a size proportionate to the dimensions of the gold particles. This is a self-evident proposition, but is worth mentioning because it is not always sufficiently recognized. When the gold occurs in relatively coarse grains, associated only with quartz or other equally innocuous materials, then the conditions render amalgamation a comparatively simple and easy proceeding. But, as a rule, this is not the case; and it more often happens that the gold, though in actual metallic grains, is in such an exceedingly fine state of subdivision that it is necessary to reduce the mineral to a practically impalpable pulp, in order to liberate the metal, while the presence of matters other than gold and rock helps to complicate the process of amalgamation.

"It would seem almost superfluous to insist that in all cases amalgamation is a very delicate metallurgical operation, demanding *absolute contact* between the gold and mercury, and that failure is mainly attributable to imperfection of contact caused by the interposition of some other body. So delicate is it that the grease which may be imparted to the surface of a sovereign by mere handling in the fingers will act as a deterrent.

"The chief hindrances to amalgamation having their origin in the ore are:

(1) When the gold particles have been beaten so as to render them very dense and compact.

(2) When their surfaces have become studded with barren rock.

(3) When they have been flattened so as to render them abnormally buoyant.

(4) When they are so minute as to remain long suspended in flowing water.

(5) When they are coated with a film, usually of some metallic salt, (iron oxide, also grease and a film due to hydrogen sulphide).

(6) When sulphurets present in the mineral have commenced to undergo decomposition, whereby sulphates are liberated.

(7) Dirt, etc.

"The first two evils are entirely due to faults in the reducing machinery, and the remedy can only be applied there. Probably their occurrence is too rare to be an important matter.

"The risk of 'float' gold (by which is meant gold that remains long in suspension in water) arising from the causes named in (3) and (4) is much more real, though some authorities affect to disbelieve in its existence. In my experience, it is a potent factor of loss in amalgamation; and while there can be no doubt that flattening does, in some instances, take place in the stamp battery, I am convinced that microscopic fineness of the gold particles is much more often a natural feature than one created by over-stamping. It is a source of waste which is very generally neglected, partly because considerable care and skill are required to determine its extent, and partly because with ordinary appliances, it is almost impossible of prevention. Therefore, where paying returns are got from the coarse gold saved, no trouble is taken to reduce this evil, and hence few mill managers have given that attention to the subject which it deserves. It is only where there is no coarse gold, and where success consequently depends upon saving the fine gold, that the question assumes such importance as to command study. Quite recently I have seen properties in America where, despite the fact that nearly the whole of the gold is free, yet the amalgamation mills built to deal with the mineral have failed, owing, it is said, to the fineness of the gold, and chlorination mills have been erected in their stead. This you may consider to be an extreme case; but Cosmo Newbery found gold at the rate of 42 ounces per ton in some slimes that only coloured the water from a New Zealand ore; and in another instance at the rate of 20 ounces per ton in slimes escaping from Frue vanners. Therefore I repeat that the 'float' gold difficulty is an actuality, and not to be lightly dismissed as imaginary. And to go a step further, I contend that with many ores the gold is so fine that the creation of slimes may be an absolute desideratum, and that to stop short of it may mean leaving gold imprisoned in the grains of mineral. For the advocate of amalgamation to cry out against slimes is simply to admit his inability to grapple with the question. Either he must find a means of dealing with exceedingly fine and float gold, or he must retire in favour of chlorination or some other solution process. I believe, however, that amalgamation can be made to do the task efficiently and cheaply, though not on the lines in vogue now.

"'Coated' gold is not uncommon. In some cases the term 'rusty' is well applied, the native gold particles being shielded by a film of iron oxide. In other instances the gold is rendered black by a jacket of manganic oxide of iron; or the envelope may consist of silica or a silicate of iron; while in the Transvaal it has been asserted that mineral oil, permeating the formation, has proved a serious obstacle to amalgamation. Even ores which have been roasted to drive off sulphur, arsenic, etc., are not always free from the same drawback, as imperfect roasting may result in the gold being concentrated in melted monosulphide of iron, or coated with a skin of magnetic oxide. So pernicious is this coating of the gold that, even when the coat is thin enough to be transparent, the gold will resist amalgamation after weeks of immersion in mercury.

"The presence of only clean sulphurets, especially the common cubical iron pyrites, does not materially interfere with amalgamation. But it is rare to find auriferous mineral which does not contain a larger or smaller percentage of the readily decomposed cupreous, or arsenical, or antimonial sulphides, which on decomposition, seriously affect the usefulness of the mercury, apparently by forming sub-sulphates with it, and adhering to its surface. They thus lead to a double loss — of mercury, which is sulphated and washed away, and of gold, which cannot reach the mercury through the film of sulphate.

"It may appear to be unnecessary to lay stress upon the urgency of starting with clean and pure mercury, yet that is a point often overlooked. Moreover, on exposure to the air, the surface of the mercury will become oxidized sufficiently to hinder actual contact with gold. Another important consideration, which is apt to be lost sight of, is the value of having a good body and large surface of mercury. When the mercury is broken up into a number of tiny atoms, the oxidation of the multiplied surfaces must be enormously hastened, and the efficiency thereby reduced. When the particles become very fine, they are rendered actually valueless as amalgamators, and finally disappear in the tailings, especially in the presence of even small proportions of sulphides undergoing decomposition." *

* McDermott and Duffield give the following table, showing the result of a number of typical gold mills with the small losses experienced:

Name of Mine or Company.	Average of Ore.	Assay of Tailings.	No. of Stamps.
Homestake Company	4 to 4½ dwts.	½ to ¾ dwts.	120
Alaska Mining Co.	5 "	½ to 1 "	240
El Callao	25 "	3½ "	60
Plumas Eureka	7½ "	1 "	60
Yuba	8½ "	½ "	15

" Amalgamation is essentially a wet operation, and cannot be satisfactorily accomplished except in the presence of water. Hence it is of importance to secure water which is free from salts in solution and solids in suspension. Mine waters are especially bad on this account. In a low temperature amalgamation is sluggish, and therefore it is customary to supply heat in cold weather; but summer water is often much less pure than winter water, and decomposition of the sulphurets is more rapid in the presence of heat, so that these two conditions may combine to more than counteract the advantages of genial climate."

The ores to which amalgamation in its various forms is applicable may be classified as follows: [1]

1. Free milling ores from which the gold can readily be extracted by the application of mercury to the pulverized ore.

2. Ores of high- or medium-grade which do not amalgamate well even though the amount of sulphides present is small.

3. Ores running high in sulphides.

4. Ores in which the gold-content is chemically combined or enclosed in a coating of some metallic salt.

Following plate amalgamation the pan or barrel process should be employed and may effect an economical treatment when the former method fails. The patio process is also applicable to the same ores as pan amalgamation, and was in fact the forerunner of that method of treatment.

The various methods of amalgamating gold and silver ore are described in the order of their development, namely, the patio process, plate, pan and barrel amalgamation.

As the patio process originated in Mexico it is but natural to expect to find it developed to its highest state of perfection there. For which reason the following descriptions are taken from Mexican practice: [2]

" The ore as it comes from the mine is generally sorted near the top of the shaft, and broken into pieces not exceeding the size of a hen's egg. In this state it is carried to the *hacienda de beneficio* or reduction-works: these consist of a series of buildings containing the various machinery, stores, etc., placed round one or more large

[1] Gold Amalgamation and Concentration, McDermott and Duffield, 1890, p. 25.

[2] Federated Institute of Mining Engineers, Vol. 9, pp. 162–167.

stone-paved courtyards or patios. The ore is then crushed in a *molino* or mill; usually this is in the form of a Chilian wheel, consisting of a circular stone-paved dish about 6 to 12 inches deep, and 10 to 12 feet in diameter, with a wooden or stone post in the center 3 to 5 feet high. To this is pivoted a horizontal shaft or axle on which runs a vertical stone roller, 6 to 10 feet in diameter and 12 to 18 inches wide; the outer end of the shaft projects beyond the circular path of the roller and one or more mules or horses are harnessed to it, and by going round in a circle cause the roller to crush the ore. One of these mills with nine mules, working three at a time for three hours, will crush about 6 tons in twenty-four hours, or one with a cast-iron bottom will crush 8 tons, but the presence in the latter case of metallic iron in the crushed ore is said sometimes to interfere with the reduction. Occasionally a stamp mill is used generally of eight stamps, with wrought-iron heads and wooden stems, driven by spur-wheels, actuated by mules or horses. A mill of this kind driven by twelve mules, three at a time, will crush 4 to 6 tons in twenty-four hours, and for labor will require in that time two *arreadores* or drivers, and five or six boys to feed and carry away the ore.

"The *granza*, or crushed ore from the stamps is then taken to the *arrastras* or *tahonas*, where water is added. These consist of a circular stone pavement about 12 feet in diameter, round which is a curb of wood or stone forming a water-tight tub about 2 feet deep: in the middle is a block of wood or stone containing a footstep in which works the iron pivot on the foot of an upright shaft, the top of which is carried by a journal on a horizontal beam. This upright shaft carries two or four horizontal arms to the outside ends of which mules or horses are harnessed, and from each of these is hung, by two cords or chains, a *voladero* or runner of stone, 3 to 4 feet long 1½ to 2 feet wide, and 12 to 15 inches thick which drags over the stone bottom and so grinds the ore (in some cases cast-iron bottoms are used).

"An ordinary *arrastra* driven by four mules, working two at a time for six hour shifts, will grind from ½ ton to 1½ tons in twenty-four hours; at Fresnillo, when driven by steam-power a 12 feet *arrastra* will grind 1½ tons, and one 16 feet in diameter 3 tons in eight hours. Two men, or one man and one boy will look after and charge five ordinary *arrastras* in the day time, and one man will look after ten or twelve at night. The water used is generally one and a half times the weight of the ore.

"When sufficiently ground, the liquid ore now called *lama* is either ladled out of the *arrastras* into barrels and carried, or run out through spouts, into the *lameros* or settling-tanks, where it partially dries. When a sufficient quantity has been collected to form a *torta*, it is taken out on to the patio and placed in a semi-liquid state between planks made tight with horse-dung, where under the clear sky and rarefied air it soon dries sufficiently to be ready for treating. A *torta* may contain any quantity from 15 to 80 tons, according to quality of ore, time of year, size of plant, or other circumstances. A common size is about 50 tons which when ready for treading will occupy a circle of about 50 feet in diameter and 10 to 12 inches thick.

"The operations are now taken in charge of by the *azoguero* or amalgamator (a word derived from *azogue* or mercury).

"The first proceeding is to sprinkle salt over the *torta*, in quantity varying from 2½ to 6 per cent of the weight of ore. This salt is sometimes obtained from the coast, but generally from inland salt-lakes, in which case it is often very impure. The *torta* is then turned over with shovels, and has its first *repaso*, or treading by eight to fifteen animals, for 4 to 5 hours; one or two men with bare feet and legs, standing near the middle, hold cords attached to the halters of the mules or horses, and drive them in circles commencing from the outside of the *torta* and working towards the center, and taking care that every part of it shall be well trodden and mixed.

"Twenty-four hours after this, *magistral* is added. This is prepared by slowly roasting in a reverberatory furnace a mixture of copper and iron-pyrites to which a little salt has been added. The sulphate of copper formed by this process generally amounts to between 20 to 40 per cent of the whole, and is the chief agent in reducing the ore, although the salts of iron assist. The quantity of *magistral* used varies, according to its quality and the variety of ore, but is generally from 1 to 2 per cent, of the weight of the ore. Sometimes sulphate of copper is used instead of *magistral*, when 5 pounds to the ton of ore is generally sufficient. Less *magistral* is used in winter than in summer. After adding the *magistral*, the *torta* is trodden for an hour, and then the first quantity of mercury, called the *encorporo*, is added; this is generally about two-thirds of the quantity intended to be used for the reduction, which is usually about six times the weight of the silver expected. The mercury is squeezed through a canvas bag so that it may fall on the *torta* in finely-divided globules, and a further *repaso* takes place immediately afterwards. Sometimes the salt, *magistral,* and first quantity of mercury are added to the *torta* together.

"After the salt, *magistral* and mercury have been added to and mixed with the *torta,* chemical action commences, and is watched carefully by the amalgamator by means of trials of samples (*tentaduras*) of about 8 ounces each, taken from twenty or thirty different parts of the *torta,* and washed in a *jicara* or vanning-horn. This has been compared to a mirror in which the *azoguero* can see what is going on in the *torta.* On the first trial, soon after the *repaso,* on stirring the contents of the spoon with the fingers, and agitating it at the surface of a vessel of water, the light dirt is washed off, and the remaining metallic substances and mercury are closely examined. At this stage the mercury contains but little silver, and its color and state of division give the only indications of the working of the *torta.* If the color is natural or slightly bronzed the reaction is too slow, the *torta* is cold, and more *magistral* is wanted; if the surface is moderately grey, all is going on well, but if it is dark grey and the upper part of the *tentadura* shows ashy-grey powder, *descho,* which will not unite into globules, the reaction is too rapid, the *torta* is hot, the *repasos* must be stopped, and lime or ashes added to reduce the loss of mercury. Generally, the color of the mercury guides the proportion of *magistral,* the condition of the *limadura* indicates the daily progress, and the solidity of the amalgam determines the addition of mercury and the end of the operation.

"Twenty-four hours after the *encorporo,* if the proportion of *magistral* is right, and the process doing well, amalgam will be found in the mercury, little *desecho* is seen, and the *limadura* is coarser and more consistent, and it can be compressed by the thumb into *pastillas* or lozenges.

"When the *limadura* becomes dry, and will not give a drop when pressed by the thumb, more mercury is added to the *torta* in small quantities; this is called *cebar* (to feed it).

"The whole process lasts from fifteen to forty days, according to the quality of the ore and the season of the year, taking longer in winter. The *repasos* required vary in number from eight to twenty or twenty-five, and generally take place every two days, or every day if required, a torta of 50 tons requiring six or eight animals for six hours at a time. They are more frequent in winter than in summer, and they hasten the process when frequently used. In an experiment, two *tortas* of the same ore were put on the patio at the same time, one with eight *repasos* of five or six hours at intervals of three or four days took twenty-seven days, the other trodden day and night by the same number of animals took eighty hours. The yield of silver and loss of mercury were about the same, but the increased speed did not pay for the extra cost of labor.

"When the chemical action has ceased, and the silver which can be extracted has been taken up by the mercury, the *torta* is then said to be *rendido* and the operation is finished.

"The chemical reactions which take place during the process are complicated and difficult to understand. The ore contains native silver, chloride of silver, and the sulphides of various metals containing silver; the general result is that the sulphate of copper and chloride of sodium (salt) react on each other, and on the sulphide of silver, converting the latter into chloride, in which form it can be reduced by the metallic mercury.

"In the Zacatecas district, then the *torta* is finished (*rendido*), a further quantity of mercury, called the *baño* or bath, often amounting to four-fifths of the quantity already used, is generally added, and after one more *repaso* the ore is carried in tubs or hand-barrows to the *lavaderos* or washers (circular tanks of wood or masonry with the bottom formed of one stone). These tanks vary in size, but are often about 9 feet in diameter by 6 feet deep; they are fitted with vertical shafts carrying stirrers, the stirrers of two tanks being driven by a mule-gin. Each tank will wash 2½ tons per hour, the ore is put in, in small quantities, water being run in at the same time and the stirrers kept revolving. The mud and water are tapped off through holes in the sides, and the amalgam, which, owing to the quantity of mercury added in the *baño* is very liquid, is left in the bottom and ladled out into bowls or *bateas*. A good deal of amalgam goes away in the slimes from the washers, and these are rewashed by hand on *planillas* or sloping-tables, but much is still lost. At Guanajuato, the ore passes through three washers, one after the other, which is a better system and saves some of this waste.

"The amalgam from the washer is taken to a room called the *azogueria*, where it is filtered through a strong leather bag (*manga*) with a canvas bottom, attached at the top to an iron ring suspended from a beam. The mercury gradually passes through the canvas into a bowl beneath, leaving in the *manga* a pasty mass of amalgam still containing four to five parts of mercury to one of silver. This is emptied out of the *manga* on to a leather-covered table, and pressed into moulds about 3 inches thick, of such a shape that six of them, when put together form a circular cake, with a hole through the middle. Each piece (*marqueta*) will weigh about 20 pounds. These cakes are piled up into a column on a grating under a copper or cast-iron bell (*capellina*) about 3 feet high, 18 inches in diameter, and 1½ inches thick, which is raised or lowered by a capstan; the base of this fits into a hollow in a stone or iron base-plate through which cold water is constantly kept running. An annular fire-place of stone, adobe, or iron, is built round the bell and filled with wood or charcoal, which is fired for from eight to twenty-four hours. As the heat volatilizes the mercury, it is condensed by the cold water and runs through an iron pipe into a special reservoir. . . .

"From 2,000 pounds of amalgam one should obtain 400 pounds of silver, almost free from mercury. The silver forms a porous spongy mass; it is generally very pure, running over 990 fine; it is fused and cast into bars, and the greater part of it is taken to the various mints, where it is coined into Mexican dollars.

"The loss of mercury in retorting, when carefully done, is very small, sometimes as low as one ounce in 100 pounds. Out of a batch of 170 pounds of amalgam which the writer saw retorted in flasks in February, 1894, the loss was about 4 ounces."

"To-day, in the adjoining Loreto mill (to the Purisima) of the Real del Monte Company,[1] the process has reached its highest stage of development, and successfully competes with other processes for the extraction of silver from these ores.

"As employed at Loreto, the *patio* process enjoys all the benefits of modern methods. The ore, which assays 1 to 1.25 kilograms of silver per metric ton (29 to 36 ounces per ton of 2,000 pounds) and 5 to 6 grams of gold per metric ton (0.14 to 0.17 ounces per ton), is crushed in steel chilean mills and passed through 80-mesh wire cloth. Repeated experiments have demonstrated that fine grinding is one of the principal factors in obtaining a high extraction of silver. The ore from the chilean mills is concentrated over Johnston tables; the concentrate, assaying 10 kilograms (292 ounces) of silver and 60 grams (1.74 ounces) gold per ton, and containing, therefore, 35 per cent of the total silver and gold in the ore, is shipped to Germany.

"The residue, assaying 800 grams (23 ounces) of silver and 4 grams (0.12 ounces) of gold per ton, is treated in the *patio* in the

[1] Eng. and Min. Jour., Vol. 79, p. 564.

Patio Mills at Pachuca, Mexico. (From Mining and Scientific Press.)

usual way with salt, sulphate of copper and quicksilver. The *torta* is laid in a long rectangle, 10 inches thick, and resembles in appearance a stretch of muddy road. Instead of horses, plows operated by electric motors move slowly up and down through the *torta*, turning over every part and exposing it to the sun's rays. The extraction is 90 per cent of the silver and 30 per cent of the gold contained after the first concentration.

"After amalgamation in the *patio*, the residue is twice concentrated over Wilfley and Johnston tables, the final concentrate, assaying 1.25 kilograms (36 ounces) of silver and 25 grams (0.72 ounces) of gold per ton, being shipped to Mexican smelters. The gold-silver bullion obtained from the *patio* is parted in the Loreto mill with sulphuric acid, the silver being precipitated by copper. The sulphuric acid is manufactured on the ground, and the copper sulphate, obtained as a by-product, is used in the *patio*. . . .

"Electric power is used throughout the mill, and no fuel is required except to retort the silver amalgam.

"It is not unlikely that the introduction of electric power will again place the *patio* process in the front rank for the treatment of clean silver ores in warm, dry climates such as that of Mexico, where there is a scarcity of cheap fuel; and the rejuvenation of the process in Pachuca, the place of its origin, reflects great credit on the ability of the metallurgists of that district to adapt themselves to, and make the fullest use of, new conditions."

Plate and Barrel Amalgamation. — These processes may be included in stamp mill practice, which also includes inside- and outside-plate amalgamation, or both, and concentration of the sulphurets by blankets, tables, etc. Descriptions of the operations in a number of the large mines of the United States are given, which will serve to illustrate a variety of practice.

Gold-milling practice as exemplified by the operations in the gold belt of South Dakota is described by T. A. Rickard in his excellent paper Gold-Milling in the Black Hills and at Grass Valley, extracts of which are given herewith: [1] "The ore is dumped at the shaft's mouth into the rock-breakers. At the time of Prof. Hofman's investigations, all the Homestake mills were using the Blake, and the Caledonia had just introduced a Gates crusher. Since that time the Gates has replaced the Blake rock-breaker in every mill on the Belt. Furthermore, the rock-breaker is now placed in the shaft house instead of at the mill. This follows the tendencies of modern practice

[1] T. A. I. M. E., Vol. 25, pp. 910, 918, 921 and 922, 1895.

in California, where the crusher at the mine delivers the broken ore to the tramway, which carries it to the mill, or sometimes to a second rock-breaker. The latter arrangement relieves the stamps of the hard work of stone breaking, facilitates pulverization in the mortar and gives uniform conditions more favorable to successful amalgamation. . . .

"All the batteries are placed upon flat sites in two rows back to back, save at the Father de Smet, where two rows of batteries face each other and discharge toward the center of the mill. The latter arrangement gives a larger storage capacity to the bins overhead, but this advantage is obtained at the greater cost of darkening the amalgamating-tables.

"The mortar is the most interesting feature of the Homestake mills. The changes in the dimensions made since 1888, the date of Prof. Hofman's paper, are as follows:

	1888.	1895.
Weight	5400 pounds	7300 pounds
Length of base	54¾ inches	56¾ inches
Width of base	27¼ "	28¼ "
Height	54½ "	58¼ "
Inside width at the level of the lip	13½ "	12½ "

"The Homestake mortar combines, to a notable degree, the two excellent features of a rapid discharge and a high percentage of amalgamation. Its width at the issue used to be 13½, was then diminished to 13, and in the newest design is 12 inches. The depth, by the introduction of chuck-blocks, is raised to from 9 to 11 inches. The mortar becomes thereby both narrower and deeper than the Californian pattern, its narrowness compelling a rapid expulsion of the pulp, and giving the mill a capacity nearly twice that of the average Californian battery when working ore of similar character. At the same time the depth of the mortar prevents the scouring of the inside plate, and permits the arrest of the gold by this plate, and by the free mercury added with the ore, so that the percentage of extraction follows closely in the wake of the roomy mortar of the Colorado mill, the crushing capacity of which is only one-quarter that of the Homestake. The following comparison will be of interest:

COMPARISON OF TYPICAL MILLS.

	Width at Issue.	Depth of Discharge.	Weight of Stamp.	Number of Drops per Minute.	Height of Drop.	Crushing Capacity per Stamp per 24 Hours.
	Inches.	Inches.	Lbs.		Inches.	Tons.
Golden Star, Deadwood, S. Dakota	12½	9 to 11	850	85	9½	4
Hidden Treasure, Black Hawk, Col.	24	13 to 15	550	30	17	1
North Star, Grass Valley, Cal.	17½	4	850	84	7	1½
Pearl, Bendigo, Australia	15	3¼	840	74	7¼	2¼

"It will be seen how closely the crushing capacity is related to the interior width of the mortar at the level of the issue. Notwithstanding its rapid crushing, the Homestake mortar retains a percentage of the total gold extracted which compares well with any of the other districts, and is superior to some of them, though this factor will be affected by the variety of screen in use. . . .

"The process of gold-extraction consists of amalgamation within the mortar upon outside plates and in traps, supplemented in a rudimentary way by an inadequate effort to concentrate the sulphides of the tailings.

"The mortar becomes an amalgamating apparatus by the use of the inside copper plate and the addition of free mercury. About 50 per cent of the total amalgam is obtained from these inside plates. At the Deadwood-Terra the proportion reaches 70 per cent. . . .

"On issuing from the battery the pulp falls from 6 to 10 inches before striking the aprons or first amalgamating-tables. This serves no particular purpose, while the actual damage possible to the plates by the scouring of their surface due to the impact of the pulp is obviated by the interposition of a splash-board, which breaks the fall of the sand and water. This splash-board might be placed at such an angle as would permit of its use as an amalgamating device by lining it with a copper plate

"In the Homestake Company's mills the aprons are 10 feet in length and 4½ feet wide. Those in the Highland mill are only 8 feet long. In all these mills two apron-plates deliver the pulp to one tail-plate having a size equal to one apron. At the Deadwood-Terra the aprons are somewhat larger, namely, 11 feet by 4 feet 8 inches, but the tail-plate is 8 feet long and only 16 inches wide. The latter is called, very appropriately, a sluice-plate, and is a truly absurd devise for arresting the gold.

"In the Homestake mills, both apron- and tail-plate have a slope of $1\frac{1}{2}$ inches per foot, the minimum gradient at which the tables can clear themselves of the pulp. Both tail-plate and apron are dressed each morning, the aprons are cleaned up partially each day, and more completely deprived of their amalgam at the bi-monthly general clean-up, when both the tail-plates and the inside mortar plates are gone over.

"The traps are intended to arrest escaping amalgam. The Golden Star mill has two at the head of the tail-plate. They are 18 inches deep. They are preceded by a shallow trap or riffle 2 inches deep, which is stated to do better work because of the more regular passage of the pulp. These traps catch about 1 per cent of the total amalgam."

Further practice in gold-milling is given in the excellent paper of R. A. Kinzie on the Treadwell Group of Mines, Douglas Island, Alaska.[1] Extracts of this paper are given below: "The character of the ores on Douglas island is peculiarly adapted to the simple methods of extraction in use. As explained above, the gold is contained in an altered syenite in the form of free gold, and in the sulphides, the principal gold-bearing minerals being iron pyrites, arsenopyrite, molybdenite and calcite. The ore on the surface has been subject to little oxidizing action, and, perhaps, that on the lowest level is even more free-milling than that in the surface-pits. . . . 48.04 per cent of the gold is caught on the plates by amalgamation, and the balance, or 51.96 per cent, is contained in the sulphurets and tailings. . . .

"The crushers are located in the head-frames of the various mines, and are of the gyratory type. When the ore is hoisted out of the mine it is spilled by self-dumping skips on to a grizzly formed by 1 inch by 10 foot pieces of iron, bolted together by 1 inch iron bars, and placed 2 inches apart by disc-shaped pieces of cast-iron. The over-size from the grizzlies goes direct to the crushers, and the under-size passes through and falls into the ore-bins situated directly beneath the crushers.

"Too much stress cannot be laid upon the great effect of efficient crushing as related to the duty and output of a stamp mill. This is particularly true on the island, where the crushing capacity is in

[1] T. A. I. M. E., Vol. 34, pp. 362–382, 1904.

excess of the demand and where there is abundant water-power which costs practically nothing. During the past year the duty of the mills has been increased over 1 ton per stamp in 24 hours, and without a doubt, 50 per cent of this increase has been caused by setting the crushers to break the rock 20 per cent smaller than before. An efficient crushing-plant for mines similar to the Treadwell would consist of four Gates-crushers arranged in pairs, one above the other, the upper to be of such a size that they would receive rocks 18 by 36 inches, and the lower to turn out a product not larger than 1.5 inches in diameter. The rock when hoisted would be dumped on grizzlies with 5-inch spacing between bars: the over-size going to the upper crushers and the under-size falling on a second grizzly with bars set 1.5 inches apart, — over-size going to the lower pair of crushers and under-size passing into the storage-bins. The product from the upper pair of coarse crushers to be spilled on a grizzly with bars 1.5 inches apart, the over-size going to the lower crusher and the under-size and crushed produce from the lower crushers falling into the bin. If the above method were used it would do away with a great deal of the bull-dozing and rock-breaking in the mines, making a very appreciable reduction in the cost of mining. . . .

"In the 300-Treadwell and 240-stamp mills, the stamps are arranged back to back, and the bottoms of the bins are made in the shape of an inverted V, so that the ore will be equally divided and fed uniformly to the stamps on either side. In the other mills, where the stamps are arranged in a single row, the bottom of the ore bins, from a point 8 feet below the track is given a slope of 45 degrees to the open ore-chutes at the level of the cam-floor. The bins are double-boarded, and on the side next the stamps are lined with 0.25-inch steel-plate, to protect them from the scouring action of the rock. From the bins the ore is taken out by openings at the level of the cam-floor, and conveyed by chutes to the hoppers of the Challenge-feeders. There is one chute and feeder for each five stamps. The 300-Treadwell, Ready Bullion, and 700-Foot mills are provided with the suspended Challenge-feeders. These are preferable to the Standard feeders, being more compact and very accessible for repairs. Both types are central feeders, the bumper-rod being placed next to the central stamp and guided in the usual way.

"There are three different kinds of mortars in use on the island. The 300-Treadwell, Ready Bullion, and 700-Foot mills use the

Fraser and Chalmers, No. 67-A type; the Mexican uses the Fraser and Chalmers No. 67, while the 240-Treadwell mills uses a special mortar made by Moran Bros. of Seattle, Wash. End- and side-liners are used in all the mills; and false bottoms are used, except in the 240-Treadwell mill, where the die rests on the bottom of the mortar. The false bottoms and liners are cast at the company's foundry, which does excellent work. The false bottoms in use consist of a piece of cast-iron 3 inches thick, and of the size and shape of the flange-portion of the die. Their object is to protect the bottom of the mortar from excessive wear.

"The stamps in the 300-Treadwell, Ready Bullion, Mexican, and 700-Foot mills, weigh 1,020 pounds, while those in the 240-Treadwell weigh when new 850 pounds. The stems, tappets, boss-heads and shoes are joined in the usual manner. The Koppel shoe is used in all the mills. A shoe lasts 3 months and crushes 489 tons of ore, which means that 0.27 pounds of iron is consumed per ton of rock crushed. The dies are cast at the company's foundry and last on an average 4.49 months, crushing 732 tons and consuming 0.16 pounds of iron per ton crushed. . . .

"The free gold is caught both inside and outside of the mortars by means of quicksilver. There is a diversity of opinion among the various amalgamators as to where, when, and in what quantities the quicksilver should be fed. The result of a series of tests in the various mills shows that the quantity of quicksilver fed in the mortars and on the plates varies directly with the gauge of the screen, and, consequently, with the coarseness of the ore. The coarser the crushing, the more quicksilver it is necessary to add to the mortars to make any saving at all.

"On the other hand, the scouring action of the coarse sands on the plates necessitates frequent dressing to keep them well coated with quicksilver. It was the practice up to 1901 to keep the plates very wet, and even though the crushing was much finer an excessive amount of quicksilver was used; . . . although the tonnage crushed per stamp has shown a marked increase, the quantity of quicksilver used per ton is only about one-half the quantity formerly used.

"The only amalgamated copper-plates used inside the mortars are the chuck-blocks. Two sizes are used at present (the 4-inch and 6-inch in height), but very little amalgam is collected from them. Formerly, they furnished 13.7 per cent of the amalgam collected, but since the fine screens were replaced they collect practically no amalgam, except during short periods in the winter when salt water is used. At these times the chuck-blocks become coated, but as soon as fresh water is again used the amalgam is scoured off, leaving the copper bare.

" The diagonal slot-screens which are used in all the mills are made of No. 23-gauge heavy Russian iron. Both the No. 4 and No. 5 are in use, these being equivalent to the 20 and 18-mesh wire screens, and are mounted in frames in the usual manner. Two widths are used, viz: 9-inch and 12-inch, — the former giving the better satisfaction.

" A screen lasts about seven weeks in all the mills except the Ready Bullion, where it lasts only fifteen days. Salt water is used in this mill, and the corroding action seems to be intensified by the scouring of the sands in the mortar, which keeps the inside surface of the screen bright, thus always furnishing a fresh surface for the action of the water. These screens do not wear out as in the other mills, but become brittle and break.

" Experiments are now in process with a make of iron-wire screen, but they have not advanced far enough for any conclusion to be reached.

" The motion of the battery-water, caused by the falling of the stamps, throws the pulp against the screen, and all particles fine enough pass through it and fall on the lip of the mortar. At the edge of the lip are placed two dash-boards arranged in steps to stop the rush of the water and sand, and cause it to drop in a steady flow on the apron-plates, which are placed immediately in front of the lip of the mortar, with the upper edge under the lip. This diminishes the scouring action, allowing the amalgam to collect near the upper end of the plate. The amalgam here is kept harder than at the lower end. This allows the lower end of the plate to be kept quite wet, which gives a better chance to catch the finer particles of gold that otherwise might float off.

" These plates are made of the Lake copper, $\frac{3}{16}$ in thick, 4 feet wide, 10 feet long, and are given a fall of 1.5 inches to the foot. The plates are prepared in the usual manner by cleaning with a weak solution of potassium cyanide and rubbing in quicksilver until the upper surface is thoroughly amalgamated. While in use they are dressed with quicksilver twice a day, and the time taken for dressing should not exceed four minutes per day.

" At the lower end of each plate is placed a wooden trough lined with copper, called the tail-box, where very little amalgam is caught. From the tail-boxes the pulp is conveyed through 3-inch pipes to the mercury-traps. These traps are made of cast-iron in the shape of a four-slided truncated pyramid, having the smaller end down. The trap is 14 inches square at the top, 15.5 inches deep, with the lower end 6 inches square. In the bottom is a 2-inch tap closed by a plug for drawing off the contents when cleaning up. Inside the trap is a block 14 by 8 inches on top, 11 inches deep and 8 by 8 inches on the bottom. The pulp from the table enters the trap through a 3-inch pipe that reaches to within 2 inches of the bottom. It then flows up through the space between the trap and the wooden block, and thence over the block into the discharge-launders.

"These boxes are usually suspended under the battery-floor and from them the pulp flows through launders, where it is divided and conveyed by 3-inch iron pipes to the distributing-boxes of two vanners.

"On the floor of the distributing-box of each vanner is placed an amalgamated copper-plate, varying with the size of the vanner used, those on the 4-foot vanner being 18 inches by 3 feet 4.75 inches, and on the 6-foot vanners 18 inches by 5 feet 9 inches. From this plate the pulp flows over the vanner, the heavy particles, including sulphurets and some free gold, being saved, while the lighter pass over the tail of the vanner into the tailings-launders, which discharge into Gastineaux channel . . . . 48 per cent of the value contained in the ore is recovered by concentration. For purposes of concentration two sizes of Frue vanners are used: the 4-foot and 6-foot. These vanners are so arranged that the pulp from 5 stamps is divided between 2 vanners. This style of concentrator is very well adapted to the ore. . . . The wear and tear on the machines is very light in all the mills, with the exception of the Ready Bullion, where the vanners get more than their share of the destructive effects of salt water in use.

"When a stamp is crushing 5.6 tons of ore in 24 hours, each stamp requires 4.25 gallons, and each vanner 1.5 gallons, of water per minute. In the mills where the 4-foot vanners are used they are overloaded. This accounts for both sizes of vanners using the same amount of water.

"There is a little less than 2 per cent of concentrates in the ore. The concentrated product has a value of about $51 per ton in all the mills, with the exception of the Ready Bullion, where the concentrates assay about $35 per ton.

"In connection with each mill is a storage-bin for concentrates, holding about 400 tons. These bins are situated near the mill, and when the concentrates have been collected at the vanners and shoveled into cars, they are trammed to a small hydraulic elevator which raises the loaded car to the level of the top of the bin, where it is dumped. From these storage-bins the concentrates are drawn off through chutes into special cars holding 2.5 tons, and hauled by locomotives to the wharf, where they are dumped through chutes directly into the hatches of the barges which transport the concentrates to the Tacoma Smelter, where it is treated. . . .

"The clean-ups in the various mills are all conducted in the same fashion, and are so regulated that they will be finished by the fifteenth of each month.

"The first day of the clean-up is devoted to the amalgam traps, and the tank in the amalgamating-room.

"To clean a trap, 5 stamps are hung up and the feed-water shut off. When the pulp has ceased to flow through the trap, the wedge that holds the wooden center-piece is loosened and the center-piece removed, first being carefully washed to cleanse it of any adhering amalgam. Then the tap in the lower end is opened and the contents of the trap allowed to flow out into a small launder, which conveys the material to a central tank. The trap is then carefully washed out, the tap and wooden center-piece replaced, and it is ready for use. It takes an average of 5 minutes to clean each trap. When all the traps have been cleaned, the contents of the receiving-tanks after being roughly washed is collected and taken to the amalgamating-barrel for further treatment. In the meantime the contents of the tank in the amalgamating-room has been removed. This is added to the product from the mercury-traps, and the total charged into the amalgamating-barrel.

"This barrel is made of cast-iron, 20 inches in diameter and 4 feet long. It is supported in a horizontal position by iron trunnions cast in the head, and is driven at the rate of 15 revolutions per minute by a belt leading to one of the vanner-counter shafts.

"The barrel is charged through a hand-hole in the top, which can be hermetically sealed; from 300 to 500 pounds of ore constituting a charge. From 75 to 125 ounces of mercury is then added, 6 iron cannon-balls put in to act as grinders, and the barrel filled with water. The hand-hole cover is then put on, and the barrel started revolving. The charge is left in the rotating-barrel 12 hours; the barrel is then opened and the charge allowed to run out into the amalgamating-pan. This pan is made of cast-iron 4 feet in diameter. Around the edge, with the exception of a space 8 inches wide, to serve as an outlet, is a rim 2.5 inches high. The bottom is made slightly concave to resemble a Mexican *batea*. The concentrating motion of the *batea* is imitated as closely as possible. This is obtained by means of an eccentric belt, driven from one of the countershafts of the mill. When the barrel is stopped, the cannon-balls are taken out and put in the pan, which is immediately started. By the motion of the pan the heavy contents are concentrated in the middle, while the lighter are washed off by means of a stream of water flowing through it, the concentrated product being kept in motion, and at the same time ground, by means of the cannon-balls.

"When the concentrate is cleaned of all light material the pan is stopped and the pieces of iron, etc., removed. The amalgam is then put in a pan, the finer particles of iron removed by means of a magnet, and the other foreign material by a sponge or other means. When the amalgam is clean it is put in small cloth bags and the quicksilver pressed out by means of a hydraulic ram, designed by one of the mill-foremen. The pressed cakes of amalgam are weighed and sent to the assay-office to be retorted and melted into bullion.

"The second and succeeding days are devoted to the cleaning of the batteries and amalgamating-plates. These are cleansed at the rate of 4 batteries of 5 stamps per day. (In the Treadwell 300-stamp mill, 5 batteries are cleaned per day.)

"To clean up a battery the feed is shut off, and the stamps allowed to drop until they begin to pound on iron, then they are hung up. The water is then shut off, and the splash-boards, curtains, screens and check-blocks are removed. The water remaining in the mortar is dipped out, and the coarse sand around the top of the dies shoveled into buckets to be put back into the mortar when the clean-up is over. The lip of the mortar and the plates are then carefully hosed off (a trough being first put in the tail-box to catch any loose amalgam) and the entire surface of the plate covered by a wooden cover for steaming. A space of 0.75 inch is left between the cover and the plate by means of three slats 0.75 inches thick nailed to the bottom of the cover. Sacks or other coverings are placed over the ends and edges to prevent the escape of steam; the end of a steam-hose is then introduced through a hole in the cover, the steam turned on and allowed to remain so from 20 to 30 minutes. In the meantime a second battery is prepared, and any renewals made ready, so that no time will be lost when the mortar is cleaned out. While the plate is being steamed the chuck-block is cleaned of any adhering amalgam, recoated with quicksilver and is ready to be replaced; while the sand-distributing box on the vanners, corresponding to the batteries shut down, are taken off and the amalgam removed from the copper-plate by means of chisels. This amalgam is collected, the plates dressed in the usual manner, the distributing-box replaced, and the vanner is ready for starting. When the plate has been sufficiently steamed, the steam is shut off, and the cover removed and taken to the next plate that has already been prepared for its reception. The steamed plate is then allowed to cool for a few seconds, when the operation of removing the amalgam commences. This is done by scraping the plates with sharp chisels, and as much amalgam as possible is removed without exposing the copper. The amalgam is then collected, taken to the amalgamating room and locked up for further treatment.

"Two men now begin work on the mortar, and to protect the plates a wooden platform is placed at the head for the men to stand on. If there are no renewals necessary (but this is unusual) only a portion of the sand is taken out. If necessary the shoes are removed by driving a wedge through the eye left in the boss-head just above the end of the shank of the shoe and forcing it out. The sand is then dug out of the mortar by means of sharp-pointed hand-picks and scoops, the die and liners removed, and the mortar thoroughly cleaned. All pieces of iron, together with the worn-out shoes and dies and liners, are taken to the amalgamating-room to be thoroughly cleaned, and the heavy sand taken to the clean-up barrel.

"The liners and false bottoms are then put in and the die set on the false bottom, while the fine sand first removed from the mortar is tamped around the die to hold it in place. The shoe is then set on the top of the die with a collar of wooden shims around its neck. A 3.25-inch block is then placed on the top of the neck of the shoe, and the stamp lowered until the boss-head rests on the block. The keys of the tappets are loosened, and the tappet is allowed to fall down to the finger, where the keys are tightened. If the shoe has been removed a 9.25-inch block is placed on top of the die and the tappets set as above. Each stamp is then successively dropped and hung up, when the shoe is firmly fixed in the boss-head. The recesses for the chuck-block, screens, etc., are washed out, and the chuck-block, screens and dash-boards put in place. The plate is then washed with a weak solution of cyanide, when quicksilver is sprinkled over its surface and thoroughly rubbed in with whisk brooms. The quicksilver is evenly distributed by rubbing with cloths moistened with a weak solution of cyanide. Some ore is now fed into the mortar, working the feeder by hand, the water turned on, the small clean-up trough removed from the tail-box and the stamps allowed to drop. Particular care is paid to the feeding of ore when the stamps are started, as the mortar is empty of all ground material.

"The heavy sands from the mortar are treated in the clean-up barrel in the manner described above, while the amalgam removed from the plates and chuck-blocks is simply ground in the clean-up pan and the amalgam cleaned in the usual manner."

In order that the reader may familiarize himself with the practice in other localities, the following references are given: [1]

The following brief summary of pan amalgamation is given in Gold Amalgamation and Concentration: [2]

"After copper-plate amalgamation, the next simplest and most economical process is that of pan amalgamation, which is adopted either on the raw or roasted ore. Usually roasting of gold ores is unsatisfactory as a preparation for amalgamation, and puts part of the gold in a condition most unfavorable for allowing contact with the quicksilver; besides involving often a loss of gold in the actual roasting, sometimes even to a very marked extent. In roasting some gold ores it is found advantageous to add a small percentage of salt to the charge, but on other ores this increases largely the loss of gold by volatilization.

"In some exceptional ores, where there are practically no base metals present, roasting can be adopted without these ill effects; but even then its commercial advantages must be carefully considered. The roasting operation is frequently effective in softening and cracking the hardest rock particles, so as to facilitate grinding in the pan, and consequently improving the amalgamation. This is also found to be the case in preparing a free ore for chlorination, as the gas will better penetrate the particles and attack the imbedded gold.

"The old fashioned stone arrastra, though slow, is an excellent

[1] Arizona—T. A. I. M. E., Vol. 25, p. 130, 1895; California—T. A. I. M. E., Vol. 24, p. 208; Colorado — Eng. and Min. Jour., Vol. 78, p. 911. Bull; Colo. School Mines, Jan. 1905, and Mines and Minerals, Vol. 27, p. 341; Montana — Mines and Minerals, Vol. 26, p. 492; Nevada — Eng. and Min. Jour., Vol. 81, p. 1236; South Dakota — T. A. I. M. E., Vol. 17, p. 498.

[2] Gold Amalgamation and Concentration, McDermott and Duffield, 1890, pp. 25, 26, 27, 83-86.

amalgamator of fine gold; and there are circumstances in which this simple and readily-built machine is well worth the consideration of the millman on either raw or roasted ores, as giving a greater efficiency than an iron pan.

"The raw pan amalgamation is conducted either by the old tank system, or by the modern continuous process. In the former, the crushed ore is run into large shallow settling tanks, which are dug out by hand and charged into the separate pans; while in the continuous process, the pulp runs through a line of pans and settlers connected by pipes, so that no handling or settling of the pulp is required. . . .

"Pan amalgamation is effective chiefly on native gold, native silver, chloride of silver, and simple sulphide of silver. When the silver is in combination with sulphides, antimonides, arsenides, and tellurides of the baser metals, the pan process becomes ineffective and expensive. By contact with iron surfaces, heat, and the addition of some chemicals — chiefly salt and sulphate of copper — partial decomposition of the complex minerals is effected, and some of the silver amalgamated; but the wear of iron, loss of quicksilver, cost of power and chemicals, and the production of base bullion, together go far to neutralize the gain made in recovery of the silver. In such cases a great benefit is derived from combining concentration with amalgamation for the two processes are applicable to different minerals. The light flocculent chlorides and sulphides of silver can be amalgamated to a high percentage, while concentration is almost useless on them in the form they exist in a free or decomposed ore. On the other hand, concentration can be made very effective on the undecomposed complex minerals, for which amalgamation is ill adapted.

"There are two methods of combining the processes according to their order, i.e., whether the pans are used first or the concentrators. In either case, the Boss continuous process of pan amalgamation is much more convenient and economical than the old settling tank and intermittent charge system. The former process, as is well known, consists in placing pans and settlers in a row on one level, connecting them all by short pipes, feeding the pulp continuously into the first pan of the series, and allowing it to discharge continuously from the last settler. Its advantages consist in economy of space and labor and the dispensing with the trouble of settling tanks; and, in connection with concentration after amalgamation, its great superiority lies in its continuous operation, as insuring a regular feed to the concentrators, which is all important, and almost impossible to obtain from the intermittent settler discharge of the old tank process. When concentrators are used before the pans, the tank system can be used, as well as if the stamps discharge direct to the tanks; but the continuous amalgamation of the tailings of the concentrators, if the Boss system be used, would simplify the adoption of the pointed box system of automatic settling.

"In regard to the relative advantages of the two orders of succession, it may be briefly stated that concentration before amalgamation is the natural method, because it relieves the pans of the base minerals, which are a disadvantage in the amalgamation, and the subsequent concentration of which is made more difficult by the grinding or attrition of the minerals in the pans. The only argument against the universal adoption of this order rests on the disadvantage of sometimes having native metals (and some chlorides and sulphides) enter the concentrations, instead of appearing as bullion, which they otherwise would do; and also that very perfect settling of the slimes from the concentration tailings is necessary to prevent loss of flakey silver chlorides and sulphides. Where the free metal is gold, the first-named disadvantage can be overcome by using copper plates before the concentrators, and this process was adopted by the Montana Company with great success, after first trying pans before the concentrators. The change in the order of working by the Montana Company has been productive of a considerable gross increase in percentage extracted from the ore, a reduction of one-half in the loss of quicksilver, and a saving in the wear of pan-castings, fuel, and chemicals; as well as the production of a higher grade of bullion. In this company's 50-stamp mill, the tailings of the concentrators run into the usual settling tanks because the Boss process is not employed."

The Freiberg or German barrel process was employed at an early date in amalgamating gold and silver ores, especially the former, in the United States. The ores treated were raw or roasted, but when operating upon sulphurets it was the usual practice to roast them. A charge of about 300 pounds of finely ground ore was mixed with water until a consistency of cream was obtained. Salt, iron pyrites, scrap iron and mercury were added and the whole put into a strong barrel, which was revolved at a fairly rapid rate for a period of some fourteen hours. At the end of the period the silver and mercury united forming an amalgam, which could be readily separated from the mud by washing. It is evident then that the barrel process necessitated fine crushing apparatus and considerable machinery. Further, the labor required was relatively great while the work done was small. The barrel wore out rapidly and had to be replaced frequently.[1]

The clean-up barrel of to-day is practically the only surviving remnant of the Freiberg process, being used to complete the amalgamation of stamp battery residues and other similar materials.

Concentration — Cripple Creek and Coeur d'Alêne Practice. — The concentration of ores is essential to their economical treatment being more necessary with the low- than the high-grade ores. The work of concentration should begin underground when practicable, which, with surface sorting, may be sufficient to prepare an ore for shipment to smelting works or may serve as the preliminary work to more extended subsequent wet or dry treatment.

The treatment of the sulphurets, resulting from stamp-milling, by jigs, buddles, tables, both shaking or bumping and canvas, was largely employed in the early days of mining in California and other Western states and is still common practice. However, with the adoption of the improved forms of mills, such as the ball and tube mills and the introduction of the chlorination and cyaniding processes, the methods of milling the ores of the precious metals have been considerably changed.

The following described methods employed in the Cripple Creek district are taken from the United States Geological Survey Report, Professional Paper, No. 54:[2]

" In treatment and sorting of the ore at the mines various plans have been adopted. The general occurrence of friable tellurides in cracks and fissures forms the principle upon which the sorting and separation is based. The fines are invariably much richer than the coarse stuff, and the separation of the two classes becomes of importance. The ore is usually broken on plank floors with canvas underneath to avoid loss of the fine material. A rough preliminary sorting is effected in the mine — at least in places where wide stopes are being operated. The further treatment varies in the different mines. Very rich ore containing from 4 ounces upward is usually sacked and sent to the smelters. At the Portland mine the following process is adopted, the scheme being outlined in the

[1] Mineral Resources of the West, 1867, p. 29, and the Mining and Metallurgy of Gold and Silver, J. A. Phillips, pp. 386–387, 1867.

[2] Geology and Gold Deposits of the Cripple Creek Districts, Colorado U. S. G. S., Professional Paper, No. 54, pp. 136–137, 1906.

eighth annual report of the company by Mr. Charles J. Moore formerly its consulting engineer, as follows:

" The ore from the various stopes is not separated but dumped in two bins after passing over 1-inch grizzlies. The hand sorting is done at six tables with four men at each. The waste from the sorting slides down over an incline 15- by 4-foot sheet-iron plate perforated with half-inch holes and is continually sprayed in order to wash off the fines. Before going to the dump the waste from the washer is finally picked over on a belt conveyer.

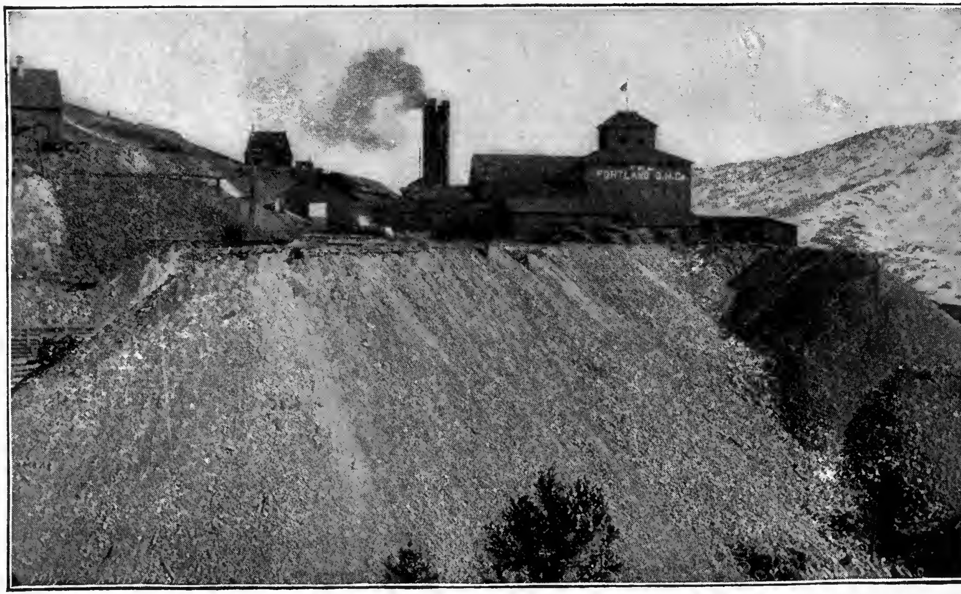
" At the Mary McKinney mine the ore from the stopes is shoveled into a Crane washer, a local invention composed of a 46-inch by 15-foot trommel with three-fourths inch holes, separating out the dry fines. The coarse is discharged into a smaller strongly inclined and perforated trommel about 15 feet long, the near end partly submerged in a tank of water. By this device the ore is washed, the fines falling into the tank and the coarse being carried up by means of an endless screw and discharged at the higher end of the trommel on a conveyor belt 50 feet long and 20 inches wide, on which the ore is sorted by five men. The capacity is said to be 100 tons per eight hours.

" At the El Paso mine ten bins are used and the ores from various stopes are kept apart. The classification is effected by two or three parallel screens under a protecting 3- by 15-foot grizzly, with bars 4 inches apart. The first screen has one-inch perforation, the second three-fourths inch. The dry fines below three-fourths inch average $75 per ton, those between one inch and three-fourths inch $25. From each bin the ore slides down on a sorting table, while sprays wash off the remaining fines, which are collected in tanks. These fines are of very high value. Ten sorters are employed. The present output (March, 1904) is 50 tons per day.

" In former years the sorting of the ore was much neglected, as evidenced by the numerous rich dumps in the camp. Even now the arrangement at many mines is imperfect.

" The cost of mining is, as a rule, very high, though few accurate data are available on this subject. Mr. J. R. Finlay, the former manager of the Portland mine, makes the following statement, which is well worth quoting:

" ' A study of the situation shows that these high costs result from the amount and character of the waste that must be handled with the ore. As is well known, the largest ore-bodies of Cripple Creek are not solid masses of uniformly valuable mineral, but contain



Surface Plant and Dumps, Portland Mine, Cripple Creek, Colorado.

volumes of rock into which the gold-bearing solutions have penetrated along multitudes of crevices. The problem of getting the best results in such veins is essentially one of concentrating the values. The peculiar character of the ore renders concentration difficult, if not impossible, by any method other than hand sorting. Ordinarily the concentration of ores may be effected cheaply by mechanical means, depending on the difference in specific gravity between the valuable and the worthless minerals. In the case of Cripple Creek ores this difference can not be depended upon. When the rock is blasted, a large part of the valuable material in the seams is reduced to an extremely fine powder, practically the lightest part of the mass; another part of the values will adhere to the rocks, while another small part is probably heavier than the average.' "

Further details of gold and silver milling methods are given in the description of stamp-milling practice under the head of Plate Amalgamation.

The concentration previously described was that applied especially to the sulphurets resulting from stamp-milling gold and silver ores. Under the present heading the treatment of lead-silver ores is dealt with in particular.

Probably the best illustration of the practice in concentrating lead-silver ores is that of the Coeur d'Alêne region, Idaho. Extracts from J. R. Finlay's paper on the Mining Industry of the Coeur d'Alêne, Idaho, are given below:[1]

" The process employed is substantially the same at all the mines and consists of coarse crushing and separation by jigs. Most of the ores contain the galena in segregated streaks of practically clean material, which separates under crushing, and is easily caught. The difficulty increases greatly when the galena is intimately mixed with iron carbonate, zinc-blende and quartz. Such ores require much finer crushing, and the use of a much greater number of vanners, buddles, shaking tables, etc., to separate the slimes. The following description of the process at the Standard mill will serve as a concrete example of the best current practice:

" The crude ore from the mine is dumped from railroad cars into a bin of about 600 tons' capacity, whence it is fed by gravity to a No. 5 Gates crusher, which reduces it to something over one inch diameter. From the crusher a 15-inch belt conveyor carries it to another bin, whence it passes by gravity to the roughing-rolls, which reduce it to pieces of $\frac{1}{2}$ to $\frac{3}{4}$ inch in diameter. From the

[1] T. A. I. M. E., Vol. 33, pp. 256–270, 1903.

roughing-rolls it is elevated to a double set of trommel-screens, which size it into an 'oversize' of more than 15 millimeters diameter, and into sizes which pass through 15, 10, 7 and 3 millimeter screens. The fines which pass the 3 millimeter screens are not jigged, but go at once to V-boxes or hydraulic classifiers. The slimes passing over the V-boxes go to settling-tanks, where the heavier material is caught and sent to Wilfley tables and Frue vanners. All the tailings from Wilfleys and vanners, together with the overflow from the settling-tanks, go to a 'canvas' plant of 52 tables of 6 square yards each. Material caught on the canvas-tables is reconcentrated on two Wilfley tables.

"Returning to the coarse material classified by the trommels, the oversize, or what passes over the 15 millimeter screens, goes to the coarse or 'bull' jigs, and what passes through the 15, 10 and 7 millimeter screens goes to finer jigs.

"Part of the tailings from the coarse jigs is retained as 'middlings,' to be further treated, and part is allowed to go directly to the creek as worthless. The middlings thus saved are passed through fine rolls, and then to Huntington mills, which reduce the pulp until it passes a 40-mesh screen.

"The finer jigs, i.e., the 15, 10, 7 and 5 millimeter jigs, also select a percentage of 'middlings,' which are likewise passed through fine rolls, in three sets, according to the coarseness of the material. Thence this material passes to the 'middling' jigs, which take out some clean ore. All of the tailings from these 'middling' jigs are reground in another set of Huntingtons to 40-mesh. All the material ground by the Huntington mills goes to the Wilfley tables and Frue vanners with the slimes from the settling tanks and V-boxes above described.

"This mill concentrates about 500 tons of crude ore per day. Its machinery consists of the following: A No. 5 Gates crusher; two 15-inch belt-conveyors; six sets of 15-inch by 26-inch belt-rolls; four 5-foot Huntington mills; twenty-eight Hartz jigs, arranged in 14 pairs; 2 lines of trommels; an 'oversize' trommel, for middlings; 4 elevators; 18 Wilfley tables; three 4-foot Frue vanners, and 52 canvas tables.

"Power for the main mill is derived from two Pelton wheels, one of 4-foot diameter under a 32-foot head, and one of 6-foot diameter under 235-foot head. A third (24-inch) Pelton, under 235-foot head, runs a dynamo for electric lighting, and a fourth runs the Gates crusher."

METALLURGY.

Pyritic Smelting — Process and Practice. — Ores can be decreased in bulk by water and fire concentration. The former method is often rendered impossible or impracticable, as where a partial concentration has been effected by natural means. Rich sulphide ores may be both decreased in bulk and increased in value by fire concentration as results in matte smelting. Ores suitable for smelting may be grouped into two general classes, namely, smelting ores, i.e., ores contain base metals in considerable quantities, and dry ores, or those containing little or no base metals — the precious metals predominating.

" When lead, copper or zinc were present in the ores in any considerable quantity they became so rebellious that amalgamation was out of the question, and smelting, with its necessary adjunct of concentration, became necessary. As the dressed ores were rich, and contained a large product condensed into a small one, and as this product was usually sold, sampling works sprung up, in which the value of a large quantity of ore was carefully ascertained by processes more or less mechanical, in which, as rapidity of execution as well as correctness of results were necessary, a number of tools for reducing the ore to powder now generally used were invented.

" The first attempts at smelting, as they were usually conducted by persons of no great experience, were not very successful. In fact, the early history of the now very successful American methods is a record of failures. When the smelting of silver ores became a necessity, English methods were first introduced by the Cornish miners, only a few of the German and Swedish furnaces being used. But as the English type of furnaces requires a considerable amount of good fuel, of a kind not generally found in the West, and the use of wood in them requires great skill, shaft furnaces gradually took their place, for the most part for treating ores containing gold, copper, silver, and lead by smelting. Some of the processes adopted from the old works in Europe found themselves in circumstances where the conditions of transportation, labor, or fuel were such that they could not compete with other districts, so that they gradually disappeared, and were succeeded by the same processes in a new dress or in a new phase to such an extent that the plant and the process, as it is now used in the West, would hardly be recognized by their inventors. Little by little it was ascertained that when the ore contained any volatile material, although it might be in small quantities, it would carry off with it very considerable portions of the precious metal; and then arose the idea of condensing chambers, until gradually, without any one person having invented them, the methods have grown into the simple and very beautiful processes which are now in use in the West.[1] . . .

"Every kind of furnace for roasting was invented and tried. These were usually some kind of reverberatory furnace, and were the subject of a large number of patients, and were altered and modified with more or less permanent success. Attempts were made to make the work wholly mechanical by the use of revolving cylinders into which the ore and salt were charged by machinery, in order to get rid of the difficult hand labor required and the necessary exposure to fumes in roasting in ordinary reverberatory furnaces. A few of these survive in the Bruckner and Teates furnaces, but as a general thing the cost of repairs to these contrivances, and the necessity of more engine power or of separate engines in the absence of machine shops near at hand, increased the expense of working beyond the gain in diminished labor." [2]

"One of the smelters (of Colorado) may be taken as illustrating the methods followed in treating ore. A large portion arrives in a crushed condition, being purchased through middle men owning sampling works, who crush it for sampling purposes. The ores, which come to the smelter direct from the mines, are crushed on arrival to prepare them for sampling and smelting. The ore is first carefully sampled, tested by assaying, etc., and the exact value determined, remaining untreated until the owner is satisfied as to the value. On his assenting to the value stated, it is at once paid for and becomes the property of the smelter. The ore containing sulphur is subjected to a preliminary roasting to get rid of the sulphur. The ore, roasted and unroasted, is smelted together at a very high temperature, the waste or slag being skimmed off or otherwise separated and thrown away, and the valuable product, being either lead bullion or copper matte, is then separated by special processes into gold, silver, copper, and lead.[3]

The object and operation of pyritic smelting are summed up in a very comprehensive way in a paper by Dr. E. D. Peters, Jr., which is in part quoted here: [4]

[1] School of Mines Quarterly, Vol. 3, pp. 159, 160, 1881–82.

[2] Ibid., Vol. 3, p. 158.

[3] Mines and Minerals, Vol. 19, pp. 99–100.

[4] Mineral Industry, 1893 and 1894, p. 265, etc., and The Metallurgy of Gold, Eissler, 1900, pp. 339, 342.

"1. By pyritic smelting is understood the treatment of sulphide ores in a blast furnace, or a similar apparatus, in such a manner that a considerable proportion of the heat produced by the oxidation of the sulphides is utilised in their fusion, by which means a considerable proportion of the ordinary carbonised fuel — or, in favourable cases, the whole of it — may be omitted, the sulphide ores thus practically smelting themselves, and often furnishing enough superfluous heat to admit of a considerable addition of non-sulphide ore.

"2. This process occupies a kind of intermediate position between the two widely diverse operations of calcination and bessemerising. It differs from calcination in that it goes further, its object being not merely to oxidise (burn off) the sulphur contents of the ore under treatment, but also to effect this combustion of the sulphur so rapidly as to produce a smelting heat at a certain point in the furnace, the work being conducted with such skill as to leave the lumps of ore above this point in a solid condition, their interstices offering a free passage to the blast, while below this line the fusion is as complete as though coke had been used to effect the result.

"3. It differs from bessemerising in several particulars, the most important one practically being that in bessemerising the air-blast is forced through a bath of liquid sulphides (matte), the blast being of sufficient strength to support the molten column above it, and thus prevent it entering the small tuyere holes through which the stream of air is supplied; while in pyritic smelting it is essential that the charge above the tuyeres, which are placed above that portion of the furnace in which the molten products collect, shall not begin to soften sufficiently to impede the circulation of the blast, which has only the very moderate pressure commonly used in copper smelting.

"4. Mr. Robert Sticht claims that no particular form of furnace is essential to the success of pyritic smelting, and that the same can be satisfactorily carried out in any kind of blast furnace that would be suitable for smelting with ordinary fuel.

"Pyritic smelting resumes itself to-day in a method where the smelters are simply running on rather a low percentage of coke and a sufficient volume of blast to obtain some good from the heat generated by the combustion of the sulphides in the charge. This method in its most pronounced form is characterised by layer-charging, low pressure, and great volume of wind, a heated blast, and the use of 1½ to 3 per cent or more of coke, according to the amount of pyrites in the ore.

"5. The difficulties which present themselves in the working of the process are: —

"(a) Mounting of the heat toward the top of furnace, causing softening of the charge, soon followed by the scaffolding, or sticking up of the furnace. This is perhaps the most constant and gravest of all difficulties that the pyritic smelter has to contend with. It may result from a variety of causes, among which the most common is too dense a charge — i.e., too much fine ore in the charge. The only remedy is to increase the proportion of coarse ore in the charge by using the pyritous ore in lumps of 20 to 40 pounds weight; to use a large proportion of slag in lump form; and if conditions permit, to employ a considerable proportion of limestone in lumps of rather large size. Too low pressure of blast is sure to make the top of the furnace hot. The remedy is obvious. Heating the blast by means of extraneous fuel to a temperature of at least 1,000 degrees F. has an excellent effect on this condition of things, and usually far more than repays the cost of running and maintaining the necessary stoves.

"(b) A much less common cause of a hot furnace top is the presence of too much iron pyrites in the charge. As is well known to all persons familiar with the calcination of iron pyrites (bisulphide of iron, FeS_2), one of two atoms of sulphur of which it is composed separates very easily from the pyrites, volatilising at a low red heat, and burning with a blue flickering flame, if sufficient oxygen be present to support combustion. This is exactly what happens in the upper zone of the blast furnace. One atom of sulphur, if volatilised in a metallic form, and melting with the heat, runs into all the interstices of the charge, sticking it all together like glue, and soon forming an impermeable crust, which, of course, quickly blocks up the furnace. For this reason, matte, which contains only one atom of sulphur, or even less, makes the best material for pyritic smelting.[1] The matte may be charged in 20 to 50 pound lumps, and, unless containing too large a proportion of the very basic sulphides of iron, or a considerable amount of magnetic oxide, will yield heat enough to smelt itself and the requisite silicious flux ores. The iron of the sulphides yields by its oxidation about as much useful heat as the sulphur.

"(c) The presence of volatile sulphides, such as zinc blende and galena, is said to exercise a very bad influence on this process.

[1] No doubt this difficulty must have been overcome, as I believe the heavy pyritic ores at the Mount Lyell Mine are treated direct without any preliminary operation.

"(d) Too high a furnace. For both mechanical and chemical reasons it is important that the height should be no greater than is necessary to keep the top reasonably cool when the furnace is running properly.

"6. The pattern of furnace. As pyritic smelting is slower than ordinary smelting, a large area and a large volume of air is the main requisite.

"7. Pyritic smelting is adapted to a great variety of ores, provided always that a certain proportion of them contain a sufficient supply of oxidisable substances to produce and maintain the required temperature. Arsenic, antimony, tellurium, and similar metalloids may furnish an important supply of heat, and are more thoroughly volatilised than by the ordinary smelting process. Heavy spar is not obnoxious, being thoroughly decomposed into barium silicate and sulphurous acid.

"8. The cleanest and most satisfactory work has, thus far, been done on a slag containing 35 to 45 per cent silica.

"9. The losses in silver and gold are no greater — in gold possibly less — than in ordinary smelting.

"10. A small amount of copper, say a minimum of ¾ per cent, is essential to clean slags, unless either lead, bismuth, arsenic, antimony, or tellurium are present in such proportions, and under such conditions, as will enable one or other of them to take the place of the copper to a certain extent as a collector of values. But in any case, the extraction of silver is likely to suffer, though the saving of the gold may be as perfect as with copper. If running with a matte very low in copper, and otherwise so constituted that it has little affinity for the precious metals, it is of the first importance to keep the slags as silicious as possible.

"11. It has been established by a tolerably varied experience, that, under favourable conditions, pyritic smelting is more economical than the ordinary methods employed. In other words, it is more economical to utilise the sulphur and iron of suitable ores to smelt them with (even considering the cost of the required hot blast), together with a reasonable proportion of non-pyritous ores, where such are available, than to employ carbonaceous fuel to burn up this same sulphur and iron in a calcining furnace, and then to use still more carbonaceous fuel to smelt these calcines.

"12. Pyritic smelting demands oxidation, which means the abolition of all boshes, or other decided contraction of the furnace shaft toward the hearth, and the limitation of the coke used to the smallest possible quantity. It means slow smelting, that the cupola in its upper zones may act as a calciner, while opposite the tuyeres it is operating, though feebly, as a Bessemer converter, which means a light pressure but great volume of blast, and a very long, narrow furnace. With the slow rate of smelting we need great area of shaft, and with the light blast we cannot use a wide furnace, hence its length must be augmented."

Details of pyritic smelting may be obtained from Dr. Peters's "Modern American Methods of Copper Smelting."

Chlorination — Processes and Practice. — In a paper by C. A. Stetfeldt on the Russel lixiviation process the following excellent review of the various processes which have been successfully employed in the treatment of gold and silver, especially gold-bearing silver ores, is given. In all of the cases cited, the ores are first roasted with salt and subsequently washed with water. Extracts of Mr. Stetfeldt's paper are given below:[1]

"*The Kiss Process.* — The ore is lixiviated with calcium hyposulphite. The percentage of gold extracted depends upon the temperature at which roasting is conducted. A dark-red heat must only be used, so that the formation of monochloride is favored, and that of metallic gold, as much as possible, avoided.

"We here run the risk of effecting an incomplete chlorination of the silver, and if the ore contains copper, so much cuprous chloride may be formed and left undecomposed, that bullion of very low fineness will result.

"*The Patera and Roeszner Process.* — The ore is lixiviated with a cold solution of brine which has been saturated with chlorine gas. G. Kuestel states, that ores, treated by this process in Hungary, yielded 98.9 per cent of the silver, and nearly all the gold. Even with such a good record the method seems to me inapplicable on a large scale, and for ores rich in silver. The solubility of silver chloride, in cold brine, is slight, and the handling of large quantities of solutions, saturated with chlorine, must be an insufferable annoyance. Roeszner modifies the process by first lixiviating with hot brine, to dissolve the silver chloride, and then extracts the gold with a cold solution of salt, saturated with chlorine.

"*Hofmann's Process.* — O. Hofmann first extracts the silver chloride and a part of the gold with a hyposulphite solution, and then the rest of the gold by the Plattner process. Results with

[1] T. A. I. M. E., Vol. 13, pp. 84–89, 1884–85.

concentrations from the Tarshish Mine, California, showed a saving of 96 per cent of the silver, and 95 per cent of the gold. . . .

"*The Swansea Process.* — The process is based upon the fact that gold has a much greater affinity for copper than silver, which was already known at Oker at the time when the precious metals were extracted from copper by the old-fashioned 'Saiger' process. The mode of operation is as follows: — The residues from the Ziervogel process are melted in a reverberatory furnace, with pyritic ores. The concentrated copper matte, so produced, is roasted for 'black copper,' which, in falling to the bottom of the hearth, collects the gold, and also precipitates impurities of the matte, such as Sb, As, and Pb. At a certain stage of the process and after the charge has been brought to a high temperature, the furnace is tapped, and the metallic bottoms are separated from the matte. By repeating the operation, more gold can be extracted from the matte. It lies in the nature of this process that the separation of the gold cannot be complete, and the concentrated copper matte, after a second treatment, contains about ¼ ounce gold per ton. . . .

"*The Electrolytic Process.* — In Europe the tendency is, at present, very much in favor of the electrolytic process. The complete separation of the precious metals, and the great purity of the electrolytic copper, provided the process is conducted with the necessary precautions, are strong arguments in its favor. First successfully introduced in England, it has been in operation for several years, on the continent, especially in Germany. The principal works there are those at Hamburg, Oker, and near Eisleben. The details of the process are everywhere guarded with the utmost secrecy, and admission to the works is generally refused. No literature of any value, from a technical standpoint, exists. . . .

"The electrolytic process permits the use of currents of low intensity only. With increased differences in the composition of the electrodes, the difference in their electric potential also increases, and a marked polarization of the current must be the result. But perhaps of still greater importance is the durability of the copper solution into which the electrodes are immersed. Certain impurities concentrate in this solution more and more, and are finally precipitated on the cathode. The peculiarity of arsenic to precipitate the sooner on the cathode, the lower the electric current is in intensity, was also known to physicists before it made itself felt in electrolytic works. That the process does not offer great technical difficulties, or require an experience of several years, has been demonstrated by its successful introduction at the metallurgical works of Mr. Balbach, Newark, N.J. The plant, of 800 pounds daily capacity, is by no means a model of construction, but it works well and with profit. . . .

"*The Hunt and Douglas Process.* — The matte is roasted, and the oxide of copper dissolved by dilute sulphuric acid in the presence of a soluble chloride. Gold, silver chloride, lead sulphate, and oxide of iron and antimony, remain as insoluble residues. The copper is precipitated from the warm solution as cuprous chloride by sulphurous acid, and the sulphuric acid regenerated. In decomposing the cuprous chloride, after separating it from the acid solution, by iron, ferrous chloride is formed, to be used again for chloridizing the copper of subsequent charges.

"In conducting the sulphurous acid through the copper solution, care must be taken to have the gas practically free from an excess of air. Otherwise more sulphuric acid will be formed than cuprous chloride, the latter absorbing oxygen rapidly, and becoming reconverted to cupric chloride.

"This process has, so far, not been introduced to work copper-matte on a large scale, and nothing has been published about its technical difficulties, or its economy. From a theoretical standpoint it is very promising, especially for mattes containing antimony and arsenic. The cuprous chloride produced by this process is perfectly pure.

"*Hartmann's Process.* — Another process for treating copper-matte, based upon the regeneration of sulphuric acid, is in operation at Vivian's works, Swansea. The roasted matte is dissolved in sulphuric acid, as is done in Freiberg, the gold and silver remaining in the insoluble residue. From the solution copper is precipitated by sulphuretted hydrogen, and the sulphuric acid regenerated. Sulphuretted hydrogen is gained by passing sulphurous acid from a roasting-kiln, together with steam, through a column of hot coal. The gas ascends a tower through which the copper-solution is showered. Any loss in sulphuric acid is made good by copper sulphate contained in the roasted matte. The precipitate of copper sulphide is oxidized by a patented process — details not known to me — said to dispense with the use of fuel, and then reduced to copper in a reverberatory furnace. It is claimed that from very impure matte a copper of superior quality is obtained. This seems to me somewhat doubtful. To remove all arsenic from a copper-matte by roasting is not possible. Arsenates, formed in roasting, are soluble in sulphuric acid. It is true, arsenic is precipitated from a solution by sulphuretted hydrogen before copper. But a separation in this way seems to me, practically, difficult to accomplish."

The lixiviation of gold from ores by means of the Plattner chlorination process is described by Küstel:[1]

"(1) The auriferous concentrates from the stamping mill having been perfectly oxidised, are moistened with water and put lightly, by means of a sieve, into a wooden vat, coated with tar and rosin, and having a perforated false bottom upon which a filter is made, for which there are numerous ways. When filled a close-fitting cover is placed on top.

"(2) Chlorine gas, produced by decomposing salt and peroxide of manganese with sulphuric acid, is introduced between the false and true bottoms, and made to permeate upwards through the ore mass. After the expiration of from fifteen to forty-eight hours, the gas is found to appear abundantly on the ore mass, and is then shut off, and the vat allowed to remain a few hours under the influence of the gas. The cover being removed, pure water is added to fill the vat even with the top surface of the ore; the fine particles of gold, under the action of chlorine, have changed from metal to a soluble terchloride, and in this condition it is drawn off or leached out with water, fresh water being added until a test shows no trace of gold.

"(3) A prepared solution of sulphate of iron — the usual precipitant — is carefully added to this drawn-off solution, and the gold thrown down as a black or brownish precipitate; this is gathered, washed, and melted into ingots of nearly pure gold.

"The process is thus based upon the property of chlorine gas to transform metallic gold into soluble chloride of gold, and with some kinds of pyrites it is very perfect if well executed, but the following requirements have to be carefully observed:

"(1) The gold must always be in a metallic state. Quartz, free from other earths and sulphurets, containing very fine gold, can be subjected to chlorination without other preparation than moistening with water. . . . Sulphuretted ore requires a perfect roasting. The presence of lead makes a careful roasting necessary, commencing with a very low temperature. All metals, except gold, must be transformed into oxides. Sulphates are injurious.

[1] Treatise on Concentration of all Kinds of Ores, including the Chlorination Process, Küstel, 1868, and the Metallurgy of Gold, Eissler, 1900, pp. 345 and 346.

"(2) The chlorine gas must be free from muriatic acid. From the generator the gas is forced through clear water, by which the muriatic acid is absorbed. The muriatic acid dissolves the oxides, and causes, when sulphides are present in consequence of defective roasting, the formation of sulphuretted hydrogen, by which soluble chloride of gold is precipitated. The muriatic acid dissolves also oxides of metals precipitated by the addition of sulphate of iron with the gold.

"(3) There must be no other substances in the charge which will unite with the free chlorine, since this would occasion a great waste of gas, and a failure in the desired separation of gold from other metals.

"(4) There must be no reaction in the mass treated with chlorine which will prematurely precipitate the gold before the final solution is obtained and drawn off.

"(5) In a word, it is required that all the gold, and, if possible, nothing else, shall be obtained in the final solution. Precipitation and melting then present no special difficulties.

"Generally the concentrated sulphurets from the gold mills are subjected to the chlorination process; but also ores consisting of quartz and free gold, without admixture of other earths or sulphurets, can be treated by this process without any further preliminary treatment than reduction to powder."

The following description of the operation and results of the Russell chlorination process on silver ores at Aspen, Colorado, is taken from W. S. Morse's paper on that subject:[1]

"The weight of the roasted ore treated was 31,775.338 tons, which was leached in 546 charges, averaging 58.19 tons. Each charge required about 22.5 cubic feet of water, or about 60 inches in depth in the tank, to completely saturate it. After washing and removing soluble salts, about 50 inches of solution will saturate the charge.

"The following method of leaching was followed, as a rule:

1. The ore was charged into one volume of water, followed by a second volume of wash-water, and by:

2. Three volumes of warm ordinary solution (about 1.8 per cent of hyposulphite);

3. One volume of extra-solution (average about 0.5 per cent of $CuSO_4$);

[1] T. A. I. M. E., Vol. 25, pp. 142–145, 1895.

4. One volume of warm ordinary solution;
5. One volume of extra-solution;
6. Two volumes of warm ordinary solution; and
7. The last wash-water, the dividing line between solution and wash-water being drawn when about one and one-fourth volumes of wash-water had been applied.

"This treatment was varied as to quantity of solution applied and strength of extra solution, but the above is about an average. The average time of leaching each charge was about 100 hours. This includes stops of every kind.

"The average leaching-rate was 13 inches per hour. This was the natural leaching-rate; but, as a rule, in leaching after the ore had been washed, the leaching-rate was cut down to 10 inches per hour. . . .

"Silver was precipitated from solutions with sodium sulphide; part of the time with a polysulphide, Na_2S_2, made from caustic soda and sulphur; and part of the time with a monosulphide, Na_2S, imported from Germany in the form of crystals.

"The total of sulphides produced was 442,576 pounds, divided as follows:

	Pounds.	Assaying, Ounces per Ton.	Containing Oz. of Silver.
Solution-sulphides	313,417	3790	593,069.12
Wash-water sulphides	95,442	2875	136,535.66
Lead carbonates	33,717	432	7,698.84
Total contents of product.	....	....	737,303.62

APPARENT EXTRACTION.	Ounces of Silver.
Contents of roasted ore	782,586.09
Contents of tailings	103,702.36
Calculated contents of sulphides	678,883.73

"On this calculation the apparent extraction of 86.74 per cent of the silver in roasted ore is based.

	Ounces of Silver.
Actual contents of sulphides by corrected assay	737,303.62

"On this calculation the actual extraction of 94.21 per cent of the silver in roasted ore is based.

Differences between calculated and actual contents of sulphides = 6.78 per cent or	58,419.89

ACTUAL EXTRACTION.

Contents of raw ore	861,488.05
Contents of roasted ore	782,586.09
Loss in roasting and dust-loss (9.157 per cent)	78,901.96
Contents of product	737,303.62

Or 94.21 + per cent of the silver in roasted ore and 85.58 + per cent of the silver in raw ore."

A brief description of the methods of treatment in the chlorination plants of the Cripple Creek district is given under heading Technical Details of the paper on the district by W. Lindgren and F. L. Ransome, which is given herewith in part:[1]

"The different chlorination plants use practically identical processes.

"A type is the Standard plant of the United States Reduction and Refining Company at Colorado City, which treats Cripple Creek ores exclusively, has a capacity of 450 tons per day. All the ore received goes to the sampler. The ore is there crushed to three-fourths inch mesh, and one-twenty-fifth of it is taken out for finer crushing and quartering for the assay and analysis sample. Belt conveyors take the ore from the sampler to the bedding room, where it is loaded from hoppers into cars, and thence dumped in heaps on the bedding floor below. With ore of ordinary grade sufficient homogeneity of the mixture is secured by dumping alternately on different heaps small carloads from different shipments. But high-grade ores are mixed more carefully with those of lower value.

"From the bedding floor the ore is taken by belt conveyors to the driers — long tables where the ore is moved by mechanical rakes, and heated sufficiently to drive off moisture. It is next trammed to hoppers, whence it goes to the rolls to be crushed to about 20-mesh size, and then fed into the roasters. These are of the Holthoff-Wethey type, have a capacity of 100 tons per day each, and employ an average temperature of about 1,600° F. The roasted ore is cooled in its journey back underneath the furnaces, and is then conveyed on an inclined belt to the barrel house, where it is loaded into hopper cars and finally charged into the chlorination barrels.

"The 10 barrels, of a capacity of 10 tons, are about 20 feet long and 5 feet in diameter. The exact composition of the lixiviating solution is not made public, but it consists essentially of a solution of electrolytically generated chlorine in water. The strength of the

[1] Geology and Gold Deposits of the Cripple Creek District, Colorado, U. S. G. S., Professional Paper No. 54, pp. 140–142, 1906.

solution used is determined not so much by the value of the ore as by the composition of the gangue. About 100 gallons of the solution are used for each ton of ore, and this amount contains 1 to 2½ pounds of chlorine.

"When the barrels have been charged with ore and solution, they are sealed and rotated for two or three hours, at the end of which time a valve at the bottom of the barrel is opened, and one at the top is connected with water pressure. The solution is thus made to pass through an interior filter of the Sloan type, and the pulp is washed for two to four hours. About 100 gallons of water per ton of ore are added during the washing, making the total bulk of gold-bearing solution about 200 gallons for each ton of ore. After the pulp is sufficiently washed, and the manhead is removed from the barrel, the barrel is rotated, and the pulp emptied into a launder by which it is conveyed to Wilfley tables on a floor beneath. There are 20 of these concentrators, arranged in batteries of 5. The headings from four of the five pass to the fifth, and the concentrates from this table, which represent about one two hundred and fiftieths of the total pulp, are saved and sent to the smelters. They have a value of $20.00 to $30.00 per ton. For the presence of the greater part of the gold in them the following explanation is offered: when the ore is roasted, pyrite is oxidized and converted partly into magnetite (Fe_3O_4), which is only slightly attacked by the chlorine solution. Any gold which may have been inclosed in the pyrite is thus protected from the action of the solvent, and without concentration would be lost. Besides magnetite other iron oxides and barite are noticeable constituents of the final concentrates, and a molybdenum mineral is said to be present at times. Finely divided free gold is occasionally seen on the last table.

"After passing through the filters the lixiviating solutions together with the wash water pass to the sand boxes where the coarser sediment which has escaped the filter quickly falls and is returned to the barrels; then to the settling tanks, where they remain for eight hours and allow practically all the material in suspension to separate out. During this time a gelatinous precipitate, said to be a basic aluminum silicate, forms and falls to the bottom. On account of the difficulty of washing this precipitate thoroughly, a small loss of gold may take place.

"From the settling tanks the solution is drawn into lead-lined monte-jus, and thence forced by air pressure into precipitating tanks. Into these the precipitating agent, hydrogen sulphide, is introduced direct from the generator. Precipitation is continued until tests show no more gold in solution, the time required being thirty to forty minutes. After the precipitate settles the supernatant liquor is drawn off and run through filter presses, and before leaving the building is passed through sand filter to counteract possible leakage or breakage of these presses.

"When sufficient precipitate has collected at the bottom of the precipitation tanks, it is drawn into a small monte-jus, and forced through the filter presses, of which there are six. Finally the presses are cleaned and the precipitate is dried, roasted, melted with flux, and cast into bricks. On ores of average grade an extraction of about 95 per cent is obtained, but since the actual loss approaches a constant amount, the percentage of recovery is higher for rich ores.

"Chlorine for the solution of the gold is generated electrolytically at the plant. A hot saturated solution of salt is treated in McDonald cells, the chlorine being piped away, and the concentrated caustic-soda solution collected as a by-product.

"Among the principal mines from which this mill treats ores are the Abe Lincoln, American Eagle, Elkton, El Paso, Findley, Golden Cycle, Shurtloff, Strong, Theresa, and Vindicator. In April, 1904, the plant was handling about 250 tons daily."

Cyanidation. — A general synopsis of the treatment of ores by the cyanide process as given by Eissler is as follows: [1]

"First Stage: Passing an alkaline Solution or caustic wash through the ore to the point of saturation, as the tailings always contain a certain amount of organic matter, acid salts, etc. By running on this alkaline solution, a considerable saving is effected in the consumption of cyanide of potassium, and the tailings get the advantage afterwards of the full strength of the strong solution. Strength of this first alkaline solution may be 0.15 per cent KCy, and may contain 4 ounces of caustic soda per ton of solution. Caustic soda dissolves out organic matter. Excess of lime destroys cyanide. Second Stage: The Strong Cyanide Solution. — This solution varies in strength from 0.3 to 0.5 per cent in KCy to suit the richness and nature of the tailings under treatment, and the proportion of solution to be run on should not be less than one-third the weight of tailings in the vats. When this solution is run on, though the first solution has drained out, the tailings still contain a considerable quantity of the former solution. This should be displaced by allowing the second solution, or strong solution, to drain down

[1] The Metallurgy of Gold, Eissler, pp. 484–486, 1900.

immediately the vats are filled with the strong solution, for, say, about two hours (according to the capacity of vats and nature of tailings), and when this has been displaced, sufficient strong solution should be run on to make up the required proportional amount.

"The vat is now full of strong solution, which, in some cases, may be leached out immediately, though generally it is advisable to leave it in contact with the mass for a short period — say three hours — to give the solution time to penetrate any lumps.

"When this solution is leached out, or only a very small stream is coming away, it should be allowed to continue draining for about four hours longer. During these last four hours air is taking the place of the solution, and the gold is in contact with a strong solution of KCy, in presence of oxygen, which produces a more rapid and effectual dissolving of the gold.

"For proof: Take two watch glasses, fill both with cyanide solution of the same strength. In one, place a piece of gold leaf on the surface of the solution, while in the other immerse the gold under the solution. The gold leaf on the surface in presence with air disappears rapidly, and is completely destroyed, whilst the other dissolves very slowly.

"Third Stage: The Weak Solution. — After the strong solution has been run on, we may safely assume that most of the gold is now in solution, and the object of the third operation is to wash out the dissolved gold. Therefore, after the strong solution has been drained out, sufficient weak solution containing 0.15 per cent KCy is run on till the total quantity of solution and washes represent 75 to 80 per cent of the weight of the ore.

"Fourth Stage: The Water Wash. — After the weak solution water wash is applied, and the quantity so applied is not less than 7 per cent of the weight of the ore, and indeed more is necessary."

A certain amount of interest attaches itself to the successful operation of the cyanide process, Mercur Mines, Utah, owing to the fact that commercial results were first obtained in the United States in its adaptation by the mills of this district. The following extracts are taken from an article descriptive of the cyanide plant of the Golden Gate mill, at Mercur, Utah.[1]

"The ore is coarsely crushed, and delivered to the leaching tanks without intermediate treatment. Being oxidized and very porous, this ore is an ideal one for simple cyaniding. The values are extracted cheaply, but the percentage of extraction is not as high

[1] Mining Machinery, June, 1898.

as it would be if a roasting plant were added to the equipment. In the Golden Gate Mine the ledge is tapped at a depth of 1,500 greater than in the Mercur Mine. Much of the ore contains either arsenic or sulphur, and is therefore not amenable to the simple cyanide process. For two years the De La Mar Company carried on an extensive series of experiments with the view of finding a modification of the process that could be successfully applied to their ores. In the meantime the Company has been gradually adding to its holdings. The most recent addition is less than 7 acres in extent and more than a quarter of a million dollars was paid for it. The development work has gone on continuously, and enormous bodies of ore have been blocked out.

"Like other ores found in such large bodies, the De Lamar ore is low grade, running from $7 to $12 per ton. . . .

"The sulphide and arsenical ore from the second set of bins in the crusher building is discharged into two Brown straight drying furnaces. These dryers occupy the second portion of the mill, and are located near the side walls, leaving room in the center for an additional dryer when the capacity of the mill is increased to 800 tons per day. The dryers are of the reverberatory type, with hearths 60 feet long and 12 feet wide, and they are fired by gas. They have a nominal capacity of 175 tons each per day, but if necessary can handle more than 250 tons each. Only the arsenical and sulphide ores are run through the dryers, one furnace being reserved for each kind. . . .

"The third compartment of the mill contains the fine-crushing machinery, which is divided into three units, one for each kind of ore, but all of it receiving the same treatment. The ore is first sized in a Berthellet separator, which is an inclined covered screen, the cover being lined on the inside with rubber belting so arranged that the ore impinging on the screen strikes the rubber belt, and being thrown back on to the screen again, the continuation of this operation keeps the screen in a vibratory state. This permits a fine separation to be made, and as the ore particles strike the screen at an angle of 45 degrees a much coarser screen can be used for a given sized product than that indicated by the size of the screened ore. The oversize from the Berthellet separators passes through one of the three sets of 36 by 15 Gates rolls, and then into one or two of four sets of 26 by 15 Gates rolls. The fines from the Berthellet separator are also passed through this latter set of rolls. . . .

"From the rolls the ore is elevated to revolving screens, from which the oversize is sent back to the rolls, and the ore that has been crushed to 10-mesh into one of three bins of 1,000 tons capacity. The ore from these last bins is carried on Robins belt conveyers to the roasting furnaces. The roasting department of the mill is divided into three levels, each of which is 33 feet wide and 295 feet long. Two of these levels are occupied by the four furnaces now in use, the third one being reserved for future enlargement. The roasting furnaces are of the reverberatory type, designed by Horace F. Brown, in which the operating mechanism of the stirring carriages is carried in side compartments cut off from the main furnace hearth by a slotted wall which preserves the moving parts from heat and dirt. These furnaces are each 12 feet wide by 100 feet long, and, like the dryers, are fired by a mixture of producer and water gas furnished by the Loomis gas plant. The products of combustion from the four roasting furnaces, together with the sulphur and arsenic fumes, pass into a dust chamber and then into a large flue running underground up the hill. The products of combustion from the two dryers also discharge into this flue which terminates farther up the hill in a steel smoke-stack. The ore, after roasting on the main hearth of the furnace, is elevated to a cooling hearth built over the arch of the furnace and running its entire length, is discharged into a trough and conveyed by a spiral conveyor laterally to the side of the furnace, to a spout, down which it travels to a storage bin cut out under the furnace floor in the centre of the mill.

" The siliceous ore is discharged into this bin directly from the steel storage bins without roasting. . . .

" The next level in the mill contains ten 25 by 50 feet leaching tanks 5 feet deep. From the level of the top of these tanks a tunnel runs under the ore bin, in which the residue of the siliceous ore is stored. The proper amount of each kind of ore is drawn from the storage bin and carried in cars through the tunnel to the tank being filled. Men with shovels spread the ore evenly after it is dumped from the cars. The cyanide solution is then turned on to the ore, and after leaching out the gold, passes through the filter which covers the bottom of the tank, and is drawn off to the precipitating tanks which occupy the last level of the mill.

" After the cyanide solution has been drawn off, and the ore washed with several applications of water to remove the remainder of the solution, the tailings are shoveled through two trap-doors in the bottom of the tanks into cars, which convey these tailings to the dump."

The Dorcas is the only mill treating ordinary telluride ores by the cyanide process in the Cripple Creek district. This mill is located at Florence and treats high-grade ores. The ore is passed through crushers, rolls and a dryer and is roasted in a Holthoff oil-burning furnace. There are twelve 140 ton steel leaching tanks some 30 feet in diameter. The strength of the solution ranges from 0.6 to 0.8 per cent. The gold is precipitated with zinc shavings, while any remaining coarse gold is caught on Wilfley tables over which the tailings are run.[1]

Owing to the difficulties experienced in cyaniding the gold ores of Republic, Washington, a description of the process successfully employed is especially interesting and instructive. The following extracts are taken from the paper by F. Cirkel on the milling of the Republic ores:[2]

" A casual inspection of the ore of the Republic Mining Camp would give the impression that it is of a poor quality as far as the contents in precious metals is concerned; the quartz is of a peculiar milk-white appearance, devoid of all sulphides or any other metals generally associated with gold; in most of the gold, even in panning, we hardly detect any visible gold, except by microscopical examination, and yet, this ' hungry-looking quartz, ' — as it is generally termed in western miners' language — contains gold and silver values sometimes up to several thousand dollars per ton. When the Republic Mining Company, owners of the Republic mine, were confronted with the problem of gold extraction from their ore, it was readily acknowledged that the difficulties of finding a suitable process were great, so much so, that it took two years before a definite plan as to the character of the mill was decided upon. Experiments showed at once that the cyanide method generally in vogue would not answer the purpose — it being found that many alterations in the old method had to be made, if to be of any use at all. It was found that the cyanide solution did not thoroughly percolate through the pulp ground to 40-mesh fineness, thus leaving a large percentage of the gold undissolved; in order to liberate all the gold it was necessary to pulverize the ore to very fine mesh, and this difficulty discarded at once the use of stamps alone. The experiments, however, showed conclusively that if the ore were pulverized, the so-called agitating cyaniding process was apparently the only solution of the difficulty. It was the Pelatin-Clerici process

[1] Geology and Gold Deposits of the Cripple Creek District, Colorado, U. S. G. S., Professional Paper No. 54, p. 140, 1906.

[2] Journal of the Canadian Mining Institute, Vol. 5, pp. 274-280, 1902.

which was adopted by the Republic people, and which treated under special patents the ore as outlined above, and it was decided to build a mill for a daily capacity of 30 tons. The main feature of this method of treatment is to dissolve precious metals from ores and precipitate same from their solution in one single operation. The apparatus most extensively used so far is a tank provided with an amalgamated copper bottom, a metallic stirrer and electrical connections. The ores to be treated by this process may be pulverized by any dry or wet system; pulp from stamp batteries may be run into Pelatin-Clerici tanks; dry pulverized ores, concentrates, tailings, slimes, may be added to the solution in the tanks. The process is an electrical one; to the pulp are added common salt and the chemicals which from actual tests have proved the best solvents of the precious metals; an electrical current is passed through the pulp, while it is continuously stirred, dissolution and precipitation proceed at the same time. Coarse gold will go down by gravity and amalgamate at the bottom; all metals are saved in the shape of amalgam. Clean-ups are made from time to time, and a product is obtained which requires retorting and melting into bars. . . . The 'Gold and Silver Extraction Co., of America,' undertook the responsibility for the treatment of the Mountain Lion ore at a royalty of 10 cents per ton at the same time guaranteeing an extraction of at least 85 per cent of gold and of at least 60 per cent of silver. The mill was constructed in 1899, and although the process employed did not give the satisfaction anticipated, I believe it is of interest to give here a brief description of the same, for the reason that it is the only mill of its kind ever erected in the gold mining camps of the western Pacific States.

"The ore is raised out of the mine through a vertical shaft in a self-dumping skip and dropped into a grizzly, the coarser passing through a 9 by 15-inch Blake rock crusher, and thence with the finer material into a 200-ton ore bin. From that it is delivered into self side dumping cars, and passing down an automatic tramway, is dumped into ore bins at the top and east end of the mill. It is automatically handled from the moment it leaves the mine until the tailings are sluiced out of the mill. From the bins the ore goes to 4 stamp batteries, each having five 200-pound stamps, which drop seven inches, crushing the ore 30-mesh fine. From the stamps the pulp passes over amalgamated copper plates, thence to four Huntingdon mills, in which it is reground from 80 to 100-mesh fine. It is then raised by bucket elevators to the settling tanks, in which it is freed from the major part of the water. The pulp from the settlers is transferred to agitating tanks, in which it receives an eight-hour treatment with all excess of cyanide solution, and then allowed to settle. All the clear solution is decanted off, and a second solution of cyanide, weaker than the first, added to the pulp in the agitators for a second contact. After this the charge is sluiced off to big percolating or filter tanks, and here allowed to settle. The clear liquor is then drawn off, and the remaining solution is drawn through the pulp by means of a vacuum pump. This completes the percolation. The charge is then washed to free it from the cyanide, and the tailings sluiced out. The solution which contains the dissolved gold, coming from the agitators and the filtering tanks, passes through boxes with zinc shavings, and in these the gold is precipitated in the form of black slimes.

"The solution, freed from its gold contents, is pumped into the large storage tanks, where, after being strengthened by the addition of fresh cyanide, it is ready for treatment of a fresh charge of ore. It requires from 36 to 48 hours from the time the ore goes into the stamps to complete the operation of saving gold. . . .

"The mill was started on the 15th of March, 1900, and for the first two cleanups gave by amalgamation and cyanide a total saving of nearly 70 per cent gold and 37 per cent of the silver, and by actual bullion recovery only 64 per cent gold and 35 per cent silver. The causes for the low percentage recovered in bullion were apparently due to bad agitation and coarseness of the pulp treated, and after repeated experiments it was found that owing to the coarseness of the pulp, agitation of the whole was not practicable; the fines and coarse, after leaving the plates, were separated, the fines agitated and the coarse treated by percolation. For several months the mill was run on this improved plan, with a number of other changes, and below is a compendium of the results obtained:

	Treated Tons.	Assay Value.		Gross Value.	Assay Value.		Slag.	Total.	Per cent Saving.
		Gold.	Silver.		Amalgamation.	Cyanide.			
May......	2135	12.39	1.87	30445.10	7042.40	5231.75	269.66	12543.81	41.2
June	2225	10.20	1.73	26544.25	4195.71	5901.55	269.66	10366.92	39.0
July......	2202	8.50	1.38	21755.76	4449.64	8101.84	359.40	12910.88	59.3
August...	1806	7.49	1.47	16181.76	3773.94	5988.25	256.20	10018.39	61.9
Sept......	1711	8.11	1.44	16340.15	3314.57	4275.67	145.42	145.42	47.3
Oct.......	1880	7.95	1.55	17860.05	3918.74	6265.30	239.57	239.57	58.3

Milling Cost, per ton .... $3.73 Average Saving of 54.9 per cent.

"We see from the above table of mill statistics that the average saving during a six months' run was only 54.9 per cent of gold and 26.9 per cent of silver, instead of 85 per cent gold extraction and 60 per cent silver extraction as guaranteed by the Gold and Silver Extracting Co., of America, and which percentage of extraction the metallurgical experts confidently predicted would be verified, and continued by actual mill operations. In consequence of this disappointing result, the mill was closed on November 1, 1900."

For a description of the plant of the above described operations the reader is referred to the following reference.[1]

The regenerative action of alternating currents on foul cyanide solutions was discovered by Mr. W. H. Davis, which is due to the precipitation of the foul matter. Further, the resulting solution is considerably more active, having a higher solvent power than a normal solution. The increased efficiency is probably due to cyanogen freed by electrolysis, being held dissolved in the solution. This process was installed at the Smuggler-Union mines, Colorado, in 1902.[2]

There are two general methods of precipitation employed in the cyanide process, namely the MacArthur-Forrest and the Siemens-Halske. These are described by John Hays Hammond as follows:[3]

"*The MacArthur-Forrest Process.* — In this process the gold is precipitated by zinc, the solution passing upward through a succession of compartments, in which are placed zinc shavings or filings, resting on a movable tray of coarse screening. About twenty precipitation boxes, 20 feet by 3 feet by 3 feet 9 inches in size, are used. The gold-bearing solution is brought into close contact with the zinc, causing the deposition of the gold, partly as a metallic coating on the zinc and partly as gold slimes, which sink to the bottom of the box. As the zinc is gradually dissolved by cyanide more is added.

"Once or twice a month the boxes are emptied, and the gold slimes are treated with dilute sulphuric acid, then dried and melted in crucibles. The dried slimes contain about 15 to 20 per cent of gold, and after fluxing with borax and soda an ingot of 0.750 to 0.800 fineness in gold and 0.100 in silver is obtained. The slag, carrying from 5 to 50 ounces of gold per ton, is usually sold to smelters.

[1] Journal of the Canadian Mining Institute, Vol. 5, pp. 274–280, 1902.

[2] Special Rept. Census Office, Mines and Quarries, 1902, p. 599.

[3] Ibid., p. 601.

"This precipitation process yields satisfactory results only with solutions containing more than 0.1 per cent of cyanide, the weaker solutions not being acted upon by zinc. An improvement of the method is the addition of lead to the zinc, whereby the combination of the two metals forms a galvanic couple, which also reacts with weaker solutions, such as are employed, for example, in the treatment of slimes.

"*The Siemens-Halske Process.* — In this process the solution flows through compartments very similar to the zinc boxes above described, but the zinc shavings are here replaced with lead strips (0.1 pound per square foot) or shavings hung between iron plates placed vertically and longitudinally in the box, about 4 inches apart. The lead strips are connected with the negative, and the iron plates with the positive, pole of a dynamo, and the solution is thus electrolytically decomposed, the gold being plated on the lead cathode. The iron plates are wrapped in canvas to prevent short circuiting. The current employed is from 2 to 3 volts giving a current density of about 0.06 amperes per square foot of cathode. Once a month the lead sheets are removed and replaced, and the gold coated lead is melted and cupelled, yielding a bullion of 0.880 fine in gold and 0.100 in silver. The litharge is sold to smelters. The solutions passing through the treatment boxes are collected in tanks, and are made up to a proper strength by adding the necessary KCy.

"The cost of the Siemens-Halske process is slightly greater than that of zinc precipitation, and the percentage of extraction is about the same. But the Siemens-Halske process may be applied to any solution, weak or strong."

The introduction of the filter press emphasized the importance of fine grinding and thus permanently established fine grinding methods — the finer the product treated by the cyanide process the higher the extraction — a rule with few exceptions.

Filter press work had its origin in Australia and although introduced into the United States was never very popular, probably owing to the high cost of installation and operation. One of the most successful installations in this country is that at the Gold Road mine, near Kingman, Arizona, where two five-ton Dehne presses have been operating for a number of years.

Some few years ago filter pressing was tried at the Consolidated Mercur Company's mill, in Utah, but without success. However, the work lead to the adoption of a vacuum filter at the same mill, which with various modifications has been installed at a number of mills in this country. It is possible, considering the results obtained, that the days of the filter press as a mere filtering device have begun to wane.[1]

A description of the Moore vacuum filter, as given by Mr. F. L. Bosqui, is in part as follows: [2]

" The unit of the Moore filter is a rectangular wood frame covered with canvas and provided with a vacuum drain pipe extending to the lowest point of the interior. These frames are grouped together in clusters or ' baskets,' which are raised and lowered by means of a hydraulic crane. When lowered into a suitable compartment containing the slime pulp, the vacuum is applied to a common pipe connected with each frame, the solution is drawn through the canvas, and a slime cake varying from five-eighths to seven-eighths inch in thickness is deposited on each side of the filter frame. The cluster of filter frames carrying the charge of slime, weighing several tons, is then lifted from the pulp, shifted automatically to an adjoining compartment containing the wash, where it is again lowered, the vacuum applied, and the displacing operation carried on. The load is again raised and shifted to a bin, where the cakes are discharged by introducing air or water into the interior of the frames.

" The objections to the Moore filter are the high first cost of the mechanism required to shift the slime load, and the high cost of maintenance. The unmechanical and cumbersome features of this system led to the introduction by Cassel of a stationary filter, and the elimination of the awkward mechanism of the Moore scheme. It remained for Butters to simplify the Cassel principle and so modify it as to make it a pronounced success at his Virginia City plant. In the Butters filter, the leaves are set in a rectangular box or tank, the bottom of the box consisting of a series of pointed pockets to facilitate the discharge of the spent cakes. The frames are approximately 5 by 10 feet, and consist of a piece of cocoa matting with a sheet of canvas quilted on each side, the whole being stretched on a frame of half-inch pipe and securely sewed to this pipe frame, which, in turn, is supported on a timber header. The bottom arm of the frame is perforated with small holes, through which the solution enters the pipe when the vacuum is applied. On one side the pipe frame is projected through the wooden header, and is connected with a common pipe leading to the vacuum pump. The frames stand parallel in the filter box at about four and one-

[1] American Min. Congress Papers, Vol. 9, pp. 53, 56, 1906.

[2] Ibid., Vol. 9, pp. 56–60, 1906.

quarter-inch centers. The slime pulp is drawn from the slime reservoir and pumped into the bottom of the filter box until all the frames are immersed. The vacuum is then applied until a cake of suitable thickness is deposited, and the excess of pulp is then returned to the slime reservoir. This operation is repeated for the wash, and the cake finally discharged into the bottom of the box by introducing water under a low head into the interior of the leaves. The accumulated cakes from each charge are removed by sluicing.

"This system possesses the great advantage of simplicity and low cost of maintenance. A plant of any size can be operated by one man, who stands on a platform on a level with the top of the filter box, and manipulates the pumps with levers, and the valves with a simple drum and sheave mechanism. . . .

"This type of filter has been installed, or is in process of installation, at the following plants:

Works of Charles Butters & Co., Virginia City, Nevada.
Combination mine, Goldfield, Nevada.
At the two large Butters plants in Central America.
Guadalupe mine, Inde, Durango, Mexico.
Tonopah Mining Company, Tonopah, Nevada.
Montana-Tonopah Mining Company, Tonopah, Nevada, and several other plants of which I have no record.

"Considering the rapid adoption of the vacuum filter, the prediction may safely be made that it will, before long, supersede the old method of filter pressing, and be accepted as the final solution of the slime problem. There are certain conditions, however, where the product to be handled is too low-grade to admit even of vacuum filtering, and which require special study and a special process. The need of a special process to suit a unique condition was never better exemplified than in the case of the Homestake ore.

"I will not take up here a consideration of the difficult problems encountered, and successfully solved by Mr. Merrill at the Homestake in the cyaniding of mill tailings, averaging less than $1.50 per ton in value. The next and most serious problem to engage his attention was the treatment of the slime, of which 1,600 tons per day had been run to waste from the Homestake mills, of an average value of about 80 cents per ton. Mr. Merrill has devised a filter press, the unique feature of which is that it can be automatically discharged by sluicing without being opened, thus doing away with the chief objection to the old type of press, namely, the cost of operating. This press is of the common flush plate and distance frame pattern, but consists of much larger units. The dimensions of the press are as follows:

Number of frames, 92.
Size of frame, 4 feet by 6 feet.
Length of press, 45 feet.
Capacity of press, 26 tons.
Weight of press, 65 tons.
Thickness of cake, 4 inches.

"The slime pulp is admitted to this press, through a continuous channel at the center of the top of the frames. When the cake is formed, cyanide solution is forced into the cake through channels at the upper corners.

"At the bottom of the frames there extends a continuous channel, within which lies a sluicing pipe, provided with nozzles which project into each compartment. This pipe can be revolved through an arc of any magnitude, so as to play a stream into any part of the cake, washing it down into the annular space between the center channel and the sluicing pipe. When the press is being filled and leached the discharge ends of this pipe are sealed.

"The method of operating is as follows:

"The slime, after partial dewatering, consists of about three parts of water to one of solids. In this form it is charged by gravity to the presses at about thirty pounds pressure. The leaching with cyanide solution is done in the press, the effluent solutions being conducted to four precipitating tanks, where the values are recovered by zinc dust. There is no power cost for agitating or elevating, except for elevating the solution to the press. There will be only six-tenths ton of solution handled per ton of slime, of which only three-tenths ton will be precipitated. All filtering will be done by gravity at a cost of two cents per ton.

"This plant is being erected on the basis of tests made in a ten-ton press of the type described. In all 1,291 tons were treated, with the following results:

	Per Ton.
Average assay value of slime before treatment	$0.91
Average assay value of slime after treatment	.10
Extraction by assay per ton, 90 per cent or	.81
Recovered in precipitate per ton, 91 per cent or	.83

The tendency of modern practice in cyaniding is toward fine grinding, the elimination of the leaching tanks, and efficient methods of filtering.

According to Mr. T. A. Rickard,[1] "The claim often made in behalf of cyanidation as against chlorination, that the former does not and the latter does require a previous preparatory roasting of the ore, is being minimized by the fact that a rough calcination is in many cases advisable, even in cyanidation, because of the physical, rather than chemical changes produced in the ore; changes rendering the material more friable, and so more easily pulverized, and more porous, and therefore better leached and more quickly filtered."

[1] Mineral Industry, 1894, p. 648.

CHAPTER VII.

PRODUCTION OF GOLD AND SILVER.

INTRODUCTORY REMARKS.

A DETAILED account of the distribution and occurrence of the precious metals, gold and silver, has been given in previous chapters and to make complete that record it is necessary to consider in the same relation their production. As gold and silver are the basis of the monetary systems of the world it is somewhat difficult to separate their production and use in one particular country from the other countries of the world's community, which condition of affairs is becoming more pronounced from year to year owing to the improved facilities of travel and transportation.

Owing to the relation which exists between money and industry there is a natural and wide-spread interest in the production of the precious metals.

The history of the production of gold and silver, and more especially the former, has been one of extremes, i.e., from periods of low production and even scarcity to times when the yield has been abnormally large. At such times the advisability of their use as standards of value has been questioned. The single- or gold-standard has now been adopted by many of the leading nations, and will, in time, probably, be accepted by all, thus raising the question of available supply.

The principal sources of supply in the past were: the gold treasures of the New World, and the gold-placers of Brazil; the placers of Russia; and later, the auriferous deposits of Cailfornia and Australia. Yet, notwithstanding the large outputs which at times seem practically inexhaustible the supply could not be maintained, and a steady downward movement began.

Eminent authorities as geologists, mining engineers and financiers after a careful consideration of the question were a unit in the opinion that the supply of gold was uncertain, that there was small hope of any considerable new discoveries, and that the output would decline to such an extent that economically the metal would lose its status.[1]

In 1880 according to Mr. Alexander Del Mar it was "but too evident that the future supply of these metals will not only fail to keep pace with the growth of population and commerce, but they will absolutely diminish."[2] A seemingly obvious conclusion from a study of the world's supply and demand, but it may confidently be said that as long as workable deposits of the precious metals can be found, be they high- or low-grade, there is little reason to fear any material reduction in output. The search for gold is universal and persistent, and is growing in intensity and determination from decade to decade. With a record of no over-production or surplus on the market there has been an increased demand for it and its purchasing power has been enhanced.

There was a turning point, however, in the production of gold and silver, and an increase was observed, which, although slow at first, grew in volume until a marked yearly increase was attained. In a review of the gold and silver production, in 1892, Mr. S. F. Emmons concluded that the annual production of the United States would soon "increase to $40,000,000, and perhaps more;" and that of the world would "increase to $150,000,000 within a few years, and perhaps to $200,000,000 before the close of the decade."[3] Commenting upon these statements Mr. Waldemar Lindgren says: "These predictions have been greatly exceeded by the results of the work of the last few years. The treasures of South Africa and West Australia were found; in Alaska and British Columbia new deposits of wonderful extent were opened; and even in such presumably well prospected regions as Colorado, California, Arizona, Montana and Mexico, new finds were constantly reported, and the production rose steadily and rapidly."[4]

In the twenty years following 1880 the world's annual production of gold increased from approximately $100,000,000 to nearly $300,000,000, while that of the United States had advanced from $33,000,000 to $79,000,000 — the direct result of new discoveries and improved methods of treating refractory and low-grade ores.

Mr. W. Burrell, having in mind conditions obtaining in Australia

[1] Die Zukunft des Goldes, Wien, 1877, and T. A. I. M. E., Vol. 33, p. 791.

[2] History of the Precious Metals, Alexander Del Mar, 1880.

[3] "Mineral Resources of the United States," Calendar year, 1892, U. S. G. S., pp. 90–93, 1893.

[4] T. A. I. M. E., Vol. 33, p. 792, 1903.

rather than elsewhere, gives the following reasons for his conclusions regarding the probable decrease in production of gold: "first, the recent rate of increase must soon be checked by the natural exploitation of the more easily worked gold-bearing formations; second, the apparent impossibility of very much further reduction in costs of treatment, and mining costs generally; and third, the enormous capacity there exists in most of the great commercial countries to absorb any comparatively larger output."[1] It is possible that the time will come when the supply will depend more upon improvements in processes of extraction of the metals than in the development of new districts, but predictions based upon such assumptions are extremely unreliable. Evidently then the most reliable source of information upon which to base conclusions as to the available supply of precious metals is the character and occurrence of the various known and workable deposits.

The quantity of gold and silver found in nature is extremely limited, and although deposits of considerable extent and unusual richness, known as bonanzas, are occasionally found, they are quickly exhausted, and are relatively of small importance compared with the large, low-grade deposits that maintain a uniform production for years.

The terms "low-grade" and "high-grade" as applied to ores are variable both with respect to time and locality. A change or improvement in method of treatment, mining, handling or extracting the values from the ore are the most potent causes of change of standard. At present ore ranging in value from $3.50 to $8.00 is considered low-grade, although the term is applied more usually to the former figures. All ore of a value of $8 to $30 may be considered as medium-grade, while that above $30 or $40 is high-grade. Formerly, in many localities, all ore below $50 was considered low-grade and too poor to work. Ores running from $15 to $30 are occasionally yet called high-grade.[2] Probably the most important source of gold is placer deposits, for the reason that the gold is easily extracted and being in the free state requires little or no subsequent treatment. These deposits like the bonanzas are too quickly exhausted to be of any permanent value as a source of supply. It would then seem that from the standpoint of permanency of output our main reliance must be placed upon auriferous ores of which there is a wide range and it is constantly being extended.

[1] Mines and Minerals, Vol. 27, p. 69.

[2] T. A. I. M. E., California Mines and Minerals, p. 4, 1899.

On the other hand silver has always been obtained chiefly from ores by metallurgical treatment and it was largely through the treatment of argentiferous ores that the metallurgical treatment of other metals was made possible. The discovery of bonanzas such as those of the Comstock lode was mainly responsible for the rapid progress made in the metallurgical treatment of both silver and gold.

There is, however, another feature in connection with the production of gold and silver, namely, the element of risk which is less prominent in placer- than vein-mining. Profit is probably the chief incentive to the search for deposits and methods of extracting the precious metals. The great profits which accrue to the lucky finders or possessors of rich deposits, when made public, lead others to seek such investments. The result is, an extensive search is made which leads to the discovery, perhaps, of a few other rich deposits and a large number of poor or worthless ones. However, money is expended on all alike, which is often lost in misdirected efforts. A disgust and distrust of such investments come as a reaction and capital and labor withdraw. Nevertheless the production does not immediately feel the effect of this change of sentiment, because the rich mines are yielding large returns prior to their exhaustion. Later when the production is at a low point, the discovery of a new bonanza or deposit may cause the history of the district to repeat itself, yet it is rarely the case that the turning point in production and the change in public interest are coincident.

The local and largely temporary over-production of the precious metals has in many cases caused a decided decline in their purchasing power, especially noticeable in California, Australia and Russia, which, according to Jevons, was responsible for Holland's adoption of the silver standard and bi-metallism by other countries — a decline of from 8 to 15 per cent occurred. A further effect of increased production is the reduced cost of production. This is especially true of gold, while as silver decreases in annual production the cost of its production has increased.

As to the effect of a possible increase in cost of production of gold, assuming $3 to be the average cost per ton of ore mined, Mr. R. W. Barrell considers that an increase of 10 per cent, would not materially affect the properties now operating but might have some effect upon the exploitation of new properties. With an increase of 25 per cent, a number of the large mines might have to close and the general effect would be a decrease in production. While with an increase of 40 per cent, practically none but the mines producing high-grade ore could operate and the production would be curtailed by at least 75 per cent. Further, he holds that an increase in production of 5 per cent could be readily absorbed without any indication of a surplus on the market.[1]

With the comparatively large amount of gold and silver stocks accumulated in the world at the present time the discovery of especially rich mines has a less disturbing influence, which together with a better understanding of the economic relation between money and metals, have materially reduced the number and extent of the fluctuations in investment and production.

It is undoubtedly true that the actual and relative amounts of the precious metals produced depend largely upon their abundance in nature and the relative profits resulting from their production. The relatively small amounts of these metals found in ores and the difficulty often experienced in extracting the values are most effective regulators of production.[2]

"The demand for gold and silver has always been due to their use in money; the uses in the industries, chiefly as ornaments and articles of luxury, are due rather to the fact that the metals are used in, and are easily convertible into, money than to their intrinsic physical properties, so that it may be said almost the entire demand for both gold and silver has always been on account of their use in money. It is because their possession is an evidence of wealth and brings to their possessor the consideration and homage of his fellows, that there is a demand for them, and not because their physical properties are so superior to those of many other metals as to justify the difference in their prices. There is not now and never will be any large use in the industries dependent upon the intrinsic properties of either gold or silver that would give it a value at all comparable with its present price, or that would induce its production in large amounts." [3]

PRODUCTION OF THE UNITED STATES.

In 1894 the United States lost the first place in the world as a producer of gold, its production having been exceeded by that of Australasia by $290,670. In 1889 California held first rank among the States in gold production, its product, as estimated by the Director of the Mint, being nearly four times that of Colorado and

[1] Mines and Minerals, Vol. 26, pp. 455 and 456.
[2] The Mineral Industry, 1894, pp. 298–304.
[3] Mineral Industry, 1894, p. 298.

there was besides this a small annual increase. However, notwithstanding this formidable handicap in the race for supremacy in output of gold, Colorado, in 1897, attained and exceeded and has still retained the ranking position in production.

In 1902 the ores of Colorado yielded more than one-third of the gold and more than one-fourth of the silver obtained from ores in the United States, while California contributed one-fifth of the gold produced in the States. Following California came Alaska with one-ninth of the total gold product and more than one-half of the placer gold in the States. The other principal producing states had a relative production as shown by the following order: South Dakota, Montana, Utah, Arizona, Oregon, Nevada and Idaho. The yield from the other states and territories was less than $1,000,000 each.

With Colorado leading in the production of silver, Montana held the second place and was a close second to Colorado, contributing nearly one-fourth of the silver produced from ores in the United States, the larger part (nearly three-fourths) being derived from the smelting of copper ores. Utah stood third in rank as a producer of silver, yielding over one-fifth of the total product. Idaho and Nevada came next in order.

Silver was obtained chiefly in the treatment of argentiferous lead ores, the order of production in the principal producing states, was Idaho, Utah and Colorado, the product being $10,291,494, $8,261,095 and $7,296,925 respectively. The relative proportion of silver to lead in value in the ores being: $\frac{3}{4}$ to $\frac{1}{4}$, in Colorado; $\frac{2}{3}$ to $\frac{1}{3}$, in Utah; and $\frac{1}{3}$ to $\frac{2}{3}$ in Idaho.

Compared with the value of the gold product in California and South Dakota, the silver output is insignificant, while in Montana and Utah the silver-content of the ores exceeds that of the gold.

Up to 1895 there was a substantial increase in the production of silver in Colorado and Montana, following which there was a decided decline, while, since 1889, the silver output of Utah has materially increased. Nevada and Idaho occupying the fourth and fifth positions respectively in the production of silver, had a reversal take place, Idaho steadily forging to the front. From 1889 to 1899 the silver output of Nevada gradually fell off until it became of little relative importance, but since 1900 there has been a decided increase.

There was a relative shifting of positions of the two precious metals in the various states in 1902; in Colorado in 1889 the gold product amounted to $3,883,859 and that of silver estimated at the commercial rate of 93.5 cents per fine ounce, to $17,500,000; while in 1902 the value of gold was $26,414,800 and the commercial value of silver $7,740,227. The decrease of nearly $10,000,000 in commercial value of the silver product was made up by an increase in the gold output and there was a surplus of $13,000,000 in the aggregate commercial value of the two metals.[1]

In 1905 nine states and territories produced 99.5 per cent of the gold output of the United States. Colorado still ranked first, while next in order came California, Alaska and South Dakota. In the production of silver Montana led but was closely followed by Colorado and Utah.

As silver is now produced largely as a by-product from ores worked principally for other metals, its production will continue irrespective of the demand or the commercial value. The principal silver producing states in 1905 were: Montana and Arizona (from the copper mines) and Colorado, Utah and Idaho (from the lead mines.)[2]

"The estimated production of refined silver is equal to the total silver production of domestic refineries less the silver contents of foreign ores reduced in the United States. . . . The excess appearing from year to year in the production reported by the mine operators, as compared with the product of refineries, is easily accounted for by the fact that the former is largely an estimate of the assay contents of all ore mined, regardless of the quantity of ore which will eventually be left on the dump after sorting, as being of too low-grade to pay freight and reduction; nor are the losses in smelting always considered by the mine operator in estimating the assay contents of his ore."[3]

The relatively large increase in gold production of the North American continent during the past decade has been due to the following causes: first, the discovery and development of new districts throughout the productive portions of the country; second, the operation under more favorable conditions of many of the old districts; third, the development of metallurgical processes, especially copper smelting; fourth, the working of low-grade ores and wastes by lixiviation processes; and fifth, improvements in placer-working appliances.

[1] Mines and Quarries, 1902, Special Report of the Dept. of Commerce and Labor, Bureau of the Census, p. 555.

[2] Mineral Industry, 1905, p. 218.

[3] Mines and Quarries, 1902, Rept. Bureau of Census, p. 553.

In the following table are given the number of producing mines, ore production, and average value of gold and silver per ton in 1905, by states:[1]

TABLE I.

State and Territory.	Number of Mines.			Ore Production from Deep Mines. (Short Tons.)	Average Value of Gold and Silver Per Ton of Ore from Deep Mines.
	Placer.	Deep.	Total.		
Alabama	1	2	3	16,525	$2.46
Alaska	* 1,100	18	* 1,118	1,422,515	2.46
Arizona	12	122	134	2,678,059	1.62
California	658	481	1,139	2,696,603	5.06
Colorado	23	490	513	2,504,087	12.73
Georgia	* 12	* 10	* 22	* 16,000	* 4.18
Idaho	152	105	257	1,669,038	3.58
Maryland	....	2	2	2,698	5.51
Montana	78	254	332	5,020,137	2.47
Nevada	10	122	132	432,202	21.25
New Mexico	21	52	73	145,629	3.03
North Carolina	7	16	23	18,831	6.76
Oregon	167	66	233	150,268	8.03
South Carolina	....	2	2	49,493	1.92
South Dakota	12	20	32	1,837,411	3.86
Tennessee	1	2	3	399,330	.15
Texas	....	6	6	22,345	10.49
Utah	7	114	121	2,181,061	5.41
Virginia	* 3	* 4	* 7	* 800	* 5.35
Washington	16	35	51	46,650	10.17
Wyoming	7	6	13	31,007	.87
Total	2,287	1,929	4,216	21,340,689	4.82

* Estimated.

[1] U. S. G. S., Mineral Resources, 1905, p. 121.

The sources of gold and silver as reported from the mines in the states and territories during 1905 are arranged according to character of ore and by states in Table II:[1]

TABLE II.

State.	Placers.		Dry or Siliceous Ores.		Copper Ores.		Lead Ores.	
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Alabama	50	5	1,959	331	....	....	....	....
Alaska	586,499.53	75,092	166,168.13	31,107	3,433.62	26,525	....	....
Arizona	2,064	306	67,572	441,952	55,668	1,480,732	9,270	594,330
California	285,029.17	27,367	617,856.11	607,161	10,867.46	388,169	464.40	53,477
Colorado	4,855.71	908	1,165,232.96	6,107,559	3,884.13	55,388	31,667.99	3,883,827
Georgia	1,451	100	3,159	271	78	669	....	....
Idaho	16,470	3,482	34,282	861,637	833	486,450	362	7,277,408
Maryland	....	....	717	93	....	....	....	....
Michigan	....	....	....	....	....	251,011	....	....
Montana	19,200.07	2,573	154,792.94	1,797,722	52,881.44	10,624,594	4,899.10	798,855
Nevada	400.25	98	253,015.54	6,183,588	51.33	1,689	1,460.39	291,953
New Mexico	4,805.34	662	10,371.92	295,484	44.43	19,962	137.87	53,084
North Carolina	484	100	5,224.50	3,000	372	17,130	....	....
Oregon	12,172.06	1,945	54,970.23	85,177	835.94	1,825	....	1,689
South Carolina	....	....	4,601.00	111	....	....	....	....
South Dakota	443.27	52	337,673.43	182,697	....	....	....	....
Tennessee	10	1	....	....	201	95,521	....	....
Texas	....	....	12	387,506	....	....	....	....
Utah	322	61	64,383	94,497	125,897	2,301,349	17,805	3,104,375
Virginia	39	41	202	173	....	....	....	....
Washington	311.48	60	18,993.99	107,737	290.16	6,374	....	11,205
Wyoming	102.38	11	961.11	86	230.32	3,559	....	....
Total	934,709.26	12,826	2,962,147.36	17,187,889	255,567.83	15,762,947	66,066.75	16,070,203

State.	Zinc Ores.		Copper-Lead or Copper-Lead-Zinc Ores.		Lead-Zinc Ores.		Total.	
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Alabama	....	....	....	....	....	....	2,009	336
Alaska	....	....	....	....	....	....	756,101.28	132,724
Arizona	....	....	121	88,392	717	....	135,412	2,605,712
California	....	....	....	....	....	....	914,217.14	1,076,174
Colorado	1,846.39	916,391	....	....	3,047.55	535,234	1,210,534.73	11,499,307
Georgia	....	....	....	....	....	....	4,688	1,040
Idaho	....	....	10	30,653	76	19,463	52,033	8,679,093
Maryland	....	....	....	....	....	....	717	93
Michigan	....	....	....	....	....	....	....	253,011
Montana	....	....	140.20	7,556	....	....	231,913.75	13,231,300
Nevada	....	4,753	....	....	....	....	254,927.51	6,482,081
New Mexico	....	....	....	....	....	....	15,359.56	369,192
North Carolina	....	....	....	....	....	....	6,080	20,230
Oregon	....	....	....	....	....	....	67,978.23	90,636
South Carolina	....	....	....	....	....	....	4,601	111
South Dakota	....	....	....	....	....	....	338,116.70	182,749
Tennessee	....	....	....	....	....	....	211	95,522
Texas	....	....	....	....	....	....	12	387,506
Utah	95	18,108	38,500	5,290,122	1,690	227,959	248,692	11,036,471
Virginia	....	....	....	....	....	....	241	177
Washington	....	....	....	....	....	....	19,595.63	125,376
Wyoming	....	....	....	....	....	....	1,293.81	3,655
Total	1,941.39	939,252	38,771.20	5,416,723	5,530.55	782,656	4,264,734.34	56,272,496

[1] U. S. G. S., Mineral Resources, 1905, pp. 122 and 125.

APPROXIMATE DISTRIBUTION, BY PRODUCING STATES AND TERRITORIES, OF THE PRODUCT OF GOLD AND SILVER IN THE UNITED STATES FOR THE CALENDAR YEAR, 1905.

(As estimated by the Director of the Mint.)

TABLE III.

State or Territory.	Gold.		Silver.		Total Value. (Silver at Commercial Value).
	Fine Ounces.	Value.	Fine Ounces.	Commercial Value.	
Alabama....	2,008	$41,500	300	$183	$41,683
Alaska......	722,026	14,925,600	169,200	103,212	15,028,812
Arizona.....	130,192	2,691,300	2,605,700	1,589,477	4,280,777
California...	928,660	19,197,100	1,082,000	660,020	19,857,120
Colorado....	1,243,291	25,701,100	12,942,800	7,895,108	33,596,208
Georgia......	4,586	94,800	900	549	95,349
Idaho.......	52,032	1,075,600	8,125,600	4,956,616	6,032,216
Maryland....	817	16,900	100	61	16,961
Michigan....	....	....	253,000	154,330	154,330
Missouri.....	....	....	12,900	7,869	7,869
Montana.....	236,520	4,889,300	13,454,700	8,207,367	13,096,667
Nevada......	259,246	5,359,100	5,863,500	3,576,735	8,935,835
New Mexico.	12,858	265,800	354,900	216,489	482,289
N. Carolina..	5,994	123,900	13,200	8,052	131,952
Oregon......	60,222	1,244,900	88,900	54,229	1,299,129
S. Carolina..	4,600	95,100	200	122	95,222
S. Dakota...	334,460	6,913,900	179,000	109,190	7,023,090
Tennessee...	160	3,300	95,400	58,194	61,494
Texas.......	92	1,900	417,200	254,492	256,392
Utah........	248,691	5,140,900	10,319,800	6,295,078	11,435,978
Virginia.....	242	5,000	200	122	5,122
Washington .	17,899	370,000	119,400	72,834	442,834
Wyoming....	1,146	23,700	2,700	1,647	25,347
Total......	4,265,742	88,180,700	56,101,600	34,221,976	122,402,676

TABLE IV.

PRODUCTION OF GOLD AND SILVER IN THE UNITED STATES FROM 1792 TO 1844, AND ANNUALLY SINCE.[1]

(The estimate for 1792–1873 is by R. W. Raymond, Commissioner, and since by Director of the Mint.)

Year.	Gold.		Silver.	
	Fine Ounces.	Value.	Fine Ounces.	Commercial Value.
1792 to July 31, 1834.	677,250	$14,000,000	....	....
July 31, 1834 to Dec. 31, 1844.	362,812	7,500,000	193,400	$253,400
1845.........	48,762	1,008,000	38,700	50,200
1846.........	55,341	1,140,000	38,700	50,300
1847.........	43,005	889,000	38,700	50,600
Total......	1,187,170	24,537,000	309,500	404,500
1848.........	483,750	10,000,000	38,700	50,500
1849.........	1,935,000	40,000,000	38,700	50,700
1850.........	2,418,750	50,000,000	38,700	50,900
1851.........	2,660,625	55,000,000	38,700	51,700
1852.........	2,902,500	60,000,000	38,700	51,300
1853.........	3,144,375	65,000,000	38,700	52,200
1854.........	2,902,500	60,000,000	38,700	52,200
1855.........	2,660,625	55,000,000	38,700	52,000
1856.........	2,660,625	55,000,000	38,700	52,000
1857.........	2,660,625	55,000,000	38,700	52,400
1858.........	2,418,750	50,000,000	38,700	52,000
1859.........	2,418,750	50,000,000	77,300	105,100
1860.........	2,225,250	46,000,000	116,000	156,800
1861.........	2,080,125	43,000,000	1,546,900	2,062,000
1862.........	1,896,300	39,200,000	3,480,500	4,684,800
1863.........	1,935,000	40,000,000	6,574,200	8,842,300
1864.........	2,230,087	46,100,000	8,507,800	11,443,000
1865.........	2,574,759	53,225,000	8,701,200	11,642,200
1866.........	2,588,062	53,500,000	7,734,400	10,356,400
1867.........	2,502,196	51,725,000	10,441,400	13,866,200
1868.........	2,322,000	48,000,000	9,281,200	12,306,900
1869.........	2,394,562	49,500,000	9,281,200	12,297,600
1870.........	2,418,750	50,000,000	12,375,000	16,434,000
1871.........	2,104,312	43,500,000	17,789,100	23,588,300
1872.........	1,741,500	36,000,000	22,236,300	29,396,400
Total......	58,279,778	1,204,750,000	118,568,200	157,749,900

[1] Rept. Director of Mint, 1906, p. 123.

TABLE IV.—*Continued.*

Year.	Gold.		Silver.	
	Fine Ounces.	Value.	Fine Ounces.	Commercial Value.
1873	1,741,500	$36,000,000	27,650,400	$35,881,600
1874	1,620,122	33,490,900	28,868,200	36,917,500
1875	1,619,009	33,467,900	24,539,300	30,485,900
1876	1,931,575	39,929,200	29,996,200	34,919,800
1877	2,268,662	46,897,400	30,777,800	36,991,500
1878	2,477,109	51,206,400	35,022,300	40,401,000
1879	1,881,787	38,900,000	31,565,500	35,477,100
1880	1,741,500	36,000,000	30,318,700	34,717,000
1881	1,678,612	34,700,000	33,257,800	37,657,500
1882	1,572,187	32,500,000	36,196,900	41,105,900
1883	1,451,250	30,000,000	35,732,800	39,618,400
1884	1,489,950	30,800,000	37,743,800	41,921,300
1885	1,538,373	31,801,000	39,909,400	42,503,500
1886	1,686,788	34,869,000	39,694,000	39,482,400
1887	1,603,049	33,136,000	41,721,600	40,887,200
1888	1,604,478	33,167,500	45,792,700	43,045,100
1889	1,594,775	32,967,000	50,094,500	46,838,400
1890	1,588,877	32,845,000	54,516,300	57,242,100
1891	1,604,840	33,175,000	58,330,000	57,630,000
1892	1,597,098	33,015,000	63,500,000	55,662,500
1893	1,739,323	35,955,000	60,000,000	46,800,000
1894	1,910,813	39,500,000	49,500,000	31,422,100
1895	2,254,760	46,610,000	55,727,000	36,445,500
1896	2,568,132	53,088,000	58,834,800	39,654,600
1897	2,774,935	57,363,000	53,860,000	32,316,000
1898	3,118,398	64,463,000	54,438,000	32,118,400
1899	3,437,210	71,053,400	54,764,500	32,858,700
1900	3,829,897	79,171,000	57,647,000	35,741,100
1901	3,805,500	78,666,700	55,214,000	33,128,400
1902	3,870,000	80,000,000	55,500,000	29,415,000
1903	3,560,000	73,591,700	54,300,000	29,322,000
1904	3,892,480	80,464,700	57,682,800	33,456,000
1905	4,265,742	88,180,700	56,101,600	34,222,000
Total	75,318,731	1,556,974,500	1,498,797,900	1,276,285,500
Grand Total.	134,785,679	2,786,261,500	1,617,675,600	1,434,439,900

THE WORLD'S PRODUCTION.

There is a constant shifting of positions by the principal countries in the production of gold and silver, especially the former. As previously stated the United States lost the first place as a producer of gold in 1894, having been surpassed by Australasia. In 1902 the United States held second place, still being preceded by Australasia; South Africa, Russia and Canada holding the third, fourth and fifth positions, respectively. In the same year the total output of the British possessions was about $154,000,000, being more than one-half of the world's production. The United States came second with a product of $80,000,000 or more than one-fourth; together these two nations contributed fully four-fifths of the output of the gold mines of the world.

In 1904 the ranking positions of the three principal gold-producing countries were: Australasia, first, Africa, second, and the United States, third. In 1905 the order was again changed, being: Africa first, the United States second, and Australasia third. It is probable that the position of second rank now held by the United States, will be maintained for some time to come, yet it is possible that the discovery and development of a number of large producing mines of high-grade product of the bonanza or propylitic type, such as have been discovered recently in Nevada, might advance the production of the United States well toward the position of first rank.

In 1902 Mexico led in the production of silver, her output exceeding one-third of the world's production. The United States was a close second having a product of one-third that of the world. Of the total output of the world, North America contributed 71.9 per cent, while Central and South America added 14.1 per cent, making a total for the American continent of six-sevenths of the world's silver output. During the years 1903, 1904 and 1905 the yield in silver of the United States and Mexico experienced a rapid change, and in 1905 there was a reversal in the positions previously held for some years. The yield in ounces for the three years beginning with 1903 was as follows: in 1903, the United States, 54,300,000 and Mexico, 70,499,942; in 1904, the United States, 57,682,800 and Mexico, 60,808,978; and in 1905, the United States, 56,101,600 and Mexico, 54,652,893.[1]

A report on the world's production of precious metals made in 1897 by M. de Foville, Director of the French Mint, is an interesting and instructive summary, a review of which is given below. History is divided into four unequal periods: The first ends with the Middle Ages, and is of historical interest only.

" In the fifteenth century Europe possessed a slender stock of gold and silver, whose total has been usually estimated at one thousand million of francs — $200,000,000. The second period begins with the discovery of America, and closes in the middle of the

[1] Mines and Quarries, Report Bureau of Census, 1902, p. 563, and Report Director of Mint, 1906, pp. 125–127.

WORLD'S PRODUCTION OF GOLD AND

TABLE V.

Country.	Gold.		
	Kilograms (fine).	Ounces (fine).	Value.
North America:			
United States	132,682	4,265,742	$88,180,700
Mexico	22,963	738,261	15,261,200
Canada	21,798	700,800	14,486,800
Africa	170,522	5,482,296	113,329,100
Australasia	129,291	4,156,692	85,926,500
Europe:			
Russia	33,542	1,078,356	22,291,600
Austria-Hungary	3,698	118,875	2,457,400
Germany	100	3,227	66,700
Norway	......	......	......
Sweden	55	1,775	36,700
Italy	66	2,128	44,000
Spain	......	......	......
Greece	......	......	......
Turkey	9	289	6,000
France	......	......	......
Great Britain	170	5,450	112,700
South America:			
Argentina	8	265	5,500
Bolivia	33	1,061	21,900
Chile	1,427	45,886	948,500
Colombia	3,888	125,001	2,584,000
Ecuador	284	9,117	188,500
Brazil	3,076	98,906	2,044,600
Venezuela	258	8,293	171,400
Guiana:			
British	2,544	81,789	1,690,700
Dutch	952	30,597	632,500
French	2,718	87,387	1,806,400
Peru	711	22,852	472,400
Uruguay	75	2,419	50,000
Central America	2,277	73,212	1,513,400
Asia:			
Japan	5,011	161,105	3,330,300
China	2,673	85,918	1,776,100
Korea	3,385	108,844	2,250,000
Siam	73	2,351	48,600
India (British)	17,537	563,817	11,655,100
British East Indies	2,235	71,854	1,485,400
Dutch East Indies	2,128	68,426	1,414,500
Total	566,189	18,202,991	376,289,200

SILVER FOR THE CALENDAR YEAR[1] 1905.

— *Continued.*

Silver.			
Kilograms (fine).	Ounces (fine).	Commercial Value.	Coining Value.
1,745,318	56,101,600	$34,222,100	$72,535,400
1,700,249	54,652,893	33,338,300	70,662,300
185,878	5,974,875	3,644,700	7,725,100
19,276	619,620	378,000	801,100
390,791	12,561,600	7,662,600	16,241,300
6,376	204,960	125,000	265,000
57,870	1,860,169	1,134,700	2,405,100
181,090	5,820,947	3,550,800	7,526,100
7,554	242,805	148,100	313,900
770	24,765	15,100	32,000
23,574	757,777	462,200	979,700
124,439	4,000,000	2,440,000	5,171,700
25,791	829,025	505,700	1,071,900
1,178	37,874	23,100	49,000
9,275	298,152	181,900	385,500
5,210	167,479	102,200	216,50
4,671	150,149	91,600	194,100
88,175	2,834,298	1,728,900	3,664,500
12,377	397,853	242,700	514,400
21,131	679,245	414,300	878,200
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
160,828	5,169,659	3,153,500	6,684,000
.....	.....	.....	.....
42,355	1,361,449	830,500	1,760,300
74,971	2,409,879	1,470,000	3,115,800
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
5,690	182,889	111,500	236,500
4,894,837	157,339,962	95,977,400	203,429,400

[1] Rept. Director of Mint, 1906, p. 127.

present century; the third extends from 1850 to 1875, comprising the third quarter of the century, and the fourth, beginning in 1875, extends to the present time. In constructing any approximately accurate table of the production of gold and silver during the 402 years which have elapsed between the date of the discovery of America and the last year of complete returns — 1896 — it is evidently necessary that some uniform terms should be used both of quantity and of value. The director of the French mint favors the usual standard of comparison of 15½ to 1, estimating the value of each kilogram of gold at 3,444 francs 44 centimes, and of each kilogram of silver at 222 francs 22 centimes. A kilogram, it may be noted, is equal to 2.6803 pounds, or 32.16 ounces troy.

"Beginning with the period between 1493 and 1850, comprising 358 years, he finds that the total production of gold was 4,752,070 kilograms, valued at 16,368,200,000 francs, and of silver 149,826,750 kilos, valued at 33,294,800,000 francs. The average annual production of gold, which begins with 5,800 kilos, reaches at the end of the period 54,759 kilos, while the average annual production of silver, which begins with 47,000 kilos, closes with 780,415 kilograms. But, while at the beginning of the period the average annual value of the production of gold is double that of silver, it is less than 10 per cent in excess of it at the end of the period, and but for the gold discoveries in this state (California) the average annual value of the silver product would have been very much greater. In the second period — 1851 to 1875 — is reached a time in which the gold production greatly exceeded in value that of silver, except as to the one or two years with which it closes. Between 1856 and 1860 the annual average of gold production was 201,750 kilos, valued at 694,900,000 francs, and of silver 904,990 kilos, valued at 201,100,000 francs. For the entire period the production of gold was 4,775,625 kilos, valued at 16,449,400,000 francs, or a little over the entire value of the preceding 358 years. Of the 73,000,000,000 francs of gold and silver produced between 1493 and 1875, South America yielded 26,000,000,000, Mexico, 18,000,000,000, and the United States, 8,000,000,000; the contribution of the New World amounting in all to 53,000,000,000 francs.

"In the period between 1876 and 1895 there is a steady increase in production of silver, accompanied by a temporary decrease of the gold product from its highest point, which was followed by a rapid increase to figures greatly in excess even of those reached during the early days of the Australian and Californian discoveries. As compared with 1876, the production of gold in 1895 was twice as great, while that of silver had increased 2½ times. In the 402 years over which this review extends, it appears that there have been produced 45,000,000,000 francs in gold and 55,000,000,000 francs in silver, making for the whole period an average annual production of the precious metals of about 250,000,000 francs. But the annual averages of our time, as compared with those of previous centuries, show an extraordinary rate of progression. For example, the average annual product of the sixteenth century was 80,000,000 francs, that of the seventeenth 115,000,000, and for the eighteenth 193,000,000 francs. For the first half of the nineteenth century the annual production of both metals averaged about 227,000,000 francs, but for the twenty-five years following, between 1851 and 1875, there is a leap to the annual average of 930,000,000 francs, two-thirds of which was in gold. But even this average is exceeded between 1876 and 1885, in which ten years, however, the production of silver reaches a nominal value about equal to that of gold. Since 1886 the increase in the annual production of the precious metals has been still more rapid than in the ten years preceding. The average between 1886 and 1890 was 1,340,000,000 francs per annum, of which 750 millions represented silver at its nominal coinage value. Between 1891 and 1895 the annual average was 1,934,000,000 francs, and during these five years the course of progression has been so rapid that we pass from a gold product in 1891 of 677,000,000 francs to one of 1,030,000,000 francs in 1895, while of silver the annual production has advanced from 939,000,000 francs of nominal value in 1891 to 1,114,000,000 francs in 1895, the production of the precious metals between 1851 and 1895 being almost exactly equal to that of the whole preceding period since the discovery of America."[1]

[1] Min. and Sci. Press, Vol. 75, p. 166.

TABLE VI.

WORLD'S PRODUCTION OF GOLD AND SILVER SINCE THE DISCOVERY OF AMERICA — 1492.[1]

Period.	Gold.			
	Number of Years.	Production.		
		Annual (Kilos).	Total (Kilos).	Total Value.
1493–1520	28	5,800	162,400	$107,836,848
1521–1544	24	7,160	170,400	114,102,912
1545–1560	16	8,510	136,160	87,305,536
1561–1580	20	6,840	136,800	90,835,080
1581–1600	20	7,380	147,600	96,870,400
1601–1620	20	8,520	170,400	113,149,960
1621–1640	20	8,300	166,000	110,227,320
1641–1660	20	8,770	175,400	116,467,680
1661–1680	20	9,260	185,200	122,974,600
1681–1700	20	10,765	215,300	142,961,844
1701–1720	20	12,820	256,400	167,875,680
1721–1740	20	19,080	381,600	253,389,080
1741–1760	20	24,610	492,200	326,831,120
1761–1780	20	20,705	414,100	275,970,920
1781–1800	20	17,790	355,800	236,257,840
1801–1810	10	17,778	177,780	118,148,000
1811–1820	10	11,445	114,450	75,998,160
1821–1830	10	14,216	142,160	94,397,940
1831–1840	10	20,289	202,890	135,722,280
1841–1850	10	54,759	547,590	363,609,260

[1] Materials Toward the Elucidation of the Economic Conditions Affecting the Precious Metals, for years 1793 to 1850, Dr. Adolph Soetbeer; Mineral Industry, 1894, p. 299, and Reports Directors of Mint.

TABLE VI.— *Continued.*

Period.	Silver. Production. Annual (Kilos).	Silver. Production. Total (Kilos).	Silver. Production. Total Commercial Value.	Weight Ratio of Silver to Gold.	Value Ratio, Gold to Silver.
1493–1520	47,000	$ 1,316,000	$ 81,434,080	8.1	10.75
1521–1544	90,200	2,164,000	138,015,440	12.6	11.25
1545–1560	311,600	4,985,600	293,510,720	36.6	11.30
1561–1580	299,500	5,990,000	346,428,040	43.8	11.50
1581–1600	418,900	8,378,000	470,573,600	56.8	11.80
1601–1620	422,900	8,458,000	459,963,960	49.6	12.25
1621–1640	393,600	7,872,000	372,831,760	47.4	14.00
1641–1660	366,300	7,326,000	344,770,800	41.8	14.50
1661–1680	337,000	6,740,000	298,366,320	36.4	15.00
1681–1700	341,900	6,838,000	302,702,680	31.8	14.97
1701–1720	355,600	7,112,000	309,757,000	27.7	15.21
1721–1740	431,200	8,624,000	380,666,720	22.6	15.08
1741–1760	533,145	10,662,900	479,636,640	21.7	14.75
1761–1780	652,740	13,054,800	590,339,960	31.5	14.73
1781–1800	879,060	17,581,200	774,099,760	49.4	15.09
1801–1810	894,150	8,941,500	380,926,140	50.3	15.61
1811–1820	540,770	5,407,700	231,666,820	47.2	15.51
1821–1830	460,560	4,605,600	194,015,220	32.4	15.80
1831–1840	596,450	5,964,500	251,261,360	29.4	15.75
1841–1850	780,415	7,804,150	326,900,140	14.3	15.83

TABLE VI. — *Continued.*

Year.	Gold.		Silver.		Weight Ratio, Silver to Gold.	Value Ratio, Silver to Gold.
	Kilos.	Value.	Kilos.	Commercial Value.		
1851	107,153	$ 67,600,000	875,600	$ 37,651,000	8.1	15.46
1852	198,315	132,800,000	888,735	37,638,000	4.5	15.59
1853	233,975	155,500,000	888,735	38,509,000	3.9	15.33
1854	191,845	127,500,000	888,735	38,509,000	4.5	15.33
1855	203,280	135,100,000	888,735	38,393,000	4.4	15.38
1856	222,013	147,600,000	904,270	39,073,500	4.1	15.38
1857	200,572	133,300,000	904,270	39,355,000	4.5	15.27
1858	187,632	124,700,000	904,270	39,073,500	4.9	15.38
1859	187,933	124,900,000	906,490	40,722,400	4.9	15.19
1860	164,460	119,300,000	906,490	39,459,500	5.5	15.29
1861	171,215	113,800,000	1,013,617	43,474,200	6.0	15.50
1862	162,228	107,800,000	1,025,955	43,423,800	6.4	15.35
1863	160,999	107,000,000	1,105,659	47,864,500	6.9	15.37
1864	170,027	113,000,000	1,172,349	50,645,500	6.9	15.37
1865	180,860	120,200,000	1,189,152	51,182,100	6.6	15.44
1866	182,215	121,000,000	1,357,477	58,411,200	7.4	15.43
1867	156,485	104,000,000	1,448,332	61,843,800	9.3	15.57
1868	165,062	109,700,000	1,341,444	57,145,300	8.1	15.59
1869	159,795	106,200,000	1,269,295	54,071,700	8.0	15.60
1870	160,848	106,900,000	1,378,855	58,876,100	8.6	15.57
1871	160,999	107,000,000	1,903,999	81,300,700	11.8	15.57
1872	149,849	99,600,000	2,034,852	86,521,800	13.5	15.63
1873	144,487	96,200,000	1,967,683	82,120,000	13.6	15.92
1874	136,090	90,800,000	1,719,901	90,673,000	12.4	16.17
1875	146,704	97,500,000	1,939,539	77,578,000	13.2	16.59
1876	156,034	103,700,000	2,107,210	78,322,000	13.5	17.88
1877	171,532	114,000,000	2,174,619	75,240,000	12.7	17.22

1878	179,055	119,000,000	2,326,432	84,644,000	13.0	17.94
1879	164,008	109,000,000	2,174,531	83,383,000	12.6	18.40
1880	160,397	106,600,000	2,322,999	85,636,000	14.5	18.05
1881	154,980	103,000,000	2,453,581	89,777,000	16.0	18.16
1882	153,626	102,000,000	2,690,109	98,230,000	17.5	18.19
1883	143,575	95,400,000	2,774,227	98,986,000	19.2	18.64
1884	153,039	101,700,000	2,537,564	90,817,000	16.6	18.57
1885	163,105	108,400,000	2,841,572	97,564,000	17.4	19.41
1886	159,509	106,000,000	2,896,882	92,772,000	18.1	20.78
1887	159,156	105,775,000	2,992,451	94,031,000	19.0	21.13
1888	165,659	110,197,000	3,424,771	102,283,000	20.6	21.99
1889	185,809	123,489,000	3,901,809	112,399,700	20.9	22.10
1890	178,825	118,848,700	4,180,532	132,399,700	23.3	19.76
1891	196,586	130,650,000	4,267,380	135,524,800	21.6	20.92
1892	220,133	146,297,600	4,757,955	133,822,600	21.6	23.72
1893	256,236	158,437,551	5,339,746	134,241,121	20.9	26.43
1894	293,542	175,645,704	5,205,065	105,429,034	17.9	32.81
1895	302,882	201,292,265	5,667,691	119,027,829	18.7	32.65
1896	316,254	220,181,781	5,786,567	124,894,789	18.2	33.55
1897	359,040.6	238,616,168	5,576,531.7	107,197,981	15.4	29.85
1898	431,515.8	286,803,462	5,575,335.5	105,364,505	10.9	29.13
1899	469,929.9	312,307,819	5,434,353.0	104,100,163	11.5	29.79
1900	392,331.8	260,743,830	5,599,216.2	110,451,012	14.2	30.66
1901	398,507.0	264,840,477	5,438,433.2	102,769,792	13.7	29.47
1902	448,085.5	298,412,993	5,121,469.0	86,216,294	11.2	26.08
1903	491,553.0	326,566,926	5,291,545.2	91,043,221	10.6	26.70
1904	525,255.0	349,088,293	5,669,124.4	104,772,752	10.7	28.60
1905	571,422.5	378,411,754	5,638,183.3	109,382,829	9.4	30.17

(1 kilo gold = $664.60.)

J. H. Curle, in a paper entitled The Greatest Gold Producing Mines appearing in the London *Economist,* gives a list of thirty of what he considered the biggest producers in 1903, which is as follows: [1]

No.	Name of Mine.	Locality.	Monthly Yield.
1.	Homestake	South Dakota	425,000
2.	Simmer and Jack	Transvaal	390,000
3.	Boulder Perseverance	West Australia	315,000
4.	Robinson	Transvaal	310,000
5.	Golden Horseshoe	West Australia	300,000
6.	Champion Reef	India	300,000
7.	Rose Deep	Transvaal	290,000
8.	Mysore	India	275,000
9.	Waihi	New Zealand	255,000
10.	Geldenhuis Deep	Transvaal	255,000
11.	Portland	Colorado	250,000
12.	Mount Morgan	Queensland	250,000
13.	Great Fingall	West Australia	240,000
14.	Crown Reef	Transvaal	235,000
15.	Village Main Reef	Transvaal	230,000
16.	Crown Deep	Transvaal	230,000
17.	City and Suburban	Transvaal	230,000
18.	Great Boulder	West Australia	225,000
19.	Ferreira	Transvaal	220,000
20.	Oroya-Brownhill	West Australia	220,000
21.	Ivanhoe	West Australia	220,000
22.	Ferreira Deep	Transvaal	210,000
23.	Geldenhuis Estate	Transvaal	205,000
24.	Angelo	Transvaal	190,000
25.	Langlaagte Estate	Transvaal	180,000
26.	Robinson Deep	Transvaal	175,000
27.	Camp Bird	Colorado	170,000
28.	New Primrose	Transvaal	170,000
29.	May Consolidated	Transvaal	165,000
30.	Glen Deep	Transvaal	160,000

According to R. W. Raymond the various estimates of the world's production of silver for 1800, 1846, 1850, 1854, 1865, and 1867, are as follows: [2]

[1] Eng. and Min. Jour., Vol. 76, p. 697, and Economist, London, Oct. 17, 1903.

[2] T. A. I. M. E., Vol. 4, p. 187, 1876. A short discussion is also given in connection with the table.

TABLE VII.

Country.	Estimate of J. Arthur Phillips for 1800.	Estimate of Birkmyre for 1846.	Estimate of J. Arthur Phillips for 1850.	Estimate of Birkmyre for 1850.	Estimate of J. D. Whitney for 1854.	Estimate of J. Arthur Phillips for 1865.	Estimate of W. P. Blake for 1867.
	Weight, lbs. Troy.	Value, £ Sterling.	Weight, lbs. Troy.	Value, £ Sterling.	Value, U. S. Coin.	Weight, lbs. Troy.	Value, U. S. Coin.
Russian Empire	58,150	167,831	60,000	171,817	$ 928,000	58,000	$ 700,000
Scandinavia		32,346	20,400	35,607	328,000	15,000	
Great Britain		109,989	48,500	160,000	1,120,000	60,500	
Hartz		138,022	31,500	138,022	480,000	28,000	
Prussia			21,200		480,000	68,000	
Saxony	141,000	198,200	63,600	...	960,000	80,000	8,600,000
Other German States		...	2,500	198,200	48,000	2,500	
Austria		282,654	87,000	286,971	1,440,000	92,000	
France		...	5,000	...	80,000	18,000	
Italy		7,444	...	7,444	...	25,000	
Spain		227,499	125,000	440,210	2,000,000	110,000	
Australia / British America	...	...	10,000	...	128,000	9,500	20,000
Chili	183,000	297,029	238,500	297,029	4,000,000	299,000	
Bolivia	271,300	460,191	130,000	460,191	2,080,000	136,000	
Peru	401,850	1,000,583	303,150	1,000,583	4,800,000	299,000	10,000,000
New Granada	5,000	42,929	13,000	42,929	208,000	15,000	
Brazil	1,200	2,003	675	2,227	11,200	1,500	
Mexico	1,440,500	3,457,020	1,650,000	5,383,333	28,000,000	1,700,000	19,000,000
United States	...	1,864	17,400	73,532	852,000	1,000,000	15,500,000
East Indies	...	56,265	...	56,265	...	...	...
Africa	...	1,056	...	1,056	...	...	...
Various other countries	...	33,000	...	33,000	...	...	...
Total	2,337,300	£6,515,925	2,827,425	£8,788,416	$47,443,200	4,017,000	$53,820,000
Approximate value in U. S. coin	$36,250,000	$31,537,000	$43,853,000	$42,536,000	$47,443,300	$62,303,000	$53,820,000

TABLE VIII.

Showing the Tentative Distribution of Gold Production of North America According to Age of Primary Deposits.[1]

Unit: $M^2\$ = \$1,000,000$.

Divisions. United States.	Distribution of Total Production. From Discovery to 1900, incl. $M^2\$$.				Distribution of Production of 1900. $M^2\$$.			
	Pre-Cambrian.	Mesozoic (Pacific Coast Belt).	Late Cretaceous or Early Tertiary (Central Belt).	Tertiary (Mostly Post-Miocene).	Pre-Cambrian.	Mesozoic (Pacific Coast Belt).	Late Cretaceous or Early Tertiary (Central Belt).	Tertiary (Mostly Post-Miocene).
Alaska		29.7		1.0		7.8		0.4
Arizona		22.1		20.0			2.0	2.2
California		1350.0		30.0		14.8		1.0
Colorado			34.0	217.1			2.7	26.1
Idaho		90.0		22.8		0.7		1.0
Montana			200.0 ?	3.5 ?			4.7	
Nevada			20.0	230.0			?	20.0
New Mexico			7.6 ?	10.0 ?			0.4	9.4
Oregon		54.0		0.5 ?		1.7		
South Dakota	74.0			16.0	3.8			2.4
Utah			25.0	2.0			4.0	?
Washington		10.0		11.4		0.2		0.5
Wyoming	1.0				0.1			
Appalachian states (Mainly Georgia and the Carolinas.)	47.0				0.3			
Total	122.0	1555.8	286.6	564.3	4.2	25.2	13.8	36.0

[1] T. A. I. M. E., Vol. 33, p. 810, 1903.

British North America.								
Nova Scotia	13.7	....	....	....	0.6	....	....	....
Quebec	2.0 ?	....	....	....	....	....	....	....
Ontario	1.2 ?	....	....	....	0.3	....	....	....
British Columbia	....	70.7	....	....	....	4.7	....	....
N.W. Territory	....	52.6	....	....	....	22.3	....	....
	16.9	123.3	....	....	0.9	27.0	....	....
Mexico	....	40.0 ?	....	160.0 ?	....	2.0 ?	....	7.0 ?
Total	138.9	1719.1	286.6	724.3	5.1	54.0	13.8	43.0

Note to Table VIII. — It should be expressly stated that this table is only a first tentative estimate, as in very many cases the data for exact sub-division are not available. The distribution for 1900 is, of course, probably more nearly correct than the segregation of the total product attempted in the first part of the table.

Detailed information regarding the value of ores showing, in certain cases, the analysis and the production of the various mines, districts and states, are given in the following pages. A table has also been compiled in which are given maximum, minimum and average values, and when available, other information of interest in this connection. (See Appendix of Tables.) Vein and gravel mines are considered separately, as has been done heretofore.

PRODUCTION BY STATES AND TERRITORIES.

Southern States. — Among the oldest of the gold mining regions of the United States is the Appalachian gold belt, which extends from the Canadian boundary to Alabama. The following states are gold producing: Alabama, the Carolinas, Georgia, Maryland, Virginia and Tennessee, of which the first two mentioned are most important. The total production of gold of this region from 1799 to 1905, inclusive, is estimated to be $48,759,700, which includes a certain amount of silver alloyed with the gold. From 1877 to 1905, inclusive, $9,759,700 represents the output. The total average production of gold for the 20 years ending with 1900, is about $300,000; while the average yearly production for the six years from 1900 to 1905, inclusive, is $298,283, the maximum being $500,000 for the year 1882. In 1905 the product was $299,800.

The distribution and extent of gold mining in South Carolina, prior to the war, are given below, and represent the mines operating in 1859:

Chesterfield and Lancaster counties	21	working mines.
Spartanburg, Union, and York counties	19	" "
Abbeville and Edgefield counties	10	" "
Greenville and Pickens counties	8	" "
Total in state	58	" "

In 1895 gold mining operations were almost exclusively confined to the Haile mine, and conditions were practically unchanged as late as 1901.

The following estimates regarding the southern gold mining industry for the year 1889 are taken from the United States Census Report of 1890:[2]

Total number of producing mines (of these, only eight were producing between 10,000 and 50,000 dollars per year)	42
Total number of tons of ore produced	123,745
Total yield of gold bullion	$ 318,261
Grand total of expenses, wages, etc	535,285
Total value of mines and plants	5,281,801
Total value of mills and reduction works	620,681

[1] South Carolina Resources, etc., State Board of Agriculture, Charleston, 1883, and T. A. I. M. E., Vol. 25, p. 718, 1895.

[2] Census Report of 1890 and T. A. I. M. E., Vol. 25, p. 688, 1895.

In Table IX are given the number and kind of producing mines in the Southern states in 1905, together with their output and average yield of ore per ton:[1]

TABLE IX.

State and Territory.	Number of Mines.			Ore Production from Deep Mines (Short Tons).	Average Value of Gold and Silver Per Ton of Ore from Deep Mines.
	Placer.	Deep.	Total.		
Alabama	1	2	3	16,525	$2.46
Georgia	* 12	* 10	* 22	* 16,000	* 4.18
Maryland	....	2	2	2,698	5.51
North Carolina	7	16	23	18,831	6.76
South Carolina	....	2	2	49,493	1.92
Tennessee	1	2	3	399,330	.15
Virginia	* 3	* 4	* 7	* 800	* 5.35
Total	24	38	62	503,677	3.76

The range in value of ores for a number of particular cases is given in the table of Yield of Ores. (See Appendix of Tables.)

A general average of 200 assays of Silver Hill, North Carolina, ore gives the following results:

	Per cent.
Galena	21.900
Pyrite	17.100
Chalcopyrite	1.800
Zinc-blende	59.200
Silver and gold	0.025
Total	100.025

The following values have been given for the so-called refractory ores of the Southern states: "Gold, $5; silver, 5 ounces; copper, 6 per cent; sulphur, 20 per cent. Another class of ore ranges about as follows: gold, $6; silver, 12 ounces; lead, 30 per cent; zinc, 20 per cent; sulphur, 10 per cent. Others again about $20 in gold, 10 per cent copper, and 10 per cent sulphur. These are minimum values so far as regards gold and silver. In the first named the united value of the product would be, say, $20 per ton, while in the second instance, it would be a little more than double that."[2]

[1] U. S. G. S., Mineral Resources, 1905, p. 121.

[2] Eng. and Min. Jour., Vol. 58, p. 411.

* Estimated.

The following table shows the amount of gold produced by the mines of Tennessee since 1831 up to and including 1905. [1]

TABLE X.

(PRODUCTION OF GOLD ONLY.)

Years.	Value.	Years.	Value.	Years.	Value.
1831	$1,000	1839	$300	1847	$2,511
1832	1,000	1840	104	1848	7,161
1833	7,000	1841	1,212	1849	5,180
1834	3,000	1842	....	1850	1,507
1835	100	1843	2,788	1851	2,377
1836	300	1844	2,240	1852	750
1837	....	1845	3,202	1853	149
1838	1,500	1846	2,642	1854	....

(GOLD AND SILVER PRODUCT.)

1799–1879	155,300	1884	300	....	....
1880	1,500	1885	300	1889	750
1881	1,750	1886	500	1890	1,001
1882	250	1887	500	1891	519
1883	750	1888	1,100	1892	1,006

(GOLD PRODUCT ONLY.)

1893	....	....	....	1902	140
1894	....	1898	900	1903	800
1895	....	1899	....	1904	4,300
1896	....	1900	100	1905	3,300
1897	....	1901	....	....	....

In the early days of mining the two most prosperous years were 1833 and 1834, the production in the former year being $7,000, which was not exceeded until recent times when in 1905 an output of $7,400 was attained.

The production of silver in the Southern states from 1877 to 1906 inclusive is shown on following page.[2]

[1] Resources of Tennessee, 1874, p. 266.

[2] Mineral Industry, 1895–1905.

TABLE XI.

Year.	Georgia.	North Carolina.	South Carolina.	Virginia.	Year.	Georgia.	North Carolina.	South Carolina.	Virginia.	Tennessee.	Alabama.
1877	......	......	......	......	1892	......	......	......	......	......	....
1878	......	......	......	......	1893	......	......	......	......	......	....
1879	......	......	......	......	1894	$ 205	$ 222	$ 192	......	......	....
1880	......	......	......	......	1895	5,152	6,614	2,524	......	......	....
1881	......	......	......	......	1896	......	......	......	......	......	....
1882	......	$25,000	......	......	1897	......	......	......	......	......	....
1883	$1,000	3,000	$500	......	1898	......	......	......	......	......	....
1884	......	3,500	500	......	1899	......	......	......	......	......	....
1885	......	3,000	......	......	1900	248	6,944	248	......	......	$ 62
1886	1,000	3,000	500	......	1901	240	12,180	120	$ 420	......	60
1887	500	5,000	500	......	1902	212	11,077	159	3,127	$6,519	53
1888	500	3,500	200	......	1903	216	5,940	162	5,130	7,020	....
1889	464	3,879	232	$13	1904	870	8,584	290	3,886	34,336	116
1890	517	7,757	517	......	1905	543	7,966	121	121	57,576	181
1891	517	6,465	646	......	1906	668	7,281	......	......	......	....

Tables XII and XIII give the production of the Southern gold-fields from the inception of mining up to the present time.

TABLE XII.

Years.	Maryland.	Virginia.	North Carolina.	South Carolina.	Georgia.	Alabama.	Tennessee.	Total.
	Dols.	Dols.	Dols.	Dols.	Dols.	Dols.	Dols.	Dols.
1799–1879	2,500	3,091,700	19,659,600	2,587,900	14,180,500	365,300	155,300	40,042,800
1880	250	11,500	95,000	15,000	120,000	1,000	1,500	244,250
1881	500	10,000	115,000	40,000	125,000	1,000	1,750	293,250
1882	1,000	15,000	215,000	25,000	250,000	3,500	250	509,750
1883	500	7,000	170,000	57,000	200,000	6,000	750	441,250
1884	500	2,500	160,500	57,500	137,000	5,000	300	363,300
1885	2,000	3,500	155,000	43,000	136,000	6,000	300	345,800
1886	1,000	4,000	178,000	38,000	153,500	4,000	500	379,000
1887	500	14,600	230,000	50,500	110,500	2,500	500	409,100
1888	3,500	7,500	139,500	39,200	104,500	5,600	1,100	300,900
1889	16,962	4,113	150,174	47,085	108,069	2,639	750	316,330
1890	16,962	6,496	126,397	100,294	101,318	2,170	1,001	354,638
1891	11,264	6,699	101,477	130,149	80,622	2,245	519	332,975
1892	1,000	5,002	90,196	123,881	95,251	2,419	1,006	318,755
1893	114	6,190	70,505	127,991	100,375	6,362	250	311,787
1894	978	7,643	52,927	98,763	99,095	4,092	329	263,827
1895	......	....	....	....	....	......	......	*310,600
1896	......	....	....	....	....	......	......	*264,300
1897	......	....	....	....	....	......	......	*249,737
1898	......	....	....	....	....	......	......	*263,153
1899	......	....	....	....	....	......	......	*500,000
1900	100	3,200	35,444	121,248	116,948	1,962	100	279,002
1901	......	5,720	67,680	46,820	124,740	3,160	......	245,120
1902	2,500	6,227	101,777	122,059	98,012	2,553	6,519	339,647
1903	500	18,630	76,440	100,862	62,216	4,400	7,820	270,868
1904	2,400	7,686	132,484	122,090	97,770	29,416	38,636	530,482
1905	16,900	5,121	131,866	95,221	95,343	41,681	60,876	452,008

* Product for Alabama, Georgia, North Carolina, and South Carolina in Gold and Silver.

ESTIMATE OF THE PRODUCTION OF GOLD AND SILVER IN THE SOUTHERN STATES FROM 1793 TO 1879.

TABLE XIII.

Statement of Gold and Silver produced in the Southern States; Deposited at the United States Mint and Assay Offices from 1793 to 1879 inclusive.

Year.	Amount.	Year.	Amount.	Year.	Amount.
1793–1823	$ 47,000	1842	$ 723,761	1861	$141,778
1824	5,000	1843	1,050,100	1862	6,298
1825	17,000	1844	928,095	1863	1,624
1826	20,000	1845	986,849	1864	6,093
1827	21,000	1846	992,792	1865	33,345
1828	46,000	1847	1,018,079	1866	202,000
1829	140,000	1848	850,692	1867	106,903
1830	466,000	1849	891,968	1868	155,660
1831	519,000	1850	658,605	1869	191,738
1832	678,000	1851	500,539	1870	168,057
1833	868,000	1852	711,449	1871	138,791
1834	898,000	1853	486,184	1872	164,461
1835	686,300	1854	323,489	1873	158,952
1836	667,000	1855	362,349	1874	141,647
1837	282,000	1856	325,820	1875	150,612
1838*	358,750*	1857	141,810	1876	138,256
1839	429,648	1858	349,323	1877	159,009
1840	427,311	1859	379,677	1878	162,925
1841	544,661	1860	231,398	1879	186,123

* "The years 1838 to 1847 exclude the amounts deposited at the New Orleans Mint, which were not available for each year. The total amount at New Orleans in those years, from the Southern states, was only $116,086."

In order to give an idea of the fluctuation during the 86 years from 1793 to 1879, Table No. XIII is given. These figures, however, comprise only the United States Mint and Assay Office receipts, and do not include such bullion as went abroad, was sold directly to local jewellers, or was coined by Christian Bechtler at Rutherfordton, North Carolina.[1] The source of gold and silver product of the Southern goldfields for the year 1905 is shown in Table XIV.[2]

TABLE XIV.

State.	Placers. (Fine Ounces.)		Dry or Siliceous Ores. (Fine Ounces.)		Copper Ores. (Fine Ounces.)		Total. (Fine Ounces.)	
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Alabama	50	5	1,959	331	......	......	2,009	336
Georgia	1,451	100	3,159	271	78	669	4,688	1,040
Maryland	......	......	717	93	......	......	717	93
North Carolina	484	100	5,224.50	3,000	372	17,130	6,080	20,230
South Carolina	......	......	4,601	111	......	......	4,601	111
Tennessee	10	1	......	......	201	95,521	211	95,522
Virginia	39	4	202	173	......	......	241	177

[1] T. A. I. M. E., Vol. 25, p. 687, 1895.

[2] Mineral Resources, U. S. G. S., 1905, pp. 122 and 125.

According to J. D. Whitham[1] the shales of the Panhandle, West Virginia, have yielded some $5,340,000 worth of precious metals.

The Southern Appalachian states maintain an aggregate output of $380,500 in gold and 110,300 fine ounces of silver. A change in source from that of 1904, is noted in that there has been an increase in silver from the Tennessee copper ores and a decrease in the gold output from South Carolina. There was considerable activity in the quartz-mining industry of Alabama and Maryland, while North Carolina like South Carolina showed a marked depression; however, the Iola mine, in Montgomery County, kept up the output. The two mines ranking first in importance in the South are the Haile, of South Carolina, and the Iola, of North Carolina.[2]

Alaska. — It was not until 1880 that Alaska began to assume some importance as a gold producer, at which time an output of some $6,000 is reported, but is hardly more than a rough estimate. The silver product prior to 1894 is estimated by the Director of the Mint at probably $11,000 coinage value, while his estimates for the years 1894, 1895 and 1896 are $28,782, $86,880, and $187,867 respectively. The amount of silver, coinage value, produced by the Apollo Consolidated mine in 1896 was $39,620, which came chiefly from the sulphurets. The Alexander Archipelago probably produced the remainder for that year.[3]

The million-dollar mark was reached in the gold production in 1892, and in 1897 it had attained about $2,400,000 in value. The rapid rise of the succeeding years is shown by the following figures: in 1899, $5,500,000; in 1900, $8,200,000; in 1902, $8,345,800; in 1904, $9,304,200; and in 1905, $14,650,100. The total gold production of Alaska up to and including 1905, is probably very close to $79,102,425.

The estimated number of placer mines operating in 1905 was 1,100, while there were 18 deep mines producing (against 7 in 1902) making a total of 1,118. There were 1,422,515 short tons of ore produced by the deep mines, which had an average value of $2.46 in gold and silver.

As a means of comparison of the relative values of the gold and silver product, Table XVI, showing production of these two metals, is given:[4]

[1] Eng. and Min. Jour., Vol. 48, p. 71.

[2] U. S. G. S., Mineral Resources, 1905, p. 117.

[3] U. S. G. S., 18th Ann. Rept., Pt. 3, p. 11, 1896–97.

[4] U. S. G. S., 18th Ann. Rept., Pt. 3, p. 132, 1896–97, and from Mineral Industry, Mineral Resources and Repts. of the Director of the Mint.

TABLE XV.[1]

The Production of Gold from the Various Sources (Stated in Dollars).

Year.	Alaska-Treadwell Mines.	Mexican Mine.	Other Quartz Mines of South-eastern Alaska.	Stream Placer Mines of South-eastern Alaska.	Apollo Consolidated Mine.	Beach Placers.	Cook Inlet Placers.	Yukon Placers.	All Alaska; Estimate of the Director of the Mint.
1880	...	...	...	6,000	...	...	...	...	6,000
1881	...	...	...	13,374	...	...	...	...	13,374
1882	}	...	...	20,000	...	...	...	...	150,000
1883	} 10,903	...	2,000	140,000	...	...	...	...	300,000
1884	}	...	100,000	50,000	...	...	...	...	200,000
1885	242,319	...	...	...	...	...	...	...	300,000
1886	366,180	...	...	...	...	...	...	...	446,000
1887	476,934	...	...	...	...	...	...	...	675,000
1888	429,889	...	...	...	...	...	...	...	850,000
1889	652,491	...	250,000	25,000	...	...	...	...	900,000
1890	613,191	...	68,238	25,000	...	...	...	50,000	762,500
1891	765,673	...	21,843	120,000	780	...	...	100,000	1,020,045
1892	676,226	...	110,820	180,900	30,216	2,500	...	110,000	1,080,446
1893	779,782	...	7,400	...	47,847	6,000	...	200,000	1,000,000
1894	555,307	204,042	19,400		35,297	...	...	409,000	1,113,550
1895	818,690	226,258	277,676	2,265	225,395	17,854	50,000	709,000	1,615,300
1896	693,576	245,861	482,382	40,000	400,313	39,000	120,000	800,000	2,055,710
1897	586,857.42	335,628.67	838,308	...	...	...	...	...	2,439,582
1898	677,655.13	375,882.36	956,818(?)	...	...	...	...	...	2,517,121
1899	1,153,367.60	347,414.97	1,203,395	...	...	...	...	...	5,831,355
1900	860,736.58	315,005.45	914,177	...	...	...	...	...	8,166,187
1901	1,304,720.54	339,452.31	337,603	...	...	...	...	...	6,998,726
1902	1,598,963.42	426,732.56	540,842	...	...	...	...	...	8,283,409
1903	...	...	...	...	...	...	...	...	8,614,700
1904	...	...	...	...	...	...	...	...	9,304,200
1905	...	...	...	...	...	...	...	...	14,650,100

[1] U. S. G. S., 18th Ann. Rept., Pt. 3, p. 12, 1896–97, while that portion between 1896 and 1905 was compiled from The Mineral Resources, Mineral Industry and Repts. of the Director of the Mint.

TABLE XVI.

Year.	Production of Gold.	Rank among States and Territories.	Production of Silver.	Rank of Production of Silver.	Rank in Production of both Precious Metals.	Amount of Output from Yukon Placers, all Gold.	Per cent of Gold from the Yukon in Alaska.	Number of Yukon Miners.
1880	$ 6,000	0	$ 0.00	0	0	$ 0.00	0	(?)
1881	15,000	14	144.30	0	15	0.00	0	(?)
1882	150,000	12	0.00	0	12	Small.	0	50
1883	300,000	9	0.00	0	10	* 1,000.00	....	50
1884	200,000	10	0.00	0	11	Unknown.	....	75
1885	282,000	9	2,000.00	11	11	† 25,000.00	....	75
1886	446,600	9	2,000.00	14	11	† 75,858.88	....	200
1887	675,000	9	300.00	....	11	‡30,000.00 30,000.00	4	200 50
1888	850,000	8	3,000.00	10	9	40,000.00 35,000.00	4	100 150
1889	900,000	9	10,343.00	14	11	35,000.00 40,000.00	4	150 125
1890	762,500	9	9,697.00	14	11	50,000.00	7	150 150
1891	900,000	10	10,343.00	14	11	100,000.00	11	200 150
1892	1,000,000	9	10,343.00	14	11	110,000.00	11	225 175
1893	1,010,100	9	10,860.00	14	11	200,000.00	20	500 200
1894	1,113,550	9	28,782.00	12	11	409,000.00	37	400 600
1895	1,615,300	7	86,880.00	12	9	709,000.00	44	600 800
1896	2,014,263	....	45,798.72	....	....	800,000.00	39	700 1000
1897	2,700,000	....	149,475.00	....	....	....	....	....
1898	2,820,000	....	87,390.00	....	....	....	....	....
1899	5,125,000	....	163,845.00	....	....	....	....	....
1900	8,171,000	....	45,446.00	....	....	....	....	....
1901	6,885,700	....	28,740.00	....	....	....	....	....
1902	8,345,800	....	148,760.00	....	....	....	....	....
1903	8,614,700	....	77,544.00	....	....	....	....	....
1904	9,304,200	....	122,264.00	....	....	....	....	....
1905	14,650,100	....	144,313.00	....	....	....	....	....

* E. R. Scidmore. † G. M. Dawson. ‡ In bracketed figures the upper set refers to British territory; the lower to Alaska.

The various sources from which the precious metals are derived in Alaska, together with the amounts obtained in fine ounces, are given in Table XVII.[1]

TABLE XVII.

Metal.	Placers.	Dry or Siliceous Ores.	Copper Ores.	Total.
Gold	586,499.53	166,168.13	3,433.62	756,101.28
Silver	75,092.00	31,107.00	26,525.00	132,724.00

By far the most interesting and important mining operations in Alaska are those of the three companies on Douglas Island, namely: the Alaska-Treadwell, the Alaska-Mexican, and the Alaska-United mining companies, which are controlled by the same interests and operated under a joint management.

Although the yield of the ore in these mines has been on the decline for a number of years the costs of mining and extracting have also been reduced and the tonnage has been increased several times over.

The following statements of results accomplished in two of these mines are shown in the following tables:[2]

[1] U. S. G. S., Mineral Resources, 1905, pp. 122 and 125.

[2] Mines and Quarries, 1902, Rept. Bureau of Census, p. 557.

TABLE XVIII.

BULLION SHIPMENTS FROM PARIS OR TREADWELL MINE, 1890 TO 1902.

(From beginning of work to May, 1903.)

Date.	Tons Crushed.	Yield.			Operating Profits.	Yield per Ton.	Operating Costs per Ton.
		Total.	Free Gold.	Concentrates (Sulphurets).			
Total........	4,624,289	$11,144,912.24	$7,069,917.85	$4,074,994.39	$5,667,149.58	$2.41	$1.18
June to May							
1890–91..........	220,686	769,765.80	531,185.77	238,580.03	418,209.90	3.49	1.59
1891–92..........	239,633	707,017.37	508,894.81	198,122.56	361,980.16	2.95	1.44
1892–93..........	237,235	694,658.74	504,785.46	189,873.28	385,613.79	2.94	1.30
1893–94..........	220,043	705,948.03	518,194.34	187,753.69	429,948.86	3.20	1.25
1894–95..........	241,278	626,327.06	411,070.66	215,256.40	309,534.56	2.60	1.31
1895–96..........	263,670	782,229.67	528,958.80	253,870.87	497,342.22	2.97	1.08
1896–97..........	242,027	676,064.88	452,407.30	223,657.58	376,450.90	2.79	1.24
1897–98..........	254,329	586,857.42	389,740.00	197,117.42	313,075.60	2.31	1.20
1898–99..........	250,408	677,655.13	441,282.25	236,372.88	386,792.34	2.71	1.28
1899–1900........	557,960	1,153,367.60	773,165.69	380,201.91	669,301.20	2.07	0.86
1900–1901........	457,802	860,736.58	559,126.37	301,610.21	377,417.34	1.88	1.05
1901–1902........	682,893	1,304,720.54	665,591.27	639,129.27	481,633.94	1.91	1.20
1902–1903........	756,325	1,598,963.42	785,515.13	813,448.29	659,849.77	2.11	1.24

TABLE XIX.

BULLION SHIPMENTS FROM ALASKA-MEXICAN MINE, 1894 TO 1902.

(From beginning of operations to December 15, 1902.)

Year.	Tons Crushed.	Yield.			Operating Profits.[1]	Total Yield per Ton.	Operating Costs per Ton.	Operating Profits per Ton.
		Total.	Free Gold (including Base Bars).	Concentrates (Sulphurets).				
Total	1,293,662	$2,816,278.83	$1,859,261.20	$957,017.63	$587,911.92	$2.18	$1.73	$0.45
1894	73,141	204,042.46	154,643.33	49,399.13	60,215.60	2.79	1.97	0.82
1895	79,439	226,258.07	155,637.54	70,620.53	71,391.78	2.85	1.95	0.90
1896	101,702	245,861.98	169,532.32	76,329.66	61,650.43	2.42	1.81	0.61
1897	158,005	335,628.67	226,321.71	109,306.96	87,101.46	2.12	1.57	0.55
1898	162,457	375,882.36	257,484.67	118,397.69	100,663.07	2.31	1.69	0.62
1899	166,054	347,414.97	231,841.23	115,573.74	62,333.42	2.09	1.73	0.38
1900	166,449	315,005.45	223,105.08	81,900.37	33,821.02	1.89	1.69	0.20
1901	178,960	339,452.31	213,923.07	125,529.24	24,709.63	1.90	1.76	0.14
1902	207,455	426,732.56	216,772.25	209,960.31	86,025.51	2.06	1.64	0.41

[1] Included in the operating profits is a total of $3,573.79, distributed as follows: Profit on sale of 31,000 shares of stock in 1893, $575.95; interest received in 1898, $694.46; interest received in 1899, $1,682.76; interest received in 1900, $620.62.

The estimated output of the mines of Douglas Island for 1900 was $2,000,000.

The following table shows the gold and silver production of Alaska, separately stated, for the year 1905, in standard ounces and value:[1]

TABLE XX.

Source.	Gold.		Silver.	
	Standard Ounces.	Value.	Standard Ounces.	Value at 57 cents.
Nome.......	245,058.665	$4,558,091.17	59,816.31	$ 34,095.30
Fairbanks...	289,588.663	5,386,349.13	66,605.39	37,965.07
Balance of Alaska...	267,802.586	4,981,128.10	61,594.59	35,108.92
Total......	802,449.914	14,925,568.40	188,016.29	107,169.29

The total annual production of gold in Alaska for 1905 was close to $14,650,100, while that of silver was $144,313. The marked increase in gold production was due mainly to the Fairbanks placer district on the Tanana, Yukon Basin. The Nome placers and the quartz mines showed moderate increases over their previous yield.

Arizona. — The production of gold from this territory began in the early 70's and increased slowly until in 1881 the one-million mark was reached and there was little change from this output till 1892, which year marks the turning point in production; the subsequent increase was decided and quite uniform. Two millions in gold were produced in 1895, $4,200,000 in 1900, and $4,357,600 in 1903. However, in 1904 there was a decrease of over $1,000,000, which was not materially bettered during 1905, when the product was $3,500,000. The total gold production of Arizona during the period 1877–1905, inclusive, was about $52,996,800. The production of gold is largely confined to Cochise, Yavapai, Pima, Pinal and Yuma counties, among which Yavapai County usually leads.[2]

The number of mines operating during 1905 were as follows: 12 placers, and 122 deep mines, making a total of 134. The amount of ore produced was 2,678,059 short tons, the average value in gold and silver being $1.62. The gold production of this territory is obtained mainly as a by-product of copper smelting.

[1] Report of the Director of the Mint, 1905, p. 47.

[2] T. A. I. M. E., Vol. 33, 814, 1903, and Mineral Industry, 1905.

The output of silver during 1905 was 3,400,000 fine ounces with a commercial value of $2,074,000. The total production of silver from 1877 to 1905 was $72,051,569.

The total yield of metals from the Tombstone district up to and inclusive of 1903 was: 163,000 ounces of gold, 21,500,000 ounces of silver and 500 tons of lead, and, as has been suggested, a correction of 15 per cent, for the gold and silver output, should be added to make up for losses in pan amalgamation, which would swell the product to 187,000 ounces gold and 22,500,000 ounces in silver. The proportion of gold to the silver-content of ores was then about .18 to 22.36, or 1 to 120; however, there is a wide variation in the proportion between the precious metals in the different mines. In the Contention and Grand Central mines the proportion ranges from 1 to 80 even to 1 to 400 — the latter being the yield of ores from the superficial limestone deposits. The production may be grouped as follows, according to formation: one-half of the gold and silver produced has come from the upper shales; about one-third has been derived from the blue and white limestone, while the remainder was obtained from the Lucky Cuss limestone at various points along the outcrop.[1]

The Dividend group of mines, at Chaparal, produces an ore about 15 per cent of which is smelted; the remainder is milled. The mill ore usually runs from $20 to $25 per ton.[2]

Before the incorporation of the Silver King mine it is estimated that one million dollars had been produced. From that time to and including 1881, the production was $1,973,458.68.[3]

The source of gold and silver, as reported by the mines, by kinds of ore, is given in Table XXI:[4]

TABLE XXI.

(Fine Ounces.)

Metal.	Placers.	Copper Ores.	Lead Ores.	Copper-Lead or Copper-Lead-Zinc Ores.	Lead-Zinc Ores.	Dry or Siliceous Ores.	Total.
Gold	2,064	55,668	9,270	121	717	67,572	135,412
Silver	306	1,480,732	594,330	88,392		441,952	2,605,712

[1] T. A. I. M. E., Vol. 33, p. 34, 1903.

[2] Eng. and Min. Jour., Vol. 78, p. 833.

[3] Ibid., Vol. 35, p. 270.

[4] U. S. G. S., Mineral Resources, 1905, pp. 122, 123 and 125.

The production of gold and silver during the period from 1866 to 1906 and 1877 to 1906, is given in Tables XXII and XXIII.[1]

TABLE XXII.

(Gold Product.)

Year.	Yield.	Year.	Yield.	Year.	Yield.
1866		1880	$ 400,000	1894	$1,990,966
1867	$ 500,000	1881	1,060,000	1895	1,965,300
1868	500,000	1882	1,065,000	1896	2,579,000
1869	1,000,000	1883	950,000	1897	2,700,000
1870	800,000	1884	930,000	1898	2,400,000
1871	800,000	1885	880,000	1899	2,575,000
1872	625,000	1886	1,110,000	1900	2,725,000
1873	500,000	1887	830,000	1901	4,193,400
1874	487,000	1888	871,000	1902	4,112,300
1875	750,000	1889	910,174	1903	4,357,600
1876	....	1890	1,000,000	1904	3,343,900
1877	300,000	1891	975,000	1905	2,691,300
1878	500,000	1892	1,070,000	1906	3,223,800
1879	800,000	1893	1,010,100		

TABLE XXIII.

(Silver Product.)

Year.	Yield.	Year.	Yield.	Year.	Yield.
1877	$ 500,000	1888	$3,000,000	1899	$1,191,600
1878	3,000,000	1889	2,343,977	1900	1,073,275
1879	3,550,000	1890	1,292,929	1901	1,765,553
1880	2,000,000	1891	1,913,535	1902	1,612,843
1881	7,300,000	1892	1,369,980	1903	1,829,034
1882	7,500,000	1893	2,334,817	1904	1,571,578
1883	5,200,000	1894	969,755	1905	1,672,592
1884	4,500,000	1895	561,174	1906	1,835,283
1885	3,800,000	1896	1,342,000		
1886	3,400,000	1897	796,577		
1887	3,800,000	1898	1,310,850		

Temporary suspension of operations in some of the more important mines of the Yavapai districts south of Prescott has been responsible for the decrease in gold output. The production of silver has also

[1] Tables compiled from Reports of the Director of Mint, the Mineral Resources of the United States, and the Mineral Industry.

been affected by conditions in the Yavapai districts, yet the decrease is not as great as it would have been had not reopening and unwatering operations been actively carried on in the Tombstone mines.

California. — It is difficult to more than approximate the early gold-production of this state, but from 1849 to and including 1900 it is estimated at $1,380,000,000. However, the figures from 1877 are much more accurate, and the production for the period 1877 to 1905, inclusive, is close to $439,165,645. From 1849 to 1853 there was a rapid increase in production of gold to the $65,000,000 mark, after which there was a steady decline until in 1873 the yearly output was only $18,000,000. From 1873 to 1893 there was considerable fluctuation, but the tendency was downward, approximately $12,000,000 being reached in 1893. The years 1853 and 1893 then mark the maximum and minimum points in the gold production of California after gold mining had become a fixed industry. Since 1893 there has been a slow but more or less regular increase noted. In 1900 the output was $15,800,000; in 1902, $16,792,100; and in 1905, $19,168,045.

Statistics show that there was a decrease in placer-gold produced, amounting to $1,100,000 in 3 years — being reduced from $4,300,000 in 1897 to $3,200,000 in 1900.[1]

The gold mining industry has passed through many vicissitudes, not the least of which was the closing of the hydraulic mines as a result of the débris controversy.

Of the mines operating in the state in 1905, 685 were placers and 481 were deep mines, making a total of 1,139, which yielded some 2,696,603 tons of ore, with an average value of $5.06 per ton.

Judging from the number of operators in the state, California is probably more actively engaged in mining than any other state. In 1902 the number of operators was one-third of the total number reported in the United States, and eliminating from the total the argentiferous lead mines, of which there were 447, California still had two-fifths of the operators reported.[2]

The production of gold and silver obtained through the different operations in 1905 is shown in Table XXIV.[3]

The yield of the veins of California is independent of their size as is shown by the following data: The Eureka-Idaho shoot in the vicinity of Grass Valley, a vein not exceeding 2 or 3 feet in width, produced over $25,000,000; the Soulsby mine, at Soulsbyville, Tuolumne

[1] T. A. I. M. E., Vol. 33, p. 816, 1903.

[2] Mines and Quarries, Rept. Bureau of the Census, 1902, p. 558.

[3] Report of the Director of the Mint, 1905, p. 68.

County, produced over $6,000,000 and is about 3 feet wide, and the Sheep Ranch mine, in Calaveras County, which does not exceed 4 feet in width and is usually less than 3 feet, has yielded $3,000,000.[1]

TABLE XXIV.

County.	Quartz.	Dredge.	Hydraulic.	Drift.	Placer.	Total.
Alpine	$ 575					$ 575
Amador	2,412,575		$ 27,256	$ 890	$23,024	2,463,745
Butte	16,459	$2,296,673	57,945	155,353	88,204	2,614,634
Calaveras	1,504,302	190,660	35,000	53,230	32,483	1,815,675
Del Norte			5,000		5,590	10,590
Eldorado	240,707	29,538	15,880	66,602	34,533	387,260
Fresno	43,796				5,428	49,224
Humboldt			39,204		6,620	45,824
Inyo	165,600				100	165,700
Kern	1,295,079				836	1,295,915
Lassen	149,000					149,000
Los Angeles	15,010				125	15,135
Madera	60,881					60,881
Mariposa	376,383				15,228	391,611
Mendocino			40			40
Mono	319,974		150			320,124
Monterey					4,000	4,000
Nevada	3,084,303		47,512	68,450	11,973	3,212,238
Placer	138,532		156,161	219,387	91,754	605,834
Plumas	184,051		18,850	12,720	68,719	284,340
Riverside	36,036					36,036
Sacramento		599,311		40,777	28,500	668,588
San Bernardino	418,102				75,386	493,488
San Diego	91,312				18,500	109,812
San Luis Obispo					300	300
Santa Barbara					725	725
Shasta	828,666		900	1,900	21,034	852,500
Sierra	400,092		53,507	48,745	18,646	520,990
Siskiyou	368,438	7,127	300,013	9,945	120,011	805,534
Stanislaus	50,240					50,240
Trinity	294,588	2,350	344,707	4,290	47,953	693,888
Tulare	2,313					2,313
Tuolumne	1,297,082		1,000	8,374	6,618	1,313,074
Ventura					1,200	1,200
Yuba	11,612	201,314	30,771		80,807	324,504
Undistributed		20,000	25,000	31,526	15,000	91,526
Total	13,805,708	3,346,973	1,158,896	722,189	823,297	19,857,063

The Mother lode, one of the large veins in the state, had produced up to 1899 between seventy and one hundred million dollars worth of gold. The Keystone, Old Eureka, Utica, Plymouth, Consolidated and Kennedy, have each yielded from 5 to 12 millions, while several others have recorded productions of from 2 to 3 millions. This lode in Amador County alone has produced from $35,000,000

[1] Min. and Sci. Press, Vol. 88, p. 178.

to $50,000,000. The product of the whole lode exclusive of the placers largely derived from it is approximately $100,000,000. For several years prior to 1899 the lode had yielded one-fifth of the annual gold product, while its entire yield lay between one-third and one-fourth the gold obtained by quartz-mining.[1]

The yield of the placers has been variously estimated — W. H. Pettee estimated the yield of California placers to be 4.75 cents per cubic yard, which was based on the Cement Mining Company's work at North Fork, where 43 million cubic yards of gravel had been washed, yielding 2 million dollars; Laur's estimate was 16 cents, while Prof. Silliman's was 30 cents per cubic yard.

Sixteen years of operating at Sebastopol Hill, by the American Company, shows a yield of 25 to 30 cents per cubic yard, while the entire yield of the gravel lying between the Middle and South Yubas has been estimated at from 30 to 35 cents per cubic yard.[2]

Averages of figures obtained from different operations, as hydraulic-, drift-, river- and beach-mining gave an approximate estimate of the yield of the various gravels found in the state. An average of thirteen hydraulic operations, in which the value of the gravels ranged from $12 to $822 per ton, gives $152.05 per ton. Four drift mines showed an average of $103.25 per ton, the range being from $15 to $271. Similarly, four river-mining operations gave an average of $14.21 per ton, range $10 to $27 per ton, while ten beach workings gave an average of $6.82, with a range of 80 cents to $18.50 per ton.[3]

The total yield of California hydraulic mines during 1906 was about $975,000, of which $635,669 has come from Del Norte, Humboldt, Siskiyou and Trinity counties, all of which are drained by the non-navigable streams emptying into the Pacific, and to which the legal restrictions against hydraulic-mining do not apply. The $339,471 remaining is accredited to the counties in the drainage basin of the Sacramento and San Joaquin rivers, where the Caminetti law is in force, and the Débris Commission has jurisdiction.[4] This gives an idea of the condition of hydraulic-mining in the state at the present time.

The source of the gold and silver product for 1905, as reported from the mines, by kind of ore is given in Table XXV:[5]

[1] T. A. I. M. E., Mines and Minerals of California, p. 63.

[2] Min. and Sci. Press, Vol. 23, p. 24, The Auriferous Gravels of the Sierra Nevada of California, Vol. I, p. 371, and Eng. and Min. Jour., Vol. 11, p. 120.

[3] Min. and Sci. Press, Vol. 69, p. 230.

[4] Min. and Sci. Press, Vol. 94, p. 53.

[5] U. S. G. S., Mineral Resources, 1905, pp. 122, 123 and 125.

TABLE XXV.

(Fine Ounces).

Metal.	Placers.	Copper Ores.	Lead Ores.	Dry or Siliceous Ores.	Total.
Gold.......	285,029.17	10,867.46	464.40	617,856.11	914,217.14
Silver......	27,367	388,169	53,477	607,161	1,076,174

The following table shows the gold and silver product for the period 1848 to 1905.[1]

TABLE XXVI.

Year.	Gold. Dollars.	Silver. Dollars.	Year.	Gold. Dollars.	Silver. Dollars.
1848	10,010,000 *	....	1877	15,000,000	1,000,000
1849	49,000,000	....	1878	15,260,679	2,373,389
1850	50,000,000 †	....	1879	17,600,000	2,400,000
1851	55,000,000	....	1880	17,500,000 ‖	1,100,000
1852	60,000,000	....	1881	18,200,000	750,000
1853	65,000,000 ‡	....	1882	16,800,000	845,000
1854	60,000,000	....	1883	14,120,000	1,460,000
1855	55,000,000	....	1884	13,600,000	3,000,000
1856	55,000,000	....	1885	12,700,000	2,500,000
1857	55,000,000	....	1886	14,725,000	1,400,000
1858	50,000,000	....	1887	13,400,000	1,500,000
1859	50,000,000 §	....	1888	12,750,000	1,400,000
1860	45,000,000	....	1889	12,586,722	1,373,807
1861	40,000,000	....	1890	12,500,000	1,163,636
1862	34,700,000	....	1891	12,600,000	969,697
1863	30,000,000	....	1892	12,000,000	330,000
1864	26,600,000	....	1893	12,080,000	367,618
1865	28,500,000	....	1894	13,570,397	441,941
1866	25,500,000	....	1895	14,928,600	302,933
1867	25,000,000	....	1896	15,235,900	402,600
1868	22,000,000	....	1897	15,000,000 ¶	452,790
1869	22,500,000	....	1898	15,300,000	378,690
1870	25,000,000	....	1899	15,100,000	357,480
1871	20,000,000	....	1900	15,650,000	719,051
1872	19,000,000	....	1901	16,891,400	555,360
1873	17,000,000	....	1902	16,792,100	477,424
1874	18,000,000	....	1903	16,104,500	503,010
1875	17,000,000	....	1904	19,109,600	888,850
1876	17,753,000	....	1905	19,168,045	667,937

[1] Table compiled from Reports Director of Mint, Mineral Resources, Mineral Industry, and School of Mines Quarterly, Vol. 3, p. 80.

* Discovery of gold in California.

† From 1850 to 1856 river-mining was an important factor in the production of gold.

‡ Hydraulic-mining operations were inaugurated in 1853.

§ The decline noted was due largely to the discovery of the Comstock lode, which detracted the attention from California.

‖ The effect of the State and Federal injunctions against hydraulic-mining in California was to completely close the mines by 1887.

¶ Improvements in methods of mining and milling began to affect the output of gold; not an unimportant factor was dredging. The first modern dredge was built in California in 1897 — the revival of placer-mining.

The past few years have shown considerable fluctuation in output of the mines of California, 1905 showing no decline (nor any material increase) in the gold production. The activity in dredging operations was probably responsible for the slight increase. Nevada County, which includes the Grass Valley district, led, having a yield of over $3,000,000.

There was a falling off in silver production for 1905, owing to the decreased output of siliceous ores in Kern County, also the copper ores in Shasta County. However, from the present outlook in the copper districts a material increase in silver may be expected from that source in the future.[1]

Canada: Silver Islet Mine. — For reasons already given a discussion of the Silver Islet ore-deposit, Ontario, Canada, has been given in connection with each of the subjects considered, and accordingly its production of the precious metals is herewith given.

From the beginning of operations in September, 1870, to the close of navigation, in 1878, 2,174,499.5 ounces refined silver had been obtained, which had a value of $2,921,727.24. Adding to this amount that mined since its discovery and operation by the Montreal Mining Company, a total of $2,948,019.81 was produced by this mine. The total production of the mine when it was abandoned was $3,039,557.49.

The output of the Silver Islet mine from 1868 to the fall of 1871 was as follows:

	Weight in Pounds.	Value per Ton.	Total Value.
Under the Montreal Mining Co.........	27,073⅜	$1,646.80	$ 23,115.35
Under new proprietors, 1870	155,543	1,175.80	92,153.23
Under new proprietors, 1871, Newark..	183,453	1,507.64	138,291.88
Under new proprietors, 1871, Wyandotte	778,468½	1,296.48	504,640.13
Lost on propeller Coburn	10,000	1,040.00	5,200.00
Total...........................	1,154,537⅞	$1,322.44	$763,400.59

The silver extracted from the ore mined from 1874 to 1875, inclusive, is as follows:

Season of 1872	310,744.02 ounces
Season of 1873	289,763.77 ounces
Season of 1874	250,021.75 ounces
Season of 1875	145,902.50 ounces
Total..	996,432.04 ounces

[1] U. S. G. S., Mineral Resources, 1905, p. 115.

At the commercial price of silver of $1.20 per ounce, the value of this silver amounts to $1,195,718.45.[1]

The analyses of samples of the Silver Islet ore are given below, each representing an average of about 13 tons:

	AI.	I. May, 1872.	I. June, 1873.	IV. June, 1871.	IV. June, 1871.
CaO........	7.57	19.39	19.94	23.15	22.90
MgO........	6.94	4.35	9.65	6.28	7.73
Al_2O_3.......	....	....	..........}	} 7.53	} 3.84
Fe_2O_3.......	1.88	....	..........}		
Pb.........	40.24	....	....	....	0.80
Cu..........	....	....	....	....	
Zn..........	2.27	....	....	....	
Ag.........	8.30	2.85	....	0.114	0.1445
S...........	3.36	....	....	1.03	0.64
Silicates....	13.23	27.20	30.50	36.13	33.78

The Roman numerals indicate classes into which the ore was separated: AI, containing between 2,000 and 4,000 ounces of silver per ton, or 7 to 14 per cent; II, 600 to 2,000 ounces or 2 to 7 per cent; III, above 100 ounces or 0.3428 per cent; and IV, the waste of the mine, averaging 40 ounces, or 0.14 per cent.[2]

In the fall of 1878 the second bonanza was struck, which is said to have yielded 800,000 ounces of silver.[3]

Colorado. — Although mining began in a more or less desultory way in Colorado shortly after the discovery of gold in California, yet it was not until 1877 that accurate data were collected regarding the output. From 1877 to 1905, inclusive, the gold production amounted to $332,976,047, while the total estimated production from the year 1858 to and including 1905 was $379,776,047. Unlike California, and a number of the Western states, the placers of Colorado were comparatively few, and the values were often quite irregularly distributed. It is not surprising therefore that the production of the early mining days was relatively small — the output from early placer-mining for the period 1858 to 1867 being estimated at $25,000,000 or $30,000,000.

The production of gold during 1877 to 1890 was between $3,000,000 and $4,000,000, being derived principally from the ores of Gilpin, Clear Creek and Boulder counties, and to a certain extent

[1] T. A. I. M. E., Vol. 8, pp. 248, 249 and 252, 1880.

[2] T. A. I. M. E., Vol. 2, pp. 91 and 92, 1873.

[3] Eng. and Min. Jour, Vol. 34, p. 322.

from the San Juan region. Beginning with 1890 the gold production showed a decided and rapid increase, reaching $9,500,000 in 1894, $19,100,000 in 1897 and attaining a maximum of $28,800,000 in 1900. Since 1900 there has been a marked decrease, although in 1902 the maximum output was closely approached by a production of $28,500,000. In 1905 the output was $25,577,947.

The rapid increase in gold production was largely due to developments in the Cripple Creek district, discovered in 1892, and to great activity in the San Juan region of southwestern Colorado. The output of Cripple Creek for 1900 was $18,100,000, while the San Juan region, comprising the counties of Ouray, San Juan and San Miguel, yielded $4,000,000. Leadville and the adjoining country produced $2,700,000 in gold, and Gilpin, Clear Creek and Boulder counties also produced $2,700,000.[1] Gilpin County is the largest producer of the three last mentioned, its ores being auriferous pyrites with free-gold, the gold being saved by amalgamation and concentration. In 1897 the county produced $3,500,000 in gold; in 1898, $3,000,000; in 1899, $3,100,000; and in 1900, $2,700,000. Cripple Creek has produced more gold than any other vein-mining district in the United States. The total production during the years 1892 to 1900, inclusive, was $77,300,000.

San Juan yields both gold and silver, which occur separately and together. The total gold production up to and including 1900 was $24,000,000.

Although placer mining has been carried on quite extensively at certain points in Colorado, its output has not added materially to the gold production of the state, being only 3.77 per cent in 1880. However, a gradual increase has been effected by the employment of dredgers, hydraulic elevators, etc. In 1897 the placer-gold product was $200,000, while in 1900 it was $700,000.[2]

During 1905 there were 23 placer mines and 490 deep mines operating in the state, making a total of 513. These mines produced 2,504,087 tons of ore of an average value in gold and silver of $12.73.

[1] T. A. I. M. E., Vol. 33, p. 819, 1903.

[2] Ibid., Vol. 33, pp. 820, 821, 1903. For tonnage of ore sold or treated, number of producing mines, and tenor of ores by counties in 1904 and 1905, see Mineral Resources, 1905, p. 188.

A classification is given in Table XXVII of the mines of Colorado, by counties, showing the chief products:[1]

TABLE XXVII.

County.	Gold Placer Mines.			Deep Mines.								Total Mines producing.
	Hydraulic.	Surface.	Dredge.	Gold.	Silver.	Gold and Silver.	Gold, Silver, Copper.	Gold, Silver, Copper, Lead.	Gold, Silver, Lead.	Silver, Lead.	Silver, Lead, Zinc.	
Boulder		1		14	1	12	3					31
Chaffee	1			1		2	5	1	3		2	15
Clear Creek		3		3	1	11	9	1	12	2	7	49
Conejos						*						*
Custer					2	3†						5†
Dolores						1	1		2		1	5
Eagle		1		1		1	3			2	1	9
Gilpin		1		9		30	20	1	5			66
Grand							1					1
Gunnison				5		6	2		3		2	18
Hinsdale						2		4	4			10
Jefferson			2				2‡					4
Lake				2	9	12	2	5	14	12	5	61
La Plata						3	1					4
Mineral					4				5		1	10
Ouray						6	4	1	2		1	14
Park	3	2		1	4	1	2		4	2		19
Pitkin					6					13	6	25
Routt		2										2
Saguache								1	3			4
San Juan				2		5	3	4	2	3	1	20
San Miguel	1			1		7	2	1	6	1		19
Summit	5		1	1	2	6			10	2	7	34
Teller				88								88
Total	10	10	3	128	29	108	60	19	75	37	34	513

* Included in Custer County. † Including Conejos County.
‡ Two copper mines.

The source of the gold and silver products in Colorado, by kinds of ore in 1905, and by counties is shown in Tables XXVIII.[2]

[1] U. S. G. S., Mineral Resources, 1905, p. 189.
[2] U. S. G. S., Mineral Resources, 1905, pp. 190 and 191.

TABLE

(Fine

County.	Placers.		Deep Mines.			
			Dry or Siliceous Ores.		Copper Ores.	
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Boulder	4.83	2	12,650.09	70,919	....	....
Chaffee	726.07	131	73.38	5,035	349.49	23,586
Clear Creek	91.00	45	21,944.25	348,019	420.48	3,361
Conejos	....	.....	140.00	900	....	....
Custer	....	.....	1,200.43	32,059	5.00	100
Dolores	....	.....	1,476.22	47,030	12.05	4,708
Eagle	7.60	2	2,176.86	42,487	2.00	80
Gilpin	6.53	3	66,763.11	322,609	2,762.73	13,992
Grand	....	.....	....	....	1.50	22
Gunnison	....	.....	964.13	37,046	7.93	1,060
Hinsdale	....	.....	363.83	7,567	7.23	1,169
Jefferson *	....	.....	....	....	....	....
Lake	....	.....	50,909.47	2,244,343	....	....
La Plata	....	.....	12,187.61	93,258	....	....
Mineral	....	.....	395.14	745,172	....	....
Ouray	....	.....	107,835.55	158,048	312.18	3,530
Park † *	2,641.36	695	18,600.25	144,547	....	2,400
Pitkin	....	.....	....	401,663	....	....
Routt	334.03	30	....	....	....	....
Saguache	....	.....	33.52	35	....	....
San Juan	....	.....	42,679.14	263,138	3.54	1,380
San Miguel	....	.....	79,297.81	1,094,235	....	....
Summit *	....	.....	....	....	....	....
Teller	....	.....	745,542.17	49,449	....	....
Unapportioned	1,044.29	.....	....	....	....	....
Total	4,855.71	908	1,165,232.96	6,107,559	3,884.13	55,388

* Included under Park County.

XXVIII.

Ounces.)

Deep Mines.						Total.	
Lead Ores.		Zinc Ores.		Lead-Zinc Ores.			
Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
...	...	...	...	...	...	12,654.92	70,921
417.34	29,912	...	3,595	...	13,006	1,566.28	75,265
1,779.61	280,177	...	...	131.08	60,835	24,366.42	692,437
...	...	...	...	...	...	140.00	900
...	...	...	...	...	...	1,205.43	32,159
68.54	7,288	...	...	125.00	17,500	1,681.81	76,526
...	783	81.88	3,135	...	...	2,268.34	46,487
612.96	4,297	...	...	...	...	70,145.33	340,901
...	...	...	...	...	...	1.50	22
384.77	13,780	5.22	1,763	...	...	1,362.05	53,649
209.01	45,683	...	...	...	...	580.07	54,419
...	...	...	...	...	...	...	...
4,043.11	954,999	1,759.29	488,954	390.00	345,466	57,101.87	4,033,762
...	...	...	...	...	...	12,187.61	93,258
8,416.95	69,017	...	...			8,812.09	814,189
4,724.79	144,828	...	...	...	...	112,872.52	306,406
371.76	9,614	...	3,000	2,401.47	98,427	24,014.84	258,683
12.00	1,651,913	...	415,944	...	...	12.00	2,469,520
...	...	...	...	...	...	334.03	30
.30	4,366	...	...	...	...	33.82	4,401
8,158.06	486,326	...	...	...	...	50,840.74	750,844
2,468.79	180,844	...	...	...	...	81,766.60	1,275,079
...	...	...	...	...	...	...	...
...	...	...	...	...	...	745,542.17	49,449
...	...	...	...	...	...	1,044.29	...
31,667.99	3,883,827	1,846.39	916,391	3,047.55	535,234	1,210,534.73	11,499,307

† Includes Jefferson and Summit counties for silver only.

A partial analysis, i.e., determination of the metallic contents of the rich Cripple Creek ores are as follows:[1]

TABLE XXIX.

	1	2	3
Gold	0.35	0.0506	0.060
Silver	none or trace	0.0075	0.0103
Copper	0.03	0.0059	0.0070
Lead *	0.18	....	....
Bismuth	0.0025	....	....
Molybdenum	0.018	0.0015	0.0018
Tellurium	....	0.0742	0.0920
Tellurium dioxide	0.36	....	....

* From another sample of same class of ore.

1. Oxidized ore from 100-foot level of Stratton's Independence mine. Analyst, W. F. Hillebrand. Mine assays give 107 ounces of gold per ton.

2. Telluride ore, El Paso mine. Au and Mo determined on 100 grains; Te on 50 grains. Analyst, W. F. Hillebrand; results of assays: 2.19 to 2.07 ounces Ag, 14.53 to 15.60 ounces Au, per ton.

3. Similar ore, El Paso mines. Analyst, W. F. Hillebrand; results of assays: 2.87 to 3.00 ounces Ag, 17.75 to 19.63 ounces Au, per ton.

"The average tenor of gold (in the Cripple Creek district) in the ores is about $30, or 1.5 ounces per ton, and at various mines ranges from one ounce up to 3 or 4 ounces. Ore with less than $12 per ton is rarely mined. Small amounts of ore with up to 2,500 ounces of gold per ton have been mined. The pyrite is rarely auriferous except when admixed with tellurides. The ores contain on an average only about one ounce of silver to 10 ounces of gold. In some mines the proportion is very much less. Small shipments have been made of tetrahedrite ore rich in silver. The tenor of the ore as mined has decreased somewhat in the last ten years, but this is probably mostly due to lowered operating and reduction expenses."[2]

The decrease in tenor of the Cripple Creek ores is shown to good advantage by the following data.[3]

[1] U. S. G. S., Geol. and Gold Deposits of the Cripple Creek Dist., Colo., Professional Paper No. 54, 173, 1906.

[2] U. S. G. S., Geol. and Gold Deposits of the Cripple Creek Dist., Colo., Professional Paper No. 54, pp. 6 and 7.

[3] U. S. G. S., Professional Paper No. 54, p. 171.

TENOR OF GOLD ORE FROM PORTLAND MINE.

	Per Ton.		Per Ton.
1894	$71.00	1902	$26.00
1895	54.00	1903	29.00
1897	60.00	1904	26.92
1900	39.00	1905	23.60

Assay and analysis of sample from the Smuggler vein, Telluride, Colorado.[1]

BATTERY SAMPLE.	Oz. per Ton.
Au	0.53
Ag	13.10

An analysis of ore milled at the Camp Bird mine, Ouray County, Colorado, in 1903, is as follows:[2]

	Per cent.
Silica and insolubles	85.20
Galena	.50
Copper pyrites	.80
Iron pyrites	6.50
Magnetite	.50
Blende	3.00
Rhodonite	2.50
Alumina	1.50
	100.50

The following is an assay of an average ore from the Leadville district, made in 1886:[3]

TABLE XXX.	Per cent.
Carbonic acid	5.58
Oxide of lead	24.77
Silica	22.59
Sulphur	0.90
Protoxide of iron	0.89
Peroxide of iron	24.86
Protoxide of manganese	4.03
Silver	0.31
Lime	2.36
Magnesia	3.04
Arsenic	0.01
Antimony	0.02
Potash and soda	0.98
Chlorine	0.09
Water	5.53
Alumina	3.99
Gold, copper, zinc	Trace.

[1] U. S. G. S., 18th Ann. Rept., Pt. 3, p. 835, 1896–97.
[2] T. A. I. M. E., Vol 33, p. 536, 1903.
[3] U. S. G. S., Monograph No. 12, p. 620, 1886.

Silver, 90.5 ounces to the ton; lead, 23 per cent; iron, 18 per cent; silica, 22.59 per cent.

Owing to the importance of the Cripple Creek district as a factor in the production of gold in Colorado, the following table is given, which covers the period of 1891 to 1905:[1]

TABLE XXXI.

Year.	Gold.	Silver. (Fine Ounces.)	Year.	Gold.	Silver. (Fine Ounces.)
1891	$ 449	....	1900	$18,073,539	80,166
1892	583,010	....	1901	17,261,579	90,884
1893	2,010,367	5,019	1902	16,912,783	62,690
1894	2,908,702	25,900	1903	12,967,338	42,210
1895	6,879,137	70,448	1904	14,504,350	66,638
1896	7,512,911	60,864	1905	15,411,724	49,449
1897	10,139,709	57,297			
1898	13,507,244	68,195	Total.....	$154,331,096	762,280
1899	15,658,254	82,520			

The production of gold and silver in the Leadville district, by decades, is given in Table XXXII, beginning with 1860, after the inauguration of the Carbonate ore era:[2]

TABLE XXXII.

Period.	Gold.	Silver.	Lead.	Copper.	Zinc.
1860–1878	$6,900,000	$11,700,000	$3,000,000		
1879–1888	2,291,000	106,415,000	36,136,000	$1,500,000	
1889–1898	7,906,000	73,054,000	23,776,000	3,065,000	
1899–1904	10,329,000	49,473,000	12,743,000	2,459,000	$9,439,000
Total.	$27,426,000	$240,642,000	$75,655,000	$7,024,000	$9,439,000

The gold and silver production of Colorado from 1866 to 1905 is given in Table XXXIII.[3]

In 1905 Colorado led in the production of gold and was second in the production of silver. The permanency of several of the principal producing districts, as Cripple Creek, the San Juan region and probably Leadville and Gilpin counties, is practically assured by

[1] U. S. G. S., Mineral Resources, 1905, p. 213.

[2] Mining Magazine, Vol. 11, p. 435.

[3] Compiled from the Mineral Resources, Mineral Industry and Rept. Director of the Mint.

TABLE XXXIII.

Year.	Gold.	Silver.	Year.	Gold.	Silver.
1866	$17,000,000	....	1886	4,450,000	16,000,000
1867	2,500,000	....	1887	4,000,000	15,000,000
1868	3,250,000	....	1888	3,758,000	19,000,000
1869	4,000,000	....	1889	3,883,859	23,757,751
1870	3,675,000	....	1890	4,150,000	24,307,070
1871	4,663,000	....	1891	4,600,000	27,358,384
1872	4,661,465	....	1892	5,300,000	21,758,750
1873	4,020,263	....	1893	7,525,000	20,432,000
1874	5,188,510	....	1894	9,549,731	14,638,696
1875	5,302,810	....	1895	13,527,300	11,687,150
1876	....	....	1896	14,867,971	15,097,500
1877	3,000,000	4,500,000	1897	19,579,637	12,722,227
1878	3,366,404	5,394,940	1898	23,534,531	13,866,535
1879	3,225,000	11,700,000	1899	26,508,675	13,771,731
1880	3,200,000	17,000,000	1900	28,762,036	12,472,500
1881	3,300,000	17,160,000	1901	27,693,500	10,869,083
1882	3,360,000	16,500,000	1902	28,466,207	8,176,602
1883	4,100,000	17,370,000	1903	22,540,100	7,014,708
1884	4,250,000	16,000,000	1904	24,395,800	8,312,328
1885	4,200,000	15,800,000	1905	25,701,100	7,811,239

the character of recent developments. It, however, remains to be seen whether increased depth of working with the consequent increased cost of operating will materially reduce the output or maintain it at its present status.

Idaho. — In this state, as in most of the others in which mining was done at an early date, the records as to production are of little or no value and only a rough estimate can be made. Idaho is claimed to have yielded $112,800,000 in gold alone up to and including 1900. Since then the production has been $7,669,245, which includes 1905. The total production then, inclusive of 1905, has been $120,469,245. Probably the maximum annual production was reached in 1866, when the extremely rich placer mines were being actively worked. A steady drop in production of gold occurred until in 1878 only $1,150,000 was obtained as the yearly output. However, in 1888 the gold product had increased to $2,400,000 and has fluctuated between $1,250,000 and $2,300,000. During the past few years the output of the placer mines has remained pretty close to the $500,000 mark. The main source of the gold production is Owyhee County and the veins of Gold Hill, Atlanta, Rocky Bar and Custer.

The silver product amounted to 8,679,093 ounces, valued at

$5,242,172, in 1905, showing an increase of 1,012,711 ounces in quantity and $853,168 in value over 1904. The chief source of the silver is the lead-silver mines of the Coeur d'Alêne region, Shoshone County, which is alone credited with 7,292,986 ounces. Owyhee County ranks second in point of yield, having produced 846,035 ounces in 1905.[1]

Of the 257 mines operating in the state in 1905, only 105 of them were deep mines, the remaining 152 being placers. The yield of the deep mines was 1,669,038 tons, having an average value of $3.58 in gold and silver per ton.

The following table gives the classification of mines by chief product in Idaho in 1905, by counties:[2]

TABLE XXXIV.

County.	Non-producing Mines.	Mines reporting Product.	Gold Placer Mines.				Deep Mines.					Total.
			Hydraulic.	Drift.	Dredge.	Total.	Gold.	Silver.	Copper.	Lead.	Zinc.	
Ada and Bannock	19	4	2	...	...	2	1	1	...	...	...	23
Bingham	11	7	7	...	...	7	...	...	...	...	...	18
Blaine	61	18	4	...	...	4	...	...	...	11	3	79
Boise	88	40	30	...	1	31	7	1	...	1	...	128
Canyon	......	4	4	...	...	4	...	...	...	...	...	4
Cassia	10	7	6	...	...	6	...	...	...	1	...	17
Custer	39	10	3	...	1	4	2	...	2	2	...	49
Elmore	45	13	3	...	...	3	8	2	...	...	...	58
Fremont	8	1	...	...	...	...	...	...	1	...	...	9
Idaho	129	45	23	7	...	30	13	2	...	...	...	174
Kootenai	40	2	...	...	...	...	...	2	...	...	...	42
Latah	20	7	7	...	...	7	...	...	...	...	...	27
Lemhi	172	19	10	...	...	10	6	1	...	2	...	191
Lincoln	7	2	2	...	...	2	...	...	...	...	...	9
Nez Perce	47	27	25	...	...	25	2	...	...	...	...	74
Oneida	......	2	2	...	...	2	...	...	...	...	...	2
Owyhee	27	7	3	...	...	3	...	4	...	...	...	34
Shoshone	133	37	8	1	1	10	...	...	2	24	1	170
Washington	48	5	2	...	...	2	1	...	2	...	...	53
Total	904	257	141	8	3	152	40	13	7	41	4	1,161

The source of gold and silver production in Idaho, by kinds of ore, in 1905, by counties, is given in Table XXXV.[3]

[1] U. S. G. S., Mineral Resources, 1905, p. 217.
[2] U. S. G. S., Mineral Resources, 1905, p. 224.
[3] U. S. G. S., Mineral Resources, 1905, pp. 216, 217.

TABLE XXXV.

(Fine Ounces.)

County.	Placers.		Siliceous Ore.		Copper Ore.		Lead Ore.		Mixed Ore. Copper-Lead-Zinc Ore.		Mixed Ore. Copper-Lead Ore.		Mixed Ore. Lead-Zinc Ore.		Grand Total.	
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Ada and Bannock	104	16	73	100											177	116
Bingham	276	4													276	4
Blaine	258	9					3	335,756	9	24,743			76	14,046	346	374,554
Boise	6,351	1,478	721	182			288	300							7,360	1,960
Canyon	71	3													71	3
Cassia	140	11									1	16			141	27
Custer	947	524	299	230	385	24,452	1	11,408							1,632	36,614
Elmore	1,126	186	5,389	2,769											6,515	2,955
Fremont		0				6									0	6
Idaho	2,289	254	8,254	4,905											10,543	5,159
Kootenai		0		7,080	3	14,292									3	21,372
Latah	225	21													225	21
Lemhi	1,440	421	3,239	336			70	38,600							4,749	39,357
Lincoln	156	6													156	6
Nez Perce	951	193	259												1,210	193
Oneida	393	15													393	15
Owyhee	68	7	14,798	846,035											14,866	846,042
Shoshone	1,640	331			246	390,000		6,891,344				5,894		5,417	1,886	7,292,986
Washington	35	3	1,250		199	57,700									1,484	57,703
Total	16,470	3,482	34,282	861,637	833	486,450	362	7,277,408	9	24,743	1	5,910	76	19,463	52,033	8,679,093

The gross value of the product of the principal lead-silver mines of the Coeur d'Alêne district in 1903 was as follows:[1]

Standard-Mammoth	$2,544,918
Morning	1,635,612
Bunker Hill and Sullivan	1,604,538
Last Chance	1,409,672
Hercules	850,258
Hecla	655,721
Tiger-Poorman	580,477
Helena-Frisco	465,287
Gold Hunter	166,000
Other mines	151,735
Total	$10,064,218

The production of gold, silver and lead from the Coeur d'Alêne district for 1904 and total from 1884 is as follows: gold, $144,690 and $4,770,177; silver, $3,512,895 and $34,163,655; and lead, $9,271,672 and $69,040,856. The total value of all for 1904 was $12,929,257 and since 1884, inclusive of 1905, $107,974,688.[2]

The average value of the Coeur d'Alêne ores in silver is a trifle over one-half ounce to each per cent of lead per ton. During the year 1903–4 the ore obtained from Bunker Hill and Sullivan mine averaged 3.9 ounces of silver and 8.8 per cent lead — the range of values being 3.6 to 6.8 ounces silver and 8 to 16 per cent lead per ton. In 1905 the richest ore produced came from the Hercules mine and contained approximately 45 ounces silver and 50 per cent lead to the ton.[3]

The following fragmentary data give an approximate idea of the output of the Warren mining district:[4]

TABLE XXXVI.

Year.	Placer.	Quartz.	Total.
1869	$385,000	$35,000	$420,000
1871			160,000
1872			56,000
1875			*120,000
1881	108,800	18,672	127,472
1882	115,280	11,170	126,450
1884	83,000	17,000	
1886			† 124,077
1887			‡ 145,000

* Approximate.

† $121,881 gold, $2,196 silver.

‡ $141,127 gold, $3,873 silver.

[1] Mining Magazine, Vol. 12, p. 30.

[2] Coeur d'Alêne Souvenir, 1906, p. 105.

[3] Mining Magazine, Vol. 12, pp. 31 and 32.

[4] U. S. G. S., 20th Ann. Rept., Pt. 3, p. 238, 1898–99.

No later data is available, but the output has not varied much from that of 1887, the last year given.

The gold and silver production of the placer mines of Idaho for the year 1905, by counties, is shown in Table XXXVII.[1]

TABLE XXXVII.

(Fine Ounces.)

Counties.	Gold.	Value.	Silver.	Value.	Total Value.
Ada	104	$2,150	16	$10	$2,160
Bingham	276	5,705	4	2	5,707
Blaine	258	5,333	9	5	5,338
Boise	6,351	131,287	1,478	893	132,180
Canyon	71	1,468	3	2	1,470
Cassia	140	2,894	11	6	2,900
Custer	947	19,576	524	317	19,893
Elmore	1,126	23,276	186	113	23,389
Idaho	2,289	47,318	254	153	47,471
Latah	225	4,651	21	13	4,664
Lemhi	1,440	29,768	421	255	30,023
Lincoln	156	3,225	6	4	3,229
Nez Perce	951	19,659	193	116	19,775
Oneida	393	8,124	15	9	8,133
Owyhee	68	1,406	7	4	1,410
Shoshone	1,640	33,902	331	200	34,102
Washington	35	724	3	2	726
Total	16,470	340,466	3,482	2,104	342,570

The production of gold and silver during the period of years 1866 to 1905 is given in Table XXXVIII:[2]

TABLE XXXVIII.

Year.	Gold.	Silver.	Year.	Gold.	Silver.
1866	$17,000,000	....	1887	$1,900,000	$3,000,000
1867	6,500,000	....	1888	2,400,000	3,000,000
1868	7,000,000	....	1889	1,984,159	4,056,482
1869	7,000,000	....	1890	1,850,000	4,783,838
1870	6,000,000	....	1891	1,680,000	5,216,970
1871	5,000,000	....	1892	1,721,364	3,712,500
1872	2,695,870	....	1893	1,646,900	3,058,167
1873	2,500,000	....	1894	2,081,281	2,071,785
1874	1,880,004	....	1895	1,779,600	2,236,951
1875	1,750,000	....	1896	2,155,300	3,623,400
1876	....	....	1897	2,000,000	3,587,400
1877	1,500,000	$250,000	1898	2,050,000	3,661,492
1878	1,150,000	200,000	1899	1,750,000	2,859,840
1879	1,200,000	650,000	1900	2,067,000	3,741,130
1880	1,980,000	450,000	1901	2,273,900	2,358,000
1881	1,700,000	1,300,000	1902	1,475,000	3,103,044
1882	1,500,000	2,000 000	1903	1,570,400	3,513,996
1883	1,400,000	2,100,000	1904	1,503,700	4,529,916
1884	1,250,000	2,720,000	1905	1,250,845	5,262,344
1885	1,800,000	3,500,000	1906	....	....
1886	1,800,000	3,600,000	....	....	....

[1] U. S. G. S., Mineral Resources, 1905, p. 223.

[2] Table compiled from Mineral Resources, Mineral Industry and Repts. Director of Mint.

Judging from the operations of the placer mines during the past decade it seems probable that they will continue an important factor in the gold production of Idaho. With regard to the future of the lode-mines there is considerable uncertainty owing to the nature of developments made. The deposits which have been developed largely in the past partook of the nature of bonanzas, being quickly exhausted; thus periods of idleness followed others of great activity. The production of silver, on the other hand, will probably increase owing to its occurrence in the lead deposits, and being a by-product its output will not be affected by commercial conditions.

Montana.—The discovery of placers in 1862 marks the beginning of the mining industry in Montana. It is claimed that the output of placer gold during the five years, beginning with 1862, was about $65,000,000. The known output from 1877 to 1905 inclusive, was $107,292,000, while the total since discovery approximates $227,192,000 inclusive of 1905.

The characteristic condition of Montana's gold production has always been its relative uniformity, not being subject to any sudden changes. From 1862, to and including 1866, there was an increase which culminated in the maximum output, in 1866, of $16,000,000. Shortly after this a decline began, and in 1875 and 1882 the production was $2,700,000 and $2,500,000 respectively. However, in 1887 the output was $6,000,000, which increase was occasioned by the smelting of auriferous silver ores and the development of several large quartz-veins bearing gold and silver values. The production of silver began in 1872. There was a subsequent falling off in gold to $3,600,000 in 1894, and from 1897 to 1905 the gold production has varied between approximately $4,400,000 and $5,100,000, being $5,064,600 in 1905.

In 1902 Colorado led in the production of silver, Montana coming second; however, in 1904 Montana ranked first, producing $8,472,698 compared with $8,312,328 for Colorado, while in 1905 her silver-product was $8,235,000, exceeding that of Colorado by $491,182.

During later years a considerable amount of the precious metal production has come from the smelting of copper ores, especially those from Silver Bow County.[1]

Two-thirds of the gold production in 1880, or about $2,400,000, was derived from placers; in 1884 the ratio was reduced to two-fifths, or $960,000 to $2,400,000 — during late years the output of placers has been fairly constant. An output of $600,000 in 1900 compared with a total of $4,700,000 was recorded, while in 1905 it had dropped to $396,901, or practically $400,000.

[1] T. A. I. M. E., Vol. 33, pp. 825 and 826, 1903.

The gold-quartz and auriferous silver-quartz ores yielded $1,400,000 in 1897, and $2,300,000 in 1900, while the lead and mixed smelting ores for the same years yielded approximately $1,200,000 and $700,000 respectively. Further, the gold production of the copper ores of Butte is assuming considerable importance, being for the period 1882 to and including 1900, about $14,500,000, and in silver and copper $86,000,000 and $331,000,000. The silver-veins of Butte have also added materially to the output of both gold and silver.[1]

As producers of placer-gold Madison and Beaverhead counties held the first place, Prickly Pear and Confederate gulches being the chief producers in later years. With the beginning of deep mining the gold and silver-gold, smelting and milling, ores immediately became important factors in the production of the precious metals. The following counties lead in the production of gold, being given in the order of importance: Lewis, Clark, Jefferson, Deer Lodge, Silver Bow, Granite, Meagher, Fergus, Madison and Beaverhead.

In 1905 there were 332 mines being worked in Montana, of which 78 were placers and 254 were deep mines. These mines produced 5,020,137 tons of ore at an average value in gold and silver of $2.47.[2]

In Table XXXIX is a classified list of the mines of Montana by counties, with regard to chief product for 1905: [3]

TABLE XXXIX.

County.	Non-producing Mines.	Gold Placer Mines.				Deep Mines.					Mines reporting Product.
		Hydraulic.	Drift.	Dredge.	Total.	Gold.	Silver.	Copper.	Lead.	Total.	
Beaverhead	16	1	...	...	1	1	3	1	...	5	6
Broadwater	11	4	...	...	4	13	3	1	2	19	23
Cascade	2	...	...	...	...	...	6	...	...	6	6
Chouteau, Meagher and Ravalli	12	3	...	...	3	2	...	...	...	2	5
Deer Lodge and Flathead	19	5	...	...	5	2	...	...	1	3	8
Fergus	6	...	...	...	...	5	...	...	...	5	5
Granite	21	7	...	...	7	11	7	1	...	19	26
Jefferson	17	3	...	1	4	12	21	3	3	39	43
Lewis and Clark	18	21	...	...	21	19	4	...	1	24	45
Madison	23	10	...	1	11	49	3	...	3	55	66
Missoula	16	8	...	...	8	1	1	2	...	4	12
Park	6	1	1	1	3	3	...	...	...	3	6
Powell	10	8	...	2	10	9	...	...	1	10	20
Silver Bow	21	1	...	...	1	...	20	40	...	60	61
Total	198	72	1	5	78	127	68	48	11	254	332

[1] T. A. I. M. E., Vol. 33, p. 828, 1903.

[2] For average value of ore by counties, see Mineral Resources, 1905, p. 246.

[3] U. S. G. S., Mineral Resources, 1905, p. 247.

The amount, contents and value of ore sold by the Elkhorn mine of the Elkhorn district, Jefferson County, are given in Table XL.[1]

TABLE XL.

Year.	Ore.	Silver.	Gold.	Lead.	Total Value.	Value per Ton.
	Tons.	Ounces.	Ounces.	Pounds.		
1898	1,700.309	214,908.89	230.626	532,429	$104,945.83	....
1897	715.241	96,872.10	109.147	179,341	48,478.44	$67.78
1896	554.234	90,787.29	85.566	149,367	50,355.59	90.85

Car load lots of ore from the Elkhorn mines shipped in 1894 gave assays as follows:

Sulphide ore: Zinc, 32.6; silver, 180.6; gold, 0.13; lead, 14.
Oxidized silver: Zinc, 17.3; silver, 223.3; gold, 0.17; lead, 12.8.

According to W. H. Weed: " Although native silver is of common occurrence in oxidized portions of the deposit, no free gold has, so far as the writer knows, ever been found. The ratio of gold to silver in the ores is very constant, and approximates 1,000 ounces of silver to one ounce of gold."[2]

The value of the ores in the Judith Mountains district is quite variable, ranging from many thousands per ton as in the bonanzas of the Spotted Horse mine, to the more universal low-grade ores. The average is as a usual thing low, not exceeding $10 per ton.[3]

The source of the gold and silver product in Montana, by kinds of ore, in 1905, by counties, is given in Table XLI:[4]

[1] U. S. G. S., 22d Ann. Rept., Pt. 2, p. 418, 1900–01.
[2] U. S. G. S., 22d Ann. Rept., Pt. 2, pp. 475 and 476, 1900–01.
[3] Ibid, 18th Ann Rept., Pt. 3 p. 592, 1896–97.
[4] U. S. G. S., Mineral Resources, 1905, pp. 247 and 248.

TABLE XLI.

(Fine Ounces.)

County.	Placers.		Deep Mines.										Total.	
			Siliceous Ores.		Copper Ores.		Lead Ores.		Copper-Lead-Zinc Ores.		Total.			
	Gold.	Silver	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver	Gold.	Silver.	Gold.	Silver.
Beaverhead	35.31	4	72.00	7,200	6.00	2,160	....	38,781	......	.....	78.00	48,141	113.31	48,145
Broadwater	238.15	38	4,608.49	24,371	....	....	938.95	34,218	......	.....	5,547.44	58,589	5,785.59	58,627
Cascade	....	.....	161.18	34,196	....	....	22.00	381,512	......	.....	183.18	415,708	183.18	415,708
Chouteau, Meagher & Ravalli	194.68	23	7,539.07	5,939	....	....	....	....	......	.....	7,539.07	5,939	7,733.75	5,962
Deer Lodge & Flathead	682.04	58	8,202.00	6,237	....	....	537.94	31,464	......	.....	8,739.94	37,701	9,421.98	37,759
Fergus	....	....	60,719.80	3,369	....	....	....	....	......	.....	60,719.80	3,369	60,719.80	3,369
Granite	135.40	14	7,197.73	705,436	.22	821	20.00	12,000	......	.....	7,217.95	718,257	7,353.35	718,271
Jefferson	289.59	55	7,723.36	180,244	6.00	2,544	745.30	250,339	1.20	956	8,475.86	434,083	8,765.45	434,138
Lewis & Clark	574.39	85	26,759.72	147,215	120.93	828	49.10	5,462	......	.....	26,929.75	153,505	27,504.14	153,590
Madison	13,122.13	1,985	21,158.49	111,047	19.35	66	887.78	24,742	......	.....	22,065.62	135,855	35,187.75	137,840
Missoula	2,067.26	90	100.00	1,438	41.50	3,495	....	....	......	.....	141.50	4,933	2,208.76	5,023
Park	278.83	42	2,170.07	798	....	....	....	....	......	.....	2,170.07	798	2,448.90	840
Powell	1,471.97	157	66.59	518	....	....	1,698.03	20,337	......	.....	1,764.62	20,855	3,236.59	21,012
Silver Bow	110.32	22	8,314.44	569,714	52,687.44	10,614,680	....	....	139.00	6,600	61,140.88	11,190,994	61,251.20	11,191,016
Total	19,200.07	2,573	154,792.94	1,797,722	52,881.44	10,624,594	4,899.10	798,855	140.20	7,556	212,713.68	13,228,727	231,913.75	13,231,300

Table XLII gives the production of gold and silver in Montana during a period of years beginning with 1866 and including 1905:[1]

TABLE XLII.

Year.	Gold.	Silver.	Year.	Gold.	Silver.
1866	$18,000,000	....	1886	4,425,000	12,400,000
1867	12,000,000	....	1887	5,230,000	15,500,000
1868	15,000,000	....	1888	4,200,000	17,000,000
1869	9,000,000	....	1889	3,139,327	17,468,960
1870	9,100,000	....	1890	3,300,000	20,363,636
1871	8,050,000	....	1891	2,890,000	21,139,394
1872	6,068,339	....	1892	2,891,386	15,262,500
1873	5,178,047	....	1893	3,575,000	13,294,000
1874	3,844,722	....	1894	3,651,410	8,077,151
1875	3,573,600	....	1895	3,677,586	9,825,305
1876	....	....	1896	4,324,700	10,548,120
1877	3,200,000	750,000	1897	4,496,431	10,049,112
1878	2,260,511	1,669,635	1898	5,247,913	8,633,352
1879	2,500,000	2,225,000	1899	4,819,157	10,039,680
1880	2,400,000	2,500,000	1900	4,698,000	8,801,148
1881	2,330,000	2,630,000	1901	4,744,100	7,879,020
1882	2,550,000	4,370,000	1902	4,373,600	7,019,214
1883	1,800,000	6,000,000	1903	4,411,900	6,826,842
1884	2,170,000	7,000,000	1904	5,097,800	8,472,698
1885	3,300,000	10,060,000	1905	5,064,600	8,235,000

It is not probable that the output of gold and silver in Montana will suffer any material decrease in the near future, owing primarily to the discovery and development of large deposits of low-grade ores, and to a less extent to the output of the placers. However, a number of the large mines have been exhausted. Any serious decline in price of copper would also affect the production of gold and silver, constituting, as they do, a valuable part of the returns from copper mining.

Nevada. — Nevada has been made famous by the stupendous production of the Comstock lode, which if maintained would not only have put it in the lead as a producer of the precious metals, but would have caused it to maintain that position. In 1877 the Comstock yielded $14,500,000 in gold and $21,800,000 in silver, which was the banner year in its production of gold, the following years witnessing a decline. In 1893 the total output of gold from the state was less than $1,000,000. However, an increase in gold pro-

[1] Table compiled from Mineral Resources, Mineral Industry and Reports Director of the Mint.

duction began subsequent to 1893, and for the period 1897 to 1900 the yield was $3,000,000, $3,000,000, $2,200,000, and $2,000,000 per year respectively. In later years the De Lamar, in Lincoln County, has been largely responsible for the increase, although the Comstock, Eureka and other districts have made substantial additions.

For a time the Comstock lode furnished more than one-half of the total silver output of the United States. Following the abandonment of a large part of the deep mines on the lode, in 1886, silver-mining in Nevada dropped to insignificant proportions, and that, too, when silver was nearly twice as high as in 1902. In time, however, improved methods have made it possible to resume operations in the submerged levels, and even at the present low price of silver many of the mines are working at a profit. To work the deep mines necessitates the investment of considerable capital, which in turn requires the maintenance of a large output. Consolidation of interests naturally resulted, which is shown by the fact that in 1902 three-fifths of the total yield was produced by five operators, each with a production valued at over $100,000, while the production of one company was over $1,000,000.

The total gold production of Nevada since 1860, the date of discovery of mining districts, is estimated at $268,255,000, while the Comstock contributed from 1859 to 1900, inclusive, $148,000,000. The recorded output of the state during the period 1877 to 1905, inclusive, was approximately $117,955,000.

The total yield of the Comstock lode, to and including 1900, is claimed to have been $368,000,000, of which $148,000,000 was gold and the remainder, or $220,000,000, was silver.

As a placer-mining state, Nevada is not of much consequence, although an annual output of from $20,000 to $100,000 is recorded.[1]

During 1905 there were 132 gold and silver producing mines in Nevada, of which 10 were placers, and 122 were deep mines. The yield of these mines was 432,202 tons, having an average gold and silver content of $21.25.[2]

[1] T. A. I. M. E., Vol. 33, pp. 829 and 830, 1903, and Mines and Quarries, 1902, Rept. Bureau of Census, p. 562.

[2] For value and tonnage of ore, concentrates, etc., in Nevada in 1905 by counties, see Mineral Resources, 1905, p. 264.

The following table gives the mines classified by principal product by counties, in Nevada for 1905:[1]

TABLE XLIII.

County.	Non-producing Mines.	Mines reporting Product.	Gold Placer Mines.			Deep Mines.						
			Hydraulic.	Sluice.	Total.	Gold.	Silver.	Copper.	Lead.	Zinc.	Mixed ores.	Total.
Churchill and Douglas	27	7	....	1	1	2	2	..	2	..	....	6
Elko	26	9	2	1	3	2	2	..	1	..	1	6
Esmeralda	136	30	....	..	..	22	5	1	2	..	....	30
Eureka	15	11	....	..	..	1	..	..	9	..	1	11
Humboldt	58	4	....	..	..	2	2	..	..	..	....	4
Lander	35	7	....	..	..	1	5	1	..	..	....	7
Lincoln	160	14	....	2	2	10	1	..	..	1	....	12
Lyon	29	6	....	1	1	4	..	1	..	..	....	5
Nye	175	12	....	..	..	2	9	..	1	..	....	12
Ormsby	11	......	....	..	..	..	..	..	..	..	....	......
Storey	30	13	....	..	..	13	..	..	..	..	....	13
Washoe	60	5	....	1	1	4	..	..	..	..	....	4
White Pine	66	14	....	2	2	2	1	1	8	..	....	12
Total	828	132	2	8	10	65	27	4	23	1	2	122

The yield of the Comstock ores has been variously given, but in reality seldom exceeds $50 per ton, while for large quantities of ore $15 is probably a closer average. The average yield of twelve mines in 1872, the total production being $13,569,724, of which $12,000,000 was taken, was $19.60 per ton. The following figures illustrate the wide variation in value of ore from the various mines on the Comstock lode: Consolidated Virginia, average $600 per ton; the Utah, $3 to $12, principally in gold; Sierra Nevada, average $5.50; Virginia Consolidated and California, average (1875) $150; Savage, $10 to $12; Hale and Norcross (1874), $14 to $17; Bullion, $10 to $15; and the Belcher, $25 to $35. The quartz in the Bullion carried two-thirds silver and one-third gold, while the deepest ore-body in the Chollar carried three-fifths gold and two-fifths silver; the upper body yielded two-thirds gold and one-third silver. Although the cases cited are for special mines and localities, yet they are valuable in indicating the range in values.[2]

[1] U. S. G. S., Mineral Resources, 1905, p. 264.

[2] Eng. and Min. Jour., Vol. 18, p. 404.

Two analyses are given below of ore from the Savage and Kentuck mines. The ore is from the lower levels, and was analyzed in 1869:[1]

ANALYSES OF COMSTOCK ORES.

	Savage.	Kentuck.
Silica	83.95	91.49
Protoxide of iron	1.95	0.83
Alumina	1.25	1.13
Protoxide of manganese	0.64	....
Manganese	2.82	1.37
Lime	0.85	1.42
Sulphide of zinc	1.75	0.13
Sulphide of copper	0.30	0.41
Sulphide of lead	0.36	0.02
Sulphide of silver	1.08	0.12
Gold	0.02	0.0017
Bisulphide of iron	1.80	0.92
Potassa and soda	1.28	1.05
Water	2.33	0.59
	100.38 W. G. Mixter.	99.48 A. Hague.

The following analyses of ore from the so-called "middle depth" of a number of the Comstock mines illustrate the range in constituents and values:[2]

TABLE XLIV.

	California Mine.	California Mine.	Ophir Mine.	Yellow Jacket.	Yellow Jacket Mine.
Silica	67.5	65.783	63.38	98.310	96.560
Sulphur	8.75	11.35	7.919	.693	.160
Copper	1.30	1.31	1.596	....	....
Iron	2.25	2.28	5.463	.575	2.800
Silver	1.75	1.76	2.786	.150	.05
Gold	.059	.57	.059	.005	.001
Zinc	12.85	11.307	14.455	....	....
Lead	5.75	6.145	4.151	....	....
Antimony	....	....	.087	....	....
Loss	.25	....	....	.267	.429
	100.00	100.00	99.896	100.00	100.00
	London	Swansea	G. Attwood	W. F. Rickard	W. F. Rickard

[1] Gold, Its Occurrence and Extraction, A. G. Lock, p. 175, 1882, and Mining Industry, Vol. 3, p. 80, J. D. Hague, 1870.

[2] Mining Industry, Vol. 3, p. 80, 1870.

TABLE XLV.

PRODUCTION OF THE LEADING MINES OF THE COMSTOCK LODE, WHICH INCLUDES THE PRODUCT UP TO AUGUST, 1877.[1]

Bonanza.	Date of Discovery.	Position.	Depth.	Length.	Width.	Tons.	Average Yield.	Bullion.
Ophir, No. 1	1859	Surface	200	200	40	109,166	$48.00	$ 5,210,000
Gould & Curry, Savage	1860	"	400	900	30	777,783	39.70	30,881,397
Gold Hill	1863	"	450	1000	30	1,037,412	25.39	26,340,762
Yellow Jacket, Kentuck, Crown Point	1864	100 feet	350	500	35	418,051	32.02	13,389,068
Belcher	1864	surface	150	200	30	55,288	34.39	1,901,117
Chollar Potosi	1865		300	500	50	553,958	25.39	13,985,415
Overman	1866	"	200	250	30	110,669	14.26	1,578,388
Seg. Belcher	1866	'	80	50	20	4,961	20.49	101,453
Caledonia	1866	"	100	100	25	16,613	12.89	212,761
Hale & Norcross	1866	400 feet	350	350	35	313,270	24.97	7,822,233
Sierra Nevada	1868	....	200	300	40	111,497	7.89	883,108
Crown Point, Belcher	1871	900 feet	500	600	60	1,374,528	42.40	58,110,240
Con. Virginia, California	1873	1100 feet	500	700	90	1,090,360	93.55	104,007,653
Ophir, No. 2	1874	1300 feet	300	300	30	264,000	20.70	5,548,055
Justice	1874	200 feet	500	400	10	112,964	21.38	2,395,974
Total	....	....	....	....	....	6,350,520	42.89	272,367,624

[1] The Comstock Lode, J. A. Church, 1879, p. 7.

Comstock total gold and silver production, from discovery and commencement, 1859 to 1900.[1]

TABLE XLVI.

Year.	Ore (Tons).	Gold, Value.	Silver, Value.	Total Value.	Average per Ton.
1859	....	$30,000.00	....	$30,000.00	......
1860	10,000	550,000.00	$200,000.00	750,000.00	$75
1861	140,000	2,500,000.00	1,000,000.00	3,500,000.00	25
1862	250,000	4,650,000.00	2,350,000.00	7,000,000.00	28
1863	450,000	4,940,000.00	7,460,000.00	12,400,000.00	28
1864	680,450	6,400,000.00	9,600,000.00	16,000,000.00	24
1865	430,745	6,133,488.00	9,700,232.00	15,833,720.00	37
1866	640,282	5,963,158.00	8,944,737.00	14,907,895.00	23
1867	462,176	5,495,443.20	8,243,164.80	13,738,608.00	30
1868	300,560	3,391,907.60	5,087,861.40	8,479,769.00	28
1869	279,584	2,962,231.20	4,443,346.80	7,405,578.00	26
1870	238,967	3,481,730.16	5,222,595.24	8,704,325.40	36
1871	409,718	4,099,811.46	6,149,717.19	10,249,528.65	25
1872	384,668	4,894,559.86	7,341,839.79	12,236,399.65	32
1873	448,301	8,668,793.40	13,003,187.13	21,671,980.53	48
1874	526,743	8,990,714.06	13,486,071.09	22,476,785.15	43
1875	546,425	10,330,208.62	15,495,312.92	25,825,521.54	47
1876	598,818	12,647,464.08	18,971,196.12	31,618,660.20	53
1877	562,519	14,520,614.68	21,780,922.02	36,301,536.70	65
1878	272,909	7,864,557.64	11,796,836.47	19,661,394.11	72
1879	178,276	2,801,394.33	4,202,091.49	7,003,485.82	39
1880	172,399	2,051,606.00	3,077,409.00	5,129,015.00	30
1881	76,049	430,248.00	645,372.00	1,075,620.00	14
1882	90,181	697,385.60	1,046,078.40	1,743,464.00	19
1883	125,914	802,539.54	1,203,809.29	2,006,348.83	16
1884	188,369	1,261,313.60	1,577,438.40	2,838,752.00	15
1885	266,147	1,729,531.25	1,415,071.04	3,144,602.29	14
1886	238,780	2,054,920.15	1,681,298.31	3,736,218.46	16
1887	223,682	2,481,176.85	2,030,053.78	4,511,230.63	20
1888	271,152	3,169,209.07	4,458,058.66	7,627,267.73	28
1889	286,144	2,590,973.32	3,358,949.95	5,949,923.27	21
1890	286,075	1,992,349.03	2,988,523.56	4,980,872.59	17
1891	188,647	1,380,857.02	2,071,285.53	3,452,142.55	18
1892	133,678	1,043,158.86	1,130,088.77	2,173,247.63	16
1893	109,780	1,123,262.54	748,841.70	1,872,104.24	17
1894	97,049	768,880.63	512,587.09	1,281,467.72	13
1895	63,558	548,873.68	365,915.79	914,789.47	14
1896	39,240	340,258.36	226,835.57	567,088.93	14
1897	17,850	223,808.63	149,205.76	373,014.39	21
1898	10,766	123,023.89	82,015.92	205,039.81	19
1899	6,780	103,006.74	68,671.16	171,677.90	25
1900	35,300	384,423.56	319,441.70	700,865.26	20
Total..	10,698,681	146,613,877.61	203,636,062.84	350,249,940.45	
Total plus mill tailing				368,013,803.61	

[1] Mines and Quarries, 1902, Report Bureau of Census, p. 563.

The output of the Nevada mines decreased from a maximum in 1878 of $19,546,513 in gold and $28,130,350 in silver, a total of $47,676,314 or nearly 50 per cent of the product of the United States, to $3,520,000 in silver and $2,679,675 in gold, a total of $6,199,675 in 1891.

The following reasons have been given for this decline:[1]

"1. Failure of the Big Bonanza, primary cause.

"2. Remoteness of undeveloped portion of the state from railways.

"3. The avaricious policy of railways, when they can be reached.

"4. And the absence of centrally located competing 'custom' reduction works.

"5. The Comstock mill-ring, which owned the entire political and judicial organization of the state."

The following summary of the Yield of the Comstock mines to 1879 was made by Mr. Church:[2]

Duration of mining	20 years
Number of bonanzas	16
Tons of ore extracted	6,500,000
Value of ore per ton, nearly	$56.00
Yield in mills	$44.60
Yield from tailings and slimes, per ton	$5.00
Lost in tailings, per ton	6.00
Total value of ore	$363,671,605.00
Yield in mills	291,171,605.00
Yield from tailings and slimes	32,500,000.00
Lost in tailings	40,000,000.00

The analysis of an average of the Richmond ore (Eureka, Nevada) as made in 1878 is as follows:[3]

	Per cent.		Per cent.
Lead oxide	35.65	Lead	33.12
Bismuth			
Copper oxide	.15	Copper	.12
Iron protoxide	34.39	Iron	24.07
Zinc oxide	2.37	Zinc	1.89
Manganese oxide	.13		
Arsenic acid	6.34	Arsenic	4.13
Antimony	.25	Antimony	.25
Sulphuric acid	4.18	Sulphur	1.67
Chlorine		Lime	1.14
Silica	2.95	Magnesia	.41
Alumina	.64	Water and carbonic acid	10.90
		Silver and gold	.10
		Total	100.52

27.55 Troy ounces ($35.61) silver per ton of 2,000 pounds.

1.59 Troy ounces ($32.87) gold per ton of 2,000 pounds.

[1] Eng. and Min. Jour. Vol. 28, p. 356.

[2] Min. and Sci. Press, Vol. 38, p. 86.

[3] U. S. G. S., Monograph No. VII, p. 60, 1884.

TABLE XLVII.[1]

SOURCE OF THE GOLD AND SILVER PRODUCT OF NEVADA BY KINDS OF ORE FOR 1905, AND ARRANGED ACCORDING TO COUNTIES.

(Fine Ounces.)

County.	Placers.		Deep Mines.								Grand Total.	
			Siliceous Ores.		Copper Ores.		Lead Ores.		Total.			
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Churchill and Douglas.	0.97	......	101.59	167	......	......	11.17	3,710	112.76	3,877	113.73	3,877
Elko	299.92	68	6,424.20	11,950	......	......	11.22	10,775	6,435.42	22,725	6,735.34	22,793
Esmeralda	......	......	95,359.62	20,750	......	......	667.58	72,947	96,027.20	93,697	96,027.20	93,697
Eureka	......	......	......	......	......	......	753.97	77,387	753.97	78,475	753.97	78,475
Humboldt	......	......	1,897.07	5,864	......	......	......	......	1,897.07	5,864	1,897.07	5,864
Lander	......	......	181.94	27,093	38.70	199	......	......	220.64	27,292	220.64	27,292
Lincoln	42.96	5	51,293.32	59,621	......	......	......	......	51,293.32	63,286	51,336.28	63,291
Lyon	4.84	......	1,909.65	36,478	12.62	1,490	......	......	1,922.27	37,968	1,927.11	37,968
Nye	......	......	64,945.70	5,443,487	......	......	......	8,048	64,945.70	5,451,535	64,945.70	5,451,535
Storey	......	......	29,674.41	577,747	......	......	......	......	29,674.41	577,747	29,674.41	577,747
Washoe	9.67	2	1,081.62	416	......	......	......	......	1,081.62	416	1,091.29	418
White Pine	41.89	23	146.43	15	......	......	16.45	119,086	162.88	119,101	204.77	119,124
Total	400.25	98	253,015.55	6,183,588	51.32	1,689	1,460.39	291,953	254,527.26	6,481,983	254,927.51	6,482,081

The production of silver from zinc ores in 1905 amounted to 4,753 ounces and was confined to Eureka and Lincoln counties.

[1] U. S. G. S., Mineral Resources, 1905, p. 265.

According to Mr. J. E. Spurr's estimate, in 1904, the average value of the ores mined in the Goldfield district was from $200 to $300 per ton and even more. The average value of shipping and milling ore in 1905 was about $200, and $40 to $50 per ton respectively.

The following analysis of the Florence mine ore was published in the *Goldfield News* of April 7, 1905 :[1]

Gold	Ounces per ton	70.21	Zinc	Per cent	.3
Silver	Ounces per ton	7.8	Arsenic	Per cent	.3
Copper	Per cent	6.9	Sulphur	Per cent	13.20
Iron	Per cent	28.5	Silica	Per cent	43.44

The production of gold and silver for the years 1866 to 1905, inclusive, is given in Table XLVIII:[2]

TABLE XLVIII.

Year.	Gold.	Silver.	Year.	Gold.	Silver.
1866	$16,000,000	....	1887	2,500,000	4,900,000
1867	20,000,000	....	1888	3,525,000	7,000,000
1868	14,000,000	....	1889	3,506,295	6,072,241
1869	14,000,000	....	1890	2,800,000	5,753,535
1870	16,000,000	....	1891	2,050,000	4,551,111
1871	22,500,000	....	1892	1,571,500	2,062,500
1872	25,548,801	....	1893	958,500	1,329,400
1873	35,254,507	....	1894	1,137,819	652,145
1874	35,452,233	....	1895	1,509,323	527,120
1875	40,478,369	....	1896	2,410,538	805,200
1876	....	....	1897	3,000,000	896,850
1877	18,000,000	26,000,000	1898	3,000,000	466,080
1878	19,546,513	28,130,350	1899	2,371,882	342,585
1879	9,000,000	12,560,000	1900	2,006,200	842,394
1880	4,800,000	10,900,000	1901	2,963,800	1,087,500
1881	2,250,000	7,060,000	1902	2,895,300	1,985,486
1882	2,000,000	6,750,000	1903	3,388,000	2,727,270
1883	2,520,000	5,430,000	1904	4,307,800	1,563,158
1884	3,500,000	5,600,000	1905	4,700,000	3,660,000
1885	3,100,000	6,000,000	....	....	....
1886	3,090,000	5,000,000	....	....	....

NOTE.—The gold and silver product is combined in the table for the years 1866–1875.

New Mexico.—The output of the early placer mining done by the Spaniards and Mexicans as early as the 16th century is impossible to estimate, but probably was not large.

Prior to 1846 it is claimed that the production from both placer mines and vein-workings often yielded as much as $30,000 to $250,000 per year.[3] During 1877 the gold-yield was about $300,000, which gradually increased to $1,000,000 in 1889, then fell to $400,000 in 1897,

[1] U. S. G. S., Bull. No. 303, 1907, p. 38.

[2] Table compiled from Mineral Resources, Mineral Industry and Repts. Director of Mint.

[3] Memoir of a Tour to Northern Mexico, 1846–7, published by Congress, p. 24.

rising again until in 1900 it amounted to $800,000; in 1905 it was $413,400. From 1877 to 1905, inclusive, the output was about $15,559,400, while the total product from 1860 to and including 1905 was $19,860,000. The production of silver for 1905 was $152,500, and for the years 1900, 1902 and 1904 it was $269,266, $242,316 and $124,468, respectively.

Deposits of gold and silver occur in many parts of the territory, although Grant County has probably been most productive, containing as it does the Pinos Altos ore-bodies.

The gold production from the placers varies between $20,000 and $150,000 annually; during 1904 and 1905 the yield was $149,424 and $99,335, respectively, the decrease being due to a falling off in yield from Colfax County.[1]

The total number of mines operating in New Mexico during 1905 was 73, 21 being placers and 52 deep mines. The output of ore from the latter was 145,629 short tons, the average yield of which was $3.03 per ton in gold and silver.

A classification of the producing mines by chief product for 1905 and arranged by counties is given in Table XLIX:[2]

TABLE XLIX.

County.	Gold Placer Mines.			Deep Mines.							Total Mines producing.
	Hydraulic.	Surface Placer.	Dry Wash.	Gold.	Silver.	Copper.	Zinc.	Gold and Silver.	Gold, Silver, and Copper.	Silver, Lead.	
Colfax	5	* 1		1							7
Doña Aña						† 2		1		2	5
Grant		3			‡ 5	5	1	1	§ 3	2	20
Lincoln		3		1		1			‖ 1		6
Luna							1			4	5
Otero		1	1			1			1		4
Rio Arriba	1										1
San Miguel						2					2
Santa Fé			1	4							5
Sierra	2		1		1	‡ 1			1		6
Socorro		1		2			¶ 3	1	1	1	9
Taos			1	1							2
Valencia						1					1
Total	8	9	4	9	6	13	5	3	7	9	73

* Dredge.
† One copper-zinc mine.
‡ One silver-copper mine.
§ One gold, silver, copper, zinc mine.
‖ Gold-silver, copper and lead.
¶ One copper, silver, lead-zinc mine.

[1] T. A. I. M. E., Vol. 33, pp. 831, 833, 1903, and Mineral Resources, 1905, p. 278.

[2] U. S. G. S., Mineral Resources, 1905, p. 277.

The source of the gold and silver production of New Mexico in 1905 according to character of ore and arranged by counties is given in Table L:[1]

TABLE L.

(Fine Ounces.)

County.	Placer.		Deep Mines.						Total.	
			Siliceous Ore.		Copper Ore.		Lead Ore.			
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Colfax, Otero, Rio Arriba and Taos.	1,649.68	185	22.02	2	2.00	89	......	......	1,673.70	276
Doña Aña	....	.....	324.60	347	......	......	......	21,429	324.60	21,776
Grant	529.37	202	1,560.78	59,053	4.84	6,339	130.61	21,035	2,225.60	86,629
Lincoln	109.33	5	245.00	131	......	......	7.26	* 621	361.59	757
Luna	....	.....	....	......	......	......	.....	5,199		† 5,199
San Miguel, Santa Fé and Valencia.	193.60	35	108.40	7	......	......	......	......	302.00	42
Sierra	2,316.11	235	2,475.05	4,514	.....	4,011	......	......	4,791.16	8,760
Socorro	7.25	.....	5,636.07	231,430	37.59	9,523	.....	† 4,800	5,680.91	245,753
Total	4,805.34	662	10,371.92	295,484	44.43	19,962	137.87	53,084	15,359.56	369,192

* Copper-lead ore. † Two thousand ounces from copper-lead-zinc ore.

The approximate yields from the different mines in the Lake Valley district are given below:[2]

	Ounces of Silver.
Bridal Chamber	2,500,000
Thirty Stope	1,000,000
Emporia Incline	200,000
Bunkhouse	300,000
Bella Chute	500,000
Twenty-five Cut	200,000
Apache and scattering	300,000
Total	5,000,000

An analysis of ore from the Apache mine, being the average of a year's shipment (4000 tons) is given below:[3]

Silver	Ounces per ton	47.7	Iron	Per cent	13.9
Lead	Trace		Manganese	Per cent	18.2
Silica	Per cent	28.5	Zinc	Per cent	4.0

[1] U. S. G. S., Mineral Resources, 1905, pp. 277 and 278.

[2] T. A. I. M. E., Vol. 24, p. 150, 1894.

[3] Ibid., Vol. 24, p. 165, 1894.

The above represents ore principally from the Incline and Bunkhouse, with some from the Thirty Stope and Twenty-five Cut.

The gold and silver production of New Mexico during the years 1867 to 1905, inclusive, is given in Table LI.[1]

TABLE LI.

Year.	Gold.	Silver.	Year.	Gold.	Silver.
1867	$500,000	....	1886	$400,000	$2,300,000
1868	250,000	....	1887	500,000	2,300,000
1869	500,000	....	1888	602,000	1,200,000
1870	500,000	....	1889	815,655	1,617,578
1871	500,000	....	1890	850,000	1,680,808
1872	500,000	....	1891	905,000	1,713,131
1873	500,000	....	1892	950,000	1,031,250
1874	500,000	....	1893	913,100	358,468
1875	325,000	....	1894	567,751	398,275
1876	....	....	1895	1,051,979	267,430
1877	175,000	$500,000	1896	475,800	469,700
1878	175,000	500,000	1897	470,000	209,265
1879	125,000	600,000	1898	480,000	262,170
1880	130,000	425,000	1899	500,000	253,215
1881	185,000	275,000	1900	832,900	263,266
1882	150,000	1,800,000	1901	688,400	338,040
1883	280,000	2,845,000	1902	581,100	242,316
1884	300,000	3,000,000	1903	244,600	97,578
1885	800,000	3,000,000	1904	381,900	124,468
....	....	....	1905	413,400	152,500

NOTE. — Gold and silver product combined from 1867 to 1875.

There is little reason to suppose that the gold and silver output of New Mexico will do anything but increase for many years to come, lying as it does between Colorado and Mexico, both of which are large producers of the precious metals. Further, it is well known that all of the mountain ranges of the territory contain encouraging indications of the occurrence of both gold and silver deposits, some of which belong to the bonanza or propylitic type.

Oregon. — The gold production of Oregon since the beginning of mining is estimated at $62,056,000. Following the exhaustion of the rich placers the output decreased to a minimum of $800,000 in 1888. The development of quartz-mining has caused an increase to take place, and at intervals beginning with 1899 the gold production has been as follows: $1,500,000 in 1899; $1,700,000 in

[1] Table compiled from Mineral Resources, Mineral Industry, and Reports Director of the Mint.

1900; $1,817,000 in 1902; $1,310,000 in 1904; and in 1905 it was $1,320,200.[1]

The production of silver in Oregon during 1905 was $49,752, while at periods of two years beginning with 1900 it has run as follows: in 1900, $71,548; in 1902, $49,449; and in 1904, $77,256.

In 1905 there were 167 placer mines and 66 deep or quartz mines operating in the state, making a total of 233. The deep mines yielded some 150,268 short tons of ore, which had an average value of $8.03 in gold and silver per ton.[2]

In Table LII is given a classification of the producing mines of Oregon according to product for 1905 and arranged by counties:[3]

TABLE LII.

County.	Non-Producing Mines.	Gold Placer Mines.				Deep Mines.					Total Mines Reporting Product.
		Hydraulic.	Drift and Dredging.	Sluicing.	Total.	Gold.	Silver.	Copper.	Lead.	Total.	
Baker	212	17	....	2	19	17	....	1	....	18	37
Coos	7	....	....	2	2	....	....	....	....	......	2
Crook	6	....	....	1	1	....	....	....	....	......	1
Curry	17	8	....	7	15	2	....	....	....	2	17
Douglas	53	7	....	9	16	3	....	....	....	3	19
Grant	117	11	1	1	13	11	....	....	....	11	24
Harney	5	....	....	....	......	....	....	....	....	......	......
Jackson	96	22	....	9	31	8	....	....	....	8	39
Josephine and Lane	197	31	1	22	54	18	....	1	....	19	73
Lake	1	....	....	....	......	....	....	....	....	......	......
Lincoln	1	....	....	....	......	....	....	....	....	......	......
Malheur	11	2	....	6	8	4	....	....	....	4	12
Marion	9	....	....	....	......	....	....	....	....	......	......
Union	7	....	....	....	......	....	1	....	....	1	1
Wallowa	12	....	....	....	......	....	....	....	....	......	......
Wheeler	......	6	....	2	8	....	....	....	....	......	8
Total	751	104	2	61	167	63	1	2	....	66	233

[1] T. A. I. M. E., Vol. 33, p. 833, 1903.
[2] U. S. G. S., Mineral Resources, 1905, p. 121.
[3] Ibid., p. 288.

The source of the gold and silver production of Oregon by kinds of ore for 1905 and by counties is shown in Table LIII.[1]

TABLE LIII.

(Fine Ounces.)

County.	Placers.		Deep Mines.							Total.	
			Siliceous Ores.		Copper Ores.		Lead Ores.	Total.			
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Silver.	Gold.	Silver.	Gold.	Silver.
Baker	1,232.40	297	36,089.00	54,864	5.10	....	....	36,094.10	54,864	37,326.50	55,161
Coos and Crook	66.76	21	....	.....	.....	....	....	....	.....	66.76	21
Curry	322.22	45	60.47	17	.....	....	....	60.47	17	382.69	62
Douglas	23.12	15	624.42	1,389	.....	....	....	624.42	1,389	897.54	1,404
Grant	1,163.76	262	3,105.14	24,493	.....	....	....	3,105.14	24,493	4,268.90	24,755
Jackson	2,148.00	356	2,210.59	541	.....	....	....	2,210.59	541	4,358.59	897
Josephine and Lane	5,872.23	793	12,742.98	3,853	830.84	1,825	....	13,573.82	5,678	19,446.05	6,471
Malheur	757.07	112	137.63	20	.....	....	....	137.63	20	894.70	132
Union and Wheeler	336.50	44	....	.....	.....	....	1,689	....	1,689	336.50	1,733
Total	12,172.06	1,945	54,970.23	85,177	835.94	1,825	1,689	55,806.17	88,691	67,978.23	90,636

The yield of the placer mines for the year 1905 by counties, is given below:[2]

TABLE LIV.

(Fine Ounces.)

County.	Hydraulic Mines.		Surface Placers, Drift and Dredging.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Baker	1,184.03	$24,476	48.37	$1,000	1,232.40	$25,476
Coos and Crook	....	....	66.76	1,380	66.76	1,380
Curry	213.38	4,411	108.84	2,250	322.22	6,661
Douglas	172.02	3,556	101.10	2,090	273.12	5,646
Grant	1,059.99	21,912	103.77	2,145	1,163.76	24,057
Jackson	2,054.15	42,463	93.85	1,940	2,148.00	44,403
Josephine and Lane	5,456.11	112,788	416.12	8,602	5,872.23	121,390
Malheur	524.87	10,850	232.20	4,800	757.07	15,650
Union and Wheeler	318.50	6,584	18.00	372	336.50	6,956
Total	10,983.05	227,040	1,189.01	24,579	12,172.06	251,619

[1] U. S. G. S., Mineral Resources, pp. 289 and 290, 1905.

[2] Ibid., p. 289, 1905.

The production of gold and silver in Oregon from 1866 to 1875, inclusive, is shown in Table LV:[1]

TABLE LV.

Year.	Gold and Silver.	Year.	Gold and Silver.
1866	$8,000,000 *	1872	$2,000,000
1867	3,000,000	1873	1,376,400 †
1868	4,000,000	1874	609,070 ‡
1869	3,000,000	1875	1,246,978 ‡
1870	3,000,000		
1871	2,500,000	Total	$28,732,448

* Estimated by some as high as $20,000,000.
† Estimate of total by Wells, Fargo Express Company; Oregon only.
‡ Oregon only.

The production of both gold and silver for the period 1877 to 1905 is given in Table LVI:[2]

TABLE LVI.

Year.	Gold.	Silver (Coinage Value).	Total.	Year.	Gold.	Silver (Coinage Value).	Total.
1877	1,000,000	$100,000	$1,100,000	1892	1,491,781	$64,080	$1,555,861
1878	1,000,000	100,000	1,100,000	1893	1,690,951	13,557	1,704,508
1879	1,150,000	20,000	1,170,000	1894	2,113,356	10,315	2,123,671
1880	1,090,000	15,000	1,105,000	1895	1,837,682	15,192	1,852,874
1881	1,100,000	50,000	1,150,000	1896	1,290,964	71,811	1,362,775
1882	830,000	35,000	865,000	1897	1,354,593	109,643	1,464,236
1883	660,000	3,000	663,000	1898	1,216,669	165,916	1,382,585
1884	660,000	20,000	680,000	1899	1,467,379	187,932	1,655,311
1885	800,000	10,000	810,000	1900	1,694,700	71,548‖	1,766,248
1886	990,000	5,000	995,000	1901	1,818,800	96,060‖	1,914,860
1887	900,000	10,000	910,000	1902	1,816,700	49,449‖	1,866,149
1888	825,000	15,000	840,000	1903	1,290,200	63,720‖	1,353,920
1889	1,200,000	38,787	1,238,787	1904	1,309,900	77,256‖	1,387,156
1890	1,087,000	129,199	1,216,199§	1905	1,244,900	53,653‖	1,298,553
1891	1,994,622	296,280	2,290,902				

§ Census reports: gold $964,000; silver, $23,383; total, $987,383.
‖ Commercial value.

The approximate output of gold from 1866 to 1899, inclusive, was $59,000,000. That from 1861 to 1865, inclusive, was roughly $50,000,000. The total production to and including 1899 was $109,000,000, of which silver constituted but a very small amount.

The production of gold and silver in the Blue Mountains, or Baker, Grant and Union counties, is given in the following table:[3]

[1] U. S. G. S., 22 Ann. Rept., Pt. 2, p. 569, 1900–1901.
[2] U. S. G. S., 22 Ann. Rept., Pt. 2, p. 570, 1900–01.
[3] U. S. G. S., 22 Ann. Rept., Pt. 2, p. 573, 1900–01.

TABLE LVII.

(Compiled from the Reports of the Director of the Mint.)

Year.	Baker.			Grant.			Union.			Total.
	Gold.	Silver.	Total.	Gold.	Silver.	Total.	Gold.	Silver.	Total.	
1880	$226,647	$400	$227,047	$85,400	$543	$85,943	$60,347	....	$60,347	$373,337
1881	250,000	10,000	260,000	280,000	20,000	300,000	40,000	....	40,000	600,000
1882	190,000	5,000	195,000	240,000	25,000	265,000	60,000	$800	60,800	520,800
1883	160,000	2,500	162,500	200,000	15,000	215,000	45,000	300	45,300	422,800
1884	160,000	2,500	162,500	200,000	15,000	215,000	45,000	300	45,300	422,800
1885	348,044	....	348,044	194,600	....	194,600	7,322	....	7,322	549,966
1886	396,115	9,005	405,120	198,580	....	198,580	20,650	....	20,650	624,350
1887	173,558	5,153	178,711	163,896	11,797	175,693	15,000	....	15,000	369,404
1888	190,000	5,000	195,000	140,000	10,000	150,000	15,000	....	15,000	360,000
1889	463,604	7,500	471,104	73,989	9,550	83,539	574,989	1,028	576,017	1,130,660
1890	335,000	127,540	462,540	90,000	129	90,129	400,000	....	400,000	952,669
1891	873,058	217,833	1,090,891	124,487	4,297	128,784	625,956	3,500	629,456	1,849,131
1892	367,587	3,257	370,844	53,780	40	53,820	753,715	1,900	755,615	1,180,279
1893	728,947	10,454	739,401	198,650	....	198,650	420,237	3,046	423,283	1,361,334
1894	447,996	2,251	450,247	129,853	....	129,853	1,059,070	8,100	1,067,170	1,647,270
1895	942,482	7,963	950,446	101,853	....	101,853	144,800	3,000	147,800	1,200,099
1896	800,000	20,000	820,000	100,000	....	100,000	300,000	....	300,000	1,220,000
1897	796,741	50,088	846,829	86,969	4,880	91,841	211,699	36,071	247,770	1,186,440
1898	525,945	42,690	568,635	143,463	32,769	176,232	292,324	67,816	360,140	1,105,007
1899	582,348	55,766	637,766	217,054	86,626	303,680	114,212	19,466	133,678	1,075,124
Total	8,958,073	9,542,625	9,542,625	3,022,564	235,631	3,258,197	5,205,331	145,327	5,350,648	18,151,470

The output of the Bohemia district, western Oregon, for 1893–1897 is shown in the following table:[1]

TABLE LVIII.

Year.	Free Gold.	Concentrates.	Total Output.
1893	$11,000	....	....
1894	13,000	$10,000	$23,000
1895	14,500	10,000	24,500
1896	17,000	10,000	27,000
1897	35,900	10,000	45,900

The gold and silver production of Oregon during the period 1877 to 1905, inclusive, is given in the following table:[2]

TABLE LIX.

Year.	Gold.	Silver.	Year.	Gold.	Silver.
1877	1,000,000	100,000	1892	1,400,000	82,500
1878	1,000,000	100,000	1893	1,645,300	9,227
1879	1,150,000	20,000	1894	1,422,056	16,687
1880	1,090,000	15,000	1895	825,105	7,631
1881	1,100,000	50,000	1896	1,226,000	40,998
1882	830,000	35,000	1897	1,354,593	50,703
1883	660,000	20,000	1898	1,216,669	74,763
1884	660,000	20,000	1899	1,275,000	83,412
1885	800,000	10,000	1900	1,640,000	91,995
1886	990,000	5,000	1901	1,818,100	94,379
1887	900,000	10,000	1902	1,816,700	49,449
1888	825,000	15,000	1903	1,290,200	63,720
1889	964,309	23,382	1904	1,309,900	77,256
1890	1,100,000	96,969	1905	1,320,200	49,752
1891	1,640,000	297,374	1906	1,369,900	66,858

Mr. Waldemar Lindgren concludes as follows regarding the probable future of the mining industry in Oregon:[3] "In spite of the introduction of dredges and an increased activity in placer-mining, the product from these deposits will doubtless continue to diminish, while there is good reason to suppose that within the

[1] U. S. G. S., 20th Ann. Rept., Pt. 3, p. 8, 1898–99.

[2] Compiled from Reports Director of Mint, Mineral Resources and Mineral Industry.

[3] T. A. I. M. E., Vol. 33, p. 834, 1903.

next few years the output from the quartz mines will show a fair increase."

South Dakota. — The total production of this state from 1877 to 1900 was $89,400,000; from 1900 to and including 1905 was $34,247,800, which makes a grand total of $123,648,000, beginning with 1877. As the mines were discovered in 1876 this amount would not be materially increased by its addition were the exact amount for that year known. The increase in production of the Black Hills, practically the only source of supply of the precious metals, has been very rapid, and ranged between $2,000,000 and $3,000,000 annually from 1877 to 1889. In 1881 it was $4,000,000 and has been practically $7,000,000 since 1900 — in 1905 it was $6,951,600.[1]

The silver product in 1905 was $84,430, having fallen considerably since 1900, when it was $128,961, the number of fine ounces of product for these years being 138,409 and 210,000, respectively.

Of the 32 producing mines in the state in 1905, 20 of them were deep mines and 12 were placers. The deep mines yielded 1,837,411 tons (short) of gold and silver ore with an average value of $3.86 per ton.[2]

The classification of the producing mines of South Dakota with respect to character of ore during 1905, by counties, is given in Table LX:[3]

TABLE LX.

County.	Mines Reporting Production.	Gold Placer Mines.			Total.	Deep Mines.		
		Hydraulic.	Drift Mines.	Surface Placers.		Gold and Silver.	Gold and Copper.	Total.
Custer	5	......	1	2	3	1	1	2
Lawrence	19	......	......	4	4	15	......	15
Pennington	8	2	1	2	5	3	......	3
Total	32	2	2	8	12	19	1	20

[1] T. A. I. M. E., Vol. 33, p. 834.

[2] U. S. G. S., Mineral Resources, 1905, p. 121, and for production of gold, silver and copper ores in tons with values, see Mineral Resources, 1905, pp. 293 and 294.

[3] U. S. G. S., Mineral Resources, 1905, p. 294.

The source of gold and silver in South Dakota during 1905 with respect to kinds of ore and by counties is given in Table LXI.[1]

TABLE LXI.

(Fine Ounces.)

County.	Gold.			Silver.		
	Placers.	Deep Mines Siliceous Ores.	Total.	Placers	Deep Mines Siliceous Ores.	Total.
Custer	21.73	12.43	34.16	3	....	3
Lawrence	170.38	336,311.15	336,481.53	18	182,579	182,597
Pennington	251.16	1,349.85	1,601.01	31	118	149
Total	443.27	337,673.43	338,116.70	52	182,697	182,749

The value of the ores of the Homestake mine, Lawrence County, is shown by the following figures for 1880, 1888 and 1902: Mill runs of ore in 1880 gave a range in value of from $3 to $3.25 per ton, while a later clean-up gave a value of $4 per ton. In 1888 there were mined 243,355 tons of ore which yielded $3.68 in gold and $0.13 in silver, making a total of $3.71 per ton. For the first ten months of 1902 the Homestake mill treated 1,218,000 tons of ore with 900 stamps, which yielded $4,303,000. An output of 21,500 ounces of gold was obtained from ore which yielded less than $3.60 per ton.[2]

However, the siliceous ores have higher values, the average for 1900 being between $10 and $15 per ton, while certain ore-bodies average $20 to $25 and certain portions run as high as $100 per ton. The general average is given at $12 to $18 per ton.[3] In the Trojan group of mines the gold and silver content of the ore has a value of from $40 to $60 per ton.[4]

As the principal mines of the Black Hills are situated in the southern part of Lawrence County, this county is by far the most important as a producer of precious metals. The following list gives the names of the mines, how developed and kind of plant connected with each operated in 1905:[5]

[1] U. S. G. S., Mineral Resources, 1905, p. 295.
[2] Eng. and Min. Jour., Vol. 30, p. 57, and Ibid., Vol. 75, p. 82.
[3] Eng. and Min. Jour., Vol. 69, p. 227.
[4] Ibid., Vol. 30, p. 107.
[5] U. S. G. S., Mineral Resources, 1905, p. 296.

Company.	Development.	Reduction Plant.
Gilt Edge Maid Mining Company.	By shaft 350 feet deep and drifts on two levels; open cuts.	Dry-crushing cyanide plant with rolls.
Spearfish Gold Mining and Reduction Co.	By tunnels in flat limestone.	Cyanide plant; capacity, 200 tons.
Alexander Maitland properties.	By vertical shaft and a drift 3,800 feet in length.	40-stamp wet-crushing cyanide plant.
Lundberg, Dorr & Wilson.	By tunnels, 1,800 feet in length	Wet-crushing cyanide plant; capacity, 90 tons.
Clinton Mining and Mineral Co.	By tunnels several thousand feet in length.	To custom mill.
Dakota Mining and Milling Co.	....	Wet-crushing cyanide mill; capacity, 120 tons.
Golden Reward Consolidated Gold Mining Co.	By vertical shafts, up to 587 feet in depth; about 25 miles of tunnels and drifts.	Dry-crushing cyanide mill, capacity 200 tons
Hidden Fortune Gold Mining Co.	Crosscuts and drifts......	Wet-crushing cyanide mill; capacity, 250 tons.
Horseshoe Mining Co....	....	Cyanide plant destroyed by fire, 1905.
Imperial Gold Mining Co.	By tunnel 2,000 feet long.	Dry-crushing cyanide mill; capacity, 150 tons.
Monarch Gold Mining Co.	By tunnel 1,150 feet long.	Ore sent to smelter.
Portland Mining Co.	Tunnels about two miles in length.	To smelter and custom mill.
Wasp No. 2, Mining Co..	....	Cyanide plant; capacity, 125 tons.

The gold and silver production of South Dakota during the period of years 1877 to 1906 is given in Table LXII.[1]

TABLE LXII.

Year.	Gold.	Silver.	Year.	Gold.	Silver.
1877	$2,000,000	....	1892	$3,700,000	$82,500
1878	3,000,000	....	1893	4,005,400	109,792
1879	3,420,000	$10,000	1894	3,299,100	37,153
1880	3,600,000	70,000	1895	3,869,500	45,858
1881	4,000,000	70,000	1896	4,919,000	301,950
1882	3,300,000	175,000	1897	5,300,000	298,950
1883	3,200,000	150,000	1898	5,720,000	189,345
1884	3,300,000	150,000	1899	5,848,464	208,530
1885	3,200,000	100,000	1900	6,625,000	128,793
1886	2,700,000	425,000	1901	6,601,800	214,655
1887	2,400,000	540,000	1902	6,965,400	180,306
1888	2,600,000	100,000	1903	6,826,700	119,448
1889	3,091,137	135,331	1904	7,024,600	108,460
1890	3,200,000	129,292	1905	6,951,600	84,430
1891	3,550,000	231,929	1906	6,822,700	105,196

Utah. — It is claimed that the placer gold amounted to about $1,000,000 in 1867. The main source of the precious metals has been the lead and copper ores, the development of which began in 1870. The annual production of gold fluctuated between one-half and one million dollars up to 1890, after which year it rose from $700,000 to $1,900,000 in 1896. In 1900, it was $4,000,000; in 1902, $3,600,000; in 1904, $4,215,000; and in 1905, $4,651,200. From 1877 to 1905, inclusive, the output has been approximately $43,948,300, while the total production to and including 1905 was $46,848,300.[2]

The silver product for 1905 was 12,000,000 fine ounces, having a value of $7,320,000. The production beginning with 1900, for intervals of two years, up to 1904 is as follows; in 1900, $5,745,912 or 9,267,600 ounces; in 1902, $5,740,801 or 10,831,700 ounces; and in 1904, $7,240,894 or 12,484,300 ounces. Utah was third in the production of silver in 1905 being a close second with Colorado, Montana leading.

[1] Table compiled from Mineral Resources, Mineral Industry and Reports Director of Mint.

[2] T. A. I. M. E., Vol. 33, p. 836, 1903.

In 1905 there were 121 mines being worked in Utah, of which 7 were placers and 114 deep mines. The yield of the deep mines was 2,181,061 tons of gold and silver ore, having an average value of $5.41 per ton.[1]

The mines of Utah, classified by chief product in 1905, by counties, are given in Table LXIII:[2]

TABLE LXIII.

County.	Non-producing Mines.	Mines Reporting Product.	Gold Placer Mines, Hydraulic.	Deep Mines.					
				Gold.	Silver.	Copper.	Lead.	Zinc.	Total.
Beaver, Piute, & Sevier......	126	9	......	1	3	2	3	......	135
Box Elder, Morgan, Millard, Washington, & Weber......	120	9	......	1	3	2	3	......	129
Grand, Garfield San Juan and Uinta	32	8	7	1	......	......	......	......	40
Juab	77	32	......	......	2	11	19	......	109
Salt Lake.......	83	27	......	......	......	10	17	......	110
Summit & Wasatch	59	14	......	......	1	......	11	2	73
Tooele..........	89	15	......	3	1	2	8	1	104
Utah	52	7	......	......	......	......	7	......	59
Total	638	121	7	6	10	27	68	3	759

[1] For production of gold and silver with associated metals, see Mineral Resources, 1905, p. 306.

[2] U. S. G. S., Mineral Resources, 1905, p. 315.

The following table gives the source of production of gold and silver in Utah according to kinds of ore during 1905, by counties:[1]

TABLE LXIV.

(Fine Ounces.)

County.	Placers.		Siliceous Ores.		Copper Ores.		Lead Ore.		Zinc Ore.	
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Beaver, Piute, and Sevier..........	....	....	19,391	61,132	1,281	33,181	15	1,400	95	18,108
Box Elder, Morgan, Millard, Washington and Weber..........	....	....	554	26,309	....	2,620	18	2,570	....	......
Grand, Garfield, San Juan and Uinta..........	322	61	14	......	....	....	......	....	....	......
Juab..........	....	....	132	6,600	77,610	1,656,391	194	256,169	....	......
Salt Lake..........	....	....	......	......	46,912	608,907	1,823	524,664	....	......
Summit and Wasatch.	....	....	......	......	92	....	13,143	2,094,136	....	
Tooele..........	....	....	44,292	456	2	250	127	39,474	....	......
Utah..........	....	....	......	......	......	....	2,485	185,962	....	......
Total........	322	61	64,383	94,497	125,897	2,301,349	17,805	3,104,375	95	18,108

County.	Mixed Ores.						Total.	
	Copper- Lead-Zinc Ore.		Copper-Lead Ore.		Lead-Zinc Ore.			
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Beaver, Piute, and Sevier..........	......	....	480	129,623	......	....	21,262	243,444
Box Elder, Morgan, Millard, Washington and Weber....	......	....	......	....	......	....	572	31,499
Grand, Garfield, San Juan and Uinta..	......	....	......	....	......	....	336	61
Juab..........	......	....	20,503	1,818,174	1,318	159,748	99,757	3,897,082
Salt Lake..........	102	29,250	15,751	1,187,643	63	1,802	64,651	2,352,266
Summit and Wasatch	1,403	1,804,700	83	64,959	86	34,370	14,807	3,998,165
Tooele..........	176	254,908	1	429	223	32,039	44,821	327,556
Utah..........	1	436	......	....	......	....	2,486	186,368
Total..........	1,628	2,089,294	36,818	3,200,828	1,690	227,959	248,692	11,039,471

The output of the Tintic district, from 1880 to 1896, inclusive, is given in Table LXV.[2]

[1] U. S. G. S., Mineral Resources, 1905, pp. 307 and 308.

[2] U. S. G. S., 19th Ann. Rept., Pt. 3, pp. 615 and 686, 687, 1897–98.

TABLE LXV.

Year.	Gold.	Silver.	Year.	Gold.	Silver.
1880	3,012	8,682	1889	14,940	2,055,700
1881	2,332	105,354	1890	24,633	3,801,700
1882	3,000	232,558	1891	19,444	2,901,730
1883	2,000	224,800	1892	16,470	2,011,642
1884	1,500	612,016	1893	15,097	1,990,860
1885	868	868,925	1894	18,066	2,582,033
1886	2,300	825,000	1895	27,525	3,517,166
1887	3,200	1,412,463	1896	40,470	3,955,843
1888	7,110	1,201,620			
			Total	201,967	28,308,092

The average proportion of gold to silver in the ores of the Tintic district is about 1 to 400, but varies considerably in different mines: in the Mammoth, 1 to 20; in the Centennial Eureka, 1 to 100; in the Eureka Hill, 1 to 250; in the Bullion-Beck, 1 to 350; and in the Gemini, 1 to 2,000.

The relative metallic constituents of the ore taken from an average of 240,000 tons coming from a majority of the mines are as follows:

Gold	Ounces	0.1356	per ton.
Silver	Ounces	52.440	per ton.
Copper	Pounds	11.200	per ton.
Lead	Pounds	270.000	per ton.

The average value of the ore is close to $40 per ton. The Centennial Eureka ores average about $80. In general ores worth $10 to $25 per ton are milling, while those worth more than $25 are smelting ores. The low-grade ores, when rich in base metals, although poor in the precious metals, often yield a better profit by smelting than by milling.[1]

The average assays of the Daly-West ore, for the years 1901 and 1902, are given in the following table:[2]

TABLE LXVI.

	1901					1902				
	Silver.	Gold.	Lead.	Copper.	Zinc.	Silver.	Gold.	Lead.	Copper.	Zinc.
	Oz.	Oz.	%	%	%	Ozs.	Ozs.	%	%	%
Crude ore	61.15	0.05	23.28	2.45	17.7	52.66	.041	19.40	1.90	9.40
Concentrates.	46.68	.06	26.95	1.64	16.8	52.68	.040	28.71	1.67	16.50

[1] U. S. G. S., 19 Ann. Rept., Pt. 3, p. 687, 1897–98.

[2] U. S. G. S., Mineral Resources, 1905, p. 327.

This table shows that a higher grade of ore was mined during 1901 than in 1902, and further that the concentrates did not run so high in values.

For the gold and silver production of Utah for 1870 to 1906, inclusive, see table LXVII.[1]

TABLE LXVII.

Year.	Gold.	Silver.	Year.	Gold.	Silver.
1870	$1,300,000	....	1892	$660,175	$7,400,250
1871	2,300,000	....	1893	853,600	5,671,533
1872	2,445,284	....	1894	868,031	3,711,898
1873	3,778,200	....	1895	1,149,356	4,296,115
1874	3,911,601	....	1896	1,899,900	5,933,526
1875	3,137,688	....	1897	1,845,938	3,999,804
1876	....	....	1898	2,372,442	3,827,773
1877	350,000	$5,075,000	1899	3,506,582	4,279,695
1878	392,000	5,208,000	1900	3,972,200	5,745,912
1879	575,000	6,250,000	1901	3,690,200	6,456,480
1880	210,000	4,740,000	1902	3,594,500	5,740,801
1881	145,000	6,400,000	1903	3,697,400	6,046,272
1882	190,000	6,800,000	1904	4,215,000	7,240,894
1883	140,000	5,620,000	1905	5,140,900	6,228,205
1884	120,000	6,800,000	1906	5,172,200	7,706,346
1885	180,000	6,750,000	....	....	
1886	216,000	6,500,000	....	....	
1887	220,000	7,000,000	....	....	
1888	290,000	7,000,000	....	....	
1889	487,666	9,057,014	....	....	
1890	680,000	10,343,434	....	....	
1891	650,000	11,313,131	....	....	

NOTE. — The gold and silver products are combined from 1870 to 1875.

If we may judge from indications in the smelting world there is good reason to expect a still further increase in the production of the precious metals, especially gold. The copper ores lead in the yield of gold, while the copper-lead ores are most productive of silver. Prospecting and development work is being actively engaged in, and several promising discoveries have been made in recent years.

Washington. — Owing to the custom employed in the early days of uniting in the returns the production of gold from Washington and Oregon, hardly an approximation of the output can be made. The yield from 1877 to 1905, inclusive, was $10,729,300. It has been estimated that the production prior to 1868 was $10,000,000, which, if correct, would make the total output to the end of 1905 about $23,229,300. An output of $300,000 was recorded for 1877, subsequently it fell to $100,000, but recovered and reached the

[1] Table compiled from Mineral Resources, Mineral Industry and Report Director of Mint.

$400,000-mark in 1896. Since then the production has increased, until in 1900 it was about $700,000, and then decreased again. In 1902, 1904 and 1905 the following outputs are given: $272,200, $327,900 and $368,800, respectively.[1]

The silver production of Washington, for 1905, was $70,410 or 115,412 ounces, showing a decided falling-off from 1902, when it was $328,070 or 619,000 ounces. In 1902 and 1904 the yield was $328,070 or 619,000 ounces and $86,942 or 149,900 ounces, respectively.[2]

There were 16 placers and 35 deep mines operating in 1905. The deep mines produced 46,650 tons of ore averaging $10.17 per ton in gold and silver values.

The mines, classified according to character of ore for the year 1905, and arranged according to counties, are given in Table LXVIII.[3]

TABLE LXVIII.

County.	Non-Producing Mines.	Mines Reporting Production.	Gold Placer Mines.				Deep Mines.				
			Hydraulic.	Drift.	Sluice.	Total.	Gold.	Silver.	Copper.	Lead.	Total.
Asotin	10	3			3	3					
Chelan	41	3					3				3
Clark	3	1			1	1					
Cowlitz	3										
Ferry	70	4					4				4
Franklin	1	1			1	1					
King	40	1					1				1
Kittitas	50	11	2	3	3	8	2		1		3
Lewis	2										
Lincoln	17										
Okanogan	131	6			1	1	3	2			5
Skagit	12										
Skamania	8	1							1		1
Snohomish	81	7			1	1	3		3		6
Stevens	104	10					4	4	1	1	10
Whatcom	45	3		1		1	1	1			2
Yakima	1										
Total	619	51	2	4	10	16	21	7	6	1	35

[1] T. A. I. M. E., Vol. 33, pp. 837 and 838, 1903.

[2] Mineral Industry for 1905, p. 219.

[3] U. S. G. S., Mineral Resources, 1905, p. 335.

The source of the gold and silver production, by kinds of ore during 1905, by counties, is given below:[1]

TABLE LXIX.

(Fine Ounces.)

County.	Placers.		Deep Mines.			
			Siliceous Ores.		Copper Ores.	
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Asotin, Clark and Chelan	54.42	8	611.46	613	....	....
Ferry and Franklin.	.92	......	4,162.81	34,945	....	....
King and Kittitas	127.32	30	775.21	838	....	....
Okanogan	4.84	......	107.05	10,690	....	....
Skamania and Snohomish	16.93	4	1,649.59	25,790	289.04	4,152
Stevens	....	......	8,022.50	12,768	1.12	2,222
Whatcom	107.05	18	3,665.37	22,093	....	....
Total	311.48	60	18,993.99	107,737	290.16	6,374

County.	Deep Mines.				Total.	
	Lead Ores.		Total.			
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Asotin, Clark and Chelan.	......	....	611.46	613	665.88	621
Ferry and Franklin	......	....	4,162.81	34,945	4,163.73	34,945
King and Kititas.	......	....	775.21	838	902.53	868
Okanogan	......	....	107.05	10,690	111.89	10,690
Skamania and Snohomish	......	....	1,938.63	29,942	1,955.56	29,946
Stevens	......	11,205	8,023.62	26,195	8,023.62	26,195
Whatcom	......	....	3,665.37	22,093	3,772.42	22,111
Total	......	11,205	19,284.15	125,316	19,595.63	125,376

[1] U. S. G. S., Mineral Resources, 1905, p. 335.

There are three grades of ore produced in the Republic mine: the highest running from $360 to $100 per ton, averaging between $175 and $200; medium ore varying from $100 to $30 and averaging $65 per ton; and the lowest grade, ranging from $30 to $5, and averaging about $20 per ton.[1]

The gold and silver production for Washington for the period of years 1866 to 1906 is given in Table LXX:[2]

TABLE LXX.

Year.	Gold.	Silver.	Year.	Gold.	Silver.
1866	$8,000,000	....	1889	186,156	36,801
1867	3,000,000	....	1890	204,000	90,505
1868	4,000,000	....	1891	335,000	213,334
1869	3,000,000	....	1892	373,561	123,750
1870	3,000,000	....	1893	222,100	118,411
1871	2,500,000	....	1894	195,100	71,290
1872	2,000,000	....	1895	144,092	64,336
1873	1,585,784	....	1896	405,700	184,458
1874	763,605	....	1897	449,664	145,159
1875	1,246,978	....	1898	600,000	160,215
1876	....	....	1899	750,000	178,740
1877	300,000	50,000	1900	718,200	139,190
1878	300,000	25,000	1901	580,500	206,640
1879	75,000	20,000	1902	272,200	328,070
1880	410,000	....	1903	279,900	159,030
1881	120,000	....	1904	327,900	86,942
1882	120,000	....	1905	370,000	72,060
1883	80,000	500	1906	352,600	93,841
1884	85,000	1,000	....	....	....
1885	120,000	70,000	....	....	....
1886	147,000	80,000	....	....	....
1887	145,000	100,000	....	....	....
1888	145,000	100,000	....	....	....

NOTE. — The gold and silver production for Oregon and Washington are combined for the years 1866 to 1875.

The Republic mining district is the principal producer in Washington, and will probably continue to be an important source of precious metal production. There is a great field in this territory for the development of the mining industry, and there is but little doubt but that new and important discoveries will add considerably to the output of gold and silver.

[1] Eng. and Min. Jour., Vol. 68, p. 725.

[2] Table compiled from Mineral Resources, Mineral Industry and Reports Director of Mint.

Wyoming. — With this state, as with Washington and Oregon, the early production of gold has been rendered uncertain by its having been united with that of neighboring states and territories. The production given in the Mint Reports for the period from 1868 to 1900 was only about $500,000. The yield for 1900, and at intervals of two years, ending with 1904, was as follows: In 1900, $34,200; in 1902, $38,800; and in 1904, $16,400. In 1905 it was $20,700. The total output from 1868 to and including 1905 was $626,400. The variation in gold output during the past six years has been great having ranged from $3,600 to $38,800, which variation was for the two successive years of 1903 and 1902.[1]

The silver production of Wyoming has been even more variable than that of gold as in 1900 and 1901, when an output of 200 ounces in the former year was increased to 21,400 ounces in the latter. The range in amount and value of the silver produced from 1900 to 1905, inclusive, was as follows: in 1900, 200 ounces or $124; in 1901, 21,400 ounces or $12,840; in 1902, 5000 ounces or $2,650; in 1903, 200 ounces or $108; in 1904, 4,400 ounces or $2,552; and in 1905, 3,528 ounces or $2,152, respectively.[2]

In 1905 there were only 13 mines producing gold and silver, of which 7 were placer workings and 6 were deep mines. The deep mines yielded 31,007 tons of ore averaging $0.87 per ton.

The mines of Wyoming, classified according to kinds of ore, operating during 1905 and arranged by counties is given in Table LXXI:[3]

TABLE LXXI.

County.	Mines Reporting Production.	Gold Placer Mines.			Deep Mines.		
		Surface Placers	Drift Mines.	Total.	Silver.	Copper.	Total.
Albany	2	1	......	1	......	1	1
Carbon	1	......	......	......	......	1	1
Crook	3	2	1	3	......	......	
Fremont	5	2	......	2	3	......	3
Natrona	1	......	......	......	......	1	1
Uinta	1	1	......	1	......	......	
Total	13	6	1	7	3	3	6

[1] T. A. I. M. E., Vol. 33, p. 839; 1903, Mineral Industry, 1903, p. 144.

[2] Compiled from Mineral Industry for the respective years.

[3] U. S. G. S., Mineral Resources, 1905, p. 339.

The source of gold and silver production in Wyoming in 1905, by counties, is given in the following table:[1]

TABLE LXXII.

(Fine ounces).

Metal.	Placers.	Deep Mines.			Total.
		Siliceous Ores.	Copper Ores.	Total.	
Gold........	102.38	961.11	230.32	1,191.43	1,293.81
Silver......	10	86	3,559	3,645	3,655

The following table gives the production of gold and silver in Wyoming from 1870 to 1873 and 1900 to 1906, inclusive:[2]

TABLE LXXIII.

Year.	Gold.	Silver.	Year.	Gold.	Silver.
1870	$100,000	....	1902	38,800	2,650
1871	100,000	....	1903	3,600	108
1872	100,000	....	1904	16,400	2,552
1873	50,000	....	1905	23,700	1,630
1900	34,200	124	1906	26,400	869
1901	12,700	12,840			

NOTE. — The gold and silver productions are combined for the years 1870 to 1873, while no separate record is obtainable for the period 1874 to 1899, the amount being so small that it is given with that of the less important states.

Much unprospected ground exists in Wyoming, especially in the northwestern portion, which will in all probability produce some valuable mineral deposits. Wyoming is situated similarly to New Mexico, i.e., lies between two great gold producing States — Colorado and Montana, and for that reason might be expected to share in their mineral wealth. It is not improbable to suppose that such may be the case.

Other States. — The remaining states, although not included in the list of producing states, as given in the preceding pages,

[1] U. S. G. S., Mineral Resources, 1905, p. 339.

[2] Table compiled from Mineral Resources, Mineral Industry and Reports Director of Mint.

contain sufficient gold and silver to warrant a brief consideration in this connection. However, owing to the exceedingly small amount usually found, either in a separate state or associated with other metals, and owing to the irregularity of occurrence, the search for, and exploitation of such deposits, has proven in most cases very unprofitable. These states are considered in alphabetical order, rather than in accordance with their importance as producers, although those particular states in which precious metals occur in very small amounts are grouped together and briefly considered. Reference to previous statements regarding the states is made in order that the desired information may be obtained without reiteration.

Arkansas. — Although many statements have been made regarding the value of the ores from this state, yet practically no record is obtainable showing the actual yield of the mines.

The following analysis of a sample of ore from the Montezuma mine is taken from a paper by C. P. Conrad on Silver in Arkansas:[1]

Gray copper (dull)	880 ounces
Galena, high-grade	75 ounces and $9 gold
Galena, low-grade	48 ounces
Quartz with azurite and malachite	153 ounces
Gray copper (metallic)	225–260 ounces
Quartz (no metal showing)	18–25 ounces
Brown "carbonates"	377 ounces and $12 gold
Selvage clay	78 ounces

Average of 8 assays: 235.5 ounces silver; 2.66 ounces gold.

Indiana. — The total yield of gold from the glacial drift in this state is claimed by different authorities to be $2,900 and $10,000 up to 1875.[2] Under the head of Silver Mines the following facts are given for the year 1888 in one of the mining journals: The silver mines of Dubois County produced 1500 pounds of silver (bullion) daily through a local smelter. The ore runs, according to the United States Mint assay reports, 58 ounces in silver and 4.10 ounces in gold per ton.[3] According to the reports of the Geological Survey of Indiana, $70 was collected at Gold Branch of Pine Creek, probably in 1873 and in 1874, $1,000 was produced by Brown County. Morgan County was also reported to have "yielded considerable" gold, but the amount was not given.[4]

[1] Eng. and Min. Jour., Vol. 30, p. 186.
[2] Sixth Report State Geologist Indiana, 1875, Folio 107.
[3] Min. and Sci. Press, Vol. 56, p. 102.
[4] Geology of Indiana, 1873, p. 224, and 6th Ann. Rept., p. 108.

Iowa. — Gold was reported to occur "in nearly paying quantities" at Wadena, while on Brush Creek, "In one case an experienced miner is reliably reported to have realized a dollar per day for some months in extracting the shining dust with a small rocker and with inadequate water supply." [1]

Massachusetts. — The Newburyport silver mines are interesting, owing to their discovery and operation during Revolutionary times and also on account of their richness in precious metal content. However, no record of the production is available.[2]

The following assay returns are given on a sample of the ore of the Newburyport mines:

	Per Ton 2240 lbs.
52 per cent lead at 6 cts. per lb.	$69.84
.1736 per cent silver at $1.29 per oz. Troy	72.87
.0017 per cent gold at $20.60 per oz. Troy	11.43
Total	$154.14

According to a report made by Prof. R. H. Richards, on the ore of the Merrimac Silver Mining Company's mine, the gray copper contains $4,583.93 per ton in silver and $26.69 per ton in gold, giving a total of $4,611.62 per ton. Further, from a report made on the mine by Prof. F. L. Vinton there were 40,000 tons of ore in sight which, when concentrated, would yield 4,000 tons of ore worth $94 per ton, being worth $376,000. The ore occurs in a vertical chimney.[3]

The Davis mine, at Charlemont, yielded ore which sold at $4.00 at the mine or $5.00 at tide-water.[4]

Maine. — A number of mines were producing on a small scale during the later seventies and early eighties; among the more important were the Sullivan and Waukeag and Gouldsborough. The latter mine encountered a streak of antimonial silver worth $4,000 per ton in 1880.[5] The Sullivan mine made several shipments of bullion during 1879 and 1880. The first was on March 23, and amounted to 3750 ounces of silver; the second was on March 30, and was 3033 ounces. On February 23, 1881, assays of stamp battery pulp gave an average value of $35 per ton in silver. The Golden Circle stamp-mill produced $294 from a run on 30 tons of ore.[6]

[1] The Pleistocene History of Northeastern Iowa, 11th Ann. Rept. Director U. S. G. S., 1891, p. 486.

[2] T. A. I. M. E., Vol. 3, pp. 442 and 443, 1874.

[3] Hitchcock, Geology of New Hampshire, Vol. 3, Pt. 5, p. 35.

[4] Special Correspondence, D. C. Reed, Oct., 1904.

[5] The Portland Argus, Mar. 27, 1880.

[6] Special Correspondence to the Eng. and Min. Jour., March 23, and Feb. 23, 1881.

The Mount Glines property is reported to have yielded from $7.50 to $49.68 per ton in values, although only a trace of gold and a few ounces of silver were found by the United States Geological Survey.[1]

Michigan. — The native silver mines of Ontonagon and vicinity were responsible for an extensive mining excitement and the expenditure of considerable money in the erection of stamp-mills, but hardly more than 50 tons were treated. Mill runs were reported, showing a value of $33.28 per ton. Another test on 4½ tons gave 163 ounces of silver with a coinage value of $50.70 per ton.[2] Silver is a common constituent of the copper ores of Keweenaw Point, and a number of the copper mines have yielded quite large amounts. The Cliff mine is said to have produced $5,000 a year in silver alone.[3] During later years, with the greatly increased copper output, there has resulted a correspondingly greater production of silver as a by-product. According to the Director of the mint the output of silver from this source in 1905 amounted to 253,011 fine ounces.

The gold field, known as the Dead River Gold Range, situated near Ishpeming, Michigan, was the scene of quite active mining operations during the late eighty's and early ninety's. An average of 11 assays of the ores mined here showed $20.80 in gold, and $9.50 in silver per ton. The total production during the period 1883 to 1897 amounted to $664,484.73 — the Ropes mine alone yielding $1,286.74 in 1883.[4] The average annual yield for the few years following 1897 was $42,000, but operations in this region have long since been abandoned.

Minnesota. — Although there is no recorded output of gold or silver from this state, yet in 1894 considerable development work was being done. The Little American mine, situated some three miles south of the international boundary, was reported as operating a five-stamp mill on the free-milling ores, and a run of 30 tons of ore in 48 hours yielded about $500 in gold and one-half a ton of concentrates.[5]

[1] U. S. G. S., Bull. No. 225, pp. 82–84, 1904.

[2] Trans. Lake Superior Inst. Min. Eng'rs., Vol. 2, p. 67, 1894, and Min. and Sci. Press, Vol. 31, pp. 98 and 130.

[3] Eng. and Min. Jour., Vol. 20, p. 575.

[4] Annual Report Commissioner of Mineral Statistics, 1883, pp. 98, 99, and Mines and Mineral Statistics of Michigan, Ishpeming, 1897, p. 172.

[5] Eng. and Min. Jour., Vol., 58, p. 581.

Missouri. — Gold has been obtained from the glacial drift in several counties in this state, but not in sufficient quantities to pay for working. The lead ores of southeastern Missouri contain from 1 to 1¾ ounces of silver per ton, and the yield from this source, in 1905, was 12,900 ounces.

New Hampshire. — The Dodge vein, near Lyman, is reported to have produced $50,000 up to the end of 1877, the ore running from $3 to $19 per ton.[1]

The Milan mine produced matte from a local smelter worth $60 per ton. The Bedell mine yields ore assaying $12 per ton, while the quartz ore from the Hartford and Moulton mine runs $30 gold, and $10 silver. The Eaton lead mine yields 24 ounces silver. The Sheburne lead mine, worked during 1846–49, had ore running 36 to 84 ounces silver, which was claimed to be worth $80 per ton, at least a lot of 5 tons produced that result.[2]

Texas. — Although not a producer of precious metals of any great importance in the past, Texas is now forging to the front. The production of gold and silver during 1905 was 387,506 ounces of silver, valued at $234,054 and 12 ounces of gold, with a value of $248. The corresponding output for 1904 was 385,576 ounces of silver and 9 ounces of gold.[3]

The Hazel mine of El Paso County, which was closed in 1902, is said to have produced up to 1891 some $60,000 of silver ore. The Presidio mine, situated near Shafter in Presidio County, was opened in 1884 and is reported to have produced $300,000 annually in silver for a number of years.[4]

Vermont. — Sluicing operations at Plymouth Five Corners in this state yielded returns which have been variously reported at from $9,000 to $13,000.[5]

Following the discovery of several gold nuggets at Plymouth the washing of gravels was begun and continued through 1855–1861.[6]

Ore obtained from the Readsboro mine in 1884 is said to have yielded from $30 to $40 per ton, $25 of which was in gold. Ten tons of ore taken from the Taggart mine, Bridgewater, yielded

[1] U. S. G. S., 16th Ann. Rept., Pt. 3, p. 330, 1894–95.

[2] Hitchcock, Geol. Survey of New Hampshire, Vol. 3, Pt. 5, pp. 7–31, and Special Correspondence to the Eng. and Min. Jour.

[3] U. S. G. S., Mineral Resources, 1905, pp. 304 and 305.

[4] Eng. and Min. Jour., Vol. 74, p. 150.

[5] Rept. Vermont State Geologist, G. H. Perkins, 1903–4, pp. 56–57, and U. S. G. S., Bull. No. 225, 1904, p. 88.

[6] Ibid., Bull. No. 225, 1904, p. 88.

374 pennyweights of gold. However, analysis of the ores by the United States Geological Survey gave no gold and slightly over one ounce of silver, copper and lead running about 6 per cent.[1]

The following list of states, owing to the extremely small amounts of the precious metals found as yet within their borders, is given without comment, except that the reader is referred to the chapters on History and Occurrence, for what is known regarding their occurrence, distribution and output: Arkansas, Connecticut, Illinois, Kansas, Kentucky, Mississippi, Nebraska, New Jersey, New York, Ohio, Oklahoma, Panama, Pennsylvania, and Wisconsin.

It has not been thought advisable to give the production of the various mines and districts in which they occur in the previous discussion, owing to the incomplete and often unauthentic records available; however, much information can be obtained regarding the same from the references given in the Table of Yields.

NOTE. — Apparent discrepancies occurring in the above statistics result largely from the necessity of using, in their compilation, different authorities. A difference of several thousand dollars is often noted for the same year in two different reports by the same authority.

FINENESS OF GOLD AND SILVER.

In the consideration of the production of gold and silver it is necessary to know the fineness of the metals in order to ascertain their intrinsic value. The gold mined in certain localities of North America is remarkably pure — in the early days the gold obtained in a number of mines in California was considered the highest in value, but later, according to Mint reports, it was excelled by that of Cripple Creek. Placer gold, as formerly pointed out, is usually of higher grade than that from quartz mines, due to the refining action of the streams. The highest average fineness of California gold was that from the placers around Folsom, Sacramento County, which was worth over $20 an ounce, running from 974 fine, or $20.13 to 978 fine, or $20.21 per ounce. The lowest grade gold from this state comes from Bodie and seldom exceeds 580½ fine or $12 per ounce, often falling as low as 484 fine, or $10 per ounce.

The San Guiseppe mine, near Sonora, Tuolumne County, California, is a quartz mine which produces gold uniformly between 982 and 987 fine, or $20.29 and $20.40 per ounce. One lot of 90 tons of ore went 998 fine, or $20.6305.[2]

[1] U. S. G. S., Bull. No. 225, 1904, pp. 85, 87.
[2] T. A. I. M. E., Mines and Minerals of California, p. 177, 1899.

Records of the United States Mint at Denver show that on several dates (Mar. 14, 1893; May 11, 1893; Aug. 29 and March 5, 1894) gold was deposited from the Cripple Creek mines having a fineness of 999. The average value of the placer gold of Cripple Creek is $20 per ounce.[1]

The gold of Nova Scotia is remarkable for its purity, being on an average 22 carats fine. The assay value is between $19.97 and $20.25. A value of $19.50 was taken as a basis in the calculation of the gold production by the Gold Commissioner of Nova Scotia.[2]

The average fineness of gold or silver of a county, say nothing of a state, cannot be relied upon in determining value, owing to the wide variations noted between localities of no great distance apart. Averages are, however, usually assumed for convenience of calculation. See Appendix of Tables, Table VI.

[1] Min. and Sci. Press, Vol. 70, p. 346.

[2] Am. Jour. Min., Vol. 2, p. 388.

APPENDIX OF TABLES.

TABLE I.— DISCOVERY OF GOLD AND SILVER

Locality.	State.	Kind of Mine.	How Discovered.
Arbacoochee district, Cleburne County.	Alabama	Placers............	Prospecting, probably
Kaknu River..............	Alaska......	....do...........	Prospecting (1st discovery).
Fraser and Thompson rivers ..	....do......	....do...........	....do............
Ketchikan district..........	....do......	....do...........	....do............
Juneau, Gold Creek.........	....do......	....do...........	....do............
Treadwell mines, Douglas Island.	....do......	....do...........	....do............
Omalak mine, Yukon region..	....do......	Veins (silver and lead)	....do............
....do.................	....do......	....do...........	....do............
Annette Island.............	....do......	....do...........	....do............
Klondike region............	....do......	Veins (silver and lead)	....do............
Ravillagigido Island.........	....do......	Veins (gold).......	....do............
Nome on Anvil Creek........	....do......	Placers..........	....do............
Alsek district..............	Yukon Ter...	Placers............	....do............
Fairbanks district, Pedro Creek	Alaska......	....do...........	....do............
Santa Rita district..........	Arizona.....	Veins (silver).......	Revealed by Indian .
Silver King mine...........	....do......	....do...........	Prospecting........
Tombstone................	....do......	Veins (silver and gold).	....do............
Hillside mine...............	....do......	....do...........	....do............
San Franciscoquito	California ...	Placers............	Probably accidental .
Santa Clara River..........	....do......	....do...........	Accidental.........
North Fork Dry Diggings, Auburn Ravine.	....do......	....do...........	Prospecting........
Coloma..................	....do......	....do...........	Accidental.........
Grass Valley..............	....do......	....do...........	Prospecting........
....do.................	....do......	Vein (gold)........	....do............
Gold Hill, Grass Valley......	....do......	....do...........	....do............
Empire mine, Grass Valley...	....do......	....do...........	....do............
Gold Bluff................	....do......	Beach placers.......	....do............
Althouse Creek............	S. do......	Placers............	....do............
Georgia Hill, Yankee Jim's...	....do......	....do...........	Accidental.........
Indiana Hill...............	....do......	....do...........	Prospecting........
Shaw's Flat, Tuolumne Table Mt.	....do......	Ancient gravels.....	Auriferous Character of ancient gravels first recognized here.
Amargoza mine, San Bernardino County.	....do......	Veins (gold)........	Accidental.........
Bodie...................	....do......	Placers (probably)...	Prospecting........
Idaho mine...............	....do......	Veins (gold)........	....do............
Sulphur Creek, Colusa County.	....do......	....do...........	....do............
Meadow Lake.............	....do......	....do...........	....do............
Amargoza mine, San Bernardino County.	....do......	....do...........	Rediscovered by prospecting..........
Randsburg region..........	....do......	....do...........	Prospecting........
Rico Mt. district, Dolores River	Colorado....	Placers............	....do............
Gilpin County.............	....do......	Veins (gold)........	....do............
Gregory lode, Clear Creek.....	....do......	....do...........	....do............

MINES AND DISTRICTS IN THE UNITED STATES.

By whom Discovered.	Date of Discovery.	Reference.
....	1848	Eng. and Min. Jour., Vol. 55, p. 486.
P. P. Doroshin..........	1848	U. S. G. S., 18 Rept., Pt. 3, p. 82.
....	Prior to 1860	Eng. and Min. Jour., Vol. 76, p. 807.
W. C. Ralston and others...	1870–74	Min. and Sci. Press, Vol. 83, p. 98.
R. T. Harris and Joe Juneau.	July 9, 1880	Eng. and Min. Jour., Vol. 41, p. 230.
....	Summer of 1881	Mines and Minerals, Vol. 24, p. 251.
In 1894 was claimed to be most northern mine in Alaska.	1881	Eng. and Min. Jour., Vol. 58, p. 610.
	1886	Ibid., Vol. 76, p. 852.
James Bowden...........	1891–92	Min. and Sci. Press, Vol. 83, p. 98.
....	Aug. 17, 1896	Eng. and Min. Jour., Vol. 76, p. 808.
....	1897	Min. and Sci. Press, Vol. 83, p. 98.
Two Laplanders..........	1898	Eng. and Min. Jour., Vol. 76, p. 852; Vol. 69, p. 105.
Dawson Charley (an Indian).	1902	
Pedro..................	July, 1902	Min. and Sci. Press, Vol. 87, p. 370. Eng. and Min. Jour., Vol. 78, p. 216.
Yaqui Indians...........	1769	Min. and Sci. Press, Vol. 40, p. 296.
General Stoneman's Soldiers	1873	Eng. and Min. Jour., Vol. 35, p. 238.
Ed. Schefflin, his brother and Richard Gird.	1878	Min. and Sci. Press, Vol. 90, p. 189.
J. Lawler...............	1887	Eng. and Min. Jour., Vol. 50, p. 163.
Aborigines..............	1838	Min. and Sci. Press, Vol. 47, p. 292.
Andres Castello..........	1841	Ibid., Vol. 51, p. 322.
Claude Chana............	May 16, 1848	T. A. I. M. E., California Mines and Minerals, p. 289.
James Marshall..........	Jan. 19, 1848	Min. and Sci. Press, Vol. 47, p. 320.
....	1849	Min. and Sci. Press, Vol. 81, p. 120.
....	June, 1850	....do....................
McKnight..............	Oct., 1850	....do....................
G. D. Roberts...........	Oct., 1850	....do....................
....	1850	Ibid., Vol. 43, p. 104.
....	1850	Ibid., Vol. 80, p. 432.
Prospectors.............	Summer, 1851	Ibid., Vol. 60, p. 394.
J. F. Talbott............	1852	Ibid., Vol. 61, p. 50.
Prospectors.............	1854	T. A. I. M. E., California Mines and Minerals, p. 356.
Emigrants..............	1856	Min. and Sci. Press, Vol. 32, p. 314.
Bodie (a prospector).......	Sept., 1859	Ibid., Vol. 36, p. 258.
T. J. Pegg and others......	May 8, 1863.	Ibid., Vol. 34, p. 290.
....	1863	Eng. and Min. Jour., Vol. 42, p. 186.
H. H. Hartley............	1863	Min. and Sci. Press, Vol. 68, p. 118.
J. B. Osborne...........	1876	Ibid., Vol. 32, p. 314.
Placer miners............	1895	T. A. I. M. E., California Mines and Minerals, p. 400.
W. G. Walton and others...	1833	U. S. G. S., 22 Rept., Pt. 2, p. 238.
Oldest gold district in Colorado.	May, 1859	Eng. and Min. Jour., Vol. 62, p. 267.
Party of seven Georgians on way to California.	May, 1859	T. A. I. M. E., Vol. 26, p. 835.

TABLE I.—

Locality.	State.	Kind of Mine.	How Discovered.
Jackson's Bar, Idaho Springs..	Colorado....	Placers...........	Prospecting........
Leadville district...........	....do......	....do............	....do............
Rico district, San Juan County	....do......	Veins (silver).......	....do............
Caribou district.............	....do......	Veins (gold and silver).	....do............
Mt. McClellan..............	....do......	Veins (silver).......	....do............
Hahns Peak...............	....do......	Placers............	....do............
Lamertine mine, Idaho Springs	....do......	Veins (gold and silver).	....do............
Little Giant vein, Silverton...	....do......	....do............	....do............
Red Cloud mine, Gold Hill, Boulder County.	....do......	Veins (gold)........	Telluride of gold was first discovered here for Colorado.
La Plata district............	....do......	Veins (gold and silver).	Prospecting........
Elkton mine...............	....do......	Veins (gold)........	....do............
Golden Fleece mine.........	....do......	Veins (gold and silver).	....do............
Sheridan mine, San Miguel district.	....do......	....do............	....do............
Trout and Fisherman mines, San Juan County.	....do......	....do............	Accidental.........
Gold and Silver Chief claims, San Miguel County.	....do......	....do............	Prospecting........
Bassick mine, Silver Cliff district.	....do......	....do............	....do............
Fryer, Carbonate and Iron Hills	....do......	Veins (lead and silver).	....do............
Roaring Fork district, Aspen..	....do......	Veins (gold and silver).	....do............
Aspen..................	....do......	Veins (silver).......	....do............
Pitkin, Gunnison County	....do......	Veins (gold and silver).	....do............
Mt. Pisgah, Cripple Creek....	....do......	Veins (gold)........	....do............
Victor mine, Cripple Creek....	....do......	Veins (gold and silver).	First location on north side Bull Mt.
Poverty gulch, Cripple Creek..	....do......	....do............	Prospecting........
Four-mile Placers..........	....do......	Placers............	....do............
Independence mine..........	....do......	Veins (gold)........	....do............
Camp Bird mine............	....do......	....do............	....do............
Leather's Ford, Dahlonega ...	Georgia.....	Placers...........	(Second gold excitement in States).
Habersham County.........	....do......	....do............	Prospecting........
Pen d'Oreille River.........	Idaho......	....do............	....do............
....do..................	....do......	....do............	....do............
Coeur d'Alene Mts..........	....do......	....do............	....do............
Florence district...........	....do......	....do............	....do............
Boise Basin, Pioneersville....	....do......	....do............	....do............
Silver City and De Lamar....	....do......	....do............	....do............
Murray and Deta on Prichard Creek, Coeur d'Alenes.	....do......	....do............	....do............
Bunker Hill and Sullivan mines	....do......	Veins (lead-silver)...	Accidental.........

Continued.

By whom Discovered.	Date of Discovery.	Reference.
G. A. Jackson............	Jan. 21, 1859	Min. and Sci. Press, Vol. 58, p. 60.
....	1860	Min. Magazine, Vol. 11, p. 431.
Baker's expedition.........	1860	Eng. and Min. Jour., Vol. 31, p. 92.
....	1860–61	Ibid., Vol. 24, p. 105.
J. C. Huff and R. W. Steele.	Summer of 1864	Am. Jour. Min., Vol. 1, p. 186.
....	1865	U. S. G. S., Bull. 285, p. 28.
A Frenchman.............	1867	Mines and Minerals, Vol. 20, p. 385.
Miles T. Johnson..........	1871	Eng. and Min. Jour., Vol. 76, p. 230.
Identified by Dr. A. Eilers..	1871	T. A. I. M. E., Vol. 19, p. 335.
....	1873	Eng. and Min. Jour., Vol. 66, p. 667.
....	About 1874	Min. and Sci. Press, Vol. 72, p. 284.
Captain E. T. Hotchkiss....	1874	Eng. and Min. Jour., Vol. 76, p. 307.
John Fallon..............	1875	Ibid., Vol. 30, p. 185.
Prospectors fishing.........	Fall, 1875	Ibid., Vol. 27, p. 239.
....	1876	T. A. I. M. E., Vol. 29, p. 286.
E. G. Bassick............	1877	Mines and Minerals, Vol. 23, p. 487.
....	1879	Min. Magazine, Vol. 11, p. 431.
P. W. Pratt and Smith Steel.	July 3, 1879	T. A. I. M. E., Vol. 26, p. 845.
....	1879	Eng. and Min. Jour., Vol. 39, p. 277.
....	About 1880	Ibid., Vol. 62, p. 559.
....	1884	Min. and Sci. Press, Vol. 72, p. 284.
....	Aug. 23, 1891	Eng. and Min. Jour., Vol. 56, p. 193.
Robt. Womack...........	Feb., 1891	Ibid., Vol. 68, p. 67 and Vol. 59, p. 103.
Hugh Morrison...........	1891	Ibid., Vol. 60, p. 102.
W. C. Stratton...........	July 4, 1891	Ibid., Vol. 68, p. 67.
Walsh...................	1896	T. A. I. M. E., Vol. 33, p. 501.
....	1829	Eng. and Min. Jour., Vol. 52, p. 615.
....	1829	T. A. I. M. E., Vol. 25, p. 679.
French Canadian..........	1852	Eng. and Min. Jour., Vol. 60, p. 172.
....	1854	Am. Jour. Min., Vol. 1, p. 133.
Capt. Mullen's men.........	1858–59	Eng. and Min. Jour., Vol. 60, p. 172.
....	1861	U. S. G. S., 20 Rept., Pt. 3, p. 233.
Party with Grimes	Aug., 1862	Am. Jour. Min., Vol. 6, p. 2.
Party led by Jordan.......	1863	U. S. G. S., 20 Rept., Pt. 3, p. 108.
....	Early '80s	Min. Magazine, Vol. 12, p. 27.
Kellogg	Sept. 17, 1885	Souvenir of Coeur d'Alene district, 1906, p. 45.

TABLE I.—

Locality.	State.	Kind of Mine.	How Discovered.
Big Buffalo district	Idaho	Veins (gold)	Prospecting
Western part	Kansas	Placers	....do
Trego and Ellis counties	....do	Gold in shale	....do
Montgomery County	Maryland	Placers	
Newburyport mines	Mass.	Veins (lead-silver)	
Cliff mine, Keweenaw Point	Michigan	Vein (native copper and silver).	....do
Marquette	....do	Veins (lead-silver)	....do
Huron Mts., Marquette	....do	Veins (gold)	....do
Iron River, Ontonagon	....do	Veins (silver)	....do
Rainy Lake district	Minnesota	Veins (gold)	....do
Oro Fino or Pierce mine, Bitteroot and Clearwater Mts.	Montana	....do	....do
Horse Prairie Creek	....do	Placers	....do
Baboon Mt., Boulder Mountain district.	....do	Veins (gold)	....do
Helena	....do	Placers	....do
Elkhorn district	....do	Vein (silver)	....do
Travona lode, Butte	....do	....do	
Elkhorn mine, Elkhorn district	....do	Veins (gold)	....do
Gold Cañon	Nevada	Placer	....do
Comstock lode	....do	Vein (gold and silver)	(First discovery in district).
Esmeralda district	....do	Veins (gold and silver).	....do
Aurora	....do	....do	Prospecting
Esmeralda district, bononza, West lode.	....do	....do	....do
Eureka district	....do	....do	....do
Tonopah	....do	Veins (gold)	....do
Goldfield and Bullfrog	....do	....do	....do
Combination lode, Goldfields	....do	....do	....do
The Eaton mine	N. H.	Vein (silver)	....do
Township of Franconia and Lisbon.	....do	Veins (gold and silver).	....do
Pinos Altos	New Mexico	Veins (gold and silver).	....do
Lake Valley	....do	Veins (silver)	....do
....do	....do	....do	....do
Reed mine Cabarrus County	N. C.	Veins (gold)	Nugget accidentally found.
Barringer mine, Montgomery County.	....do	....do	Prospecting
Portis mine	....do	....do	....do
Josephine County	Oregon	Placers	....do
Bohemia district	....do	Veins (gold)	....do
....do	....do	Placers	....do

Continued.

By whom Discovered.	Date of Discovery.	Reference.
....	Aug., 1898	Min. and Sci. Press, Vol. 82, p. 105.
Party of seven Georgians on way to California.	Fall of 1849	T. A. I. M. E., Vol. 26, p. 835.
Mr. Artz	1894	Eng. and Min. Jour., Vol. 73, p. 891.
....	1849	U. S. G. S., 20 Geol. Rept., Pt. 6, p. 112.
....	Oct. 10, 1874	T. A. I. M. E., Vol. 3, p. 442.
....	Summer, 1845	Foster and Whitney's Rept., 1850, p. 128.
....	1863	....
....	1864	....
....	1872	Min. and Sci. Press, Vol. 26, p. 294.
(Were probably known of before).	1893	Eng. and Min. Jour., Vol. 58, p. 581.
....	1860	U. S. G. S., Bull. 213, p. 69.
....	June, 1863	....
John Allen and Barney Hughes.	1864	Eng. and Min. Jour., Vol. 60, p. 583.
....	1865	....
A. M. Hoster	1869	U. S. G. S., 22 Rept., Pt. 2, p. 411.
....	Jan. 2, 1875	Ibid., 22 Rept., Pt. 2, p. 411.
....	1875	Mines and Minerals, Vol. 20, p. 349.
Kelly and Orr	1850	Min. and Sci. Press, Vol. 40, p. 342.
Peter O'Riley and Patrick McLaughlin.	June 8, 1859	U. S. G. S., Monograph No. 4, p. 37.
J. M. Brady, J. C. Cory and E. R. Hicks.	Aug. 22, 1860	Min. and Sci. Press, Vol. 36, p. 296.
....	1862	School of Mines Quarterly, Vol. 3, p. 133.
....	1862–63	Min. and Sci. Press, Vol. 36, p. 409.
....	Feb. 7, 1851	Min. and Sci. Press, Vol. 35, p. 8.
	1864	U. S. G. S., Monograph No. 7, p. 3.
James Butler	Apr., 1900	Min. and Sci. Press, Vol. 86, p. 338.
Harry Stimler and William Marsh.	1902	U. S. G. S., Bull. 303, p. 8.
A. D. Mayers and R. C. Hart	May 24, 1903	U. S. G. S., Bull. 303, p. 8.
....	1826	Special Correspondence to the Eng. and Min. Jour.
....	1831	....
....	1866	Am. Jour. Min., Vol. 2, p. 386.
Mr. Everts	1876	T. A. I. M. E., Bi-Monthly Bull., Jan., 1908, p. 3.
G. W. Lufkin	Aug., 1878	T. A. I. M. E., Vol. 24, p. 138.
Conrad Reed (a boy)	1799	Eng. and Min. Jour., Vol. 80, p. 877.
....	1825	U. S. G. S., 20 Rept., Pt. 6, p. 116.
....	1840	Eng. and Min. Jour., Vol. 77, p. 168.
....	1851	Ibid., Vol. 74, p. 582.
....	1858	Ibid., Vol. 73, p. 889.
W. W. Oglesby and Frank Brass.	1858	U. S. G. S., 20 Rept., Pt. 3. p. 7.

TABLE I.—

Locality.	State.	Kind of Mine.	How Discovered.
Griffin Gulch, Blue Mt. district	Oregon......	Placers............	Prospecting........
Virtue mine, Blue Mt. district.	....do......	Veins (gold)........	....do............
Musick ledge..............	....do......	....do............	(First vein of importance found here)
Black Hills................	S. Dakota...	Placers............	Prospecting........
Homestake mine............	....do......	Veins (gold)........	....do............
Coca Creek................	Tennessee....	Placers............	....
El Paso..................	Texas.......	Veins (silver)......	....
Presidio mine, Shafter district.	....do......	....do............	....do............
Bingham and little Cottonwood Cañons.	Utah.......	....do............	....do............
Bingham..................	....do......	Placers............	....do............
Emma mine, Little Cottonwood Cañon.	....do......	Veins (silver)......	....do............
Tintic district.............	....do......	Veins (silver, lead and copper)	....do............
Chrisman and Mammoth mine, Tintic district.	....do......	....do............	....do............
Mercur mines, Lewiston Cañon.	....do......	Veins (gold).......	....do............
Ontario mine, Park City.....	....do......	Veins (gold and silver).	....do............
Silver Reef, Washington County	....do......	Silver in sandstone..	Accidental.........
Camp Floyd district, Mercur mines	....do......	Veins (gold)........	Prospecting........
	Virginia.....	Placers...........	....
Tellurium and Vaucluse mines	....do......	Veins (gold)........	....do............
Louisa County............	....do......	....do............	....do............
Peshastin district...........	Washington..	Placers............	....do............
....do..................	....do......	Veins (gold)........	....do............
Culver vein...............	....do......	....do............	....do............
Republic mine.............	....do......	....do............	....do............
Mountain Lion.............	....do......	....do............	....do............
Douglas Creek.............	Wyoming....	Placers............	....do............
Silver Islet, Ontario.........	Canada......	Veins (silver).......	....do............
....do..................	....do......	Second bonanza ...	Mining............
New Fane	Vermont....	Nugget in gravel ...	Accidental find.....

Continued.

By whom Discovered.	Date of Discovery.	Reference.
Griffin and others.........	Fall, 1861	U. S. G. S., 22 Rept., Pt. 2, p. 563.
....	1862	Ibid., 22 Rept., Pt. 2, p. 563.
....	1891	Ibid., 20 Rept., Pt. 3, p. 7.
Half-breed Indian.........	1874	Min. and Sci. Press, Vol. 86, p. 212.
Manuel Brothers..........	1875–76	Ibid., Vol. 88, p. 63.
....	1831	U. S. G. S., 20 Rept., Pt. 6, p. 112.
Monks of the Order of St. Francis.	1680	Min. and Sci. Press, Vol. 27, p. 394.
J. W. Spencer............	1848 (about)	Eng. and Min. Jour., Vol. 74, p. 150.
General Connor's Soldiers...	1863	T. A. I. M. E., Vol. 16, p. 3.
California Miners..........	1864	U. S. G. S., Bull. No. 213, p. 119.
Woodman and Chisholm....	1868	Min. and Sci. Press, Vol. 46, p. 272.
....	Dec., 1869	U. S. G. S., 19 Rept., Pt. 3, p. 613.
....	1871	Mines and Minerals, Vol. 19, p. 153.
....	1871	Ibid., Vol. 19, p. 81.
Rector Steen.............	June 15, 1872	U. S. G. S., Bull. 213, p. 34.
John Barbee	1873	Mines and Minerals, Vol. 20, p. 323.
Arie Pinedo..............	Apr. 30, 1879	Eng. and Min. Jour., Vol. 63, p. 403.
....	1831	Min. and Sci. Press, Vol. 31, p. 210.
....	1832	U. S. G. S., 20 Rept., Pt. 6, p. 116.
George Fisher............	1845	Eng. and Min. Jour., Vol. 6, p. 407.
....	1860 or 1862	U. S. G. S., Bull. 213, p. 76, Eng. and Min. Jour., Vol. 54, p. 608.
....	1873	U. S. G. S., Bull. 213, p. 76.
Saunders and Culver.......	1873	Eng. and Min. Jour., Vol. 54, p. 608.
Ryan and Creason.........	Mar. 5, 1896	Ibid., Vol. 68, p. 635.
Arthur Best..............	Mar. 20, 1896	Ibid., Vol. 69, p. 285.
Iram M. Moore...........	Fall, 1868	Ibid., Vol. 60, p. 539.
Thomas MacFarlane.......	July 10, 1869	T. A. I. M. E., Vol. 8, p. 228.
....	1878	Eng. and Min. Jour., Vol. 34, p. 322,
Reported by Z. Thompson...	1826	Appendix to Thompson's Vermont, p. 48.

TABLE II.—OCCURRENCE AND MINERALOGICAL

Locality.	State.	Metalliferous Minerals and Metals and Bearers of the Precious Metals.	Gangue Minerals.
General	Alabama	Auriferous ochre, quartz reefs and saprolites.	Garnets, red ochre, quartz and saprolite.
Creighton and Walker mines.	....do...	Lenses of auriferous quartz in graphitic slate.	Quartz, slate and schist.
Moss back, Arbacoochee district.	....do...	Free gold in quartz, slates and sandstone.	Quartz, slate, sandstone.
General	Alaska	Pyrite, galena, chalcopyrite, arsenopyrite, pyrrhotite, blende, pyrargyrite, siderite.	Quartz, calcite, biotite, chlorite, orthoclase.
Yukon	....do...	Pyrite, galena	Quartz
Nome	....do...	Mispickel, blende, antimony, chalcopyrite, magnetite, cinnabar.	Quartz, calcite
Silver Queen	....do...	Pyrrhotite, blende, chalcopyrite, galena, pyrite, mispickel, native and ruby silver.	Quartz
Bald Eagle mine, Sumdum Bay.	....do...	Galena, blende, mispickel, pyrite	Quartz
Tellurium and Funter's Bay, War Horse mines.	....do...	Auriferous pyrite and pyrrhotite.	Quartz, calcite and chlorite
Apollo Con. mine, Island of Unga.	....do...	Pyrite, galena, chalcopyrite, blende, native copper.	Quartz
Ketchikan district	....do...	Mispickel, galena, tellurides, pyrite, blende and chalcopyrite.	Quartz
Berner's Bay district, Comet mine.	....do...	Pyrite, galena, chalcopyrite, blende.	Quartz
Kingston and Johnson veins.	....do...	Pyrite, pyrrhotite, chalcopyrite.	Quartz
Alaska Treadwell mines.	....do...	Pyrite, chalcopyrite, galena, blende, pyrrhotite, mispickel.	Quartz, calcite
Silver Bow Basin	....do...	Pyrite, galena, blende, siderite	Quartz, calcite
Sheep Creek Basin	....do...	Pyrrhotite, galena, blende, pyrite, mispickel, ruby silver.	Quartz
Cleveland Peninsula	....do...	Gold-quartz	Quartz
Gravina Island	....do...	Pyrite, blende, gold-quartz	Quartz
Annette Island, Ketchikan district.	....do...	Argentiferous and auriferous tetrahedrite and free-gold.	Quartz
Allison mine, Ketchikan district, Kassan Peninsula.	....do...	Chalcopyrite, magnetite	Quartz, hornblende
Mt. Andrew mine, Ketchikan district.	....do...	Chalcopyrite, magnetite, pyrite	....do
Copper Queen mine, Ketchikan district.	....do...	Chalcopyrite, magnetite, manganese oxide.	....do

ASSOCIATION OF GOLD AND SILVER.

Form of Deposit.	Country Rock.	Method of Treatment.	Remarks.	Reference.
Veins and impregnations.	Schists, granites, gneisses, crystalline schists, marbles.	Milling and smelting.	Gold-bearing....	Fed. Inst. M. E., Vol. 14, pp. 93 and 96.
Quartz lenses.	Slate and schist.	Milling......	....do.........	T. A. I. M. E., Vol. 26, p. 466.
Veins and impregnations......	Slate and sandstone.	....do......	....do.........	Eng. and Min. Jour., Vol. 47, p. 458.
Quartz veins	Metamorphic and igneous rock.	Milling and smelting.	Gold and silver-bearing.	U. S. G. S., Bull. 213, p. 42, Ibid., 18 Rept., Pt. 3, p. 62.
Quartz veins	Igneous and metamorphic rocks.	Smelting.....	....do.........	Ibid., 18 Rept., Pt. 3, p. 292.
....do......	....	Milling......	Gold-bearing....	Inst. Min. and Met., Vol. 9, p. 181.
....do......	Carbonaceous and micaceous schists.	Milling and smelting.	Gold and silver-bearing (galena is argentiferous)	U. S. G. S., 18 Rept., Pt. 3, p. 73.
....do......	....	....do......	Gold-bearing....	Ibid., 18 Rept., Pt. 3, p. 73.
....do......	Schists.........	Milling......	....do.........	Ibid., 18 Rept., Pt. 3, p. 77.
....do......	Andesite and dacite.	Milling and smelting.	....do.........	Ibid., 18 Rept., Pt. 3, p. 83.
....do......	....	Milling......	....do.........	Min. and Sci. Press, Vol. 83, p. 98.
....do......	....	Milling and smelting.	....do.........	Mines and Minerals, Vol. 21, p. 435.
....do......	....	Milling......	....do.........	Ibid., Vol. 21, p. 435.
....do......	Carbonaceous slate.	....do......	....do.........	Ibid., Vol. 21, p. 435.
....do......	....	....do......	....do.........	Ibid., Vol. 21, p. 435.
....do......	Carbonaceous and micaceous schists.	Milling and smelting.	Silver-bearing...	Ibid., Vol. 21, p. 435.
....do......	Diabase altered to serpentine.	Milling......	Gold-bearing....	Min. and Sci. Press, Vol. 83, p. 98.
....do......	Siliceous and chloritic schists and limestone.	Milling and smelting.	....do.........	Ibid., Vol. 83, 98.
....do......	....	....do......	Gold and silver-bearing.	Ibid., Vol. 83, p. 98.
....do......	Diorite, quartz-porphyry and serpentine.	....do......	....do.........	Ibid., Vol. 83, p. 99.
....do......	....do.........	....do......	....do.........	Ibid., Vol. 83, p. 99.
....do......	....do.........	....do......	....do.........	Ibid., Vol. 83, p. 99.

TABLE II.—

Locality.	State.	Metalliferous Minerals and Metals and Bearers of the Precious Metals.	Gangue Minerals.
Dolomi district, Kassan Peninsula.	Alaska...	Argentiferous tetrahedrite, pyrite, free-gold.	Quartz...........
Niblack anchorage...	....do...	Chalcopyrite, magnetite, pyrite..	Quartz...........
Copper Mountain....	....do...	Malachite, chalcopyrite, native copper, silver-lead ores.	Quartz...........
Pearce mine........	Arizona..	Cerargyrite, bromyrite, argentite iodyrite.	Quartz...........
Tombstone: near surface.	....do...	Silver chlorides, carbonate of lead, oxides of manganese and iron.	Quartz...........
At 600 feet depth....	....do...	Sulphide of lead and silver and zinc.	Quartz, porphyritic rock.
Lucky Cuss mine, Tombstone	....do...	Galena, blende, alabandite......	Quartz...........
Yavapai County	....do...	Chalcopyrite, mispickel, copper glance.	Oxides of iron and manganese.
Silver Bell Mt. district, Big Bug Mountain.	....do...	Cuprite, malachite, azurite, chalcocite, chalcopyrite, bornite, pyrite.	Quartz...........
Portland mine, Silver Bell district.	....do...	Galena, blende, pyrite, chalcopyrite and silver near the surface.	Quartz...........
Prescott district.....	....do...	Chlorides and sulphides of silver, galena.	Quartz...........
Prescott district, Tuscumbia and Trinity	....do...	Chlorides of silver, brittle silver, galena, blende.	Quartz, barytes.....
Mount Union.......	....do...	Galena, pyrites..............	Quartz...........
Crown King mine, Yavapai County.	....do...	Auriferous and argentiferous pyrite.	Quartz, clay.......
Oro mine, Yavapai County.	....do...	Galena, pyrite...............	Quartz (white).....
Dividend group, Chaparal.	....do...	....do....................	Quartz...........
Pinal County, Silver King mine	....do...	Gray copper, siderite, ruby silver, native silver, pyrite, blende, galena, argentite.	Quartz, calcite, barite.
Bradshaw mine......	....do...	Malachite, azurite, black oxides, cuprite, bornite, chalcocite, chalcopyrite.	Schists...........
Poland-Lynx Creek mine.	....do...	Pyrite, blende, galena, bornite, chalcopyrite.	Diorite, siliceous matter.
United Verde.......	....do...	Bornite, melaconite, chalcopyrite, cuprite.	Quartz...........
Harshaw...........	....do...	Horn silver (free-milling)......	Porphyritic rock....
Hillside vein........	....do...	At surface gold and silver chloride; with depth copper and iron pyrites, galena, blende, arsenopyrite.	Quartz...........

Continued.

Form of Deposit.	Country Rock.	Method of Treatment.	Remarks.	Reference.
Quartz veins.	Limestone......	Milling and smelting.	Gold and silver-bearing.	Min. and Sci. Press, Vol. 83, p. 99.
....do......	Greenstone......	....do......	....do.........	Ibid., Vol. 83, p. 99.
....do......	....	....do......	....do.........	Ibid., Vol. 83, p. 99.
Veins.......	....	....	....do.........	Eng. and Min. Jour., Vol. 63, p. 571.
....do......	Porphyry, slates and limestone.	Smelting....	....do.........	Ibid., Vol. 49, p. 361.
....do......	....do.........	Milling......	....do.........	Ibid., Vol. 49, p. 361, and Min. and Sci. Press, Vol. 91, p. 190.
....do......	....	Milling and smelting...	Gold-bearing....	T. A. I. M. E., Vol. 33, p. 29.
....do......	Granite and metamorphic rocks.	....do......	Gold and silver-bearing.	Ibid., Vol. 45, p. 435.
Veins and replacements of limestone.	Limestone......	....do......	....do.........	Ibid., Vol. 77, p. 639, and Ibid., Vol. 78, p. 755.
....do......	Dolomitic limestone.	....do......	Gold, silver and copper-bearing.	Eng. and Min. Jour., Vol. 77, p. 639.
Veins.......	Slate, quartz.....	Milling......	Gold and silver-bearing.	T. A. I. M. E., Vol. 11, p. 289.
....do......	Granite.........	....do......	....do.........	Ibid., Vol. 11, p. 289.
....do......	....do.........	....do......	....do.........	Ibid., Vol. 11, p. 289.
....do......	....	Milling and smelting.	....do.........	Eng. and Min. Jour., Vol. 78, p. 832.
....do......	Granite, metamorphic rock.	....do......	....do.........	Ibid., Vol. 78, p. 832.
....do......	Schists.........	....do......	Gold, silver, lead.	Ibid., Vol. 78, p. 832.
Chimney of quartz-bearing minerals	Igneous and metamorphic rocks.	....do......	Silver, copper...	Colliery Eng., Vol. 12, p. 73, Eng. and Min. Jour., Vol. 35, pp. 254, 270.
....do......	Schists.........	....do......	Gold, silver, copper.	Eng. and Min. Jour., Vol. 78, p. 832.
....do......	Granite, granitoid-diorite	....do......	....do.........	Eng. and Min. Jour., Vol. 74, p. 622.
Veins and massive deposits.	Shales, sandstones and limestones.	....do......	....do.........	Ibid., Vol. 86, p. 70.
Mineral found in joints and cleavage planes.	Porphyritic rock.	Milling......	Gold and silver..	Ibid., Vol. 49, p. 362.
Veins.......	....	Milling and smelting.	....do.........	Ibid., Vol. 50, p. 162.

TABLE II.—

Locality.	State.	Metalliferous Minerals and Metals and Bearers of the Precious Metals.	Gangue Minerals.
La Fortuna mine....	Arizona..	Oxidized pyritic minerals, no sulphides.	Quartz..........
Harqua Hala, Mammoth of goldfield and Mammoth of Pinal.	....do...	(General exceptions) Pyrite, blende practically free from silver.	Quartz..........
General...........	Arkansas.	Galena, gray copper, brittle copper, sulphides and carbonates of silver.	Quartz..........
Central gold belt.....	California	Auriferous pyrite.............	Quartz, dolomite...
Father lode........	....do...	....do....................	Greenstone, quartz..
Mother lode........	....do...	....do....................	Quartz, calcite, amphibolitic schists.
Eastern...........	....do...	Argentiferous galena, sulphides of antimony, arsenic and copper,	Quartz, calcite, oxides of iron.
Baliol mine, Mother lode.	....do...	Pyrite, chalcopyrite, galena	Quartz, calcite.....
Mariposa County	....do...	Gold in ankerite, mariposite and quartz.	Ankerite, mariposite, quartz.
Black Hawk Mts., San Bernardino County.	....do...	Gold-bearing limestone........	Limestone........
Redding, French gulch and Deadwood districts.	....do...	At surface free-gold, with depth sulphides.	Slate and porphyry..
Randsburg district, Southern California.	....do...	Gold-bearing quartz..........	Quartz..........
Forbestown, Butte County.	....do...	Free-gold and auriferous sulphurets.	Quartz..........
Hedges, Dan Diego...	....do...	Gold-bearing horneblende schists.	Siliceous hornblende schists.
Calaveras county.....	....do...	Volcanic tufa and mud, gold-bearing.	Tufa, mud, gravel ..
Manzanita, Monticello and Clyde mines, Sulphur Creek.	....do...	Pyrite, pyrrhotite...........	Quartz..........
Cerros or Cedros Island.	....do... (Lower)	Native sulphur and carbonate of bismuth, gold-bearing.	Diorite, diabase, quartz, porphyrite.
Calico district.......	California	Hydrosilicate, carbonate of copper, haloid salts of silver.....	Jasper, barytes.....
Carbonate mine, Oro Grande district.	....do...	Galena, carbonate of lead, pyrites.	Quartz..........
Mazeppa, Golden Rule, and Juniper Mines, Mother lode, Tuolumne county.	....do...	Gold and auriferous pyrite......	Quartz, calcite.....
Sulphur Creek district, Colusa County	....do...	Auriferous sulphurets and cinnabar.	Quartz, slate.......
Tiogo and Mono Pass.	....do...	Sulphides of antimony, lead, zinc, copper, iron, pyrrhotite.	Quartz..........

Continued.

Form of Deposit.	Country Rock.	Method of Treatment.	Remarks.	Reference.
Veins	Metamorphic rocks.	Milling	Gold-bearing	Min. and Sci. Press, Vol. 84, p. 34.
....do......	....	Smelting	....do.........	Eng. and Min. Jour., Vol. 58, p. 366.
....do......	Trenton slates ...	Milling	Silver-bearing ...	Ibid., Vol. 29, p. 385.
Impregnations	Dolomite, slates, schists.	....do......	Gold-bearing	Min. and Sci. Press, Vol. 80, p. 644.
Veins	....	....do......	....do.........	Ibid., Vol. 89, p. 136.
....do......	Slates and igneous rocks.	....do......	....do.........	Ibid., Vol. 89, pp. 210, 271.
....do......	Limestone, granites.	....do......	Gold, silver	Ibid., Vol. 73, p. 480.
....do......	....	Milling and smelting.	Gold-bearing	Ibid., Vol. 87, p. 165.
....do......	Diabase	Milling	....do.........	T. A. I. M. E., California Mines and Minerals, p. 365.
....do......	Limestone	....do......	....do.........	Min. and Sci. Press, Vol. 80, p. 148.
Contact deposit.	Contacts of slate and porphyry.	Milling and smelting.	....do.........	T. A. I. M. E., California Mines and Minerals, p. 375.
Veins	Diorite	Milling	....do.........	Ibid., p. 400.
....do......	....	Smelting	....do.........	Ibid., p. 279.
Impregnations	Siliceous hornblende schists.	Milling	....do.........	Min. and Sci. Press, Vol. 80, p. 148.
Bedded deposits.	Volcanic tufa and mud.	....do......	....do.........	Ibid., Vol. 80, p. 148.
Dikes	Metamorphic rocks, serpentine and slates.	Milling and smelting.	....do.........	Eng. and Min. Jour., Vol. 42, p. 186.
Breccia	Breccia of diorite, quartz, diabase, porphyrite.	Milling	....do.........	Ibid., Vol. 51, p. 516, and Vol. 51, p. 627.
Veins	Laparite and tufas.	Milling and smelting.	Silver-bearing....	T. A. I. M. E., Vol. 15, p. 720.
Contact deposit.	....	....do......	Gold, silver	Eng. and Min. Jour., Vol. 51, p. 627.
Veins	Slate, chloritic schists.	Milling	Gold-bearing	T. A. I. M. E., California Mines and Minerals, p. 349.
....do......	Serpentine and slates.	Milling and smelting.	....do.........	Min. and Sci. Press, Vol. 34, p. 280.
....do......	Schists	Milling	....do.........	Ibid., Vol. 69, p. 36.

TABLE II.—

Locality.	State.	Metalliferous Minerals and Metals and Bearers of the Precious Metals.	Gangue Minerals.
Soulsby district......	California	Copper and iron pyrites, pyrrhotite, blende.	Quartz...........
West Point district...	....do...	Copper and iron pyrites, pyrrhotite.	Quartz............
Coulterville.........	....do...	Cinnabar....................	....
Pine Hill...........	....do...	Gold-bearing quartz, barite, kaolinite.	Decomposed kaolinized diabase and barite.
Rathgeb, San Andreas	....do...	Gold-bearing clay, quartz, uraninite.	Quartz, clay, uraninite.
Big Bend Mt., Butte County.	....do...	Gold-bearing barite............	Barite............
Silver Islet mine, Ontario.	Canada..	Pyrite, galena, blende, argentite, chalcopyrite, niccolite, smaltine, stephanite, cobaltite, macfarlanite, pyrargyrite, native silver.	Calcite carrying carbonate of manganese, quartz, rhodochrosite, plumbago.
General............	Colorado.	Chalcopyrite, argentiferous galena.	Quartz............
Cripple Creek.......	....do...	Pyrite, galena: blende, tetrahedrite, molybdenite, stibnite, tellurides, (gold, silver and lead tellurides).	Quartz, fluorite, dolomite, roscolite rhodochrosite.
Pine Creek..........	....do...	Hematite, pyrite, chalcopyrite, galena.	Barite, calcite......
Leadville...........	....do...	Cerussite, lead carbonate, cerargyrite, galena, pyrite, chalcopyrite, blende	Gypsum, heavyspar, iron carbonate, quartz, hydrous silicates (of alumina).
Good Hope mine, Vulcan.	....do...	Telluride of copper, petzite, native tellurium.	....
Golden Fleece mine, Lake Christobol.	....do...	Petzite, hessite..............	Quartz...........
Clear Creek.........	....do...	Pyrite, chalcopyrite, galena, blende, gray copper, brittle silver.	Quartz, barite, fluorspar.
Crested Butte, Gunnison county.	....do...	Lead carbonate, galena, blende, pyrite.	....
Silver Cliff.........	....do...	Iron oxide and chloride of silver.	Porphyry ....
Logan mine, Rico, Dolores County.	....do...	Lead and copper carbonates, galena, chalcopyrite.	Quartz...........

Continued.

Form of Deposit.	Country Rock.	Method of Treatment.	Remarks.	Reference.
Granite veins.	Granite........	Milling......	Gold-bearing....	Min. and Sci. Press, Vol. 69, p. 36.
Veins.......	....	....do......	....do.........	Ibid., Vol. 69, p. 36.
....do......	Diabase........	....	....do.........	Ibid., Vol. 69, p. 36.
Impregnated zones.	Decomposed and kaolized diabase.	....do......	....do.........	Ibid., Vol. 69, p. 36.
Veins.......	Augite schist and diabase.	....do......	Gold and uraninite (rather uncommon).	Ibid., Vol. 67, p. 180.
....do......	....	....do......	Gold-bearing....	Min. and Sci. Press, Vol. 70, p. 344.
....do......	Siliceous slate...	Milling and smelting.	Silver-bearing...	Eng. and Min. Jour., Vol. 23, p. 54.
....do......	....	....do......	Gold, silver.....	Am. Jour. Min., Vol. 1, p. 397.
....do......	Andesite, breccia, granite, phonolite.	....do......	....do.........	U. S. G. S., Professional Paper No. 54, p. 122, Min. Sci. Press, Vol. 72, p. 285, Min. Sci. Press, Vol. 91, p. 36.
....do......	....	....do......	....do.........	Min. and Sci. Press, Vol. 73, p. 173.
....do......	Limestone......	....do......	Gold and Silver-bearing.	U. S. G. S., Monograph No. 12, p. 376, Ibid., Vol. 57, p. 106.
....do......	....	Smelting....	Gold and silver with tellurium.	Eng. and Min. Jour., Vol. 76, p. 386.
Contact veins.	Coarse and fine breccia and tufas.	Milling and smelting.	Gold, silver.....	Ibid., Vol. 76, p. 346.
Veins.......	Gneiss composed of quartz, feldspar and black mica.	....do......	Silver-bearing...	Ibid., Vol. 13, p. 260, and Ibid., Vol. 27, p. 73.
....	....	....do......	Silver-bearing...	Ibid., Vol. 63, p. 597.
Breccia......	Agglomerate of boulders and breccia.	Smelting....	Gold, silver.....	Ibid., Vol. 27, p. 57.
Contact vein.	Iron capping and lime bottom.	Milling and smelting.	Silver, gold, lead.	Min. and Sci. Press, Vol. 81, p. 341.

TABLE II.—

Locality.	State.	Metalliferous Minerals and Metals and Bearers of the Precious Metals.	Gangue Minerals.
Battle Mt. mines, Eagle County.	Colorado	Pyrite, galena, silver and black manganese ores.	Quartzite, ferruginous earth.
Newman Hill.......	....do...	Pyrite, chalcopyrite, galena, blende, tetrahedrite, argentite, stephanite, polybasite, pyrargyrite, proustite.	Rhodochrosite, quartz.
San Juan region.....	....do...	Hübnerite, galena, chalcopyrite, blende, pyrite.	Manganese and oxide calcium, quartz, iron oxide.
Grand View mine, Ouray.	....do...	Blue and white carbonate of copper, pyrite, chalcopyrite, galena.	Quartz............
Summit County	....do...	Iron and copper oxides and sulphides, galena.	Calcite, quartz......
Ouray County	....do...	Iron oxide, green copper carbonate.	Quartz, lustrous coal
California mine, Gilpin County.	....do...	Mispickel, galena, pyrite, chalcopyrite, tetrahedrite, blende.	Quartz, feldspathic material.
Bassick mine, Rossita.	....do...	Gold and silver in quartz, occurring partly as tellurides.	Quartz............
Richmond and Eureka Consolidated, Leadville.	....do...	Auriferous and argentiferous carbonate of lead.	Limestone.
Smuggler-Union mine, Telluride.	....do...	Antimonial silver, pyrite, galena, chalcopyrite, blende.	Quartz, rhodochrosite, calcite, barite.
Aspen Mt. mines, Pitkin County.	....do...	Blende, lead sulphate, polybasite, stephanite, galena.	Dolomite, barite, heavyspar, porphyry.
Standley mine, Idaho Springs.	....do...	Pyrite, chalcopyrite, bornite, peacock copper.	Quartz............
Bassick mine, Silver Cliff.	....do...	Sulphide, carbonate and hydrous silicate of zinc; pyrite, galena, gray copper, tellurium.	Igneous rock and granite.
Camp Bird mine, Imogene basin, Ouray County.	....do...	Pyrite, galena, chalcopyrite, blende, magnetite, blende, rhodonite, arsenic.	Quartz, calcite, rhodonite, chlorite.
Globe Hill, Cripple Creek	....do...	Pyrite......................	Quartz............
Red Cloud mine, San Juan County.	....do...	Chalcopyrite, tellurium, blende, galena, pyrite, bornite.	Quartz............
Leadville gold belt...	....do...	Gold-bearing quartz...........	Quartz............
Handies Peak district.	....do...	Galena, pyrite, bornite, chalcopyrite, blende.	Quartz............

Continued.

Form of Deposit.	Country Rock.	Method of Treatment.	Remarks.	Reference.
Bedded deposits, pockets in limestone and quartzite.	Limestone, quartzite.	Milling and smelting.	Gold, silver.....	Eng. and Min. Jour., Vol. 53, p. 545.
Veins.......	Shale, sandstone.	....do......	....do.........	Ibid., Vol. 54, p. 175.
....do......	Igneous rocks, shales, and quartzite.	....do......	Gold, lead, silver ores.	Ibid., Vol. 67, p. 499, Ibid., Vol. 26, p. 115.
....do.....	Igneous rocks...	Smelting....	Gold, silver.....	Ibid., Vol. 26, p. 405.
....do......	Slates..........	....do......	Gold does not occur in quartz, gold and silver.	Ibid., Vol. 51, p. 516.
....do......	Coal...........	....	Silver occurs in coal.	Ibid., Vol. 33, p. 90.
....do......	Gneiss, granite, schists.	Milling and smelting.	Gold, silver.....	Ibid., Vol. 54, p. 245.
Deposit in duct of extinct hot spring.	Andesite, granite.	....do......	....do.........	Colliery Engineer, Vol. 12, p. 73.
Chamber deposits.	Limestone......	....do......	....do.........	Ibid., Vol. 12, p. 73.
Veins.......	Igneous rock and conglomerate.	....do......	Most common silver and lead, gold also occurs.	T. A. I. M. E., Vol. 26, pp. 453–455.
Contact veins.	Limestone and dolomite.	...do......	Lead and silver-bearing.	Ibid., Vol. 17, p. 156, Eng. and Min. Jour., Vol. 39, p. 277.
Veins.......	Archaen gneiss and schists.	....do......	Gold, silver.....	Colliery Engineer, Vol. 14, p. 283.
Volcanic duct.	Andesite, granite.	....do......	....do.........	Mines and Minerals, Vol. 23, p. 489.
Veins.......	San Juan breccia and andesites.	....do......	....do.........	T. A. I. M. E., Vol. 33, pp. 499–511.
Massive deposits.	Granite, phonolite, andesitic breccia.	....do......	....do.........	Eng. and Min. Jour., Vol. 59, p. 151.
Veins.......	....	....do......	....do.........	Eng. and Min. Jour., Vol. 38, p. 209.
Contact deposits.	Limestone and eruptives.	Smelting....	....do.........	Eng. and Min. Jour., Vol. 59, p. 77.
Veins.......	....	Milling and smelting.	Gold-bearing....	Ibid., Vol. 38, p. 245.

TABLE II.—

Locality.	State.	Metalliferous Minerals and Metals and Bearers of the Precious Metals.	Gangue Minerals.
Continental Divide zone.	Colorado.	Tetrahedrite, galena, pyrite, blende.	Quartz
Lost Peak zone	....do...	Bornite, antimonial copper glance.	Quartz
Glacier Peak zone	....do...	Freibergite, galena, hornsilver	Quartz
American Nettie mine, Ouray.	....do...	Pyrite, chalcopyrite, blende, galena, gray copper, petzite, bismuth, copperas.	Sandstone, gypsum, ocherous iron stone
Smuggler lode	....do...	Rhodochrosite, argentite, siderite.	Quartz, calcite
Vulcan mine	....do...	Sulphur, pyrite and gold	Quartz, jasper, iron oxide.
La Plata mines	....do...	Sylvanite	Quartz
Bear Creek, Silverton	....do...	Tellurides of gold and silver, pyrite, tetrahedrite, chalcopyite, bornite, galena, blende, gray copper, marcasite, azurite, arsenopyrite, malachite, hematite, limonite.	Quartz, calcite, barite, kaolinite.
Yellow Rose mine, Mt. Sneffels district.	....do...	Gray copper, blende, galena, iron and copper pyrites.	Quartz
Kokoma mine, Tenmile district.	....do...	Carbonate of lead stained by hydrate of iron.	Quartz, calcite, barite.
Rico district	....do...	Galena, gray copper, polybasite, pyrite, argentite, chalcopyrite, blende.	Quartz and andesite.
....do	....do...	Pyrite, galena, blende, gray copper.	....do
Sylvanite mine	....do...	Pyrite, ruby silver, silver sulphide.	Quartz, barite.
Lamartine mine, Idaho Springs.	....do...	Galena, blende, gray copper	Gneiss.
Geyser mine, Silver Cliff district.	....do...	Galena, blende, chalcopyrite, argentite, gray copper, ruby silver, polybasite.	Gneiss, igneous rocks
Golden Age mine, Boulder.	....do...	Pyrite, galena, blende, chalcopyrite, free-gold.	Quartz
Boulder County	....do...	Free-milling: galena, blende, copper and iron pyrites, telluride ores (calaverite, sylvanite, petzite).	Quartz
Sheridan mine, San Miguel.	....do...	Free-gold, galena, pyrite, chalcopyrite, blende.	Quartz, horse-porphyry.
Virginius mine, Ouray County.	....do...	Galena, gray copper	Quartz
Topeka mine, Central City.	....do...	Blende, pyrite	Quartz
Lumpkin County	Georgia..	Auriferous pyrite, and quartz and schists.	Quartz and schists.
Blue Ridge	....do...	Auriferous quartz and slate	Quartz, slate, itaclumyte.

Continued.

Form of Deposit.	Country Rock.	Method of Treatment.	Remarks.	Reference.
Veins	....	Milling and smelting.	Gold, silver	Eng. and Min. Jour., Vol. 38, p. 245.
....do	....	Smelting	Gold-bearing	Ibid., Vol. 38, p. 315.
....do	....	Milling and smelting.	Gold, silver	Ibid., Vol. 38, p. 315.
Bedded contact.	Sandstone and shale.	....do	Gold, silver, native copper.	Ibid., Vol. 76, p. 7, Mines and Minerals, Vol. 21, p. 243.
Veins	Augite-andesite ..	....do	Gold, silver	Ibid., Vol. 76, p. 119.
Quartz breccia.	Quartzite	Milling	Gold-bearing	Mines and Minerals, Vol. 18, p. 562.
Veins	Sedimentary rock above, diorite below.	....	....do	Eng. and Min. Jour., Vol. 66, p. 667.
....do	Quartzites, lava flows, schists, slates.	Milling and smelting.	Lead, zinc, copper, gold, silver.	U. S. G. S., Bull. 285, pp. 25–26.
....do	....	Smelting	Silver-bearing	Eng. and Min. Jour., Vol. 32, p. 200.
....do	Limestone	Milling and smelting.	Gold in earthy lead carbonate.	Ibid., Vol. 31, p. 430.
Impregnation	....do	Smelting.	Native, brittle and hornsilver.	Colliery Engineer, Vol. 17, p. 360.
Contact deposits.	....do(?)	....do	Silver, lead, zinc, copper.	Ibid., Vol. 17, p. 360.
Veins	diorite	....do	Native silver, silver-bearing.	Eng. and Min. Jour., Vol. 46, p. 499.
....do	Gneiss, granite ...	Milling and smelting.	Lead, copper, silver.	Mines and Minerals, Vol. 20, p. 386.
....do	....	....do	Silver-bearing ...	Ibid., Vol. 18, p. 296.
Contact veins.	Quartz-porphyry, granite and gneiss.	....do	Gold-bearing	T. A. I. M. E., Vol. 19, p. 323.
Veins	Granite, gneiss ..	....do	....do	Ibid., Vol. 19, p. 323.
....do	Porphyritic and dioritic in character.	....do	Gold, silver	Eng. and Min. Jour., Vol. 30, p. 185.
....do	....	....do	....do	Ibid., Vol. 76, p. 268.
Mineralized zones, veins.	....	....do	Gold-bearing	Mines and Minerals, Vol. 20, p. 82.
Veins	Hornblende and gneissoid-schists.	Milling	....do	Eng. and Min. Jour., Vol. 58, p. 559.
....do	Slate.	....do	....do	Ibid., Vol. 24, p. 258.

TABLE II.—

Locality.	State.	Metalliferous Minerals and Metals and Bearers of the Precious Metals.	Gangue Minerals.
Western Central:			
(1) Silver veins	Idaho ...	Blende, galena, pyrargyrite, argentite, tetrahedrite.	Quartz ....
(2) Gold-silver	....do...	Galena, blende, pyrargyrite, stephanite, argentite, pyrite.	....do............
(3) Gold-veins	....do...	Pyrite, galena	....do............
(4) Silver-lead	....do...	Argentiferous galena, blende	Actinolite, quartz, calcite, ilvaite.
Pearl district	....do...	Pyrite, galena, blende, antimony (in depth).	Quartz ....
Gibbsonville district ..	....do...	Auriferous pyrite, silver sulphide (?)	....do............
De Lamar mine, Silver city district.	....do...	At surface: sulphides of silver, hornsilver with depth: gold-quartz	....do............
Ramshorn mine, Bay horse, Custer County.	....do...	Siderite, chloride of silver, gray copper.	....do............
Wood River district ..	....do...	Wood River type: galena, siderite. Croesus type: chalcopyrite, pyrrhotite.	Siderite .... Quartz and siderite ..
Florence gold district.	....do...	Tellurides, pyrite, gold-quartz ...	Quartz ....
Warren district	....do...	Pyrite, arsenopyrite, tetrahedrite, gold-quartz, galena, blende.	....do............
Little Giant vein	....do...	Pyrite, argentite, tellurides, bromide of silver, tetrahedrite, galena, blende, arsenopyrite.	....do............
Red Cloud	....do...	Iron and copper pyrites	....do............
Gold Star mine	....do...	Auriferous pyrite	....do............
Jumbo mines	....do...	Pyrite, galena	....do............
Coeur d'Alêne district.	....do...	Galena, blende, pyrite, siderite ..	Quartz, iron oxide, manganese.
Atlantic lode, Sawtooth Range.	....do...	Native silver, stephanite, argentite, pyrargyrite.	Quartz ....
Boise Basin	....do...	Pyrite, arsenopyrite, blende, free-gold.	Granite, porphyry ...
Thunder Mt., Mackay .	....do...	Native gold in rhyolite and pyrite	Rhyolite ....
White Knob mine, Mackay.	....do...	Pyrite, chalcopyrite	....
Seven Devils, Washington and Southern counties.	....do.	Green copper carbonate, bornite, chalcopyrite, specular iron.	Iron garnets, alumina silicates of iron and lime.
Mt. Caribou, gold deposits.	....do..	Pyrite, hematite	Quartzite, iron oxide, calcite.

Continued.

Form of Deposit.	Country Rock.	Method of Treatment.	Remarks.	Reference.
Veins.......	Granite, metamorphic rocks.	Milling and smelting.	A little gold, silver-bearing.	U. S. G. S., 20 Rept., Pt. 3, p. 75.
....do......	....do.........	....do......	Gold, silver.....	Ibid., 20 Rept., Pt. 3, p. 75.
....do......	....do.........	....do......	A little silver, gold-bearing.	Ibid., 20 Rept., Pt. 3, p. 75.
....do......	....do.........	....do......	Silver, lead.....	Ibid., 20, Rept., Pt. 3, p. 75.
....do......	....	....do......	Gold, silver, lead.	Eng. and Min. Jour., Vol. 77, p. 1042.
....do......	Siliceous schists..	Milling......	Gold, silver.....	Mines and Minerals, Vol. 19, p. 277.
....do......	Basalt, granite, rhyolite.	....do......	....do.........	Eng. and Min. Jour., Vol. 77, p. 885.
....do......	Metamorphic schists.	Milling and smelting.	Gold, silver, copper.	Mines and Minerals, Vol. 21, p. 174.
....do......	Sedimetary rocks; slates and limestones.	....do......	Silver and lead, gold.	U. S. G. S., 20 Rept., Pt. 3, p. 127.
....do......	Granite........	....do......	Gold, silver.....	Ibid., 20 Rept., Pt. 3, p. 232.
....do......	....do.........	....do......	Gold-bearing....	Ibid., 20 Rept., Pt. 3, pp. 237–245.
....do......	....	....do......	Gold, silver.....	Ibid., 20 Rept., Pt. 3, p. 246.
....do......	....	....do......	Gold-bearing....	Min. and Sci. Press, Vol. 82, p. 293.
....do......	....	....do......	....do.........	Ibid., Vol. 82, p. 293.
....do......	....	....do......	....do.........	Ibid., Vol. 82, p. 293.
....do......	Quartzites and schists.	....do......	Silver-bearing...	T. A. I. M. E., Vol. 33, p. 241.
....do......	Archaean granite	Milling......	Gold, silver.....	Eng. and Min. Jour., Vol. 59, p. 128.
Zones of granite and porphyry with quartz stains.	Micaceous gray granite.	Smelting....	Gold-bearing....	Min. and Sci. Press, Vol. 81, p. 400.
Lodes, masses.	Rhyolite-porphyry.	Milling......	Gold, silver.....	Ibid., Vol. 84, p. 62.
Contact vein.	Hanging-wall limestone, foot-wall porphyry.	Smelting....	....do.........	Ibid., Vol. 84, p. 62.
....do......	Diorite and porphyry.	....do......	....do.........	Ibid., Vol. 83, p. 4.
Veins.......	....	Milling and smelting.	Gold-bearing....	Mines and Minerals, Vol. 19, p. 56.

TABLE II.—

Locality.	State.	Metalliferous Minerals and Metals and Bearers of the Precious Metals.	Gangue Minerals.
Washington mine, Boise Basin.	Idaho	One vein yields gold-bearing quartz, the other silver ore, native, ruby and antimonial silver.	Quartz, iron oxide...
Emperador.........	Isthmus of Panama.	Cinnabar, native mercury, gold amalgam.	Ferruginous quartz..
Gove and Trego counties.	Kansas ..	Auriferous and argentiferous shales.	Shales............
Montgomery County .	Maryland	Gold-quartz.................	Quartz............
Beaver mine, Dead River.	Michigan	Galena, blende, chalcopyrite, antimonial silver.	....do............
Iron River, Ontonagon.	....do...	Argentiferous, quartzless sandstone and shale.	Sandstone and shale.
Little American mine, Rainy Lake district.	Minnesota	Marcasite, pyrite, native silver...	Quartz, calcite.....
Bitterroot Range and Clearwater mountains.	Montana.	Lead and copper minerals......	....
Marysville district....	....do...	Sulphides and sulphantimonides of silver.	....
Elkhorn district......	....do...	Galena, bornite, tetrahedrite, pyrite, blende, silver sulphides.	Quartz, dolomite, garnet, pyroxene, fragments of country-rock.
Butte (silver belt)...	....do...	Enargite, chalcopyrite, bornite, chalcocite, blende.	Gypsum, sericite, rhodochrosite.
Drumlummon mine..	....do...	Sulphides and sulphantimonides of silver.	Quartz............
Fisher district.......	....do...	Pyrite, galena................	....do............
Ammon mines, Fergus County.	....do...	Auriferous limestone and porphyry.	Limestone and porphyry.
Big Indian mine, Helena.	....do...	Auriferous quartz and granite....	Quartz, hornblende, granite.
Judith Mt. district...	....do...	Free-gold, tellurides, pyrite, and silver mineral in small quantities.	Quartz and fluorite .
Black Pine, Granite Mt. lode.	....do...	Malachite, tetrahedrite.........	Quartz............
General............	N. H....	Pyrite, chalcopyrite, magnetite ..	Quartz............
Bridgewater copper mine.	N. J....	Carbonate and green phosphate of copper, red oxide of copper, native copper.	....

Continued.

Form of Deposit.	Country Rock.	Method of Treatment.	Remarks.	Reference.
Veins.......	Granite and diorite.	Milling and smelting.	Gold, silver.....	Eng. and Min. Jour., Vol. 78, p. 297.
....do......	Decomposed porphyry.	Milling......	Gold-bearing....	Eng. and Min. Jour., Vol. 34, p. 173.
Bedded deposits.	Shales.........	....	Gold and silver..	U. S. G. S., Bull. 202, 1902.
Veins......	Micaceous schists.	....do......	Gold-bearing....	T. A. I. M. E., Vol. 18, p. 391.
....do......	Hanging-wall granite, foot-wall talcose slate.	....do......	Gold, silver.....	Eng. and Min. Jour., Vol. 46, p. 238, Eng. and Min. Jour., Vol. 52, p. 119.
Bedded deposits.	Slate, shale and sandstone.	....do......	Silver-bearing...	Ibid., Vol. 20, p. 575, and T. A. I. M. E., Vol. 8, p. 488.
Bedded veins.	Gneiss, schists, eruptive granite.	....do......	Gold and silver-bearing.	Eng. and Min. Jour., Vol. 58, p. 509.
Veins......	....	Smelting....	Gold, silver.....	U. S. G. S., Bull. No. 213, p. 67.
....do......	Granite, slates, sandstones.	Milling and smelting.	Gold-bearing....	Ibid., Bull. No. 213, p. 89.
....do......	Marbles, quartzites, hornstones, igneous rocks.	Smelting....	Silver-bearing...	Ibid., 22 Rept., Pt. 2, p. 459.
....do......	Granite, aplite and porphyry.	....do......	....do.........	Mines and Minerals, Vol. 20, p. 350.
....do......	Sedimentary rock.	....do......	....do.........	U. S. G. S., Bull. No. 213, p. 89.
....do......	....	Milling......	Gold-bearing....	Min. and Sci. Press, Vol. 83, p. 78.
Jointed laminated structure.	Limestone and porphyry.	....do......	....do.........	Eng. and Min. Jour., Vol. 59, p. 416.
More like a bed than a lode.	Granite........	....do......	....do.........	Ibid., Vol. 78, p. 225.
Impregnated limestone next porphyry contact.	Limestone, porphyry.	Milling and smelting.	Gold, silver.....	U. S. G. S., 18 Rept., Pt. 3, p. 589.
Blanket vein.	Quartzite.......	Milling......	Silver-bearing...	Mines and Minerals, Vol. 26, p. 492.
Veins.......	Talcose slates....	....do......	Gold, silver.....	Am. Jour. Min., Vol. 2, p. 390.
....do......	....	Smelting....	Silver-bearing...	Eng. and Min. Jour., Vol. 33, p. 90.

TABLE II.—

Locality.	State.	Metalliferous Minerals and Metals and Bearers of the Precious Metals.	Gangue Minerals.
Lake Valley mine....	N. Mex..	Galena, pyrolusite, cerargyrite ..	Quartz (flint)......
Hopewell and Bromide districts, Rio Arriba County.	....do...	Copper, gold and silver in quartz and wall rock.	Quartz and wall rock (altered amphibolite).
Mogollon Range.....	....do...	Argentiferous and auriferous sulphides.	Quartz, calcite.....
Montezuma district...	Nevada..	Galena, chloride and sulphide of silver.	Quartz............
Silver Peak, Esmeralda County.	....do...	Gold-quartz..................	....do............
Tonopah...........	....do...	Pyrite, galena, iron and silver sulphates, oxides, carbonates, chlorides, with depth silver sulphides, argentite, ruby silver.	Quartz, calcite.....
White Pine.........	....do...	Green and gray chlorides, with hornsilver, lead and copper.	Quartz............
Gold Mt. State line lode.	....do...	Pyrite, phosphate of lead.......	Oxide of manganese, oxide of iron, quartz.
Bullfrog mine, Bullfrog district.	....do...	Silver chloride, native silver, auriferous talcose quartz.	Talcose quartz......
Goldfield..........	....do...	Pyrite, tetrahedrite and probably tellurides of gold.	Quartz............
Comstock mines.....	....do...	Blende, chalcopyrite, antimony, pyrite, stephanite, argentiferous fahlore, manganese, silver chloride and sulphide.	Quartz, clay, porphyry.
Ophir mine, Comstock lode.	....do...	Pyrite, chalcopyrite, galena, blende, tetrahedrite, molybdenite.	Quartz, calcite.....
Candelaria, Esmeralda district.	....do...	Galena, tetrahedrite, hornsilver..	Quartz............
Pioche.............	....do...	Oxides, carbonates, and phosphates of lead (originally galena), blende, hornsilver, sulphide of silver.	Hydrous oxides of iron and manganese.
General............	N. C.....	Brown iron ore, pyrite, chalcopyrite.	Quartz............
Carolina Gold Belt...	... .do...	Auriferous sulphides, fine free-gold (pyrite, blende, chalcopyrite, galena, mispickel).	Quartz, slates, schists.
King's Mountain.....	....do...	Pyrrhotite, pyrite, chalcopyrite, blende, tetrahedrite, galena, mispickel, altaite.	Dolomite, calcite, fluorite, quartz.

Continued.

Form of Deposit.	Country Rock.	Method of Treatment.	Remarks.	Reference.
Contact deposits.	Shales, quartzites, limestone and porphyry.	Milling and smelting.	Silver-bearing...	T. A. I. M. E., Vol. 24, p. 148.
Veins	Altered amphibolite.	Milling.....	Gold, silver, copper.	U. S. G. S., Bull. No. 285, p. 81.
....do......	....	....do......	Gold, silver.....	Ibid., Bull. No. 285, p. 85.
....do......	Complex of granite, gneiss, schist on which lie dolomite, limestone, slate.	Milling and smelting.	Silver-bearing...	Min. and Sci. Press, Vol. 82, pp. 75–78.
....do......	....do.........	Milling.....	Gold-bearing....	Ibid., Vol. 82, p. 73.
....do......	Porphyry.......	Smelting....	Gold, silver.....	Min. and Sci. Press, Vol. 88, p. 364; Ibid., Vol. 82, p. 231; Ibid., Vol. 91, p. 361.
....do......	Hornblende, andesite.	Milling.....	Silver-bearing...	Min. and Sci. Press, Vol. 18, p. 18.
....do......	Slate, granite...	....do......	Gold-bearing....	Ibid., Vol. 18, p. 62.
....do......	Rhyolite, porphyry, limestone, andesite.	Milling and smelting.	Gold, silver.....	Eng. and Min. Jour., Vol. 80, p. 12; Min. and Sci. Press, Vol. 90, p. 273.
....do......	Basalt and rhyolite.	....do......	Gold-bearing....	Min. and Sci. Press, Vol. 90, p. 394.
....do......	Proplite or porphyry and syenite.	Milling.....	Gold, silver.....	Eng. and Min. Jour., Vol. 18, p. 404; Mines and Minerals, Vol. 26, p. 3.
....do......	....do.........	....do......	....do.........	Min. and Sci. Press, Vol. 71, p. 233.
....do......	....	Milling and smelting.	Silver-bearing...	Ibid., Vol. 82, p. 78.
....do......	Quartz, porphyry	....do.......	....do.........	Eng. and Min. Jour., Vol. 51, p. 171.
....do......	Slates and schists.	Milling.....	Gold, silver.....	Am. Jour. Min., Vol. 1, p. 313.
Disseminations and veins.	Schists, slates...	....do......	Gold-bearing....	T. A. I. M E., Vol. 25, p. 667; Eng. and Min. Jour., Vol. 31, p. 397.
Veins.......	Limestone, schists	....do......	Gold, silver.....	Ibid., Vol. 31, p. 39.

TABLE II.—

Locality.	State.	Metalliferous Minerals and Metals and Bearers of the Precious Metals.	Gangue Minerals.
Southern	Oregon	Pyrite, chalcopyrite	Quartz
Silver Springs, Wasco County.	....do...	Silver chloride	....
Elkhorn and Rock Creek district.	....do...	At the surface, chloride of silver; in depth, argentiferous galena and blende.	Quartz and clay gouge.
Bohemia district, Lane and Douglas counties.	....do...	Auriferous and argentiferous sulphides.	Quartz
Blue Mountains	....do...	Pyrite, arsenopyrite, blende, galena, chalcopyrite, cinnabar, tellurides, stibnite, pyrargyrite.	....do...
Carolina gold belt	S. C.	Auriferous sulphides, fine-gold	....do...
Homestake mine	S. Dak.	Pyrite, arsenopyrite, lead carbonate.	Quartz, calcite, dolomite.
Deadwood and Galena, Black Hills.	....do...	Galena, lead carbonate, free-gold	Quartz, feldspar
Black Hills	....do...	Coal, bearing gold	Coal
Presidio mine, Shafter	Texas	Argentiferous galena, chloride of silver.	Dolomitic limestone.
De Lamar Mercur mines.	Utah	Orpiment, cinnabar, realgar	Quartzite, shale, limestone.
Mercur mines	...do...	(1) Silver ledge carries, stibnite, gold and silver (2) Gold ledge carries, realgar, cinnabar, pyrite.	Quartz, calcite, barite.
Tintic mines	....do...	Native gold, tellurium, galena, blende, cerargyrite, enargite, chalcopyrite, tennanite.	Quartz
Chloride Point, Mercur district.	....do...	Galena, cerussite, stibnite, malachite, azurite, red oxide of copper, chloride of silver.	Calcite, barite, gypsum.
Bingham cañon mines.	....do...	Galena, cerussite anglesite blende, calamine, cerargyrite, pyrargyrite, pyrite, realgar, chalcopyrite, enargite, lead carbonate, black copper sulphide.	Quartz, calcite, barite, rhodochrosite.
Silver Reef	....do...	Sulphide and chloride of silver, native silver, hornsilver.	Quartz
Horn Silver mine, Frisco.	....do...	Hornsilver, sulphate of lead	....do...
State Line district	...do...	Pyrite, oxides of iron and manganese.	....do...

Continued.

Form of Deposit.	Country Rock.	Method of Treatment.	Remarks.	Reference.
Veins.......	....	Milling and smelting.	Gold, silver	Min. and Sci. Press, Vol. 87, p. 391.
Sinter deposits.	Saline sinter deposits.	....	Silver-bearing...	Ibid., Vol. 34, p. 415.
Veins.......	Granite, schists, gneiss, quartzites.	....do......	Gold, silver.....	Eng. and Min. Jour., Vol. 62, p. 128.
Lodes and breccia.	Andesite........	....do......	....do........	Ibid., Vol. 73, p. 889.
Veins.......	Granite, schists, gneiss, quartzites.	....do......	....do.........	U. S. G. S., 22 Rept., Pt. 2, p. 604.
Veins and disseminations.	Slates, schists ...	Milling......	Gold-bearing....	T. A. I. M. E., Vol. 25, p. 667.
Veins and bedded deposits.	Mica schists.....	....do......	Gold, silver.....	Min. and Sci. Press, Vol. 87, p. 187.
Veins.......	Porphyry.......	....do......	Gold, silver, lead.	Eng. and Min. Jour., Vol. 30, p. 57.
Bedded deposit.	Coal...........	....do......	Gold-bearing....	T. A. I. M. E., Vol. 29, p. 227.
Impregnations	Limestone......	....do......	Silver-bearing...	Eng. and Min. Jour., Vol. 74, p. 150.
Bedded deposits.	Shale, limestone.	Milling and smelting.	Gold and silver-bearing.	Ibid., Vol. 68, p. 754.
....do......	......do.......	....do......	....do.........	Ibid., Vol. 63, p. 404; U. S. G. S., 16 Rept., Pt. 2, p. 368.
Bedded deposits and veins.	Sedimentary rocks.	....do......	Gold, silver.....	U. S. G. S., 19 Rept., Pt. 3, p. 685.
Bedded deposits.	Altered and shattered limestone.	....do......	Silver-bearing...	Min. and Sci. Press, Vol. 77, p. 451.
Veins and disseminations.	Carbonaceous quartzites, limestones, calcareous shale.	Smelting....	Gold, silver, copper, lead, zinc.	U. S. G. S., Bull. 213, p. 118, Mines and Minerals, Vol. 19, p. 378, Eng. and Min. Jour., Vol. 79, pp. 1176–1178.
Bedded deposits.	Sandstone......	....do......	Silver-bearing...	Eng. and Min. Jour., Vol. 29, p. 25.
Contact veins.	Hanging-wall, trachyte, footwall, limestone and quartzite.	....do......	....do.........	Colliery Engineer, Vol. 12, p. 50.
Veins.......	Porphyry.	Milling and smelting.	Gold, silver.....	Min. and Sci. Press, Vol. 84, p. 101.

TABLE II. —

Locality.	State.	Metalliferous Minerals and Metals and Bearers of the Precious Metals.	Gangue Minerals.
Ontario mine	Utah	At surface, chloride of silver; in depth, polybasite, blende, pyrite.	Quartz
Deep Creek region	....do	Gold in tremolite with a little pyrite.	Tremolite
Leeds	....do	Green carbonate of copper, nodules of iron, carbon and chloride of silver.	Carbon, clay, shale
Annie Laurie mine, Piute County.	....do	Gold and silver, bearing quartz and calcite.	Quartz, calcite
Old Telegraph mine	....do	Galena, blende, pyrite, carbonate of lead.	Quartz, ochres
Maude mine, Toquerville.	....do	Silver chloride in mineral sinter	Sinter deposits
Daly-West mine	....do	Silver-lead carbonates and sulphides.	Quartz
General	Virginia	Pyrite, chalcopyrite	..do
Orange County	....do	Pyrite, chalcopyrite	..do
Stafford County	....do	....do	..do
Fluvanna County	....do	Pyrite, tellurium, iron oxide	Sandy quartz
Louisa County	....do	Oxide of iron and free-gold	Quartz, slate
Monte Christo mine	Wash.	Chalcopyrite, galena, blende, pyrite, arsenopyrite.	Tonalite, andesite
Silverton district, Snohomish County	....do	Chalcopyrite, galena, ruby silver, mispickel, pyrrhotite, pyrite, bornite.	Quartz
Independent mine, Silverton district.	....do	Realgar, pyrite, arsenopyrite, galena, blende.	..do
Republic mine	....do	Pyrite, marcasite, pyrrhotite, galena, arsenopyrite, magnetite, chalcopyrite, bornite, cuprite, blende, millerite, stibnite, argentite.	..do
Monte Cristo district	....do	Blende, argentiferous galena, mispickel.	Largely arsenical pyrite.
Stevens County	....do	Galena, sulphide of silver	Limestone
Weston County	Wyoming	Pyrite and gold in coal	Coal
Montreal River	Wisconsin	Argentiferous quartzless sandstone and shale.	Sandstone and shale.

Continued.

Form of Deposit.	Country Rock.	Method of Treatment.	Remarks.	Reference.
Veins, contacts and replacements	Limestone......	Milling and smelting.	Silver-bearing...	Colliery Engineer, Vol. 12, p. 49.
....	....do.........	Milling......	Gold-bearing....	Eng. and Min. Jour., Vol. 53, p. 253.
Bedded deposits.	Sandstone......	Smelting.....	Silver-bearing...	Ibid., Vol. 23, p. 317.
Veins.......	Dactite.........	Milling......	Gold, silver.....	U. S. G. S., Bull. No. 285, p. 87.
Bedded......	Limestones and shales with intrusives.	Milling and smelting.	....do.........	T. A. I. M. E., Vol. 16, p. 26.
Mineral spring sinter.	Sinter.........	....	Silver-bearing (?)	Min. and Sci. Press, Vol. 34, p. 415.
Veins.......	....	....do......	Silver, gold, lead.	Ibid., Vol. 82, p. 242.
....do......	....	Milling......	Gold-bearing....	Am. Jour. Min., Vol. 2, p. 389.
....do......	Talcose slate....	Milling and smelting.	Gold-bearing....	Eng. and Min. Jour., Vol. 6, p. 377.
....do......	....	....do......	Gold, silver.....	Ibid., Vol. 6, p. 377.
....do......	....	Milling......	Gold-bearing....	Ibid., Vol. 6, p. 393.
Veins of quartz and impregnations in state	Slates..........	....do......	....do.........	Ibid., Vol. 6, p. 393.
Breccia......	Tonalite, andesite.	Milling and smelting.	Gold, silver.....	U. S. G. S., 22 Rept., Pt. 2, p. 865.
Veins.......	Slates..........	....do......	Silver..........	Eng. and Min. Jour., Vol. 72, p. 105.
....do......	Schists, granite	....do......	Gold, silver.....	Ibid., Vol. 73, p. 832.
....do......	Foot-wall, andesite-porphyry, hanging-wall, porphyritic conglomerate.	....do......	Gold, silver.....	Ibid., Vol. 68, p. 636.
....do......	Back slate overlying metamorphic granite.	....do......	....do.........	Ibid., Vol. 55, p. 343.
Bedded deposits.	Limestone......	Milling......	Silver-bearing...	Mines and Minerals, Vol. 18, p. 313.
....do......	Coal...........	....	Gold...........	Min. and Sci. Press, Vol. 90, p. 184.
....do......	Sandstone, shale.	....	Silver-bearing...	T. A. I. M. E., Vol. 8, p. 488.

TABLE III.—TABLE SHOWING GEOLOGICAL DISTRIBUTION OF GOLD AND SILVER.

Locality.	State or Territory.	Geological Age.	Form of Deposit.	Kind of Country-Rock.	Remarks.
Southeastern	Alaska	Mesozoic or older	Bedded		Gold-bearing.
Chistochina	do	Post-Permian and pre-Eocene	Veins	Metamorphic	do.
Douglas Island	do	Triassic	do	Carbonaceous slate	do.
Unga Island	do	Post-Miocene	do	Andesite	Gold, copper, lead, zinc.
Seward Peninsula	do	Paleozoic	do		Gold-bearing.
Yukon	do	Chiefly pre-Cambrian	do		do.
Fortuna mine	Arizona	Pre-Cambrian-Algonkian or Huronian in part.	do	Granite and old crystalized sedimentary rocks.	Gold, silver, lead.
Black and Bradshaw ranges, Prescott.	do	Pre-Cambrian	do	Schist, granite, and eruptives	Gold, silver, copper.
Silver King	do	Archæan	do	Granite, prophyry, syenite, slate, gneiss.	Silver-bearing.
Eastern	California	Jurassic	do	Slates	Gold-bearing,
		Tertiary	do	Lavas	Gold, silver.
Onion Valley, Plumas County.	do	do	do	Quartz, rhyolite	Gold-bearing.
Bodie	do	do	do	Hornblende-andesite	Gold, silver.
Southern	do	do	do	Rhyolite	Silver-bearing.
Sierra Nevada	do	Principally in Paleozoic or Jura-Trias.	do		Gold-bearing.
Silver Mt. district, Alpine County.	do	Tertiary	do	Andesitic-tufas	Gold and silver in Chalcedonic quartz.
Monitor district	do	do	do	Volcanic rocks	Gold, silver.
Coulterville	do	Lowest Cretaceous	do		Gold, mercury.
Calico district	do	Pliocene	do	Laparites, tufas, sandstones	Silver chloride.
Duncan mine, Thunder Bay.	Canada	Lower Silurian	do	Black slates of upper copper formation.	Silver-bearing.
Rainy Lake district, Ontario.	do	Laurentian-Huronian	do	Metamorphic rocks (schists)	Gold-bearing.

Sierras	California	Tertiary-Pliocene and Miocene	Ancient placers.	Gravels	Gold-bearing.
Later deep placers	do	post-Pliocene or latest Tertiary	do	do	do.
Oldest and deepest placers.	do	Eocene and lower Miocene	do	do	do.
Bear Creek near Silverton.	Colorado	Pre-Cambrian	Veins	Schists, slates, quartzites	Gold, silver.
American Nettie mine, Ouray	do	Cretaceous	do	Dakota sandstone	Gold, silver.
Contention mine, Telluride.	do	Tertiary	do	Conglomerate	do.
Good Hope mine, Vulcan.	do	Algonkian	do	Crystalline schists, mica schists	do.
Ruby Chieftan vein, Irwin district.	do	Upper-Cretaceous	do	Sandstone, shales	do.
La Plata mines, Storm Peak.	do	Mesozoic	do		do.
Rico district, San Juan Mts.	do	Lower Carboniferous, Tertiary, Pleistocene.	do	Limestone	Lead, silver.
Leadville	do	Cambrian, Silurian, Carboniferous	Massive	Cambrian, quartzites, Silurian and Carboniferous limestone.	do.
Eagle River	do	Carboniferous	Contact	Limestone	Anglesite.
Aspen	do	do	Massive	Limestone, dolomite	Lead, silver.
Cripple Creek, Teller County.	do	Pre-Cambrian	Veins	Granite, phonolite, mica schists	Gold, silver.
Smuggler vein	do	Post-Cretaceous or early Eocene	do	Andesites and rhyolites	do.
Creede	do	Probably Carboniferous	do	Limestones and eruptives	Silver-bearing.
Dahlonega district	Georgia	Carbo-Silurian (Ocoee)	do	Schists, slates	Gold-bearing.
Region between Trenton and Medina	do	Cincinnati	do	Hard hornblendic gneiss	do.
Coeur D'Alêne district.	Idaho	Algonkian (pre-Cambrian)	do	Sedimentary rocks and limestones	Lead, silver.
Boise Basin	do	Archæan	do	Granite-porphyry	Silver, gold.
Warren district	do	Pre-Miocene	do	Granite	do.
Thunder Mt.	do	Tertiary and later	Bedded	Basalt and tufaceous materials	Gold-bearing.
Wood River	do	Post-Carboniferous, post-granitic and pre-Miocene.	Veins	Limestone, shale, sandstone	Gold, silver, lead.
Western	Kansas	Cretaceous	Bedded	Shale	Gold, silver.

TABLE III. — *Continued.*

Locality.	State or Territory.	Geological Age.	Form of Deposit.	Kind of Country-Rock.	Remarks.
Rainy River district	Minnesota	Laurentian, Keewatin, Coutchiching	Veins	Granite, gneiss, schists	Gold-bearing.
Madison County	Montana	Cambrian		Limestone	Gold, silver.
Butte, Silver Bow County.	do	Post-Carboniferous or post-Laramie.	do	Basic and acidic granite	Silver, lead, zinc.
Missoula County	do	Lower Cambrian or Algonkian	Impregnations	Slates	Gold-bearing.
Bitterroot Range and Clearwater Mts.	do	Late Mesozoic	Bedded		do.
Goldfield	Nevada	Tertiary	Veins	Andesites, rhyolites	Gold-bearing.
Tonopah	do	do	do	do	Gold, silver.
White Pine	do	Devonian	do	Limestone, shale	do.
Comstock lode	do	Tertiary	do	Lavas (chiefly andesites)	do.
Eureka	do	Cambrian	Impregnations	Limestone	Lead, silver.
Three authentic occurrences.	New York	Lower Silurian	Veins		Gold-bearing quartz.
Lake Valley	New Mexico	Silurian	Massive	Quartzite limestone	Lead, silver.
General	do	1, pre-Cambrian, 2, post-Cretaceous, including late Cretaceous and middle Tertiary.	Veins		Gold, silver.
Green Mts.	New Hampshire.	Algonkian	do	Talcose rocks	Gold-bearing.
General	North Carolina.	Tertiary, Cretaceous, Triassic, or pre-Cambrian.	do	Schists and slates	do.
Blue Mts.	Oregon	Post-Triassic, pre-Neocene	do	Slates and granite	do.
Bohemia district	do	Eocene or early Miocene	do	Andesites	do.
Elkhorn and Rock Creek districts	do	Jura-Trias	do	Granites, schists, and quartzites	Gold, silver.
Southwestern	do	Pre-Tertiary and to or through the upper Cretaceous.	do	do	Gold-bearing.

South Black Hills	South Dakota.	Algonkian, Cambrian, Carboniferous and recent.	Veins	Eruptives and schists	do.
Homestake and Deadwood mines.	do	Post-Cretaceous	do	Felsite in porphyry	do.
Northern Black Hills	do	Cambrian-Algonkian	Bedded and veins	Sandstones, schists	Gold, silver, lead.
Ragged Top	do	Carboniferous	Veins	Gray sandstones	Gold-bearing.
Galena and Carbonate.	South Dakota.	Carboniferous	Veins	Sandstone	Lead-silver (siliceous ore).
General	South Carolina	Tertiary, Triassic, Cretaceous, or pre-Cambrian	do	Schists, slates	Gold-bearing.
General	Tennessee	Carbo-Silurian	do	do	Gold-quartz.
Box Elder	Utah	Cambrian and Carboniferous	do		Lead, silver.
Brigham	do	Carboniferous	Bedded	Below, quartzites; above, limestone.	do.
Silver Reef	do	Triassic	Impregnations.	Sandstone	Silver-bearing.
Western	do	Lower Carboniferous	Bedded	Granite and limestone	Gold, silver, lead, copper.
Monte Cristo	Washington	Late-Pliocene or early Pleistocene	Veins	Granite and slates	Gold, silver.
General	Wyoming	Cretaceous and Tertiary	do	Gneiss, schists, granites	Gold-quartz.
Rainy Lake district	Canada	Laurentian-Huronian	do	Metamorphics	do.
General	Nova Scotia	Cambrian or pre-Cambrian	do	Metamorphosed fragmentary deposits.	do.
General	Mexico	Silver, Carboniferous, Triassic and Cretaceous.	do		Gold, silver,
Chihuahua	do	Cretaceous	do		Silver-bearing.

TABLE IV.—YIELD OF ORES

Locality.	Kind of Ore.	Yield of Ore per Ton. Range.
Alabama.		
Pinetucky, Randolph County.	Gold-bearing	As high as 40 to 150 dollars.
Mossback mine, Arbacoochee district.	....do	Assays from 25 to 30 dollars.
Turkey Heaven district	....do	Mill returns, 6 dollars, assay value, 6 to 12 dollars.
General	....do	Quartz carries 3 to 4 ounces up to 2,000 dollars; the decomposed schists yield from 1 to 2.5 dollars.
Alaska.		
Annette Island, Ketchikan district.	Quartz carrying silver-bearing tetrahedrite and free gold.	Silver, 600 to 2000 ounces; gold, runs in the hundreds.
Berners Bay, Comet and Bear mines.	Chalcopyrite, galena, gold and mispickel.	50 to 60 dollars
Bald Eagle mine, Sumdum Bay.	Galena, blende, mispickel, gold.	40 to 50 dollars
Sheep Creek Basin, Silver Queen mine.	Galena, blende, chalcopyrite, mispickel, pyrrhotite, gold, silver.	....
Tellurium and War Horse mines, Funter's Bay.	Pyrrhotite, chlorite, bearing gold, also pyrite.	10 to 15 up to 150 dollars
Apollo Consolidated mine, Unga Island.	Galena, blende, chalcopyrite, pyrite, gold-bearing.	....
Gravina Island, Ketchikan district.	Free gold in quartz and pyrite in schists, gold, copper, silver, lead.	1.5 to 5 dollars gold, 1 to 5 ounces silver.
Near Sitka	Pyrite, chalcopyrite, mispickel, gold-bearing.	....
Niblack Anchorage, Ketchikan district.	Pyrite, chalcopyrite, magnetite and quartz, gold and silver-bearing.	2 to 4 dollars in gold; 3 ounces silver.
Ketchikan district, general	Gold and silver-bearing	(1) Gold, 1 to 5 dollars; silver, 1 to 5 ounces. (2) Gold, 6 dollars; silver, 7 ounces. (3) Gold, 2 to 4 dollars; silver, 3 ounces, etc.
Cleveland Peninsula, Ketchikan district.	Gold-quartz	1 to 2.5 dollars, gold
The Tundra	Auriferous gravel, depth 37 feet.	126 to 433 dollars per ton — or 15 cents to 5.5 dollars per pan.
Nome	Gold-bearing	20 to 40 dollars

BY DISTRICTS AND MINES.

Yield of Ore per Ton. Average.	Percentage Total Content.	Value of Concentrates per Ton and Degree of Concentration.	Reference.
Average assay returns 100 dollars.	....	Assay of concentrates 300 to 400 dollars.	Eng. and Min. Jour., Vol. 63, p. 256, Ibid., 55, p. 486, T. A. I. M. E., Vol. 25, p. 726.
....	....	....	Eng. and Min. Jour, Vol. 47, p. 458.
3 dollars..........	....	....	Ibid., Vol. 55, p. 486.
....	....	....	Fed. Inst. Min. Engrs., Vol. 14, p. 93.
....	....	....	Min. and Sci. Press, Vol. 83, p. 98.
....	....	....	U. S. G. S., 18 Rept., Pt. 3, p. 76.
....	....	....	Ibid., 18 Rept., Pt. 3, p. 76.
40 dollars.........	....	....	Ibid., 18 Rept., Pt. 3, p. 73.
10 dollars.........	....	....	Ibid., 18 Rept., Pt. 3, p. 77.
8 dollars..........	....	Four-fifths caught on plates.	Ibid., 18 Rept., Pt. 3, p. 83.
4 to 6 dollars......	....	Sulphurets: pyrite and blende, chalcopyrite, 2 to 5 per cent in high-grade ore.	Min. and Sci. Press, Vol. 83, p. 98.
5 dollars..........	....	....	U. S. G. S., 18 Rept., Pt. 3, p. 77.
....	....	....	Min. and Sci. Press, Vol. 83, p. 99.
....	....	....	Ibid., Vol. 83, p. 98.
....	....	....	Ibid., Vol. 83, p. 98.
....	....	....	Int. Min. and Met., Vol. 9, p. 181.
....	....	....	Ibid., Vol. 9, p. 181.

TABLE IV.

Locality.	Kind of Ore.	Range. Yield of Ore per Ton.
Arkansas.		
Silver City	Galena, gray copper, brittle copper, chlorides and sulphides.	Assays range from a few up to 500 dollars.
General	Gold and silver	9 to 12 gold, 216.77 ounces silver, or 70 to 1200 dollars.
Arizona.		
Hillside mine	Gold and silver	Running as high as 1000 dollars.
Congress mine, Prescott	....do	....
Silver King mine, Pinal County.	Silver ores	Mills as high as 200 dollars...
Tombstone	Gold and silver	Gold, $\frac{5}{8}$ to 1 ounce; silver, 60 to 400 ounces.
Contention and Grand Central mines.	....do	Gold, 1 ounce; silver, 80 ounces; gold, 20 ounces; silver, 80 ounces.
Henry Clay and Harqua Halla districts.	....do	10 to 150 dollars
Yavapai County	....do	Gold, 10 to 20 dollars; silver, 12 to 60 ounces.
Lucky Cuss, Tombstone	Gold in alabandite	Runs as high as 12 dollars...
California.		
Carbonate mine, San Bernardino County.	Galena, carbonate, etc., bearing gold and silver.	From a few hundred to 25,000 dollars.
Clear Creek	High-grade gold ore	50 to 400 dollars
Empire mine, Grass Valley..	Gold-bearing quartz	Less than 1 up to 60 and even 200 dollars.
Yellow Aster, Randsburg ...	....do	....
Panamint, Death Valley	Free-milling gold ore	Coso district, 2 to 9.60 dollars; Wild Rose district, 81 to 193 dollars.
Cedros Island	Gold in native sulphur	....
Manzanita, Monticello and Clyde mines, Colusa County.	Sulphurets and cinnabar gold-bearing.	In 1877 ore ran as high as 42 dollars, since then less than 10 up to 100 dollars.
Calico mines	Silver-bearing	Variable, but seldom below 20 and up into the hundreds.
Forbestown district, Butte County.	Gold-quartz, little free gold.	....

— Continued.

Yield of Ore per Ton. Average.	Percentage Total Content.	Value of Concentrates per Ton and Degree of Concentration.	Reference.
....	....	....	Eng. and Min. Jour., Vol. 29, p. 385.
Average of five veins, 216.77 ounces silver.	....	....	Ibid., Vol. 30, pp. 186, 187.
....	....	....	Ibid., Vol. 50, p. 162.
....	....	Vanner sulphurets yield $140 to $250 gold and a few ounces silver.	Ibid., Vol. 51, p. 629.
....	....	....	Colliery Engineer, Vol. 12, p. 73.
70 dollars.........	Gold, 20 to 25 per cent.	Percentage saved by milling, 85 silver, and 45 gold.	T. A. I. M. E., Vol. 33, p. 34; Min. and Sci. Press, Vol. 91, p. 190; Eng. and Min. Jour., Vol. 49, p. 361.
....	....	....	T. A. I. M. E., Vol. 33, p. 34.
20 to 25 dollars....	....	....	Eng. and Min. Jour., Vol. 73, p. 796.
Milling ore averages 20–25 dollars.	Copper, 3 to 6 per cent.	Concentration 8 to 1. 15 per cent. smelter ore.	Ibid., Vol. 78, p. 833, and Ibid., Vol. 63, p. 212.
....	....	....	T. A. I. M. E., Vol. 33, p. 31.
....	....	....	Eng. and Min. Jour., Vol. 51, p. 627.
....	....	....	T. A. I. M. E., California Mines and Minerals, p. 375.
....	....	Sulphurets: 2½ to 3½ per cent.	Min. and Sci. Press, Vol. 81, p. 184.
40 dollars	....	....	T. A. I. M. E., California Mines and Minerals, p. 399.
Average for Panamint, 18 dollars.	....	....	Eng. and Min. Jour., Vol. 80, pp. 916, 917.
Average of assays 100 dollars.	....	....	Ibid., Vol. 51, p. 627.
....	....	....	Ibid., Vol. 42, p. 186, Min. and Sci. Press, Vol. 34, p. 280.
....	....	....	T. A. I. M. E., Vol. 15, p. 731.
....	....	Sulphurets run from 100 to 200 dollars.	Ibid., California Mines and Minerals, p. 284.

TABLE IV.

Locality.	Kind of Ore.	Yield of Ore per Ton. Range.
California.—Continued.		
Randsburg	Gold-quartz	Runs as high as 100 dollars
Golden West mine, Blue Cañon.	....do	5 to 100 dollars
Sierra Nevada	Auriferous slates often cut by dikes.	50 cents to 50 dollars
Mother lode	Gold-bearing	1 to 25 dollars free gold
Enterprise district		
Nashville, Eldorado County	Gold-quartz	3 to 15 dollars
Calaveras County	Gold in volcanic tufa, mud and gravel.	
Golden Cross mines, Cargo Muchacho district.	Gold-bearing	
Canada.		
Silver Islet, Thunder Bay	Silver-bearing	Hand specimens ran as high as 2000 to 2500 dollars.
Colorado.		
Bassic mine, Rosita	Ore occurs partly as the telluride of gold and silver.	Ore assays from 200 to 5000 dollars.
Robert E. Lee on Fryer Hill	Silver and lead	Chloride ores range from 2000 to$20,000on 150-foot level.
Newman Hill	Gold and silver	Horizontal ore-bodies; gold, 2 to 9 ounces; silver, 300 to 800 ounces, cross-veins. At contact: gold, 2 to 9 ounces; silver, 200 to 500 ounces.
Cripple Creek	Ores contain but little silver as a rule.	35 to 40 dollars and 50 to 85 dollars.
Victor mine, Cripple Creek	Gold-bearing	
Wild Horse mine, Cripple Creek.	Gold and silver	
Independence mine, Cripple Creek.	Gold-bearing	
Aspen	Galena, blende, copper, silver.	Smelting ore ranges from 125 to 150 ounces.

— Continued.

Yield of Ore per Ton. Average.	Percentage Total Content.	Value of Concentrates per Ton and Degree of Concentration.	Reference.
40 dollars			T. A. I. M. E., California Mines and Minerals, p. 401.
			Ibid., p. 298.
			Colliery Engineer, Vol. 11, p. 274.
Low-grade, less than 7 dollars; medium-grade, 7 to 12 dollars; high-grade, above 12 dollars. Average pay ore carries 1 to 2 per cent sulphides, 75 to 100 dollars.		Value of sulphurets, 40 to 125 dollars.	Min. and Sci. Press, Vol. 76, p. 105.
9 dollars free gold			T. A. I. M. E., California Mines and Minerals, p. 284.
			Ibid., p. 310 (1868).
3 dollars			Min. and Sci. Press, Vol. 80, p. 148.
2 to 5 dollars			T. A. I. M. E., California Mines and Minerals, p. 403.
Tens of tons ran as high as 10,000 dollars.			Eng. and Min. Jour., Vol. 26, p. 388 (1878).
			Colliery Engineer, Vol. 12, p. 73.
			Min. Magazine, Vol. 11, p. 433.
			Eng. and Min. Jour., Vol. 54, p. 175.
Silver, 1 ounce, gold 10 ounces.			U. S. G. S., Professional Paper No. 54, p. 171.
Average shipping ore 250 dollars.			Eng. and Min. Jour., Vol. 56, p. 193.
		Below 8th level, smelting ore 90 dollars.	Ibid., Vol. 87, p. 87.
Gold, 4½ ounces			Ibid., Vol. 68, p. 68 (1899).
	Zinc, 15 per cent; copper 5 per cent.	Lead abundant enough for smelting.	Ibid., Vol. 39, p. 277 (1885).

TABLE IV.

Locality.	Kind of Ore.	Yield of Ore per Ton. Range.
Colorado. — Continued. Grand View mine, Ouray....	Gold and silver, galena, copper carbonate.	Assays run as high as 25 ounces gold, 43 ounces silver. Mill runs 100 to 150 dollars, 14 to 20 dollars being silver.
Sylvanite mine............	Silver-bearing...........	....
Rico district..............	Gold and silver...........	Gold, 2 to 9 ounces; silver, 300 to 800 ounces.
Tom Thumb mine, Hahn's Peak.	Gold, silver, lead.........	Assays show that there are from 30 to 50 cents per ton gold in rock.
Emma mine, Aspen........	Lead, silver..............	Always assayed over $200 per ounce silver and not less than 20 per cent lead.
Enterprise mine, Rico......	Gold and silver..........	....
C. O. D., Cripple Creek.....	Gold, silver, gray copper...	....
Golden Ring, Cripple Creek..	Gold and silver	....
Rocky Point group, Battle Mt., Cripple Creek.	Gold and silver...........	One-half-product gold.......
Eagles, Cripple Creek.......	....do.................	....
Fryer, Carbonate and Iron hills, Leadville.	Silver and lead...........	Ran as high as 120 dollars silver and 30 per cent lead.
Portland mine............	Gold-bearing............	23.60 to 71 dollars.........
Standley mine, Idaho Springs	Gold and silver...........	Gold, 1.50 to 1.75 dollars; silver, 70 to 100 ounces.
Leadville................	Gold, silver and carbonate of lead.	Assays show gold and silver values 40 to 70 dollars.
Vindicator mine, Cripple Creek.	Gold and silver...........	....
Topeka mine, Central City...	Gold-bearing............	Two classes rich quartz ore: milling, 40 and 60 dollars; smelting, 655 to 1589 dollars.

— *Continued.*

Yield of Ore per Ton. Average.	Percentage Total Content.	Value of Concentrates per Ton and Degree of Concentration.	Reference.
....	....	....	Eng. and Min. Jour., Vol. 26, p. 405.
142.21 ounces......	....	....	Ibid., Vol. 46, p. 499.
Cross-vein ores average 12 dollars.	....	....	Colliery Engineer, Vol. 17, p. 360.
Gold, 2 ounces; silver, 52 ounces; lead, 51.8 per cent.	....	....	U. S. G. S., Bull. 285, p. 32 (1905).
....	....	....	Eng. and Min. Jour., Vol. 39, p. 277 (1885).
Gold, .5 to 3 ounces; silver, 100 to 200 ounces.	Lead, 0 to 10 per cent; zinc, 0 to 15 per cent.	....	U. S. G. S., 22 Rept., Pt. 2, p. 327.
On 10th level, ore 80 dollars, average.	....	....	Eng. and Min. Jour., Vol. 87, p. 87.
Below 8th level, 80 dollars, average.	....	....	Ibid., Vol. 76, p. 87.
60.36 dollars......	....	....	Ibid., Vol. 53, p. 545.
60 dollars.........	....	....	Ibid., Vol. 76, p. 86.
....	....	....	Mining Magazine, Vol. 11, p. 433
....	....	10th level of Hidden Treasure, 35 dollars; sorted ore increased in value twice.	Eng. and Min. Jour., Vol. 76, p. 86 (1903); U. S. G. S., Professional Paper No. 54, p. 171 (1905).
Gold, 2½ to 4½ ounces; silver, 30 to 40 ounces.	High values of silver and low gold values in upper levels, the silver decreases and gold increases with depth.	....	Colliery Engineer, Vol. 14, p. 283 (1894).
....	Lead 15 to 30 per cent	....	Ibid., Vol. 12, p. 73.
Smelting ore 50 dollars on 10th level.	....	....	Eng. and Min. Jour., Vol. 76, p. 86.
Hanging-wall vein (free-milling), 20 dollars; foot-wall vein, milling ore 9.38, smelting 51.30 dollars.	....	....	Mines and Minerals, Vol. 20, p. 82.

TABLE IV.

Locality.	Kind of Ore.	Yield of Ore per Ton. Range.
Colorado.—Continued.		
Hull City, Cripple Creek	Gold, silver, gray copper	
Doctor Jackpot, Cripple Creek	Gold and silver	
Findley, Cripple Creek	do	
Gold Coin, Cripple Creek	do	Below 12 dollars, low-grade
Camp Bird, Ouray	Gold-bearing	
Pharmacist, Bull Hill, Cripple Creek.	Gold and silver	20 to 30 dollars
Virginius mine, Ouray	Gold, silver, galena, gray copper.	
Shurtloff mine, Cripple Creek	Gold and silver	
Golden Cycle mine, Cripple Creek.	do	
La Plata mines, Silver Lake Basin.		
Vulcan mine	Auriferous pyrite	4 to 14 dollars
Rico, Dolores County, Enterprise Hill.	Gold, silver, lead	4.75 to 7.50 dollars
Hibernia tunnel, cutting Enterprise Hill.	Gold-bearing shale	
Lamartine mine, Idaho Springs.	Gold and silver	
Smuggler-Union, Telluride	do	
Georgia.		
Dahlonega	Gold-quartz	
Finley mine	do	
General	Gold-bearing	1.25 to 1.50
Idaho.		
Blaine County	Gold and silver	Silver values range from 96 to 204 dollars.

— *Continued.*

Yield of Ore per Ton. Average.	Percentage Total Content.	Value of Concentrates per Ton and Degree of Concentration.	Reference.
Low-grade, 11 dollars; 40 dollars average.	....	....	Eng. and Min. Jour., Vol. 87, p. 87.
40 dollars.........	....	....	Ibid., Vol. 76, p. 86.
12th level yields smelting ore 35 dollars.	....	....	Ibid., Vol. 76, p. 87.
22 to 34.50 dollars..	....	....	Ibid., Vol. 76, p. 86.
33.41 dollars.......	....	....	T. A. I. M. E., Vol. 33, p. 528.
....	....	....	Mining Magazine, Vol. 11, p. 417 (1904).
Galena when free from copper assays 50 ounces silver.	No gold at surface, but increases to 2 ounces in depth.	....	Eng. and Min. Jour., Vol. 76, p. 268.
8th level yields smelting ore, 45 dollars.	....	....	Ibid., Vol. 76, p. 87.
10th level smelting ore, 35 dollars.	....	....	Ibid., Vol. 76, p. 86.
15 dollars........	....	....	Ibid., Vol. 66, p. 667 (1898).
....	....	....	Mines and Minerals, Vol. 18, p. 562.
....	33⅓ per cent gold; 66⅔ per cent lead and silver.	....	Min. and Sci. Press, Vol. 81, p. 341.
6 dollars..........	....	....	U. S. G. S., 22 Rept., Pt. 2, p. 327.
Smelting ore 100 dollars; milling ore, 8 to 10 dollars.	....	....	Mines and Minerals, Vol. 20, p. 386 (1900).
Milling ore average content slightly over: gold, ½ ounce, silver, 12 ounces.	....	....	T. A. I. M. E., Vol. 26, p. 459 (1896).
5 to 6 dollars......	....	....	Eng. and Min. Jour., Vol. 26, p. 97 (1848–49).
2 dollars..........	....	....	Ibid., Vol. 26, p. 243.
....	....	....	School of Mines Quarterly, Vol. 3, p. 208.
Average of various mines: 96, 105, 113, 121, 135, 166, 200, 204 dollars.	....	....	Min. and Sci. Press, Vol. 82, p. 293.

TABLE IV.

Locality.	Kind of Ore.	Yield of Ore per Ton. Range.
Idaho. — Continued.		
Thunder Mountain, Mackay..	Free-milling gold in rhyolite, silver also occurs.	Gold carries considerable silver.
Dewey Butte, Thunder Mt...	Gold-bearing.............	6 to 20 dollars............
Ramshorn mine, Bayhorse, Custer County.	Gold, silver and copper....	25 to 500 up to 1000 dollars.
Little Giant mines, Warren district.	Tetrahedrite, galena, blende, arsenopyrite, gold and silver.	Gold, 60 to 90 dollars; silver, 8 to 25 dollars.
Elkhorn and Parker mines...	Gold, silver, lead.........	Gold, 2 to 5 dollars; silver, 50 to 100 ounces.
St. Louis mine............	Gold and silver..........	....
Warren district............	Gold and silver..........	Free-milling gold-quartz, 20 to 100 dollars.
Mayflower vein, Warren district.	Gold and silver-bearing galena, blende, tetrahedrite.	....
Gibbsonville.............	Gold-quartz, pyrite, silver..	Pyrite yields 30 to 130 dollars; one-third free-milling.
Minnie Moore, Wood River district.	Lead and silver.	....
Compensation group........	....do..................	60 to 240 ounces silver; 50 to 70 per cent lead.
The Della mine............	....do..................	60 to 80 per cent lead; 120 to 166 ounces, silver.
Hercules mine, Coeur d'Alêne district.	....	Probably the richest ore mined in district.
Washington mine, Boise Basin.	Gold and silver..........	....
Florence district...........	Gold-bearing.............	Assay value, 18 to 50 dollars.
Jumbo mine, Bitter Root Range.	Galena, pyrite, gold and silver.	Gold, about 10 dollars; silver, 3 to 4 ounces.
Blue Jacket mines, Seven Devils.	Bornite carrying gold and silver.	....
De Lamar mining district....	....do..................	12 to 20 dollars.
Coeur d'Alêne district	Lead and silver..........	Silver, 15 to 20 ounces; lead, 55 to 75 per cent.

—Continued.

Yield of Ore per Ton. Average.	Percentage Total Content.	Value of Concentrates per Ton and Degree of Concentration.	Reference.
8 dollars, gold......	....	....	Min. and Sci. Press, Vol. 84, p. 62.
....	....	....	Eng. and Min. Jour., Vol. 74, p. 274.
Average of all ores milled give 100 ounces silver.	....	....	Mines and Minerals, Vol. 21, p. 174.
Gold, 107 dollars; silver, 9.85 dollars.	Ratio of gold to silver: 60 to 8 dollars and 90 to 25.	....	U. S. G. S., 20 Rept., Pt. 3, p. 246.
....	Lead, 50 per cent.	....	Ibid., 20 Rept., Pt. 3, pp. 210, 211.
Five foot vein average of ore, 75 dollars.	....	....	Min. and Sci. Press, Vol. 82, p. 105 (1901).
Probably above 50 dollars.	....	....	U. S. G. S., 20 Rept., Pt. 3, pp. 237, 245.
First class ore yields 100 ounces of silver.	First class ore, lead, 60 per cent.	....	Ibid., 20 Rept., Pt. 3, p. 202 (1898–99).
Gold, 14 to 18 dollars; remainder silver.	....	Sulphurets 30 to 130 dollars.	Mines and Minerals, Vol. 19, p. 277.
First grade ore, silver, 110 ounces.	First grade ore, lead 70 per cent.	....	Eng. and Min. Jour., Vol. 77, p. 1006.
Silver, 120 ounces; lead, 60 per cent.	Lead, 50 to 70 per cent.	....	Ibid., Vol. 77, p. 1006.
Smelting ore; silver, 10 ounces; lead, 60 per cent.	Lead, 60 to 80 per cent.	....	Ibid., Vol. 77, p. 1006.
Silver, 45 ounces; lead, 50 per cent.	Lead, 50 per cent.	Mills concentrate to 50 and 60 per cent lead.	Mining Magazine, Vol. 12, p. 32 (1905).
20.40 dollars......	....	....	Eng. and Min. Jour., Vol. 78, p. 297 (1904).
....	....	....	U. S. G. S., 20 Rept., Pt. 3, p. 235.
5-foot vein yields ore worth 20 dollars.	....	....	Min. and Sci. Press, Vol. 82, pp. 105 and 293 (1901).
Gold, 15 dollars; silver, 8 ounces.	....	....	Ibid., Vol. 83, p. 4.
40,000 tons averaged by milling 11 dollars.	....	Percentage extraction 85.	Eng. and Min. Jour., Vol. 77, p. 885, and U. S. G. S., 20 Rept., Pt. 3, p. 127 (1898–99).
Silver, 37 ounces; lead, 57 per cent.	Lead, 55 to 75 per cent.	Concentrates from Mace mill; lead, 50 to 60 per cent; silver, 25 to 40 ounces.	Mines and Minerals, Vol. 20, p. 304 (1899).

TABLE IV.

Locality.	Kind of Ore.	Yield of Ore per Ton. Range.
Idaho.—Continued.		
Buffalo Hump, Buffalo Hump ledge.	Free-milling gold ore......	From a few dollars up to 20.
Mother lode, Bitter Root Range.	....do..................	....
Poorman mine............	....do..................	....
Boise Basin..............	....do..................	12 dollars................
Sunnyside mine, Mysterious Slide.	....	....
Hattie, Golden Star, Tip Top, Black Cinder, etc.	(In gold belt) gold and silver.	....
Silver City district.........	Silver sulphide and horn-silver, becoming gold-bearing quartz in depth.	....
Lucky Boy and Mt. Queen mines, Boise Basin.	Gold and silver..........	5 to 8 dollars.............
Sullivan mine, Coeur D'Alêne district.	Lead and silver..........	Silver, 3.6 to 6.8 ounces; lead, 8 to 16 per cent.
Henrietta mine...........	Gold and silver..........	....
Indiana.		
General..................	Gold and silver (?).......	....
Kansas.		
Gove and Trego Counties....	Argentiferous shale........	.007 to .097 ounces or .004 to .06 dollars silver.
Maryland.		
Montgomery County........	Gold-quartz.............	12 to 30 dollars ....
Montana.		
Elkhorn district...........	Gold, silver, lead.........	67.78 to 90.85 dollars......
Butte...................	Granite, quartz-porphyry...	1 ounce silver to 20 pounds copper.
Ammon mines, Fergus County	Auriferous limestone.......	16 to 40 dollars..........

— *Continued.*

Yield of Ore per Ton. Average.	Percentage Total Content.	Value of Concentrates per Ton and Degree of Concentration.	Reference.
8.5 dollars........	....	....	Min. and Sci. Press, Vol. 82, p. 105.
Vein 15 feet wide 12.60 dollars.	....	....	Ibid., Vol. 82, p. 105 (1901).
13 dollars in 1872; 27 dollars in 1870.	....	....	U. S. G. S., 20 Rept., Pt. 3, p. 127 (1870–72).
12 dollars.........	....	....	Eng. and Min. Jour., Vol. 78, p. 297 (1904).
10 to 12 dollars....	....	80 and 92 per cent extraction	Ibid., Vol. 78, p. 392.
10 dollars, gold.....	....	....	Min. and Sci. Press, Vol. 82, p. 293.
Mill yield 11 dollars.	....	Percentage extraction 85.	Eng. and Min. Jour., Vol. 77, p. 885 (1904).
....	....	....	Min. and Sci. Press, Vol. 79, p. 149.
Silver, 3.9 ounces; Lead, 8.8 per cent.	Lead, 8 to 16 per cent.	Degree of concentration: 7 to 1 up to 12 to 1.	Mining Magazine, Vol. 12, p. 32 (1905.)
Smelting ore: gold, 3 to 4 dollars; silver, 100 ounces.	....	....	U. S. G. S., 20 Rept.. Pt. 3, p. 133.
Assays: gold, 4.10 ounces; silver, 58 ounces.	....	....	Min. and Sci. Press, Vol. 56, p. 102 (1888).
....	....	....	Eng. and Min. Jour., 74. p. 112 (1902).
....	....	....	T. A. I. M. E., Vol. 18, p. 391 (1888).
Average selling price 67.78 dollars.	Lead, 12.5 per cent.	Mill yield: gold, .0031, silver, 36.3 ounces. Smelting: 135.4 ounces gold; .152 ounces, silver; 12.5 per cent lead.	U. S. G. S., 22 Rept., Pt. 2, pp. 418, 474 (1896–97).
....	Gold, 3 per cent; silver, 23 per cent; copper, 74 per cent.	....	Mines and Minerals, Vol. 20, p. 348 (1900).
....	....	....	Eng. and Min. Jour., Vol. 59, p. 416.

TABLE IV.

Locality.	Kind of Ore.	Yield of Ore per Ton. Range.
Montana.—Continued.		
Marysville district	Sulphides and sulphantimonides, gold.	....
Black Pine, Granite Mountain.	Argentiferous malachite and tetrahedrite.	....
Fisher district	Free gold and sulphides	....
Judith district	Gold and silver	From a few to 1000 dollars
Boulder district	Gold and silver, free-milling above, refractory below.	Assays show 4 to 20 dollars gold.
Big Indian mine	Gold-bearing quartz, granite, hornblende (bedded deposit).	2 to 2.5 dollars
Massachusetts.		
Newburyport mines	Gold, silver, lead	....
Michigan.		
Beaver, Dead River Range	Galena, chalcopyrite, blende and quartz.	Two veins; 30 to 502 dollars.
Ishpeming, Dead River, Gold Range.	Galena, black antimonial silver carrying gold in quartz.	10 to 300 dollars
Ontonagon, Collins mines, Scranton, Iron River.	Silver-bearing	....
Nevada.		
White Pine	Silver-bearing	120 to 10,000 dollars
Goldfields	Gold and silver	200 to 300 up to the thousands of dollars.
Tonopah	Gold and silver	1st class ore runs as high as 600 dollars. 2d class, gold, 12 to 15 dollars; silver, 50 to 80 ounces.
Richmond and Eureka Consolidated.	Gold, silver, lead	Gold and silver, 4 to 70 dollars; lead, 15 to 30 per cent.
Esmeralda county	Gold and silver	5 to 60 up to 280 dollars
Pioche	Gold, silver and copper	Gold, up to 7.60 dollars, silver, 50 to 100 ounces.
Kendall and Sandstorm claims	Gold and silver	Usual run of ore: 12 to 75 up to 250 dollars.
Comstock lode mines	Gold and silver	Bonanza ore 30 to 50 up to 1000 dollars.

— Continued.

Yield of Ore per Ton. Average.	Percentage Total Content.	Value of Concentrates per Ton and Degree of Concentration.	Reference.
60 dollars, gold.....	....	....	U. S. G. S., Bull. 213, p. 89.
....	Average of ore milled, 25 ounces silver.	....	Mines and Minerals, Vol. 26, p. 492.
12 dollars.........	....	....	Min. and Sci. Press, Vol. 83, p. 78.
10 dollars.........	....	....	U. S. G. S., 18 Rept., Pt. 3, p. 592.
....	....	....	Eng. and Min. Jour., Vol. 60, p. 584.
....	....	....	Ibid., Vol. 78, p. 225.
Gold, 11.43; silver, 72.87; lead, 69.84 dollars.	....	....	T. A. I. M. E., Vol. 3, p. 442.
12 dollars silver....	....	....	Eng. and Min. Jour., Vol. 52, p. 119.
....	....	....	Ibid., Vol. 46, p. 238 (1888).
4½ tons yielded 45.27 dollars.	....	....	Min. and Sci. Press, Vol. 31, p. 130.
600 dollars........	....	....	Ibid., Vol. 18, p. 18.
Milling ore worth 40 to 50 dollars.	....	....	Min. and Sci. Press, Vol. 90, p. 394 and U. S. G. S., Bull. 303, p. 38 (1907).
Gold, 1 ounce; silver, 100 ounces (average of outcrop.)	....	Ore shipped runs 400 to 500 ounces silver; 100 dollars gold.	Min. and Sci. Press, Vol. 83, p. 192–193; Min. and Sci. Press, Vol. 82, pp. 230, 231 (1901)
....	....	....	Colliery Engineer, Vol. 12, p. 73 (1891)
Average of various mines: 10, 20, 40 and 60 dollars.	....	....	Min. and Sci. Press, Vol. 82, p. 78 (1901).
....	Lead, 30 to 50 per cent, copper 5 to 10 per cent.	....	Ibid., Vol. 83, p. 164.
....	....	....	Ibid., Vol. 90, p. 151.
Average between 1859–1874, 42.89 dollars. Average of 12 mines 19.60 dollars.	....	....	Eng. and Min. Jour., Vol. 18, p. 404 (1872), Colliery Engineer, Vol. 12, p. 50, and The Comstock Lode, Church, 1879, p. 7.

TABLE IV.

Locality.	Kind of Ore.	Yield of Ore per Ton. Range.
Nevada. — Continued.		
Bullfrog, Montgomery–Shoshone mine.	Ruby silver, chloride of silver, gold and silver in talc-quartz.	Values run as high as 200 to 500 dollars.
Great gulch vein, Esmeralda County.	Gold and silver (free gold)	....
Baliol mine, Mother lode	Galena, chalcopyrite, pyrite	8 to 10 dollars
Gold mountain	Auriferous quartz, pyrite	5 to 15 dollars
Combination mine, Goldfield.	Auriferous tetrahedrite and bornite, most important.	10 dollars to 4 and 5 hundred.
New Mexico.		
Bankhouse workings, Lake Valley mines.	Basic ore containing cerargyrite, and manganiferous ore.	Cerargyrite ore 200 to 500 ounces; manganiferous ore 20 to 30 ounces silver.
Oregon.		
Blue Mountain	Chiefly gold	8 to 40 dollars
Green back, Grave Creek district.	Gold-bearing	....
Bohemia district, Lane and Douglas counties.	Gold and silver	From below 10 up to 20 dollars.
Musick mine, Bohemia district.	Gold, silver, lead, zinc, copper.	
Waldo district	Gold-bearing, copper	Gold, 2.5 to 10 dollars; copper, 10 to 16 per cent.
New Hampshire.		
Waterford	Magnetic iron, chalcopyrite, pyrite, gold.	From four localities: values run, 30 to 40 up to 312.42 to 867 dollars.
Dodge vein	Pyrite, galena, gold	3 to 19 dollars
Pennsylvania.		
Philadelphia	Auriferous clay	3 cents per cubic foot
Panama.		
Isthmus	Gold-quartz	Assays run, 40 to 120 dollars.

— Continued.

Yield of Ore per Ton. Average.	Percentage Total Content.	Value of Concentrates per Ton and Degree of Concentration.	Reference.
Average between 25 and 50 dollars.	33.33 per cent silver, 66.66 per cent gold.	....	Eng. and Min. Jour., Vol. 80, p. 12.
20 dollars.........	....	....	Min. and Sci. Press, Vol. 82, p. 73.
....	....	....	Ibid., Vol. 87, p. 165.
....	....	....	Ibid., Vol. 18, p. 62.
Original ore assayed 48 ounces and sacked tailings 18.3 ounces.	....	Battery recovery 62 per cent.	Ibid., Vol. 95, pp. 397–398.
....	....	....	T. A. I. M. E., Vol. 24, p. 148.
Average between 8 and 20 dollars.	....	Concentrating and smelting ores range from 30 to the hundreds.	U. S. G. S., 22 Rept., Pt. 2, p. 567.
Free gold 16 dollars.	....	....	Min. and Sci. Press, Vol. 87, p. 391.
16 dollars.........	....	Smelting ore, Musick vein, 70 dollars; smelting ore, Helena vein, 125 dollars.	Eng. and Min. Jour., Vol. 73, p. 889.
Gold, .10 ounces; silver, .80 ounces.	Zinc, 3.84 per cent; lead, .49 per cent; copper, 1.23 per cent.	Concentrates assayed: gold, .8 ounce; lead, 10.48 per cent; copper, .79 per cent; silver, 5.6 ounce; zinc, 6.44 per cent.	U. S. G. S., 20 Rept., Pt. 3, p. 23 (1898–99).
....	Copper, 10 to 16 per cent.	....	Min. and Sci. Press, Vol. 87, p. 391.
....	....	....	American Jour. of Min., Vol. 2, p. 390.
....	....	....	U. S. G. S., 16 Rept., Pt. 3, p. 330.
....	....	....	Gold, Its Occurrence and Extraction, p. 181.
....	....	Sulphurets, 120 to 160 dollars.	Eng. and Min. Jour., Vol. 6, p. 377.

TABLE IV.

Locality.	Kind of Ore.	Yield of Ore per Ton. Range.
Panama. — Continued.		
Emperador	Ferruginous quartz, gold-bearing.	5 to 10 dollars
Pacific side	Gold-quartz and porphyry	30 to 60 dollars
South Carolina.		
Haile mine	Gold-bearing	
North Carolina.		
Jones and Keystone mine	Gold-bearing	
Portis mine	do	2 to 20 dollars
King Mountain	do	Lenses and stringers yield 4.15 to 7.66 dollars.
Gold belt, Southern States	do	Gold, values 5 to 20 dollars; Total value 20 to 40 dollars.
South Dakota.		
Trojan group of mines	Gold and silver in equal amounts.	40 to 60 dollars
Bald Mt., Black Hills	Gold-bearing	3 to 100 dollars. 35 dollar ore considered high-grade.
Homestake mine	Gold and silver	
Black Hills	Gold-bearing	2 to 10 and 10 to 100 dollars, mill runs, 3 to 3.25 up to 4 dollars.
Texas.		
Bonanza and Alice Ray Mines	Gold and silver-bearing	20 to 30 ounces silver, trace of gold, 60 to 65 dollars
Utah.		
Leeds	Argentiferous sandstone, blue carbonates of copper and native silver.	Ore runs as high as 20 to 1,200 dollars.
Bingham	Gold, silver, lead, copper, zinc.	Fissure ore; gold in pyrite, .80 to 2.20 dollars. Lode ore: gold in copper ores, .50 to 2.50 dollars.
Ontario mine	Gold-bearing	40 to 140 dollars and up to 1000 dollars in outcrops.
Tintic district	Gold and silver	

—*Continued.*

Yield of Ore per Ton. Average.	Percentage Total Content.	Value of Concentrates per Ton and Degree of Concentration.	Reference.
....	....	....	Eng. and Min. Jour., Vol. 34, p. 173 (1882).
....	....	Sulphurets less in value here than at Emperador.	Eng. and Min. Jour., Vol. 6, p. 377.
7 dollars..........	....	....	School of Mines Quarterly, Vol. 3, p. 208.
2.5 dollars.........	....	....	School of Mines Quarterly, Vol. 3, p. 208.
2.5 dollars.........	....	....	Eng. and Min. Jour., Vol. 77, p. 168.
200 ton poorest ore yielded 1.70 dollars per ton.	....	....	Ibid., Vol. 54, p. 34.
....	....	....	Ibid., Vol. 58, p. 411.
....	....	....	Eng. and Min. Jour., Vol. 30, p. 107.
10 to 20 dollars....	....	....	Min. and Sci. Press, Vol. 87, p. 187.
Gold, 3.68 dollars (3.60, 1902); silver, 0.03 dollars.	....	....	Eng. and Min. Jour., Vol. 75, p. 82; T. A. I. M. E., Vol. 17, p. 577 (1888).
10 to 15 dollars; siliceous ore 12 to 18 dollars; 2 to 5 dollar ore worked.	....	....	Eng. and Min. Jour., Vol. 69, p. 227 (1900) and Eng. and Min. Jour., Vol. 30, p. 57; Colliery Engineer, Vol. 11, p. 274 (1891).
Probably 60 dollars.	30 per cent lead; 25 to 30 per cent zinc.	....	Geol. Surv. Texas, 1 Ann. Rept., 1889, p. 223.
20 to 50 dollars....	....	....	Eng. and Min. Jour., Vol. 23, p. 317.
Silver, 65 ounces; lead, 45 per cent; gold, 2 to 2.50 dollars.	Lead, 45 per cent.	....	Ibid., Vol. 79, p. 1178.
....	....	....	Colliery Engineer, Vol. 12, p. 50.
Gold and silver, 0.1356 and 52.44 ounces; copper and lead 11.2 and 270 pounds.	40 dollars...	Milling ores, 10 to 25 dollars; smelting ores, over 25 dollars.	U. S. G. S., 19 Rept., Pt. 3, p. 687 (1898).

TABLE IV.

Locality.	Kind of Ore.	Yield of Ore per Ton. Range.
Utah. — Continued.		
Chloride Point mine, Tooele County.	Gold and silver	Gold, .50 to 1.50 dollars; silver, 15 to 40 ounces.
Horn Silver mine, Frisco....	Lead and silver	Silver, 30 to 90 ounces; lead, 5 to 45 per cent. Sulphate of lead ore carries silver, 40 to 50 ounces; lead, 30 to 40 per cent.
Park City	Silver-bearing	High-grade ore-bodies run from 40 to 700 dollars.
Daly West mine, Park City..	Lead and silver	....
Eldorado mine, Box Elder County.	Gold, silver, lead	....
Mercer mines, Camp Floyd district.	Cinnabar carrying gold, auriferous quartz and limestone.	An immense area that would yield from 1.20 to 1.70 dollars, gold.
De Lamar Mercur mines	....do	Base ore, 2 to 60 dollars; ordinary ore, 3 to 12 dollars.
Old Telegraph mine	Pyrite, galena, blende, lead carbonate.	Pyrite ore: gold, 1 dollar; silver, 5 to 6 ounces; carbonate ore: gold, 1 dollar; silver, 10 to 12 ounces.
Annie Laurie mine	Gold and silver	Ore runs up into hundreds of dollars per ton.
Silver Reef	Hornsilver changing to sulphides below.	5 to 30 dollars ....
Virginia.		
Fauquier County	Gold-bearing	From a few to 30 dollars....

— *Continued.*

Yield of Ore per Ton. Average.	Percentage Total Content.	Value of Concentrates per Ton and Degree of Concentration.	Reference.
....	....	Shipping ores: silver, 100 to 250 ounces; gold, 1 to 2.50 dollars.	Eng. and Min. Jour., Vol. 66, p. 605 (1897).
....	....	....	Colliery Engineer, Vol. 12, p. 50.
28 to 29 dollars....	....	Milling ores run 54.32 ounces; smelting ores (the best) 94.82 dollars.	U. S. G. S., Bull. 213, p. 120 (1902).
Gold, 1.20 dollars; silver, 62.95 ounces.	Lead, 23.65 per cent; copper, 3 per cent; zinc, 25.24 per cent; iron, 13.5 per cent.	Concentrates run: lead, 35.63 per cent; silver, 52.64 ounces; gold, 1.05 dollars; copper, 1.74 per cent; zinc, 13.3 per cent; and iron, 13.5 per cent.	Eng. and Min. Jour., Vol. 68, p. 455.
Gold, 2 to 6 dwt.; silver, 30 ounces.	Lead, 20 to 85 per cent	....	Min. and Sci. Press, Vol. 82, p. 93.
Cinnabar yields gold averaging between 10 and 50 dollars.	....	....	Min. and Sci. Press, Vol. 19, p. 82, and Mines and Minerals, Vol. 19, p. 130.
....	....	....	Eng. and Min. Jour., Vol. 68, p. 754.
....	....	....	T. A. I. M. E., Vol. 16, p. 26.
E. vein: gold, 5.60 to 12 dollars; silver, 2.05 to 2.30 ounces; W. vein: gold, 4.8 to 11 dollars; silver, 32 to 68 cents.	....	....	U. S. G. S., Bull. 285, p. 89 (1905).
....	....	....	Colliery Engineer, Vol. 12, p. 73.
6 dollars..........	....	....	Eng. and Min. Jour., Vol. 6, p. 377.

TABLE IV.

Locality.	Kind of Ore.	Yield of Ore per Ton. Range.
Washington.		
Republic mine	Gold-bearing (3 grades)	(1) 100 to 360 dollars; (2) 30 to 100 dollars; (3) 5 to 30 dollars; range in values, 20 to 1000 dollars.
Louise mine, Monte Cristo	Gold and silver	High-grade chalcopyrite ore, 28 to 30 dollars.
Republic district	....do	6 to 50 dollars
Night Hawk, Okanogan County.	Gold, silver, copper	....
Mountain Lion mine	Gold and silver	20 to 100 dollars; main vein 100 dollars.
Stevens County	Galena and silver sulphide in limestone.	Silver, 25 to 100 ounces
Coville Reservation	....do	Silver, 25 to 125 ounces; gold 3 dollars.
Monte Cristo	Galena, blende, pyrite, chalcopyrite, gold, silver.	Maximum gold contents, 1.4 ounces; maximum silver contents, 18 ounces.
Wyoming.		
Grand Encampment, Cox mine, Saratoga district.	Gold, silver, copper	....

— *Continued.*

Yield of Ore per Ton. Average.	Percentage Total Content.	Value of Concentrates per Ton and Degree of Concentration.	Reference.
Average of No. 1, 175to 200 dollars; average of No. 2, 65 dollars; average of No. 3, 20 dollars.	Silica, 93 per cent.	Smelting ore: gold, 8.75 ounces; silver, 7 ounces.	Eng. and Min. Jour., Vol. 66, p. 545, and Vol. 68, p. 725 (1898).
Gold, 15 ounces rich bunches; silver, 49 ounces, average 20 to 25 dollars.	Ratio gold to silver 2 to 1; copper, 13 per cent.	....	U. S. G. S., 22 Rept., Pt. 2, pp. 851–852; Eng. and Min. Jour., Vol. 55, p. 343.
50 ounces silver and 1 ounce gold; general average, 12 to 16 dollars.	....	....	Eng. and Min. Jour., Vol. 74, p. 74 (1902).
Gold, 72 dollars; silver, 19 dollars; copper, 105.6 dollars.	....	....	Mines and Minerals, Vol. 22, p. 310 (1902).
....	Ratio of gold to silver, 1 : 2.	....	Eng. and Min. Jour., Vol. 69, p. 286 (1900).
....	Lead, 40 to 70 per cent.	....	Mines and Minerals, Vol. 18, p. 313 (1898).
....	Lead, 30 per cent.	....	Ibid., Vol. 18, p. 313.
Gold, 0.6 ounces; silver, 7 ounces.	....	....	U. S. G. S., 22 Rept., Pt. 2, p. 803.
Assays yield: gold, 17.16, and silver, 3.87 dollars.	Copper, 48.8 per cent.	....	Mines and Minerals, Vol. 20, p. 28 (1899).

TABLE V.—YIELD OF GRAVEL BY DISTRICTS AND MINES.

Locality.	Yield per Cubic Yard.		Reference.
	Range.	Average.	
Alaska.			
Tundra	From shaft 37 feet deep, 126 to 433 dollars.		Inst. Min. and Met., Vol. 9, p. 181.
Klondike	9 to 50 dollars		Eng. and Min. Jour., Vol. 76, p. 808 (1903).
California.			
Big Lagoon, beach gravel.	20 to 50 dollars per ton		Min. and Sci. Press, Vol. 69, p. 230.
Bald Mountain		5.85 dollars	Auriferous Gravels of the Sierra Nevada of California, p. 437.
Polar Star Mine, Indiana Hill.		5.22 dollars	Ibid., p. 425.
Excelsior mine, Smartsville.		34 cents	Min. and Sci. Press, Vol. 78, p. 589.
Wisconsin Hill		34 cents	Auriferous Gravels of the Sierra Nevada of California, p. 117.
Sebastopol Hill	30 to 35 cents	Average depth of 40 ft. yielded 25 to 30 cents.	Eng. and Min. Jour., Vol. 11, p. 120.
Bloomfield mine		Top gravel, 3.37 cents, bottom gravel, 32.9 cts.	T. A. I. M. E., California Mines and Minerals, p. 25 (1876–77).
Nevada County	2.5 to 13 dolls.		Ibid., p. 276.
Malakoff		2.9 cents	Ibid., p. 25 (1870–74).
Harmony mine, Nevada City channel.	Cemented gravel, when crushed yielded 10 to 13 dollars.		Ibid., p. 276 (1899).
Gold Run		4.75 cents	Auriferous Gravels of Sierra Nevada of California, p. 152.
North Fork		4.2 cents	Min. and Sci. Press, Vol. 23, p. 24.
General		Laur's estimate, 16 cents, Silliman's estimate, 30 cts.	Ibid., Vol. 23, p. 24.
Colorado.			
Four Mile placer	20 cents and upwards.		Eng. and Min. Jour., Vol. 60, p. 102.
Lake, Douglas and Spring creeks	1 to 2 dollars	1 dollar	Eng. and Min. Jour., Vol. 60, p. 539.
Idaho.			
Snake River	.75 to 2.50 dolls.	Probably average 30 cents for 10 foot depth.	Min. and Sci. Press., Vol. 81, p. 610.
Sheep Creek	15 to 70 cents		Eng. and Min. Jour. Vol. 68, p. 395.,

TABLE V. — *Continued.*

Locality.	Yield per Cubic Yard.		Reference.
	Range.	Average.	
Idaho. — Continued.			
Boise Basin, Idaho City.	....	6 cents........	Min. and Sci. Press, Vol. 81, p, 400 (1898).
Montana.			
Drummond, Flint Creek.	....	Lake bed gravel yields 2 cents.	Eng. and Min. Jour., Vol. 68, p. 575.
Cedar Creek........	....	50 cents.......	Ibid., Vol. 67, p. 143.
Helena............	20 to 50 cents ..	....	Ibid., Vol. 44, p. 167 (1887).
Nebraska.			
Milford............	13 assays showed 62 cents to 5.50 dollars.	8 to 10 dollars per ton.	Eng. and Min. Jour., Vol. 67, p. 408 (1896–97).
New Mexico.			
Santa Rita.........	.50 to 1.25 dolls.	....	Min. and Sci. Press, Vol. 81, p. 280.
Oregon.			
Gold beaches, Coquille River.	50 to 75 cents per ton.	....	Min. and Sci. Press, Vol. 71, p. 121.
Thoss Flat, Galice.	....	15 cents........	Ibid., Vol. 80, p. 432.
Blue Mountain.	For whole bank 10 to 35 cents.	....	U. S. G. S., 22 Rept., Pt. 2, p. 637.
Southern..........	....	6 to 8 cents.....	Min. and Sci. Press, Vol. 87, p. 216.
Snake River........	.75 to 2.50 dolls.	....	Ibid., Vol. 81, p. 610.
Utah.			
Bingham Cañon.....	18 to 20 cents...	Argonaut cut, 18 cents lowest, 6 ft., 6 cents for 30 ft.	U. S. G. S., Bull. 213, p. 119 (1902).
West Mountain......	6 to 15 cents....	....	Ibid., Bull. 213, p. 120.
Washington.			
Snake River........	.75 to 2.50 dolls.	....	Min. and Sci. Press, Vol. 81, p. 610.
Wyoming.			
Lake, Douglas and Spring creeks.	1 to 2 dollars ..	1 dollar........	Eng. and Min. Jour., Vol. 60, p. 539.

TABLE VI.—FINENESS AND VALUE OF GOLD AND SILVER.

Locality.	Fineness. Units, or per Mill. Gold.	Fineness. Units, or per Mill. Silver.	Value. Dollars, per ounce. Gold.	Value. Dollars, per ounce. Silver.	Source.	Reference.
Alabama.						
Arabacoochee	964	......	......	......	Placers.	Eng. and Min. Jour., Vol. 55, p. 486.
Arizona.						
Fortuna mine	890	......	......	......	Veins	Ibid., Vol. 63, p. 664.
Alaska.						
Turnagain Arm, Resurrection and Bear creeks.	740	......	......	......	Placers	U. S. G. S., 18 Rept., Pt. 3, p. 82.
Apollo Consolidated mine, Unga Island.	767	......	......	......	Veins	Ibid., 18 Rept., Pt. 3, p. 84.
Chistochina	....	......	18–18.72	......	....	Ibid., Bull. 213, p. 74.
California.						
Sacramento and Stanislaus counties.	$\frac{4}{5}$ running 900	......	......	......	Placers	T. A. I. M. E., California Mines and Minerals, p. 76.
Butte County	922	......	......	......	....	Ibid., p. 88.
San Guiseppe mine, Tuolumne County.	982–987	......	20.29–20.40	......	Veins	Ibid., p. 177.
Neale mine near San Guiseppe.	950.5	......	19.64	......	Veins	Ibid., p. 177.
Table and Bald Mts.	950	......	19.63	......	Placers	do.
Spanish Hill, El Dorado County.	987	......	20.40	......	do	do.
Newhall, Los Angeles County.	955.5	......	19.75	......	do	do.
Folsom, Sacramento County.	974–978	......	20.00	......	do	do.
Bodie, Mono County.	411.5–580.5	......	12.00	......	do	do.
Do	130.5	......	2.69	......	do	do.
Calaveras County	627–987	......	12.96–20.42	......	....	do.
Johnsville, Plumas County.	985	......	20.36	......	Placers	do.
Sacramento County	898	......	18.56	......	do	T. A. I. M. E., California Mines and Minerals, p. 176.
Average of all counties	817.8	......	16.90	......	do	do.
Juarez district, Lower California.	....	......	20.00	......	do	Min. and Sci. Press, Vol. 89, p. 20.
Average fineness, 80 localities.	883.6	112.4	......	......	....	Min. and Sci. Press, Vol. 44, p. 345.
Between Ocean Beach and Point San Pedro.	950–953	......	......	......	Beach gravel.	Ibid., Vol. 37, p. 210.

TABLE VI. — *Continued.*

Locality.	Fineness. Units, or per Mill.		Value. Dollars, per ounce.		Source.	Reference.
	Gold.	Silver.	Gold.	Silver.		
Colorado.						
Gilpin County	Mill bullion 700–850	......	Bullion 16.65	......	Veins ...	Eng. and Min. Jour., Vol. 54, pp. 223, 245.
Cripple Creek	993–999	......	......	......	....do...	Min. and Sci. Press, Vol. 70, p. 346.
Camp Bird, Ouray County.	740	......	......	......	....do...	T. A. I. M. E., Vol. 33, p. 511.
Leadville	....	......	17–19 & 15	......	Placers and veins.	U. S. G. S., Monograph, 12 p. 515.
Average fineness of 9 localities.	820.5	175.5	......	......	....	Min. and Sci. Press, Vol. 44, p. 345.
Georgia.						
Loud mine	800–880	......	......	......	Veins ...	U. S. G. S., 16 Rept., Pt. 3, p. 258.
South Mountain	825	......	......	......	....do...	Ibid., 16 Rept., Pt. 3, p. 258.
Throughout state	950	......	......	......	....do...	Ibid., 16 Rept., Pt. 3, p. 258.
Average fineness of 10 samples.	922.8	73.32	......	......	....	Min. and Sci. Press, Vol. 44, p. 345.
Raburn, White, Dawson and Cherokee counties.	950–975 900–960 900–925 950–975	......	......	......	Veins ...	Eng. and Min. Jour., Vol. 42, p. 201.
Idaho.						
Idaho Basin, Gambrinus mine.	....	......	15.50	......	....do...	U. S. G. S., 18 Rept., Pt. 3, p. 696.
Boulder	680–718	......	15.50 16.00	......	....do...	do.
Forest King	700	......	......	......	....do...	do.
Washington	....	......	15.00	......	....do...	do.
Illinois	....	......	15.00	......	....do...	do.
Ebenezer	....	......	16.50	......	....do...	do.
Gold Hill	800–900	......	17.50	......	....do...	do.
DeLamar	....	......	10	......	Placers ..	Ibid., 20 Rept., Pt.3, p. 163.
Average fineness, 413 localities.	780.6	213.4	......	......	Placers ..	Min. and Sci. Press, Vol. 44, p. 345.
Gibsonville	....	......	14–18	......	Veins ...	Mines and Minerals, Vol. 19, p. 277.
Florence district	660–705 & 650	......	......	......	Placers & veins	U. S. G. S., 20 Rept., Pt. 3, pp. 234, 235.
Warren district	710–720	......	15	......	Placers ..	Ibid., 20 Rept., Pt. 3, p. 241.

TABLE VI. — *Continued.*

Locality.	Fineness. Units, or per Mill. Gold.	Fineness. Units, or per Mill. Silver.	Value. Dollars, per ounce. Gold.	Value. Dollars, per ounce. Silver.	Source.	Reference.
Idaho.— Continued.						
Little Giant mine, Warren district.	Bullion 580–641	......	......	......	Veins ...	U. S. G. S., 20 Rept., Pt. 3, p. 246.
Turner's Claim, Idaho City.	....	......	16.75	......	Bench gravel.	Ibid., 18 Rept., Pt. 3, p. 676.
East Hill, Idaho City	....	......	16.50–16.75	......	....do...	do.
Barker's claim	850	......	......	......	....do...	do.
Pioneersville	770–912	......	15.35	......	....do...	do.
Granite Creek	850	......	......	......	....do...	do.
Fall Creek	775	......	......	......	....	do.
Ophir Creek	910	......	......	......	....	do.
Placer County	840–912	......	......	......	Placers ..	Eng. and Min. Jour, Vol. 68, p. 396.
Thunder Mountain, Mackay.	....	......	12.00	......	Veins ...	Min. and Sci. Press, Vol. 84, p. 62.
Snake River, above Boise River.	....	......	17–19	......	Placers ..	Ibid., Vol. 81, p. 610.
Boise River, below mouth of Snake River.	....	......	14–16	......	....do...	do.
General	770–912	......	Probably 15–16.75	......	....do...	U. S. G. S., 18 Rept., Pt. 3, p. 676.
Michigan.						
Iron River	....	950	......	......	Veins ...	Min. and Sci. Press, Vol. 31, p. 130.
Montana.						
Drummond	900	......	......	......	Placers ..	Eng. and Min. Jour., Vol. 68, p. 575.
Cedar Creek	934	......	......	......	....do...	Ibid., Vol. 67, p.143.
Elkhorn mine	....	400–850 & 900	......	......	Veins ...	U. S. G. S., 22 Rept., Pt. 2, p. 475.
Average fineness of 14 samples.	895.1	100.9	......	......	Placers ..	Min. and Sci. Press, Vol, 44, p. 345.
Nevada.						
Comstock lode	Bullion 150–250	......	11–12	......	Veins ...	Eng. and Min. Jour., Vol. 51, p. 232.
Nova Scotia	....	......	Placers 19.75 20.25 19.5 standard	......	....	Am. Jour. Min., Vol. 2, p. 388.
North Carolina.						
Carolina Gold Belt...	900	......	......	......	Veins ...	U. S. G. S., 16 Rept., Pt. 3, p. 258.
Davis mine, Union Co.	450	......	......	......	....do...	do.
King's Mountain	929	71	......	......	....	....

TABLE VI. — *Continued.*

Locality.	Fineness. Units, or per Mill.		Value. Dollars, per ounce.		Source.	Reference.
	Gold.	Silver.	Gold.	Silver.		
New Hampshire.						
Dodge vein	917	......	......	......	Veins ...	U. S. G. S., 16 Rept., Pt. 3, p. 330.
New Mexico.						
Santa Rita	....	......	18.25–18.60	......	Placers ..	Min. and Sci. Press, Vol. 81, p. 280.
Oregon.						
Canyon Creek, Blue Mts.	900–990	......	......	......	Placers ..	U. S. G. S., 22 Rept., Pt. 2, p. 636.
Susanville and Dixie Creek.	860	......	......	......	....do...	do.
Rye Valley and Mormon Basin.	650–800	......	......	......	....do...	do.
Nelson	700–740	......	......	......	....do...	do.
Burnt River, bench gravels.	970	......	......	......	....do...	do.
Burnt River streams	922	......	......	......	....do...	do.
Olive Creek and Granite.	680–800	......	......	......	....do...	U. S. G. S., 22 Rept., Pt. 2, p. 637.
Josephine County	....	......	18–19	......	....do...	Eng. and Min. Jour., Vol. 74, p. 582.
Average fineness of 77 samples.	872.7	123.3	......	......	....	Min. and Sci. Press, Vol. 44, p. 345.
South Dakota.						
Homestake	820	170	......	......	Veins ...	T. A. I. M. E., Vol. 17, p. 573.
Highland	830	155	......	......	....do...	do.
Terra	825	160	......	......	....do...	do.
Deadwood	850	140	......	......	....do...	do.
De Smet	820	170	......	......	....do...	do.
Black Hills	904	96	......	......	....do...	do.
Do	....	......	18.50	......	Placers ..	Min. and Sci. Press, Vol. 89, p. 20.
Lead and Central City.	....	......	18	......	....do...	do.
Average of 7 samples showing fineness.	923.5	72.5	......	......	....do...	Ibid., Vol. 44, p. 345.
Utah.						
Mercur mines	....	......	20	......	Veins ...	Mines and Minerals, Vol. 19, p. 82.
Bingham	850–875	......	......	......	....	U. S. G. S., Bull. 213, p. 120.
Silver Reef, east workings.	....	985	......	......	Bedded deposits	Mines and Minerals, Vol. 20, p. 323.
Silver Reef west workings.	....	850	......	......	....do...	do.

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