STATISTICS AND TECHNOLOGY OF THE PRECIOUS METALS.

CHAPTER I.—GEOLOGICAL SKETCH OF THE PACIFIC DIVISION.

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It is the purpose of this chapter to present such an outline of the geology of each of the states and territories west of the Rocky mountains as will serve to assist those unfamiliar with the country in forming an idea of the character and distribution of its mineral resources, and to convey such rudimentary information concerning the relations which the ore deposits bear to the larger features of the geological structure as is necessary to an intelligent perusal of the statistical chapters. The information available for this purpose is far from ample. The government geological explorations of the last twenty years have done a large amount of extremely valuable work, some of which has made a permanent mark on the history of the science; but the territory is so vast that many decades must elapse before even the preliminary explorations are completed. The collections and the data gathered by the census experts are also very valuable. Few mines, however, can be properly understood without a somewhat extended examination of the surrounding country, for which the experts had no time, and the information is therefore rather fragmentary.

The order adopted in sketching the states and territories is not that which would have been chosen had the information been more complete. Washington territory and Oregon are placed after California, because little is known of them directly, while certain inferences may be legitimately drawn from the analogous territory embraced in the last-named state, and Idaho is described after Nevada and Utah for similar reasons.

The regularity of the distribution of ores in the Pacific division and its relations to the singularly uniform topography long ago drew the attention of writers to the resources of this region. Mr. W. P. Blake (*a*) first published a note on the subject in 1866, and his statement was accepted and enlarged upon by Mr. King (*b*) in 1870. The more detailed technical and scientific investigations of later years have greatly increased our knowledge of the distribution and extent of the ores, and it will now scarcely be maintained that there are more than four well-defined and continuous ore belts west of the Rocky mountains. Beginning at the east, the first is that at the western foot of the Wahsatch and the southwestern continuation of that range. With the exception of the Leeds (Silver Reef) district, all the important ore deposits of Utah lie in the foot-hills of this range, bearing a very definite relation to the main line of crests. The gold and copper belt of California stands for a long distance in a similar relation to the Sierra Nevada. The quicksilver belt in the California coast ranges is not quite so regular in its occurrence, yet its direction is very nearly parallel to the coast, and it is very persistent, though nowhere broad, for some 300 or 400 miles. The Arizona belt is less known than any of the others, but no one can glance at a map of the territory showing the mining districts without perceiving that these lie in a northwestern and southeastern line diagonally across the country. The mining districts in Nevada are extremely numerous, so much so indeed that some grounds could be given for assuming a belt to run in almost any desired direction, but they are scarcely close or regular enough in any one line to compel the observer to regard them as connected.

These four distinct belts appear to have an intimate connection with the four great orographical changes which the region west of the Rocky mountains has undergone during its geological history. The last of these was post-Miocene, and resulted in the uplift of the Pacific Coast ranges and the great interior valley of California, with a large part of Oregon and Washington territory. The disturbing force seems to have been most powerful to the north and south of San Francisco, or approximately in the region marked by the quicksilver deposits. A post-Cretaceous upheaval raised the whole western central portion of the continent now occupied by the complex system of the

a Annotated catalogue of the principal mineral species hitherto recognized in California, etc. Report to state board of agriculture, p. 26.

b *Exploration of the 40th Parallel*, iii, p. 5.

Rocky mountains. The Wahsatch forms the western edge of this uplift, and the dislocation took place on an old fault coincident with the present western foot of that range. Here also lie the numerous mines of Utah. The Sierra Nevada and the ranges of the Great Basin were raised by a post-Jurassic uplift. The line of most intense disturbance coincided with the Sierra, and the greatest dislocation occurred along its western foot, in the gold belt, though it also extended to the south of that wonderful series of deposits. The earliest disturbance in the far west was that which raised the Palæozoic strata of eastern Nevada, western Utah, and a portion of Arizona above the surface of the ancient sea. The western limit of this Palæozoic area has been traced in detail across the belt surveyed by the exploration of the fortieth parallel, and in that latitude it trends nearly north and south in longitude 117° 30′. To the south the limit has been fixed at a considerable number of points, though it has not been followed in detail. South of Austin the course of the western edge of the Palæozoic is somewhat west of south, and it enters California a little north of Owen's lake. In this region it is deflected toward the southeast, crosses the Colorado river in Virgin cañon, passes by Prescott, and on through Arizona to the neighborhood of Tombstone. The main Arizona belt of deposits has the same trend as the border of the Palæozoic, and nearly coincides with it in position. In short, though the relation still requires much investigation, the Arizona mineral belt appears to stand in nearly the same relation to the western edge of the post-Carboniferous upheaval as do the belts of Utah and California to the other uplifts. That these relations exist as a matter of fact is beyond question, though it is possible that they may be accidental. In any case, however, the uplifts, as such, are not to be regarded as the cause of the formation of the mineral belts; these must rather be due to the fissuring of the rocks and the dislocations attending the orographical changes. There is evidence that the post-Carboniferous uplift in the state of Nevada and in southeastern California was comparatively gentle, and that it was not attended by any considerable crumpling of the strata. This would account for the fact that the number of ore deposits at its edge in these states is not very large. Nevertheless, the lead deposits of Battle Mountain, the Austin mines, the Candelaria district (which includes the famous Northern Belle mine), Panamint, and Cerro Gordo all occur at or close to the western edge of the Palæozoic. Taken in connection with the geological similarity of their position to that of the Arizona mines, these deposits may perhaps fairly be regarded as the rudiments of a belt. In Arizona the area in which the contact occurs has been too little investigated to allow of any statement as to the violence of the uplift, but, all things considered, it would be remarkable if it should not ultimately prove to have been attended by much disturbance.

This theory of a relation between the ore-belts and the lines of uplift is, of course, not to be understood as equivalent to the assertion that the deposits are to be found only along a single line representing the actual main fissure of the uplift. One is apt to think of the dislocation attending an orographical change as confined to a single vertical or highly inclined surface, but every geologist is aware that this is not an exact view. Simple fissures in the earth's crust are very rare, and parallel sets of fissures, with cross fractures and stringers into the surrounding country, are the rule even in the case of insignificant cracks. In disturbances such as those of the great uplifts a considerable belt of country is almost necessarily crushed and torn, and innumerable rents and cracks standing in most complex relations to one another penetrate the rocks in many directions. The breadth of such a zone must usually be measured in miles.

It may be that some of the ore deposits of the Pacific division are independent of volcanic action, but the association of eruptive rocks with ores is a rule with comparatively few apparent exceptions, and in many cases the agency of solfataric action (*a*) is manifest. This has long been recognized by observers.

That there are relations between the rocks inclosing ore deposits and the character of the ores has been known to miners for centuries, but the study of the nature of this dependence is comparatively new. It is far too complex a subject to be discussed in this chapter, but it may at least be stated that the census collections and data appear to confirm, emphatically, the existence of such relations. Lead ores are almost invariably accompanied by limestone, and veins in granite present only a very small number of associations of minerals, which are possibly reducible to a single one. Deposits in metamorphic rocks, too, though more varied than the others, appear to represent but a few types. It was not practicable, however, for the experts to make such minute examinations of the mines as would have been necessary to furnish material for a conclusive investigation of this subject.

With some hesitation most of the determinations of the ore and gangue minerals, the country rocks, and the kind of deposit, are introduced county by county. There can be no doubt that the list of ore minerals is often imperfect. The determination of the wall rocks is subject to some uncertainty without a thorough examination in the field as well as in the study, and the nature of a deposit is in many cases not to be decided by a single visit. It is probable, however, that the determinations of rocks and minerals are nearly always correct as far as they go, and in the cases in which the character of the ore deposits was not clear as much may generally be inferred from the statement regarding them. The tables, therefore, contain much information of value, and many suggestions to such geologists and miners as are careful to remember that they are not exhaustive statements. Except in a few cases, in which I happened to have visited the localities, the determination of the character of the deposits rests on the authority of the experts. The determinations of rocks and minerals inclosed in parenthesis are also due to the experts,

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a As originally employed, the term solfataric action denoted only the effect of gaseous emanations from volcanic vents. In use, however, it has gradually come to include the action of heated waters charged with these gases or holding them in solution, and is so employed in this chapter.

while the remainder I have made from the specimens collected by my assistants. The difficulties met with in making these determinations were considerable, for rocks near ore deposits are usually much altered, and the ore minerals need much closer attention than in ordinary specimens of merely mineralogical interest. A few minute particles of such minerals in a hand specimen often make the difference between waste rock and rich ore and the inspection of the samples needed to be correspondingly searching.

Maps of the states and territories of the Pacific division accompany the sketches. These are necessarily on a small scale, but present the leading features sufficiently well to assist the reader in following the descriptions. On them are entered signs indicating the distribution of gold, silver, and quicksilver. These are not designed to represent every spot where precious metals have been detected, but to indicate at a glance their general distribution.

GEOLOGICAL SKETCH OF CALIFORNIA.

The mineral resources of California are extremely varied, but are also of very unequal importance. Its gold production is an essential factor in determining the relations of the mediums of exchange throughout the world, its total value since 1849 exceeding $1,200,000,000. Its quicksilver production, also, though of far less value, exceeds that of any other country. The total known product of California from 1850 to the close of 1880 was a trifle less than 91,600,000 pounds, of an average value of 71 cents, and has yielded above $65,000,000. It is important as an adjunct to the precious-metal industries no less than as an independent source of profit. The silver product yields above a million per year; and the coal-fields, though not of the best, furnish a large part of the supply necessary for home consumption. Asphalt and petroleum are obtained in small quantities, and some sulphur and borax are extracted, while lead is reduced only as an incident of the silver industries, and copper and iron, though their ores are plentiful, are worked on a small scale only. Tin, chromic iron, black oxide of manganese, and other useful minerals also occur in the state, but as yet contribute little to its commercial prosperity.

The great industrial importance of the gold production of California has drawn the attention of many geologists and engineers to the geology of the state, and the literature on the subject is comparatively extensive. The Pacific railroad survey, Mr. J. A. Phillips' work on gold and silver, the reports of the mining commissioners, the proceedings of the California Academy of Sciences, and the scientific journals of America and Europe, all contain contributions to the subject; but the chief source of authority is the volumes of the state geological survey of California, conducted under the charge of Professor J. D. Whitney, who had the assistance of Messrs. Clarence King, W. H. Brewer, W. M. Gabb, William Ashburner, W. H. Pettee, and others. Unfortunately, the legislature ceased to appropriate funds for the survey in 1874 before a single geological map had been issued. Professor Whitney, however, has continued to work up the material collected, and has issued a number of volumes during the last eight years. The census reports and collections also furnish some information of value from a geological point of view, but the following sketch owes most to the data collected by Professor Whitney and his assistants or recorded in the volumes published under his supervision.

The interior of California forms a long, oval valley. Its greater diameter is parallel to the coast, and extends from the neighborhood of Fort Téjon to Mount Shasta, a distance of 450 miles, while the average width is about 40 miles. This valley is surrounded by mountains, except at a single point, where San Francisco, San Pablo, and Suisun bays afford an outlet for the drainage gathered by the Sacramento river from the north and the San Joaquin from the south.

Though the mountain ranges inclosing this basin unite at its extremities, the Great Valley is not a mere undisturbed area between different ranges of a complex chain; on the contrary, the Sierra Nevada to the east and the Coast ranges to the west represent upheavals of different characters and widely distant eras. The Sierra Nevada is a single range forming the western rampart of the elevated plateau of the Great Basin, and was raised in post-Jurassic times. The Coast ranges consist largely of detritus from the Sierra; they were uplifted for the most part at the end of the Miocene, and constitute a mountainous belt of country to which even the name of chain can scarcely be applied. No term answering to the Coast ranges was used by the Spanish settlers of the country, but they gave special names to a considerable number of small ranges within the Coast belt, and these are still in use. The elevation of the Coast ranges is greatly inferior to that of the Sierra, a number of peaks of the latter exceeding 14,000 feet, while none of the culminating points of the Coast ranges appear to rise more than 6,000 feet above sea level.

Both the Sierra Nevada and the Coast ranges are greatly metamorphosed and contain extensive deposits of useful minerals, and the alteration of the strata and the deposition of ore are probably in each case related phenomena; but the metamorphosis and ore-deposition of the Coast ranges occurred long after the cessation of similar activity in the Sierra, and led to widely different results. The more remarkable deposits of the Coast ranges are cinnabar, chromic iron, coal, asphalt, and mineral oil, while gold and copper are characteristic of the western slope of the Sierra, lead and more or less auriferous silver occurring very extensively on the eastern slope, of which only a portion lies within the limits of the state.

The backbone of the Sierra is granitic, the higher summits and a large part of the western slope of the range being of this rock, except in the northern portion of the state, where it has been covered by basaltic and andesitic lavas. The granite penetrates some of the accompanying strata in dikes, and Professor Whitney regards it as beyond question of eruptive origin, while some other geologists see in it only highly metamorphosed sedimentary material reduced to a plastic state *in situ*. Except at the northern end of the Great Valley, near Mount Shasta, and near Owen's lake, no Palæozoic strata have been identified. In the Gray mountains, Shasta county, a limited area of Carboniferous limestone occurs, amply identified by fossils. A small amount of limestone with the same external characteristics occurs farther south, and Professor Whitney regards it as not improbably of the same age. From a mining point of view, however, it is insignificant, carrying little gold. The principal strata on the west flank of the Sierra are Jurassic and Triassic, occurring chiefly and characteristically as slates and shales. They are highly metamorphic, contain few fossils, and have been profoundly disturbed, showing that the range was uplifted since their deposition. These are the main gold-bearing rocks, and will be more particularly described further on. Near the foot of the range are areas of Cretaceous and Tertiary beds, chiefly marine, nearly horizontal, and resting unconformably on the upturned auriferous slates. Above the Mesozoic slates lie fresh-water auriferous gravels, mainly of Tertiary age, and these toward the north are in part covered by flows of Tertiary and post-Tertiary lavas. Inyo and Mono counties lie to the east of the Sierra. The metamorphic slates and limestones of this region are for the most part Triassic, though the Jurassic is probably also represented, and are covered to a great extent by volcanic rocks. Mr. Gilbert has shown that the eastern edge of Inyo county reaches the Palæozoic area.

The Jura-Trias strata extend to the east of the Sierra about as far as longitude 117° 30′. They rest directly upon Archæan schists and granite, and the long interval of time which they represent seems to have been extremely quiet, for no non-conformity has been detected in the series. At the close of the Jurassic, however, the whole area from the western foot of the Sierra to the middle of the state of Nevada was raised above the ocean and compressed from west to east, resulting in the formation of a number of parallel ranges, of which the most westerly were the Sierra Nevada and the Blue Mountain range of Oregon. Ore deposits occur on the eastern as well as on the western flank of the Sierra, but their character and mode of occurrence differ from those prevailing in the gold belt.

The Coast ranges, or the western mountainous belt between Mount Shasta and fort Téjon, are for the most part composed of more or less altered rocks of Cretaceous and Tertiary age. The geologists and the paleontologists of the state survey divided the Cretaceous into lower and upper, and, while recognizing the later divisions of the Tertiary, failed to find anything certainly corresponding to Eocene. Of late, however, it has been shown that the fossils of what had been considered as the Upper Cretaceous exhibit strongly marked Tertiary affinities, and it seems by no means impossible that the beds in question, which are sometimes called the Téjon group, and include the Monte Diablo coal-fields, really represent the Eocene. Considering that differences of climate must always have existed, whether more or less marked than those of the present time, it is not strange that doubtful cases like those of the Téjon group, the Laramie beds, and the Australian coal-bearing rocks occur, but rather that it is so often possible to determine the correspondence of strata in widely separated areas.

Though the Coast ranges here and there show granitic rocks, granite is of only local importance, and does not appear to form the central mass, as is the case with the Sierra. The body of these ranges is made up of crumpled and fractured strata, indicating, according to Professor Whitney, sharp and sudden elevations and depressions, extending through the Pliocene epoch. To the southward the prevailing rocks are Tertiary, but north of the bay of San Francisco these almost disappear, the Cretaceous becoming predominant. Volcanic rocks are not widely spread, most of the known occurrences being found between San Francisco and Clear lake.

It appears, therefore, that the elevation of the coast as a whole was comparatively recent. While the quartz veins were forming, and while the gravels were accumulating on the west flank of the Sierra, the region of the Coast ranges and the Great Valley were wholly or partly under a gulf or sea, shallow in parts and surrounding more or less extensive islands. The existence of this shallow sea must have had an important influence on the climate of the Sierra, for, supposing the evaporation to have been the same, nearly the whole amount of moisture now distributed through the Coast ranges and the interior of California would have fallen on the Sierra in addition to its present rainfall. But evaporation is considerably more rapid from shallow seas than from deep ones, and the rainfall on the Sierra must consequently have been enormous. The chief uplift of the Coast ranges took place at the close of the Miocene, and the great metamorphism and ore-deposition are probably for the most part referable to the same period, though it is likely that the still later volcanic eruptions induced a portion of them. The Pliocene or post-Pliocene disturbances were comparatively gentle, but Professor Whitney regards the break at the Golden Gate, the prevalence of volcanic rocks from that point north to Clear lake, and the disturbances of the Pliocene south of San Francisco bay, as connected phenomena.

The region south of fort Téjon has been much less investigated than the central portion of the state. It appears to possess some extremely interesting geological features, but also to present unusual difficulties. The San Gabriel range north of Los Angeles has a granitic axis, and it is possible to trace this granite ridge uninterruptedly through Los Angeles, San Bernardino, and San Diego counties into Lower California, and along the peninsula to within a few miles of the old mission of Santa Gertrudis. (*a*) The sedimentary rocks accompanying this granite ridge are for the most part highly metamorphosed, and are frequently penetrated by dikes of granite. They are nevertheless considered by both Professor Whitney and Mr. Gabb as of Cretaceous and Tertiary age, and the uplift is referred, like that of the Coast ranges proper, to the close of the Miocene.

a Geological Survey of California, ii, 137.

Besides the bitumen springs of Ventura and Los Angeles counties, there are gold mines in this southern California range, but few details have been published as to their occurrence, and their geological relations are still to be studied.

The character of the rocks of the Coast range shows that the Cretaceous and Tertiary sea near the present coast was shallow, but there is evidence that the Great Valley represents a former depression of immense depth. This, however, would not prevent the gulf at the foot of the Tertiary Sierra from being as warm, for example, as the Gulf of Mexico, for the temperature of the water of a land-locked basin depends on the depth of the inlet to it, and if this is small the water of the basin will be warm.

In Russia and Australia the Silurian is the gold-bearing formation, and Sir Roderick Murchison enunciated the somewhat rash generalization that gold was to be looked for only in the Palæozoic. In California it is amply proved by rare but characteristic fossils that the gold-bearing sedimentary rocks are Mesozoic. Generalizations similar to Murchison's have been attempted with reference to ores of other metals, but the simple fact seems to be that eruptive activity or metamorphism is usually a concomitant of the concentration of ores in veins and other allied deposits, and that the older the rocks the greater the general probability that they will have been subjected to action of this description. In the search for coal the fact that the important deposits of the best character are confined to one formation has been of great economical value. The geological indications accompanying the occurrence of veins are to be sought, not in the age of the rocks, but in evidences of disturbance and of certain kinds of decomposition of the surrounding country. The decomposition or alteration of rocks in the neighborhood of ore deposits has been but little studied by geologists until lately, for very sufficient reasons; but of the fact of a connection between it and the deposition of ore California affords excellent examples. The "bed-rock" or auriferous slates of the gold belt is characteristically altered, and the metamorphic stratum in which cinnabar occurs are at once recognized by those familiar with them as "quicksilver rock".

The belt of metamorphic rocks which incloses the greater part of the gold-quartz veins of California is insignificant in width and of little industrial importance south of the southern boundary of Mariposa county. To the north of that line, however, it suddenly widens. Passing northward, the breadth of the belt is stated at about 25 miles in Tuolumne county, 24 miles in Calaveras, 12 in Amador, and 30 in El Dorado. In Placer it is not well exposed, being covered by gravel and volcanic rocks. North of Placer county the metamorphics occupy most of the western slope of the range for a considerable distance, with occasional irregularly distributed patches of granite, but in Butte county the edge of the great lava fields, which occupy much of the surface of northeastern California, are encountered, and cut off the central mining region. The same gold-bearing series seems to reappear in the northwestern counties, but its character and relations are less well understood, and its industrial importance is smaller than in central California.

As illustrative of the structure of the gold belt, Professor Whitney describes in some detail the important portion lying between the Merced and the Stanislaus rivers. Starting from the west, or at the bottom of the Sierra, the first rock encountered is horizontally stratified and undisturbed Tertiary sandstone. To this succeeds the belt of Mesozoic metamorphics in nearly vertical strata. The lower edge is composed of talcose and chloritic slates, weathering irregularly, and locally known as "grave-stone" slates. Next comes a wide belt of a dark-grayish green, somewhat porphyritic, material, which shows a sheeted structure, though not the fine lamination of clay slates. This was known to the state survey as "porphyritic green slate", but Professor Whitney and Mr. Wadsworth are inclined to regard it as a metamorphosed diabasitic tufa. This belt incloses another of argillaceous slate, carrying Jurassic fossils, with which is associated the "mother lode", or the "great quartz vein". Accompanying the argillaceous slate and the mother lode is a band of serpentine. (*a*) In the southern portion of this section the serpentine is confined to the northeast side of the argillaceous slate, but near the Stanislaus river it widens out, occurring in irregular patches and on both sides of the slates.

The strike of the metamorphosed rocks is, as a whole, parallel to the trend of the Sierra, but there are many sharp deflections. The dip of the slates in the southern and central portion of the gold belt is nearly vertical, and usually to the northeast; but in the northern portion, where the belt widens out, the dip becomes irregular, and over wide areas is to the west, becoming flatter as the distance from the crest of the range increases.

Though not confined to the argillaceous slates, or even to the metamorphic strata, the gold-quartz veins of California are more frequent and richer in the argillaceous slates than elsewhere, many fine veins beside the "mother lode" occurring in it. The veins are usually parallel to the stratification, as the following quotation shows: (*b*)

> A very heavy quartz vein passes a little south of Big Oak Flat, Tuolumne county, cutting the strata of slate in which it is contained at a small angle, the lines of bedding of the wall-rock appearing to run nearly northwest and southeast, while the vein of quartz has a strike of N. 30° W.; it dips to the east at an angle of 30°, the slates themselves standing nearly vertical. This is, perhaps the most marked instance hitherto observed in the state of a heavy quartz vein differing essentially both in dip and strike from the inclosing rocks.

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a The origin of serpentine is a disputed point. If it is a fact, as eminent mineralogists have maintained, that it occurs as an alteration of hornblende and pyroxene as well as of olivine, there appears to be no difficulty in accounting for its presence in metamorphic rocks. Chlorite and serpentine, however, are occasionally confounded.

b *Geological Survey of California:* Geology, vol I, p. 237.

The most remarkable primary metalliferous deposit of California is the mother lode already referred to. Many of the great mines of the state are upon it, and others are in its immediate vicinity on veins which most likely have an intimate structural connection with it. It extends from a point a few miles southeast of the Merced river, in Mariposa county, to near the center of Amador, a distance of about 80 miles. Though the croppings are in places hidden by overlying rock or detritus, they are visible for a great portion of the distance at such frequent intervals that the identity of the lode is not doubtful. It is more than probable that it extends to the north of the point indicated, but it cannot be traced with absolute certainty.

This powerful lode (a) is made up of irregularly parallel plates of white compact quartz and crystalline dolomite or magnesite (b) more or less mixed with green talc; and these plates, which somewhat resemble the "combs" of ordinary lodes, are either in contact or separated from each other by intercalated layers of talcose slate. The quartz is chiefly developed in the central portion of the vein; and, from its color and resistance to decomposition, it gives rise to a very conspicuous outcrop, forming the crest of the hills, so that it can be readily seen from a distance of several miles. The dolomitic or magnesitic portion decomposes somewhat readily, and it becomes a kind of "gossan" or cellular, ferruginous mass, of a dark-brown color, often traversed in every direction by seams of white quartz. The quartz is the auriferous portion of the lode, although it is far from being uniformly impregnated with gold. Most of the mines which have been worked between the Merced and the Stanislaus are on the northeast side of the great quartz vein, either in contact with it or in some parallel band of quartz subordinate to or at a little distance from it. The talcose-slate bands in the vein are often themselves more or less auriferous.

Professor Whitney does not regard it as by any means proved to be a fissure vein, or even an exclusively segregated one; on the contrary, it seems to him most likely the result of metamorphic action on a belt of rock of peculiar composition, and perhaps originally largely dolomitic in character.

Besides the quartz veins in the metamorphics of California, there are also many in the granites of the same region. Though of less importance than those in the sedimentary rocks, many of them have been worked with profit, but no careful comparison has been instituted between the two classes of veins. In some instances at least, and when near the slates, the veins in the granite are parallel to the stratification of the metamorphic rocks, and are also essentially gold veins. It is probable, however, that on closer investigation they will be found to present characteristic differences.

Gold never occurs in nature unassociated with silver, and silver, it is said, is never wholly free from gold; but there seems, nevertheless, to be a natural distinction between gold veins and silver veins. In Nevada, Arizona, and throughout Mexico gold usually occurs only in minute particles entangled in sulpho-salts of silver and other metals, except near the surface, where atmospheric action has decomposed the original matrix. Though the value of the gold in such cases sometimes equals or exceeds that of the accompanying silver, the latter usually greatly surpasses it in weight. In the gold belt of California, on the other hand, the gold occurs in great part as flakes or even as masses, often not immediately in contact with sulphides, and carrying in alloy only 0.100 or 0.200 of metallic silver. As a rule, the gold does not assume a crystalline form in the California mines, but more or less perfect octohedral forms have been found at Spanish Dry Diggings and at Byrd's valley. Cubical crystals have not until lately been observed, and Professor Whitney notes that he has neither seen nor heard of any in the state. (c)

Sulphides always accompany the gold in the veins, though these minerals are not always found in contact with the larger particles of the metal. So general is the association, however, that when, as is often the case even with rich quartz, the gold is not visible to the naked eye, miners judge of the value of the ore by the quantity of sulphurets. Quartz with plenty of sulphurets and no visible gold often occurs in large bodies, and is apt to pay better in the long run than ore with very coarse gold, or "specimen quartz", as it is called by the miners. The minerals embraced under the term "sulphurets" are considerable in number, but the most common are pyrite, mispickel, zincblende, and galena. Though seldom containing the greater part of the gold, it is rarely that the sulphurets do not include a portion of the metal in such a way that it cannot be extracted by amalgamation. Concentration of the sulphurets, followed by chloridation, is then the readiest means of extraction. There is an occurrence of cinnabar in gold quartz veins inclosed in slate in Calaveras and one in Mariposa.

The distribution of gold in the veins is usually very irregular, and while on some veins it will pay to extract the ore from wall to wall, in most cases certain belts or chimneys of rock only are remunerative.

Had the veins been deposited in the slates before they were raised into their present position in post-Jurassic times, they must have been much faulted and broken. This is not the case, nor is it probable that veins could have formed in undisturbed strata. On the other hand, there can be no doubt that the auriferous gravels have been formed at the expense of eroded croppings of the quartz veins; and the veins, or most of them, must therefore have been deposited before the gravels. These, according to Professor Whitney, were accumulated during the whole of the Tertiary period, while Cretaceous gravels appear to be entirely absent. The range was above water during

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a Professor Whitney: *Auriferous Gravels*, p. 46.

b In the only specimen which has thus far been chemically examined the supposed dolomitic portion proves to be an intimate mixture of quartz and magnesite.

c In December, 1882, however, Mr. James Terry purchased a specimen of gold from Louis Abraham, Kearney street, San Francisco, which is said to have come from Eldorado county, between Plumas and Placerville, which shows a number of fine cubical crystals with full faces and sharp edges. The same specimen also shows well-developed dodecahedrons, trapezohedrons combined with the cube and octohedron, a cube the corners of which are truncated by a trapezohedron, and possibly other combinations.

the Cretaceous, and such fresh-water deposits as accumulated on its west slope seem to have been swept away during the succeeding period. The natural inference would seem to be that the formation of the veins occurred between the end of the Jurassic and the beginning of the Tertiary, and that it was intimately connected with the upheaval of the Sierra and the metamorphism of the strata of preceding epochs.

Substantially coincident with the area of gold veins is that of the auriferous gravels of California. In the gold-bearing regions of all countries secondary deposits of the metal, associated with gravel or sand, have played a large part, because the gold may be separated from such loose material at a low cost. In California, however, the gravels have proved particularly important because of the invention and development there of the peculiar system of hydraulic mining, which consists in washing the gravels into sluices provided with quicksilver by the aid of powerful jets of water. The great importance of this system is due to the fact that it is among the least costly methods of handling material, if it is not the very cheapest known. It costs under favorable circumstances but five cents per cubic yard, or, say, three cents per ton, and sometimes even less. It thus renders deposits of gravel valuable which under most conditions would be absolutely worthless. Several conditions, however, are necessary to the successful prosecution of hydraulic mining, among which the most important are a deep gravel bank, abundance of water with a great head, and some available valley at a lower level than the bank, into which the gravel from which the gold has been extracted may be washed. The topographical and climatic conditions in the Sierra are peculiarly favorable for this process, while in Australia, where gravel is abundant, circumstances rarely permit the application of this method of extraction.

The gravel consists of bowlders and pebbles of various rocks, with silt, clay, and volcanic ash. The gold occurs as nuggets and fine particles, free or nearly free from rock, but also as fragments of gold quartz, and is accompanied by a variety of other heavy substances, as magnetite, garnet, and zircon; rarely and locally also by cinnabar, platinum and iridosmine, diamonds, native copper, and other substances of high specific gravity. One of the striking features of most deep gravel banks is the so-called "blue lead". This name is applied to the lower portions of banks, which are generally somewhat closely compacted and possess the color of the blue clays occurring all over the world. Although the "blue lead" has led to wholly untenable theories as to the character of the gravel deposits, its nature is very readily accounted for. Loose materials near the earth's surface are everywhere impregnated with a small amount of organic matter carried down from the surface by water and filtered from it by the porous strata. This organic matter, in the absence of free oxygen, exercises a slow but inevitable reducing action on ferric oxide and on some ferric compounds, and gives the soil the bluish color characteristic of the presence of iron in the ferrous state. Close to the surface, however, oxygen, either gaseous or in aqueous solution, more than counterbalances the reducing action of the organic matter, and above a certain line the gravel is consequently reddened by ferric oxide. In shallow deposits the gravel is usually reddened to the bottom, but of course this does not necessarily imply that such gravels have a different origin from those of a bluish tint.

To a very large extent the deep gravels are covered by a capping of volcanic material, sometimes as solid black basalt, and sometimes as loose volcanic "ash"; and while some banks are not thus covered, these are rarely at any great distance from volcanic capping. The volcanic material has protected the gravels in many cases from erosion, but there is also a connection in their deposition. The gravels occur in ancient river beds, which formed the natural channels for the flow of lava as well as of water. Volcanic eruptions occurred during the period of the gravel formation, as well as at its close, and sheets of ash or even of solid lava are found in the banks as well as upon them. When the lava cap is thick and solid the gravels can only be mined by drifting, and are not workable by the hydraulic process.

Besides the deep gravels, which date from a period prior to the volcanic eruptions, there are many accumulations of recent origin. The bars of the present river system have yielded great quantities of gold, and there are many shallow placer deposits which are no doubt due to the modern erosion of quartz croppings, while others are a consequence of the erosion of older gravels. The modern gravels, however, are trifling in quantity as compared with the older deposits. Some of the shallow placers are no doubt mere remnants of deeper Tertiary gravels which have not been wholly carried away by the erosion of the present epoch.

The bed-rock of the gravel deposits varies in character, being either limestone, granite, or metamorphic slate; but the last is the rule, and few important deposits occur far from the slate bed-rock, which, as has been explained, is the main, though not the exclusive, habitat of the gold veins. In nearly all cases the gravel rests in local depressions, early recognized by the California miners as the beds of former streams. Many of the gravels, it is true, are high above the present drainage system, and even form the tops of hills; but this is due to the erosion of the present stream-beds, which have been cut down to a great depth since the gravel period. The bed-rock is usually rough, consisting of nearly vertical slates, and the natural crevices, or "riffles", large and small, thus formed often contain extremely rich gravel. As might naturally be supposed, the greater part of the gold is generally found near the bed-rock, for as gold is about seven times as heavy as ordinary rock every disturbance of a gravel bar in a stream tends to shift the gold to a lower level. Sometimes, however, rich gravel is again deposited over a comparatively firm stratum in the gravel, and occasionally gold is quite uniformly disseminated through a whole bank.

An idea has been current in the mining region that by some process masses of gold in the gravel have increased in size. For this there is absolutely no valid evidence. The rounded masses of gold found could not have been deposited from solution in that form or with such a surface. They have been beaten and worn into shape, much as the accompanying pebbles have been formed, the only difference being due to the fact that gold is malleable. Professor Whitney believes it probable that the higher croppings of the gold veins were richer and contained larger masses of gold than the lower portions of the veins still in place, and if there was any difference at all it was probably of that character. As Professor Newberry (*a*) points out, however, the gravels represent vastly more vein-quartz than has been extracted by deep mining, and the proportion of large masses of gold met with in the veins probably bears as great a ratio to the total weight of quartz extracted, as do the nuggets in the gravels to the quartz from which their metallic contents were derived.

The investigations of the state survey have shown that the deep gravels were deposited by rivers which headed in the high Sierra and ran in a westerly direction, emptying into the sea, which, in Tertiary time, occupied the great valley of California. Although all the details of the former river system cannot now be traced out, the courses and relations of the channels developed by hydraulic mining seem to establish this point beyond a question. There were two great rivers in the Pliocene epoch, one corresponding to the American and the other to the Yuba; but the Bear river of that time probably emptied into the American at a considerable height above the valley.

The gravels cannot possibly have accumulated under the present conditions of precipitation. A far greater erosive power than that exhibited by the California streams of to-day must have been exerted at the time in question, as no one can doubt who has ever visited the gold belt. For a long time past the present rivers have merely been deepening their narrow courses, and when freshets occur they merely serve to sweep the cañons clear of *débris*, but cannot alter the course of the stream. The width of the old channels, as well as the character of the deposits, shows that the old rivers were tumultuous streams of great volume, which frequently burst their bounds and formed new beds.

The evidence of enormous erosive power during the deposition of the gravel has been so apparent to all observers that some of them have called in the action of great glaciers to account for the occurrence of the deposits. According to Professor Whitney this is incorrect; indeed, he holds that the former glaciers of the Sierra did not come into existence until after the greater part of the gravels occupied their present position. The bed-rock which the gravels cover, and which they have protected not only from erosion but even from atmospheric action, shows no traces of glacial polishing and scratching. This is in marked contrast to the higher regions of the range, where the glacial markings are almost as fresh as in the Alps. Nor are occurrences frequent which can possibly be confounded with moraines, while the fossils found indicate, according to Mr. Lesquereux, a climate a few degrees warmer than that of the present time.

Professor Whitney believes the great precipitation necessary to account for the large rivers of the Tertiary in California to have been mainly due to the prevalence of higher temperatures at that period and to the accompanying increased evaporation from the surface of the ocean. It is at least conceivable that the climate should have been something like that of the Khassia hills, upon parts of which the hot winds from the bay of Bengal deposit some 500 inches of rain yearly. The presence of a sea at the foot of the range must have largely increased the rainfall, as has been pointed out. It is to be inferred from Professor Whitney's remarks that he supposes the climate of the Sierra to have been too warm for glaciers during the Tertiary. He regards the present climate, on the other hand, as too dry to permit of their formation, though there can be no doubt of their existence in the higher part of the range above the gold belt up to within a comparatively short time. A few small glaciers on the northern slopes of mount Shasta are now the only remnant of the former ice system of the state. The Sierra glaciers were of the mountain type, however, comparable at their greatest extension with those of modern Switzerland, and nothing like a general glaciation or a diluvial period ever existed in California.

The following sections of auriferous gravel deposits are selected from a large number furnished by the reports of the special experts to illustrate the mode of occurrence of the gravels in various portions of the state:

BONANZA MINE.

MOKELUMNE HILL DISTRICT, CALAVERAS COUNTY, CALIFORNIA.

I	Lava cap in places.		
II	Alternating fine and coarse sand with pebbles (chiefly quartz)	Maximum, 125 feet; average, 75 feet.	Richest portion usually lower 15 feet above bed-rock. In places gold nearly evenly disseminated throughout deposit.
III	Cement. A quartzose (also granitic and slaty) conglomerate, cemented with sesquioxide of iron.		
IV	Bed-rock, slate.		

The ancient channel on which this mine is located is traceable, with intermittent breaks, for 10 miles. The channel is 500 feet wide, the outer edges barren, and the pay channel is 300 feet wide.

a School of Mines Quarterly, November, 1881.

LAGRANGE HYDRAULIC MINE.

LAGRANGE DISTRICT, STANISLAUS COUNTY, CALIFORNIA.

I	Red sand	Maximum, 300 feet; average, 40 feet.	
II	Coarse red gravel, containing pebbles of granite, etc		
III	Red cement ("hard-pan")		
IV	White siliceous clay		
V	Red cement (same as III)		
VI	Sand with pebbles		
VII	Loose yellow sand		
VIII	Dark-colored gravel, containing *débris* of granite, argillaceous slate, "serpentine," etc., with some quartz.		Lowest 6 feet 8 inches richest.
IX	Bed-rock at Lagrange "diorite and slate"; at Patricksville "basaltic tufa" (no specimen).		

Quartz forms but a small proportion of the gravel, which is chiefly granite, etc. Generally the upper workings do not pay, 90 per cent. of the gold being obtained from near the bed-rock; but sometimes the upper horizon is the richest. At Patricksville, gravel is overlaid by tufa; not much tufaceous cropping at Lagrange. Ancient river bed. Deposit in patches for 1 mile wide by 2½ miles long.

LYON DRIFT MINE.

PLACERVILLE DISTRICT, EL DORADO COUNTY, CALIFORNIA.

I	"Lava" or a consolidated sediment of volcanic origin	60–130 feet.	
II	Mountain gravel	0–50 feet.	
III	Granitic sand, in places consolidated	0–20 feet	
IV	Gravel	Maximum, 20 feet; average, 3½ feet.	
V	Bed-rock, slate.		

Three benches of ancient river, overlaid with volcanic matter, 60 to 130 feet wide, are here traceable for 3,000 feet.

ORION MINE.

IOWA HILL, PLACER COUNTY, CALIFORNIA.

I	Sand and fine gravel	Maximum, 180 feet; average, 100 feet.	All pays. Richest near bed-rock.
II	Coarser blue gravel		
III	Bed-rock, black slate, rough.		

No lava; no quicksand. Ancient river bed, said to be 2,000 feet wide, traceable 2½ miles.

VAN EMMONDS' MINE.

MICHIGAN BLUFFS, PLACER COUNTY, CALIFORNIA.

I	Very little lava.		
II	Fine gravel, alternating with sand strata	Maximum, 60 feet; average, 30 feet.	All pays; but white gravel nearest bed-rock best.
III	Blue gravel		
IV	White gravel		
V	Bed-rock, rough slate		

Petrified wood, leaves of oak, pine, etc., found in sand strata. It is unusual to meet white gravel beneath the blue.

MORRIS RAVINE MINE.

MORRIS RAVINE DISTRICT, BUTTE COUNTY, CALIFORNIA.

I	Hard, solid lava cap in places.		
II	Fine quartz gravel	Maximum, 150 feet; average, 40 feet.	A little gold throughout. Blue gravel richest.
III	Rotten bowlders		
IV	Blue gravel	8–20 feet.	
V	Bed-rock, chloritic and clay slates, rough and decomposed.		

Pipe-clay occurs irregularly throughout deposit. Quicksand met with.

SPRING VALLEY MINE.

CHEROKEE DISTRICT, BUTTE COUNTY, CALIFORNIA.

I	Lava cap over part of claim.		
II	Fine quartz gravel	25–150 feet. (Maximum depth, 400 feet; average, 200 feet.)	Best pay in III and IV on bed-rock.
III	Rotten bowlders of yellow slate mixed with quartz gravel	5–15 feet.	
IV	Blue gravel	15–80 feet.	
V	Bed rock, where exposed, described as "basalt" like the cap, probably metamorphic. Surrounding country rock is slate.		

Water and quicksand found in large quantities at the depth of 300 feet. Barren pipe-clay, 25 to 150 feet in places, as a rule overlying rich gravel.

HUNGARIAN HILL MINE.

PLUMAS COUNTY, CALIFORNIA.

I	Soil	Maximum, 110 feet; average, 75 feet.	Gold throughout gravel. All pays.
II	Loose gravel, same character from surface to bed-rock		
III	Generally soft slate bed-rock; in places hard siliceous slate. Rough, with projecting points in some places rising nearly to surface.		

River bed, with rim-rock on each side, 250 feet wide; traceable, 3½ miles. No lava, water, or quicksand.

CARROLL DRIFT MINE.

McADAM'S CREEK DISTRICT, SISKIYOU COUNTY, CALIFORNIA.

I	Loam	4 feet.	Maximum, 115 feet; average, 73 feet.	None barren, but only a small portion pays for drifting. The pay streak is 200 feet wide and length of claim.
II	Loose tailings	6 feet.		
III	Wash gravel, with clay and sand	10 feet.		
IV	Compact yellowish-white clay (water level)	18 inches to 4 feet.		
V	Coarse yellowish gravel (bulk of deposit)			
VI	Quartzose matter	3-6 inches.		Good pay.
VII	Greenish gravel	12 feet		Best pay on bed-rock and in bed-rock to a depth of 2 feet.
VIII	Bed-rock, rotten brown slate and hard fine-grained blue slate.			

Bed of McAdam's creek. Mining is carried on over a length of 3½ miles by a width of 150 to 600 feet.

OAK GROVE DRIFT MINE.

McADAM'S CREEK DISTRICT, SISKIYOU COUNTY, CALIFORNIA.

I	Loam	4 feet.	Average, 65 feet.	None of the gravel is barren.
II	Loose tailings	6 feet.		
III	Wash gravel, with clay and sand	10 feet.		
IV	Compact yellowish clay (water level)	18 inches to 4 feet.		
V	Coarse yellow gravel			
VI	Quartzose matter	4 to 6 inches.		Good pay.
VII	Yellow gravel			The best pay is 1 to 3 feet on bed-rock and 1 to 3 feet in bed-rock.
VIII	Bed-rock, brown slate, ridgy and seamy in places; in others soft and open.			

PACIFIC MINE.

HUMBUG DISTRICT, SISKIYOU COUNTY, CALIFORNIA.

I	Loose wash gravel	5 feet.	Maximum, 50 feet; average, 45 feet.	Contains but little gold.
II	Coarse yellow gravel, containing many large bowlders	8 feet.		
III	Fine sand	6 inches to 2 feet.		None barren.
IV	Yellow gravel	20 feet.		
V	Dark yellow gravel	1 foot.		
VI	Blue gravel	8 inches to 10 feet.		Best pay.
VII	Bed-rock, blue slate.			

River bed traced for 1 mile, average 50 feet wide.

BUNKER HILL MINE.

DEL NORTE COUNTY, CALIFORNIA.

I	Red loam mixed with fine gravel	15 feet.	Maximum depth of bank, 125 feet; average, 80 feet. Maximum depth of gravel, 50 feet; average, 30 feet.	None of the gravel is barren, but the richer portion is near bed-rock.
II	Loose gravel	15 feet.		
III	Gray cement streak, 60 feet wide. Large bowlders in best ground	20 feet.		
IV	"Serpentine" bed-rock easily piped, having blue slate under it (Leavens). Specimen determined as highly metamorphic dioritic-looking rock.			

Channel one-half to three-quarters of a mile, 150 feet long; course a little west of north.

Large deposits of copper ores have been found in the auriferous slate series, especially in Calaveras county. Copperopolis is the principal point, but there are also deposits at Campo Seco, and again further north near Ione City. Prospects have also been found on the same line beyond this point. The ores are native copper and carbonates near the surface, replaced by a mixture of iron and copper pyrite below the water-line. The deposits have the same dip and strike as the inclosing chloritic slates. Extensive shipments were made in former years.

Mono and Inyo counties, though politically united to California, considered from a physico-geographical point of view, form a portion of the Great Basin. The sedimentary rocks of Mono county appear to be Mesozoic, but the western edge of the great Palæozoic area which covers the eastern portion of the Great Basin crosses the California line about due south of Columbus, Nevada, passing near Owen's lake and then diverging to the southeast. Great quantities of lava are met with in both counties, as throughout the Great Basin. The deposits of these counties also bear a much closer resemblance to those of Nevada than to those of central California. The best known mining localities are Bodie, Cerro Gordo, and Panamint, but none of them have formed the subject of any detailed geological investigation.

The bullion of Bodie is usually regarded as gold, because its silver contents are much less valuable than the accompanying gold. Reports made to the director of the mint for the year 1880 show that from 5 to 63 per cent. of the value of the bullion produced by the various mines was silver, which also formed 17.91 per cent. of the value of the total product ($3,063,699 13). It follows that from 45.7 to 96.5 per cent. of the weight of the bullion from different mines and 77.72 per cent. of the total weight was silver. In 1879, when a smaller portion of the colorados were worked out, silver only formed 65.2 per cent. of the entire weight. Bodie metal may therefore very properly be regarded as a highly doré silver bullion, similar to that of the Comstock lode, and as essentially different from that of the gravel and slate region ordinarily known as the gold belt.

The Comstock was at first worked for gold. The Bulwer, the Syndicate, and the Standard Consolidated, which show but little silver, are on top of a hill where the water-level is far from the surface and the quartz is reddened to a great depth; the Bodie Consolidated, Noonday, and others are at lower elevations. The sulphurets of these mines are not oxidized, and the bullion shows a large amount of silver.

The gangue minerals of these deposits are base sulphurets, quartz, and calc-spar. They are inclosed in extremely decomposed rock, bearing clear signs of solfataric action. The rock is so highly altered that tolerably fresh specimens are not obtainable near the mines. Slides of the freshest specimens collected are not decisive as to the character of the rock. They show plagioclase, and apparently some orthoclase, accompanied by mica and a little hornblende; the ground mass also contains quartz. Only a detailed examination in the field will decide what name the rock should bear.

The mines of Cerro Gordo were not in operation during the census year. The deposits, which at one time were very productive, were masses of argentiferous lead ores occurring in limestone, and consisting for the most part of carbonate, sulphate, and other decomposition products of galena. Schists and slates were also met with in the mines, as well as a granite-porphyry. This is said to occur as a dike in the Union mine and elsewhere, and is locally called syenite, though it is quartzose and micaceous. Panamint was for a short time a very flourishing camp, its prosperity being derived from veins in limestone carrying chiefly argentiferous gray copper ore or freibergite, associated with galena and zincblende. Mining is still being carried on, but the richer deposits were soon worked out. The age of the limestones of Cerro Gordo and Panamint is unknown. Both districts lie near the contact between the Palæozoic and the Mesozoic, and may belong to either; but limestones are exceptional in the Trias and Jura of the Sierra region, while they predominate in the Palæozoic area.

Gold has been found at a great number of points in the Coast ranges proper and in the western ranges of southern California. No doubt large individual profits have been made at certain localities, and it is by no means impossible that as good or better veins than those found await discovery. It is scarcely likely, however, that after thirty years of skillful prospecting any important gold-mining region has escaped observation. A few years since great hopes were raised by the prospects on veins in the slates and on the contact between slates and granite in the Julian and Banner districts near San Diego, but they have fallen short of the expectations excited.

The so-called Gold Bluffs along the coast of the northern counties, especially near the mouth of the Klamath river, are bluffs which contain extremely small quantities of gold, and seem to be beds of detritus left by the shifting of the river channels. The sea encroaches upon them, and when the surf strikes the beach in certain directions and with a certain strength the gold is concentrated in comparatively rich sands, which are gathered and treated in apparatus of various designs by amalgamation.

The only quicksilver ore of great importance is cinnabar, although metacinnabarite, the black sulphide, is rather abundant in a few mines, and metallic quicksilver sometimes accompanies the deposits of its compounds. The metacinnabarite described by Dr. G. E. Moore was amorphous, but according to Mr. Goodyear it also occurs as minute crystals. Cinnabar is found in a great number of localities in the Coast ranges for 100 or 150 miles north and south of San Francisco, always, so far as known, in metamorphic rocks of Cretaceous age. The character of the metamorphism is generally peculiar, and the so-called quicksilver rock is readily recognizable. It is a silicified chert-like material, often reddened by iron oxide, and usually accompanied by serpentine or serpentinoid matter. In almost all cases pyrite or marcasite and bituminous matter accompany the cinnabar, and mispickel and copper pyrite are reported in a few instances. At Sulphur Banks, on Clear lake, native sulphur occurs in great quantities with the quicksilver ore, and native gold has been found in water-worn masses of cinnabar not far from the same locality. The converse occurrence of cinnabar in two of the quartz veins of the Sierra gold belt has already been noticed. Stibnite is reported as occurring with cinnabar at the Lake mine near Knoxville. The usual gangue minerals are quartz, calcite, and magnesite.

Cinnabar does not occur in well-marked veins, but generally in irregular bodies distributed through the rock. In the New Almaden mine, which has been much more extensively worked than any other in the state, these bodies appear, from a model constructed by the owners, to lie on a curved surface, indicating a geometrical relation between the positions of the several ore-bodies, though an obscure one. At this mine the masses of ore are usually connected by tiny seams of the same material. There is a strong similarity between this mode of occurrence and that of many lead-ore deposits in limestone, and it may be that the problem of their true character is the same.

The quicksilver country north of San Francisco is a volcanic region, while to the south volcanic rocks are subordinate in some localities and wanting in others. To the south, too, there is no indication of any recent deposition of the ore, while to the north deposition is still actually in progress. No general inference as to the genesis or the age of the deposits can therefore be drawn without further investigation, while the great similarity in the association of minerals suggests a similar origin for most of them.

The Sulphur Banks, on Clear lake, forms the subject of a recent paper by Professors Le Conte and Rising. (*a*) At that point cinnabar with pyrite and some bituminous matter, as well as free sulphur, is now being deposited. The hot waters rising to the surface are charged with sulphides of ammonium and of the fixed alkalies, and appear to carry in solution cinnabar and pyrite, which are deposited, in the opinion of the authors, by reduction of temperature and pressure, probably assisted by neutralization through the percolation of free sulphuric acid from the surface. The deposition of sulphur is a surface phenomenon. It may also have attended the formation of the deposits to the south of San Francisco and have been subsequently removed by erosion.

The only Californian coal-fields of great importance are those near Monte Diablo, which occur in sandstones of the Upper Cretaceous or Téjon group. According to Professor S. F. Peckham's examination, (*b*) these coals carry from 5 to 11 per cent. of ash, 4½ to 5¼ per cent. of sulphur, and from 11½ to 13 per cent. of water. The refuse dumps of these mines frequently take fire spontaneously from the oxidation of pyrite. Coal of the same age occurs under less favorable conditions at Corral Hollow, in the Monte Diablo range. Seams are found here and there all along the Coast ranges, but they are usually thin, and even when of a workable thickness are so faulted and broken as to be of small value.

Lignite of Pliocene age is found at Ione valley, Amador county, and is used along the line of the railroad to some extent at Dog creek, near the Truckee river.

In southern California there are vast quantities of bitumen, from which asphalt and a certain quantity of illuminating oils are obtained. The bitumen occurs in shales of the Miocene, which are in large part too much disturbed to permit of the accumulation of pressure necessary to induce flowing wells. Many of these bitumens, though thin as they issue from the ground, oxidize and are converted into hard asphalts. According to Professor Peckham, the California bitumens are composed of a different series of hydrocarbons from those which make up the petroleums of Pennsylvania.

AMADOR COUNTY.

This county lies directly across the main gold belt. Quartz mining takes the first rank, though there are gravel deposits, and hydraulic mining is carried on to a considerable extent. The gold in the veins is associated with iron and copper pyrite, marcasite, mispickel, and small quantities of galena. The gangue is chiefly quartz, but some calcite is occasionally found in the veins. The country rocks are slate and granite, the former being predominant, but a greenstone also occurs, which, though much decomposed, is probably a diabase or proterobase. The mother lode has been traced with certainty from Mariposa to about the center of Amador. Copper is found in the western portion of the county, but it is not at present worked, and a lignite occurs at Ione City which is of considerable local importance.

AMADOR.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
AMADOR CITY.				
Keystone	(Gold, chalcopyrite, galena), pyrite and quartz	Proterobase (?)*	Proterobase (?)*	Vein.
JACKSON.				
Monte Richard	(Gold), iron-stained quartz	(Greenstone or augite-porphyry, called granite)	Proterobase	Vein.
Oneida	(Gold, galena, chalcopyrite, and marcasite), pyrite and quartz.	Greenstone, probably an augite-porphyry.	do	Do.
Zeile	(Gold, pyrite, rarely galena and chalcopyrite, quartz).	(?)	Quartzite	Do.
PLYMOUTH.				
Pacific Mining Company (Empire, etc., mines).	(Gold), indeterminable black sulphurets and quartz			Vein.
SUTTER CREEK.				
Consolidated Amador	(Gold, galena, chalcopyrite, mispickel), pyrite and quartz.	(Clay mica slate)	(Talcose slate)	Vein.
VOLCANO.				
Madeira	(Gold), galena, calcite, and quartz.			

* Examined microscopically.

a American Journal, vol. 24, p. 23, 1882.

b Geological Survey of California: Geology, II, p. 44.

BUTTE COUNTY.

A large part of Butte county lies in the Great Valley, and produces no gold; but the eastern portion contains extensive gravel deposits, which are continuations of those of Plumas and Yuba. Much of the gravel is covered by a cap of basalt, and the bed-rock is, in all the cases reported, sandstone or metamorphic slate.

BUTTE.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
CENTERVILLE.				
Big Butte creek	(Gold gravel)	(Sandstone)	Basalt cap*	Placer.
CHEROKEE.				
Spring Valley	(Gold gravel)	Altered diabase*		Do.

* Examined microscopically.

CALAVERAS COUNTY.

Both quartz and gravel mining are actively pursued in this county, which lies across the gold belt. The auriferous quartz carries iron and copper pyrites, mispickel, galena, and zincblende. The wall rocks in all the cases reported are metamorphic. The mother lode crosses this county. The gravel is of the ordinary character, and, as usual, is accompanied by more or less basaltic lava. Copper deposits occur below or to the west of the gold belt at and near Copperopolis.

CALAVERAS.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mines.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
ANGEL'S.				
Potter Prospect	Gold, galena, and quartz			Vein.
MOKELUMNE HILL.				
Gwin	(Gold, mispickel, zincblende), pyrite, chalcopyrite, and quartz.	(Black slate)	(Black slate)	Do.

DEL NORTE COUNTY.

Auriferous gravels are the chief metalliferous deposits of this county, the bed-rock consisting of slate and other sedimentary strata. Beach sands are also worked to a small extent on the coast.

DEL NORTE.

[NOTE.—Determinations in parentheses are given on the authority of the expert.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
Bunker Hill	(Gold gravel)	Metamorphic dioritic rock		Placer.
China Creek	do	Schist and shale		Do.
Del Norte	do	Slate		Do.
Happy Camp	do	do		Do.
Muc-a-muc	do	Shale		Do.
Wingate	do	Slate		Do.

EL DORADO COUNTY.

El Dorado lies across the gold belt, and contains a great deal of gold quartz, while the placers are comparatively insignificant. Some of them, however, buried under heavy caps of lava, are profitably worked by drifting. The gold quartz carries the usual sulphurets, pyrites, mispickel, and zincblende. The country rock is chiefly slate. Copper ores also occur in the western part of the county.

EL DORADO.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
PLACERVILLE.				
Lyon	(Gold gravel)	Slate	Lava cap, basalt, pumice*	Placer.
Placerville	(Gold, pyrite), talc and quartz	(Greenstone and slate)	(Greenstone and slate)	Vein.
Springfield	Gold, pyrite, mispickel, quartz, (zincblende and galena).	(Slate)	(Slate)	Do.

* Examined microscopically.

FRESNO COUNTY.

Fresno extends from the crest of the Sierra to the Coast ranges. It lies to the south of the main gold belt, but contains a few gold quartz veins in the Potter ridge district and elsewhere, carrying the usual sulphurets, and being inclosed in slates. At the western edge of the county is the famous New Idria quicksilver mine, in which cinnabar is accompanied by pyrite and bituminous matter. According to Mr. Goodyear, the ore does not occur in a vein, at least of the typical character, but in irregular bodies, distributed in metamorphic sandstone and shale.

FRESNO.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
SAN CARLOS.				
New Idria	Cinnabar, (pyrite, chalcopyrite, and bitumen)	Sandstone and shale	Sandstone and shale	Vein.
POTTER RIDGE.				
Fresno Enterprise	(Gold, sulphurets, and quartz)	(Slate)	(Slate)	Do.

HUMBOLDT COUNTY.

There is no gold-quartz mining in Humboldt, and the placer mines are not extensive, compared with those of the central counties. The gravels appear to represent modern river bars of the Klamath, along the banks of which they are found, in some cases, however, at a very considerable elevation above the present stream. As in Del Norte, there are auriferous beach sands, which can be worked with profit when certain combinations of wind and waves have effected a preliminary concentration of the auriferous material.

INYO COUNTY.

The most important mines in this county carry argentiferous lead ores with calcareous gangue. They occur either in limestone or in limestone associated with granite and schist. The deposits are chimneys, or bodies of an irregular form, such as lead ores frequently assume elsewhere. Copper ores, associated with those of lead, also occur. Where copper is the principal constituent the gangue is usually siliceous. The copper veins occur in limestone or in granite, or on the contact between the two. The lead ores are galena, cerussite, anglesite, and probably lead ocher, accompanied by argentite and other silver minerals. The copper ores are chalcopyrite, stromeyerite, tetrahedrite, bornite, and carbonates. They are usually argentiferous. In addition to the gangue minerals mentioned, fluorite is found in the Defiance mine, in a silver-lead deposit between granite and limestone. There are also gold-quartz veins in granite in the county, and some small gold placers. At the Lee mine argentite and horn-silver are reported as occurring in limestone.

INYO.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
CERRO GORDO.				
Ignacio	(Milling ore), quartz	(White limestone)	Schist (white limestone).	
Jefferson	Galena, cerussite, and anglesite	Marble	Marble.	
San Felipe	Polybasite and copper stains and quartz	...do	...do.	
Union Consolidated	Galena and limonite	{ ..do Granite, porphyry dike*. }	...do	Vein.
COSO.				
Defiance	Galena, cerussite, chalcopyrite, malachite, fluorspar, calcite, and pyrite.	(Granite)	Siliceous limestone	Vein.
Josephine	(Gold quartz)	...do	(Granite)	Do.
New Coso Company (including Lucky Jim and Christmas Gift).	Galena, cerussite, calcite, and (anglesite)	Granite	Limestone (containing barium).	Do.
Mariposa	(Gold, auriferous pyrite, and quartz)	(Granite)	(Granite)	Do.
Phœnix	Cerussite and anglesite	Limestone and schist	Limestone and schist	Bedded vein.
KEARSARGE.				
Kearsarge	Cerussite, micaceous iron, limonite, (tetrahedrite, cerargyrite, and argentite), quartz.	Granite*	Granite*	Vein.
PANAMINT.				
Hemlock	Stromeyerite, (tetrahedrite, galena, pyrite, and zinc-blende), quartz.			
LOOKOUT.				
Modoc Consolidated	(Cerussite, carrying gold and silver, with arsenic and antimony; calcite, iron oxide, and manganese minerals.)	(White limestone)	(Blue limestone)	Bedded vein.
RUSS.				
Brown Monster	(Cerussite, galena, bornite, malachite, pyrite, and quartz.)	(Blue limestone)	(Blue limestone)	Vein.
FISH SPRINGS.				
Golden Wreath	(Gold, auriferous pyrites, and quartz)	Granite	Granite	Flat vein.
Alabama	(Gold quartz)	(Granite)	(Granite)	Vein; also small placer.
Lee	(Horn-silver, argentite, and quartz)	(Limestone)	(Limestone)	Deposits.

* Examined microscopically.

KERN COUNTY.

Kern county lies south of the main gold belt; it nevertheless contains some gold-quartz veins in its northeastern portion, in the Sierra range, as well as some shallow placer gravels.

LAKE COUNTY.

The only important mineral deposits of Lake county are those of quicksilver, which occur at a number of points in considerable quantities, accompanied by pyrite, sulphur, bituminous matter, and quartz. The inclosing rocks are metamorphic. The deposits are associated in some cases with basalt.

LAKE.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
Great Western	Cinnabar, pyrite, bitumen, and quartz	Metamorphic	Metamorphic	Vein.
EAST LAKE.				
Sulphur Banks	(Cinnabar, native sulphur, bitumen, pyrite, borax, alum, and quartz.)	Sandstone and basalt	Sandstone and basalt	Irregular deposit.

LASSEN COUNTY.

This county contains gold-quartz mines. The veins are associated with rocks which are in part metamorphic and probably also in part eruptive, but the specimens in the collection are so decomposed as to be indeterminable. Enormous quantities of lava cover much ground in this part of the state that would probably otherwise be remunerative.

LASSEN.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
HAYDEN HILL.				
Brush Hill	(Gold), quartz	Indeterminable	Indeterminable	Vein.
Golden Eagle	do	do	do	Do.

LOS ANGELES COUNTY.

There is some silver mining in this county. Antimonial silver ores and argentiferous galena occur with pyrite, copper ores, and quartz inclosed between wall rocks which are chiefly sedimentary, but probably in part eruptive. Asphalt, petroleum, and coal, as well as salt, are also found in the county.

LOS ANGELES.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
SILVERADO.				
Blue Light	Galena, pyrite, and quartz	Limestone and quartzite	Limestone and quartzite	Vein.
Dunlap	Galena, zincblende, pyrite, (antimony and copper stains).	Quartzite	Shale.	
Phœnix	do	Probably diorite	Probably diorite.	

MARIPOSA COUNTY.

This is the most southerly county on the gold belt, and contains many gold-quartz veins inclosed in slate. Argentite, proustite, and (it is said) silver telluride are also found. The southern end of the mother lode is in this county on the famous "Mariposa estate".

MARIPOSA.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
MARIPOSA.				
Hiti	(Free gold, galena, copper pyrite, occasionally gold; pyrite, zincblende quartz, telluride ore.)	Graphitic slate	Graphitic slate	Vein.
SEBASTAPOL.				
Modesta	Proustite, argentite, and quartz, (telluride ore)			Probably vein.
Coe	(Free gold quartz)		(Slate)	Vein.

NAPA COUNTY.

In this as in the adjoining county, Lake, the principal useful mineral found is cinnabar, which occurs in the usual serpentinoid and arenaceous metamorphic strata. The Redington mine is one of the most important quicksilver producers in the state.

NAPA.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
OAT HILL.				
Napa Consolidated	Cinnabar, with sandstone and clay, (bituminous matter).	Sandstone	Sandstone	Vein.
Redington	Cinnabar, metacinnabarite, marcasite, bitumen, quartz, (mispickel).	Serpentine	Schist	Irregular bodies.

MONO COUNTY.

This county seems to contain two classes of deposits. The highly doré silver, or low-grade gold of Bodie, is found in eruptive rocks of as yet undetermined character. A portion of the gold is free, but a large part of it is associated with complex silver sulphides, accompanied by quartz and calcite as gangue minerals. The other districts are granitic and carry chalcopyrite, copper glance, and carbonates, with galena, zincblende, argentite, and other silver minerals.

MONO.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
BLIND SPRING.				
Comanche	Copper glance, chalcopyrite, zincblende, probably tetrahedrite, chrysocolla, (partzite, malachite, clay, and quartz).	Granite	Granite	Vein.
Diana and Kerrich	Copper glance, chrysocolla, copper carbonates, limonite (partzite and malachite), with earthy and (decomposed granitic gangue).	do	do	Do.
Modoc	Copper glance, chrysocolla, copper carbonates, (galena and horn-silver).			
BODIE.				
Bechtel Consolidated	(Gold and silver bearing quartz)	(Porphyry)	(Porphyry)	Vein.
Bodie Consolidated	do			Do.
Boston Consolidated	(Gold and silver bearing iron-stained quartz)			Do.
Bulwer	(Quartzose and feldspathic vein matter carrying gold and silver.)			Do.
McClinton	(Gold and silver bearing quartz)	(Birdseye porphyry)	(Birdseye porphyry)	Do.
Noonday	do			Do.
Oro	(Pyrargyrite and proustite)	(Porphyry)	(Porphyry)	Do.
Standard Consolidated	(Gold and silver bearing quartz)	do	do	Do.
Defiance	(Gold, silver, quartz, and feldspathic matter)	Indeterminable (volcanic)		Do.
Goodshaw	(Auriferous quartz)	(Porphyry)	(Porphyry)	Do.
Jupiter	(Argentiferous gold quartz)	(Volcanic)	(Volcanic)	Do.
HOMER.				
Maybell	(Gold, silver, iron pyrite, galena, and quartz)	Quartz-porphyry (?)	Quartz-porphyry?	Vein.
May Lundy	do	Granite	Granite	Do.
INDIAN.				
Illinois	Tetrahedrite, zincblende, and quartz	(Granite and porphyry)	(Granite and porphyry)	Vein.
Tower	Galena, zincblende, native silver, tetrahedrite, (pyrargyrite, pyrite, and quartz).	do	do	Do.

NEVADA COUNTY.

Nevada has always been one of the most productive counties in the state, both the quartz and the placer mines yielding very large amounts. The quartz mines are for the most part in the slates characteristic of the main gold belt, but some of them are in granite, and some of them are on the contact between granite and slate. The gold is accompanied by iron and copper pyrites, mispickel, galena, and zincblende. As elsewhere in the gold belt, the proportion of silver is extremely small, even by weight. Though the larger part of the gold is free, the sulphurets are ordinarily much richer than the quartz taken as a whole, and it usually pays to concentrate them and subject them to the Plattner chloridation process. The placer deposits are in part covered by volcanic rocks, chiefly basalt. The cap over a large area, however, is not so deep as to prevent the gravel from being worked, as it does to a considerable extent in the counties further north, while the amount of volcanic material has been sufficient to protect the gravel from extensive erosion. One of the great Tertiary rivers flowed through this county in a southwesterly direction and gave rise to the large gravel accumulations.

NEVADA.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
GRASS VALLEY.				
Idaho	Free gold, galena, iron and copper pyrites, and sometimes zincblende, quartz.	Magnesian metamorphic rock.	Magnesian metamorphic rock.	Vein.
New York	Gold, pyrite, zincblende, galena, quartz, (copper pyrite).	Slate	Slate	Do.
Rocky Bar	(Gold), pyrite, (zincblende, galena, iron, and copper pyrite), quartz.	Metamorphic	Metamorphic	Do.
NEVADA CITY.				
Merrifield	Pyrite and quartz.			
Murchie	(Gold), pyrite, (galena, copper, and iron pyrite), quartz.	Granite	Granite	Vein.
Providence	(Gold, iron, and copper pyrite, galena, zincblende, and quartz.)	Slate	do	Do.

PLACER COUNTY.

Placer lies directly across the gold belt, and is one of the principal producing counties. The gold-quartz veins occur for most part in slates, though some are found in granite, and they present the usual association of sulphurets. The auriferous gravels have been sufficiently protected by volcanic material to escape radical erosion without being so deeply covered as to be inaccessible. Iron-ore deposits are abundant.

PLACER.

[NOTE.—Determinations in parentheses are given on authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
COLFAX.				
Rising Sun	(Gold quartz)	(Granite)	(Granite)	Vein.

PLUMAS COUNTY.

The gold belt in the latitude of Plumas county is not so sharply defined as further south. Deposits of the precious metal, however, are abundant, both as veins and in gravel. The association of sulphurets accompanying the gold is the same as in Nevada county. The wall rocks are either slates and other metamorphic rocks or granite or both. The slates are sometimes so intersected by auriferous quartz as to give the veins a reticulated character. Although the production of the placer mines is considerable, a large part of the gravel is supposed to be inaccessible through the presence of heavy overlying sheets of basalt.

PLUMAS.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
CHEROKEE.				
Plumas Eureka	(Gold), iron and copper pyrites, galena, quartz	Metamorphic diorite *	Metamorphic diorite *	Vein.
GENESEE VALLEY.				
Genesee	(Gold), slate and quartz	Slate	Slate	Reticulated vein.
INDIAN VALLEY.				
Gold Stripe	(Gold generally free from sulphurets), quartz	(Slate)	Quartzite	Vein.
Green Mountain	(Gold, pyrite), quartz	(Decomposed granite)	(Decomposed granite)	Do.
Monitor	Gold, quartz	(Granite)	(Slate)	Do.
Plumas National	(Quartz), pyrite and mispickel	Slate	Slate	Do.
SENECA.				
Savercool	(Gold), pyrite sandstone, and quartz	(Clay slate)	(Clay slate)	Vein.
Sunnyside Gravel	(Auriferous gravels)		Basalt cap	Placer.

* Examined microscopically

SACRAMENTO COUNTY.

The deposits of Sacramento county are mainly gravels, and are confined to its eastern and northern borders, where it adjoins Placer, El Dorado, and Amador. These gravels are in fact the western extremities of the extensive fields occurring in the more eastern counties. A larger product is usually accredited to the county than it actually yields, much bullion being shipped within its borders which is produced elsewhere. This is a consequence of the commercial importance of several towns of the county, among which is the capital of the state.

SAN BERNARDINO COUNTY.

There are veins in granite in this county which carry gold, copper, silver, and lead. There are also copper veins in limestone. Tin ore deposits are found at Temescal, where the ore is of an unusual character, but these are not now worked. Platinum sand is said to occur.

SAN BERNARDINO.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
CLARK.				
Ally	(Argentiferous), stromeyerite	Limestone	Limestone	Vein.
Ivanpah	(Argentiferous), stromeyerite, copper carbonates, (limestone).	Limestone, probably dolomitic.	Limestone, probably dolomitic.	Do.
Lizzie Bullock	(Argentiferous), stromeyerite, copper carbonates, (limestone).	do	do.	
DRY LAKE.				
Desert Chief	(Silver ore), limonite, and quartz	(Granite)	(Granite)	Vein.
Oriflamme	Free gold, limonite, and quartz			Probably vein.
SILVER MOUNTAIN.				
——	(Gold), stromeyerite, malachite, lead, and quartz	(Granite)	(Granite)	Vein.
SAN JACINTO.				
——	Cassiterite and quartz.			
——	Granitic or dioritic sand, said to carry platinum.			

SAN DIEGO COUNTY.

There are some gold-quartz veins in San Diego occurring in metamorphic rocks and granite. Salt also forms one of the resources of this county.

SAN DIEGO.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
BANNER.				
Hubbard	Gold, sulphurets, and quartz	Slate	Slate	Vein.
PINECATE.				
Gold State	(Gold, copper and silver in traces), quartz	(Granite and slate)	(Granite and slate)	Do.
CARGO MUCHACHO.				
Madre, Padre, and Cargo Muchacho mines.	(Free gold), quartz	Metamorphic	Metamorphic	Do.

SAN LUIS OBISPO COUNTY.

There are several occurrences of cinnabar in metamorphic rocks, which appear to be similar to the more northern deposits of this ore. Chromic iron is found in considerable quantities.

SAN LUIS OBISPO.

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
SAN LUIS OBISPO.				
Flores Iron	Chromic iron	Augitic porphyry	Augitic porphyry.	
London Iron	do	Metamorphic *	Metamorphic.*	
SAN SIMEON.				
Oceanic	Cinnabar, sulphur	Sandstone	(Shale)	Impregnation.
Polar Star	Cinnabar.			

* Microscopically examined.

SANTA BARBARA COUNTY.

No important deposits, except of bitumens, are found in this county.

SANTA BARBARA.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
SANTA BARBARA.				
Las Prietas	(Cinnabar, chrome iron)		(Serpentine)	Impregnation.

SANTA CLARA COUNTY.

The chief mineral resources of this county are the cinnabar deposits of the New Almaden and Guadalupe mines. They form irregular deposits, in many cases connected by veinlets of ore. The cinnabar is accompanied by pyrite, calcite, magnesite, and bitumen. Dolomitic limestone, shale, and serpentine are the inclosing rocks.

SANTA CLARA.

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
New Almaden	Cinnabar, mercury, bitumen, calcite, magnesite, and pyrite.	Limestone, shale, serpentine, and dolomite.		Vein.
Guadalupe	Cinnabar (and calc-spar), bitumen, magnesite, quartz.	Serpentine	Serpentine	Do.

SHASTA COUNTY.

There are veins in the schists and granites of this county which carry silver ores and gold associated with iron and copper pyrite, galena, and zincblende. A very remarkable occurrence is that of the Mad Ox mine, where native gold is found in calcite. The deposit is reported as a 2½-foot vein. The foot wall is schist and the hanging wall a siliceous limestone. Quartz and pyrite also occur in this vein as gangue minerals. Shasta contains some gold-placer mines.

SHASTA.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
IRON MOUNTAIN.				
Lost Confidence	(Silver and gold.) The silver is probably present as chloride, limonite, copper, pyrite, marcasite (argentite; the pyrite is rich), quartz.	Schist	Schist	Vein.
NEAR IGO.				
Dry Creek, or Hardscrabble	(Gold)	Slate bed-rock		Placer.
PITTSBURGH.				
Potter Mining Co.	Copper oxide, sulphide and carbonate, limonite, pyrite, (silver and zincblende).	Slate (porphyry and slate)	Slate (porphyry and slate).	
SOUTH FORK.				
Chicago	Galena, pyrite, quartz, (chalcopyrite, antimony, ruby silver, native silver, gold, and zincblende).	(Granite)	(Granite)	Vein.
WHISKY CREEK.				
Mad Ox	Native gold in calcite, limonite, quartz, pyrite, (sulphurets and talcose schist).	Schist	Siliceous limestone	Do.

SIERRA COUNTY.

Sierra county lies between Nevada and Plumas, and shares the geological character of those counties. Both its placer and quartz mines produce largely, but present no characteristics not shared by those of the adjoining regions.

SISKIYOU COUNTY.

Siskiyou county contains gold-quartz veins occurring in metamorphic rocks and accompanied by pyrite, mispickel, etc. Greenstone is reported as the hanging wall of the Black Bear and the Klamath, but no specimens of this rock have been received, and it is therefore impossible to pronounce with certainty as to its character. The principal product of the county, however, is derived from the placers, many of which are worked as drift mines.

SISKIYOU.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
INDIAN CREEK.				
Bay City	(Auriferous gravel)	Argillaceous limestone bed-rock.		Placer.
Coyote Gulch	do	Metamorphic bed-rock		Do.
Williams Drift	do	do		Do.
M'ADAMS CREEK.				
Carroll Drift	(Auriferous gravel)	Slate bed-rock		Placer.
Duncan Cameron	do	do		Do.
Hardscrabble	do	do		Do.
Hiyou Gulch	do	Shale bed-rock		Do.
Lincoln, Hart, & Henry	do	do		Do.
Oak Grove	do	do		Do.
Siwash	do	do		Do.
ORO FINO.				
John Young	(Auriferous gravel)	Slate bed-rock		Placer.
QUARTZ VALLEY.				
Johnson	Gold, limonite, and quartz	Brecciated metamorphic rock.		Vein.
SCIAD VALLEY.				
Fort Goff Creek	(Auriferous gravel)	Schist bed-rock		Placer.
Thompson Creek	do	do		Do.
YREKA.				
Pellet and Truitt	(Auriferous gravel)	Schist bed-rock		Do.
SOUTH FORK SALMON.				
Black Bear	(Gold, mispickel, and quartz)	(Siliceous slate and quartzite).	(Greenstone)	Vein.
SAWYER'S BAR.				
Klamath	(Gold, pyrite, and quartz)	(Siliceous slate)	(Greenstone)	Do.

STANISLAUS COUNTY.

This county lies to the southwest of Tuolumne and Calaveras. The mining interests are not large, and consist principally of placer deposits in its northeastern portion, near the boundaries of the counties just mentioned. The gravels of Stanislaus form an extension of those of the adjoining counties.

SONOMA COUNTY.

The only ores found are those of quicksilver, the chief mine being the Great Eastern. As usual, the ore is associated with pyrite and bitumen, the accompanying rocks being sandstone, limestone, and a rock so highly metamorphosed as to resemble basalt until seen under the microscope.

SONOMA.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
GUERNEVILLE.				
Great Eastern	Cinnabar, bitumen, (pyrite)	Sandstone and limestone	Metamorphic*	Vein.

* Microscopically examined.

TRINITY COUNTY.

Though gold-quartz veins occur, placers form the principal deposits of the county. The bed-rock in all the cases reported is sedimentary, and is usually slate. The Johnson mine shows beautiful occurrences of radial marcasite.

TRINITY.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
CAÑON CREEK.				
Berger	(Auriferous gravel)	Schist bed-rock		Placer.
DOUGLAS CITY.				
Smith's Flat	(Auriferous gravel)	Slate		Placer.
INDIAN CREEK.				
Johnson	(Auriferous gravel)	Slate		Placer.
RED HILL.				
Mammoth	(Auriferous gravel)	Slate		Placer.
Center Placer	do	Sedimentary		Do.
Chapman	do	Slate		Do.
Lewiston	do	do		Do.
Trinity	do	do		Do.
Weaver Basin	do	Slate		Do.
Wiltshire	do			Do.
CINNABAR.				
Altoona	Cinnabar and quartz	Serpentine.		

TUOLUMNE COUNTY.

Tuolumne county lies across the main gold belt. Though placer deposits occur, the mineral wealth of this county is chiefly in the form of gold-quartz veins, which are found both in the slates and the granite. The minerals accompanying the gold appear to be independent of this difference in the character of the wall-rocks, and present the usual association of quartz with iron and copper pyrites, galena, etc. The mother lode runs entirely across this county.

TUOLUMNE.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
CONFIDENCE.				
Confidence	(Gold, galena, pyrite, and quartz)	(Granite)	(Granite)	Vein.
JAMESTOWN.				
Harris & Heslip	(Gold quartz)	(Slate)	(Slate)	Vein.
SONORA.				
Golden Gate	(Gold, galena, chalcopyrite, pyrite, calcite, and quartz.)	(Slate)	(Slate)	Vein.
SOULSBYVILLE.				
Soulsby	(Gold, galena, pyrite, and quartz)	(Granite)	(Granite)	Vein.

VENTURA COUNTY.

Bitumens yielding oil and sulphur deposits are found in Ventura.

YUBA COUNTY.

Though there are quartz veins in this county, the principal deposits are placers, which, though they were among the first worked in the state, still yield largely. Comparatively little of the gravel is covered by lava.

OTHER COUNTIES.

Alpine, Colusa, Mendocino, Merced, Tehama, and Tulare counties all produce precious metals, though not in large quantities, and very little is known of the details of their occurrence, but there is nothing to lead to the supposition that the character of the deposits differs essentially from that of the quartz veins and placers of the better known regions adjoining them.

GEOLOGICAL SKETCH OF OREGON AND WASHINGTON TERRITORY.

The topography of Oregon and Washington territory bears a general resemblance to that of California. Near the coast are low ranges, separating from the sea a long valley, to the east of which rise important chains. The mean rainfall in the western portions of this region is very great, and much country is covered by dense forests. To the east of the great ranges the climate and physical character of these two political divisions are similar to those of the adjoining territory of Idaho. Both Washington territory and Oregon produce coal in important quantities, but the precious-metal production of the more northern area is very small, while Oregon yields above a million a year in gold.

Extremely little is known of the geology of these areas, which have been examined almost exclusively with reference to their bearing on doubtful points in the geology of regions to the south and southeast. Mr. King, in his *Systematic Geology*, gives the main facts known on the subject; and some information regarding it is to be found in the Pacific railroad reports and in the *American Journal of Science*.

As has been mentioned, the Sierra Nevada mountains were formed during a great post-Jurassic upheaval. The Cascade range, however, is more recent, although from a topographical point of view it might be regarded as a continuation of the great Sierra. The real northern representative of the Sierra is the Blue Mountain range of eastern Oregon, for both are due to the same orographical cause. The coast of the Pacific ocean of the Cretaceous period, therefore, bent eastward to the north of California, and followed the Blue Mountain range northward. The Blue mountains are composed, like the Sierra, of granite and metamorphic strata, and in the latter Mr. King found Triassic fossils. It is probable that nearly or quite all of the metamorphic rocks of Oregon east of the Blue range are Triassic or Jurassic. The Cascade range contains marine upper-Cretaceous beds, (*a*) but so far as is known none of later date, and it was probably raised above water-level at the close of the Cretaceous. It was certainly uplifted before the Miocene, for during this epoch a fresh-water lake occupied the interval between it and the Blue mountains. West of the Cascade range, and near the coast on the other hand, Cretaceous and Tertiary strata predominate both in Washington territory and in Oregon, and it is probable that the coast ranges of Washington and Oregon, like those of California, were elevated chiefly by a post-Miocene disturbance.

Throughout the Miocene immense volumes of lava reached the surface in Oregon and Washington territory, and the area occupied by it perhaps forms the largest lava field in the world. It spared an irregular belt along the coast and failed to cover the northeastern corner of Washington and part of eastern Oregon, but buried the rest of the country, in part to a great depth.

Besides granite, the principal massive rock of Oregon and Washington is basalt, but andesites also occur in great quantities. The bed-rock of the Wickaiser mine, Ochoco district, Wasco county, Oregon, is shown by a slide in the census collection to be diorite, proving at least that earlier eruptive rocks are not entirely absent. The ore deposits are chiefly veins in granite or metamorphic strata, and do not appear to be associated with volcanic rocks.

Much the most important mining region of Oregon is Baker county, which lies in the southeastern corner of the state and adjoins Idaho. The gold veins of this region are in granite and metamorphic slates in and near the Blue mountains, and may thus be considered as occurring on a continuation of the gold belt of California. They are accompanied by auriferous gravels, which are of much local importance, though of greatly inferior volume to those of California and Idaho. The same arguments which are held to prove the Tertiary age of the gravels of California would probably apply to these also, but detailed information bearing upon the point is not available. Trias-Jura strata are also exposed in the Cascade range at a few points where the overlying material has been removed by erosion, and a little gold quartz and gravel have been discovered in such localities; for example, in Lewis county.

In the northern part of California, as has been mentioned, the gold-bearing rocks have a wide distribution, and are not confined to a comparatively narrow belt, as they are in the middle of the state. Similarly the gold mines of Josephine and Jackson counties, which adjoin California and lie to the west of the Cascades, do not seem to bear a direct relation to the main ranges; but it is noteworthy that this region of scattered deposits in the two states is also that in which the Sierra and the Coast ranges meet, and are so entangled that as yet no one has succeeded in discriminating the two systems. The geological relations of the Skagit mines, in Washington territory, on the upper waters of the Skagit river, are not known further than that the gold is found in the bed of the present streams and that the surrounding country is mainly granitic. Auriferous sands are found on the southern coast of Oregon, as in northern California, and are worked as wind and tide permit.

Coal-beds are frequent in the belt of country west of the Cascade range. Of these the most important are found at Coos bay, in Oregon, and at Bellingham bay, in Washington territory. The age of the Bellingham bay seams is known to be the same as that of the Monte Diablo coal or Upper Cretaceous, and those of Coos bay are probably also of this period. Iron ore is abundant, and has been smelted to a small extent, but under the disadvantage of high rates for labor. Quicksilver is found at the New Idrian cinnabar mine, Douglas county. Its occurrence seems to be similar to that of the California mines, and it represents the northern end of the series of deposits, the southern extremity of which is in San Luis Obispo county, California. It would be incorrect, however, to characterize this entire series as a "belt", for toward the north the known occurrences are at long intervals.

a These are of the Téjon group, and may prove to be Eocene.

Whatcom and Yakima counties are the only ones in Washington territory from which gold mines are reported, though small quantities of gold are also obtained from the sands of the Columbia river, while King and Thurston counties produce coal. Oregon, Baker, Grant, Wasco, Douglas, Josephine, Jackson, and Umatilla counties are reported as containing gold mines. Coos yields auriferous beach sands and coal, Clackamas iron, and Douglas cinnabar.

OREGON.

BAKER COUNTY.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls. Foot.	Walls. Hanging.	Character of deposit.
BURNT RIVER.				
Gold Ridge	Quartz, gold, and pyrite	Granite	Granite	Vein.
CONNER CREEK.				
Conner Creek	Quartz, limonite, (gold and sulphurets)	Slate, basalt dike*	Slate, basalt dike*	Do.
FARRIS GULCH.				
Farris Gulch	(Auriferous gravel)	Granite		Placer.
POCAHONTAS.				
Bailey	(Auriferous gravel)	Granite		Do.
Lew. Cooper & Co	...do	Argillaceous sandstone		Do.
Salmon Creek	...do	Granite		Do.
Tom Payne	Quartz, gold, (and iron and copper pyrite)	Slate	Slate	Vein.
RYE VALLEY.				
Powers & Co	(Auriferous gravel)	Sandstone		Placer.
Rye Valley	Quartz, stromeyerite, copper carbonates, (antimonide of silver and iron pyrite).	Granite	Granite	Vein.
SHASTA.				
Manadus	(Auriferous gravel)	Gneiss		Placer.
SILVER CREEK.				
California	Quartz, mispickel, pyrite, (stephanite, gold and silver bearing pyrite).	(Unknown)	Granite	Vein.
WILLOW CREEK.				
Boswell	(Auriferous gravel)	Slate		Placer.
Virtue	Quartz, gold, (iron and copper pyrite)	Shale	Shale	Vein.

* Examined microscopically.

COOS COUNTY.

Pioneer Black Sand	Magnetite, titanic iron, quartz, and gold.			

DOUGLAS COUNTY.

New Idrian	Cinnabar, limonite, (feldspar, manganese oxide)		Sandstone	Vein.

GRANT COUNTY.

ELK CREEK.				
Deep Creek	(Auriferous gravel)	Slate		Placer.
Elk Creek	...do			Do.
GRANITE.				
Buffalo	Galena, pyrite, quartz, (stephanite and mispickel)	Quartzite	Slate	Vein.
Barne & Lucas	(Auriferous gravel)	Shale		Placer.
Klopp & Johnson	...do	...do		Do.
Monumental	Tetrahedrite, polybasite, chalcopyrite, pyrite, quartz, (mispickel and zincblende).	Granite	Granite	Vein.
Trail creek	(Auriferous gravel)	Granite		Placer.

JACKSON COUNTY.

APPLEGATE.				
Chapel & Co	(Auriferous gravel)	Slate		Placer.
Grand Applegate	...do	...do		Do.
UNIONTOWN.				
Gin Lin	(Auriferous gravel)	Slate		Placer.
STERLING.				
Sterling	(Auriferous gravel)	Slate		Placer.

JOSEPHINE COUNTY.

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
GRAVE CREEK.				
Steam Beer	(Auriferous gravel)	Slate		Placer.
YANK.				
Sugar Pine	Galena, pyrite, chalcopyrite, and quartz.			

WASCO COUNTY.

Mine.	Ore and gangue.	Foot.	Hanging.	Character of deposit.
OCHOCO.				
Wickaiser & Co	(Auriferous gravel)	Diorite *		Placer.

* Examined microscopically.

WASHINGTON.

YAKIMA.

[NOTE.—Determinations in parentheses are given on the authority of the expert.]

Mine.	Ore and gangue.	Foot.	Hanging.	Character of deposit.
PESHASTON.				
Shaeffer	Quartz, (gold), and pyrite	Metamorphic	Metamorphic	Vein.
SWANK.				
Swank	(Auriferous gravel)	Sandstone (and slate)		Placer.

GEOLOGICAL SKETCH OF NEVADA.

That portion of the wide area included between the Sierra Nevada and the Wahsatch range, the drainage of which does not find its way to the sea, was called the Great Basin by Frémont. The name has passed into general use, but with a somewhat extended signification, and, as commonly employed, includes to the south the desert region lying between the southern California ranges and the Colorado plateau, and to the north so much of Oregon as lies east of the Blue Mountain range and a somewhat indefinite portion of Idaho. The state of Nevada, with the western half of Utah, constitutes the larger and more important part of the Great Basin.

Leaving the mountains out of consideration, the basin may be considered as a high plain with an average elevation of perhaps 4,500 feet; but the central portion is higher than the edges, the belt of country next west of the Wahsatch and that next east of the Sierra being about 4,000 feet above sea-level, while near the middle of Nevada the elevation is about 6,000 feet above tide-water.

The Great Basin is strikingly characterized by rather short mountain ranges with nearly meridional trend, separated by valleys a few miles wide. The culminating peaks rise from 2,000 to 6,000 feet above the level of the surrounding country, and the ranges often present an imposing appearance, though they are greatly inferior to the Sierra and the Wahsatch as topographical features. Many of the valleys are totally devoid of vegetation, and present a surface of alkaline salts (mostly sodium chloride, carbonate, or sulphate), but the greater portion of the country is thinly clothed with "sage brush", low-growing shrubs with dull gray-green foliage, the most abundant of which is *Artemisia tridentata;* on the higher portion of the mountains, where a certain amount of moisture is supplied by the slow melting of the scanty snowfall, nut-pines, junipers, and mountain mahogany grow to a limited extent. The few streams are also fringed with narrow belts of vegetation.

The principal rivers of Nevada are the Humboldt, the Carson, the Truckee, and the Quinn. All of these streams dwindle after reaching comparatively level ground by evaporation and absorption, and at last empty into small salt lakes which have no outlets. The alkali deserts unquestionably mark the positions of similar lakes now completely dried away.

Though there are many contributions to the geology of Nevada, no complete survey of it has ever been made. The exploration of the fortieth parallel, however, covered a belt of 100 miles in width and extended across the state from east to west, beside taking in some outlying districts of importance; and most of the statements as to the general geology of Nevada in this account are derived from the publications of that survey.

The Archæan is exposed at a large number of points along the crests of the mountain ranges of Nevada, and these, taken in connection with the overlying strata, show that prior to the Palæozoic era a mountain system covered the area of Nevada and extended to the east as far as the 104th meridian. This system, however, seems to have been entirely suboceanic, for the ranges were extremely lofty, yet they presented broader and smoother surfaces than subaerial erosion is ever known to produce.

During the Palæozoic a continent occupied western Nevada and most of California, its eastern shore intersecting the 40th parallel in longitude 117° 30′ (a few miles west of Austin) and trending nearly north and south. The sediments from this western continent, as well as from comparatively unimportant islands, accumulated throughout the Palæozoic era on the sea-bottom, which subsided as the load increased, until the strata reached the enormous thickness of 40,000 feet near the shore, thinning out to the eastward. The Palæozoic was an era of extreme quiet, so that the geologists of the fortieth parallel were able to detect no unconformity in its strata. During the Carboniferous period the Palæozoic sea was for the most part so deep that the sediments were almost exclusively limestones, in which it is hopeless to look for coal. Near the shore, however, land plants, associated with carbonaceous beds, occur in a single horizon, but even this is underlaid and overlaid by calcareous deposits and is of limited extent. At the close of the Palæozoic era the land and the sea changed places. The sea-bottom, from longitude 117° 30′ to and including the Wahsatch, rose above the surface of the water, while the continent which had stretched to the west sank and formed an ocean floor, upon which the sediments from the new continental area were deposited. The Triassic and Jurassic periods were also extremely quiet, and the strata are conformable throughout.

At the close of the Jurassic age the western ocean, with its original floor of Archæan ranges overlaid by twenty odd thousand feet of conformable Trias-Jura sediments, suffered abrupt orographical uplift, resulting in the formation of a series of sharp folds and elevating a portion of the ocean area, extending from the eastern shore outward and westward as far as the present west base of the Sierra Nevada, making an addition to the continent of 200 miles, the Sierra itself constituting the most western and most elevated of the newly-formed mountain ranges. The character of the orography of this period of disturbance is that of tangential compression, in which the gentler action was close to the old shore in the meridian of 117° and most powerful in the crumpled western slope of the Sierra Nevada, where the Triassic and Jurassic series have their enormous thickness crushed into a mass of almost indistinguishable folds, the rocks thrown into vertical dip and crowded together, making a belt of strata about fifty miles broad. This orographical action continued southward as far as the defined range of the Sierra Nevada extends and northward along the whole shore of the Pacific, probably as far as the Alaskan peninsula. Passing northward from the region of the fortieth parallel, where the new addition to the continent measured about 200 miles from east to west, the zone of crumpled Mesozoic was depressed so that the new ocean shore at the beginning of the Cretaceous age touched the west base of the Jurassic fold of the Blue mountains of eastern Oregon. (*a*)

It is not certain that the whole system of Basin ranges dates from the post-Jurassic disturbance, for the corrugation of the Palæozoic area east of 117° might have accompanied its uplift immediately after the Carboniferous. There are considerable grounds, however, for supposing that uplift to have been comparatively quiet, and it is on the whole probable that all the ranges were raised by the same movement which crumpled the Trias-Jura strata of the Sierra.

The views of the various geologists who have studied the basin ranges are not uniform as to the character of the dynamical action which resulted in the upheaval of these mountains. The geologists of the fortieth parallel regard the ranges as composed of synclinal and anticlinal folds more or less obscured by longitudinal compression and by faulting long subsequent to their upheaval. Pfaff (*b*) and others hold that faults are the extreme results of forces tending to form folds in an imperfectly elastic material, and that folds consequently frequently pass over into faults; and as long ago as 1870 Mr. Emmons (*c*) pointed out a case of this kind in the Toyabe range. Messrs. Powell and Gilbert, on the other hand, from investigations made mainly to the south of the fortieth parallel belt, maintain that many of the uplifts are purely monoclinal in character.

The Cretaceous is wholly wanting in the state of Nevada as well as in the great Sierra. This area was certainly above sea-level during that epoch, and if any fresh-water deposits formed they were swept away before Tertiary strata covered and protected them. Professor Whitney considers the absence of Cretaceous fossils in the Sierra as so remarkable that he infers the possibility that this area was unsuited to animal and vegetable life. (*d*)

The Tertiary and the Quaternary eras in Nevada were characterized by the presence of lakes, which occupied different localities as orographical disturbances altered the drainage system. The present period of desiccation, during which evaporation has so increased and precipitation so diminished that the lakes no longer overflow and the salts brought into them by the streams are retained in nearly saturated solution, has not been a long one from a geological standpoint; and, according to Professor Whitney, it is shorter than that during which man has been an inhabitant of the Pacific coast. Mr. King presents evidence to show that there has been more than one period of desiccation in the Quaternary.

The massive rocks of the Great Basin are very numerous, and are referable to three distinct eras of eruptive activity. The granites are found only associated with Archæan rocks, and never penetrate overlying strata. Important eruptions of diorite and diabase accompanied the post-Jurassic upheaval; while in the Tertiary and Quaternary andesites, rhyolites, and basalts were ejected in great quantities, usually reaching the surface along lines of disturbance established in the Mesozoic era. The crests of a large portion of the Nevada ranges are still covered by these lavas, among which rhyolite predominates. Propylite, which had been supposed to exist at a number of points in the Great Basin, does not appear to be an independent rock, but to represent a certain stage of decomposition. (*e*)

Recent advances in the microscopical study of rocks tend to show that sanidin feldspar is of much rare occurrence than has hitherto been supposed. A recent revision (*f*) of the fortieth parallel collection by Messrs.

a *Exploration of the Fortieth Parallel*, vol. i, p. 537.
b *Mechanismus der Gebirgsbildung*.
c *Exploration of the Fortieth Parallel*, vol. iii, 326.
d *Auriferous Gravels*, p. 319.
e *Monographs United States Geological Survey*, vol. iii.
f *Third Annual Report of the United States Geological Survey*.

Hague and Iddings, to the results of which the writer has had access in advance of their publication, shows that there are probably no true trachytes among the rocks hitherto collected from the Great Basin.

Ore deposits occur at a great number of points in Nevada, carrying gold, silver, lead, copper, and other useful minerals. They are not limited to rocks of any age. The Archæan granite of Austin, the Palæozoic strata of Eureka and White Pine, and the Mesozoic rocks of Washoe are sufficient examples of this fact. The deposits occur in the mountains, as is usual the world over, and as the Nevada mountains are disposed in parallel ranges, of course the mines also occur in parallel belts. There is a perceptible tendency to the development of the same minerals at different points on the same belt, though there are no ore-bearing zones comparable in continuity with the gold and the quicksilver belts of California. The possibility that the deposits of Battle mountain, Austin, Candalaria, etc., form a continuation of the Arizona belt has already been adverted to.

In most cases it is impossible to determine the age of the deposits, yet there are many phenomena indicating a connection between them and eruptive activity, and they are probably for the most part referable either to the post-Jurassic period of upheaval or to that of the more recent volcanic eruptions. The gold veins of California, as has been explained, are post-Jurassic; and the Idaho gold veins are probably, at least in part, of the same age. It is difficult to suppose that the similar physical conditions prevailing in Nevada during the same period were not attended by similar mineralogical results. The Comstock, however, is probably very recent and a concomitant of volcanic eruptions in its immediate neighborhood. Mr. King drew attention (*a*) to the fact that no ore pebbles have been found in the Tertiary lake beds of Nevada, and this statement still remains valid so far as the exploration of the fortieth parallel is concerned. Nor are prospectors known to have found any indications of ore in these beds. This negative evidence is all in favor of the supposition that the deposits are mainly Tertiary and post-Tertiary.

THE COMSTOCK LODE.—The Comstock lode is situated in Storey county, about 10 miles from the eastern limit of the Sierra, and lies on the east flank of the Virginia range. In twenty-one years it has produced a little over $306,000,000 worth of bullion, of which $132,000,000 was gold. The mines on this lode are the deepest in America, reaching a distance of over 3,000 feet from the surface, and containing 185 miles of galleries. The lode is extremely wide in places, and has been traced horizontally for about 4 miles. It dips east at an angle of about 45°.

The Washoe district is almost entirely made up of eruptive rocks of post-Jurassic and Tertiary age. These are in large part highly decomposed, and both their character and the structural relations of the vein have given rise to much difference of opinion between observers. According to the latest investigation, (*b*) the most productive portion of the lode is associated with a hanging wall of diabase, while the foot wall in Virginia City is diorite, and in Gold Hill metamorphic slate. To the north and south of the most productive portion of the lode, which has hitherto been between the Union and Overman mines, the vein ramifies, only its northeastern branch remaining in contact with the diabase.

A great fault attended the opening and filling of the vein. Its throw was nearly 3,000 feet at the middle of the lode, diminishing in each direction toward the extremities. The faulting action resulted in the formation of a system of fissures, which divides the country rock on each side into a series of parallel sheets. By this means the east wall, which was depressed by the fault, assumed near the surface the shape of a sharp wedge, and the projecting edge was broken through, giving rise to a secondary fissure, forming an angle of 30° to 45° with the lode plane. The lode was charged with ore and quartz by lateral infiltration from the east or hanging side, these materials being deposited wherever there was an open space or a space filled with loose fragments to receive them. Of such spaces the secondary fissure, or "east vein", as it has been called, afforded a large number, while below the junction of this fissure with the main lode such openings were comparatively infrequent. The fault mentioned did not take place all at once, and probably consisted of a great number of small movements, all in the same direction, extending over the whole period of ore deposition. Although small, these movements took place with irresistible force, and crushed such ore bodies as crossed the lines of motion to such an extent that their substance resembles ordinary commercial salt in texture and appearance.

As is usually the case in silver veins, the distribution of ore in the quartz was by no means regular; a fact probably depending on the irregularity of the leaching process. While very little of the quartz is free from traces of precious metals, only certain spots contain enough to pay the expense of extraction, and are hence known as "bonanzas". (*c*) These, however, commonly occur in the largest quartz masses.

Though the Comstock is not just now in a flourishing condition, there seems to be no reason why large ore bodies should not yet be met with. The first condition for an ore body is a space to receive it. The existence of such openings depends upon mechanical conditions which are likely to be repeated at almost any depth, though a series of bonanzas on one level, such as was found in the "east vein", is not likely to recur.

It is highly probable that the depth to which the Comstock can be explored will be limited by the extraordinary heat. The Gold Hill mines have been flooded with water of a temperature of 170° F., and as the temperature of the rock and the water increases on the whole in direct proportion to the depth boiling water may be met at

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a *Exploration of the Fortieth Parallel*, vol. iii, p. 7.

b *Monographs United States Geological Survey*, vol. iii.

c A Spanish term, the nearest equivalent of which is "pay rock".

almost any time after the 4,000-foot level is reached. The heat of the water and the rock is a remnant of volcanic action.

AUSTIN.—The property of the Manhattan Mining and Milling Company is situated at Austin, Lander county. (a) It is famous for its steady yield of above $1,000,000 of silver a year from very rich but also very rebellious ores. The Toyabe range, on which Austin lies, is near the western edge of the Palæozoic area which occupies the eastern half of the Great Basin. It has a granitic axis flanked by Palæozoic strata, and is capped to a considerable extent by rhyolite. Other eruptive rocks occur in the range, which must be for the present regarded as of uncertain character. The most important mineral deposits are found as veins in the granite, chiefly on the southern slope of Lander hill.

The outcrops on the hillside are very numerous, and many locations have been made; some within 10 or 20 feet of each other. Some of these outcrops have been proved by actual development to be well-defined and persistent fissures; others are probably mere seams or branches that pinch out or unite with stronger veins in depth; and that many must disappear in this manner seems apparent, from the fact that the number of veins or fissures cut in the deeper cross-cuts and shafts in various parts of the hill bear a very small proportion to the number of outcrops at the surface in their immediate vicinity, which, if persistent, would appear below.

The developments on Lander hill show that within this mineral belt, running north and south, there prevails a zone more favored than the rest, within the limits of which the northwest and southeast veins traversing it are especially rich in ores of high value, and beyond which the proportion of base metals is greatly increased. This zone, so far as understood, also has a north and south direction. On Lander hill it may be from a quarter to a half mile in width. Its western limit is thought to pass through the Diana and the Savage mines, so that in passing from the southeastern to the northwestern portions of those claims a perceptible diminution of the richer and purer silver-bearing minerals, and an increasing predominance of baser metals, such as lead, copper, zinc, antimony, and iron, take place. Proceeding still further west, the proportion of rich silver minerals to the baser compounds becomes still less, until the ore is quite too poor to pay for extraction. (b)

The veins are comparatively very narrow, none, so far as reported, exceeding 3 feet. Many of them, however, are so rich that they can be worked with profit when showing only 3 inches of ore. The ore minerals are pyrargyrite, proustite, stephanite, polybasite, tetrahedrite, argentiferous galena, zincblende, and iron and copper pyrites. The amount of gold is said to be so small as not to pay for separation. The gangue minerals are chiefly quartz, manganese-spar, and calcite. Near the surface the veins carried the silver as chloride, but at a depth of 150 feet this facile ore was replaced by the rebellious compounds above mentioned. There can be little doubt that the chloride was formed by the decomposition of the more complex minerals.

The granite at a distance from the veins is extremely hard and tough, but near the ore it is much softer and shows signs of decomposition. A slide of this rock in the census collection shows that it is a normal biotite granite which has been subjected to the action commonly known as solfataric. The mica has been in part converted into chlorite, and in this latter mineral bunches of epidote crystals have developed, evidently at the expense of the chlorite, while the feldspar is scarcely affected. This fact, taken in connection with the relations of the altered rocks and the whole character of the occurrence, leads to the supposition that the veins were deposited by lateral secretion. All the veins are faulted to the north for a distance of about 200 feet, and Mr. Emmons considers it not improbable that this dislocation accompanied the eruption of the rhyolite which forms mount Prometheus.

The age of formation of the veins is uncertain. The fact that faults have taken place since the ore was deposited is at least compatible with the supposition that the deposits are post-Jurassic; but were this the case, eruptive rocks of the same age would probably be formed in the neighborhood, while none such have been recognized. The formation of the veins is naturally connected with the metaphorism of the sedimentary rocks of the range, which seems to be due to later volcanic eruptions. The fact that the number of croppings occurring at the surface was larger than that of the veins found at a comparatively slight depth would also lead one to suppose that this multiplicity of outcrops was a surface phenomenon, and that no great erosion had taken place since the ore was deposited. It is not impossible that the lines of fracture were established in post-Jurassic times, and that the filling of the veins and their dislocation occurred much later.

The mines of the Manhattan Company cover a large extent of ground, more than a square mile, but the greatest depth reached is only 900 feet. The small size of the veins makes mining extremely expensive however, a very large amount of waste being necessarily extracted in stoping the veins. The richness of the ore is indicated by the fact that it is mixed for roasting so as to give a tenor of $250. The milling process consists in crushing dry, roasting with salt in a Stetefeldt furnace, and amalgamation in pans.

EUREKA DISTRICT.—The value of the ore deposits of Eureka was not determined until the year 1870, since which time, however, this has been one of the most important lead- and silver-producing districts of the country. It now produces about $4,600,000 of gold and silver, and nearly or quite 12,000 tons of lead annually.

It is remarkable geologically as affording a very extensive section of Palæozoic strata. It has recently formed the subject of a detailed investigation by Mr. Arnold Hague, whose monograph on the *Geology of the Eureka District* will appear about the same time as this volume. He has kindly given permission to print the accompanying section, showing the average thickness and the succession of the rocks, and indicating by a double line a nonconformity in the Silurian, the first thus far discovered in the Palæozoic of the Great Basin.

a Mr. S. F. Emmons has reported on the geology of the Toyabe range, and Mr. J. D. Hague on the mining and milling at Reese river. *Exploration of the Fortieth Parallel*, vol. iii.

b *Exploration of the Fortieth Parallel*, vol. iii, p. 351.

GEOLOGICAL SECTION OF THE EUREKA DISTRICT.

BY MR. ARNOLD HAGUE.

Carboniferous, 9,300 feet.	Upper coal measures	500	Light-colored blue and drab limestones.
	Weber conglomerate	2,000	Coarse and fine conglomerates, with angular fragments of chert; layers of reddish-yellow sandstone.
	Lower coal measures	3,800	Heavy bedded dark-blue and gray limestone, with intercalated bands of chert; argillaceous beds near the base.
	Diamond Peak quartzite	3,000	Massive gray and brown quartzite, with brown and green shales at the summit.
Devonian, 8,000 feet.	White-pine shale	2,000	Black argillaceous shales, more or less arenaceous, with intercalations of red and reddish-brown friable sandstone, changing rapidly with the locality. Plant impressions.
	Nevada limestone	6,000	Lower horizons indistinctly bedded, saccharoidal texture, gray color, passing up into strata, distinctly bedded, brown, reddish-brown, and gray in color, frequently finely striped, producing a variegated appearance. The upper horizons are massive, well bedded, and bluish-black in color. Highly fossiliferous.
Silurian, 5,000 feet.	Lone Mountain limestone	1 800	Black gritty beds at the base, passing into a light-gray siliceous rock, with all traces of bedding obliterated. Trenton fossils at the base. Halloysites in the upper portion.
	Eureka quartzite	500	Compact, vitreous quartzite, white, bluish, passing into reddish tints near the base; indistinct bedding.
	Pogonip limestone	2,700	Interstratified limestone argillites and arenaceous beds at the base, passing into purer, fine-grained limestone of a bluish-gray color, distinctly bedded. Highly fossiliferous.
Cambrian, 7,700 feet.	Hamburg shale	350	Yellow argillaceous shale layers of chert nodules throughout the bed, but more abundant near the top.
	Hamburg limestone	1,200	Dark-gray and granular limestone. Surface weathering rough and ragged; only slight traces of bedding.
	Secret Cañon shale (overlies the ore-bearing rock).	1,600	Yellow and gray argillaceous shales, passing into shaly limestone. Near the top interstratified layers of shale and thinly-bedded limestone.
	Prospect Mountain limestone (incloses the ore deposits).	3,050	Gray compact limestone, lighter in color than the Hamburg limestone, traversed with thin seams of calcite. Bedding-planes very imperfect.
	Prospect Mountain quartzite (underlies the ore-bearing rock).	1,500	Bedded brownish-white quartzites, weathering dark-brown; ferruginous near the base. Intercalated thin layers of arenaceous shales. Beds whiter near the summit.

It appears from this table that the ore deposits lie in the lower horizons of the Cambrian. When they were formed is quite another question. The district shows a number of massive rocks, viz: Archæan granite and Tertiary or post-Tertiary andesites, dacite, rhyolite, and basalt. The eruptions most closely associated with the mines were rhyolite, and a connection between this rock and the ore may fairly be suspected; but the deposits are still under investigation, and something more satisfactory regarding their nature and genesis than any speculation which could be offered here will probably soon be ready for publication.

The ores of Ruby Hill are argentiferous galena, accompanied by its decomposition products. Indeed, the larger part of the ore thus far mined is carbonate, mixed with some sulphate and ocher, as well as with mimetite and wulfenite, the occurrence of which indicates the presence of considerable quantities of other metalliferous mineral besides galena prior to decomposition. The ore bodies are irregular, kidney-shaped masses distributed in limestone. This rock, though highly metamorphosed, is distinctly stratified in parts, and has been proved by Mr. Hague's party to carry fossils which determine its age as Cambrian. The nature of these ore deposits has formed the subject of repeated lawsuits, and the many well-known geologists and mining engineers who have given testimony on the subject have expressed very discordant views, some holding them to be pipe veins in the limestone, while others regard the whole limestone formation between the quartzite and the shale as ore-bearing, the barren portions answering to the bone in coal seams. While the one party consider the small seams of ore sometimes found connecting the ore bodies as the rake vein corresponding to the pipes, the other party attributes these seams to the accidental presence of fissures, and ascribes no significance to them. The diversity of opinion developed as regards the deposits of Ruby Hill appears to indicate merely that large financial interests are involved in the title to this property, and not that there is anything exceptional in the character of the deposits themselves. Lead ores are more often found in limestone than elsewhere, and when so found almost always exhibit great irregularity in form and distribution. The fact is that little is definitely known with reference to the *modus operandi* of the deposition of galena. As Mr. Emmons, (*a*) in discussing the deposits of Leadville, has pointed out, if the hypothesis

(*a*) *Second Annual Report of Director of United States Geological Survey.*

often advanced that this ore has been deposited in pre-existing caves were correct concentric structure would necessarily result. He regards it as more probable that the ore has been deposited by substitution for limestone. If this can be shown conclusively, lead deposits of this character would have to be regarded as veins differing from the usual type merely in the extreme irregularity of the walls; for an ordinary vein is merely an opening in the rocks, which is always limited in horizontal extent, and probably also in depth. Into such a fissure metalliferous solutions percolate and deposit ore minerals, precipitation being due to chemical or physical causes. Usually the walls of veins are chemically inert, and hence do not lose their original form; but if the substance of the walls of a vein, instead of, *e. g.*, infiltrations of organic matter, were to induce precipitation, that fact certainly would not deprive the resulting deposit of its character as a vein, though the shape of the walls might be strangely modified.

A very remarkable feature of the Eureka deposits, shared to a greater or less degree by many others in the Great Basin, is the great depth to which decomposition, involving an accession of oxygen, has proceeded. The mines are between 1,200 and 1,300 feet deep; yet, although some water has been met of late, the permanent water-level has not been reached, and the amount of galena in the ore is scarcely more than enough to prove that the original lead mineral was the sulphide. The conversion of the galena to carbonate and sulphate, which must clearly be ascribed to the agency of atmospheric oxygen, could take place to such a depth only in an extremely dry country such as the Great Basin now is, and the decomposition must therefore have been accomplished since the early Quaternary.

CHURCHILL COUNTY.

The product of this county has for the most part been confined to borax, but there are quartz veins in the IXL district occurring in granite and on the contact between granite and limestone. They carry silver and galena, but were not worked during the census year.

ELKO COUNTY.

The deposits of the Tuscarora district, in this county, are silver ores, including light and dark ruby silver, stephanite, argentite, and, near the surface, horn-silver. They are accompanied by pyrite, often argentiferous, and form veins in highly decomposed eruptive rock. This was formerly considered to be propylite, but from the slides and specimens of the census collection and of the fortieth parallel collection, and from known occurrences in the neighborhood, it is probable that the rock should be regarded as an altered hornblende-andesite.

ELKO.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
TUSCARORA.				
Belle Isle	Stephanite; gangue quartz, pyrite, and chalcopyrite	Probably andesite*	Probably andesite*	Vein.
Argenta	Horn-silver, dark and light ruby silver, and probably stephanite; gangue country rock.	do	do	Do.
Grand Prize	Light and dark ruby silver, argentite, horn-silver near surface; gangue quartz, iron and copper pyrite, and zincblende.	do	do	Do.
Independence	Horn-silver, (sulphides on lower levels), (quartz)	do	do	Do.
Navajo	Chloride; gangue, (quartz and spar)	Andesite*	Andesite*	Do.
North Belle Isle	(Chloride, ruby, and argentiferous pyrite; gangue, spar, and quartz.)	(Birdseye porphyry)	(Birdseye porphyry)	Do.
Silver Star	(Antimonial ruby and argentiferous pyrite; gangue, spar, and quartz.)	(Porphyry)	(Porphyry)	Do.

* Microscopically examined.

ESMERALDA COUNTY.

Most of the mines of this county exploit deposits in the metamorphic slates and schists. These are broken through at numerous points by volcanic rocks, especially basalt, to which the solfataric action attending the formation of the ores is possibly due. The ores resemble some of those found in Inyo county, California, carrying sulphantimonides of silver, argentiferous galena, tetrahedrite, copper and iron pyrite, zincblende, and pyrolusite, in a quartz gangue. There are also gold-quartz veins in granite, similar to those of California. In the Columbus district there is a nickel vein.

The Northern Belle mine is sunk on a series of irregular deposits, forming a belt which is, in general, conformable to the slates in which it lies. There is much basalt in the immediate neighborhood. Most of the ore is oxidized, but a few bunches of sulphurets are left, carrying galena, tetrahedrite, etc. The Northern Belle produces about a million a year.

ESMERALDA.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
COLUMBUS.				
Mount Potosi	Gold and calcareous ocher, (lead, said to carry silver and gold); gangue quartz; (antimonial compounds).	Slate	(Porphyry)	Vein.
Nickel	Nickel in an indeterminable form.			
Monte Diablo	(Same as Northern Belle.)			
Northern Belle	Horn-silver, malachite, galena, and tetrahedrite; gangue, iron oxide, pyrolusite, pyrite, quartz, (zincblende).	Slate (called porphyry)	Slate	Do.
Victor	(Horn-silver, malachite, galena, and antimonial silver); gangue quartz, and iron oxide.		(Slate)	Do.
ESMERALDA.				
Real del Monte	Gold, (copper); gangue quartz and iron oxide			Vein.
ONEOTA.				
Indian Queen	Galena and chalcopyrite, (small quantities of sulph-antimonides of silver); gangue, pyrite, quartz, and zincblende.	Mica-schist	Mica-schist	Vein.
WILSON.				
Wilson	(Gold); gangue quartz, iron and copper pyrites	Granite	Rhyolite and limestone	Mineral belt.
Wheeler	do	do	do	Do.

EUREKA COUNTY.

The chief deposits of this county, those of Ruby Hill, have been sufficiently enlarged upon. Most of the others are also of lead ores, and occur either in or close to limestone, but some of them, those for instance of Cortez district, are accompanied by copper minerals, native silver and mispickel, and some have more or less quartz as gangue. These are of especial value in smelting the prevailing extremely basic ores.

EUREKA.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
CORTEZ.				
Garrison	Chloride, galena, tetrahedrite, native silver, and malachite; gangue, zincblende, and mispickel, (quartz).	(Limestone)	(Limestone)	Irregular deposit.
EUREKA.				
Alexandria	Cerussite, (gold and silver, gangue quartz and iron oxide.)	(Limestone)	(Limestone).	
Eldorado No. 2	(Carbonate, silver and gold, gangue quartz and iron oxide.)	Limestone	Limestone.	
Eureka Consolidated, Jackson, Richmond, Phœnix	Argentiferous galena, cerussite, anglesite, mimetite, wulfenite, with limonite and aragonite gangue.	do	do	Irregular bodies or pipe veins.
Macon City	(Cerussite containing gold and silver, gangue quartz, and iron oxide.)	do	do	Irregular mass.
Silver Lick	Cerussite, gangue quartz and iron pyrite		Shale.	
SECRET CAÑON.				
Geddes & Bertrand	Argentiferous cerussite, gangue quartz and iron oxide.	Limestone	Limestone	Irregular mass.
EUREKA.				
Silver Conner	Galena and alteration products (telluride)	Limestone	Limestone.	

HUMBOLDT COUNTY.

Most of the veins are in the Mesozoic slates, and carry ruby silver and stephanite with iron and copper pyrite and mispickel in a quartz gangue. Near the croppings the silver takes the form of chloride. Some of the veins in the slates are worked for gold, but of these a part will probably be found to carry more silver than gold when the water-level is passed. The Pride of the Mountain, Winnemucca district, is reported to be on a contact between slate and granite.

HUMBOLDT.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls. Foot.	Walls. Hanging.	Character of deposit.
MOUNT ROSE, OR PARADISE.				
Big Nick	Chloride, gangue quartz.	Slate	Slate	Vein.
Bullion of Paradise	Chloride, pyargyrite, (ruby and stephanite); gangue quartz, pyrite, mispickel, chalcopyrite, and iron oxide.	...do	...do	Do.
Live Yankee	Same as Big Nick	...do	...do	Do.
Uranus	...do	...do	...do	Do.
SIERRA, OR DUN GLEN.				
Lang Syne	Gold with quartz gangue	Silicified sedimentary rock (called porphyry).	Silicified sedimentary rock (called porphyry).	
Lucky Boy	Copper-stained quartz, (gold)	(Slate)	(Slate)	Vein.
WINNEMUCCA.				
Pride of the Mountain	(Sulphurets and antimonial silver minerals, with quartz gangue.)	(Slate)	(Granite)	Contact vein.

LANDER COUNTY.

Besides the Austin mines, sufficiently described above, there are veins of ruby silver, etc., in quartzite, and of galena with quartz gangue in Palæozoic slate.

LANDER.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls. Foot.	Walls. Hanging.	Character of deposit.
BATTLE MOUNTAIN.				
Ætna	Galena, gangue pyrite and (quartz)	Slate	Slate	Vein.
LEWIS.				
Starr & Grove	Ruby and sulphurets with (quartz gangue)	Quartzite	Quartzite	Vein.
REESE RIVER.				
Manhattan or Curtis	Dark and light ruby silver, stephanite, polybasite, tetrahedrite, galena, iron and copper pyrites, and quartz.	Granite*	Granite*	Vein.

* Microscopically examined.

LINCOLN COUNTY.

This county shows several classes of deposits. There is a considerable number of occurrences of galena and its decomposition products in limestone similar to those of Eureka and elsewhere, and which seem especially abundant in the Palæozoic limestone of the Great Basin. The Meadow Valley and Raymond & Ely are also in metamorphic strata; but these are quartzites, not limestones, and the character of the ore is correspondingly different. Below the water-level the ore consists of sulphurets of unspecified composition; above the water-level it carries horn-silver, some gold, a little lead, and manganese. In the Eldorado district there are mines in a massive rock, probably diorite, which carry argentiferous copper minerals.

LINCOLN.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls. Foot.	Walls. Hanging.	Character of deposit.
BRISTOL.				
Hillside	Galena and cerussite and (limestone)	Limestone	Limestone.	
Independence		Quartz-porphyry and shale.	Granite.	
Mendha	Galena and decomposition products	....	Limestone.	
ELDORADO.				
January	(Horn-silver), iron oxide	Probably diorite	Probably diorite.	
Savage	Stromeyerite, quartz, and calcite	Granite*	Granite*	Vein.
JACK RABBIT.				
Day	Argentiferous galena and lead carbonate, red copper ore and malachite, manganese oxide, (calc-spar and iron oxide).	Limestone	Limestone	Pockets.
ELY.				
Meadow Valley	(Gold, horn-silver, quartz, iron oxide, and manganese oxide.)	(Quartzite)	(Quartzite)	Vein.
Raymond & Ely	...do	...do	...do	Do.
Brooklyn	Galena, zincblende, iron pyrites, (antimonial silver and quartz).	Siliceous limestone	Siliceous limestone.	

* Microscopically examined.

NYE COUNTY.

Argentiferous lead ores, inclosed in limestone in the usual irregular masses, veins of silver and copper ores, accompanied by slate or granite as well as limestone as wall rocks, and veins of arsenical and antimonial silver ores, inclosed in quartz-porphyry, are all found in Nye. The famous Belmont mine is on a vein in Silurian slate which lies between granite and limestone. The vein is conformable with the slate, and carries sulpho-salts of copper, silver, and lead.

NYE.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
BELMONT.				
Belmont	Galena, probably stephanite, quartz, pyrite, (sulphurets of lead, copper, and silver).	Slate between granite and limestone.	Slate	Vein.
MOREY.				
Bay State	Sulphurets, arsenical and antimonial silver minerals and mispickel.	Quartz-porphyry*	Quartz-porphyry*	Vein.
Kaiser	Ruby silver and sulphurets, arsenical and antimonial silver minerals, and manganese spar.	do	do	Do.
Magnolia	do	do	do	Do.
TYBO.				
Tybo Consolidated	Galena and decomposition products, (horn-silver, iron oxide, quartz, and argentite).	Limestone	Limestone	Contact vein.
UNION.				
Alexander	Galena, horn-silver, (copper ores, native silver, limestone, and quartz), shale, zincblende, and iron oxide.	Limestone	Limestone	Mineral belt.

* Microscopically examined.

STOREY AND LYON COUNTIES.

The only mines of importance in these counties are those of the Comstock lode, of which sufficient mention has been made. There are, however, other silver-bearing veins in eruptive rocks of this region, though none which have yielded large and steady profits.

STOREY AND LYON.

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
THE COMSTOCK				
Utah		Diorite*	Diorite*	Vein.
Peytona	Auriferous quartz	do*	do*	Do.
Sierra Nevada, Union Consolidated, Mexican, Ophir, California, Consolidated Virginia, Best & Belcher, Gould & Curry, Hale & Norcross, Chollar, Potosi, Bullion, Exchequer, Alpha, Challenge, Confidence	Quartz, argentite, native silver, and gold, occasionally stephanite, polybasite, etc., iron and copper pyrite, rarely calcite.	Diorite*	Diabase*	Do.
Yellow Jacket, Kentuck, Crown Point, Belcher	Quartz, argentite, native silver, and gold, occasionally stephanite, polybasite, etc., iron and copper pyrite, rarely calcite.	Black slate*	Diabase*	Do.
Overman	do	Quartz-porphyry,* diorite,* and metamorphics.*	Diabase in part*	Do.
Alta	do	do	Diorite* and andesite*	Do.
Justice	Rebellious silver ores in calcareous gangue	Quartz-porphyry* and metamorphics.*	Diorite* and andesite*	Do.

* Microscopically examined.

WHITE PINE COUNTY.

The famous deposits of the White Pine district consist largely of horn-silver in irregular bodies in Devonian limestone. The chloride is accompanied by some lead minerals, however, and these predominate in the deposits of the base metal range near by. It is possible that the horn-silver of the Eberhardt & Aurora is a product of the decomposition of argentite, and it is distinguished from ordinary occurrences in limestone by the presence of large quantities of quartz gangue, but the admixture of lead minerals suggests that the ore bodies may be nearly related to the class of which the Eureka deposits are representative. There are also veins in the county associated with slate and massive rocks as well as limestone. These for the most part carry copper, besides silver and some gold. In the Robinson district there are mines the ore of which is smelted for copper. They carry gold and silver in addition to the copper, and may represent extreme cases of the mineralogical association last mentioned.

WHITE PINE.

[NOTE.—Determinations in parenthesis are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls. Foot.	Walls. Hanging.	Character of deposit.
CHERRY CREEK.				
Exchange	(Horn-silver, argentite,) and quartz	Quartzite	Diorite (?)	Contact vein.
Star	(Pyrite, galena, stephanite, quartz, and calc-spar)	Slate	Slate	Vein.
Tickup	Copper carbonates, sulphurets, (horn-silver, and quartz)	Limestone	....do	Contact vein.
NEWARK.				
Bay State	Probably tetrahedrite, with carbonates	Limestone	Limestone.	
WARD.				
Paymaster	Probably stromeyerite and sulphantimonides, quartz, calc-spar, pyrite, zincblende, and chalcopyrite.	Slate, limestone, and probably granite.	Limestone	Vein.
WHITE PINE.				
Eberhardt & Aurora	(Chloride, with siliceous limestone)	Limestone	Limestone	Impregnation.
Stafford	....do	....do	....do	Do.

The remaining counties are of little importance at present. Washoe is one of the oldest mining counties, and contains base metal mines and silver veins, but its product is now very small, while the resources of Douglas, Ormsby, and Roop are undeveloped.

GEOLOGICAL SKETCH OF UTAH.

In northern Utah the Wahsatch range trends approximately north and south. It ends to the south about latitude 39° 30′, but is nearly continuous with the western edge of the high plateau, which sweeps to the westward as the latitude diminishes. Together they form the eastern limit of the Great Basin, and divide Utah into two unequal parts, of which the western is the smaller. These two portions of the territory differ greatly. The Great Basin in Utah is characterized by the presence of the Great Salt lake and extensive areas of especially desolate alkaline desert, as well as by the system of mountain ranges mentioned in the description of Nevada. To the east of the basin lies an elevated area, of which the distinguishing characteristic is the horizontality of its strata. The general character of this region is that of a great undulating plain, though it is not utterly devoid of hills. Its soft surface is deeply carved by modern streams into fantastic pinnacles and bluffs, which, added to the prevailing extreme barrenness, gives it a strange aspect, and a large portion of it has received the significant name of "bad lands". This plain is broken in latitude 40° 30′ by the great eastern and western ranges of the Uintah mountains, which are 150 miles long, and rises at its culminating point, Emmons peak, to an elevation of about 13,700 feet. It is unlike any other range in America, being, in fact, a lofty forest-covered plateau, from which rise bare rocky peaks, composed, like the plateau, of nearly horizontal strata. It divides the Green River basin from the great plateau basin of the Colorado, but is cut through by the Green river. These two areas share the characteristics just described.

The mineral resources of Utah are extensive and varied, and comprise lead, silver, gold, copper, coal, iron, salt, sulphur, etc.

All the government surveys have done more or less work in Utah, but so far as the mining regions are concerned the chief sources of information are the publications of the exploration of the fortieth parallel and the geological volume of Captain Wheeler's survey. Dr. J. S. Newberry has printed important papers on the subject, and Mr. G. K. Gilbert has published a paper on lake Bonneville. (a)

The Wahsatch forms the boundary between two distinct geological regions. At the close of the Carboniferous the western portion of the Great Basin (including the area of the Wahsatch) was raised above the level of the

a Second Annual Report Director United States Geological Survey.

ocean, a position which it maintained throughout the Mesozoic era. The region to the east of the Wahsatch, on the other hand, remained undisturbed during the Trias and Jura, and underwent only gentle changes of elevation during the Cretaceous. The post-Jurassic upheaval, which folded up the Sierra Nevada and the Basin ranges, probably also had its effect upon the Wahsatch, but extended no farther. At the end of the Cretaceous a vast upheaval took place in the heart of the country, by which the whole system of the Rocky Mountain ranges was raised substantially to its present position, displacing the great gulf which had hitherto occupied this area. In this uplift the Wahsatch was involved, as is known, by the plication of the Cretaceous strata on its eastern slope; but the effect of the movement is not traceable further to the west. The Wahsatch range thus belongs geologically both to the system of the Basin ranges and to the Rocky Mountain system, and forms a broad boundary wall between the two.

A great fault has taken place at the western side of the Wahsatch, which forms its foot wall. Had erosion not modified the range, it would be seen to consist of Mesozoic and earlier strata continuous with those of the country east of it but bent upward near the fault-plane, so that on the west of the crest there would be a gigantic cliff, cutting the strata nearly at right angles, while the eastern face would slope steeply away from the crest, but would gradually flatten and pass over into the nearly horizontal surface of the plateaus. To the south of the Wahsatch the plateau country was also elevated at the close of the Cretaceous, but its uplift was not attended or followed by any horizontal thrust sufficient to flex the strata near the line of upheaval into mountains. The Uintah range likewise dates from the post-Cretaceous uplift, and indicates a northern and southern compression, for its character is that of a broad anticlinal. Since the post-Cretaceous there have been further orographical changes, though none which have introduced new topographical features of importance.

The great Wahsatch fault is a feature of the geology of Utah which has probably had an important influence on many of its geological phenomena, including that of mineral deposition. The geologists of the fortieth parallel have shown that, as far back as the Archæan, a fault occurred along the range coinciding for the most part with its present western foot. Renewed dislocation on the same plane occurred at the close of the Cretaceous or early in the Eocene, again in the Quaternary, and the fault appears to be in progress even at the present day, for so fresh is the most recently exposed surface that vegetation has not had time to clothe it. The observers draw the inference that such fractures in the earth's crust always remain lines of weakness, liable on comparatively slight occasion to further dislocation.

During the Trias-Jura the gulf or inland sea, of which the Wahsatch formed the western shore, was shallow in the northern and central portions of Utah, and the sediments consist of sandstones and shales, often cross-bedded by the action of currents. Numerous pools seem also to have been cut off from the main body of the water, and thus to have been exposed to evaporation. The result is seen in frequent gypsum deposits, which are, for the most part, thickest at the center and thin out toward the edges. Such conditions are not favorable to marine life, and a very large part of the strata representing the Trias-Jura contain only fragments of vegetation from surrounding coasts. At the southern end of the territory during the Jurassic the sea was deep and deposited calcareous sediments.

During the Cretaceous the water was for the most part shallow toward the north, and, in consequence of gentle oscillations in level, land and sea frequently alternated on the eastern side of the Wahsatch. Portions of the country, however, were maintained long enough above sea-level to permit of the growth of an extensive flora, and, as a consequence, the Cretaceous strata are marked by the presence of numerous carbonaceous beds, which often contain coal seams of fair thickness. In southern Utah the Cretaceous sea at certain points was deep, but throughout the plateau area most parts of it were shallow.

After the post-Cretaceous uplift, and throughout the Tertiary, the region east of the Wahsatch was occupied by great fresh-water lakes, the sediments of which toward the north, and especially near the Uintah range, are deposited unconformably on the Cretaceous. In this region they are also unconformable among themselves, showing that orographical changes took place during their deposition. In southern Utah, however, the Tertiary fresh-water strata appear to show no non-conformity either with one another or with the underlying Cretaceous. It is these fresh-water Tertiaries which have been modeled by modern streams into the fantastic forms characteristic of the bad lands. Several large lakes existed in the Great Basin during this era, and similar conditions prevailed through the Quaternary, modified only in more recent times by slight orographical changes and by greatly increased evaporation. The great Quaternary lake of Utah was Bonneville, the history of which has been studied by Mr. G. K. Gilbert. According to that geologist the present dry period in the Great Basin is not the only one which it has experienced. A long remote period of drought, during which the lake sometimes nearly or quite dried up, was succeeded by a long wet period, in which, however, there was an insufficient supply of water to permit an overflow. Next came a time so dry that the lake altogether disappeared, and then one of so much precipitation as to allow of discharge by overflow. This was followed by the present epoch, in which the area of water has been reduced to that of the Great Salt lake and the smaller bodies south of it. (*a*)

The eruptive rocks of western Utah are the same as those of Nevada, and are represented by Archæan granites, Mesozoic diorites, diabases, etc., and Tertiary or post-Tertiary andesites, rhyolites, and basalts. According to Mr. Hague, no true trachytes are found among the rocks collected in Utah by the exploration of the fortieth parallel.

a Second Annual Report of the Director of the United States Geological Survey.

An interesting series of rocks, locally called syenitic porphyries, has been collected in the West Mountain district, Oquirrh range, by the census expert, which seem to be highly augitic granite-porphyries. As in Nevada, there is an intimate relation between the ore deposits and occurrences of eruptive rocks, the former seldom being found except in the immediate neighborhood of the latter.

Metallic ores are rare east of the Wahsatch and in the plateau country, where indeed Tertiary strata occupy much of the surface. In southern Utah, however, the Triassic sandstones carry silver and copper, and especially rich strata of this age form the famous silver reefs near Leeds. To the west of the Wahsatch and along the edge of the high plateau a series of ore deposits is found from one end of the territory to the other, forming a true mineral belt. All of these are associated with Palæozoic strata, which, however, proves nothing as to the age of the deposits; indeed, it is known that some of them must be Tertiary or post-Tertiary. It seems extremely probable that these ore deposits owe their existence to the solfataric action accompanying the eruption of massive rocks, and that the points where these reached the surface were determined by the line of disturbance, of which the great Wahsatch fault is the most striking manifestation. At all events, it is a fact that the western edge of the post-Cretaceous uplift is marked in Utah by an immense number of deposits. It has been pointed out on a preceding page that there is a strong analogy between the geological relations of the mineral belt of Utah and those of California. There are ores in the Basin ranges of Utah as well as near the Wahsatch, and particularly in the Oquirrh mountains, which lie to the west of Utah lake. These are very similar to the deposits in the kindred ranges of Nevada.

The prevailing type of the ore deposits in Utah consists of more or less regular bodies of argentiferous lead ores associated with limestone, and usually accompanied by eruptive rocks. The original form of the ore was probably in all such cases galena, which in a majority of instances has yielded to decomposition processes for a long distance from the surface, and is now replaced by carbonate, sulphate, and other secondary minerals. Of such occurrences the Horn Silver mine is an excellent type and an important instance. The deposit worked by this mine lies between a foot wall of dolomitic limestone and a hanging wall of rhyolite. The nature of this lava is proved by microscopic slides in the census collection. Small masses of galena occur, but the prevalent mineral is the sulphate which has formed in consequence of oxidation of the galena. It is a significant fact that heavy spar is one of the gangue minerals, but occurs only near the rhyolite. The same district shows other volcanic rocks. An augite-andesite is found near the Horn Silver mine, and the Carbonate mine, near by, is associated with a hornblende-andesite of so-called "trachytic" habitus similar to the Mount Rose hornblende-andesite of the Washoe district.

The veins in Utah which are associated with slates or quartzites do not commonly carry a preponderance of lead ores, but are cupriferous and sometimes auriferous; the gangue in such cases is also generally quartz. Of such mines the Ontario is much the most important.

The Ontario mine in the Uintah district, Summit county, is a strong vein, several feet wide. Its ores are zincblende, galena, fahlerz, and pyrite, with some horn-silver and copper carbonate in a quartz gangue. The walls are, in the main, quartzite, but at 400 feet a porphyry was struck near the vein which appears at lower levels in contact with the vein, and it is thought will replace quartzite as the hanging wall. Unfortunately the specimens of this porphyry received are too much decomposed to make determination possible. It is full of pyrite, and has manifestly been subjected to solfataric action. The Ontario is one of the richest mines in the country. Its ore is treated by roasting in a Stetefeldt furnace and amalgamation.

The sandstones of southern Utah and the adjoining regions carry a very unusual form of ore deposits, consisting of impregnations of silver and copper, partly native and partly as sulphides. Much of the silver sulphide has also been converted into chloride. The age of these sandstones was determined by Professor J. Marcou, and subsequently by Dr. J. S. Newberry, as Triassic—a determination confirmed by Messrs. Gilbert and Howell. (*a*) The geological information which has been published on this subject is very largely due to Dr. J. S. Newberry. (*b*) After having described the peculiar character of the Triassic sea in this portion of the continent and mentioned the well-known facts regarding the silver contents of ordinary sea-water, this geologist states his opinion as to the origin of the silver and copper in the sandstones as follows:

> Near the Utah shore of this Triassic basin the water would seem to have been more highly charged than elsewhere with silver, though it was also the associate of the more abundant copper in New Mexico, the Indian territory, and Texas. Doubtless this silver was brought up in springs on the old land from the same sources which furnished so large an amount of silver to the fissure veins formed there long after. Near the old shore the drift-wood brought down by the draining streams and scattered by the shore-waves, when buried in the accumulating sediment, became more or less replaced by copper and silver, precipitated by the reducing action of organic matter which is manifested in so many different ways. The quantity of silver in some of the bays and estuaries carried by draining streams, perhaps fed in part by mineral springs, may have been greater than that in most parts of the water-basin, and hence the sediments formed there hold a quantity larger than the average. We find the same variation in the distribution of copper farther east. In some places it was so abundant that it was not all taken up by the decaying wood, but formed concretions of sulphide in the sand or clay.
>
> * * * * * * * *
>
> The ores of silver and copper plainly existed as solutions, which saturated the sand when it was collected and deposited the sulphides with sandstone after the mechanical action which transported the sediment was at an end. All this, however, was within the Triassic age, while the water was shallow and highly charged with mineral matters.

a Surveys West of the 100th Meridian, vol. 2, p. 176. *b* See especially *Engineering and Mining Journal*, vol. 31, p. 5.

He states later in the same article that he regards it as possible, though not probable, that in some places the porous sandstones of the Trias were penetrated by solutions, from which the sulphides of copper and silver were precipitated.

The undisturbed condition of some of the sandstones is certainly an argument in favor of the supposition that the ore was deposited with the sandstone, but there are considerable difficulties involved in its acceptance. Common sea-water will dissolve only an extremely small amount of silver salts, though saturated solutions of salt are capable of dissolving silver chloride in considerable quantities. If the Triassic sea held the silver in solution, it can only have been charged with the metal after isolation from the main ocean and concentration by evaporation; but it is difficult to suppose this combination of conditions prevailing over wide areas. The deposits of commern in Rhenish Prussia present very strong analogies to those of Silver Reef, but there it is an argentiferous, though otherwise very pure galena, which is disseminated through sandstone. There are strong chemical objections to supposing this galena to have been deposited directly from the ocean, or even from a land-locked basin of concentrated sea-water; yet a satisfactory theory would give an account of it as well as of the Utah silver. The theory of impregnation of the sandstones by solution presents, in my opinion, fewer difficulties. It is not easy to see why the replacement of organic matter, such as wood, by the metals would not occur as readily from an ascending solution as from sea-water, while ascending solutions would certainly favor the formation of the considerable nodules of ore sometimes found in the sandstone. May these deposits not, after all, be chemically and physically analogous to ordinary veins, though so different from them structurally? It is supposed that precipitation takes place in veins where there is room for deposition, and where at the same time relief of temperature and pressure or chemical action, especially that of organic matter, induce precipitation. In ordinary rocks such conditions are to be found mainly in fissures, but in sandstones, particularly such as carry organic matter, they may occur anywhere, and the presence of copper or lead would be as readily accounted for as that of silver. Dr. Newberry records that analyses made at his instance by Mr. J. B. Mackintosh show that the silver in some of the sandstones is accompanied by selenium in considerable quantities.

The number of workable coal-seams in Utah is very considerable. Those thus far opened lie for the most part on the eastern flank of the Wahsatch, or not far from the western edge of the high plateau, and while search for them elsewhere is by no means hopeless, these localities seem most likely to show good seams. Both Cretaceous and Tertiary beds are said to occur, (*a*) and some of them are reported to present very unusual qualities for coals of such recent date, not crumbling on exposure, containing a very small amount of water, and yielding strong coke. The great value of such beds, at an immense distance from the well-explored coal-fields of the Carboniferous era, is patent.

In the appendix will be found a report on the mining industries of Utah by Mr. D. B. Huntley, who filled the office of special expert for the territory. This paper describes the mineral resources in so much detail that any special notes on the counties are unnecessary here.

BEAVER.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
BRADSHAW.				
Cave	Cerussite, cuprite, copper carbonates, with calcite, aragonite, and limonite, (manganese oxide, native sulphur).	Limestone	Limestone	Irregular bodies.
SAN FRANCISCO.				
Horn Silver	Cerussite and anglesite predominate; galena, dufrenoysite, proustite, (pyrargyrite), cerargyrite, argentite also occur with calcite, quartz, and barite.	Limestone	Rhyolite *	Chimney.
Carbonate	Argentite, argentiferous galena, cerussite, and quartz.	Hornblende-andesite *	Hornblende-andesite *	Vein.
Grampian	Galena, cerussite, and calcite, (iron oxides and quartz).	Limestone	Limestone	Irregular bodies.
Makalola & Summit	Copper carbonates, calcite, (iron oxides, said to carry fluorspar).	Limestone and slate	Limestone and slate	Pipes.
STAR.				
Burning Moscow Hill	Cerussite	Black limestone	Black limestone.	
Crœsus	Cerussite, horn-silver, malachite, and quartz	Limestone	Limestone.	
Harrisburg	Galena, cerussite, gypsum, and pyrolusite, (limonite)	Dolomitic limestone	Dolomitic limestone	Chimney.
Osceola	Cerussite and quartz	Siliceous limestone	Siliceous limestone.	
Rebel	Galena, (cerussite and iron oxides)	Limestone	Limestone.	
Vicksburg	Galena, cerussite, free sulphur, gypsum, and quartz, (limonite).	Crystalline limestone	Crystalline limestone.	
Vulcan	Hematite and limonite used as flux	Granite *	Limestone.	
Wasco	Galena, cerussite, and clay, (limonite, little gold, or silver).	Dolomitic limestone	Dolomitic limestone	Chimney.

* Microscopically examined.

a E. E. Howell in *Surveys West of the 100th Meridian*, vol. 3, p. 278.

JUAB.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls. Foot.	Walls. Hanging.	Character of deposit.
TINTIC.				
Bonanza	(Galena, pyrite, and other minerals)	(Porphyry)	(Porphyry)	Pipes.
British	(Copper minerals, limonite, calcite, quartz, rarely gold, and manganese oxide.)	(Limestone)	(Limestone)	Mineral belt.
Carisa	Quartzose, carrying limonite and lead, probably as cerussite, (copper carbonates and sulphides).	Probably dacite,* (limestone).	Probably dacite,* (limestone).	Vein.
Elmer Ray	Erubescite, anglesite, pyrite, mispickel, quartz, (limonite).	Hornblende-andesite*	Hornblende-andesite*	Do.
Eureka Hill	Galena and its decomposition products, copper stains, hematite, quartz, calcite, (lead ocher, gold, horn-silver, and zincblende).	Siliceous limestone	Siliceous limestone	Irregular masses.
Golden Bell	Bismuthite (argentiferous).			
Golden Treasure	Siliceous and ferruginous rock (carries bismuth and silver).	Indeterminably decomposed massive rock.	Indeterminably decomposed massive rock.	Vein.
Joe Bowers	Ferruginous quartz, calcite, and cerussite (?)	Andesite, (?) decomposed and pyritiferous.	Andesite, (?) decomposed and pyritiferous.	
Mammoth	Cuprite, pyromorphite, copper carbonates, quartz, calcite, pyrolusite, (limonite, argentite, and horn-silver).	Dolomitic limestone	Dolomitic limestone	Vein.
Mammoth Copperopolis	Enargite, malachite, quartz, pyrolusite, (silver)	Limestone	Limestone.	
Morning Glory	Anglesite, iron oxide, and quartz.			
Park	Galena, cerussite, quartz, (limonite and silver, probably as argentite).	Diorite*	Diorite*	Vein.
Rising Sun	Argentiferous pyrolusite, (galena, gold, and copper)	Hornblende-andesite*	Hornblende-andesite*	Do.
Shower	Galena, cerussite, calcite, and quartz.			
Swansea	(Galena, cerussite, limonite, and quartz)	(Granite) (?)	(Granite) (?)	Do.

* Microscopically examined.

PIUTE.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls. Foot.	Walls. Hanging.	Character of deposit.
OHIO.				
Bully Boy	Galena, quartz, (cerussite).			
Copper Belt	Melaconite, (?) copper carbonates, iron oxide, (tetrahedrite, chalcopyrite, chalcosite, and quartz).	Quartz-porphyry*	Quartz-porphyry*	Vein.
MOUNT BALDY.				
Deer Trail	Galena and decomposition products, malachite, wulfenite, quartz, (lead ocher and copper sulphides).	Quartzite	Limestone	Contact vein.
Green-Eyed Monster	do	do	do	Do.
Pluto	Argentite, free gold, and calcite.			
Lucky Boy	Quicksilver selenide.			

* Microscopically examined.

SALT LAKE.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls. Foot.	Walls. Hanging.	Character of deposit.
BIG COTTONWOOD.				
Anellie	Melaconite and malachite, (lead, silver, and gold)	(Limestone)	(Limestone).	
Antelope & Prince of Wales.	Galena, limonite, copper stains, and calcite, (cerussite and manganese oxide).	Limestone	Limestone.	
Butte	Galena, limonite, calcite, pyrolusite, and quartz	do	do	Vein.
Carbonate	Galena, cerussite, limonite, and calcite	Dolomitic limestone	Dolomitic limestone.	
Maxfield	Galena, cerussite, malachite, pyrite, quartz, calcite, talc, (manganese oxide and limonite).	Limestone	Limestone	Bedded vein.
Ophir	Galena, cerussite, copper stains, pyrolusite, and iron oxide.	Blue limestone	Blue limestone.	
Reed & Benson	Cerussite, plumbic ocher, anglesite, and calcite.	Limestone	Limestone.	
Silver Mountain	Galena, cerussite, plumbic ocher, (copper stains, quartz, and limonite).	Quartzite and shale	Quartzite and shale	Bedded vein.
Thor & Bright Point	(Galena, cerussite, limonite, and quartz)	Quartzite	Quartzite	Vein.
LITTLE COTTONWOOD.				
Cincinnati	(Galena), cerussite, anglesite, and pyrolusite.			
City Rocks	(Galena), cerussite, wulfenite, cuprite, malachite, pyrolusite, and limonite.	Limestone and diorite *	Limestone and diorite. *	
Dexter	Galena and quartz.			
Emma	Galena, cerussite, anglesite, limonite, calcareous gangue, (manganese minerals).	Limestone	Limestone	Belt.
Emily	Galena, dufrenoysite, pyrite, calcareous gangue, (tetrahedrite, zincblende, and quartz).	(Quartzite)	(Quartzite)	Vein.
Equitable	(Galena and cerussite)	(Limestone)	(Limestone).	
Evergreen	(Galena, cerussite, limonite, and copper carbonates)	(Limestone and sandstone)	(Limestone and sandstone).	
Grizzly	Cerussite, copper stains, limonite, and manganese minerals.	Limestone	Limestone.	
Louise	(Limonite, quartz, with galena and cerussite)	(Limestone)	(Limestone)	Vein.
North Star	Galena, cerussite, and wulfenite	Limestone	Limestone	Vein or belt.

SALT LAKE—Continued.

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
LITTLE COTTONWOOD—cont'd.				
Oxford & Geneva	Galena, cerussite, plumbic ocher, wad, enargite, pyrite, chalcopyrite, malachite, marcasite, calcareous gangue, (oxide of manganese and quartz).			
Toledo	(Hematite, quartz carrying silver)	(Quartzite)	(Quartzite)	Vein.
Vallejo	Galena, cerussite, anglesite, copper stains, limonite, hausmannite, and wulfenite.	Dolomite	Dolomite.	
Victoria & Surpriser	Cerussite, limonite, probably horn-silver.			
Wellington	Galena, zincblende, copper pyrite, (limonite, silver, and gold).	(Black limestone)	(Black limestone)	Vein.
WEST MOUNTAIN.				
Highland Boy	Galena, chalcopyrite, (gold)	Quartzite	Limestone.	
Jordan	Galena, (gold), iron and copper pyrites, cerussite, limonite, quartz, and copper stains.	...do	Siliceous limestone	Vein.
Live Yankee	Galena, cerussite, limonite, and quartz	Granite-porphyry*	Granite-porphyry.	
Lucky Boy	Orpiment and realgar.			
May Flower	Gold, quartz, and limonite	(Between granite and quartzite.)	(Between granite and quartzite.)	Vein.
Neptune	Zincblende, galena, pyrite, (silver and gold)	Limestone	(Quartzite).	
Old Telegraph	Galena, cerussite, iron and copper pyrites, malachite, limonite, and quartz.	...do	Quartzite	Belt.
Queen	Galena, cerussite, argentite, pyrargyrite, rhodocrosite, zincblende, quartz, barite, (bornite, calcite).	Augitic granite - porphyry. (?)*	Augitic granite - porphyry. (?)*	Vein.
Stewart	Gold, quartz, limonite, galena, and chalcopyrite	Quartzite	Quartzite	Bedded vein. (?)
Stewart No. 2	Gold, quartz, limonite, (silver and copper carbonate)	(Unknown)	...do	Vein.
Telegraph 1st W. Extn	Cerussite, quartz, (galena and limonite)	(Quartzite)	(Quartzite)	Bedded vein.
The Lead Mine	Cerussite and quartz	Quartzite	Quartzite.	Belt.
Tiewaukee	Galena, binnite, zincblende, pyrite, cerussite, quartz, iron oxides, (ruby silver and native silver).	...do	...do	Do.
Victor	Cerussite, (silver and gold)	(Quartzite)	(Quartzite)	Vein.
Winnamuck	Galena, dufrenoysite, iron and copper pyrites, cerussite, limonite, zinc-vitriol efflorescence, native sulphur, (zincblende, cubanite, tetrahedrite, calcite, and gypsum).	Quartzite	Shale	Bedded vein.
Yosemite	Galena, cerussite, iron and copper pyrites, melaconite, limonite, (bornite, zincblende, and quartz).	...do	Quartzite	Vein.

* Microscopically examined.

SUMMIT.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Foot.	Hanging.	Character of deposit.
UINTAH.				
Empire	(Horn-silver), malachite, (cerussite), quartz, manganese oxide, and limonite.	Quartzite	(Said to be porphyry)	Vein.
Fairview	Cerussite, plattnerite (?) with calcareous gangue	(Quartzite)	(Quartzite).	
Ontario	Galena, argentite, (native silver), tetrahedrite, zincblende, (pyrite), horn-silver, malachite, clay, (quartz).	Quartzite	Quartzite and indeterminable diorite-like porphyry.	Vein.
White Pine	Galena, zincblende, pyrite, cerussite, malachite, (tetrahedrite, argentite, and native silver).	Limestone	Diabase (?)	Do.
Walker & Webster	Galena, cerussite, and quartz.			
Boss	(Zincblende, galena, cerussite, horn-silver, copper carbonate, manganese oxide, limonite, and quartz.)	(Siliceous limestone)	(Green porphyry)	Vein.
Woodside	(Cerussite, anglesite, galena, iron oxide, and calcite)	(Quartzite)	(Siliceous limestone)	Vein. (?)

TOOELE.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Foot.	Hanging.	Character of deposit.
CAMP FLOYD.				
Carrie Steele	Stibnite, quartz, limonite, (horn-silver and antimonial silver).	Limestone	Siliceous limestone	Bedded vein.
OPHIR.				
California	Cerussite and limonite	(Limestone)	(Limestone)	Bedded vein.
Douglas	Galena, cerussite, calcite, quartz, and limonite	...do	...do	Bedded mass.
Gem, Antelope	Galena, chalcopyrite, (limonite and pyrite)	...do	...do	Vein.
Hidden Treasure	Galena, cerussite, malachite, and limonite, (silver)	Limestone, quartz-porphyry	Slate dike	Chimneys.
Kearsarge	(Argentiferous galena, cerussite, copper carbonates, native silver, horn-silver, and limonite.)	Siliceous limestone	Sandstone	Irregular bodies.
Monarch	Cerussite, horn-silver, and siliceous gangue	Limestone and quartzite	Indeterminable porphyry	Bedded vein.
Mono	Galena, cerussite, plattnerite, (?) pyrite, (horn-silver, chalcopyrite, and limonite).	(Clay shale, close to limestone.)	(Clay shale, close to limestone.)	Vein.
Queen of the Hill	Galena, tetrahedrite, cerussite, malachite, limonite, and calcite.	Fetid limestone	Calcareous sandstone	Do.
Trace	Cerussite, limonite, and calcite, (the limonite is argentiferous).	Limestone	Limestone	Do.
Zella group	(Cerussite, horn-silver, limonite, and calcite)	...do	...do	Pipes.
RUSH VALLEY.				
First National	Galena, cerussite, limonite, (manganese minerals and copper stains).	(Siliceous limestone)	(Black limestone)	Bedded vein.
Great Basin	Cerussite, limonite, clay, (argentiferous galena, malachite, and manganese minerals).	Limestone	Limestone.	Do.

UTAH.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposits.
		Foot.	Hanging.	
AMERICAN FORK.				
Live Yankee	Galena, pyrite, quartz, (silver, gold, zincblende, and copper ore).	(Quartzite)	(Quartzite)	Vein.
Miller	Galena, cerussite, zincblende, pyrite, limonite, (silver, gold, and quartz).	Shale	Limestone	Do.
Pittsburgh	(Galena, cerussite, limonite, and clay)	(Limestone)	(Limestone)	Do.
Wild Dutchman	Galena, cerussite, zincblende, quartz, limonite, arsenical and antimonial compounds.	Limestone	Limestone	Do.
Treasure	(Cerussite, pyrite, quartz, limonite, and copper stains.)	do	do	Do.
SILVER LAKE.				
Milkmaid	Galena, cerussite, quartz, limonite, (pyrite and zincblende).	Quartzite	Quartzite	Pipes.
Wahsatch	(Galena, cerussite, limonite, and quartz)	(Quartzite)	(Quartzite)	Pockets.

WAHSATCH.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Foot.	Hanging.	Character of deposits.
BLUE LEDGE.				
Lady of the Lake	Galena, zincblende, calcite, and quartz	Granite *	(Porphyry)	Vein.
Wahsatch	Galena, cerussite, pyromorphite, and quartz	(Quartzite)	(Quartzite)	Do.
SNAKE CREEK.				
Jones Bonanza	Malachite, limonite, calcite, and (quartz)	Granite *	Granite *	Vein.
Pioneer	(Galena, cerussite, limonite, copper stains, and clay)	(Quartzite)	Shale	(?)
Utah	Galena, cerussite, zincblende, pyrite, clay, and (tetrahedrite).	Quartzite	Decomposed diorite (?) *	Vein.

* Microscopically examined.

WASHINGTON.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Foot.	Hanging.	Character of deposits.
HARRISBURG.				
Buckeye	Magnesian clay, showing flakes of silver. Sandstone with native silver and argentite. Fossil plants replaced in part by silver and horn-silver.	Sandstone and clay slate	Sandstone and clay slate	Bed.
Barbee & Walker	Sandstone with native silver and sulphurets, (horn-silver, argentite, and lignite).	Sandstone	Sandstone	Do.
Dublin	Sandstone containing horn-silver, (argentite, and native silver).	do	do	Do.
Kinner	Sandstone containing horn-silver and sulphurets, (silver, argentite, and lignite).	do	do	Do.
Leeds	(Horn-silver, argentite, native silver, carbonized vegetable matter.)	do	do	Do.
Maud	do	do	do	Do.
Stormont	do	do	do	Do.

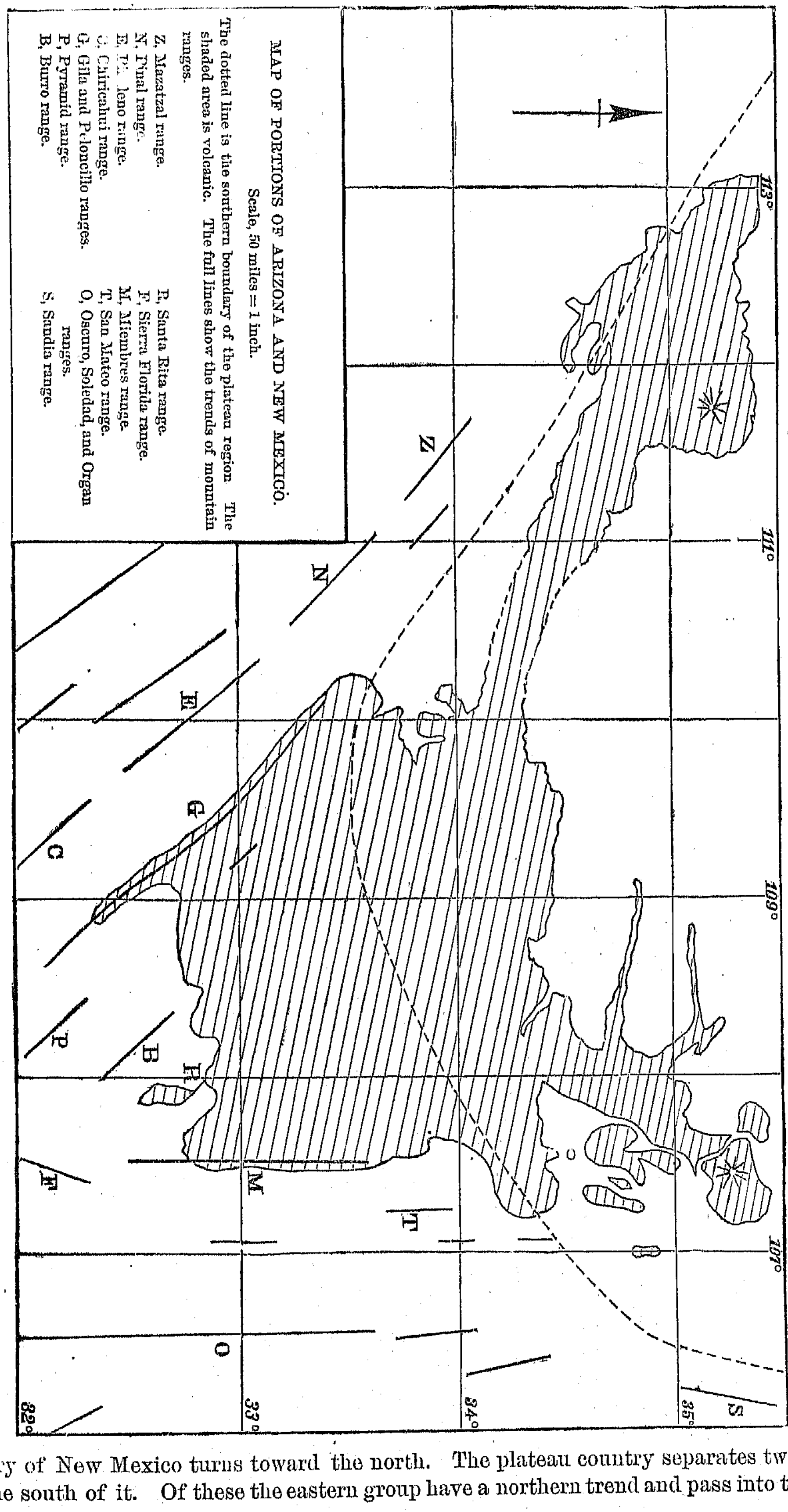
GEOLOGICAL SKETCH OF ARIZONA.

In the latitude of Salt Lake the Cordilleras, as Humboldt called the entire system of western North American mountains, occupy a breadth of over 1,000 miles. In the latitude of Tucson they are contracted to about half this width, which is still further reduced in Mexico. While Nevada occupies only a portion of the breadth of the Great Basin, Arizona, though no wider, includes a large part of the plateau region, the southern continuation of the Basin ranges, and probably a portion of the group of ranges of which those on the southern coast of California are members. The topography is thus extremely diversified and for the most part mountainous. There are fertile valleys and well-wooded mountains in the territory, but the prevalent character is one of great aridity, and in the southwestern portion there are large tracts of shifting sands, relieved only by occasional cactuses, in comparison with which the sage-brush plains of the Great Basin seem areas of luxuriant vegetation. Arizona is, of course, famous for its mines, which produce chiefly gold and silver, though lead and copper, particularly the former, are rather abundant, and will, no doubt, be exploited on a large scale when the railroad system is further developed. Coal also occurs in considerable quantities.

A number of geologists have visited Arizona. Dr. Newberry was a member of Lieutenant Ives's expedition in 1857; Major Powell and Captain Dutton have explored the Colorado cañon and a portion of the plateaus, and the geologists of Captain Wheeler's survey have contributed very greatly to a knowledge of the main features of the territory. But little detailed work, however, has been done in the mining regions, and such of the facts ascertained as are appropriate to this sketch are soon told.

Northeastern Arizona belongs to the Colorado plateau, of which about one-third falls within the limits of the territory. The Arizona plateaus are for the most part nearly level, though, as in Utah, there are folds, and even ranges, of uplifted mountains at long intervals.

The southwestern limit of the plateaus is roughly indicated by a straight line running northwest from a point in latitude 33° 30′, longitude 110°. To the east of this point the limiting line curves eastward, and in the



[From *Surveys West of the 100th Meridian*, vol. III. Drawn by G. K. Gilbert.]

adjoining territory of New Mexico turns toward the north. The plateau country separates two systems of ranges which meet to the south of it. Of these the eastern group have a northern trend and pass into the Rocky mountains of Colorado. The western group trends northwest, and is continuous with the Basin ranges of Nevada. Only the latter ranges are met in Arizona, the most westerly of those of northern trend occurring in New Mexico just east of the dividing line.

The region in which the plateaus and the two systems of ranges meet is characterized by an immense lava field covering between 20,000 and 25,000 square miles.

The relations of the two systems of ranges to the plateau country and the lava fields are shown in the sketch map on page 45, borrowed by his permission from Mr. Gilbert's report on the geology of parts of Arizona and New Mexico, to which our knowledge of the region in question is chiefly due.

Concerning southwestern Arizona there is extremely little definite information. This portion of the territory is mostly composed of granites and crystalline schists, and the mountain ranges are somewhat irregular. They appear, however, to belong to the same structural system as those of California south of fort Téjon, with which they correspond in a variety of details.

In Utah the edge of the plateau system is nearly coincident with that of the inland Cretaceous sea. In Arizona this is by no means the case, the surface of a great part of these elevated plains toward the west being of Carboniferous age, and the Triassic being largely represented on the surface. The belt of Palæozoic included in the plateau country, measured from the southwestern edge of the latter, averages about 80 miles in width. The ranges trending northwest and continuous with those of the Great Basin are also composed of Palæozoic strata, except where the Archæan is exposed or where volcanic rocks hide the sedimentary beds. Captain Dutton's investigations have established that the Jura-Trias strata formerly reached the edge of the plateau system in Arizona as they did in Utah, but have since been removed by erosion. This is shown by the presence of remnants of these beds protected by lava near the edge of the plateau, and by the impossibility of reconstructing their surface, except on the supposition that they reached this line. The elevation of the range system, judging from the analogy of the Great Basin, is most likely referable to the post-Jurassic disturbance which resulted in the formation of the Sierra Nevada. Whether the Jura-Trias beds were also raised above water-level along this line at this time is uncertain, but it would not be surprising if this should prove to be the case. The Cretaceous sea in Utah was shallow, and a slight post-Jurassic elevation would have thrown its shore far east of the Wahsatch. Such a change of shore line may have taken place in Arizona and left the western portion of the plateau dry, or the shore line may have been nearly coincident with the edge of the plateau, and the Cretaceous deposits afterward removed by erosion, like those of the Jura-Trias. The disturbance to which the Arizona ranges is due extended eastward to the edge of the plateau country, and the post-Cretaceous upheaval which raised the plateaus extended westward to the ranges, exactly as was the case in Utah. In the northern part of the territory the contact between the Palæozoic area and the crystalline rocks to the southwest of it has been traced for a long distance. This line probably lies somewhat to the northeast of the original edge of the Palæozoic, but at no great distance from it. That a portion of these strata have been removed by erosion is indicated by the occurrence of isolated patches near the main area. The most remote of these is reported as occurring in the Bill Williams Fork country, and may represent a gulf in the Palæozoic sea. Though the southwestern portion of the territory has not been systematically explored, it has been traversed in many directions by geologists who would not have failed to recognize Palæozoic strata had they encountered them, and it is probable that they are absent from that region.

The main contact between the Palæozoic and the underlying strata is laid down in the geological maps of the surveys west of the 100th meridian continuously from Virgin cañon to Camp Verde, a distance of 170 miles. Farther south the most westerly occurrences of Palæozoic shown are in the Pinal mining district near Florence and in latitude 32° 20′, longitude 109° 40′. These are probably near the edge of the area, though there is some evidence of detached patches still farther to the south, and to the west of the general course of the contact so far as traced. The Chiricahui range has been shown by Mr. Gilbert to be largely made up of Palæozoic strata, and the mines of the Tombstone district are many of them sunk on deposits in limestone. In this region limestones can hardly be other than Palæozoic, and they are reported as containing Carboniferous fossils.

The rocks adjoining the Palæozoic to the southwest are unquestionably Archæan, for their relations to the Silurian are clear at a great number of points, and their lithological character in this region is very characteristic and persistent. There seems no evidence that these Archæan rocks have been covered at any time, except where comparatively small patches of the Palæozoic have been removed by erosion near the contact. Had this area formed a sea bottom, like the corresponding region to the north, during the Trias-Jura, it is scarcely supposable that the thick sediments which must have formed should have disappeared without traces which would have been detected before now; and while only an elaborate field study can establish the facts, it seems allowable to suggest the probability that the subsidence of the Archæan, which took place at the close of the Carboniferous in western Nevada, did not extend to central Arizona, so that the continental area of the Trias-Jura embraced eastern Nevada, western Utah, and most of Arizona, excepting the northeastern corner. The Pacific coast of that time followed the meridian of 117° 30′ (approximately) to the neighborhood of Owen's lake. If the supposition stated above is correct, it must then have left the Palæozoic area and continued in a southerly or southwesterly direction. It appears most probable, on the whole, that it passed to the south of fort Téjon and out into the area at present covered by the Pacific. The coast in San Bernardino county, California, has no doubt slowly changed its elevation repeatedly, but

Professor Whitney states that, while in that county a belt of 10 or 12 miles next the coast is occupied by Cretaceous and Tertiary strata, the region back of this is composed of granite and highly crystalline rocks of the geological age, of which nothing is known. (*a*) Such descriptions of San Bernardino county as have been published, however, show that the rocks are extremely similar to the Archæan of Arizona, and in the absence of definite information it may be assumed that they are identical. If so, there is a body of Archæan reaching from San Diego to Camp Verde, a distance of about 300 miles. Its northern limit is not far from Owen's lake, and its southern extension is unknown. If the shore line of the Pacific ocean in the Mesozoic era passed westward or southwestward from near fort Téjon to the present coast, Jura-Trias strata probably underlie the coast ranges in that neighborhood, and it is possible that they may somewhere be exposed.

It is, of course, wholly impossible to assign a date to the Archæan ranges of Arizona, the more so that the topographical maps of the area are very inaccurate. These mountains scarcely appear to form a portion of the Basin range system, but they may have been raised at the same time, for, though their lithological character differs greatly from that which prevails in those ranges, the trend and general relations of the Archæan mountains certainly do not differ more from those of the Palæozoic ranges of Arizona than the Mesozoic Sierra Nevada from the ranges of the same era in western Nevada. It at least seems more likely that the Archæan ranges date from the post-Jurassic upheaval than from either of the three other important uplifts mentioned, while it scarcely seems possible that any traces of a pre-Palæozoic mountain formation should have withstood erosion till the present day unless protected by overlying rocks of later age.

Of the eruptive rocks of Arizona not much is known. Besides granite, there are enormous quantities of true basalt and of other volcanic rocks which have not yet been subjected to the minute examination necessary to classify them satisfactorily. The census collection contains numerous specimens of pre-Tertiary eruptive rocks, quartz-porphyry, diabase, and diorite. If the analogy of Nevada could be trusted, these rocks would be regarded as Mesozoic, and as probably post-Jurassic. They appear in the Palæozoic ranges, not merely as dikes, but as large masses, inclosing veins, and their extrusion was most likely a concomitant of the disturbance to which the formation of the ranges is due. Though only an examination in the field can determine the age of those mountains, the occurrence of these eruptives is another argument for referring them to the great Mesozoic upheaval.

The census collection of the Pacific division contains only a single syenite. This forms the hanging wall of the Golden Eagle mine, Globe district, Pinal county, Arizona territory. A slide shows orthoclase, a little plagioclase, hornblende, mica, and scarcely a trace of quartz. The exploration of the fortieth parallel encountered but one syenite. This was found in the Cluro hills, Cortez range, Nevada, and contains much more quartz than that from the Golden Eagle mine. The latter, however, bears a strong resemblance to the granite which is the prevailing rock in the Globe district, and is represented in the census collection by a large number of specimens. The Cluro Hills syenite is also scarcely distinguishable from the granite of the same region, and it may fairly be asked whether both are not to be considered as granites containing an unusually small proportion of quartz. As is well known, almost every fresh investigation of European syenites diminishes the number of occurrences to which the name is considered applicable, and it seems not unlikely that it will eventually disappear from the list of rocks.

The ore deposits of Arizona in a majority of cases are found in connection with massive rocks. Often both walls are granite or some later eruptive; in many cases a massive rock forms one wall of the veins, and even where limestone or shale entirely inclose the ore it is known in some cases that eruptive rocks occur close in the neighborhood. The relations of the mineral belt as a whole to the southwestern edge of the area of post-Carboniferous upheaval have already been sufficiently commented on.

APACHE COUNTY.

In the northern part of this county good coal seams exist in the Cretaceous, but at present they are little exploited for want of facilities for transportation. At the southern end of the county, where it adjoins Pima, copper ores, with blende and pyrite, occur in the veins associated with limestone and quartz-porphyry. There are also gold placer mines in the same neighborhood, and consequently there must be gold quartz veins, though none such have been reported by the experts.

APACHE.

Mine.	Ore and gangue.	Walls. Foot.	Walls. Hanging.	Character of deposit.
COPPER MOUNTAIN.				
Longfellow	Melaconite and azurite, zincblende, pyrite, with calcareous gangue.			
GREENLEE GOLD MOUNTAIN.				
Boston group	Auriferous gravel	Probably diorite		Placer.
Coronado group	Malachite and cuprite, quartz gangue	Quartz-porphyry	Quartz-porphyry.	

a Auriferous Gravels, p. 18.

MARICOPA COUNTY.

Maricopa county includes a portion of the plateau country, and extends across the range system far into the Archæan area. The principal mining district in this county is the Globe, about half of which, however, lies in Pinal county. The principal ores are argentite and cupriferous minerals, associated with galena and zincblende. The ordinary gangue mineral is quartz, but heavy spar also occurs. The inclosing rocks are usually granite or highly metamorphosed strata, but the walls of the Mexican mine appear to be diabase. This district is nearly on the contact between the Palæozoic and the Archæan.

MARICOPA.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposits.
		Foot.	Hanging.	
GLOBE.				
La Plata	Argentite, erubescite, and chalcopyrite; gangue quartz and barite.	Metamorphic diorite*	Metamorphic diorite*	Probably vein.
Mack Morris	Copper glance; gangue quartz and barite	Granite	Granite	Do.
Mexican	Copper-stained, (carries lead, silver, copper, and zinc, which on the lower levels take the form of sulphurets; also gold).	Diabase	Diabase	Do.
Richmond West	Argentite, malachite, and cuprite	Granite	Granite	Do.
Silver Nugget	Malachite and azurite, accompanied by some sulph-arsenide of copper, (also silver and horn-silver).	...do	Do.	
Vulture	Galena, chrysocolla, malachite, stromeyerite, (gold)	Mica-schist	Mica-schist	Probably vein.

* Microscopically examined.

MOHAVE COUNTY.

Mohave county lies in the northwestern corner of Arizona. The best known district is the Hualapai, containing Mineral Park, which lies a few miles to the west of the Palæozoic area. The country rock of the Mohave county mines is almost exclusively granitic, but a gneissoid structure is said to be apparent in many cases. The ore occurs in veins with quartz gangue, and consists of argentite, stephanite, ruby silver, freibergite, etc., accompanied by galena, zincblende, and copper pyrite and mispickel.

Near the croppings these ores are largely converted into horn-silver and native silver, which are readily worked; but at some distance from the surface most of them become very base. Many disappointments in the working of Arizona mines have been due not to the exhaustion of the ore, but to the fact that below the water-level the ores were found to be rebellious. Such ores can be worked at a profit under the prevailing economical conditions only when very rich.

MOHAVE.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
HUALAPAI.				
Cerbat	Quartz carrying black sulphurets and green stains, probably of chloride of silver.	(Granite)	(Granite)	Vein.
Champion	Galena and its products of decomposition, gangue quartz.	...do	... do	Do.
Fairfield		Granite*	Granite*	Do.
Indian Boy	Ruby silver, zincblende, galena, and chalcopyrite			Do.
Keystone	Galena, zincblende, and chalcopyrite and pyrite, quartz gangue.	(Granite)	(Granite)	Do.
Lone Star	Ruby silver and indeterminable black sulphuret stains; quartz gangue.			Do.
Pure Metal	Galena and cerussite with quartz gangue	(Granite)	(Granite)	Do.
MAYNARD.				
American Flag	Galena, stephanite, argentite, zincblende, and iron and copper pyrites, (freibergite, native silver, and mispickel), quartz gangue.	(Granite)	(Granite)	Vein.
Peabody	Galena and colorados; quartz gangue	...do	...do	Do.
Hackberry	(Silver chloride, argentiferous galena, and antimonial silver; quartz gangue.)	...do	... do	Do.

* Microscopically examined.

Hualapai district is very large, and contains a number of mineral neighborhoods. At Chloride veins occur in granite with quartz gangue. Near the surface the ore minerals are carbonate of lead and silver chloride. Below the water level these are replaced by galena and pyrite. The mines mentioned are: Schenectady, Schuylkill, Empire, Juno, Silver Hill, Pinkeye, Kanawha Belle, Oriental, and Porter. Near Stockton deposits are found which are similar to the foregoing, but they are reported as containing also native silver and ruby silver, as well as zincblende, chalcopyrite, and some stibnite. The mines mentioned are: Indian Boy, I. X. L., Tiger, Ed. Everett, Cupel, Dolly V., Pure Metal, Little Chief, Prince Geo., and Tigress. At Mineral Park native silver and silver chloride occur near the croppings of the veins which carry a quartz gangue and are inclosed in granite. The undecomposed minerals are argentite, ruby silver, stephanite, with some galena and zincblende, iron pyrite, and arsenical pyrite. The mines mentioned are: Keystone, Lone Star, Fairfield, Quick Relief, Conner, and Metallic Accident. At Cerbat the ore thus far mined carries horn-silver in a quartz gangue, with some native gold and silver, complex sulpharsenides, and antimonides and zincblende. The mines mentioned are: Cerbat, Black-and-Tan, Snowflake, Mocking Bird, Sixty-Three, Falstaff, Fontenoy, Champion, New London, Flora, and Paymaster.

The Maynard district, like the Hualapai, shows quartz veins in granite and mineral associations similar to that last mentioned. The mines reported are: The American Flag, Peabody, Dean, Antelope, and Mississippi.

The Cedar Valley district is also in a granite country. The ores are argentiferous galena, ruby silver, tetrahedrite, and, near the croppings, horn-silver, accompanied by zincblende, pyrite, and quartz. The mines mentioned are: Silver Queen, Hibernia, Hope, General Lee, Arnold, Billy Engle, Rainbow, Eugenie, Bunker Hill, Congress, and Gunsight.

Owens district is in a granite country, but a portion of the rock is gneissoid. The ores are argentiferous galena and argentite, with decomposition products near the croppings and a quartz gangue. The mines of the McCracken company and the Signal mine are the chief ones of the district.

PIMA COUNTY.

This county occupies the southern end of the territory, and crosses the mineral belt. It contains a very large number of districts, the most famous of which is Tombstone. Many of the mines in this district are in limestone, and carry chiefly argentiferous lead ores. Manganese minerals (pyrolusite and wad) sometimes accompany them in large quantities. There are also veins in the Tombstone district in quartzite. These carry cupriferous minerals more or less charged with silver and some free gold.

From mine reports and papers by Professor W. P. Blake it appears that the ore in the Tombstone district occurs in Palæozoic beds, probably of Carboniferous age, which have a prevailing inclination to the north and east, resting on a granitic base, which outcrops some distance to the southwest. These beds consist of a fine-grained quartzite, called by him novaculite, about 140 feet in thickness, underlaid by a light-colored dolomitic limestone and overlaid by a blue-black limestone passing into shaly beds. The principal portion of the ore is found at the horizon of this blue-black limestone. The sedimentary formations have been compressed into a series of sharp folds and fissured and traversed by dikes of pre-Tertiary eruptive rock, known in the district as diorite. The census collection from Tombstone contains both diorites and diabases. The general direction of the fissures and dikes lies between north and northeast. The ore occurs both in fissures which cross the strata either parallel to or in direct connection with the dikes and in bodies branching out from these approximately vertical bodies in a more horizontal direction, following in general the bedding planes of the formation, whose prevailing dip is to the northeast. The ore is most abundant and richest in that part of the black limestone beds which are contiguous to the quartzite, and the vertical fissures generally contract and become less rich where they cross the quartzite itself. Their continuation in the lower limestone beds has not yet been much explored. In the origin and manner of deposition of its ore bodies the district would seem to resemble that of Chañarcillo in Chili.

There are also veins in the granite, or associated with it, near Tombstone, which are similar to the other deposits of the territory found in this rock. The group of districts, including the Oro Blanco, Arivaca, Harshaw, etc., just north of the Mexican line, seem to possess much the same character as Tombstone. The country rock is granite, limestone, quartzite, or earlier eruptive rocks, and the ores are galena and its products of decomposition, ordinarily accompanied by copper minerals and charged with silver. They are sometimes auriferous. In the western part of the county there are gold and copper mines, with some lead ores. These are sunk on veins in granite, which carry, besides quartz, fluorite and heavy spar as gangue minerals.

PIMA.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls. Foot.	Walls. Hanging.	Character of deposit.
ARIVACA.				
Consolidated Arizona	Copper stains and black sulphurets in small quantities, with quartz and barite, (also chlorides and carbonates).	Quartz-porphyry	Quartz-porphyry	Vein.
DOS CABEZAS.				
Juniper	The ore shows blue stains, which are possibly horn-silver, (free gold and horn-silver), gangue quartz and limonite.	Shale	Shale	Vein.
Murphy	(Free gold and horn-silver), gangue quartz and limonite.	(Sedimentary)	(Slate)	Do.
HARSHAW.				
Hermosa	Kaolin and manganese oxides, (carbonates)	Quartzite	Quartzite.	
Holland	Cerussite and cupriferous minerals, (zincblende, galena, and antimonial minerals, gangue quartz, and limestone).	Limestone	Limestone	Pockets.
W. C. Davis	Cerussite, (galena, gangue quartz)	Granite *	...do	Do.
HARTFORD.				
Wisconsin	Malachite, (horn-silver), gangue hematite	Limestone	Do.	
MEYERS.				
Atlanta	Galena, cerussite, copper stains, gangue quartz, fluorite, and heavy spar.	(Granite)	(Granite)	Vein.
Westward	Galena, gangue quartz	...do	...do	Do.
Gunsight	Galena, horn-silver, copper stains, gangue quartz, barite, and hematite.	Granite	Granite	Do.
MULE PASS.				
Copper Queen	Malachite, gangue quartz, and calcite	Slate and limestone	Slate and limestone	Vein
ORO BLANCO.				
Alaska	Malachite, (carbonates with copper and lead)	Quartz-porphyry	Quartz-porphyry	Vein.
Longarina	Galena, cerussite, malachite; possibly stephanite and horn-silver, quartz gangue.	Quartz conglomerate	Quartz conglomerate	Do.
Montana	Cerussite, gangue quartz, and limonite	Conglomerate	Utterly decomposed	Do.*
North Pacific	(Gold), gangue red quartz	Granite*	Granite*	"Flat."
Warsaw	Galena, freibergite, and chalcopyrite, (carbonate near surface), gangue quartz (calc-spar).	Diorite*	Diorite*	Vein.
PIMA.				
Esperanza	Galena, pyrite, and chalcopyrite, gangue kaolinite	Probably diabase*	Probably diabase*	Vein.
San Xavier	Galena and chalcopyrite, gangue quartz	Limestone	Limestone	Connected pockets.
SWISSHELM.				
Mammoth and Whale	Cerussite, gangue quartz, limonite	Limestone	Limestone	Connected pockets.
Queen	Galena and cerussite, (gangue calcareous)	...do	...do	Do.
TOMBSTONE				
Bradshaw	Galena, cerussite, malachite, chrysocolla, and probably mimetite, (horn-silver), gangue clay, (quartz).	Indeterminable	Indeterminable	Connected pockets.
Contention	Cerussite, (horn-silver, gangue calcite)	Probably quartz-porphyry		Do.
Emerald	Malachite, (horn-silver), gangue, quartz, and calcite.	Black limestone	Black limestone	Do.
Empire	(Horn-silver), gangue quartz and limonite	Metamorphic*	Limestone	Do.
Grand Central	Minute specks of black sulphurets, (horn-silver and cerussite), gangue quartz and limonite.	Sandstone	(Sandstone)	Do.
Grand Dipper	Horn-silver, malachite, and chrysocolla, (gangue quartz and calcite).	Solfatarically - decomposed eruptive rock.		Vein.
Head Center	(Gold and horn-silver), gangue quartz and limonite	Quartzite*	Quartzite*	Do.
Mamie	Anglesite and cerussite, (horn-silver and copper stains)	...do	...do	Do.
Monitor	Cerussite and horn-silver, (free gold), gangue calcite, limonite, (manganese minerals).	...do	...do	Do.
Rattlesnake	Cerussite, (horn-silver), gangue iron oxide, (quartz and calcite).	Black limestone	Black limestone	Probably vein.
Red Top	Cerussite and horn-silver, (free gold), gangue limonite, and calcite, (quartz).	Quartzite	Quartzite	Vein.
Stonewall	(Chlorides and carbonates), gangue, pyrolusite	Limestone	Limestone	Pockets.
Sulphuret	Cerussite, (chloride and carbonate, gangue calcite)	Diabase	Diabase	Vein.
Sunset	(Chloride and carbonate), gangue, wad, (iron oxide)	Limestone	Limestone	Do.
Tioga	(Free gold and trace of silver), gangue, ferruginous quartz.	Granite	Quartzite	Do.
Toughnut Extension	(Chlorides and carbonates), gangue, ferruginous quartz.	(Porphyry for 100 feet), limestone in part siliceous.	(Porphyry for 100 feet), limestone in part siliceous.	Do.
Toughnut and Goodenough	Cerussite, (horn-silver and copper carbonate), gangue, limonite, and fluorite, (quartz and limestone).	Limestone, decomposed diorite, (and quartzite).	Limestone, decomposed diorite, (and quartzite).	Pockets.
True Blue	(Horn-silver), gangue, limonite, and pyrolusite	Diabase*	Diabase*	Vein.
TURQUOISE.				
Defiance	Galena and cerussite, (very little silver), gangue, quartz and limonite.	Limestone	Limestone	Vein.
Ajo	Chalcopyrite, bornite, and malachite, gangue fragments of rock.	Quartzite	Quartzite	Probably vein.

* Microscopically examined.

PINAL COUNTY.

Most of the mines of this county are found in the northeastern portion, near the edge of the Palæozoic. The ores are argentite and the sulphantimonide minerals, often associated with lead ores, commonly also with those of copper, and sometimes accompanied by zincblende. The gangue minerals are quartz, calcite, occasionally manganese compounds, and sometimes (in granite) heavy spar. Limestone, slate, sandstone, and quartzite, as well as granite, diabase, and diorite occur as wall rocks. Cupriferous minerals are less apt to be associated with limestones than with other metamorphic rocks or granite and diabase. The famous Silver King mine is in the Pioneer district in this county, and its great yield is a sufficient refutation of the statement sometimes made that large deposits of good ores do not occur in granite, for the country rock of this mine is a typical granite, though locally called syenite. A very great number of ore minerals occur in the Silver King, the specimens showing native silver, stephanite, freibergite, chalcopyrite, erubescite, stromeyerite, copper carbonates, galena, and zincblende. The gangue is quartz accompanied by barite. Half of the Globe district occurs in Pinal county. Its characteristics have already been mentioned under Maricopa.

PINAL.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
GLOBE.				
Golden Eagle	Galena, limonite, and malachite; quartz and pyrite gangue.	Syenite*	Syenite*	Vein.
Irene	(Carbonates, some lead, and a little arsenic), gangue, psilomelane, quartz, limonite, and chlorite.	Quartz-porphyry*	Sandstone	Do.
R. C. McCormick	Copper stains and specks which are probably stromeyerite, (chloride); gangue quartz, probably manganese.	Quartzite	Slate and limestone	Do.
Silver Era	(Sulphides and chlorides), gangue psilomelane and quartz.	Quartzite and slate	Quartzite and slate	Do.
Stonewall Jackson	Stromeyerite, gangue kaolinized rock	Diabase	Granite	Do.
PIONEER.				
Silver King	Native silver, freibergite, stephanite, zincblende, chalcopyrite, erubescite, malachite, azurite, galena, and stromeyerite, gangue quartz and barite.	Granite*	Granite*	Vein.
Surpriser	(Gold and carbonates), gangue quartz, probably manganese minerals.	Quartzite	Limestone and slate	Do.
El Capitan	Galena, polybasite, miargyrite, pyrargyrite, and chalcopyrite, (stephanite, argentite, and zincblende); gangue calcite and (quartz).	Diorite and slate	Diorite and slate	Do.

*Microscopically examined.

YAVAPAI COUNTY.

The mining districts of this county are chiefly in its southwestern portion, near the edge of the Palæozoic area. There are some gold quartz veins in granite and granite-porphyry in this county, and silver veins occur under similar conditions. It seems not improbable that the relations of these two classes of veins are the same as in Idaho, but this cannot be asserted without further information than is now available. Most of the deposits, however, are veins in metamorphic rock carrying lead and copper minerals as well as silver. Heavy spar occurs as a gangue in the Silver Belt mine, gneiss or granite forming the hanging wall.

YAVAPAI.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
BIG BUG.				
Silver Belt	Galena and cerussite, (oxides and chlorides), gangue barite and calcite.	Metamorphic	Metamorphic	Vein.
CHERRY CREEK.				
Mammoth	Gold quartz, gangue quartz, and iron	Granite	Granite	Vein.
HUMBUG.				
Tip Top	Pyrargyrite, zincblende, and pyrite, (chlorides on the upper levels), gangue quartz.	Granite	Gneiss	Vein.
PECK.				
Peck	(Carbonates and chlorides, galena and antimony, gangue quartz, iron oxide, and calcite.)	Slate	Quartzite	Vein.
Silver Prince	Galena, cerussite, and copper stains, (chlorides), gangue (country rock).	...do	... do	Chimneys.
TIGER.				
Tiger	Galena, zincblende, and pyrite; gangue quartz	Granite	Granite	Vein.

YUMA COUNTY.

Most of the mines of this county are near the Colorado river. They are sunk on quartz veins in highly metamorphic rocks or granite. The William Penn and other mines in the Castle Dome district are associated with a greenstone, which proves under the microscope to be diorite. The ores of Yuma county are chiefly silver ores, accompanied by lead minerals. Fluorspar and heavy spar are found in many of the veins which are inclosed in granite.

YUMA.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
CASTLE DOME.				
Flora Temple	(Argentiferous galena and anglesite), gangue, (fluorspar, calc-spar, quartz, and gypsum).	Gneiss, slate, and diorite*	Gneiss, slate, and diorite*	Vein.
Galena Chief	(Ore same as above), gangue, fluorspar, and calcite			
Norma	Galena, cerussite, and anglesite, gangue fluorspar and calcite.			
Pocahontas	Same as Norma			
William Penn	do			
SILVER.				
Princess	Galena and cerussite, (argentite and horn-silver), gangue, calcite, (quartz, fluorspar, and barite).	Granite and micaceous slate, capped with conglomerate.	Same as foot wall	Vein.
Red Cloud	Cerussite, anglesite, and horn-silver, gangue, manganese minerals, iron oxide, quartz, fluorite, barite.	Granite	Hornblende-andesite.*	
Rover	Gangue, calcite.			

* Microscopically examined.

IDAHO TERRITORY.

GENERAL CHARACTER OF THE TERRITORY.—Idaho lies in the northeastern corner of the Great Basin, directly southwest of the Bitter Root mountains. The southern portion of the territory resembles the regions farther south, its southwestern portion forming a continuation of the Nevada sage-brush deserts and the southeastern corner being the northern end of the sandy and alkaline deserts of western Utah. The upper branches of the Snake river, the sources of which are in the Yellowstone park and the Téton range, just east of the Idaho line, unite about 50 miles west of that boundary. For a short distance from the junction the course of the river is nearly south, but it bends gradually westward and northward, reaching the Oregon line on a northwest course. The area south of the Snake river is about one-fourth of the entire territory. The valley of the Snake is a plain from 50 to 100 miles in width, which is occupied by a vast sheet of recent basalt from the Wyoming line to Owyhee county. Immediately to the north of this plain, which has an elevation of a little over 4,000 feet, the character of the country changes abruptly, and most of the rest of the territory is extremely mountainous, many of the summits rising to between 10,000 and 12,000 feet above sea-level. The climate changes with the topography. Central and northern Idaho are east of Oregon and Washington territory, to the coasts of which the trade-winds of the Pacific bring an enormous amount of rain. The coast is, indeed, separated from the northern portion of the Great Basin by the Cascade range, but this is much lower and much less continuous than the Sierra Nevada to the south. The westerly winds thus bring a greater amount of moisture to northern Idaho than to Nevada, while the lofty peaks of the northern area promote its precipitation. To the north of the Snake River region Idaho is consequently well watered and well wooded, conditions of the utmost importance to profitable mining. On the other hand, the winters are long and severe, and lines of communication are extremely circuitous.

Except in the eastern counties, no portion of Idaho has been submitted to systematic geographical or geological survey, and the maps of the territory are very inaccurate. The geological information furnished by the census examination is necessarily fragmentary, presenting only data from a large number of mining localities, and but little assistance can be derived from any local publications with which I am acquainted. The following paragraphs, therefore, contain only a very rude outline of the geological conditions of the mining regions of Idaho.

A very large granite area occupies a portion of southwestern Idaho. It appears to be oval in shape, its longer diameter extending from a few miles south of Yankee fork nearly to the South Mountain district, while its shorter diameter reaches from the common boundary of Washington and Boisé counties in a southeastern direction to the Wood River country. Its total area is probably about 12,000 square miles. Not all of the country within this oval area shows granite on the surface, for Ada county is largely alluvium, and Palæozoic limestones are reported as occupying much of the more northern portions; but the extremely frequent occurrence of granite, for the most part of a single type, appears to justify the supposition that the body is continuous under the later formations.

The granite from the Idlewild mine, Carson district (Silver City), Owyhee county, is a soft gray rock with rather well developed crystals of white mica, cleavage flakes of which give the biaxial interference figure of muscovite. Slides show under the microscope that the constituents are orthoclase, oligoclase, quartz, and mica, with a little apatite and magnetite. The quartz is extremely full of fluid inclusions, many of them containing moving bubbles. The structure is the ordinary one of granite; indeed, the rock is quite typical. In the same district occur excellent quartz-porphyries, slides of which show dihexahedral quartz crystals, with the characteristic association of glass and fluid inclusions. The association of these two rocks suggests a similar origin, or, in other words, that the granite may be eruptive, but of course proves nothing. On the other hand, there is no known evidence tending to show a derivation of the granite from sedimentary rocks. The granite from the Sub Rosa mine, in the Boisé basin, is in most respects similar to that from Carson district, though about 80 miles distant from it, but contains biotite in addition to the muscovite. In several localities in the territory the granite is extremely coarse-grained, and has even furnished marketable mica sheets.

The granite has been profoundly disturbed by eruptive action, and probably at a comparatively recent date. The evidence of this is manifold. Dikes of eruptive rock, among which the principal one appears to be basalt, (*a*) are common in the granite, and as basalt appears everywhere to be the youngest of the lavas this would indicate comparatively recent action. Hot springs, too, are thickly distributed through the granite area, in many cases issuing directly from the granite, though usually within a mile or two of known occurrences of volcanic rocks. This is most naturally accounted for by supposing that there are still remnants of volcanic heat at great depths below the surface. A further and most interesting point bearing upon the structural geology of the region and the age of the disturbances is the fact that the very numerous veins found in the granite usually strike in the direction of the ranges on the flanks of which they occur. The fissures which these veins occupy must have been formed by an upheaval such as would produce these ranges, and it seems necessarily to follow that the mountains are substantially a result of upheaval, and not of erosion. This upheaval, too, must be comparatively recent in a geological sense, say as late as the Tertiary, since otherwise the results of upheaval would have been obscured by subsequent erosion. The occurrence of the immense lava fields of the Snake River valley immediately adjoining the granite area suggests that the dynamical disturbances and the thermal action manifested in the granite may be a portion of the same series of phenomena to which the Snake river eruptions are due. The age of the veins themselves is quite another matter. The facts mentioned indicate a possibility that the ores have been deposited after the upheaval which determined the present topographical character of the country; it may be through the agency of the solfataric action (*b*) accompanying the basalt eruption. Indeed, the numerous hot springs of the granite area are in many cases highly charged with alkalies and sulphhydric acid; in short, they are solfataras. They often occur in the immediate neighborhood of the mines, one of the mining districts in the Wood River country even bearing the name of the Hot Springs district. In a mineral region solfataras, active or extinct, are usually associated with ore deposits, which are commonly ascribed to their action, and it is difficult to see how the period of solfataric activity now drawing to a close can have failed to give rise to metalliferous concentrations in Idaho.

On the other hand, the structure of the country is not incompatible with the supposition that the veins are far older than the basalt and a concomitant of a former disturbance of the granite. Fissures in the earth's crust, once formed, seem never to heal, and faults have occurred at the present day on surfaces upon which movements are known to have taken place in the Palæozoic era. The recent upheavals may merely have followed old lines of movement which had been marked by veins long before the present mountains rose. An indication tending to such a view is the fact that some veins are faulted, though this is not the rule, while slickensides, showing relative motion of the walls of the veins subsequent to the deposition of ore, are very abundant. While known movements of a more recent date than the ore deposits are thus shown, the extent of these movements usually appears to be small. Much the strongest evidence of older veins is furnished by the placers of Boisé basin and the cañon of Moore's creek, a little below and south of the basin. There is, of course, every reason to suppose that auriferous gravels are accumulations from the croppings of veins. They do not represent the whole material eroded from a country, but only the heavier portion which the streams have been unable to carry to great distances. The gravels of Boisé basin are estimated to cover 30 square miles to an average depth of about 12 feet. This large mass represents not merely a very extensive erosion of the upper country, but streams of a size inconsistent with the present rainfall of the territory. It does not follow, however, that the general character of the topography of the country must have been altered by this erosion to such an extent as to obscure the relation of the strike of the veins to the trend of the ranges. Not only were these gravels deposited when the climate was much moister, but they date from a time prior to some of the basalt eruptions, for in Moore's creek, the outlet of the Boisé basin, the gravel, which is continuous with the main deposit, is covered by a basalt cap which can scarcely be younger than the Snake River bed.

In the light of the present knowledge of the country, it seems on the whole most probable that the greater part of the quartz veins of this region are of Cretaceous or possibly Tertiary age, but it is by no means unlikely that a part of them are subsequent to the basalt, and thus are of very recent date. Should this be established by future investigations, it would afford a remarkable instance of the repetition of certain chemical and physical conditions at considerable intervals in geological history.

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a As the eruptive rocks are not immediately associated with the ore deposits in any of the mines visited, specimens of this basalt were not collected.

b See note to page 6.

A very large portion of the mines in Idaho are within the granite district, and are sunk upon veins between granite walls. These veins are very similar to those in the other granitic mining districts of the Great Basin. They are numerous and rich, but narrow, being seldom above 3 feet in thickness, though there are a few wide veins, as, for example, the Atlanta, Middle Boisé district, Alturas county, which is from 50 to 75 feet across. The gangue of the veins in the granite area is quartz, accompanied by more or less decomposed granite as horse matter. The ores carry both gold and silver in very varying proportions. The gold is either free or is mechanically entangled in pyrite, mispickel, or zincblende, while the silver appears near the surface as chloride, and at lower levels as sulphide, stephanite, tetrahedrite, or as ruby silver. Zincblende appears occasionally, and galena still more rarely. In some veins gold greatly predominates, in others silver; yet the association of minerals is the same in both classes, the relative quantities only of the two precious metals varying. There is nothing to show that the two classes of veins are of different origin or age; on the contrary, every gradation between the two extremes occurs, and sometimes both are represented in the same vein. On the Atlanta lode the Buffalo and Monarch mines produce about twice as much silver as gold, while in the Yuba tunnel, more than a mile distant from the others, but on the same lode, the value of the ore is almost wholly in gold.

From a geological point of view there is little to note concerning the variations of the ore deposits of the granitic area without going into more detail than this chapter is designed to record. On the contrary, the most striking point connected with this area is the great similarity from one end to the other of the inclosing rock and the included deposits. As soon as the water-line is passed suites of specimens from the various mines are almost indistinguishable, except in point of richness. In prospecting for these veins it would be well to observe not only the float, the character of the croppings, and the like, but also evidences of disturbance, and particularly decomposition of the country rock, for both of these phenomena are likely, though not certain, to accompany the presence of ore.

The uniformity in character of the veins throughout the granite area of Idaho, in spite of a possible difference in age and their dissimilarity to those characteristic of other formations, is highly suggestive of the nature of their origin. It is almost certain that the ores of veins are precipitated from solutions, and that these solutions acquire their valuable contents either at great depths and from unknown sources, or from the rock masses adjoining the place of deposition. The latter supposition, which is known as the lateral secretion theory, has been gaining ground of late years, and it has been proved in many cases to satisfy all the known facts. Of granite in particular Professor F. Sandberger has shown that the mica frequently carries various heavy metals, and he has pointed out an exceedingly probable series of reactions by which these metals may have been concentrated in veins. In the granite of Carson district, Owyhee county, Mr. A. Simundi has detected gold (usually amounting to at least 25 cents per ton), besides silver, even at long distances from any known deposit of ore. In view of Sandberger's investigations, it is improbable that this content is due to impregnation from veins.

If it be supposed that the Idaho veins are due to metalliferous solutions rising from great depths, it would be necessary to assume that the granite has had a chemical influence on the precipitation; for if this were due merely to reduction of temperature and pressure, the differences between the deposits in granite and those in the other rocks of the territory would be inexplicable. But the Idaho granite appears to be Archæan, and the lower surface of the Archæan has never been reached in any part of the world. Whatever may underlie it, it is certainly enormously deep. It would therefore be also necessary to assume that the granite exerted little or no precipitating influence at great depths and pressures, but only within a certain, no doubt large, distance from the surface; for were the precipitating action vigorous toward the lower portion of the granite the solutions would, for the most part, be robbed of their metallic contents at a depth of miles. If this were the case, ore veins, if reached at all, would grow richer and stronger as lower levels were attained. If any rule can be established in regard to the relations between richness and depth, it is rather that veins grow less rich and strong, though strong veins, probably as a rule, continue metalliferous to a greater depth than mining can ever be carried; but the cases in which veins grow better in proportion to the depth reached are certainly very exceptional.

On the other hand, so far as the facts concerning the veins in granite in Idaho are known, the supposition that they are the result of a leaching of the granite itself, probably by heated waters, appears simple, satisfactory, and sufficient. It would account for the difference between the veins in granite and those in other rocks by the difference in the rocks themselves, and place the source of the ores in the neighborhood of their present position. Whether any actual particle of ore originally formed a constituent of the granite on the same level or a few hundred feet below, or even above, no one would of course venture to assert. The hypothesis is merely that the rock in the neighborhood of the veins has furnished their contents.

Interesting and in part extremely important ore deposits have been discovered in the sedimentary rocks adjoining the granite area, and, indeed, on all sides of it. It has been asserted that a portion of these deposits form a continuous mineral belt. So broad a statement can hardly be indorsed, but there is sufficient evidence to warrant the assertion that the zone of country immediately surrounding the granite is well worth prospecting with unusual care, and that valuable smelting ores are not unlikely to be met with at almost any part of this zone at or near the granite contact.

The most southerly of this class of deposits are those of the South Mountain and Flint districts, in Owyhee county, near the Oregon line. The country rock is chiefly limestone, and the ore argentiferous galena. No work was done in these districts during the census year or for some time before, not, it is stated, on account of lack of ore, but in consequence of financial embarrassments arising from the failure of the Bank of California in San Francisco in 1875. To the northwest of the granite lies the Heath district, in which rich galena, high-grade copper ores, iron, and lignite are reported. No description of the country rock has been published, and as the district was idle during the census year the census examination did not include a visit to it; but the association of minerals leaves little doubt that the area is sedimentary. In the Yankee Fork district, north of the granite, the country appears to consist of gneiss (*a*) and eruptive rocks, while the ores show gold and silver, but seem to carry more copper than in the granite district. The important Custer mine is in this locality. In the Bay Horse district slates are accompanied both by milling and smelting ores, lead and copper being often prominent constituents. Both this and the preceding district were visited by Mr. Williams in the depth of winter, when work on almost all the mines was stopped, and it was impossible to obtain entirely satisfactory suites of specimens.

The Wood River country lies southeast of the granite area. Limestone, slate, and granite are the prevailing rocks, and argentiferous galena (or its products of decomposition), often extremely rich, is the chief ore. As is so usually the case with galena, the ore bodies are irregularly distributed in limestone, but the true meaning of this association has never been fully explained. Mr. Emmons, in discussing the Leadville deposits, regards the galena as precipitated by substitution for the limestone, but no one as yet has indicated the probable chemical reactions involved. Milling ores also occur in the Wood River country in the granite and slate. This region was opened up during the census year, but has since acquired great importance. The geographical distribution seems to indicate that a relation exists between these lead-bearing districts and the granitic area about which they lie. It is altogether probable that the ore was deposited throughout the whole region at the same time or times, and that the differences in the character of the ore are attributable to the different chemical and physical characters of the rocks. Were the galena deposits all on one side of the granite it might well be maintained that they were wholly independent of the gold-quartz veins in the granite, but any hypothesis which will account for them independently in their actual distribution appears extremely artificial.

Besides the deposits which have been mentioned, there are also veins carrying precious metals in Warren's camp, in the northern part of Idaho county. The ores from this camp are quartzose, carrying free gold and ores of silver. The association much resembles that met in the mines of the great granite area, and the country rock is also reported by Mr. Wolters as granite. Gold mines also occur at Iowa bar, in the extreme eastern portion of the territory. Limestone and "porphyry" are said to be the accompanying rocks. Lignite has been found in various portions of Idaho, for example, in the valley of Boisé river and on Reynold's creek, in Owyhee and Oneida counties, etc., but no commercially valuable deposits have as yet been discovered. Sulphur occurs in connection with hot springs in Bear Lake county, and deposits of alkalies exist in the same portion of the territory. Considerable quantities of float cinnabar have been found in Stanley basin, at the eastern extremity of Boisé county, and along the Salmon river between the mouth of Yankee fork and the town of Sawtooth, but not in place. Cinnabar is usually associated with Cretaceous rocks on the Pacific coast, and this fact might be of use in the search for the ore if the horizons of the neighborhood had been identified. Tinstone has been found as wash in the bed of the Jordan river, Owyhee county. This is one of the few points at which tinstone has been encountered in the far west, Temescal, San Bernardino county, California, and Deer Lodge county, Montana, being the principal other localities.

The auriferous gravels of Idaho are of great volume and extent. Though of much less importance than those of California, they have been more productive than those of any other state or territory except Montana, and have probably yielded something like thirty million dollars' worth of gold.

Three distinct classes of auriferous gravels may be recognized in Idaho. The bars of the Snake river are auriferous, but the gold is in an extreme state of division, and can be recovered at a profit only in exceptional cases. Many rich but small placers occur along the banks of the Salmon and of the other rivers of Idaho, and were either deposited by the present streams during freshets, or left by a comparatively slight shifting of the channels. Small placers have usually been found near the croppings of gold veins, which have undoubtedly furnished the auriferous gravel, and a large part of the veins, as in California, have been discovered by tracing these gravels to their sources. Most of the richest of the small placers have probably been worked out; at least few new ones of remarkable value have been discovered for many years; but enough is left to furnish occupation to a considerable population. The deep gravels of Boisé basin are of a different character. The basin is surrounded except at one point by mountains, and receives no drainage from beyond its own limits; yet it is estimated to contain some 125,000,000 cubic yards of auriferous gravel, and some of it has a depth, it is asserted, of no less than 250 feet. While there is evidence of a channel in a northeastern and southwestern direction, the gravels spread over nearly the whole basin, and occur even on the tops of considerable hills. The gravels extend several miles down Moore's creek, the outlet of the basin, and are here, in part, covered by a heavy basalt cap. The pay-dirt is

a A slide of the country rock of the Charles Dickens mine shows a structure usual in highly metamorphic rocks, corresponding to its microscopical appearance, but the constituents are so thoroughly decomposed that little more can be said of it.

commonly near the bed-rock of these beds, as is usual elsewhere. Large bowlders are frequent, as are also fossil-tree stems, which are so characteristic of the auriferous gravels of California. The Boisé basin deposits are not worked out, though their yield has decreased during the last few years, owing, it is said, rather to high wages and lack of water than to dearth of good gravel. In the earlier days of mining in Boisé basin many extremely rich bars were found, which were undoubtedly concentrations from the older gravels by modern streams. Few, if any, of these rich spots can have escaped the eager search which has been made for them. It would be impossible to account for the presence of the gravels of the Boisé basin at the head of a system of drainage without a special examination undertaken for the purpose, but it may be considered certain that a great river once flowed through the basin and transported the gravel. Some secular or paroxysmal action, not improbably a concomitant of the basalt eruption, must have modified the topography in such a way as to deflect this river, but the character of the change in the drainage is unknown. The Boisé basin gravels were probably contemporaneous with those of California; for the present rainfall, as has already been pointed out, is insufficient to account for them, and it is not probable that greatly increased precipitation can have prevailed in either of two districts so similarly situated as California and Idaho without its being shared by the other. The fossil plants also seem to be the same or extremely similar, as are also the relations to the basalt.

The following sections of gravels are selected out of a considerable number to illustrate their occurrence. The third of these is noteworthy as an exception to the ordinary rule that the pay-dirt lies near the bed-rock.

CREPISCULLA HYDRAULIC MINE.

MOORE'S CREEK DISTRICT, BOISÉ COUNTY, IDAHO (SECTION IN NORTH WORKINGS).

I	Brown soil	2–3 feet.	Maximum, 70 feet	None absolutely barren, but the bulk of the gold is thought to come from the lowest quarter of the bank.
II	Uniform low-grade gravel of medium size	47 feet.		
III	Bowlder stratum (quartz and granite)	10–20 feet.		
IV	Bed-rock granite; hard when first uncovered, slacking rapidly on exposure.			

The bank shows a fine section across the river bed 550 feet wide, which is now left at the summit of a low hill. This part of the claim is from 350 to 450 feet higher than the south workings.

R. W. SPENCER'S HYDRAULIC MINE.

BOSTON, BOISÉ COUNTY, IDAHO.

I	Loam, with some small quartz bowlders	3 feet.	Maximum, 10 feet; average, 3½ feet.	Grass-root gold. Color throughout deposit. Best pay on bed-rock.
II	Quartz, gravel, and clay, with small bowlders not over 9 inches in diameter, chiefly granite.	3 feet.		
III	Bed-rock; soft, decomposed granite.			

NOBLE, LOWER & MANN HYDRAULIC MINE.

MOORE'S CREEK DISTRICT, BOISÉ COUNTY, IDAHO.

I	Soil	2 feet.	Maximum, 30 feet; average where working, 15 feet.	Upper 3 feet from surface is the paying portion.
II	Quartz, gravel, and clay	2–6 feet.		
III	Rotten bowlders of quartz and granite, 9 inches to 4 feet in diameter	10–15 feet.		
IV	Bed-rock granite; very rough, hard when first uncovered, but slacking rapidly on exposure.			

River bed 300 feet wide and 2,000 feet long on claim. The bowlder stratum, III, is too poor to pay for working by itself, but all has to be piped off to obtain grade for race—one-fifth good pay and lower four-fifths low grade.

SUMMARY BY COUNTIES.

ADA COUNTY.—There is very little mining in Ada county, the principal industry being agriculture. The occurrence of galena not far from the granite area of the adjoining counties, however, is an interesting fact, though no work was done in the Heath district, where it occurs, in the census year.

ALTURAS COUNTY.—The western portion of Alturas county, together with Boisé county, forms a great granite district, chiefly drained by the Boisé river and its tributaries. The veins in this granite carry a quartz gangue, with gold and silver ores. In some the one metal predominates, in some the other, but as a rule both are present. The ores are free gold and auriferous pyrite, native silver, both ruby silver minerals, stephanite, freibergite, horn-silver, and galena. The gangue minerals are quartz, pyrite, chalcopyrite, mispickel, zincblende, and a little calcite. Molybdenite is also reported. Nearly all the veins dip at an angle of over 45°, and the majority strike northeast and southwest, following the trend of the mountain ranges.

To the southeast of the granite, in the Wood River country, there are deposits in limestone of galena and its decomposition products, accompanied by copper and iron minerals. Milling ores are said to have been found in the slates of this region since the expiration of the census year. There are also small placer deposits on the Salmon river and its tributaries in this county.

ALTURAS.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
BONAPARTE.				
Bonaparte Consolidated	(Gold, galena, antimony, argentiferous sulpharsenide and sulphantimonide minerals, zincblende, pyrite), quartz, and calcite.	Granite	Granite	Vein.
HARDSCRABBLE.				
Crown Point Bonanza	(Gold), quartz	(Granite)	(Granite)	Vein.
Emma	do	do	do	Do.
General Grant	Gold quartz and limonite	do	do	Do.
New Ophir	Gold quartz, pyrite, mispickel, galena, and (zincblende).	do	do	Do.
MIDDLE BOISÉ.				
Jessie Benton	Ruby silver, quartz, pyrite, chalcopyrite, (arsenical and antimonial silver ore, with auriferous pyrites).	(Granite)	(Granite)	Vein.
Buffalo	(Dark and light ruby silver, native silver, auriferous pyrites, and quartz.)	do	do	Do.
Buffalo and Atlanta	(Auriferous pyrites, argentiferous sulpharsenides and sulphantimonides, quartz, and molybdenite.)	do	do	Do.
Last Chance	Gold, auriferous pyrites, ruby silver, and quartz	do	do	Do.
Monarch	Dark ruby, horn-silver, native silver, quartz, pyrite, and probably mispickel, (light ruby, auriferous pyrites, free gold, and traces of copper).	Granite	Granite	Do.
Tahoma	Argentite, an argentiferous sulpharsenide, quartz, (ruby silver, native silver, and a little free gold).	do	do	Do.
Yuba Tunnel	(Gold), quartz, feldspar, pyrite, and mispickel.			
MINERAL HILL.				
Idahoan	Rich argentiferous galena	(Limestone)	(Limestone).	
Jay Gould	Galena and cerussite	do	Do.	
QUEEN'S RIVER.				
Joe Daly	Free gold, quartz, mispickel, and limonite	Granite	Granite	Vein.
Mammoth	Quartz and galena, (native silver, free gold, light and dark ruby silver, and auriferous pyrites).	(Granite)	(Granite)	Do.
Silver Glance	Quartz and galena, (stephanite, native silver, light ruby silver, pyrite, and a little gold).	do	do	Do.
Washington	Quartz and galena, (free gold and base sulphides)	do	do	Do.
RED WARRIOR.				
Donnybrook Fair	Quartz colorado, (gold, pyrite, antimonial ores. No silver).	(Granite)	(Granite)	Vein.
New York	do	do	do	Do.
Wide West	do	do	do	Do.
Wildcat	Quartz and mispickel, (gold and silver in rebellious compounds).	do	do	Do.
Victor	Quartz colorado, (gold)	do	do	Do.
ROCKY BAR.				
Alturas Gold Hill	Gold, quartz, pyrite, and mispickel	Granite	Granite	Vein.
Idaho-Vishnu	Gold, galena, quartz, pyrite, and mispickel	do	do	Do.
SAWTOOTH.				
Columbia	Quartz, probably horn-silver and freibergite, (ruby silver).	(Granite)	(Granite)	Vein.
Pilgrim	Quartz and freibergite (ruby silver.)	do	do	Do.
Lucky Boy	Quartz and horn-silver	do	do	Do.

BOISÉ COUNTY.—This county is, for the most part, in the granite area mentioned under Alturas county. The veins carry chiefly gold, except in the Banner district, where the silver is in excess. The placer deposits of this county have hitherto been the most important in the country outside of California. Their character and occurrence have already been sufficiently described.

BOISÉ.

[NOTE—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
BANNER.				
Crown Point	A sulpharsenide of lead, probably dufreynoysite, quartz and pyrite, (ruby silver, horn-silver, mispickel, sulphur, and copper compounds).	Granite diabase	Granite dike	Vein.
Panamint	Quartz, (ruby silver)	Granite	Granite	Do.
CAÑON CREEK.				
Centennial	Gold, quartz colorado	Granite	Granite	Vein.
Ebenezer	Gold quartz, iron and copper pyrites, and mispickel.	Granite	Granite	Do.
GAMBRINUS.				
Sub Rosa	Gold quartz	Granite *	Granite *	Vein.
GRANITE.				
Gold Hill	Quartz and pyrite, (gold)	Granite	Granite	Vein.
MOORE'S CREEK.				
Crepisculla Hydraulic	(Gold gravel)	Granite		Placer.
Thorn Creek Hydraulic	do	do		Do.
SHAW'S MOUNTAIN.				
North Star	Gold quartz	Granite	Granite	Vein.
Paymaster	(Gold) quartz	(Granite)	(Granite)	Do.
Rising Sun	Gold quartz, galena, copper, pyrite, and probably mispickel, (free sulphur).	Granite	Granite	Do.

* Microscopically examined.

IDAHO COUNTY.—This county appears to contain an isolated granite area in the neighborhood of Warren's camp and Florence. The quartz veins are much the same in character as those in Boisé county, and are accompanied by small deposits of auriferous gravels.

IDAHO.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
WARREN'S CAMP.				
Various mines	Gold, native silver, horn-silver, sulphurets, and quartz.	(Slate and limestone)	(Slate and limestone)	Vein.

LEMHI COUNTY.—The important mining districts of Yankee Fork, Mount Estes, and Bay Horse lie in the southern portion of this county. In the Yankee Fork district the principal rocks appear to be gneiss and an eruptive which is possibly rhyolite. (The workings were superficial, and the specimens were too much decomposed for determination.) Free gold and silver minerals are accompanied by quartz, pyrite, and copper ores. In the Bay Horse district the country rock is slate, and the ore consists of argentiferous galena, with copper minerals and traces of gold in a quartz gangue.

LEMHI.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	WALLS.		Character of deposit.
		Foot.	Hanging.	
BAY HORSE.				
Ramshorn	(Argentiferous galena, gray copper, a little chloride and bromide of silver, copper carbonates, traces of gold, hematite and quartz.)	(Slate)	(Slate)	Vein.
YANKEE FORK.				
Charles Dickens	Iron and copper pyrites and melaconite, (gold)	Metamorphic*	Metamorphic*	Vein.
General Custer	Quartz, pyrite, and probably stephanite, (argentite).	Indeterminably decomposed yellow porphyry (locally called rhyolite).	Same as foot wall	Do.
Unknown	Same as General Custer.	do	do	Do.

* Microscopically examined.

OWYHEE COUNTY.—The mining districts of Owyhee county lie about Silver City and Wagontown, on the Jordan river. This region is separated from the granite region of Alturas and Boisé counties by the Quaternary plains of Ada county, but it is extremely probable that the granite of Silver City is a portion of the larger mass to the north. To the southwest of Silver City the surface is occupied by quartz-porphyry overlying metamorphic rocks in part, and both porphyry and granite are intersected by dikes of basalt. The ores are similar to those of the northern granitic area: gold, silver, freibergite, and sulphurets in a quartz gangue. The veins follow the general trend of the mountains to the northwest and dip at high angles. As usual, small placers accompany the gold veins.

In the South Mountain district, near the Oregon line, galena occurs in limestone. Coal has been found, but only in insignificant quantities. Tinstone has been identified as float in the Jordan river.

OWYHEE.

[NOTE.—Determinations in parentheses are given on the authority of the experts.]

Mine.	Ore and gangue.	Walls.		Character of deposit.
		Foot.	Hanging.	
CARSON.				
Black Jack	Quartz, and probably argentite, (gold and horn-silver)	Metamorphic	Quartz porphyry*	Vein.
Clearbrook	Quartz, horn-silver, and probably argentite, (gold, calc-spar, copper stains).	Muscovite granite	Muscovite granite	Do.
Empire	(Free gold and argentiferous sulphurets, quartz)	(Granite)	(Granite)	Do.
Florida Hill	Gold, quartz, limonite.			
Idlewild	Quartz, horn-silver, (some gold)	(Muscovite granite)*	(Muscovite granite)*	Vein.
Owyhee	(Free gold and argentiferous sulphurets, quartz)	do	do	Do.
Potosi	Finely divided sulphurets not determinable, quartz	Granite	Granite	Do.
Ruth	Probably argentite, quartz	Granite of somewhat gneissoid structure.	Granite of somewhat gneissoid structure.	Do.
War Eagle	(Free gold and argentiferous sulphurets, quartz)	(Granite)	(Granite)	Do.
WAGONTOWN.				
Bismarck	Gold, quartz, and limonite	(Porphyry)	(Porphyry)	Vein.
Last Chance	Gold, quartz, and limonite	Quartz-porphyry	Quartz-porphyry	Do.
Maggie	Similar to Tremont and on same vein, not specifically determinable, quartz,	(Quartz-porphyry)	(Quartz-porphyry)	Do.
Ohio	Argentite, quartz, (gold, pyrite, and antimony)	(Porphyry)	(Porphyry)	Do.
Tremont	Stephanite, quartz, and kaolin	(Quartz-porphyry)	(Quartz-porphyry)	Do.
Webfoot	Quartz, (gold, low grade)	(Porphyry)	(Porphyry)	Do.

* Microscopically examined.

OTHER COUNTIES.

In Oneida county gold quartz veins and placers are worked at Cariboo and Iowa Bar, and along the course of the Snake river in this and Cassia counties gold washings are conducted on a small scale.

The northern counties of Kootenai, Nez Percé, Shoshone, and Washington contain gold quartz veins and placers, which are not, however, worked to any considerable extent, and the conditions of their occurrence are not known.

Salt and sulphur are obtained in Bear Lake county.