GEOLOGICAL SKETCHES

OF THE

PRECIOUS METAL DEPOSITS

OF THE

WESTERN UNITED STATES,

BY

S. F. EMMONS AND G. F. BECKER,

WITH NOTES ON

LEAD SMELTING AT LEADVILLE.

EXTRACT FROM THE TENTH CENSUS OF THE UNITED STATES, VOL. XIII "STATISTICS AND TECHNOLOGY OF THE PRECIOUS METALS."

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1885.


Ex-libris
Charles Atwood
Kofoid

GEOLOGICAL SKETCHES

OF THE

PRECIOUS METAL DEPOSITS

OF THE

WESTERN UNITED STATES,

BY

S. F. EMMONS AND G. F. BECKER,

WITH NOTES ON

LEAD SMELTING AT LEADVILLE.

EXTRACT FROM THE TENTH CENSUS OF THE UNITED STATES, VOL. XIII "STATISTICS AND TECHNOLOGY OF THE PRECIOUS METALS."

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1885.

STATISTICS AND TECHNOLOGY OF THE PRECIOUS METALS.

CHAPTER I.—GEOLOGICAL SKETCH OF THE PACIFIC DIVISION.

BY GEORGE F. BECKER.

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,

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 Téjou, 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.

---

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

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, 50 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	3–20 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. Foot.	Walls. Hanging.	Character of deposit.
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.
Wingato	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. Foot.	Walls. Hanging.	Character of deposit.
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. Foot.	Walls. Hanging.	Character of deposit.
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.				
Mayhell	(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, zinchlende, galena, quartz, (copper pyrite).	Slate	Slate	Do.
Rocky Bar	(Gold), pyrite, (zinchlende, 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	Angitic porphyry	Angitic 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.
Hiyon 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.		Character of deposit.
		Foot.	Hanging.	
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. Foot.	Walls. Hanging.	Character of deposit.
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

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. Tho 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 aro very numerous, and many locations have heen made; some within 10 or 20 feet of each other. Somo of these outcrops have beeu proved by actnal dovelopment to be well-defined and persistent fissures; others are probably mero scams or hranches that pinch out or unite with stronger veins in depth; and that many must disappear in this mauner seems apparent, from the fact that tho number of veins or fissures cut in the deeper cross-cuts and shafts in various parts of the hill hear a very small proportion to the uumher of ontcrops at the surface in their immediate vicinity, which, if persistent, would appear below.

The developments on Lander hill show that within this mineral helt, running north and sonth, there prevails a zono more favored than the rest, within the limits of which the northwost and southcast veins traversing it aro especially rich in ores of high value, and heyond which the proportion of hase metals is greatly increased. This zone, so far as understood, also has a north aud south direction. On Lander hill it may ho from a quarter to a half mile in width. Its westeru limit is thought to pass through the Diana and tho Savago mines, so that in passing from tho southeastern to tho northwestern portions of those claims a perceptible diminution of the richer aud purer silver-hearing minerals, and an increasing predominance of baser metals, such as load, copper, zinc, antimony, and iron, tako place. Proceeding still further west, the proportion of rich silver minerals to the baser compounds hecomes still lcss, 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 oro 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 tho veins carried the silver as chloride, but at a depth of 150 feet this facile ore was replaced by the rebellious compounds abovo 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 wero deposited by lateral secretion. All the veins are faulted to the north for a distanco of about 200 feet, and Mr. Emmons considers it not improbablo that this dislocation accompanied the eruption of the rhyolite which forms mount Prometheus.

The age of formation of the veins is uncertain. Tho fact that faults have taken place sinco the ore was deposited is at least compatible with the supposition that the deposits are post-Jurassic; but were this tho case, eruptive rocks of the samo age would probably be formed in the neighborhood, while none such havo 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 ono to suppose that this multiplicity of outcrops was a surfaco 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 largo extent of ground, more than a squaro 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 oro 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 tho 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 samo 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 lino a nonconformity in tho Silurian, tho first thus far discovered in the Palæozoic of the Great Basin.

a Mr. S. F. Emmons has reported on tho geology of the Toyabe range, and Mr. J. D. Haguo 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	0,000	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. Foot.	Walls. Hanging.	Character of deposit.
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 Bello.)			
Northern Bello	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. Foot.	Walls. Hanging.	Character of deposit.
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 (tellnride)	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.
Uranns	......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.		Character of deposit.
		Foot.	Hanging.	
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. Foot.	Walls. Hanging.	Character of deposit.
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.	Walls. Foot.	Walls. 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.	Walls. Foot.	Walls. 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, zinchlende, pyrite, limonite, (silver, gold, and quartz).	Shale	Limestone	Do.
Pittsburgh	(Galena, cerussite, limonite, and clay)	(Limestone)	(Limestone)	Do.
Wild Dutchman	Galena, cerussite, zinchlende, 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, zinchlende, 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.
Duffin	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.

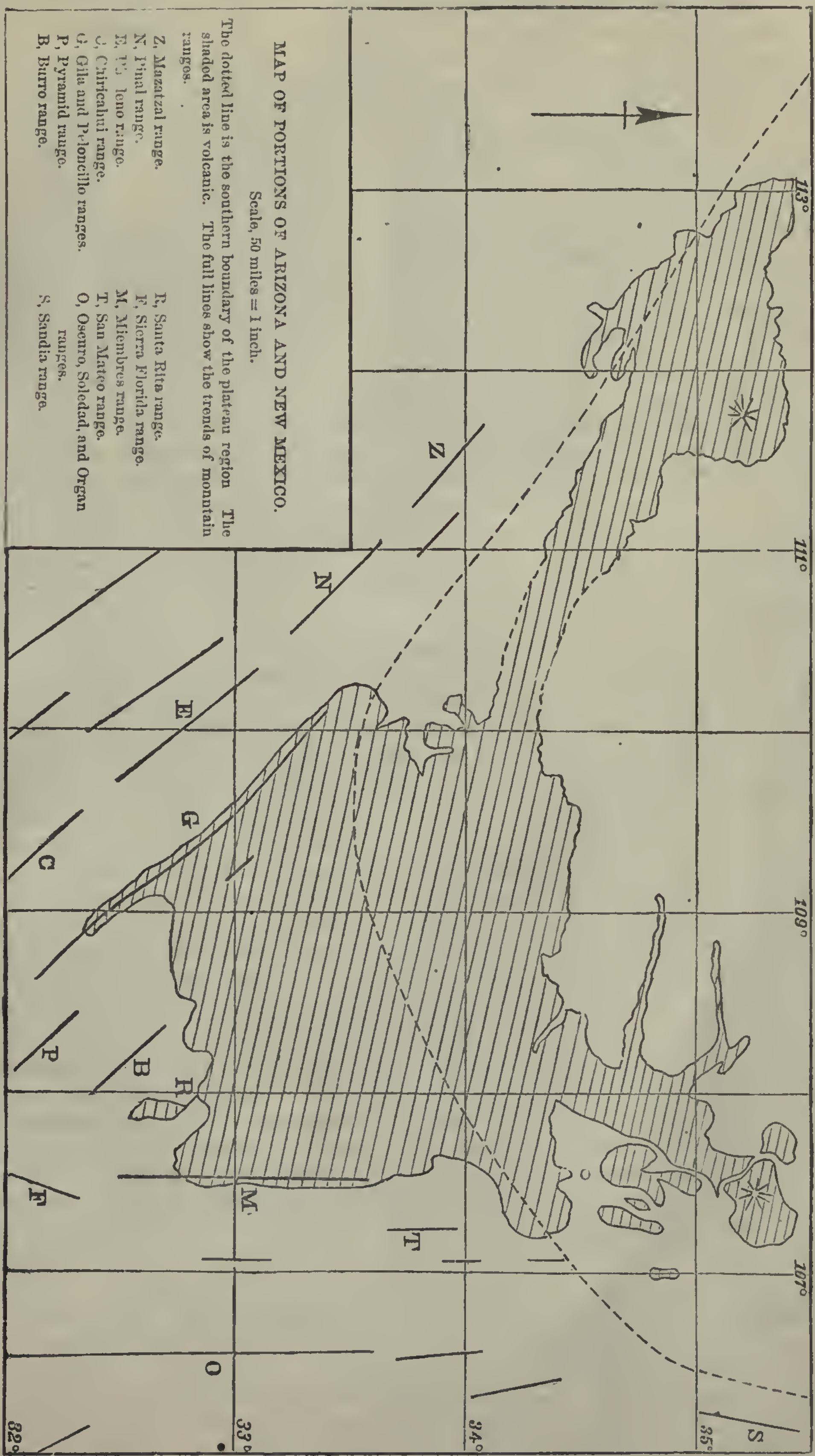
GEOLOGICAL SKETCH OF ARIZONA.

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.		Character of deposit.
		Foot.	Hanging.	
COPPER MOUNTAIN.				
Longfellow	Melaconite and azurite, zincblende, pyrite, with calcareous gangue.			
GREENLEE GOLD MOUNTAIN.				
Boston group	Auriferous gravel	Probably diorite		Placer.
Coronada 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.
Puro 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.
Tonghunt Extension	(Chlorides and carbonates), gangue, ferruginous quartz.	(Porphyry for 100 feet), limestone in part siliceous.	(Porphyry for 100 feet), limestone in part siliceous.	Do.
Tonghunt 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.

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. Foot.	Walls. Hanging.	Character of deposit.
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 pyritos).	(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. Foot.	Walls. Hanging.	Character of deposit.
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.				
Crepiscula 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. Foot.	Walls. Hanging.	Character of deposit.
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. Foot.	Walls. Hanging.	Character of deposit.
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.

Chapter II.—GEOLOGICAL SKETCH OF THE ROCKY MOUNTAIN DIVISION.

By S. F. Emmons.

In the following pages the writer has endeavored to present a brief outline of the geological structure of the states and territories of this division as far as it bears on the ore deposits of the region, the geological occurrences of the ore deposits themselves, and their mineralogical composition as far as it has been possible to determine them. Such a sketch at the present time must, from the nature of things, be extremely unequal, and, at its best, very incomplete; but it has seemed best to give it in this incomplete form, even if it merely serves to show the gaps in our knowledge and to encourage others to fill them up. The importance of the geological relations of mineral deposits has been hitherto very much underestimated, chiefly for the reason that so few competent men have given attention to their study. For this reason geological literature contains but little trustworthy information on this subject.

The material here presented has been in part compiled from data and specimens gathered by census experts, and in part from reports of government surveys, from reports by individual geologists upon mining districts, unfortunately too few in number, and from the personal observations of the writer in portions of Wyoming and Colorado. There was difficulty in obtaining men who had at the same time a knowledge of field geology and a practical acquaintance with mines, and the limited time at the disposal of those to whom the work was intrusted rendered it practically impossible to visit every mining district. Of the specimens of ore, gangue, and country rock which it was intended should be obtained from each mine a large proportion were in a too far advanced stage of decomposition for satisfactory determination. In many cases no specimens accompanied the schedules. Hence the tables of mines, country rocks, and ores which accompany the following sections are incomplete in many important instances; but it has not been thought advisable for that reason to refrain from publishing them, even in their imperfect condition, since they contain many data useful to mining engineers, and will serve as a skeleton which may hereafter be more completely clothed as additional material is obtained. In cases where no specimens were at hand it is indicated in the table, the information given being on the authority either of the experts themselves or of some person connected with the mine. At the end of another decade it is hoped that our knowledge of these important mining regions will be such as to render it possible to present the information which is here outlined in a comparatively complete form.

The maps which accompany these sketches are intended as a guide to the reader unacquainted with the geography of the country, and will serve to show those who are already somewhat familiar with it the county divisions, which have been followed in the treatment of each section. An attempt has also been made, in a very general way, to indicate by colored dots the relative distribution among actually producing mines of ores in which gold or silver predominate. These are given, as well as the rest of the material, rather as a sketch than as a finished and accurate delineation.

GEOLOGICAL SKETCH OF COLORADO.

The state of Colorado, which is included between the 37th and 41st degrees of north latitude and the 25th and 32d degrees of longitude west from Washington, has an area of 103,645 square miles. This area may be divided into three meridional belts: a plain belt, comprising a little over one-third of the eastern portion of the state; a mountain belt, lying next west of the former, and covering also about one-third of the state; and a narrower belt on the west, which is largely a mesa country, and belongs to the so-called Colorado plateau region.

According to the classification of Lieutenant Wheeler's maps, only about one-fifteenth of the whole surface is arable land, but at the time this classification was made probably only the alluvial bottom lands of the larger streams were assumed to be available for agricultural purposes. This restriction may hold good for the mesa region, but with the late rapid increase in the population of the state increasing areas of plain country to the east of the mountains have been brought under cultivation by means of irrigating ditches, and the results obtained have shown that the soil is exceptionally favorable to agriculture, the extent to which it can be profitably carried on being probably limited only by the feasibility of irrigation. A large portion of the plain country is covered by a porous, crumbling, homogeneous soil, filling irregularities of the rock surface beneath to depths of from 5 to 20 or more feet, whose external appearance strongly resembles that of the famous loess which has proved the source of fertility of many important agricultural regions in the world.

As yet no systematic studies have been made of the geology of the plain country, and the actual extent and character of this deposit is not definitely known. It seems probable, however, that it may at least be analogous to the loess which has been proved to exist farther east, in Nebraska and Kansas. An analysis of this soil, taken from the neighborhood of Golden, close to the foot-hills of the mountains, made in the laboratory of the United States geological survey at Denver, gave the following results:

	Per cent.
Silica	72.312
Alumina	12.664
Sesquioxide of iron	4.669
Lime	1.147
Magnesia	0.944
Potash	3.748
Soda	2.472
Water and organic matter	1.797
Phosphoric acid	0.228
	99.981

The lime and magnesia in this soil are in considerably smaller proportions than in ordinary loess soils, but at least 50 per cent. of the material may be supposed to be free quartz. It may be assumed, therefore, that at a greater distance from the mountains the proportion of silica will be smaller, and the more soluble and easily transportable salts greater. The same soil about 10 miles to the east of Denver, or 20 miles from the foot of the mountains, yielded 4.5 per cent. of lime and 0.8 per cent. of magnesia in a soluble form, probably as carbonate.

The climate of Colorado is essentially a dry one, though less so than that of New Mexico. In summer there are often showers, but they are too uncertain to be depended on for agricultural purposes.

Artesian wells.—The extent to which agriculture may be carried on is therefore dependent mainly upon the amount of water which is available for purposes of irrigation. The various streams which emerge from the mountains yield a sufficient supply for a comparatively narrow belt along the foot-hills, but, owing to the rapid evaporation which takes place in this dry climate, they cannot be counted on for irrigating the lands at any great distance to the eastward.

Artesian wells have been suggested as another source of supply, and government aid has been called in to make practical experiments, with a view to determining whether these wells will yield water in sufficient amount for purposes of irrigation. The water supply of artesian wells is supposed to follow the laws of hydrostatic pressure; that is, where the surface water, penetrating the earth from the surface, reaches an impermeable stratum, it follows the inclination of that stratum as an underground stream. If, then, this stratum be reached by an artesian boring at a point where the surface of the ground is sufficiently below the outcrop of that stratum, the water, seeking its original level, will flow out through this boring to the surface. The structural conditions on the great plains are theoretically favorable for obtaining flowing wells. The sedimentary formations which underlie them are upturned at their western edge against the foot-hills of the mountains, and are thus accessible to the waters which drain their surface. The surface of the plains slopes regularly to the eastward, although at a very gentle angle; so that to obtain the required difference of level it will be necessary to go some distance from the mountains, as it is found in practice that the water from artesian wells does not strictly fulfill the condition of finding its own level, but that a certain portion of the difference of elevation is lost probably by friction and the want of a perfectly free underground circulation. Of the sedimentary formations the Tertiary beds lie horizontal and are not upturned, and these, owing to their porous character, probably would not carry the required supply of water. It is advisable, therefore, to avoid sinking the wells where these still exist, and fortunately their present area is probably limited. Of the Mesozoic beds, the upper formations (the Cretaceous) are largely composed of sandstones, which are also porous and more or less permeable to water. They contain also, it is true, beds of clay, but it cannot be certainly stated that these clay beds are continuous over any great areas. It is questionable, therefore, if the Cretaceous formation will yield a large supply of water, except locally, as near Denver, where a synclinal basin is formed by a slight fold in the strata to the east of it. In the Jura, below the Cretaceous, the conditions seem more favorable, as they contain a considerable amount of clay and a comparatively persistent limestone bed. The Trias is a formation largely of sandstones, and therefore not favorable, and it is only when the Carboniferous is reached, which is made up of compact and evenly-bedded limestone, that we come to strata which are beyond doubt capable of carrying the required supply of water. The thickness of these different formations has not yet been accurately determined; but it may be assumed at the foot-hills that the Cretaceous beds are at least 3,000 feet in thickness, and the Jura and Trias 2,000 more. It will be seen, therefore, that it may require a boring 5,000 feet in depth to give a permanent and considerable flow of water. On the other hand, there are good grounds for supposing that the thicknesses of the different formations decrease to the eastward, and this supposition has been in part confirmed by actual observation along a line near the southern border of the state. It is probable, therefore, that at a sufficient distance to the eastward the thickness of the beds overlying the Cretaceous formation will be very much less than the figures above given. In the present state of our knowledge these are largely matters of conjecture, and it is only by the actual experiment of boring wells that the thickness and water-bearing properties of the different formations can be determined. It is evident, however, from what has been said, that these experimental wells should be sunk near the eastern border of the state, and at points where the greatest thickness of the upper beds is likely to have been removed, bringing the deep-seated water-carrying bed, therefore, nearest the present surfaces. To determine these points with accuracy, however, would require an accurate and systematic topographical and geological survey, which has not yet been made, and the choice of the right location must be largely a matter of chance. It seems probable, therefore, that with its exceptionally favorable conditions of climate and a soil of this character the agricultural resources of Colorado are yet but partially developed.

COAL.—Its industrial possibilities, if gauged by its natural resources in coal, the indispensable basis of almost every industrial enterprise, are almost unlimited, not less than two-thirds of the area of the state being underlaid by the coal formation. While over a great portion of this area it may lie too deep for profitable extraction, and while coal beds are by no means necessarily continuous in any particular formation over very large areas, yet the geological conditions are such that a relatively large proportion of this formation is brought to the surface and rendered available for practical working, especially along the borders of the mountain belt. Along the eastern front coal mines are already opened and working at intervals from the northern to the southern boundary of the state. Mines are also worked in the South park, in the center of the mountain belt, and in Gunnison and La Plata counties, on the western slope, while the developments in many other localities are only awaiting railroad communication and an industrial demand.

MOUNTAIN BELT.—The precious-metal production of the state is derived mainly from the mountain belt, as might have been assumed on *a priori* geological grounds, reasoning from which none would be looked for in the plain country; nor would much be expected from the mesa region, except where eruptive rocks have protruded through the sedimentary strata and formed such isolated mountain groups as the Sierra la Sal, Sierra Abajo, Sierra el Late, and others. The topography of the mountain region and the plateau country on its west, as well as its general geological structure, is pictured on the maps of the Hayden survey, of which the extreme northern strip is taken from those of the Fortieth Parallel. The most important group of rocks there represented, and intimately connected with ore deposition, viz, those of Mesozoic or Secondary age, have either entirely escaped recognition or have been classed indiscriminately as belonging either to the volcanic rocks or to granites.

The mountain belt of Colorado, which in this latitude is generally known as the Rocky mountains, to distinguish it from the other principal Cordilleran systems to the westward, the Wahsatch and the Sierra Nevada, has, taken as a whole, a due north and south trend. When examined in detail, however, it is found to be made up of a number of more or less regular chains or ridges having a general trend to the west of north, standing *en echelon* or with their ends overlapping each other, with mountain valleys of greater or less extent between them, as the result of which structure the mountains in general seem to be divided up into two chains, with large included valleys which have received the name of "parks". The general name of Colorado, or Front, range has been given to the eastern of these divisions, and that of Park range to the western. The North, Middle, and South parks and the San Luis valley are the larger of the included valleys, the three former, with the smaller Wet Mountain valley to the south, being really a portion of the same continuous line of depression, while the valley of the Upper Arkansas stands in the same relation to the San Luis valley. The eastern front of this range presents a comparatively regular north and south line, broken here and there by bay-like valleys, running up into the mountains in a northwesterly direction and following the prevailing trend of the echelon ridges. The most important of these are the Manitou and Huerfano parks and that which extends up Oil creek from Cañon City. These in earlier geological times were actual bays in the seas in which the Palæozoic and Mesozoic rocks were deposited, while the parks were partially inclosed arms of those seas.

The western front of the mountains is, however, much more irregular, and is broken by branching mountain groups extending out, also with a general northwest trend, into the mesa country of the Colorado plateau. The principal of these outlying mountain groups, commencing on the north, are the Elk Head mountains, the White River plateau, the Elk mountains, and the San Juan mountains, in all of which, as will be seen later, there is a very great development of eruptive rocks.

GEOLOGY.—The geological history of this mountain region is, briefly and in its most general outlines, as follows: At the close of the Archæan era, or in the Cambrian ocean, a large area, covering most of what is now the Colorado range, formed a large rocky island, with a number of minor islands lying to the westward, the most important of which was that which now forms the Sawatch, from which it was more or less completely separated by the waters occupying the present depressions of the North, South, and Middle parks. During the whole of the Palæozoic and Mesozoic eras a continuous sedimentation went on in the seas surrounding these islands of material derived from their abrasion. The geological record, as far as it has been studied at the present day, gives evidence of no great disturbance during this long period, although it is probable that local elevation and subsidence might have taken place; and there is some evidence to show a general subsidence of the whole area, which gave a somewhat larger field of deposition to the later sediments of these periods. Toward the close of the Cretaceous period, at the time of the formation of the coal beds, the seas became shallower, owing to a general elevation of land, and considerable portions of the outlying areas were partially inclosed. During this time, and possibly earlier, immense masses of eruptive rock were forced up through the already deposited sediments which were still beneath the water. Unlike the lava flows of modern days, however, these molten masses were not, as a rule, spread on the surface of the rocks, but congealed before they reached it, either in large masses, in dikes, or in sheets spread out between the beds. It is impossible to say how long before the close of the Cretaceous period the eruption of these Secondary igneous rocks commenced, but it is known that in certain localities it must have continued nearly to the close of the period. At some time after the close of the Cretaceous period a general dynamic movement took place in the Rocky mountains, by which the existing mountain ranges or islands were crushed together, broken, and elevated, and considerable areas of the adjoining sea-bed were lifted above its surface. In the general continental elevation which followed fresh-water lakes or inclosed seas were formed, in which, by the degradation of the newly-made land areas, considerable sediments were deposited. The outlines of these Tertiary seas, owing to the nature of the deposits made in them, which were easily eroded and carried away by subsequent atmospheric agencies, cannot be yet definitely determined. It can only be said that their area and location were frequently changed, and that during the Tertiary era, and subsequent to it, eruptions of igneous rock occurred, generally following the lines of earlier eruptions, but, unlike those, spreading out on the actual surface of the land, and in some cases beneath the sea. While the general form of the mountain area, as has been shown, was determined in the very earliest geological times, it is only since the Tertiary era, and in a great measure by erosion subsequent to the Glacial period, that the present sculpturing of the mountain forms and carving of the valleys have taken place. At what period during this history the different mineral deposits of Colorado were formed it is as yet impossible to say with any degree of definiteness. The gold deposits of Gilpin county in the Archæan may, like those of the Black hills of Dakota, be of pre-Cambrian age. It is probable, however, that some of these at least, and the silver deposits in the adjoining counties of Clear Creek and Boulder, were subsequent to the intrusion of the porphyries, which are presumably of later date. The silver deposits of Leadville are known to have been formed subsequent to the Carboniferous and previous to the dynamic movement at the close of the Cretaceous. Some of the silver deposits of Gunnison, on the other hand, must have been later than the Cretaceous, while those of Custer county and the San Juan region are in part at least presumably of post-Tertiary age.

ORES.—The ores of Colorado present an almost infinite variety of mineralogical composition, so that it is difficult to formulate any general laws with regard to their distribution or manner of occurrence. Of the actual precious-metal production of the state, by far the largest portion is derived from pyrites and galena and their decomposition products. The telluride ores of Boulder county and the auriferous pyrites of Gilpin county, with a few individual deposits in the southern portion of the state, constitute the source from which its gold is derived. With these exceptions its mineral deposits may be considered as essentially silver-bearing. The principal source of silver, as has already been stated, is argentiferous galena and its decomposition products, while argentiferous gray copper, or freibergite, is next to this the most important silver-bearing mineral. The sulphides of silver also occur, and in some cases bismuth is found in sufficient quantity to constitute an ore. As yet, so far as known, no copper is extracted from the ores of the state, except as an adjunct in the reduction of silver-bearing copper ores. Placer deposits are generally confined to the valley bottoms among high mountain ridges, and while they are locally of considerable value and importance, and were the original attraction which brought the mining community to the state, their present yield forms a very inconsiderable proportion of its precious-metal production. Prior to the discovery of the silver ores of Leadville mining in the state was principally confined to approximately vertical veins either in the Archæan rocks of the Front range or the eruptive rocks of the San Juan region; but since the limestone deposits of the Mosquito range have proved so exceptionally rich the attention of prospectors has been more and more turned to the ores which occur in sedimentary rocks, and many new districts have been discovered, but none to rival that of Leadville.

As regards geological distribution, gold is found in the Archæan and in the eruptive rocks of the Secondary age. In the sedimentary formations it is comparatively rare in limestone beds, but is not infrequent in siliceous beds. Silver is also found in the Archæan and in the Secondary eruptive rocks. In the sedimentary beds, on the other hand, it is more common in the limestones, although it is not exclusively confined to them. By far the greater portion of this metal produced in the state is derived from the limestones of the Palæozoic formations.

The most important generalization to be made with regard to the distribution of ore deposits is one that has been already noted in other countries, viz, that the largest and most important ore deposits are found where igneous rocks are most abundant. The experience of the writer leads him to further modify this by saying that it is the eruptive rocks of earlier age than the Tertiary volcanics with which valuable ore deposits are generally associated.

The mineral wealth of the state is by no means confined to the precious metals. Its coal beds are widespread, and contain both bituminous and anthracite coals. Gypsum beds are of frequent occurrence in the Triassic and Upper Carboniferous formations, and salt springs are not infrequent, and probably derive their supply from the same horizon. The Dakota group of the Cretaceous on the eastern foot-hills carries beds of most remarkably pure fire-clay. Excellent building-stone is quarried from the Archæan, which furnishes red granite; from the Mesozoic formations, which furnish white and red sandstones and valuable flags; and from the tufaceous rhyolite-lava beds of the plains.

EASTERN COUNTIES.

Weld, Arapahoe, Elbert, and Bent counties, and the eastern portion of Las Animas, lie entirely in the plain region east of the mountains. Their surface is covered to a depth of from 10 to 20 feet by a light, porous, almost loess-like soil, which is admirably adapted to agriculture wherever it is possible to bring water for purposes of irrigation. Where this is not possible, the natural grasses are most valuable for the raising of stock. No metallic minerals are to be looked for in this region, but it is underlaid by the rocks of the coal formation, which must contain extensive and valuable beds of this mineral, whose development is only dependent on the market demands and the depth below the surface at which it occurs.

LARIMER COUNTY.

This county includes the northern end of the Colorado range in Colorado, and, although mostly a mountain district, has as yet developed no considerable mineral wealth. One reason of this may be found in the fact that the range is here mainly made up of Archæan granite—a coarse, red, crumbling rock, which is characteristically developed at Sherman, on the Union Pacific railroad, and which has in this state thus far proved barren of metallic minerals. A further reason may be found in the comparatively limited development of Secondary eruptive rocks, which, so far as known, occur only in the western limits of the country bordering on the North park, at the head of Grand river. Mines have already been discovered near the western boundary of the county, at the head of Laramie river, in the Medicine Bow range.

GRAND COUNTY.

This county includes the North and Middle parks, whose surface is mainly covered by Mesozoic rocks, and are separated by a cross-range of eruptive porphyry and volcanics. In the Archæan mountains which inclose the county, and still more in the eruptive range which divides the two parks, the geological conditions are favorable for the formation of valuable deposits of minerals. As yet, however, owing to the difficulty of access and want of railroad connection, no important mines have been developed, and data from the few mining districts that exist within the county are entirely wanting. The coal-bearing formations originally covered the greater part of both park areas, but these have been removed in part by erosion.

ROUTT COUNTY.

This county, which extends from Grand county west to the Utah line, comprises the valleys of the Yampa and of the Little Snake rivers, which are underlaid by coal rocks, whose deposits come to the surface along the borders, but in the centers are too deeply buried beneath the overlying Tertiary beds to be practically available. These deposits, as elsewhere, afford no promise of metallic minerals. In the bordering mountains the only known mineral developments are the placer mines of Hahn's Peak district, which are found in the angle between the Archæan uplift of the Park range and the volcanic group of the Elk Head mountains. These placer deposits are evidently derived from the disintegration of Archæan rocks, and have yielded a small but constant return for many years past. Near the junction of the Elk river with the Yampa is an extremely interesting group of mineral springs carrying sulphur and free carbonic acid, known as the Steamboat springs. The coal-bearing Cretaceous formations occupy the valley of the Yampa river and a great part of the ridge which divides it from the White river on the south. Favorably situated outcrops are abundant, and only await the advent of railroads to become of practical value.

BOULDER COUNTY.

Topographical.—The mines of Boulder county are situated on the eastern slope of the Colorado or Front range, not far from the town of Boulder, which lies at the mouth of Boulder cañon where it debouches on the plains. The district containing the mines extends about 13 miles in a north and south direction, and from 4 to 10 miles from east to west.

The country is drained by a number of creeks, which cut deep cañons between the mountain spurs. These are, commencing on the north, the south branches of Saint Vrain creek, then James (popularly Jim) and Left-hand creeks, which join a little below Jamestown and flow out on the plains, as Left-hand creek, into the Saint Vrain at Longmont; next the various forks of Boulder creek (Four-mile, North Boulder, and Middle Boulder), which flow past the town of Boulder in a single stream, and also are tributary to Saint Vrain creek.

The town of Boulder is connected by the Colorado Central railroad with Denver on the south and Cheyenne on the north, and by the Boulder Valley railroad with the Denver Pacific railroad. A narrow-gauge railroad is also projected from Denver to run up into the mountains via Boulder. There are a number of small mining districts in this region whose limits were not definitely ascertained, but they are not in themselves important, except for purposes of description. The mines on the Saint Vrain are generally included in the Saint Vrain district. On

James creek is the Central district. South of Left hand creek is the Gold Hill district, with the Sunshine district nearer the foot-hills, and at the head of this creek is the Ward district. Still south of this, between Four-mile creek and North Boulder, is the Sugar-loaf district, and south of Boulder creek Magnolia district, while at the head of Middle Boulder creek is Caribou or Grand Island district.

GEOLOGICAL.—The general geological structure of the district is simple and typical of the mining districts on the eastern slope of the Colorado range. Along the foot-hills immediately adjoining the plains is a series of so-called hog-backed ridges, formed by upturned Mesozoic strata resting on the Archæan core of the range. These upturned sedimentary beds form a fringing belt, of a width varying with their angle of dip, along the entire extent of the eastern foot-hills. Just south of Boulder their angle is almost vertical, and they form a prominent peak, rising to an elevation of over 8,000 feet, or 3,000 feet above the plains. The upper member of the sedimentary series, the Laramie or Lignitic group, contains valuable coal deposits, whose outcrops, by erosion at Boulder, have been moved out some distance on the plains. Besides coal, these beds furnish admirable building-stone and flagging, and also fire-clay and lime. Of metallic minerals, however, they have as yet proved barren. The Archæan rocks immediately adjoining the plains have generally been found to contain but few valuable minerals, and it is not until the range has been penetrated for a distance of several miles that prominent deposits appear.

In Boulder county the mines are found within 2 miles of the plains. The Archæan rocks of the Boulder district consist mainly of gneiss, intersected by veins of pegmatite (or coarse-grained secondary granite) varying in width from a few inches to 40 or 50 feet. In addition to these there are later eruptive rocks of Secondary age, occurring either in dikes or massive bodies, of whose extent and character only imperfect data are obtainable. The prevailing gneiss of the region is of a type of rock not uncommon in other mining regions; and for purposes of description the name "*granite-gneiss*" has been adopted for this, for the reason that it is largely a massive rock, in which the bedding is either indistinct or not at all visible. At times this gneiss is coarsely crystalline, at others fine-grained, in which case the proportions of hornblende and biotite are relatively greater and the rock assumes a darker color. Quartz is always prominent in it. In the coarse rock two feldspars are visible, an orthoclase feldspar, generally of a delicate pink tinge, and a white opaque feldspar, which is triclinic, and frequently shows the characteristic striation on the basal cleavage faces. In a specimen from the eastern base of Sugar-loaf, examined microscopically, plagioclase feldspar is largely predominant, and is of two varieties, one probably oligoclase, the other labradorite. Magnetite, apatite, and pale zircons are sparingly present. This granite-gneiss generally forms rounded hills with extensive *débris* slopes, and presents but few prominent or angular outcrops.

The pegmatite veins, or gangues, as they are locally called, are mostly composed of white feldspar and quartz. Parts of them are coarsely granular and contain some mica, others are like a fine-grained granite, and in still others these two textures are found bearing irregular relations to each other. Sometimes they are not more than a finger thick, crossing the rock in every direction without intersecting each other, and sometimes they consist entirely of quartz. Two of these veins have strongly marked characteristics, and have been traced for a number of miles through the district. The first, the Maxwell gangue, runs a little east of north from Four-mile creek to Left-hand creek, crossing the road to Sunshine, two miles from Boulder, and is said to carry pyrites and some tellurides. The Hoosier gangue, which is supposed to form the western limit of the telluride belt, is about 30 feet in width, and runs through Gold Hill in a direction east of north. A specimen examined in this belt is like fine-grained granite in appearance, though consisting chiefly of quartz and feldspar, with black metallic particles macroscopically visible. The microscope shows only quartz, orthoclase, microcline, the remnants of biotite and titanite, and apatite in small prisms. The quartz contains fluid inclusions and hair-like microlites of rutile. This carries silver ore and gray copper. The telluride belt includes the Magnolia, Sugar-loaf, Gold Hill, and part of the Central districts. In this belt eruptive rocks are very rare, but the pegmatite veins are extremely common. West of this region are enormous masses of eruptive rock, and tellurides are not found.

In the Caribou district are rich silver ores carrying from 30 to 1,500 ounces of silver to the ton, and in the Ward district veins carrying free gold, with iron and copper pyrites, which have a general direction east and west, while the others are more nearly north and south.

Of eruptive rocks, that which forms the Sugar-loaf, a conical hill between Four-mile and Boulder creeks, is a fine-grained porphyritic rock of grayish color, showing in the hand specimen small white feldspars, biotite, hornblende, and titanite, the latter, of a yellow color, being quite frequent. Under the microscope the rock shows some augite and a crystalline groundmass containing a little quartz, but it is made up chiefly of feldspar, in rounded particles, not sufficiently well defined for their determination. A somewhat similar rock occurs on the north bank of Four-mile creek, which is more markedly porphyritic, its constituents being larger, and the large feldspar predominantly orthoclase. This rock is evidently a massive eruption of very considerable extent, as it apparently forms a much larger hill west of the Sugar-loaf and large outcrops up the north branch of Four-mile creek, nearer to the Ward district. In the saddle immediately east of the Sugar-loaf is a small dike of diabase, and about half a mile east is a larger one of the same rock, the former a dense black rock, in which only small plagioclase crystals can be distinguished, the other a granular mixture of augite, feldspar, and ore particles. Both are free from olivine. The former has a little globulitic glassy base, while the latter is entirely crystalline.

At Jamestown (also known as Jimtown) occurs a normal quartz-diorite of rather light color, although it contains considerable hornblende. Titanite is also abundant in this rock, and it forms a dike, running east and west, almost in the street of the town. The cliffs, over 500 feet in height near Jamestown, are formed of quartz-porphyry of a white color, which is partly due to alteration and partly to the absence of basic minerals. It is composed of pale flesh-colored orthoclase, sometimes having crystals one inch in diameter, with quartz, which is not particularly prominent, and occasionally a bleached mica. The ground-mass is micro-crystalline, and consists almost wholly of quartz, with a few small crystals of orthoclase and plagioclase feldspar. By its appearance it should be an older rock than any of the others. It contains 67 per cent. of silica, and by assay no gold.

A dike is found in the Ward district which contains pyrites, and is supposed to be a continuation of one of those in the Sugar-loaf district; but as no specimens were obtained, its determination could not be made. Still another dike, called the Black Eagle, south of Sugar-loaf, is said to have been traced 16 miles in an east and west direction.

MINES.—The mines of Boulder county are chiefly noted for the occurrence of telluride minerals, next to the native metals the richest and rarest ores that occur in nature.

The telluride belt occupies the eastern part of the district, extending to within a short distance of the sedimentary beds on the east. Its western limit may be roughly defined by a line running from Jamestown west of Gold Hill and through the Sugar-loaf. It comprises, as already stated, the Magnolia, Sugar-loaf, Central, and Sunshine districts. West of these it is said that no tellurides have been found. In Caribou district, where the earliest discovery was made in 1869–'70, the ores are mainly argentiferous galena, and are generally quite rich. In the Ward district, at the head of Left-hand creek, the ores are largely pyritiferous, and contain, where decomposed, free gold, but are generally difficult of reduction. In the Saint Vrain, on the other hand, where comparatively small developments have been made, there are large veins rich in copper, but contain little silver.

The district as a whole is characterized by exceptionally rich ores, in spite of which development has been very irregular and production uncertain. This is due in large part probably to the somewhat irregular manner of occurrence of the ores. The veins, which are popularly regarded as true fissure veins, and generally stand at a steep angle, are often of great width, but the rich ore, on the other hand, is concentrated in thin streaks and not very continuous bodies. If we confine the term true fissure vein to its narrowest limits, and apply it only to that form of vein which was once evidently a strong, deep-seated, open fissure that has been filled in by vein matter and ore foreign and distinct from the country rock, there are probably no true fissure veins in this district. As far as known, the vein material is almost without exception an alteration of the country rock, which is impregnated with rich mineral. This impregnation has taken place either along the contact of a porphyry body with the country rock or in a pre-existing vein of pegmatite, or again along some fault or jointing plane in the country rock itself which has been favorable to the concentration and precipitation of metallic minerals from their solutions. The direction of the veins is in general between northeast and northwest, but in Ward district an east and west direction seems to prevail. Their plane, as already stated, stands at a high angle, approaching the vertical.

Placers have been worked at various points in the narrow valleys which intersect the districts. Though rich, their superficial extent cannot be great, and no data have been gathered in regard to them.

MINERALS.—No exhaustive mineralogical study has yet been made of this interesting region. Among such rare deposits the temptation to discover new species is great, and it is necessary to accept with caution the statements as to their occurrence. In the list below the attempt has been made to give as complete as possible an enumeration of the unusual minerals occurring here under the following categories: I. Tellurides—*a.* Old species proved to occur, and cited by standard works on mineralogy; *b.* New species recognized by standard works on mineralogy; *c.* New species, probably good, but needing further investigation; *d.* Mixtures described as species. II. Other minerals mentioned which have not been confirmed by publication or analyses. The occurrence of those marked with an asterisk is doubtful either as a species or in point of occurrence, and needs further investigation.

I. Tellurides—*a.* Old species proved in Boulder county:

Altaite (PbTe); anal. by Genth. (Cited by Dana and Naumann-Zirkel).

Hessite (Ag_2Te); anal. by Genth.

Hessite, auriferous=petzite. Genth; not indep. sp.

Sylvanite ($AgTe_2+AuTe_2$); anal. by Genth. Cited by D. & Z.

Tellurite (TeO_2); anal. by Genth. Cited by D. & Z.

Tellurium, native, Genth. Cited by D. & Z.

b. New species recognized:

Calaverite [$M(AuTe)_2+AgTe_2$], sp. by Genth, from Calaveras co., Cal. Cited by D. & Z., sometimes regarded as a variety of sylvanite.

Coloradoite (HgTe), sp. nov. by Genth. Cited by D. & Z., orig. from Boulder co.

Schirmerite [$3(Ag_2Pb)S+2(Bi_2S_3)$], sp. nov. by Genth. Cited by D. Groth and Z. A mineral of the same name by Endlich, from the same locality, is pronounced a mixture. Orig. from Boulder co.

c. New species needing further investigation:

Ferro-tellurite ($FeTeO_4$), sp. nov. Genth. Mentioned by Groth. Orig. from Boulder co.

Magnolite (Hg_2TeO_4), sp. nov. by Genth. Orig. from Magnolia district; decomposition product of coloradoite mentioned by Groth.

d. Mixtures described as species:

Henryite, Endlich. Universally pronounced a mixture.

Lionite, sp. nov. by Berdell. Considered impure tellurium by Dana (App. III, p. 119).

Tellure-pyrite, J. A. Smith. Descr. by C. U. Sheppard; from description, probably a mixture.

e. Menorite (Ni_2Te_3), sp. nov. by Genth. Orig. from California. No anal. Smith authority for Boulder co.

II. Other minerals mentioned:

*Amalgam. Authority, Smith.

Argentite. Authority, Smith.

*Bismuth, native, sulphide, and carbonate. Smith.

Copper, native, minute crystals. Smith.

*Iodyrite. Endlich.

*Kobellite. Smith. Sp. not recognized in Dana.

Mercury. Smith.

*Pyrargyrite. Endlich.

Roscoelite. Sp. nov. Genth. Roscoe believes it a mixture.

Central district.—The most prominent mine in this district is the Golden Age, near Jamestown. It is on the contact of porphyry with the Archæan, the former constituting the hanging wall. The vein is about 40 feet in width. The richest ore comes from a streak of white quartz from 1 to 2 feet thick on the foot wall, which is sometimes almost a mass of free gold. Pyrites prevail toward the hanging wall, but small rich concentrations of gold are also found at intervals.

Gold Hill district.—This is in the telluride belt, and is traversed by the Hoosier gangue. Many of the telluride veins cross the Hoosier gangue, and are said to be richer in its neighborhood. The most prominent among these are Cold Spring and Goldsmith Maid. The Red Cloud is the oldest mine in the district, and is the one in which tellurides were first discovered in 1872. Its vein is 3½ feet in width, and the ore was tellurides at the surface and auriferous pyrites in depth. The Slide, Melvina, and Prussian are also important deposits. The Emancipation is near the Sunshine district. All these are in the granite-gneiss, which here offers but few good exposures. The Washington Avenue mine, west of Gold Hill, carries galena, blende, and pyrites.

Sunshine district.—This district comprises the easternmost development of the telluride belt. Its ores are generally of lower grade, free gold and tellurides occurring in the upper portion, passing into pyritiferous ores in depth. Prominent mines are the American, Grand View, Sunshine, Osceola, and Young America.

Sugar-loaf district.—In this district the Yellow Pine mine is an enrichment of the Hoosier gangue of pegmatitic granite. Other prominent mines are Baile's lode and the Emerson, both carrying telluride in granite-gneiss.

Magnolia district.—This is at present the southern limit of the telluride line. Here, as well as in the neighborhood of Jamestown, the gneissic character of the country rock is very distinct, and the bedding planes are easily distinguishable. The prevailing strike seems to be in a northeasterly direction, which is also that of most of the veins of the telluride belt. The Senator Hill is one of the most promising mines of the district. In the Keystone and Mountain Lion, which are said to be on the same vein, a narrow deposit only from 6 to 7 inches in width, the new mineral coloradoite is found.

Ward district.—Between Gold Hill and Ward the gneiss is much contorted and the bedding very plain, and bodies of eruptive rock, which were comparatively wanting in the telluride belt, are here frequent. The most important mines are the Niwot, Columbia, and Stoughton. The ores are sulphides of iron and copper, carrying gold, and therefore, when undecomposed, difficult to reduce.

Caribou or Grand Island district is situated at an elevation of nearly 10,000 feet above sea-level. Its most important mine is the Caribou, which was discovered in 1869, and has produced a very large amount of silver ore. This is a massive mixture of galena, chalcopyrite, and zincblende, which occurs in gneiss, but closely associated with diabase. Other important mines are the No Name (which is said to cross the Caribou and fault it), the Boulder County, and Native Silver. The ores of this district are essentially silver-bearing, but also carry some gold.

Mine.	Country rock and vein.	Ore and gangue.
CENTRAL DISTRICT.		
Golden Age (near Jamestown)	Foot wall gneiss; hanging wall porphyry. Vein vertical; strike, E. and W.; dip, 44°; 40 feet wide.	Free gold, with iron and copper pyrites and quartz.
Smuggler	Mica-schist. Strike, N. and S.; dip, 60° E	Tellurides and pyrites in siliceous gangue and altered country.
GOLD HILL DISTRICT.		
American	Granite-gneiss. Strike, NE.; dip, 84° SE	Tellurides of gold, silver, and mercury, with free gold, sulphide of iron, zinc, lead, and copper; no specimens.
Cold Spring	No specimens. From the gangue it is apparently fine-grained granite, and a much-altered porphyry is near by.	Tellurides. Specimen, evidently from the side of the vein, is attrition material; clay, rounded pieces of quartz, with pyrites and tellurides.
MAGNOLIA DISTRICT.		
Keystone	Gneiss. No specimens. Vein: dip, 65°; 2 feet wide	Tellurides in quartz gangue. No specimens.
Mountain Lion	Gneiss. Vein: strike, NE.; dip, 65°; 2 feet wide	Iron oxide and free gold, with tellurides. Gangue: quartz and feldspar.
WARD DISTRICT.		
Nelson	Decomposed mica-schist. Strike, NE.; dip, 62°	Auriferous chalcopyrite and pyrite with free gold. Gangue: quartz and altered country.
Niwot	Granite-gneiss hanging wall and porphyry foot wall. Strike, E. and W.; dip, 70° N.	Massive pyrite and chalcopyrite cemented by quartz.
SUGAR-LOAF DISTRICT.		
Emerson	Altered gneiss	The same rock impregnated with fine grains of pyrite and tellurides.
Yellow Pine	Granite, with reddish feldspars and but little mica	Gray copper, azurite, malachite, and some unknown greenish mineral in a decomposed gneiss or granite.
Baile's lode	Coarse granite-gneiss with red feldspars, in which are veins of fine-grained biotite-granite.	At the contact of granites is quartz with a little galena, pyrites, and black stains.
GRAND ISLAND DISTRICT.		
Boulder County	Vein: strike, E. and W.; dip, 55° N	Galena, pyrite, and blende in quartz; blende crystals covered by a layer of hematite.
Caribou	Syenitic gneiss. Diabase occurs in the neighborhood. Vein: strike, E. and W.; dip, 14° N. (76° ?)	A massive mixture of galena, chalcopyrite, zincblende, and a mineral called "antimony".
Horsefall lode	Mica-schist. No specimen. Strike, E. and W.; dip, 85° N	Chalcopyrite and pyrite with free gold, some galena and zincblende.
Native Silver	A fine-grained biotite-granite. Near the vein the biotite has disappeared. Vein: strike, E. and W.; dip, 5° N. (85° ?)	Mixture of galena and sulphides.

JEFFERSON COUNTY.

This county includes the foot-hill region south of Boulder county as far as South Platte river and a narrow strip of the mountain region. Although mainly a mountain county, and surrounded by important mining districts, it reports no product of the metallic minerals. On the other hand, its production of coal from Ralston creek, Golden, and Morrison, and of valuable fire-clays and building-stone all along the foot-hill region, is extremely important. From the basaltic mesas at Golden a number of interesting zeolitic minerals have been obtained by Mr. Cross, of the United States geological survey, among which are analcite, apophyllite, chabazite, laumontite, mesolite, natrolite, scolecite, stilbite, and thomsonite. Jet is also found in the Tertiary beds under the lava flows and bole.

GILPIN COUNTY.

This is the smallest county in the state, and consists of a triangular bit of mountain region, covering 180 square miles of surface, drained by the north fork of Clear creek and adjoining Jefferson county on the west. It is the oldest mining region in the state, the first gold being discovered here in Russell gulch in 1859, and is still the greatest gold producer. Its placer deposits, lying along the bottoms of deep ravines, are of limited extent, but they are extremely rich, and though most of them have been worked over several times, they still yield a certain amount of gold.

This county is entirely in the Archæan formation, which consists mainly of gneiss, the prevailing type being structureless granite-gneiss, already described in the section on Boulder county. The gneiss is penetrated by various bodies of porphyry; but, owing to the peculiar readiness with which the rocks yield to atmospheric influences, few characteristic outcrops are found, so that the geological structure is not readily recognized on the surface. Here also the veins are mainly alterations of the country rock along certain planes, and rarely, if ever, show the character of a pre-existing open fissure filled by foreign material. In some cases the vein material seems to be a porphyry dike. Many of the veins have been traced to a very considerable depth, in some cases to over 1,000 feet, and it is claimed that some have been traced in length between 2,000 and 3,000 feet. The direction of the veins lies either between north and south and northeast and southwest, or within 10° of east and west. Among the more important veins the Gregory & Briggs, Bates, and a few others belong to the former, the Bobtail, Burroughs, Gunnell, and others belonging to the latter group. In all the dip is generally near the vertical. Faulting or displacement of the vein is rare, but where the vein material is porphyry it frequently contains inclosed fragments of gneissic country rock. In one mine rounded boulders of gneiss of considerable size have been found in the vein at a depth of about 700 feet from the surface, but whether their form is due to attrition of the two walls or to the rounding action of water and mineral solutions is not known.

The ores are mainly a mixture of pyrite and chalcopyrite, with less frequently galena and zincblende, carrying more or less gold. In the northern portion of the district, however, galena ores, with zincblende and pyrite, carrying silver, occur, but as a rule contain little or no gold; and similar deposits almost surround the extremely circumscribed limits of the gold-bearing area, whose radius, taking Central City as a center, is only about 1½ miles. In the gold veins the richer ore generally occurs in streaks that are not more than one foot wide, a compact fine-grained mass of pyrite, copper pyrite being as a rule richer than the ordinary pyrite. The rest of the vein, which often attains a width of many feet, carries pyrites (irregularly disseminated through a more or less decomposed mass of country rock) either in the form of white clayey material or as a mixture of quartz and feldspar. Outside the narrow streaks of solid sulphurets, the bulk of these ores, as they are extremely difficult to smelt, are generally treated by mill process, and the percentage of loss is generally much higher than in more completely oxidized ores, or those which are free from pyrites, averaging probably 40 per cent. The richer portions of the ore and concentrations of mill tailings are sent to the smelting works in the valley below. According to Mr. A. N. Rogers, of the Bobtail mine, who has had long experience in the underground workings of this district, the veins invariably follow the cleavage planes of the country rock, the planes crossing the strata with a nearly vertical dip, while the stratification of the country rock has a dip to the eastward. He also states that the porphyry has its cleavage in common with the country rock where the cleavage does not invade the veins themselves, the joints or laminæ taking the line of the veins and lying parallel with their walls. Hence he reasons that the porphyry is older than the veins, inasmuch as the cleavage is older and intersects the porphyry. These observations are of interest as giving a slight indication of the age of deposits in the Archæan, for which, as a rule, it is impossible to obtain any definite data.

The mountain region, from 12 to 15 miles in width between the mining districts and the plains, mainly included in Jefferson county, which consists also of Archæan rocks, has hitherto proved relatively barren of valuable minerals. In this region the rocks are comparatively undecomposed and the bedding planes remarkably distinct, having a prevailing easterly dip. They are generally gneissic in character, with some granite, and, as a rule, are highly siliceous.

Minerals.—Besides the ordinary sulphides of iron, copper, zinc, and lead, sulphides and arsenides of silver are found; and among rarer minerals the occurrence of enargite (sulphide of copper and arsenic) in massive crystals in the Powers mine, in Russell district, is noteworthy. From the Wood mine, in Leavenworth gulch, a small pocket of pitchblende or uraninite was obtained by Mr. Richard Pearce, who first noticed it in the refuse of the dump. Aurichalcite is reported by Dr. Genth in connection with zinc minerals, cobellite by Dr. Loew, and melaconite by Dr. Peters with copper minerals.

The following minerals are reported from this county by J. Alden Smith and Dr. Endlich, but no analyses are given: Allophane, azurite, calamine, chalcanthite, cerargyrite, copper (native), garnet, gold (in crystals), goslarite, greenockite, jarosite, lievrite, magnesite, magnetite, magnetic pyrite, marcasite, mispickel, molybdenite, selenium, siderite, smithsonite, sulphur (native), tourmaline, willemite, wolfenite, zincite, and a variety of uranium minerals.

Mining districts.—The mining districts, like the county, are extremely small, and their limits not definitely known. The Gregory district includes the mines in the immediate vicinity of Black Hawk and Central, the most important being the Bobtail, which is the richest and largest producer, although worked on a length of only 800 feet. On the Gregory lode claims have been located over a length of 4,500 feet, but actual explorations cover an extent much less than half of this. It is expected that these two lodes, together with the Bates (which lies to the northwest of the Gregory and nearly parallel to it), whose courses are convergent, will all unite to the southward in the Mammoth lode. Nevada district, which lies to the west of the Gregory, takes in the head of Nevada gulch, and includes the California, Kansas, Burroughs, and other lodes. The Russell district lies to the south of these, in Russell gulch. The number of mines is too great to admit of any special mention, but the following table gives the data furnished by specimens collected by the census experts:

Mine.	Country rock and remarks.	Ore and gangue.
NEVADA DISTRICT.		
American Flag	Gneiss rich in biotite	Galena, copper, and iron pyrites, and some zincblende, cemented by quartz.
California	Granite-gneiss impregnated with pyrite. A dike of quartz-porphyry 2 feet thick on the hanging wall.	Pyrite, chalcopyrite, zincblende, and galena, with siliceous cement; in some portions gray copper.
Hidden Treasure	Same walls as in the California mine	Chalcopyrite and dark blende. Gangue: altered country rock.
Jones	Fine-grained granite	Dark blende, with pyrite, and some chalcopyrite. In one case these are deposited on both sides of a thin fragment of granite-gneiss.
Kansas	Biotite-gneiss; fresh on foot wall, altered on hanging wall	Fine-grained mixture of pyrite, chalcopyrite, and fahlerz.
Bennett's Kansas	Light granite-gneiss	Fine-grained mixture of pyrite and chalcopyrite, with siliceous cement, associated with fragments of wall-rock.
Kent County	Gneiss. On the hanging wall dark blende concentrated in the fissures.	Pyrite, chalcopyrite, galena, and dark zincblende, with quartz cement.
Lacrosse (Burroughs)	Fine-grained biotite-gneiss	Pyrite, with fragments of decomposed wall-rock.
Pyrenees	Dark gneiss rich in biotite	Massive galena, with chalcopyrite and pyrite; also fragments of wall-rock cemented by blende and pyrite.
Polk County	Hanging wall fine dark mica-schist	Chalcopyrite, with some pyrite cementing fragments of gneiss.

Mine.	Country rock and remarks.	Ore and gangue.
NEVADA DISTRICT—continued.		
Sayr-Burroughs	Fine-grained gneiss	Fragments of wall-rock with a little pyrite, or massive pyrite with siliceous cement.
West Flack	Gneiss	Pyrite and chalcopyrite, with quartz.
Forks	Reddish granite	Coarse pegmatite impregnated with galena, pyrite, and chalcopyrite.
GREGORY DISTRICT.		
Bobtail	Fine-grained compact granite-gneiss, partly schistose on the foot wall.	Chalcopyrite, with some pyrite, cemented by quartz.
Cashier	Granite-gneiss impregnated with pyrite	Quartz and pyrite.
Centennial tunnel	Gneiss	Chalcopyrite and pyrite in altered country rock.
German	Gneiss	Pyrite and chalcopyrite with quartz.
Minnie	Felsite-porphyry impregnated with pyrite, and carrying fragments of Archæan rocks.	Porphyry heavily impregnated with pyrite.
Smith Wain	Gneiss	Massive mixture of pyrite, chalcopyrite, zincblende, and galena. Gangue: altered country.
United Gregory	Amphibolite foot wall	Pyrite and chalcopyrite. Gangue: altered country.
RUSSELL DISTRICT.		
Haseltine	Apparently gneiss	Mixture of pyrite and fluorite; galena and fahlerz occasionally present.
Powers	Gneiss	Massive enargite, with pyrite and fluorite.
Silver Dollar	Micaceous gneiss	Enargite, fahlerz, and pyrite. Gangue: feldspar and quartz.
Wyandotte	Gneiss. A porphyry dike occurs near the mine	Pyrite. Gangue: quartz and feldspar.
ENTERPRISE AND MOUNTAIN-HOUSE DISTRICT.		
Cyclops	Gneiss. Gangue: fine-grained white quartz-porphyry	Mixture of galena, blende, chalcopyrite, and occasional ruby silver. Gangue rock: white porphyry.
Fannie	Gneiss	
Toronto	Granite. Altered porphyry occurs at 70 feet distance	Decomposed granite, in which cerussite and chlorides have been deposited.
ILLINOIS CENTRAL DISTRICT.		
Egyptian	Gneiss	Pyrite, with copper and arsenical pyrites and zincblende. Gangue: quartz and feldspar.
HAWKEYE DISTRICT.		
Hard Money	Altered gneiss	Massive galena, with some cerussite and zincblende. Gangue: bleached and kaolinized country rock.
EUREKA DISTRICT.		
Gunnell	Altered gneiss	Massive chalcopyrite and pyrite. Gangue: altered country rock.
QUARTZ VALLEY DISTRICT.		
Boss	Altered and stained gneiss	Cerussite; alteration products of galena, with stains of copper. Gangue: altered country rock.

CLEAR CREEK COUNTY.

Clear Creek county lies to the south of Gilpin, and is considerably larger than the latter, having an area of 460 square miles. It extends from the western boundary of Jefferson county to the crest of the Colorado range, and is, next to Lake county, the largest producer of silver in the state. Its mines lie mainly among the steep rocky spurs between the various tributaries of the main Clear creek, but it includes also the Geneva district across the divide on the south, at the head of the Geneva creek, a tributary of the South Platte. Like Gilpin county, this county lies in the Archæan formation, the rocks being mainly gneissic, with subordinate development of granite. Porphyry dikes seem much more frequent than in Gilpin county, but this may be due in part to the steepness of the mountain slopes, on which the character of the country rock is more readily distinguished. The veins, like those of Gilpin county, seem to be mainly alterations of the country rock along a jointing or fault-plane, and are frequently in direct connection with the porphyry dikes, which form either one of the walls or constitute the vein material itself. In some cases also the vein seems to be an impregnation of a pre-existing pegmatite vein in the gneiss.

MINERALS.—The ores of Clear Creek county are essentially silver-bearing, the silver being derived from argentiferous galena, and in part from fahlores. In the eastern or lower portion of the district, where the earliest developments were made, the ores are, however, mostly pyritiferous, and contain relatively little galena, hence yield both silver and gold. In the upper districts, around Georgetown, they are mainly silver-bearing. The rich ores are smelted directly, and are generally sent out of the district for this purpose. A very considerable proportion of the product is, however, concentration ore, which is generally an impregnation of the country rock at a greater or less distance from the main crevice. This impregnation seems to take place by preference on one side of the vein, and this is generally the foot wall. These ores are concentrated, as a rule, in Georgetown, and the concentrates are sold to smelters. A relatively small proportion of the oxidized portion of the deposits, especially those which are comparatively free from lead and zinc, are suitable for milling. There is no doubt that this district contains an unusually large proportion of valuable veins; but their development has been incommensurate with the intrinsic value of the deposits for various reasons, among which are pernicious systems of working and the abundant cases of litigation arising from the close vicinity of the veins to each other and their frequent crossings. A very large proportion of the more important mines were closed at the date of visit, and consequently the returns obtained by the expert are far from complete. Under these circumstances it were useless to attempt to form any generalizations on the direction or interdependence of the veins as a whole.

Besides the ordinary metallic sulphurets, the following minerals are reported as occurring in the county:

Anglesite, argentite, azurite, bornite, bournonite, calamine, caledonite, chrysocolla, fahlerz, garnet, minium, proustite, psilomelane, pyromorphite, silver (native), stephanite, sternbergite, stibnite, tennantite, tetrahedrite.

The following table gives the character of ore and country rock of the mines from which specimens were obtained:

Mine.	Country rock and remarks.	Ore and gangue.
BANNER DISTRICT.		
First National	Mica-gneiss; finely bedded on hanging wall; iron-stained and schistose on foot wall.	Quartz, stained reddish and yellow by iron oxide.
Big Chief	Mica-gneiss, containing on the foot wall a number of small pink garnets.	Pyrite, chalcopyrite, fahlerz, and chalcosite, with quartz matrix. Gangue: altered gneiss.
Nathan	Gneiss	Crumbling iron-stained mass with no recognizable minerals; probably altered country rock.
CASCADE DISTRICT.		
Muscovite	Hanging wall granite-gneiss; foot wall decomposed gneiss and felsite-porphyry.	Stained breccia-like mass, with no distinct metallic minerals visible.
CORRAL AND TRAIL RUN DISTRICT.		
Donaldson	Hanging wall iron-stained gneiss; foot wall grayish compact felsite.	Pyrite in quartz; smelting ore contains fahlerz; pyrite thoroughly decomposed constitutes free-gold ore. Gangue: altered gneiss.
Brooklyn	Gneiss	Pyrite and chalcopyrite with fahlerz. Gangue: quartz and feldspar.
GENEVA DISTRICT.		
Baltic	No specimen	Pyrite, chalcopyrite, blende, fahlerz, and a little galena in siliceous gangue; occasional pink calcite crystals.
GRIFFITH DISTRICT.		
Burleigh Consolidated Hercules Diamond Dunderberg Equator Junction	Gneiss, passing on one side into granite; on the other, into schists	Chiefly massive galena and chalcopyrite.
Colorado Central	Porphyry and gneiss (*a*)	Chalcopyrite and argentiferous galena.
IDAHO DISTRICT.		
Champion	Altered gneiss	Chalcopyrite and blende. Milling ore: altered country rock impregnated with particles of pyrite.
Gem	Indistinctly bedded gneiss	Arsenical fahlerz with azurite and malachite. Gangue: altered country rock.
Idaho tunnel	Hanging wall mainly white orthoclase; foot wall gneiss	Galena, zincblende, and pyrite deposited on hanging wall rock.
Victor	Gneiss indistinctly bedded	Zincblende, pyrite, etc., altered in high grade ore to a stained decomposed mass. Gangue: altered country rock.
IOWA DISTRICT.		
Mackey	Gneiss	Ore and gangue specimens both granite-gneiss, the gangue specimen having more visible pyrite than the pay ore.
MONTANA DISTRICT.		
Free American	No specimen	Galena, pyrite, and barite.
Murray	White granite whose mica is altered to a light greenish substance	Galena, pyrite, and chalcopyrite. Gangue: altered country rock.
Joe Reynolds	Foot wall mica-gneiss; hanging wall pegmatite vein	Galena. Gangue: quartz and feldspar.
MORRIS DISTRICT.		
Albro	Gneiss	Pyrite, chalcopyrite with some fahlerz. Gangue: quartz and feldspar.
Alexander	Gneiss	Galena, pyrite, chalcopyrite, and possibly fahlerz. Gangue: quartz and feldspar.
Eagle	Gneiss	Seems to be mainly country rock impregnated with chalcopyrite and other minerals invisible to the eye.
SEATON DISTRICT.		
Tropic	Gneiss impregnated on foot wall with pyrites	Brilliant mass of zincblende, with galena, fahlerz, and pyrite; concentration ore wall-rock more or less impregnated with these minerals and carrying calcite.
SPANISH BAR DISTRICT.		
Fairmount-Shafter	Gneiss impregnated with pyrites more abundantly on the foot wall.	Galena, pyrite, and pyrolusite. Gangue: feldspar in large individuals.
Freeland	Gneiss varying in depth from a hornblendic variety to a feldspathic.	Fine-grained mixture of pyrite and chalcopyrite; relative richness depending on proportion of latter. Gangue: altered country rock.
Hukill	Much decomposed gneiss	Pyrite and bornite in siliceous gangue.
Mayflower	Schistose gneiss of varying character	Pyrite and galena, with some fahlerz and zincblende either massive or mixed with siliceous gangue. Gangue: altered country rock.

a Porphyry assays 0.033 to 0.083 ounce of silver per ton, with a trace of gold.

Mine.	Country rock and remarks.	Ore and gangue.
UPPER UNION DISTRICT.		
Fred Rogers	Gneiss	Chiefly massive chalcopyrite.
Neith	Gneiss	Chiefly massive chalcopyrite.
Pioneer	Gneiss	Chiefly massive chalcopyrite.
VIRGINIA DISTRICT.		
Lake	Gneiss	Massive galena, chalcopyrite, and pyrite, with a little fahlerz. Gangue: altered country rock.
Specie Payment	Gneiss	Rich ore, pyrite in quartz; second-class ore, gneiss impregnated with pyrites.
White Cloud	Gneiss on hanging wall	Pyrite with a little galena in quartz; low-grade ore, gneiss impregnated with pyrites.
YORK DISTRICT.		
Clifford	Gneiss. Slickensides occur	Galena and zincblende. Gangue: altered country rock.

SUMMIT COUNTY.

By the recent cession of the lands of the Ute reservation a large area of the mesa region of the Colorado plateau country between the White and Grand rivers, extending as far west as the boundary of Utah, has been added to what was originally a small mountain county. This new region, with the exception of the White River plateau, at the head of the White river, in which Palæozoic rocks, cut through and partially covered by basalts, are exposed, is mainly covered by Tertiary beds, and offers little prospect of metallic wealth.

As originally constituted, the eastern end of Summit county adjoins Clear Creek and Park counties, the crest of the Colorado range separating it from the former, and the cross range connecting this with the Mosquito range and dividing the two parks from the latter, and includes a portion of the Park range, consisting of the northern end of the Mosquito range and the Gore mountains, together with the valleys of the Blue river on the east of these mountains, and of Eagle river on the west.

The high mountain portion of the county is mainly composed of Archæan rocks, but along the valley of the Blue there are fragmentary beds of Mesozoic and Palæozoic rocks which have escaped erosion, relics of a former connection of the Mesozoic seas which filled the South and Middle parks. These rest on the Archæan of the Park range, and are repeated on its west side, the Park range probably having been lifted up by the great fault movement which is so well defined in the Mosquito range. Along the upper portion of Eagle river there are Palæozoic beds dipping north and resting on the Archæan of the northern end of the Sawatch, which, as one goes westward down the stream, gradually pass under the succeeding higher Mesozoic beds, and are finally lost under the Tertiary of the lower Grand and White rivers. Associated with the lower beds is a very considerable development of Secondary eruptive rocks, which are very inadequately represented on the existing geological maps of this region.

The lofty mountain crests which bound the county on the east have hitherto been a serious barrier to the development of its ores, which, though frequently occurring in large masses, are on the average of low grade, and cannot support heavy freight or reduction charges. The recent advent into the valley of the Blue river at Frisco of the Denver and Rio Grande road promises to ameliorate this condition of things to a limited extent; but its circuitous course, which necessitates the carrying of freight from here to Denver over five times the actual distance in a straight line, still involves relatively high freight charges on supplies and ore.

In this county there is a marked connection between the prevalence of eruptive rocks of Secondary or Mesozoic age and the richness and magnitude of the ore deposits. These are not only found in the Archæan and Palæozoic systems, but also extend up as high as the Trias. As yet none of value are known to occur in the Jurassic or Cretaceous formations.

MINING DISTRICTS.—The oldest mining districts are those in the neighborhood of Montezuma and Peru, near the head of Little Snake river, the east fork of the Blue, their veins belonging to the same mineral belt as those of Georgetown, in Clear Creek county, and of Geneva gulch and Hall valley, in Park county, from which they are respectively separated only by the intervening curving crest of the Colorado range. The deposits occur in the Archæan rocks, and consist mainly of argentiferous galena and sulphurets. Several presumably valuable mines have been developed in the district, and small smelting works have been erected, with the usual want of success attendant on small capital and a limited supply of ore. No report was furnished from this district.

Numerous ore bodies have been found at the head of the Blue river, where the Palæozoic and Triassic formations have been extensively traversed by intrusive sheets of Secondary eruptive rocks. These eruptions have undoubtedly caused considerable local metamorphism of the sedimentary beds, which have further been extensively dislocated by a complicated system of faults, so that, without a careful study in the field, it is impossible to definitely determine the geological horizon of any individual deposit. The principal developments have taken place near Breckenridge, on the northwestern slopes of mounts Hamilton and Guyot.

Reports are at hand from the Helen mine, in the Bevan district, in French gulch, whose ore body is an impregnation of quartzite, called a vein, striking NNE. and dipping 60° to the southward, and some 45 feet in width. The ore is free gold, with some silver in a quartzite, iron-stained by the leaching out of the pyrites which it originally contained.

In the McKay district the Naperville mine has a deposit of argentiferous galena and carbonates occurring between an overlying porphyry and an unreported sedimentary bed below.

The Monte Cristo mine, on the slope of Quandary peak, west of the upper valley of the Blue, is a deposit of low-grade galena, with some zincblende impregnating the Cambrian quartzite. This deposit is exceptionally favorably situated for mining, the quartzite bed in which it occurs dipping eastward at the same angle as the spur of the mountain, and the overlying white limestone and succeeding rocks above having been eroded off so that it forms the actual surface of the hill and can be quarried out. In spite of its low tenor in silver, said to average 15 ounces to the ton, it seems that under proper management the mine ought to be made to pay. Veins have been discovered at many points in the Archæan rocks that form the sharp crest of the Mosquito range, often in the most inaccessible localities; but during the census year, so far as could be discovered, none were in the condition of producing mines.

Ten-mile district, between the heads of Ten-mile creek, a fork of the Blue river, and of Eagle river, is at present the most important mining region of the county. The ores occur mainly in the Upper Carboniferous limestones and in the sandstone beds immediately above them. These lie at the western foot of the Archæan mass which forms the sharp, jagged crest of the Mosquito range, and which has been lifted up by the movement of the great Mosquito fault. An area here of some 10 miles square has been the scene of most wonderful eruptive activity during or at the close of the Mesozoic epoch. In number and size the intrusive bodies of porphyry and porphyrite which occur in these sedimentary formations, either as interbedded sheets, as dikes, or as intermediate irregularly transverse bodies, exceed even those of the neighboring region of Leadville. Between these two districts, but nearer that of Ten-mile, occurs a Tertiary eruptive mass of the rather uncommon rock nevadite, or crystalline rhyolite. Although but a portion of the probable ore-bearing area has yet been prospected, the quantity of metallic minerals found here is remarkable. Unfortunately for the prosperity of the district their quality is not so satisfactory, as they mostly run very low in silver and are extremely refractory, consisting mainly of pyrites, with a very considerable admixture of zincblende. The ore deposits mostly occur in the thin beds of limestone, which are prevalent in this formation, at or near their contact with an overlying micaceous sandstone. Less frequently they are found in actual contact with an intrusive bed of porphyry, and at other times impregnating a dike of porphyry which traverses the sedimentary formations.

The most important and the typical mine of the district is the Robinson. Its ore is an argentiferous galena of exceptionally high grade, associated with pyrites and some zincblende. It occurs at or near the surface of a bed of bluish-gray limestone, overlaid by a white micaceous limestone, dipping northward at an angle of about 17°. The ore seems to be an actual replacement of the country rock. The upper layer, locally called "white iron", which is a mixture of fine-grained crumbling pyrites with white mica, nearly free from galena, seems to be a replacement of a portion of the overlying sandstone, and is practically worthless. Below this the ore consists of a varying mixture of galena and pyrites, extending at irregular depths into the limestone, and in the larger bodies occupying nearly its whole thickness. The ore chute, whose maximum width is 100 feet, has been traced over a linear extent of 1,000 feet, following the general direction of the dip. A line of fracture, probably a fault-plane, may be observed in the roof following the line of the ore body, *i. e.*, a vertical plane at right angles to the line of strike. It seems probable that this fault-plane furnished the channel through which the ore solutions reached the limestone, inasmuch as pyrites extend apparently into the fissure as far as it has been opened, and in the portions of the limestone adjoining there is no mineral matter at its contact with the overlying sandstone at a little distance from the ore body. Small bodies of mineral have also been found in the limestone along the line of several minor fault-planes, which are also at right angles to the line of strike, and whose displacement amounts at most to a few feet. The Wheel of Fortune, on the summit of Sheep mountain, at the foot of which the Robinson mine stands, has an extremely rich body of silver ore in the same or an adjacent limestone stratum and adjoining an irregular transverse body of white porphyry.

On Elk mountain ore occurs over a very large area in a thin bed of limestone at a higher horizon than that of the Robinson. This ore is a similar mixture of pyrites and galena, oxidized near the surface, and sometimes to considerable depths along certain lines, with unaltered sulphurets on either side. This almost continuous body has been developed by the adjoining claims of the White Quail, Aftermath, Milo, Badger, Raven, Eagle, and Colonel Sellers to an extent of over 2,000 feet along the strike and 700 to 800 feet on the dip. While a great portion of this immense mass is too poor in silver to pay for working, as an instance of widely extended ore deposition it is certainly remarkable. Where the same bed crosses the north end of Sheep mountain, a mile or two to the eastward, beyond an intervening gulch, similar great bodies of pyritiferous ores, with more or less argentiferous galena, are found in the Snowbank, Nettie B., Triangle, and other mines.

Ore is found following the limestone horizons at higher levels and extending probably up into the Triassic formation. In one portion of the district, called Copper mountain, copper minerals are associated to some extent with the iron pyrites.

The Pride of the West, on Jacque mountain, is a type of the deposits which follow a narrow dike of porphyry. Here the vein mass, which is from 6 to 30 feet in thickness, crosses the formation diagonally and stands nearly vertical. It is an iron-stained quartzose mass, through which run seams or veins of barite parallel with the walls, one being particularly persistent, and in connection with which the richest mineral is found. Where the siliceous gangue material is sufficiently unaltered it is found to be a decomposed quartz-porphyry. Another example of the type is the Little Chicago, which follows a dike of decomposed porphyry. This vein or dike yields an abundant supply of water, which is milky, from suspended particles of kaolin. Small jets of water from the adjoining rock also deposit hydrated oxide of iron, but the bodies of mineral as yet developed have been small and at widely separated intervals.

On Eagle river, in the neighborhood of Red Cliff, deposits of argentiferous galena and cerussite, associated with iron oxides, are also found in limestone, sometimes between it and an overlying white porphyry, and again with a limestone hanging wall and a quartzite foot wall. These limestone beds belong to the Palæozoic system, and are probably Carboniferous in age; but whether, like those of Ten-mile, they are in the upper portion of the Carboniferous, or, like those of Leadville, in the lower, is not known, nor is it of any practical importance. They are said to be very much broken and faulted. This district, as well as that of Ten-mile, is now reached by the Denver and Rio Grande railroad, and its ores are treated at Leadville or by some of the smelters on the plains.

PARK COUNTY.

Park county embraces the broad mountain valley of the South park, its boundary running along the crest of the Mosquito range on the west, and of the irregular chain which separates it from the Middle park on the northwest. It includes also, on the northeast, a portion of the Colorado range lying to the south of Clear Creek and to the west of Jefferson county. The valley plains are covered by sedimentary deposits of Mesozoic age, which, with underlying and conformable Palæozoic formations, slope up to the crest of the Mosquito range on the west, but are cut off abruptly against the Archæan on the east, probably by a fault. The coal beds of the Upper Cretaceous are thus included in this area, and have been extensively developed in the neighborhood of Como. Near Hamilton there are deposits of hematite iron ore, whose exact geological horizon is not known, and which have been but irregularly developed. Besides the less precious minerals, there are salt springs in the southern portion of the park, from which at one time rock-salt was obtained, and which probably originated in deposits of this mineral in the Triassic rocks. There are also indications of copper in the sandstones of the Trias, in the form, usual in these strata, of impregnations of carbonate of copper accompanying plant remains. As yet none have been discovered of economic value. Minerals carrying the precious metals have thus far been developed only in the Palæozoic formations, with their accompanying porphyries of Mesozoic age, and in the underlying Archæan.

In the northeastern corner of the county are the Hall Valley and the Geneva districts, whose deposits properly form part of the Clear Creek belt of silver-bearing ores and occur in the same gneissic formation. The Whale lode, in the latter district, is one of the most characteristic. The country rock is here a fine-grained gneiss, with a general strike of north and south and a steep dip to the west. It is intersected by numerous veins of pegmatite composed largely of feldspar. The lode itself runs northeast and southwest, dipping to the northwest at an angle of 65°, and is a thin vein, consisting mostly of barite, carrying also fluorite and quartz, with irregular bunches of galena and gray copper, and often separated from the adjoining portions of the lode by a clay gouge. This vein varies from an inch to 3 feet in thickness. The crevice of the lode is between 5 and 10 feet in width, and outside the above-mentioned vein consists of altered gneiss, more or less impregnated with pyrite, galena, zincblende, and a decomposition product. The pyrite is said to be confined to the decomposed wall-rock, and seldom occurs in the vein proper. There are numerous other veins in the vicinity of this lode which are also characterized by the occurrence of barite as gangue material. The Treasure Vault is said to have produced bismuth-silver ore.

The principal mineral developments of the county have taken place along the eastern slopes of the Mosquito range, and have been mainly derived from Palæozoic rocks, since, although numerous small deposits of gold and silver have been found in the underlying Archæan, which is exposed near the crest of the range and in the deeper cañons, and many interesting minerals have been obtained from them, no ore deposits of considerable value have yet been found in this formation.

The Palæozoic system here consists of the following series, commencing at the bottom:

	Feet.
Cambrian quartzite	200
Silurian or White limestone	200
Lower Carboniferous or Blue limestone	200
Middle Carboniferous or Weber grits	2,000 to 2,500
Upper Carboniferous, consisting of limestones, sandstones, and conglomerates	1,000 to 1,500

These formations, as well as the underlying Archæan, have been traversed by eruptive rocks of Secondary age, mainly quartz-porphyries and porphyrites, which, in the Archæan, occur generally in the form of irregular dikes, but in the Palæozoic system are mainly spread out in intrusive sheets between the beds. There is a marked connection between the prevalence of these eruptive masses and the development of mineral deposits. Indeed, in many cases here, as in the Leadville region, it is evident that the ore bodies are a concentration of the metallic minerals originally disseminated through the masses of these bodies and now deposited along their plane of contact with the sedimentary beds, and extending more or less into the mass of the latter. The type of these deposits may be found in mounts Lincoln and Bross, where most valuable and extensive ore bodies have been developed in the Moose, Russia, Hiawatha, and other mines, which enjoy the further distinction of being the most elevated mines in the country, their altitude varying from 13,000 to 14,000 feet. The ores are mainly argentiferous galena and its products of decomposition, carbonate and sulphate of lead and chloride of silver. Barite is a frequent gangue material in the richest portion of the deposit. Pyrite also occurs with the ore, but is generally decomposed and changed to a hydrated oxide, associated with more or less oxide of manganese. These give to the mass of the ore, which frequently contains considerable mechanical admixture of clay, a red or yellow, or, where manganese predominates, a black color. The deposits occur in irregular bodies, often of great size, in the blue limestone, and generally near its upper surface. This blue limestone now forms the surface of the spurs of the mountain, sloping east at an angle of from 10° to 15°, but was originally covered by a sheet of quartz-porphyry, portions of which still remain on the highest parts of the peak. This quartz-porphyry, to which the local name of Lincoln porphyry has been given, is of a type so widespread throughout Colorado, and seems to be so intimately connected with the rich mineral deposits, that it is worthy of a detailed description. It is so thoroughly crystalline that it is often mistaken for granite. Its most striking, although not absolutely essential characteristic, is the occurrence of large porphyritic crystals of orthoclase of rather glassy appearance, with extremely well-defined faces, either in single crystals or Carlsbad twins, in size from a half inch to 2 inches in length. The ground mass is a crystalline mixture of two feldspars, in which plagioclase sometimes predominates, with mica or hornblende generally somewhat decomposed, and frequently a large amount of free quartz in double-pointed hexagonal pyramids, which often have the appearance of rounded grains. The quartz often has a pink tinge. The rock itself, taken comparatively fresh, is of greenish-gray color, but often bleached by decomposition or weathering. As to the age of the porphyry in this region, it can only be said that it is later than the Trias; but what is apparently the same rock is found in the Gunnison region, and between the North and Middle parks, breaking through the Cretaceous strata. It is, however, distinctly older than, and of a different character from, the Tertiary eruptive rocks.

The Dolly Varden mine of Mount Bross is a similar deposit of slightly different type. Its ore, which is mineralogically similar, occurs in the mass of the limestone in close proximity to a vertical dike of white quartz porphyry. The dolomitic limestone in which it occurs is the same as that in which the previously described deposits are found; and the ore has been traced to a vertical depth of over 100 feet, and in bodies extending from 40 to 50 feet on one side of the dike in the mass of the limestone. On Loveland hill, a spur next south of mounts Bross and Lincoln, are numerous deposits in the same blue dolomitic limestone, the best known of which is the Fanny Barrett, whose ore body stands vertically or at right angles to the stratification planes, and is probably deposited along a cross fissure or jointing plane.

In Buckskin gulch, between these two mountain masses, is the oldest mine of the district, the Phillips, which is an immense mass of auriferous pyrites, also carrying some silver, deposited in the beds of the Cambrian quartzite near a dike of quartz-porphyry. The Criterion mine, on the north wall of the gulch, is also in the Cambrian quartzite—an immense body of thoroughly oxidized material, whose original character cannot be determined, but which was probably a varying mixture of galena and pyrites, carrying both silver and gold. A porphyrite dike occurs near by. Colorado Springs mine, in the Red amphitheater on the southwest face of Mount Bross, is a rich deposit of galena along the bedding-planes of the white limestone. Here both diorite and quartz-porphyry are found traversing the sedimentary beds. The Sweet Home mine, near this on the cliff face, in the underlying Archæan, is principally interesting from the minerals which it has produced—combinations of silver with arsenic and antimony. From the Tanner Boy, also in the Archæan, on the opposite side of the gulch, beautiful rhombic crystals of rhodochrosite are obtained.

In Mosquito gulch, the Orphan Boy, once an important mine, is in quartzite underlying the limestone bed. The London mine, on London mountain, at the head of Mosquito gulch, has developed two strong veins of sulphurets, carrying both gold and silver, the one with a gangue of quartz, the other of calcite, which occur either in the Blue or White limestone in connection with an intrusive bed of White porphyry. These veins stand in an almost vertical position, as the beds in which they occur are turned up at a steep angle against the London fault, which crosses the formation diagonally, and by whose movement the Archæan rocks, which form the eastern half of London mountain, are brought up into juxtaposition with the Silurian and Carboniferous beds on its western point.

Southward the masses of intrusive porphyry diminish in extent, as do also the number of developed mineral deposits. Between Horseshoe and Sacramento gulches rich bodies of galena and carbonate ore, carrying silver, have been developed in the Sacramento mine, also in the Blue limestone, to the east of the London fault, from whose surface the original covering of quartz-porphyry has been denuded. On the west of the London fault the Peerless and Badger mines, the former at the very crest of the range, find their ore in the same limestone which here was covered by the White or Leadville porphyry.

Placer deposits.—The mountain masses bordering the South park on the north and west have, owing to the great elevation, been exceptionally exposed to glacial action. An enormous amount of detrital material has in consequence been accumulated in the valleys radiating out from them, which, when rearranged and concentrated, forms valuable placer deposits. The first placer gold was discovered in Tarryall creek in the fall of 1859, and placer mining has been carried on since that time with more or less vigor in the valleys of the Tarryall and of the Platte.

Near the town of Fairplay the banks of the Platte expose a thickness of over 50 feet of gravel, which has been extensively worked over by sluice mining, but is now abandoned. At present, active work is confined to the valley of the Platte opposite Alma, where hydraulic working is carried on and a gravel bed of over 60 feet in thickness on the east bank of the creek is being developed. Two important conditions for hydraulic mining on a large scale are present in the county: first, an enormous amount of gravel, and second, an abundance of water. It only remains to be practically proved whether these accumulations of gravel are sufficiently rich to pay for working.

LAKE COUNTY.

Lake county is of small area, having only 450 square miles of surface, and occupying only about 20 miles of the upper valley of the Arkansas, its boundary following the crest of the bordering ranges. Since the discovery of the Leadville mines it has become second only to Arapahoe county in population, and furnishes three-fourths of the precious-metal product of the state. Its western boundary is the Sawatch range, which is an Archæan mass in which granite predominates over gneiss, and which abounds in dikes of porphyry. The western slopes of Mosquito range on the east, and the hills on the north which form the water-shed between the Arkansas and Grand rivers, have a basis of Archæan granite and gneiss, more or less covered by remnants of the Palæozoic formations, already described in Park county, which have escaped erosion; and their lower position relative to corresponding beds on the eastern side of the Mosquito range is due in part to faulting and in part to flexure of the beds. Within these Palæozoic formations there is an enormous development of eruptive rocks, partly occurring as irregular dikes, but in the main as immense intrusive sheets, following the bedding-planes of the sedimentary rocks. Glacial erosion here, as in other elevated districts, has played an important part in the carving of the present mountain outlines, and in the flood period following the first cold maximum of the Glacial epoch a lake was formed, which occupied the head of the Arkansas valley, and was probably almost entirely included within the present boundaries of the county. The stratified gravel and sand beds which were deposited at the bottom of this lake now form terrace-like ridges bordering the present alluvial bottom of the Arkansas river. Whether the gold contents of these gravel beds, like those of California which may have had a similar origin, will be found to be, in any portion of them, sufficiently concentrated to be worked at a profit is a question which no steps have yet been taken to solve. The gravels resulting from the carving by erosion of the later-formed gulches have, however, been found to contain paying quantities of gold; and it was to the exceptional richness of those of California gulch, discovered in the spring of 1860, that the development of the enormous silver wealth of the Leadville region is indirectly due. Of late years the prominence given to silver mining has diverted attention from the gravel deposits, and their development has been practically stopped. It is probable, however, that a profitable field for hydraulic mining will be found in this county.

The mineral product of the county is mainly confined to the California mining district or the mines immediately adjoining Leadville, those of the outlying districts furnishing but a small fraction of the aggregate product. The ores are mainly argentiferous galena associated with zincblende, and, exceptionally, a little copper. They are essentially smelting ores, and their value is greatly enhanced by the fact that thus far they have been found in an oxidized condition, the lead occurring as carbonate, the silver as chloride, in a clayey or siliceous mass of hydrated oxides of iron and manganese. Here, even to a greater degree than in Park county, the main body of the ore is confined to the horizon of the Blue or Lower Carboniferous limestone, which is here invariably covered by an intrusive sheet of White or Leadville porphyry. The ore was at first supposed to be confined to the immediate contact of the limestone with the porphyry; but as developments have proceeded it has also been found to extend into the body of limestone sometimes to a depth of over 100 feet from its upper surface, and in such cases in large but very irregular deposits, as is characteristic of ore masses occurring in this rock.

Less important ore bodies, generally carrying gold rather than silver, are found at other horizons, either along bedding-planes or in gash veins crossing the stratification. Such are the Colorado Prince and Miner Boy, in the Cambrian or lower quartzite, and the Green Mountain, Tiger, and Ontario, in the Weber grits, or Middle Carboniferous. The first mine opened in the district, and the one which has produced the largest amount of gold, is the Printer Boy, which is a deposit of free gold with carbonate of lead and galena, passing in depth into auriferous copper and iron pyrites, which occurs in a body of quartz-porphyry along a vertical plane or pair of planes nearly parallel, either as cross-joints or fault-planes. The gangue material is simply a white clayey mass resulting from the decomposition of the porphyry itself, and, although at times exceptionally rich, the ore seldom shows any visible metallic minerals. The Palæozoic formations and accompanying intrusive beds of porphyry have been compressed into gentle folds and broken by a series of faults having a general north and south direction whose movement of uplift is as a rule to the east. The prevailing eruptive rock is the White or Leadville porphyry, which generally occurs above the Blue limestone, but is also in places found below it and at other horizons. Besides these there are other intrusive sheets of different varieties of quartz-porphyry, generally of extremely local development. Along the western end or lower portion of the spurs of the Mosquito range on which the mines are situated the actual surface of the ground is very largely buried to a depth of 100 feet or more beneath an accumulation of rearranged glacial or moraine material, locally called *wash*. The extremely complicated conditions resulting from this state of things renders it impracticable within the limits of the present sketch to give any detailed description of the geological structure of the district, and the reader is referred for this purpose to the memoir of the writer on "The Geology and Mining Industry of Leadville".

The most important groups of mines of the normal Leadville type, taken in the order of their development and of their relative distance from the valley, are as follows: (1.) Those of Fryer hill, which is the western extremity of a spur adjoining Evans gulch on the south, including the Chrysolite, Little Pittsburg, Little Chief, Amie, Climax, Dunkin, Matchless, and Lee mines. In these mines the ore bodies, which reach a maximum thickness of 90 feet, lie in an approximately horizontal position, and are included between two sheets of White porphyry. In some cases these ore bodies are split up by the porphyry into two or more distinct bodies. They are distinguished from the deposits in other portions of the district by the almost entire absence of the original limestone, of which they are a replacement. (2.) The mines of Carbonate hill, which adjoins California gulch on the north, include the Carbonate, Yankee Doodle, Crescent, Catalpa, Evening Star, Morning Star, Henrietta, Ætna, and Pendery. Of these the seven first-named follow the contact of the limestone and the overlying porphyry on its dip into the hill at an angle of from 15 to 25 degrees, and are east of Carbonate fault, which runs across the face of the hill, while the last two find the limestone at a lower level on the west side of the fault. (3.) To the west of Carbonate hill a second shoulder of the spur is Iron hill, which has been elevated to its relatively higher position by the movement of the Iron fault, which, like that of Carbonate hill, runs along its western base. Here the principal mines are those belonging to the Iron Silver Mining Company, which with the Smuggler, and, south of California gulch, the Rock and Dome, find their ore at or near the surface of the easterly dipping limestone, while the ore of the Silver Wave and Silver Cord, also on Iron hill, and of the La Plata, in California gulch, is mainly found in approximately vertical but extremely irregular bodies extending down into the mass of the limestone. Other important mines of this type are (4) the Florence group, on Printer Boy hill, north of Iowa gulch; (5) the Long & Derry group, on the opposite side of the gulch, and on Breece hill (6) the Highland Chief group, overlooking Evans gulch. On Yankee hill are the Andy Johnson, Chieftain, Scooper, and others. While in Stray Horse gulch the Double Decker and adjoining mines have gold ore in the lower quartzite, the Adelaide and Argentine find carbonates of lead at the contact of the White porphyry and the upper portion of the Silurian formation.

MINERALS.—The most common minerals are cerussite, anglesite, pyromorphite, and galena; chloride, chloro-bromide and rarely iodide of silver; iron, generally as hydrated sesquioxide, but in the Breece iron mine as red hematite and magnetite, also in the deeper workings in the form of pyrite; manganese generally as a sort of wad, and frequently also as pyrolusite; zinc as calamine or silicate, and in depth as zincblende; bismuth as sulphide and as sulpho-carbonate in the Florence mine; vanadium as dechenite, or vanadate of lead and zinc, in the Morning Star and Evening Star mines. More rarely, native sulphur is found as a decomposition product of galena; also native gold and silver in the limestone deposits. Arsenic and antimony show themselves in the products of the smelters, the former very persistently, but are seldom found as definite minerals in the ores.

Outside the California district, the principal mine is the Homestake, on Homestake peak, in the northwestern corner of the county, which was developed before the discovery of the silver ores of Leadville. It is a rich body of argentiferous galena in Archæan gneiss, and is said to have produced at one time a considerable quantity of nickel ore in the form of an arsenical nickel mineral supposed to be gersdorffite. A number of less important mines have been developed along the western slopes of the Sawatch range in the Archæan which have produced small quantities of pyritiferous ores carrying galena. Their main value lies in the silver which they contain, which is also accompanied by a certain amount of gold. They are mostly reduced in the amalgamating mills which have been erected at Leadville for treating the few siliceous ores of the district which are free from lead. The comparative poverty of the mineral deposits of this district in gold is remarkable when one considers the exceptional richness of many of its placers. In the normal silver deposits of Leadville gold is present, if at all, in very minute quantities; so that it is not detected by the assayer, but is only found concentrated in the bullion. That it exists, however, is proved by its having been found occasionally in the state of native gold in the limestone deposits; for instance, in those of the Florence mine.

GUNNISON COUNTY.

Gunnison county lies to the west of Lake and Chaffee counties, its eastern boundary being formed by the crest of the Sawatch range. It originally included only the mountainous country connected with this range and the group of the Elk mountains which branch off from it in a northwesterly direction. Since the recent cession of the lands of the Ute Indian reservation it also includes a large portion of this reservation in the Colorado plateau region, extending to the boundary of Utah. Its present area of 11,338 square miles is greater than that of any county in the state.

The plateau region, as yet comparatively unexplored, is mainly occupied by nearly horizontal beds of Cretaceous and Tertiary age. Except, therefore, where the underlying Archæan rocks have been exposed by deep erosion, or the later formations have been traversed by masses of eruptive rock, this region affords little promise of return to the prospector in his search after deposits of the precious metals. In the eastern mountainous region, on the other hand, the geological conditions are such as to lead one to expect widespread and important deposits of metallic minerals. Owing to its isolated condition, being separated from the rest of Colorado by high mountain ranges whose lowest passes are over 10,000 feet high, and having been but recently reached by lines of railroad, but few actually producing mines have yet been developed within its limits. In spite of the fact that it is penetrated by two lines of railroad, the Denver and Rio Grande and the Denver and South Park, its conditions would be unfavorable for the treatment of low-grade ores—the true source of wealth of a mining region—on account of the high grades which have to be overcome by these roads in reaching it, and which, therefore, enhance the cost not only of supplies, but of the movement of ore and fuel, were it not for the fact that it contains within itself the means for treating its own ores at low cost in its coal beds, which are not only exceptionally well situated for mining, but are of a quality probably superior to any on the eastern slope of the mountains. On the completion of the extension of the former road to Utah it will have an additional outlet in that direction, free from the drawback of exceptionally heavy grades.

The geology of the western slope of the Rocky mountains presents certain contrasts to that of the eastern. In the latter region, although along certain shore-lines, by unequal erosion, beds of different horizons are found abutting against the underlying Archæan, in general the lowest Cambrian beds are those which rest directly upon it. In the western region, on the other hand, erosion discloses crystalline gneisses and granites, presumably belonging to the Archæan, in direct contact with horizons as high as the Cretaceous, and at points far removed from any well-defined shore-line. The sedimentary beds also differ somewhat in lithological constitution, and are, as a rule, considerably thicker than corresponding beds on the eastern slope. Again, the coal-forming period, which on the eastern slope was at the very close of the Cretaceous (or, as some have maintained, at the commencement of the Tertiary), in the western region, to judge from the testimony of the thickness of beds overlying it, occurred considerably before the close of this epoch. The ore deposits also, which there are found mainly in the Archæan or Palæozoic formations, in the Gunnison region are found to occur also in the Mesozoic formations even as late as the uppermost portion of the Cretaceous. The bituminous coals of the Cretaceous formation, which are generally called *lignites*, but not it seems with absolute propriety, are here locally transformed into semi-bituminous and even into anthracite coals of excellent quality.

The geological structure of the Elk Mountain region is one of such extreme complexity that only the barest and most general outlines can be presented in the limited space here allotted. According to Mr. W. H. Holmes, its structure is that of a great fault-fold, *i. e.*, an anticlinal fold, running generally with the axes of the range and broken along its crest by a fault, the eastern slope of the anticlinal being relatively gentle, but the western so steep that in one portion the beds are actually inverted. Of the sedimentary beds involved in this fold only the Carboniferous, Trias, and Jura have escaped erosion in the higher portion of the mountains, while the Cretaceous beds are left along its flanks. In the center of this fold Mr. Holmes places a mass of eruptive granite. The writer has had no opportunity of verifying Mr. Holmes' observations in the center of the range, but is quite ready to accept his solution of the structural problems involved, while making a mental reservation as to the existence of eruptive granite at this point. From observations made during a hasty visit to the southern slopes of the range along Slate creek and the heads of Ohio and Anthracite creeks he is inclined to think that this eruptive body may belong, as do the eruptive masses there, to the porphyries of Mesozoic age and of the Mount Lincoln type, already described in the section on Park county. These rocks here break through the Cretaceous strata, not only in narrow and well-defined dikes, but in immense masses, forming entire mountains of most picturesque outline, of which Crested butte and Gothic peak form the simplest type, relics of nearly horizontal Cretaceous strata extending up their sides for several hundred feet above the bottoms of the present valleys. These porphyries in the region visited are indicated on the Hayden map either as eruptive granites or as Tertiary volcanic rocks. Since they break through the Cretaceous beds, they must have been erupted in post-Cretaceous times, but probably before the deposition of any distinctly Tertiary beds, and their mode of occurrence and lithological characteristics are quite different from those of Tertiary volcanic rocks. The intrusion of such enormous masses of molten material has produced an extensive and widespread metamorphism of the sedimentary beds, and may probably account for the change of the bituminous coals to anthracite.

The Elk mountains are evidently of later age than the Sawatch, and, very possibly, even later than the Mosquito or Park range. The ore deposits of the Ruby district must be of post-Cretaceous age, since they traverse Cretaceous rocks; but as to the age of deposits occurring in the older rocks no data are yet at hand. Ore has been found in almost every portion of the Elk mountains and on the flanks of the Sawatch. The principal mining centers are Aspen, on the northeast slope of the Elk mountains, and Independence, on the west slope of the Sawatch, in the drainage of Roaring Fork; Ruby, Gothic, and a number of small towns on the southwest slope of the Elk mountains; and Pitkin and Tin Cup, on the southwest slope of the Sawatch. At Independence sulphuret ores carrying silver are found in the Archæan. The Gold Cup mine, near Alpine pass, in the Tin Cup district, occurs in a black, fine-grained limestone, not unlike the Carboniferous limestones of the Mosquito range. Its ore is a silver-bearing cerussite, associated with some oxide of copper in a ferruginous and siliceous gangue. Of the ore deposits occurring in the Cretaceous rocks in Ruby district the Forest Queen mine may be taken as a type. The vein material seems to be a decomposed porphyry; probably a narrow dike traversing the Cretaceous sandstones, and standing in an approximately vertical condition. The ore is largely ruby silver and arsenical pyrite, occurring in small crevices and fissures in the decomposed porphyry. The gangue material is sometimes simply an indistinctly banded quartz.

CHAFFEE COUNTY.

Chaffee county occupies the valley of the Arkansas river between the crests of its bounding ranges from the southern boundary of Lake county down to Fremont and Saguache counties, a little below the mouth of the South Arkansas. Its mountain slopes are composed of Archæan rocks, mainly granite, traversed by porphyry dikes, with occasional remnants of Palæozoic formations in the southern parts which have escaped erosion resting on their crests. The valley bottom, as in Lake county, contains stratified beds of gravelly formation and of recent date; but whether they are of the same age as the Lake beds of Lake county, or have been formed in the Tertiary period, is not yet definitely known. The more recent gravel deposits at the mouth of the larger cañons, as well as those along the bed of the Arkansas river, yield gold. The richest are those at Cash creek, which have been worked since the earliest discovery of minerals in this portion of the country.

Its mining districts have but few developed mines, hence data with regard to them are extremely meager. In the neighborhood of the town of Granite gold-bearing veins have been worked on the east side of the valley in former years. Near Buena Vista, also on the east side, is the Free Gold district, so called from the Free Gold mine, which is an auriferous quartz vein in a syenite containing abundant titanite. The foot-wall specimen differs from that of the hanging wall, which suggests the possibility that the vein may be on a fault-plane.

The Chalk Creek district toward Alpine pass, on the opposite side of the valley, shows also syenitic country rock which contains a little quartz. The mines from which specimens were obtained are the Black Hawk, Mary Murphy, and Hortense. The vein material of the two former is a felsitic mass which may be a decomposed porphyry. In the ore specimen the only recognized minerals are pyrite and a black mineral which seems to contain manganese. The ore of the Hortense is a decomposed quartz-porphyry, from which some metallic mineral has been removed by solution.

The Monarch district is near the head of one of the branches of the South Arkansas river. The Monarch mine, from which its name is derived, is a limestone deposit, occurring between a dark-gray limestone above and a fine-grained white limestone below. The horizon of these limestones is not known, but it is very possible that they correspond to the Blue and White limestones of Leadville. The ore, like that of Leadville, is mainly cerussite or carbonate of lead. The Columbus mine, in the same district, occurs in granite, its ore consisting of fragments and crystals of quartz, cemented together by some metallic mineral colored red or yellow by oxide of iron.

DOUGLAS COUNTY.

Douglas county lies south of Arapahoe county, and extends as far as the divide between the Platte and Arkansas rivers and east of Jefferson county, including a portion of the Colorado range lying east of the Platte cañon. As is the case further north, this portion of the range is not yet found to contain valuable metallic minerals. The coal rocks, however, underlie the plain country east of the foot-hills, though as one approaches the divide they are more and more deeply buried beneath the Tertiary deposits of which this mesa-like ridge is formed. Their outcrops can be traced from the Platte cañon to the southern borders of the county, approaching nearer and nearer to the foot-hills as one proceeds southward.

In the neighborhood of Castle Rock are mesa-like ridges, which extend almost continuously to the eastward; but west of the railroad, and between it and the foot-hills, these ridges are broken by erosion into a series of isolated buttes, and are made up of gravel and coarse conglomerate derived from the Archæan formation, belonging to the Monument Creek Tertiary of the Hayden survey, whose age has not yet been determined. In the neighborhood of Castle Rock, and for some six or eight miles to the southward, the surfaces of these mesas are covered by a light pinkish-colored rhyolitic tufa, which forms an admirable building-stone, and has been very extensively used for this purpose in Denver. The outlines of this volcanic flow have not yet been accurately determined; it extends but a short distance east and west, and has an average thickness of about 20 feet.

EL PASO COUNTY.

More than half of the area of El Paso county, which lies to the south of Douglas, is plain country. Its western mountainous area includes the partially isolated mass of Pike's peak, separated from the main Front range by Ute pass and Manitou park, which once constituted a bay or arm of the Palæozoic sea.

The only mineral of industrial importance thus far developed is coal, of which working mines exist to the east of Colorado Springs. Prospectors after the precious metals on Pike's peak have, however, developed an extremely interesting series of minerals, of which those of the cryolite group may possibly prove of economic importance. The following are the species previously recognized:

Microcline, as green amazon stone and other colors; albite; biotite, var. siderophyllite; quartz, clear and smoky; fluorite; columbite; göthite; hematite and limonite as pseudomorphs after siderite; arfvedsonite; astrophyllite; zircon.

In addition to the above the following have recently been determined by the members of the Rocky Mountain division of the United States geological survey:

Topaz, phenacite, kaolinite, a peculiar green muscovite, cryolite, thomsenolite, gearksutite, and other fluorides not yet definitely determined.

FREMONT COUNTY.

Fremont county, which lies to the east of Chaffee and Saguache counties, includes the cañon valleys of the Arkansas after it bends to the eastward and a portion of the plain country beyond Cañon City. Its mountains have a base of Archæan, which in the western portion of the county is covered by Palæozoic formations, and on the north, toward the South park, by Tertiary eruptive rocks, with probably some older porphyrics. Along the foot-hills at Cañon City occur the upturned Triassic and Cretaceous rocks, which furnish valuable building-stones. A limestone of the Colorado Cretaceous, which is remarkably pure, is used in making lime and as a flux for smelting works. From less pure limestone above the Triassic hydraulic cement is made. From Jurassic and Lower Cretaceous beds in the plains, as well as in the valley of Oil creek, petroleum has been obtained, and several wells, some over 1,000 feet in depth, have been sunk. As yet no considerable concentrations of oil have been developed. South of Cañon City is a synclinal basin in which the Laramie beds have escaped erosion, and where valuable coal mines have been opened by the railroad companies.

CUSTER COUNTY.

Custer county lies to the south of Fremont, and comprises the Wet Mountain valley, lying between the Wet mountains or Greenhorn range on the east and the north end of the Sangre de Cristo range on the west. The former mountains are a southern continuation *en echelon* of the Front or Colorado range, and consist of Archæan rocks, mainly granite, with Mesozoic formations resting against its eastern base. This range is relatively low, and its slopes gentle, except where cut through by deep cañons. The Sangre de Cristo range, on the other hand, which is a southern continuation, also *en echelon*, of the Mosquito or Park range, is a lofty imposing chain, whose rugged outlines suggest a very different composition. It has not been examined by the writer, but presumably consists of the same Palæozoic rocks that are found in the Mosquito range, resting on an Archæan base and traversed by Secondary eruptive rocks, of which the so-called Sangre de Cristo granite, outlined on the Hayden map, is very possibly a variety. The Wet Mountain valley at its widest point comprises a distance of over 20 miles from east to west between the crests of these bounding ridges. The valley bottom lies near the west side of this depression, its Quaternary covering resting either on the Archæan, or on the eruptive rocks which have broken through it.

The principal mines have been developed in the neighborhood of the towns of Silver Cliff and Rosita, and an area of 10 miles east and west and 6 miles north and south includes the greater portion of these. In this area the underlying Archæan is broken through and covered by Secondary eruptive rocks, among which diabase is the only type which has as yet been definitely determined. To these eruptions have succeeded flows of andesite and rhyolite, which outcrop at Rosita and Silver Cliff.

The town of Rosita is situated near the eastern end of the district, in the midst of a group of steep hills with smooth rounded slopes, which project out into the valley from the Wet Mountain range. The town of Silver Cliff, about six miles west of Rosita, is situated on the open plain near a mesa-like ridge, on whose cliff face, from which the town derives its name, are found the silver deposits of the Racine Boy mine. The rock of which this cliff is formed is a light pinkish-colored rhyolite, showing the characteristic finely laminated or fluidal structure. In the town itself, and along the eastern edge of the cliff, are outcrops of a dark pitchstone, probably a hyaline variety of the rhyolite. Outcrops of granite are found on the plains between Silver Cliff and in the hills around Rosita, rendering it probable that the rhyolite rests directly on the underlying Archæan. A number of isolated hills rise out of these plains, the most prominent of which is Round mountain, on which is situated the Plata Verde mine, and about two miles to the northward are the Blue mountains, in which is situated the Bull-Domingo mine. The bottom of the valley, through which runs Grape creek, lies still to the west of Silver Cliff, and has a considerable extent of arable land.

ORE DEPOSITS.—The ore deposits of this region are in many cases rather exceptional in character, and have given rise to considerable speculation as to their origin. As yet, however, no systematic or exhaustive study has been made of them on which to found a definite and satisfactory classification. Most prominent and remarkable are the Bassick and the Bull-Domingo, each situated near the northern limits of the eruptive rocks, the former a short distance north of Rosita, the latter 7 miles westward, correspondingly situated with regard to Silver Cliff. The characteristic feature common to these two mines is that the ore is found in large bodies without any definite boundary, forming a coating on irregularly-rounded fragments of the country rock. A favorite method of accounting for this mode of occurrence has been that the ore cavities are old craters or solfataric openings, in which the fragments of country rock have been tossed about and rounded by attrition and coated by a deposition from metallic vapors and solutions. While the known facts with regard to these deposits are insufficient to afford a positive theory with regard to their origin, the evidence is decidedly against this somewhat startling hypothesis. The country rock of the Bull-Domingo mine is a hornblendic gneiss, and therefore probably belongs to the Archæan. The ore, which is mainly an argentiferous galena, forms a regular semi-crystalline coating from one-eighth to one-quarter of an inch in thickness around the bowlders and pebbles of country rock, and fills the irregular interstices between them. These pebbles are not in direct contact one with the other, but are separated by the metallic coating belonging to each individual pebble. The galena is frequently covered by a second botryoidal coating, probably of a siliceous nature. The deposit is from 40 to 60 feet wide, and strikes in a northwesterly direction. No fresh specimens of the country rock of the Bassick mine were obtained, and its exact nature is not therefore known. It is said to be the same on both sides of the deposit, and to be an eruptive rock. In this case it is probable that it is a breccia, and the ore is a replacement of the matrix. According to Mr. L. R. Grabill, (*a*) the deposit is an irregular opening, nearly elliptical, in horizontal sections from 20 to 100 feet in width, and standing generally vertical to the depth of present developments, *i. e.*, about 800 feet. The fragments of country rock which fill this opening vary in size from one and a half feet in diameter to the smallest dimensions. They are rarely, if ever, in actual contact with each other, while the metallic shells which surround them are tangent. The size of the fragments, as well as the quantity of ore or metallic mineral present, decreases from the center outward, without any definite limit having yet been determined. In the shell or metallic coating which surrounds these fragments Mr. Grabill distinguishes a series of concentric layers, the innermost and thinnest consisting of a mixture of sulphides of lead, antimony, and zinc, carrying about 60 ounces of silver and from 1 ounce to 3 ounces of gold to the ton. This layer is always present. A second coating, not always found, is lighter in color, and contains more lead, silver, and gold. The third shell is mainly sphalerite or zincblende, reaching a maximum thickness of 5 centimeters, which carries from 60 to 100 ounces of silver, and from 15 to 50 ounces of gold to the ton, with considerable iron, and some copper. This constitutes the principal pay-ore of the mine. The fourth coating, when present, is formed of chalcopyrite, but is much more irregular than the previous ones, and carries as high as from 50 to 100 ounces of gold and silver. Outside of these a fifth thin coating of pyrite crystals is occasionally found. All the layers have a more or less crystalline structure. The remaining interstices between the pebbles are filled with kaolin. Another singular fact connected with the deposit is the occurrence of small fragments of charcoal in cavities between the bowlders toward the outer edges of the ore body, and most commonly near the water-level. These are sometimes partially mineralized, and at others are perfectly unaltered and retain the woody structure. The greatest depth at which they have been found is 765 feet from the surface. The other minerals found in the mine are calamine, smithsonite, jamesonite, tetrahedrite, free gold, and tellurides of silver and gold in minute quantities.

Another type of deposit in the region fills more or less vertical fissures traversing the eruptive rocks which form the hill country around Rosita. The principal of these is the Humboldt-Pocahontas vein, running northwest and southeast, a short distance north of the town. The exact character of the country rock is not definitely known. This ore carries chalcopyrite and fahlerz, with a little siderite, in a gangue of barite.

The Racine Boy mine, near Silver Cliff, forms a third distinctive type, and seems to be an irregular impregnation of the country rock, the ore in general showing a little black staining of some manganese mineral as its only visible metallic constituent. Thin films of chloride of silver are sometimes distinguishable. This is a free-milling ore of comparatively low grade, but valuable on account of its great mass. Plata Verde mine has not been worked since its mill was finished, and no data are available in regard to the character of its deposit, which is, however, in rhyolitic rock. The ore is chloride of silver, with some sulphurets, impregnating the country rock. The Terrible mine, in the Archæan, is about 12 miles northeast of Silver Cliff, and has a foot wall of fine-grained iron-stained gneiss. The vein strikes N. 20° W., and dips 78° NE. Its ore consists of a massive cerussite, sometimes cementing fragments of wall rock, the gangue material being decomposed country rock. The Gem, a newly-opened mine some 12 miles north of this district, is interesting as having afforded specimens of a rich nickel ore. On Grape creek, in the northern portion of the county, a considerable body of titaniferous magnetite has also been discovered. Both these last-named deposits are probably in the Archæan.

Ore deposits have also been developed on the east slope of the Sangre de Cristo range about 7 miles west of Silver Cliff. The Verde mine has a vein striking N. 50° W., and dipping 60° SW., said to be in granite. Its ore is a mixture of pyrite and chalcopyrite, with fahlerz.

HUERFANO COUNTY.

Huerfano county, lying south of Custer and Pueblo, is largely a plain country, and only its eastern end, which includes Huerfano park, a southern continuation of the Wet Mountain valley, extends into the mountain region. The surface of the plain country, as well as the bottom lands of Huerfano park, which was a bay in the original Archæan shore-line, is covered by Cretaceous deposits; and it is only along the crests of the bounding ridges, the Wet mountain and the Sangre de Cristo, and near the eruptive mass of the Spanish peaks, that the rocks liable to carry metallic minerals are exposed.

The schedule reports furnish data from only a single mine, the Mountain Monarch, in the Third Judicial district. This mine is situated on the north slope of the West Spanish peaks, about 10 miles south of La Veta. Its deposit is said to be a fissure vein running east and west, with a shallow dip south, and is from 3 to 6 feet wide. The ore is a banded vein material, consisting of galena, pyrite, chalcopyrite, and fahlerz. The country rock is said to be granite, and the gangue material porphyry. No specimens of either were sent in, but it seems probable to the writer that both belong to the crystalline quartz-porphyries, whose mode of occurrence has been already described, and which correspond with what is known of the eruptive mass of the Spanish peaks.

---

a Trans. A. I. M. E., August, 1882.

THE SAN JUAN REGION.

GEOLOGY.—The San Juan mining region, which embraces San Juan county, with the adjoining counties of Hinsdale, Ouray, La Plata, and portions of Rio Grande and Conejos counties, takes its name from the San Juan mountains, a lofty and irregular mass, which, like the Elk mountains, have a general northwest trend, but are of still more irregular structure, and have an even greater predominance of eruptive rocks. Owing to the prevalence of the latter, which constitute the mass of a great portion of the mountain region, the structure of the sedimentary beds is necessarily very indistinct, and the geological data which are obtainable are of the most unsatisfactory nature. The eruptive rocks occur in great masses, sections 2,000 and 3,000 feet thick being shown in the different cañons, their most characteristic and striking feature being the occurrence of immense breccia beds over wide areas throughout the region. The entire mass of these rocks has been classed by the members of the Hayden survey among the Tertiary eruptives, and they have been colored on the map as either trachytes or basalts. While basalts undoubtedly do occur, and trachytes may be found, these or later flows cover bodies of earlier eruptive rocks, and it seems probable to the writer that the deposits in the region will be found to occur mainly in the latter. This idea is supported by the examination of the specimens of the country rock brought in by census experts. Although these specimens were mainly in a condition of alteration so far advanced—as is common among eruptive rocks in the neighborhood of mines—that their original condition could rarely be definitely determined, some undoubted porphyries, diorites, and diabases occur among them, and the others can be referred, with more or less probability, to varieties of one of these types, while among the eighteen specimens which were examined microscopically only a single undoubted Tertiary rock (basalt) was found. This occurs as the foot wall of the Ohio Consolidated mine, in Hinsdale county. In some of the valleys erosion has exposed granite and gneiss, presumably of Archæan age, underlying these eruptives. At the head of the Uncompahgre river, near Ouray, beds of Palæozoic and Lower Mesozoic age are found resting on the granite and sinking to the northwest under the Cretaceous formations. The latter cover the western portions of the counties of Ouray and La Plata, which, like those of Gunnison and Grand counties, belong to the Colorado plateau region. On the southern slopes of the San Juan mountains, in San Juan county and the northeastern corner of La Plata county, there is exposed a considerable area of Palæozoic rocks, which to the southward pass under the Cretaceous formations of the valley of the San Juan. A large portion of these are of undoubted Carboniferous age, but adjoining the valley of the Animas, on the east, is a mountainous region called the Quartzite peaks, composed of rocks whose age is a matter of considerable uncertainty. The limestones which adjoin the quartzite have been considered by Dr. Endlich as Devonian mainly on the evidence of a single well-defined fossil. This fossil is, however, pronounced by Professor R. P. Whitfield to be a Carboniferous and not a Devonian type. The quartzite formations, which are supposed to underlie these, are called on the map Metamorphic-Palæozoic, the rubric of this formation, however, being included in the Archæan; a seeming contradiction of terms of which the writer has found no explanation. It is probable that the Palæozoic formations thicken to the southward, as they are known to do to the westward; and since the Devonian is well developed in Utah and Nevada, and fossils of the Waverly type have recently been found in Lake valley, New Mexico, it is very possible that this formation may be represented in the region, but its existence cannot yet be considered as determined.

ORE DEPOSITS.—The most striking feature in the mineral development of the San Juan region is the immense quartz veins traversing the eruptive rocks, which stand nearly vertical, their outcrops projecting like walls from the surface, and often traceable to a depth of several thousand feet along the sides of the deep valleys and cañons. According to Mr. R. C. Hills, these veins cross both the older eruptive rocks and what he considers as the overlying Tertiary eruptives; but it is only in rare instances that the latter have been shown to inclose valuable ore bodies, these being found generally in the older massive or brecciated rocks, whose prevailing color is some shade of green. Veins are also found in the underlying gneiss and granite; and in the western portion, especially in the neighborhood of Rico, are deposits in limestones of Carboniferous age, frequently along bedding-planes and at the contact with sheets of intrusive igneous rocks.

The deposits of the region are mainly argentiferous. In some, however, gold is the chief pay mineral; in others both gold and silver occur. Free-milling gold ores are, as a rule, comparatively rare, the majority of the ores containing a large admixture of base metals, so that they require smelting. The prevailing minerals are argentiferous galena, gray copper, generally argentiferous or freibergite, and, in the upper part of the deposits, native silver and pyrargyrite or ruby silver. Bismuth-silver minerals are found in several mines in considerable quantities. Gold is apparently derived in most part from pyrite. Barite is not uncommon as a gangue material, and fluorite also occurs, although more rarely. Compounds of antimony and tellurium are said to occur, and rarely molybdenite and some nickel minerals. The veins are said to have a banded structure, and the quartz is said to be crystalline. It must be noted, however, at the same time, that in many cases one or both walls are not well defined, and a portion at least of the vein material is quite frequently decomposed country rock. Of the age of these deposits, in the uncertainty which exists as regards the true character of the various country rocks, but little can be definitely said. Mr. Hills, who has devoted considerable study to ore deposits, especially those of Ouray county, divides the veins into three systems, which he regards as distinct and probably of different age: First, silver-bearing veins, standing at high angles (80° to 90°) and thin (6 inches to 3 feet wide), with no gouge or selvage, carrying essentially base-metal ores. Second, gold-bearing veins, large and strong, dip about 60°, gouge or selvage on one or both walls, intersecting the former, and therefore of later age. His third class differs from the first only in being wider and stronger and in carrying their ore in persistent bands or streaks. Like them, they stand at a high angle, and sometimes carry bismuth and antimony minerals. These veins are essentially gold-bearing, as even when carrying base-metal ores they contain little or no silver. According to Mr. T. B. Comstock, in an article on the geology of San Juan county,(*a*) the age of the veins of the district is probably post-Tertiary, and in their gradually varying strikes, in which there is little evidence of any systematic parallelism, he finds a tendency to radiate out from certain points which he considers centers of trachytic eruption. As, however, in the nomenclature and classification of eruptive rocks, he follows a system adopted by Dr. Endlich, and which is peculiar to that gentleman, the writer is at a loss to know what value to place on his evidence. He recognizes a primary and secondary system of veins, the latter of which cross the former, and makes the following provisory classification: First, those having a northwest trend, which are pre-eminently gray copper (freibergite) lodes; second, those with an east and west trend, the bismuth series of lodes, carrying occasionally nickel and molybdenum minerals; third, those with a northeast trend, the telluride series, with antimony and sulphides of the precious metals. From the data gathered by census experts, which are necessarily very incomplete, it appears that in San Juan county the northwest trend predominates; in the Uncompahgre district, comprising the northern portion of San Juan and the adjoining portion of Ouray county, the northeast trend predominates; while in Ouray county these two directions are about equally distributed, the east-and-west trend being in either case of subordinate importance.

SAN JUAN COUNTY.

San Juan county has an area of only 560 square miles, and includes the drainage area of the head of the Animas river. Its mines are principally found in the lofty peaks which surround the picturesque and elevated basin of Baker's park and its tributary valleys. They occur mainly in the older eruptive rocks, which here apparently rest directly on a base of gneiss and crystalline schists, presumably of Archæan age.

From Baker's park southward the Animas flows in deep cañons cut through later sedimentary rocks, which on the east consist mainly of the questionable series classed as Metamorphic-Palæozoic, and on the west of limestones of Carboniferous age. Of the later eruptive rocks which cover those of Secondary age it can only be said that, in view of the facts developed by recent more exact lithological studies, it is unfortunate that the term "trachyte" should have been so universally applied, inasmuch as late investigations of other districts where this rock was supposed to exist in large masses prove the normal type to be of extremely rare occurrence.

The mines reported by census experts belong to three principal districts: the Animas district, about Baker's park and Silverton; Eureka district, in the northeast portion of the county; and the Uncompahgre district, on the mountains between the Uncompahgre and Animas rivers, which apparently takes in also a portion of Ouray county. The region is undoubtedly one of exceptional richness in mineral developments, so that Mr. Comstock's statement that one-sixth of the area of the county is taken up by lode claims seems scarcely an exaggeration. The subjoined table gives a brief summary of the data obtained from producing mines by census experts:

Mine.	Country rock and vein.	Ore and gangue.
ANIMAS DISTRICT.		
Aspen Group	Greenish, indistinct porphyritic rock. Undeterminable. Vein: strike, NW.; dip, 80° SW.; width, 4 feet.	Galena and cerussite, with gray copper, rich in silver (freibergite).
Bowery	Altered felsite-porphyry. Vein: strike, N. 80° E.; dip, 80° S.; width, 10 feet.	"Carbonate" ore in quartz, with incrustations of ocher, azurite, and malachite. Gangue: altered country.
Cleveland Consolidated	Diorite (diabase ?). Contains fibrous uralitic hornblende, which may have come from augite; chlorite, epidote, and calcite as decomposition products. Vein: strike, N. 27° W.; dip, 75° W.; width, 4 feet.	Massive freibergite in gangue of calcite and dolomite, with a little galena.
Diamond (Emblem lode)	Dioritic (?) rock with quartz in small grains. Vein vertical; strike, NW.; width, 4 feet.	Mixture of galena, freibergite, and chalcopyrite, with barite between quartz layers, forming banded vein material.
Empire	Quartz-bearing hornblende-diorite. Vein: strike, N. 45° W.; dip, 86° SW.; width, 7 feet.	Freibergite, galena, pyrite, and chalcopyrite in quartz.
Hercules	Diorite ? (called syenite). Vein: strike, NW.; dip, 82° SW.; width, 10 feet.	Freibergite, pyrite, and some galena carrying silver.
Highland Mary	Biotite-gneiss. A dike of quartz-porphyry cuts the vein at right angles. Vein vertical; strike, N. 62° W.; average width, 10 feet.	Galena, freibergite, and chalcopyrite carrying silver, with trace of gold.
Jennie Parker	Diorite ? (called syenite). Vein: strike; NW.; dip, 80° SW.; width, 5 feet.	Argentiferous galena, freibergite, and chalcopyrite. Quartz gangue.
Molas	Hanging wall white indistinctly stratified rock, consisting of quartz and feldspar—between a quartzite and a gneiss; foot wall decomposed porphyry. Vein vertical; strike, NE.; width, 6 feet.	Galena and barite, with stains of copper minerals.
North Star (Sultan mountain)	Very much decomposed porphyry. Vein: strike, N. 36° W.; dip, 65° SW.	Massive argentiferous galena, freibergite, and zincblende, with a little pyrite.
North Star (King Solomon mountain).	Greenish felsitic rock (diorite ?). Vein: strike, N. 47° E.; dip, 74° NE.; width, 40 feet.	Argentiferous galena and cerussite, with freibergite.

a Trans. A. I. M. E., August, 1882.

Mine.	Country rock and vein.	Ore and gangue.
LAS ANIMAS DISTRICT—cont'd.		
Philadelphia	No specimen. Called "trachyte". Vein: strike, NW.; dip, 71° SW.; 2½ feet wide.	Freibergite; a little galena, with silver and some gold, in quartz gangue.
Pride of the West	Dark green compact decomposed rock, in part breccia. Undeterminable. Vein: strike, NW.; width, 28 feet.	Massive argentiferous galena, with chalcopyrite and freibergite.
EUREKA DISTRICT.		
Adelphi	Quartz-free plagioclase rock, with crystalline groundmass, probably diorite. Basic silicate changed to chlorite and calcite. Vein: strike, NE.; dip, 78° SE.; width, 3 feet.	Massive freibergite, with barite and some chalcopyrite.
Big Giant	White quartz-porphyry. Vein: strike, N. 50° E.; dip, 45° SE.; width, 23 feet.	Freibergite, argentiferous galena and pyrite, with quartz.
Bonanza tunnel	Porphyrite, with biotite, and probably hornblende, and a little quartz. Much calcite in films.	Occurs in two parallel veins, one carrying galena, the other freibergite and barite.
Columbia	Diorite? Vein: strike, NE.; dip, 86° SE	Freibergite, with some galena and pyrite.
Mastodon	Decomposed greenish rock (diorite?). Vein: strike, N. 40° E.; dip, 70° SE.; width, 200 feet.	Massive argentiferous galena, with layers of quartz parallel to the cube faces; zincblende, pyrite, and chalcopyrite also occur.
Sioux City	Greenish decomposed rock (diorite?). Vein: strike, N.; dip, 78° E.; width, 4 feet.	Mainly galena; some gray copper.
Tom Moore	Greenish decomposed rock (diorite). Vein nearly vertical; strike, NE.; width, 60 feet; pay streaks, 9 inches to 5 feet.	Argentiferous galena and zincblende; massive.
UNCOMPAHGRE DISTRICT.		
Alabama	Greenish eruptive rock, with porphyritic crystals and included fragments of red quartzite. Vein: strike, NE.; dip, 70° E.; width, 25 feet.	Argentiferous galena and freibergite, with some pyrite and chalcopyrite. Gangue: quartz and feldspar.
Alaska	Diorite or diabase microscopically similar to that of the Adelphi. Vein: strike, NE.; dip, 80° SE.; width, 30 inches.	Chiefly freibergite, with some galena, and containing bismuth-silver in considerable quantity.
Annie Wood	Hanging wall (?) plagioclase-hornblende rock; diorite (?); foot wall (?) much altered porphyritic diabase; groundmass, crystalline. Vein: strike, N. 20° to 30° E.; dip, 80° E.; 5 feet wide.	Freibergite, stephanite, ruby silver, sulphide of bismuth with chalcopyrite.
Bonanza	Greenish felsite-porphyry much altered. Vein: strike, N. 65° E.; dip, 80° SE.	Freibergite and chalcopyrite with barite. Galena and pyrite also found. Quartz gangue.
Boston	Light-colored decomposed porphyry. Vein: strike, N. 20° E.; dip, 70° SE.; width, 4 feet.	Argentiferous galena with chalcopyrite and zincblende. Gangue: quartz and altered country.
Maid of the Mist	Plagioclase rock, with both hornblende and augite. Porphyrite or diabase (?). Vein: strike, N. 20° E.; dip, 65° E.	Argentiferous galena, freibergite and zincblende, with chalcopyrite and pyrite. Gangue: quartz and altered country.
Mammoth	Greenish decomposed porphyry; basic. Vein: strike, N. 10° E.; dip, 72° SE.; width on surface, 30 to 60 feet.	Freibergite, stephanite, ruby silver, native silver, sulphide of bismuth, with pyrite in quartz and altered country.
Red Cloud	Too much altered for determination. Vein: dip, 75° SE.; width, 3 feet.	Argentiferous galena, freibergite, zincblende, chalcopyrite, and pyrite, with some gold in quartz and altered country.
Red Rogers	Greenish country rock; decomposed porphyry. Vein: strike, N. 50° E.; dip, 80° SE.; width, 4 feet.	Freibergite, stephanite, ruby silver, with barite and quartz; a little galena.
Saxon	Green decomposed porphyry. Vein: strike, NE.; dip, 85° SE.; width, 30 to 40 feet.	Freibergite, galena, and stephanite (?), with some chalcopyrite. Gangue: quartz.

OURAY COUNTY.

Ouray county includes the northern and western slopes of the San Juan mountains, with certain outlying groups belonging geologically to the same mass, and the plateau country extending westward from thence to the Utah line, which is composed mainly of nearly horizontal Mesozoic beds.

The development of the precious metals has been thus far confined, as might be expected, to the eastern and more mountainous portion of the county. In the neighborhood of Ouray, which is near the northwest limit of the eruptive area of the San Juan mountains, erosion has exposed the underlying Palæozoic formations and a small area of what is presumably Archæan. The deposits of the northern portion of the Uncompahgre district occur mostly in the sedimentary beds, but in general are more or less closely connected with the overlying eruptive rocks. The veins belong more generally to the metamorphic type, although there seems to be no marked change in their mineral constitution. Mineral Farm seems to be a somewhat exceptionally rich deposit in limestone. In Sneffles district to the west of Ouray, in Upper San Miguel district, and in Iron Springs district near Ophir, to the south, the veins, like those of San Juan county, are in eruptive rocks, and stand at a high angle, many of them, especially in the latter district, carrying considerable gold. In the neighborhood of Rico, still farther south, the ores occur in sedimentary rocks, in general parallel with the stratification and with either foot or hanging wall of porphyry. They are essentially silver-bearing, and have a clay gangue material colored by hydrated oxides of iron and manganese.

Mine.	Country rock and vein.	Ore and gangue.
UNCOMPAHGRE DISTRICT.		
Bogola	Blue-gray crystalline limestone, with chert segregations. Quartz-porphyry is said to occur.	Argentiferous galena, chalcopyrite, and pyrite, with freibergite and stibnite (?). Gangue: quartz and barite.
Dexter	Hanging wall greenish felsite-porphyry, and shale below. Foot wall shale, and quartzite below. Vein: strike, N. 20° E.; dip, 30° E. with country; width, 18 inches.	Massive argentiferous galena, native silver, stephanite, zincblende. Chalcopyrite and pyrite are said to occur. Gangue: quartz and altered country.
Golden Gate	White quartzite. Vein: strike N. 20° W.; dip, 80° W.; width, 4½ feet.	Argentiferous galena, freibergite, chalcopyrite, and pyrite in quartzite.
Grand View	Sandstone and conglomerate overlaid by eruptive rock. Vein: strike, N. 82° W.; dip, 77° S.; 18 inches wide.	Pyrite and chalcopyrite, carrying gold and silver, impregnating country rock.

Mine.	Country rock and vein.	Ore and gangue.
UNCOMPAHGRE DISTRICT—cont'd		
Riverside	Green porphyritic rock called trachyte. Vein: strike, N. 50° E.; dip, 78° S.; width, 4 feet.	Argentiferous galena, with pyrite and a little freibergite.
Union	Gray porphyritic rock called trachyte. Vein: strike, N. 40° W.; dip, 80° S.; width, 7 feet.	Argentiferous galena, chalcopyrite, and pyrite, and some stephanite.
SNEFFLES DISTRICT.		
Potosi	Greenish felsitic rock, locally called trachyte. Vein: strike, NE.; dip, 65° NW.	Freibergite, stephanite, and argentiferous galena, in white quartz and decomposed country.
Terrible	Probably altered diabase. Vein: strike, N. 80° W.; dip, 85° S	Mainly argentiferous galena. Gangue: quartz and altered country.
U. S. Depository	Undeterminable brecciated eruptive rock, locally called trachyte Vein: strike, N. 37° W.; dip, 75° SW.; width, 5½ feet.	Argentiferous galena, zincblende, and freibergite, with some pyrite.
Virginius	No specimen; locally called trachyte. Vein: strike, N. 32° W.; dip, 80° SW.; width, 4 feet.	Argentiferous galena and freibergite. Gangue: quartz and altered country rock.
Wheel of Fortune	Porphyritic rock like that generally called trachyte in the region. Vein: strike, N. 5° W.; dip, 65° W.; width, 5 feet.	Stephanite and freibergite. Gangue: quartz and porphyry.
Yankee Boy	No specimen; locally called trachyte. Vein: strike, N. 85° W.; dip, 85° S.	Argentiferous galena and zincblende, with barite and chalcopyrite. Gangue: quartz and altered country.
PIONEER DISTRICT.		
Grand View	Hanging wall decomposed porphyry or porphyrite; foot wall blue fine-grained dolomite. Deposit: dip, 45° to 72° NE., 2 to 14 feet thick.	Oxides of manganese, carrying silver, probably as chloride or sulphide.
Hope	Hanging wall porphyry (?). Foot wall limestone. Vein: dip, 25° NE.; deposit, 1 to 8 feet thick.	Hydrated iron and manganese oxides, carrying silver.
Newman	Hanging wall dark argillaceous shale. Foot wall porphyry or porphyrite. Vein: dip, 8° NW., 6 feet thick.	Iron-stained clayey mass, carrying silver, carbonate of lead, and other minerals.
UPPER SAN MIGUEL DISTRICT.		
Alta	Undeterminable; called trachyte. Dike of altered porphyry (?). Vein: strike, N. 75° W.; dip, 70° N.	Argentiferous galena and freibergite, with barite and quartz. Several parallel veins.
Cimmarron	Decomposed rock, probably porphyrite or diabase. Vein: strike, N. 22° E.; dip, 75° SE.; width, 3 feet.	Argentiferous galena, freibergite, chalcopyrite and pyrite, with some free gold. Gangue: light-colored felsitic rock, banded parallel with walls.
Gold King	Undeterminable. Porphyry (?) Vein: strike, N. 22° E.; dip, 75° SE.; width, 3 feet.	Gold-bearing quartz in altered country rock.
N. W. H., jr.	Greenish brecciated undeterminable eruptive rock called trachyte. Vein: strike, N. 16° W.; dip, 82° W.; width, 12 feet.	Quartz impregnated with galena, zincblende, chalcopyrite, and pyrite, carrying gold and silver. Gangue: quartz and altered country rock.
Palmyra	Locally called trachyte. Decomposed porphyry. Vein: strike, N. 35° W.; dip, 65° NE.; width, 4 feet.	Argentiferous galena, with barite and stibnite. Gangue: quartz and altered country.
Pandora & Oriental	Greenish undeterminable rock, locally called trachyte. Vein: strike, N. 72° E.; dip, 60° S.; width, 10 feet.	Auriferous quartz, with pyrite and chalcopyrite.
Smuggler	Greenish undeterminable breccia, locally called trachyte. Vein: strike, N. 18° W.; dip, 65° W.; width, 10 feet.	Native silver, stephanite, argentiferous galena, and zincblende. Gangue: quartz and altered country.
Summit	Undeterminable eruptive rock locally called trachyte. Vein: strike, NE.; dip, 75° NW.; width, 4 feet.	Argentiferous galena, cerussite, with stephanite and freibergite. Gangue: quartz and altered country.
IRON SPRING DISTRICT.		
Montezuma	Crystalline quartz-porphyry. Vein: strike, E. and W.; dip, 55° S.; width, 4½ feet.	Galena, cerussite, with some chalcopyrite, in quartz and altered country rock.
Nettie	White "siliceous limestone". (Porphyry?) Vein: strike, NW.; dip, 65° NE.; width, 4½ feet.	Galena, pyrite, and auriferous iron-stained quartz.
Nevada	Called trachyte. No specimen. Vein vertical; strike, NE	Galena, freibergite, chalcopyrite, and pyrite. Gangue: quartz and porphyry.
Osceola	Biotite-porphyrite. Vein: strike, N. 88° W.; dip, 70° N.; width, 4 feet.	Iron-stained auriferous quartz. Gangue: quartz and altered country.
Parson	Fine-grained very crystalline quartz-porphyry. Vein: strike, E. and W.; dip, 60 N.; width, 5 feet.	Argentiferous galena, zincblende, pyrite, and barite. Gangue: quartz and altered country.
Pike	Syenite or diorite (?) with a little quartz. Vein: strike, N. 15° E.; dip, 75° W.; width, 4 feet.	Argentiferous galena and pyrite, with a little gold, in gangue of dolomite and quartz.
Valley View	Called trachyte. No specimen. Vein, vertical; strike, NE.; dip, 90°; width, 3 feet.	Argentiferous galena and cerussite.
What Cheer	Quartz-porphyry, like Lincoln porphyry. Vein, vertical; strike, N. 40° E.; width, 4 feet.	Argentiferous galena and freibergite, with chalcopyrite, pyrite, and zincblende. Gangue: quartz and altered country.

LA PLATA COUNTY.

La Plata county lies to the south of Ouray and San Juan counties, and is largely a mesa country formed of approximately horizontal Mesozoic beds, protruding through which are the eruptive masses of the La Plata mountains and the Sierra el Late. The coal horizons underlie a large portion of the county, as well as a portion of western Ouray, and developments have been made in the more thickly settled portions.

In the census year its mines were mostly in the condition of prospects. A schedule was obtained from only one producing mine, the Comstock, in the California district, on the west side of the La Plata river, and 2½ miles north of Parrott City. Its ore deposit occurs in a dike of felsite-porphyry included in a reddish sandstone or quartzite, lithologically resembling those of the Upper Carboniferous of Park county. The deposit strikes north and south with the formation, dipping 65° to the eastward, and is apparently an impregnation or alteration of the country rock for about 6 feet in width near the hanging wall of the dike. Its ore is auriferous pyrite in a quartz gangue, with scattered spots of galena and gray copper. Specimens have been brought in from an extremely interesting deposit of copper glance in a coarse conglomerate resembling lithologically those which occur in the lower portion of the Triassic formation found to the west of Durango. A similar deposit is said to occur in the valley of the Rio Dolores, in the immediate neighborhood of a mass of eruptive rock which traverses the sedimentary conglomerate.

HINSDALE COUNTY.

Hinsdale county lies to the east of Ouray and San Juan counties, its area being mainly covered by eruptive rocks, with some exposures of underlying Archæan in the valleys tributary to the Lake fork of Gunnison river. Its mines occur mostly between Lake City and the crest of the range which divides this county from San Juan. In manner of occurrence of country rock and minerals they resemble those of the latter. Exceptionally, the country rock of the Ohio Consolidated mine, on Henson creek, 15 miles west of Lake City, is a fresh feldspar-basalt, containing olivine, which is largely altered to serpentine.

Mine.	Country rock and vein.	Ore and gangue.
GALENA DISTRICT.		
California	Porphyrite (?) Hanging wall resembles decomposed felsite-porphyry. Vein: strike N. 57° E.; dip. 55° NW.; banded structure, 4 feet wide.	Argentiferous galena, freibergite, zincblende, chalcopyrite, with calcite and rhodochrosite (?) in quartz gangue.
Ocean Wave	Gray eruptive, called trachyte. Vein: strike NE.; dip. 80° S.; width. 4 feet.	Argentiferous galena and freibergite; little native copper. Gangue: quartz and altered country.
Ohio Consolidated	Foot wall fresh feldspar-basalt, with olivine altered to serpentine; hanging wall much altered basic rock, possibly the same. Vein: strike N. 5° W.; dip, 73° W.; 3½ feet wide.	Freibergite and chalcopyrite. Gangue: quartz and altered country.
Palmetto	Gray diabase-porphyrite, with tendency to amygdaloidal structure. Vein: strike N. 25° E.; dip, 73° S.; 4 feet wide.	Chalcopyrite, stephanite, and ruby silver, with some gold in quartz gangue.
Silver Cord Extension	No specimen; locally called porphyry. Vein: strike N. 10° W.; dip, 85° E. No foot wall found.	Freibergite, with native silver and galena, chalcopyrite and zincblende. Gangue: quartz, with a little altered country.
Ulay & Ute	Decomposed undeterminable rock, locally called trachyte. Vein: strike NE.; dip, 74° (?).	Freibergite, galena, and chalcopyrite; quartz gangue.
LAKE DISTRICT.		
Belle of the West	Decomposed light-colored orthoclase rock, with little quartz; locally called trachyte. Vein: strike N. 55° E.; dip, 62° S.; width, 18 inches.	Argentiferous galena, freibergite, zincblende, and auriferous chalcopyrite; quartz gangue.
PARK DISTRICT.		
Inez	No specimen; called diorite. Vein vertical; strike N. 34° E.	Stephanite and galena, with pyrite and chalcopyrite; quartz gangue.

SAGUACHE COUNTY.

Saguache county comprises the head of San Luis valley, with the slopes of the Sangre de Cristo range, which face it on the northeast, and the Cochetopa hills on the northwest, a volcanic mass, reaching from the southern end of the Sawatch range to the San Juan mountains.

No working mines of the precious metals are reported for the census year. On the western slope of the Sangre de Cristo, not far from Hayden's pass, occurs a rich deposit of red hematite iron ore in limestone (Carboniferous ?), which is worked by the Colorado Coal and Iron Company, and to which a branch road has been extended from the Denver and Rio Grande railroad above Poncho Springs. Iron ore is also said to occur on the west slopes of the Cochetopa hills, in the valley of one of the creeks tributary to the Gunnison river.

RIO GRANDE COUNTY.

Rio Grande county comprises the very uppermost portion of the valley of the Rio Grande and the eastern end of the San Juan mountains, which is made up almost entirely of eruptive rocks, said to belong to the Tertiary volcanics.

Little Annie mine, in the Summit mining district, is the most important producing mine. It is situated about 28 miles to the southward of Del Norte, at the head of Alamosa creek. It is an exceptionally rich deposit of free gold in quartz 45 feet in width at the surface. The quartz is a peculiarly cellular rock, and the cavities are supposed to be those left by the leaching out of feldspar crystals. The country rock is probably an older porphyry. This could not be determined for want of a specimen; but it has been suggested, with considerable appearance of probability, that the so-called vein is an altered porphyry dike impregnated with mineral.

GEOLOGICAL SKETCH OF WYOMING.

The territory of Wyoming lies to the north of Colorado, having a corresponding area as measured by degrees of latitude and longitude, but set off 2° of longitude to the westward.

Although directly in the line of the main Rocky Mountain uplift, the larger portion of its area is a plain or mesa country. The Colorado range extends a short distance north of the boundary of that state, but with a very much diminished elevation. In the northwestern corner of the territory is a considerable mountain area, occupied principally by the Wind River, Shoshone, and Big Horn ranges, which are connected with the northern continuation of the Colorado range by low east and west ridges, the Sweetwater and the Seminole mountains. In the extreme northeastern portion of the territory a portion of the Black Hills uplift is included within its boundaries.

With these exceptions its area consists of broad grassy valleys or Tertiary mesas, which either form arid deserts or are covered with a somewhat scanty growth of nutritious grasses. But few large streams are found in the territory, although within its area are some of the sources of the three great river systems of the country, viz, the Green or Colorado river, which flows southward through its center; the Snake Fork of the Columbia, which takes its rise in the northwestern portions; and the Platte, Cheyenne, Powder, and Wind rivers, important tributaries to the great Missouri River system. With the exception, therefore, of narrow strips of alluvial soil in the bottom lands of these streams and their tributaries, it is of little value for agricultural purposes. On the other hand, the immense stretch of grassy plains available for grazing constitutes its great wealth.

Our geographical and geological knowledge of the territory is mainly obtained from the reports of the Exploration of the Fortieth Parallel, whose field of labor covers a narrow strip along its southern border, and from detached notes on the same field made by the Hayden survey. The last season's field-work of this survey (in 1878) covered a considerable portion of the western and northern areas of the territory, but its results are not yet printed. (*a*)

General geology.—It is doubtful whether any portion of this territory emerged from the surface of the ocean during the Palæozoic and Mesozoic eras. At the most, land areas, if they existed, were confined to the northwestern portion, consisting of what now constitutes the Wind River range, and possibly portions of the adjoining mountain areas. The mountains of Colorado find their continuation in a system of submerged reefs and small islands, stretching in a direction a little east of north to the Black hills of Dakota, and branching off in a northwesterly and westerly direction to connect with the Wind River range. In this area sedimentation, fed by material derived from the land areas of Colorado on the south, of Utah and Idaho on the west, and of Montana and the Black hills of Dakota on the north and east, went on without any important interruption until the close of the Cretaceous. As already noted in Colorado, there was a probable continental elevation toward the close of this period, resulting in the partial inclosure of the basin which forms the central portion of the territory, so that its waters became gradually fresher, and were finally shut off from all communication with the ocean. The conditions of this period were particularly favorable for the formation of coal, and the upper portion of the Cretaceous, wherever it outcrops throughout the territory, has been found to yield an abundance of this valuable mineral. After the great dynamic movement at the close of the Cretaceous large areas were still beneath the surface of fresh-water Tertiary seas, in which deposition went on with great activity. It is as yet too early to outline definitely the areas of these different seas, but it is known that within the Tertiary system there exist important developments of beds of the Eocene, Miocene, and Pliocene periods. The wealth of fossil remains of animals, fishes, and plants which have been exhumed from these beds has already given them a world-wide renown among students of the evolution of life on the globe.

The surface changes during the Quaternary have been comparatively small as compared with those of the mountain regions adjoining; and yet enormous masses of the beds deposited in the Tertiary era have been swept away. In the Wind River mountains a local system of glaciers existed relatively greater even than those of Colorado, living relics of which are said still to exist in the higher parts of the mountains. Of eruptive rocks there seems to be a singularly small development in this great area. As far as known, they are mainly confined to the Yellowstone park, in the extreme northwestern portion of the territory, whose geysers, generally considered as intimately connected with recent volcanic action, eclipse the hitherto unrivaled springs of the volcanic island of Iceland. In the midst of the Tertiary plains of the great Green River basin is found a small flow of leucite-lava, the only occurrence of this mineral, which is characteristic of the lavas of Vesuvius, hitherto discovered on the American continent. It is not to be wondered at that we have but little information about earlier eruptive rocks, since so much of the area of the country is covered by sediments deposited since their eruption and the Archæan areas in which they might be found are as yet comparatively unstudied.

Gold and silver.—As might be inferred from the above brief sketch of its geological structure, Wyoming can scarcely rival its northern and southern neighbors as a producer of the precious metals. Its actual resources have as yet, however, been scarcely developed, partly because the broad plain areas offer little inducement to the prospector, and partly because he has hitherto been debarred from the northern mountain areas by the Indian tribes to whose reservation they belonged. The only discoveries of ores of these metals which are known to the writer are confined to the Medicine Bow range, a northern offshoot of the Colorado range, to the south of the Laramie plains; to the Sweetwater and Seminole mountains, a group of hills running east and west from the northern end of the Laramie hills to the Wind River mountains; and to the mining districts near South Pass, at the southeastern end of the Wind River mountains. From the latter region alone were returns obtained by the census experts.

The Archæan nucleus of the Wind River mountains consists mainly of granite, on whose northeastern flanks rest the Palæozoic and Mesozoic formations; while on the southwest the Tertiary beds of the Green River basin come directly in contact with it. At the southeastern extremity of the range the granites give way to a series of schistose rocks, prevailingly gneiss and mica-schist, whose area extends out for some distance beyond the actual

a The writer has been favored with a glance at the topographical and geological maps of this report, from which part of the data herein contained are derived.

mountain uplift. In the foot-hills of the range, near the South pass, are the California, Miner's Delight, and Shoshone districts, the former near Atlantic City, and the latter near South Pass City. Mines were first discovered here in the fall of 1867, and the region was the scene of considerable excitement in the following year. Wild-cat speculation, danger from the Indians, and other causes have combined to prevent its proper development; so that, although the mines are now almost deserted, it would seem that their abandonment has not been necessarily due to want of good ores. From the data obtained, they seem to be mainly free-milling gold ores, occurring either in quartz veins or as impregnations of the country rock, which is mainly gneiss of both micaceous and hornblendic varieties. It is difficult to form a clear idea of the exact geological relations of the deposits, but they would seem to be in some respects analogous to those of the Black hills. Galena and copper ores are also said to have been found in the vicinity, but their exact location is not given.

Copper ores have recently been developed near the Platte river to the northwest of Fort Laramie. From the boundary of Colorado northward to the Platte river extends a broad flat ridge, known as the Laramie hills, whose surface is made up of Archæan rocks, from which the Palæozoic and Mesozoic beds, which originally covered it, have been removed by erosion. From Laramie peak, the northern extremity of this ridge, which itself was possibly an island in the Cambrian ocean, an irregular reef of Archæan rocks extended in a direction a little north of east toward the Black hills. Portions of this reef, which in Tertiary times projected above the water, now form an irregular group of hills, known as the Rawhide buttes. At the southern base of these hills, in the sedimentary rocks which rest against the Archæan, occur the deposits of copper above mentioned. The ore consists of carbonates, oxides, and silicates of copper, containing no silver, aud, thus far, not sufficient sulphur to make a matte. To what geological horizon the country rock inclosing these ores belongs is not known, nor the character of the deposits; but it seems probable that they are rather impregnations of a certain bed than a vein crossing the stratification.

Coal and iron.—The actual development of coal in Wyoming is already very considerable, and its possibilities are immense. With the exception of the mountain ridges, the entire area of the territory may be said to be underlaid by the coal formation. Over a very great portion of this area, it is true, this formation is so deeply buried beneath Tertiary deposits that it is practically unavailable. On the other hand, the coal formations are by no means absolutely horizontal over all the plain country, but have been brought to the surface by various geological movements, so that the actually known extent of its outcrops is very great. The two largest basins are those of the Laramie plains and of the Green River basin. In the former coal is worked extensively at Carbon, on the Union Pacific railroad; in the latter, coal beds have been opened at Black Buttes and Point of Rocks, on the east, and at Rock Springs, on the west of a synclinal basin lying east of Green river, while the outcrops of a second basin to the west of Green river have been found extending all along the western borders of the territory and beyond the line in Utah from near the head of Bear river, following the valley of that stream and of the south fork of Snake river as far as the junction of the latter with Henry's fork, a distance, in round numbers, of 175 miles. Outcrops have also been found extending around the northwestern point of Wind River range, at the head of Gros Ventre and Wind rivers, and at various points among the bays of the Big Horn mountains and the Black hills of Dakota. They have also been found not far from the copper mines to the north of Laramie peak. The only actual working mines, however, are those along the line of the Union Pacific railroad, which are either owned by or are indirectly under the control of that corporation. Iron ore has been discovered in immense masses in the Laramie hills at the head of Horse creek. This ore is magnetic. The specimens as yet tested have proved to contain too large a percentage of titanium to be of marketable value, but it is by no means certain that a more careful investigation may not discover beds comparatively free from this injurious constituent. A valuable deposit of remarkably pure red hematite also exists in the Carboniferous strata resting against Rawlings peak. The ore was used for some time as a mineral paint, but the mine has of late years for some unknown reason been abandoned. Petroleum is found in the rocks of the Cretaceous formation at many points, and oil of excellent quality for lubricating purposes has been obtained in small quantities; but the practical value of this formation as an oil producer has not yet been thoroughly tested. At various points in the Tertiary plains are beds of dried-up lakes containing valuable deposits of alkaline salts. These are specially frequent to the north of the Union Pacific railroad, between the Platte and Green rivers, and in one case a deposit of solid sulphate of soda 15 feet in thickness has been proved. Their actual development is awaiting the advent of some enterprising manufacturing chemist.

SWEETWATER COUNTY.

Mine.	Country rock and vein.	Ore and gangue.
CALIFORNIA DISTRICT.		
American	Fine-grained gneiss. Vein: strike, NE.; dip, S.; 2 to 8 feet wide.	Free gold in quartz.
Buckeye State	Hornblende-gneiss. Vein: strike, E. and W.; dip, N.; width irregular, 8 inches to 12 feet.	Do.
Caribou	Archæan schists. Vein: strike, NE.; dip, N.; width irregular, 8 inches to 5 feet.	Gold-bearing quartz.
Manchester	Amphibolite and gneiss. Vein: strike, NW.; dip, 45° S.; width irregular, 4 to 16 feet.	Do.
Mary Ellen	"Black granite"; no specimens; probably gneiss. Vein: strike, NE.; dip, W; average 1 foot thick. Irregular on hanging wall.	Free gold.
Victoria	Gneiss. Vein: strike, NE.; dip SE.; 1 to 4 feet wide	Do.
MINERS' DELIGHT DISTRICT.		
Hartley	Compact dark gneiss. Vein: strike, SW.; dip, S.; 6 inches to 2 feet in width.	Free gold in quartz and decomposed country.
Miners' Delight	Fine-grained gneiss. Vein: strike, NE.; dip, S.; 1 to 6 feet in width.	Free gold, with little silver in quartz.
Sidney Johnston	Gneiss and schists. Vein: strike, NE.; dip, S.; width, 6 inches to 5 feet in width.	Free gold in quartz.
Yellow Jacket	Gneiss and schists. Vein: strike, NW.; dip, S.; 1 to 4 feet in width.	Do.
SHOSHONE DISTRICT.		
Cariso	Apparently Archæan gneiss. Vein: strike, NW.; dip, S.; 2 to 8 feet wide.	Do.

GEOLOGICAL SKETCH OF THE BLACK HILLS OF DAKOTA.(a)

The Black hills of Dakota constitute a wooded island rising from 2,000 to 3,000 feet above the treeless plains of Dakota, quite isolated from the main chain of the Rocky mountains, whose foot-hills lie 100 miles further to the west. Their uplift forms an oval some 120 miles in length by 50 in extreme width, its longer axis having a direction a little to the west of north. The surrounding plain or mesa country is covered by practically horizontal beds of Cretaceous and overlying Tertiary formations.

Their geological structure is that of a singularly regular quaquaversal having a central nucleus of Archæan schists, on which rest beds of the Palæozoic and Mesozoic formations dipping away from it in every direction, the outcrops of the latter forming a series of fringing reefs, or so-called hog-back ridges, which completely encircle the island. The area in which the Archæan rocks are exposed occupies the eastern and higher portion of the hills, and also forms an oval some 56 miles in length and 24 in extreme width, its longer axis running north and south. The northwestern portion of the hills is covered by nearly horizontal beds of the Palæozoic formation, patches of which are still left in the Archæan area, while the steeper dips of the quaquaversal are found as a rule only near the foot-hills.

The Archæan rocks of the Black hills are divided by Mr. Newton into two series, an older and a newer Archæan, the former, in general, occupying the southwestern portion of the oval area above mentioned, and the latter (the newer Archæan) the northeastern portion. The latter he considers to closely resemble the Huronian of the east, and it is certainly unlike any Archæan formation yet studied in the Rocky mountains, except that of the Red Creek area in Wyoming, (b) which was also considered as corresponding to the eastern Huronian, and resembles it lithologically. The older Archæan is also somewhat different from that of Colorado, in that it contains but little gneiss. The granite which occurs in it, however, would not seem to form so much of a distinctive character from this Archæan as was thought by Mr. Newton, since it is apparently an exaggerated form of the pegmatite, which is largely developed in Colorado in secondary veins and irregular masses traversing the gneiss and schists. This older Archæan consists, according to Mr. Newton, of quartzose, garnetiferous, and ferruginous mica-schists, chloritic schists, amphibolites, and subordinate gneiss, with interlaminated veins of quartz carrying gold. In these occur large masses of granite of lenticular shape, conforming in general with the stratification of the schists, and made up of very large individuals of quartz, feldspar, and mica, crystalline in structure, but not always in complete crystals. Tourmaline crystals are quite common in the granite. This granite Mr. Newton regards, from the fact that it sometimes incloses fragments of schist and has polished contact surfaces, as distinctly of an eruptive origin, but as erupted in pre-Cambrian times. The rocks of the newer Archæan are, according to him, not essentially different in mineralogical composition, but are characterized by a much finer texture. They consist of micaceous clay slates, siliceous slates, hydro-mica schists, and quartzite. Quartzite forms an important constituent, often carries a certain amount of mica, and occurs in powerful beds from 50 to 200 and sometimes 500 feet thick. The mica-schists are often garnetiferous, and contain also staurotide crystals.

a The data for this sketch, additional to that gathered by census experts, were obtained from *A Report on the Geology and Resources of the Black Hills of Dakota*, by Henry Newton and Walter P. Jenney, observations made in 1875 and published in 1880, and from a paper by W. B. Devereux on "*The occurrence of gold in the Potsdam formation*", Trans. A. I. M. E., February, 1882.

b *Geological Exploration of the Fortieth Parallel*, vol. II, Descriptive Geology, page 269.

Gneiss also occurs, but rarely. To these should be added, from data furnished by the census specimens, a series of very fine phyllites and some actinolite schists. Interlaminated lens-shaped bodies of quartz are also noted in this series by Mr. Newton, and are by him supposed to be auriferous. Mr. Jenney considers these quartz bodies as differing in the two series, though the reasons for this difference are not apparent. Both are parallel with that bedding, and neither traverses it; both carry gold, but those in the older series he considers interlaminated fissure veins and continuous, and those in the newer series as segregated veins and not continuous. The enormous quartz bodies which have yielded the principal gold product of this region belong to the latter class.

Overlying unconformably these Archæan schists is a thickness, in round numbers, of 2,500 feet of Palæozoic and Mesozoic beds, which, according to Mr. Newton, are entirely conformable within themselves. These consist first of a thickness of 250 feet of calcareous sandstones and quartzites, having a conglomerate with calcareous cement at or near the base and local developments of glauconite grains in the upper part. In these are found well-recognized fossils of the Potsdam formation, which is classed by Mr. Newton as Silurian, but which it is now more common to group under the Cambrian epoch. Above the Potsdam sandstones are pinkish and gray limestones, passing up by a gradual transition into red and variegated sandstones, in the former of which are found well-recognized Carboniferous types. Over these are the red Triassic sandstone beds, succeeded by variegated clays and marls, with a little limestone of Jurassic age and coarse yellow sandstone, with clays and shales of the Cretaceous formation. The thicknesses given by Mr. Newton are 690 feet for the Carboniferous group and 1,440 feet for the entire Mesozoic system. The striking features in this series of deposits are the apparent absence of representatives of the formations included between the Cambrian and Carboniferous and the relative thinness of the entire series as compared with sections found in other parts of the country. The latter fact is less surprising when it is considered that the tendency of the Rocky Mountain deposits has been observed to be a thinning out toward the east, and that the Black hills were an island at least 100 miles east of the Archæan shore-line. Whether the apparent gap in the series signifies that there was actually a cessation of deposition during Silurian and Devonian times, or whether representatives of these formations exist but have not yet been detected, is a question that can only be definitely determined by far more detailed studies than have yet been made.

The geology of the Black hills is of singular interest, not only to the general but to the economic geologist, and the facts already obtained show that its history has been a remarkably varied one. According to Mr. Newton, there is evidence that the newer Archæan is unconformable to the older; in other words, that dynamic movements took place, and land existed here which was acted on by erosion before the close of the Archæan. The conglomerate at the base of the Potsdam bears unmistakable evidence of having been a beach or shore formation, and shows that new land appeared at the close of the Archæan, while the comparatively horizontal position of the Potsdam and Carboniferous beds in elevated portions of the hills seems to indicate a gradual subsidence during the Cambrian, which, if the Devonian be really wanting, must have been followed by a sufficient elevation to prevent the sediments of that period covering its area. This elevation, however, must have been of such a gradual character that the formations were not disturbed, inasmuch as the Carboniferous beds were deposited with perfect conformity on the Cambrian. At the close of the Cretaceous the area of the hills was again lifted above the sea and a second conglomerate deposited round its shores. Erosion during this time removed a large portion of the Mesozoic and Palæozoic beds to form the surrounding Tertiaries; and that elevation has gone on since Tertiary times seems to be proved by the evidence of conglomerate beds more recent than the Tertiary, which exist, according to Mr. Jenney, 300 feet above the present stream beds, and are made up of bowlders of the Archæan and other rocks from the interior of the hills. These gravels or conglomerates Mr. Jenney regards as quite distinct from those of the present stream-beds, and as probably dating back to the close of the Glacial epoch. There are thus four different ages of gravel formations, all of which, except possibly the third, have been proved to be gold-bearing:

First. The Potsdam conglomerate.

Second. That at the close of the Tertiary.

Third. That at the close of the Glacial period.

Fourth. The recent.

Of eruptive or igneous rocks, of which there are abundant outbursts, especially in the northern portion of the hills, where the richest mineral deposits have hitherto been found, Mr. Newton recognizes only those of Tertiary age. It seems probable, however, that had not his untimely death cut short his observations a further study might have led him to modify this opinion. Mr. Caswell, to whom the specimens of eruptive rock were submitted for microscopical examination, says himself that in several cases he would have classed the rocks as quartz or feldspar-porphyries had not their geological relations, as described to him, forbidden it. Among the census specimens are some which undoubtedly belong to these types. They are the rocks which are described by Mr. Devereux as breaking in dikes through the Potsdam conglomerate and spreading out over its surface in the neighborhood of Lead City. Moreover, the structural relations of the eruptive masses which form many of the prominent peaks, and which, according to Mr. Newton, have uplifted the surrounding sedimentary beds, belong rather to the type of earlier intrusive eruptives, analogous to the laccolitic bodies, than to the Tertiary volcanics, which as a rule have flowed out on the surface without exercising any considerable disturbing influence on the sedimentary beds through which they have passed.

To the economic geologist the most interesting fact in the geology of this region is the definite date given to the formation of the gold deposits. The Potsdam conglomerate is in places an actual placer deposit formed on the beach of the Cambrian ocean from the *débris* of veins at present worked in the Archæan. The gold of the Black hills is therefore distinctly of Archæan age. Mr. Devereux also recognizes a probable secondary deposition, which he considers as probably resulting from chemical solution of gold contained in the Potsdam conglomerate and redeposited in the underlying schists. He also seems to consider the deposition of certain silver-bearing ores in the neighborhood of Bald mountain, a region traversed by bodies of porphyry in the forms of dikes and sheets, which occur in the quartzite adjoining these bodies, as dependent on the eruption of the porphyry. If the section which he gives of the region in the neighborhood of Deadwood gulch be correct, the porphyry must be of subsequent date to the erosion of the Cretaceous and Palæozoic rocks, and therefore probably post-Cretaceous.

ORE DEPOSITS.—The most characteristic ores of the Black hills are auriferous pyrites, now almost completely oxidized, impregnating lenticular masses of quartz, and portions of the adjoining schist in the newer Archæan of Newton. Owing to the decomposed condition of the rock and its freedom from injurious metallic combinations these ores are so exceptionally easy of amalgamation in the stamp-mill that they yield a profitable return, even when carrying only from $4 to $6 per ton in gold. These deposits have been mainly developed in the extreme northern portion of the Archæan area at the head of the Whitewood gulch, in the vicinity of Lead, Central, and Deadwood cities. The country rock here consists of fine-grained mica-schists, argillites, or phyllites, with numerous interlaminated lenticular bodies of quartz parallel with the stratification, which has a prevailing northwesterly strike and a dip of from 50° to 75° to the northeast. The ore belts are from 40 to 200, 300, and even 500 feet in width, and consist of impregnations of these quartz masses and portions of the adjoining country rock with iron oxide, resulting from the decomposition of pyrites carrying fine gold. In these belts are barren streaks or "horses" of country rock and dikes or bodies of what is locally called porphyry. It is evident that these deposits have none of the characteristics of a true fissure vein, though they are none the less valuable on that account. It is probable also that the individual ore bodies, or lenses, are of limited extent both horizontally and vertically, or, as Mr. Jenney says, not continuous. This fact is not necessarily derogatory to the deposits as a whole, since, while one lens may pinch out, another may be found contiguous, though not exactly in the same plane. Moreover, in spite of the popular delusion in favor of fissure veins extending to the center of the earth, all known facts go to prove that all ore bodies are limited in extent, the difference between one and another being merely in the extent of the limit. Horizontally the limit is easily traced, although in depth it is sometimes beyond the present reach of practical mine development.

Another important source of gold is the cement or Potsdam conglomerate, which, though its ore is milled in the same manner as the vein material, is in fact an ancient placer deposit. It is only of local extent, is of varying thickness, and is made up of rounded and angular fragments of quartz, hematite, and Archæan schists, often with ferruginous cement, and, according to Mr. Devereux, carries free gold, distributed in an exactly analogous manner to that found in modern placers. In many cases the cement deposit is worked as a horizontal vein, while a vertical vein is described as occurring immediately beneath it. Whether Mr. Devereux would consider all these vertical veins as instances of later deposition is not known to the writer.

In mines reported from the Bald Mountain district, at the head of the Whitewood gulch, the reports show a different class of deposits, which consist of chlorides of silver and iron oxide, carrying gold, impregnating the quartzite strata to a thickness of several feet. These are probably the deposits which Mr. Devereux considers as a later formation, and connected with the porphyry outbreaks. No specimens of porphyry were returned by experts, but the district is apparently in the neighborhood of Terry's peak, the rock of which Mr. Caswell reports as a granitic rhyolite, with a completely crystalline groundmass, closely resembling granite- or felsite-porphyry.

In the Bear Butte district, 10 or 12 miles to the east of Deadwood, irregular deposits of argentiferous galena and cerussite, with oxides of iron carrying both gold and silver, occur in limestones and quartzites, sometimes parallel to the stratification, and again crossing it. Gold is also obtained from a conglomerate or breccia largely made up of fragments of what is apparently felsite porphyry. The geological relations of this class of deposits are not clear.

In Pennington county, in the central portion of the hills, free-milling gold ore is found in Archæan rocks in the Rockford, Cross, and Newton Forks districts; and to judge from the specimens of country rock sent in they occur apparently in the same Archæan formation as that of the Whitewood district, although, according to Mr. Newton's map, a portion at least of these mines would be included in the older series. It is to be noted, however, that the geological outlines of the map are confessedly imperfect, owing to the fact that Mr. Newton's material had to be worked up by another hand than his own. In the Cross district the ore-body seems to be the impregnation of a mass of actinolite-biotite schist, instead of quartz, included within the mica-schist country rock. It is to be noted, however, that in these districts, while, according to the census schedules, the formation strikes nearly north and south, its dip in the Rockford and Cross districts is to the eastward, and in the Newton Forks district to the west.

In Custer county, still farther south, are the Cole and Custer districts; in which the same lenticular masses of quartz, carrying free gold, occur in mica-schists. Both these districts are included in Newton's older Archæan area. The specimens of country rock sent in are micaceous schists, carrying considerable quartz, and sometimes garnetiferous, while the ore-bodies, in addition to the quartz, are sometimes amphibole-schists, and in one case consist entirely of fibrous tremolite. Associated with the gold is frequently a little silver. The prevailing strike is here also nearly north and south, and the dip to the westward.

Three miles to the northwest of Custer City is a mica mine, in one of the bodies of granite described by Mr. Newton. In its general character it resembles the pegmatites of Colorado, but the size of the individual constituents is actually gigantic, and the association of minerals is somewhat remarkable. The data are not sufficient to determine the exact geological relations of the rocks. The foot wall of mica-schist strikes north and south, and dips 40° to the westward. Above this a thickness of four feet is worked for mica, which occurs in large sheets over a foot in diameter, usually nearly perpendicular to the foot wall. Specimens from the zone next above the mica show albite (var. clevelandite), labradorite, beryl in crystals 2 to 3 inches in diameter, and a lithia-mica in small leaves. Above this is pure milky quartz of great thickness, said to extend to the top of the hill, over 100 feet above the vein. Whether these deposits prove of economic value or not, a visit to it would evidently be fruitful in interesting results to the mineralogist.

Placer deposits.—The placer deposits of the Black hills are apparently of great extent and richness; but, except those immediately adjoining the beds of the present streams, which are largely worked out, they have as yet proved of little practical value, owing to the difficulty of procuring a sufficient supply of water. As already stated, Mr. Jenney makes four different ages of gravel deposits. The earliest, or Potsdam conglomerate, is worked as a deep mine, and its ore is regularly crushed in the stamp-mills. Of the pre-Tertiary conglomerate no data are available as to its contents in gold. It occurs, according to Jenney, under the Miocene beds at the mouths of Spring and Rapid creeks, forming a bed 6 feet in thickness, made up of bowlders of granite, trachyte, slate, quartzite, and quartz. Mr. Jenney says the glacial deposit which occurs sometimes 300 feet above the present bed of the creek has been proved to be rich by actual test, but cannot be worked, owing to the want of a sufficient head of water. The recent deposits of the present cañons, according to data furnished by the census, have been worked principally in the Archæan area, and have an average depth of from 4 to 30 feet. Mr. Devereux gives some interesting facts concerning the placer deposits of Deadwood and its tributary gulches. According to him, these are formed in part from the disintegration of the Potsdam conglomerate bed and in part from the actual wearing away of the quartz deposits in the Archæan, which accounts for their exceeding richness; the placers of Black Tail gulch were entirely derived from the disintegration of the cement, as the Archæan, at the head of the gulch, has not been exposed to erosion in recent times. To account for the known superior fineness of placer gold over that in veins, he assumes that the chemical agencies to which the gold has been subjected since it was liberated from the vein have acted more energetically on the silver than on the gold. To prove this he shows from actual figures that while the average fineness of the gold from five different veins was 0.830, gold from the placers, which would have resulted from the disintegration of these veins, averaged about 0.900, and that the small, thin pieces of gold, which had proportionately greater surfaces than the coarser particles, were finer than the latter.

The other minerals of economic importance found in the Black Hills region are beds of gypsum, which occur in the Triassic formation, and of coal, which is mined in the Cretaceous beds to the northwest of the hills.

LAWRENCE COUNTY.

Mine.	Country rock and remarks.	Ore and gangue.
WHITEWOOD DISTRICT.		
Badger	Hanging wall felsitic rock with stratified appearance, probably eruptive. Foot wall mica-schist, with some chlorite. Ore belt vertical. Strike, NW., 200 feet wide; capped by conglomerate.	Free-milling auriferous quartz.
Black Tail	Conglomerate (cement deposit) of fragments of Archæan schist. Compact felsite overlying conglomerate. Ore body, horizontal, 14 feet thick.	Free gold in conglomerate.
Caledonia	Hanging wall phyllite, with pyrite and garnet. Foot wall mica-schist with chloritic layers. A felsite occurs whose relation is not clear. Strike, N. 5° W.; dip, 51° E. (?); two ore belts, one 40 feet, the other 182 feet wide.	Pyritiferous chloritic schists carrying gold. Chlorite apparently comes from actinolite.
Champion	Cap and hanging wall felsite-porphyry. Foot wall calcareous quartzite. Horses in vertical part of vein composed of carbonates of iron, lime, etc. Strike of formation, NE.; dip, 75° E.; ore belt, 35 feet wide.	In part steeply inclined beds, in part horizontal beds resting on upturned edges of Archæan, overlaid by porphyry.
Deadwood-Terra	Hanging wall chlorite-schist with garnet. Foot wall mica-slate formation. Strike, NW.; dip, 50° to 75° NE.	Ferruginous quartz carrying gold and a little silver scattered through a belt of Archæan, 250 feet wide.
Esmeralda	Probably Archæan. No specimens. Overlaid by conglomerate (cement).	Free gold in horizontal cement deposit, and segregated quartz lenses in schists below.
Fairview	Archæan overlaid by conglomerate. Strike, NW.; dip, 50° to 75° NE.; cement, 20 feet thick; ore belt, 200 feet wide; felsite (?), above the conglomerate.	Gold-bearing cement and quartz lenses in iron-stained mica-schist.
Father De Smet	Chloritic schists. Strike, NW.; dip, 50° to 75° NE.; ore belt, 150 feet wide, with horses of barren rock.	Quartz lenses and altered schists, with pyrite; gold-bearing.
Flora Bell	Phyllite on hanging wall. Altered schist on foot wall. Horizontal conglomerate capped by felsite (?) above. Strike, NE.; dip, 85° W.	Gold-bearing cement and schist impregnated with quartz.
Giant & Old Abe	Archæan schists impregnated with iron. Strike, NW.; dip, 50° to 75° NE.; ore belt, 60 feet wide.	Ferruginous gold-bearing quartz, with a little pyrite, impregnating schists.
Goldfinch	Quartz conglomerate, overlaid by fine-grained Potsdam sandstone; quartzite (?) below.	Cement 5 to 6 feet thick, carrying free gold.

LAWRENCE COUNTY—Continued.

Mine.	Country rock and remarks.	Ore and gangue.
WHITEWOOD DISTRICT—cont'd.		
Golden Gate	Fine-grained mica-schists. Strike, NW.; dip, 50° to 75° NE.; ore belt, 25 feet wide.	Quartz and schists, with little pyrite; gold-bearing.
Golden Terra	Mica-slate on hanging wall. Mica-schist, rich in quartz and microscopic ore grains, on foot wall. Strike, NW.; dip, 50° to 75° NE.; ore belt 300 feet wide, with "porphyry" dikes and horses of slate.	Ferruginous quartz, with little pyrite in slate.
Gopher	Fine-grained compact mica-schist. Strike, NW.; dip, 50° to 75° NE.; ore belt 60 feet wide.	Lenses of quartz and decomposed schists; gold-bearing, with little pyrite.
Great Eastern	Conglomerate of quartz and some schist, overlaid by quartz-porphyry. Dip, 15° E.; 3 feet thick; resting on schists.	Free gold in cement.
Hidden Treasure	Conglomerate of quartz and schist fragments; horizontal. Thickness, 20 feet to *nil*. Felsite above, Archæan below.	Free gold in cement.
Highland	Archæan schists. Argillite on foot wall; lenticular bodies of felsite (?) parallel with the formation. Strike, NW.; dip, 50° to 75° NE.; ore belt 550 feet wide, less felsite bodies.	Ferruginous quartz and schist, with little pyrite; gold-bearing.
High Lode	Conglomerate, resting on fine-grained Archæan schists, overlaid by Potsdam sandstone. Horizontal; 8 feet thick.	Free gold in cement.
Homestake	Archæan schists and porphyry (?) bodies. Strike, N. 10° to 38° W.; dip, 51° E.; ore belt 40 feet wide.	Ferruginous quartz and schist, with little pyrite, carrying free gold.
Lonella	Conglomerate, resting on Archæan, overlaid by sandstone. Dip, 30° E.; 7 feet thick.	Free gold in cement.
Oro Cash	Felsite-porphyry. Strike, NW.; dip, 30° NE.; ore belt 150 feet wide.	Gold-bearing hematite and limonite in quartz.
Peccho	Conglomerate, capped by felsite and resting on Archæan schists. Strike of latter, N. 5° W.	Free gold in cement, and gold-bearing quartz and schists in Archæan.
Portland	Quartzitic sandstone (Potsdam?). Strike, NW.; dip, 8° SW.; deposit, a nearly horizontal bed and a vertical vein below. Horizontal vein, 7 feet thick; vertical; strike SW., 5 feet thick.	Quartzite, impregnated with horn-silver, iron oxide, and some gold.
Rattler	Hanging wall quartzite-schist, foot wall mica-schist. Strike, NW.; dip, 75° NE.; 40 feet wide.	Ferruginous gold-bearing quartz.
Scandinavian	Archæan schists. Ore belt 38 feet wide; strike, NE.; dip, 85° NW.	Quartzose iron-stained masses, carrying gold.
Sir Roderick Dhu	Chloritic schists and mica-slates. Ore, lenticular mass; dip, 85° NW.	Lenses of quartz and pyrite, carrying gold.
Snowstorm	Fine-grained calcareous sandstone above, quartzitic schist below. Deposit, horizontal; 3 feet thick.	Quartzose mass, impregnated with gold and chloride of silver.
BEAR BUTTE DISTRICT.		
Carter	Mica-schist, with needles of decomposed hornblende. Strike, NW.; dip, 85° W.; ore belt, 100 feet wide.	Lenses of quartz, impregnated with oxide of iron, and carrying gold.
Clermont	Fossiliferous limestone on hanging wall. Vein vertical; strike, NE.; 40 feet wide.	Siliceous hematite, quartz, chalcedony, ocher, and in part earthy limestone, carrying gold and silver.
El Refugio	Quartzite. Strike, NE.; dip, 15° SE. Ore bodies irregular, following stratification; average, 2 feet thick.	Gold- and silver-bearing galena, altered to cerussite; crystals of pyromorphite and wulfenite.
Escondido	Earthy limestone. Deposit: dip, 80° E.; 5 feet wide	Galena, pyrite, and zincblende, carrying silver.
Florence	Ferruginous quartzite (Potsdam?). Horizontal; irregular bodies following stratification; 2½ feet thick.	Pyrolusite, ocher, and siliceous hematite impregnating quartzite, carrying silver.
Hoodoo	Conglomerate of felsite and stratified rocks; explored to a depth of 25 feet.	Free gold in conglomerate.
Keystone	Porphyry, with little quartz; large pink orthoclase crystals; no mica or hornblende: called "porphyritic conglomerate".	Quartz-bearing porphyry, impregnated with auriferous pyrites.
Merritt No. 2	Quartzite (Potsdam). Dip, 35° E.; deposit, 7 feet thick.	Argentiferous galena, limonite, and ocher, with little gold.
Oro Fino	Conglomerate of schist fragments, with ferruginous cement	Free gold in cement.
Rich	Breccia, or conglomerate of porphyry fragments. Dip, S. and E.	Free gold in conglomerate, with ferruginous cement.
Sitting Bull	Quartzite (Potsdam). Dip, 20° SE.; deposit, irregular bodies following stratification.	Galena and siliceous hematite, with carbonate, carrying gold and silver.
Union Hill	Conglomerate or breccia of felsite-porphyry	Country rock, stained with oxide of iron, and carrying gold.
Washington	Quartzite (Potsdam). Deposit, irregular following stratification; horizontal, 1 to 8 feet thick.	Galena, carrying gold and silver.
Yellow Jacket	Foot wall, mica-schist; hanging wall, indistinctly schistose rock. Strike, NW.; dip, 20° SW.; ore body 3 feet thick following the formation.	Cerussite, carrying silver and some gold in quartzose mass.

PENNINGTON COUNTY.

Mine.	Country rock and remarks.	Ore and gangue.
ROCKFORD DISTRICT.		
Alta	Hanging wall greenish decomposed mica-schist. Foot wall dark phyllite. Strike, N.; dip, 45° E.; ore belt, 100 feet wide.	Quartz and altered schist, carrying free gold.
California	Chloritic mica-schist. Strike, N	Decomposed schist and quartz, carrying free gold.
Evangeline	Siliceous schists. Strike, N. and S.; dip, 17° E.; ore belt, 40 feet wide.	Altered country rock, carrying free gold.
CROSS DISTRICT.		
Cross	Mica-schist. Strike, N. 17° W.; dip, 85° E.; ore belt, 100 feet wide.	Actinolite-biotite schist, carrying gold and silver.
Quincy and Little Grace	Siliceous mica-schist. Strike, N. 18° W.; dip, 85° E.; ore belt, 90 feet wide.	Do.
NEWTON FORKS DISTRICT.		
King Solomon	Light-colored phyllites, garnetiferous on foot wall. Strike, N. 15° W.; dip, 80° W.	Quartz and country rock, carrying gold and silver.
Queen Bee	Fine-grained mica-schist. Strike, N. and S.; dip, 45° W.; ore belt 10 feet wide.	Quartz and country rock, carrying free gold.
Royal Bengal Tiger	No specimen; apparently same as above mine. Strike, N. and S.; dip, 85° W.; ore belt 10 feet wide.	Quartz and schists, carrying free gold.

CUSTER COUNTY.

Mine.	Country rock and remarks.	Ore and gangue.
COLE DISTRICT.		
David City Lightning	Mica-schist, with much quartz on foot wall. Strike, N. and S.; dip, 85° W.; ore belt 8 feet wide.	Quartz and schist, carrying free gold.
Knobscott	Mica-schist; dip, N.; ore belt 30 feet wide	Lenticular masses of smoky quartz, carrying free gold.
CUSTER DISTRICT.		
Atlantic	Hanging wall mica-schist; foot wall quartzite. Strike, N. 5° W.; dip, 60° W.	Quartz, carrying free gold.
Grand Junction	Mica-schist. Strike, N. 5° W.; dip, 45° W.; ore belt 70 feet wide.	Auriferous quartz, with little silver, in a schist consisting of radiated aggregations of minute fibers of tremolite.
Hartford	Mica-schist, sometimes garnetiferous. Strike. N. 5° W.; dip, 45° W.; ore belt 100 feet wide.	Quartz and amphibolitic schists, carrying free gold.
Mammoth	Mica-schist. Strike, N. 5° W.; dip, 45° W.; ore belt 100 feet wide.	Quartz and schist, carrying free gold and some silver; garnet occurs with the quartz.
Old Bill	Hanging wall quartzose mica-schist, with garnet and pyrite; foot wall quartzite, with micaceous layers.	Quartz and country, carrying gold and little silver.
Old Charley	Probably Archæan schists; no specimens. Ore belt 300 feet wide.	Quartz masses in fine-grained gneiss, carrying free gold.

GEOLOGICAL SKETCH OF MONTANA.

PHYSICAL DESCRIPTION.—The territory of Montana, lying along the northern boundary of the United States, extends westward from the line of Dakota, at the junction of the Yellowstone and Missouri rivers, theoretically to the extreme crest of the Rocky mountains.

The eastern half, which consists of the valleys of the Yellowstone and Missouri rivers and their immediate tributaries, belongs more properly to the plain country of the northern Missouri valley. This portion of the territory is largely occupied by various Indian reservations, and its mineral wealth has been but little explored.

Of the mountainous western half, the northern portion, adjoining the British boundaries, is also but little known. From the southern boundary of Montana, near the heads of the Yellowstone and the Missouri rivers, the Rocky mountains assume a northwestern trend. The little chartographic knowledge obtained of this region is derived from the records of the Northwest Boundary survey and from the explorations for a route for the Pacific railroad made under the War Department, which give a partial knowledge of certain lines, between which are broad gaps whose topography is comparatively unknown. The Rocky mountains, which in Colorado are a compact series of chains having a general north and south trend, end abruptly in southern Wyoming; but in northwestern Wyoming they are represented by the Wind River, Shoshone, and Big Horn mountains, which take a general northwesterly direction. The Wahsatch system in Utah has also a north and south trend, and is separated from the Rocky Mountain system by the basin of the Colorado river. Through eastern Idaho this chain also loses somewhat of its continuity, and the Rocky Mountain system in Montana is apparently formed by the junction of these two systems of elevation. In general, the mountain regions in western Montana are less elevated than those of Colorado and Utah and abound in broad open valleys, so that in spite of the northern latitude the climate is relatively mild. They are well watered, the hills and valleys support an abundant growth of timber or grass, and in many of the valleys a limited amount of agriculture is possible.

GEOLOGY.—Of the geology of Montana but little is definitely known, the work of the government geological surveys not yet having extended so far north. The surface of the eastern half of the territory is probably largely covered by the Tertiary and Cretaceous formations which are found on the great plains of the south, while along the large streams are broad alluvial valleys, which extend well up to the foot-hills of the mountains and are admirably adapted for agriculture.

As well as can be determined from the scanty material at hand, the geology of the mountainous districts of western Montana is more nearly allied to that of the Wahsatch range than to that of the Rocky mountains of Colorado. Indeed, the Archæan uplift of the Front range of Colorado finds its northern continuation in the Black hills of Dakota on a line with the extreme eastern boundary of Montana. It has already been observed (*a*) that the Wahsatch range forms the geological center of the Cordilleran system, and that between the sedimentary series developed on either side of this central axis there is a great and characteristic difference. The Palæozoic formations, which in Utah and Nevada reach an aggregate thickness of over 30,000 feet, in Colorado have an average of only about 5,000 feet. Over the Great Basin area the Triassic and Cretaceous rocks are entirely wanting, and those developed on the eastern slope of the Rocky mountains, extending in the Wyoming basin as far as the flanks of the Wahsatch, are entirely different from corresponding horizons in western Nevada and California. The heavy limestones of the lower portion of the Palæozoic system are found to thicken as one follows the line of the Wahsatch northward through eastern Idaho. From the older sedimentary beds of Montana, as far as known, no fossils have yet been obtained by which to determine definitely the age of any particular horizon; but the character of specimens of limestone and argillaceous rocks received renders it probable that those developed in the mining regions

a See *Reports of the U. S. Geological Exploration of the Fortieth Parallel.*

of Montana belong to the lower portion of the Palæozoic horizon, the more so as they rest directly on granites or Archæan schists. The only geological data available are furnished by specimens collected in the southern central portion of the western half of the territory, viz, from Lewis and Clarke, Deer Lodge, Jefferson, Madison, and Beaver Head counties. Of the geology of the regions extending north from here to the British line, through Missoula and Choteau counties, but little information is available. That obtained from these counties, which is furnished simply by specimens of country rock brought in by the experts who examined this region, is too meager to afford any ideas of general structure; but there would seem to be an upheaval of Archæan rocks, exposing gneissic formations, on a north and south line through the center of this region. Along this line is also a considerable development of so-called granite, in which the most valuable ore deposits occur. A very large portion of this granite, however, proves to be a diorite of somewhat singular character, possessing certain marked characteristics, which is found from Madison, through Deer Lodge, north to Lewis and Clarke county, and it seems probable that it is an eruptive body of Archæan age, distinct from the true Archæan granite. The specimens which have been microscopically examined were obtained from near the Lexington and Alice mines, at Butte City, and the Deer Lodge lode, in Deer Lodge county; also from Union lode No. 2 and Schafer Mill, in Lewis and Clarke county. It is a crystalline rock, containing both orthoclase and plagioclase feldspars, the latter being predominant, with but little quartz; also a large proportion of basic minerals, among which hornblende, augite, and biotite all occur. This association is the more remarkable, since it seems that these minerals are all original, and the hornblende is not, as would appear at first glance, simply a decomposition product of augite. Under the microscope the former is seen, indeed, to form in many cases the periphery of the augite masses; but it is not fibrous, like the uralitic products of hornblende decomposition, but clear and homogeneous. Hornblende also occurs in distinct individuals; and, moreover, there are distinct intergrowths of biotite and hornblende, both fresh and with the biotite leaves lying parallel to the orthopinacoid of the hornblende. It would seem, therefore, that at a certain period in the growth of the rock the formation of augite may have ceased and the hornblende have formed about the already existing augite particles. The augite is pale, and contains much magnetite in small grains. The biotite changes to a green mineral, which does not seem identical with the ordinary chlorite, and this, in turn, changes into epidote. Most of the biotite is fresh, and titanite, apatite, and magnetite are present. The type described is that from the Union lode. That from Schafer Mill contains more quartz than orthoclase, and some of the quartz is intergrown with orthoclase, so as to make a distinct graphic-granite structure, visible only under the microscope. Both augite and biotite are abundant, but hornblende is relatively rare. The country rock of the Lexington mine, at Butte, has the same general character as that of the type rock. Much of the hornblende is twinned, and intergrowth of biotite is common. The rock of the Alice mine, at Butte, is somewhat coarser grained than the others, and contains a less proportion of basic silicates, augite being entirely absent from the section examined. Mica and hornblende are about equal in quantity, and the hornblende has frequently the outlines of the prism, showing that it can hardly come from the decomposition of augite. The rock from Deer Lodge lode, McClellan's Gulch district, Deer Lodge county, is somewhat different from all of the above. It contains much more quartz and orthoclase, and augite is wanting, although hornblende and biotite are similarly intergrown as in the type rock. It also contains apatite, a little magnetite, and a few pale crystals of zircon, but no titanite. A more detailed study of this interesting rock than it was possible to make by the aid of the few specimens collected by the census experts would be necessary in order to definitely determine its character. In the subjoined tables it has been provisionally called "diorite-granite", to distinguish it from the normal type of granite which occurs in the same district, but whose structural relations to it are as yet unknown.

Of rocks which could be definitely determined as belonging to the Secondary eruptive series but few specimens were brought in. There can, however, be no doubt that they are of frequent occurrence in the territory, and it seems probable that to this type may belong the so-called granites which overlie the contact deposits in limestone of the Bannack district. But little reliance can, unfortunately, be placed on the nomenclature given by miners to the rocks they find associated with their ores, since they, too, often pride themselves on having distinctive names of their own, quite independent of any scientific usage. The so-called porphyries reported from Montana mines have proved, where specimens have been sent in, to be more or less altered granites or gneisses. Of Tertiary eruptive rocks such great flows exist in Idaho on the south and west, and also in the Yellowstone park, that it is probable many may occur in the territory. The only definitely known occurrence is the rhyolite, which breaks through the diorite-granite at Butte City.

ORE DEPOSITS.—The ores of Montana are mostly of gold, silver, and copper, either separately or in combination with two or more of these metals. Argentiferous lead ores also occur, but in far smaller proportion than in Colorado, and are seldom free from other base metals. These ores are found either in veins in the crystalline rocks or as irregular deposits in sedimentary rocks, sometimes crossing the strata, but generally more or less coincident with bedding-planes. Of the deposits in crystalline rocks the majority of the best known, and those whose bodies are strong and well defined, are of the class of metamorphic veins, *i. e.*, their vein material is a portion of the country rock, more or less altered along certain planes, in which silica, calcite, and metallic minerals have replaced portions or all of the original constituents. In these deposits there is, as a rule, no definite limit or wall, or, at the most, on one side only; and it is evident that there was no pre-existent open fissure, as is theoretically supposed to have been the antecedent condition of the "true fissure vein". It may also be said that, as far as our present knowledge goes, there is no valid reason for supposing that such deposits are any less permanent or rich than those which may show evidence of having been deposited in a pre-existing open fissure.

In some cases gold-bearing ores seem to be simply impregnations of the gneissic country rock with auriferous pyrites, and probably occur in lenticular interlaminated quartz masses, such as on a very much larger scale constitute the so-called gold veins of the Black hills of Dakota. Deposits in limestone seem to be here, as elsewhere, very irregular in form, but tend to follow bedding or contact planes and cross-joints which have yielded more easy access to metallic solutions. Owing to the superior thickness of the Palæozoic formations in this region the vertical range of the deposits is probably much greater than in Colorado.

A considerable proportion of the ores are auriferous pyrites and quartz, sufficiently oxidized to mill freely; but the greater value and bulk are those of more complex composition, which require to be smelted. These have two characteristics which distinguish them from the ores of Colorado: first, a usual presence of copper, rather than of lead, as a silver-carrier, and of manganese, instead of iron, in that part of the ore which goes into the slags in smelting. Chalcocite, or copper glance, is one of the most common minerals, and oxide of manganese, passing into carbonate below the water level, is exceptionally frequent. No data are at hand for making even an approximately complete list of the minerals which occur in the territory.

PLACER DEPOSITS.—Until within a comparatively few years the main precious-metal production of Montana has been derived from its placer deposits, which are exceptionally rich. Estimates place their total yield at over $50,000,000, but it is impossible to say how close an approximation to the truth these estimates may be, since the grounds on which they are based are not given, and the determination of the yield of placer mines is the most difficult task the mineral statistician has to undertake. The first deposits were discovered in 1861 in the Pioneer district, on Gold creek, a branch of Deer Lodge river, in the county of the same name. For many years the production of the placer mines was very large; and a great many are worked at the present day, although their production has somewhat fallen off by the working out of the exceptionally rich deposits. Hydraulic mining is carried on to a very considerable extent, and many Chinese miners find ample remuneration in working over abandoned gulch mines. Owing to an unfortunate combination of circumstances the census data were collected very late in the season, when the placer mines were mostly abandoned for the winter; and the data in regard to these deposits are, consequently, very incomplete. The deposits which are worked seem to have been found mostly in rather open valleys, but comparatively high up in the mountains, and consist consequently of rather coarse gravel. For deposits of this character they are exceptionally thick, varying according to data from 5 to 65 feet; and in many cases actual bed-rock had not been reached, but only a clayey seam or false bed-rock, below which the gravel is said to be barren.

From many of the deposits fossil shells and petrified bones and tusks are said to have been obtained. No specimens, however, have been sent in. It seems likely, therefore, that these deposits are, as a rule, older than the ordinary river gravels, and may date back to the flood period following the Glacial epoch. Placer deposits are known to be worked in Beaver Head, Madison, Gallatin, Meagher, Jefferson, Deer Lodge, Lewis and Clarke, and Missoula counties, the most productive of which have been those of Alder gulch, a branch of the Stinking Water, at the head of the Jefferson river, in Madison county. Next to these are those of Deer Lodge county, the most important of which is the Pioneer district, and several in the neighborhood of Butte City which are tributary to the Deer Lodge river, the Henderson district, near Flint creek, and the McClellan Gulch district, at the head of the Big Blackfoot river.

In Lewis and Clarke county the Last Chance district, near Helena, has been a large producer; and important deposits have been worked on both sides of the Missouri river, both in this and in Meagher county, as also on the east slope of the Big Belt mountains of the latter county. Placers have also been worked in Gallatin county north of the National park, along the tributaries of the Yellowstone river. In Beaver Head county the placers near Bannack have a bed-rock of conglomerate with lime cement, containing shells and large bones, which must, it seems, have as early an origin as the Glacial epoch. The gold is coarse shot gold, with a relatively large proportion of nuggets as large as walnuts; and that derived from the Montana placers, in general, has a higher average grade of fineness than that of other territories.

DEER LODGE COUNTY (SILVER BOW COUNTY).

The most important mining district in the state is Summit valley, near Butte City, which, since the legislative action of February, 1881, is now included in the new county of Silver Bow. The ore deposits of this district all occur either in true granite or in the diorite-granite already described. The majority of the veins from which data are available have an east and west strike and dip at a high angle to the south. Besides the granite country rock, rhyolite occurs, which forms the so-called butte from which the town derives its name, ramifications from which body, it is suspected, may be found in the neighborhood of some of the important mines. The veins belong certainly to the type of metamorphic veins, *i. e.*, although the richer part of the ore is often found in a gangue of almost exclusively siliceous material and with a fairly defined wall on one side, on the other there is no definite limit, but the country rock is found to yield pay material for a varying distance from the main ore body, and the limit to which the impregnation has extended is, consequently, not determined, since only that which it would pay to work is extracted. The most important mines of the district are the Alice, Lexington, Belle, Gagnon, and North Star. Ores rich in copper and silver, and carrying an exceptionally large proportion of manganese minerals, are the prevailing type.

The Flint Creek district, near Phillipsburg, to the northeast of Butte City, has silver-bearing ores carrying zinc, copper, and lead minerals in a limestone generally white and crystalline. In the case of the Salmon mine granite is reported as occurring on the hanging wall of the vein, but as no specimens were returned it seems questionable whether it may not be a crystalline porphyry.

In the McClellan Gulch district, at the head of the Big Blackfoot river, auriferous quartz is found in a rock resembling the diorite-granite of Butte City.

LEWIS AND CLARKE COUNTY.

The principal mines of Lewis and Clarke county appear to be near Helena at its southern extremity and along the heads of Silver creek a short distance north. At Helena they are mainly gold-bearing veins in granite. In the Silver Creek region they are also gold-bearing ores, containing a little silver, but occur in slates and slaty limestones; and although standing at a high angle, and called fissure veins, it would seem that in some cases at least they are more probably segregations of quartz and mineral in bodies lying parallel with the formation.

JEFFERSON COUNTY.

In Jefferson county the ores carry both gold and silver in varying proportions, and the mines occur in various districts on either slope of the mountains lying west of the Missouri river. The ores are comparatively free from base metals, and occur in felsite-porphyry and other undetermined eruptive rocks, and in limestones parallel with the stratification-planes.

MADISON COUNTY.

In the northeast portion of Madison county, near the Jefferson river, are the Silver Star districts, whose ores occur mainly in gneiss, and are gold-bearing, with a slight admixture in some cases of lead and copper ores. The Broadway mine is reported to be a bedded deposit at the contact of limestone with granite.

In the Mineral Hill district, at the head of Willow creek, north of Virginia City, galena and quartz, carrying both gold and silver, are found in gneiss; and in the Red Bluff and Hot Springs region, near the Madison river, are ores of galena and pyrite, also mainly in gneiss, carrying both gold and silver.

BEAVER HEAD COUNTY.

In Beaver Head county, near Bannack City, auriferous pyrite in quartz, sometimes associated with galena, is found in limestone, with a hanging wall of so-called granite. The strike of this formation seems to be uniformly to the northeast, with a shallow dip of from 15° to 20° to the south and southeast. As already stated, it seems probable that the so-called granite is a quartz-porphyry or diorite. Slates and limestones can be traced northward from Bannack, through Argenta, to Glendale, near Big Hole river. At first they preserve the westerly dip observed near Bannack, which gradually steepens, and becomes vertical some 15 miles north of Argenta. The formation from here to Glendale dips to the eastward. Along Trapper creek, which flows into the Big Hole from the west, are easterly-dipping slates, apparently underlying the limestone which is found at Glendale. At its head is a cliff about 1,000 feet in height of blue-gray limestone beds, underlaid by black bituminous shale, dipping 16° to the westward; half-way up the cliff are the deposits of the Hecla Consolidated mines, which are masses of argentiferous galena, zincblende, copper, and iron pyrite, and their oxidation products, occurring on the stratification-planes of the limestone at different horizons. These ores are smelted to a lead bullion and a copper matte carrying silver. Big Hole river, some 8 or 10 miles higher up, runs through a cañon cut in gneiss, and at Dewey's flat, above the cañon, abundant gold-bearing quartz veins in gneiss are said to occur.

DEER LODGE COUNTY. (*a*)

Mine.	Country rock and vein.	Ore and gangue.
SUMMIT VALLEY DISTRICT.		
Alice	Diorite-granite, rich in plagioclase, with some augite. Vein: strike, NE.; dip, 65° NW.; 35 feet wide.	Native silver, and sulphide, with carbonate of manganese, quartz, and pyrite, carrying gold and silver. Gangue: altered country.
Anaconda	Granite (?). Vein: strike, E. and W.; dip, 75°; 8 feet wide	Chloride of silver, malachite, azurite, chalcocite. Gangue: siliceous, may be altered porphyry.
Anglo-Saxon	Granite. Vein: dip, 47° S.; 2½ to 5 feet wide	Cerussite, carbonate of manganese, and sulphide of silver in quartz; yellow stains of antimony; carries silver and little gold. Gangue: decomposed granite.
Anselmo	Granite, containing pyrites. Vein: strike, E. and W.; dip, 7° S.; 2 to 5 feet wide.	Native silver; argentite, galena, pyrite; traces of manganese, copper, and gold in quartz. Gangue: decomposed granite.
Belle	Diorite-granite. Vein vertical; strike, E. and W.	Massive chalcopyrite, with pyrite, hornite, freibergite (?), and native silver, with but little quartz. Gangue: clay, with rounded granite pebbles.
Clear Grit	True granite. Vein: strike, NW.; dip, 70° SW.; width, 15 to 17 feet (2 feet productive).	Cellular quartz, containing sulphuret of silver; little gold.
Colusa	Granite (?). No specimens. Vein: strike, NW.; dip, 70°; 14 feet wide.	Chalcocite, massive and impregnating the granite. Gangue and horse material; decomposed quartz-bearing granular rock.
Cora	Granite (?). No specimens. Vein vertical; strike, E. and W.; 26 feet wide, including horse of porphyry.	No specimens. "Copper, lead, a little zinc and silver, and antimony."
Gagnon	Granite. No specimens. No distinct walls. Vein: strike, E.; dip, 80° S.; width, 150 feet (8 feet pay).	Chalcocite, silver-bearing. Gangue: mainly quartz, with pyrite.
High Ore	Decomposed granite. Vein: strike, E. and W.; dip, 45° S.; 12 to 16 feet wide.	Chloride of silver (?) in cellular quartz; little gold.
Late Acquisition	Diorite-granite. Vein: strike, E. and W.; dip, 75° S.; 5 feet wide.	Pyrite and chalcocite in quartz; galena and chlorides said to occur; little gold. Gangue: decomposed country rock.
Lexington	Diorite-granite. Vein: strike, E. and W.; dip, 30° S.; 8 feet wide.	Galena and cerussite, with rhodonite; silver and gold bearing.
Morning Star	Granite. Vein vertical; strike, E. and W.	Auriferous pyrite; native silver and sulphuret in quartz. Gangue: altered granite.
Mountain	Granite. No specimen. Vein: strike, NW. and SE.; dip, 75° S.; 8 feet thick.	Copper. No specimens.
National	Decomposed granite. Vein: strike, E. and W.; dip, 80° S.; 20 feet wide.	Chalcocite and pyrite, carrying silver.
Nettie	Granite. Vein: strike, E. and W.; dip, 70° S.; 5½ feet wide	Psilomelane and horn-silver.
North Star	No specimens. Called granite-porphyry, may be rhyolite. Vein: strike, E. and W.; dip, vertical; 50 feet wide.	Chloride, black sulphuret, and native silver. No specimens.
Shakspeare	Granite (diorite?). Vein: dip, 90°; 20 to 40 wide; foot wall not found.	Largely chalcocite, carrying little silver.
Shonhar	"Soft granite." No specimens. Vein: strike, E. and W.; dip, 70° S.; 12 feet wide.	"Black manganese," carrying silver and little gold. No specimens.
Silver Bow Mining Company (13 mines reported in one schedule).	Granite and syenite (?). No specimens. Veins: strike, about E. and W.; dip, from 45° to 90°.	Ores carrying galena, cerussite, pyrite, chalcopyrite, and sulphurets. No specimens. Veins said to be inclosed in porphyry, probably decomposed granite (diorite).
Springfield	"Hard granite." No specimens. Vein: dip, 70° S.; pay-streak, 4 feet wide on foot wall.	"Sulphurets of silver and iron." No specimens.
Star West	Hanging wall like granite. Foot wall diorite (?). Vein: strike, ? dip, 36° S.	Freibergite and pyrite, with manganese mineral.
Stevens	Altered syenite (diorite?). Vein: strike, E. and W.; dip, 60° S.; 4 feet wide.	Cellular quartz stained yellow, carrying gold and silver. No mineral visible.
Volunteer	"Soft granite." Veins (2) 16 feet apart; strike, E. and W.; dip, 45° S.; one 3 feet, the other 8 to 15 feet wide, the former the richer.	Massive zincblende and freibergite, said to contain also horn-silver and galena.
Wabash	Granite. No specimens. Vein: strike, E. and W.; dip, "10°" (probably 80°) N.; 100 feet wide; pay-streak 2 to 6 feet.	Cellular quartz with yellowish green coating, said to contain gold and chloride of silver. Gangue: a crumbling mass of quartz and feldspar stained reddish yellow, probably altered country.
INDEPENDENCE DISTRICT.		
Mountain Boy	Granite. Vein: strike, about E. and W.; dip, 70° S.; 2 feet wide.	Quartz, impregnated with galena; pyrite, rhodochrosite, with native silver on joint-planes. Gangue: decomposed country rock.
Self-rising	"Porphyry" (?). No specimens. Vein: strike, E. and W.; dip, vertical; 3 to 7 feet wide.	Black oxide of manganese, with gold, silver, and copper. No specimens.
FLINT CREEK DISTRICT.		
Algonquin	White granular limestone (dolomitic?) near granite. Deposit: strike, N. 20° E.; dip, 45° E., in irregular bodies.	Galena, blende, gray copper, etc., in quartz. Oxide of manganese and pyrite also occur; silver bearing.
Salmon	Granite (?) hanging wall. No specimen. Limestone foot wall. Deposit: strike, N. 20 E.; dip, 45° E.	Quartz, with zincblende and copper stains, carrying silver.
Speckled Trout	Gray crystalline limestone, fine-grained on hanging wall, coarser-grained on foot wall. Vein: strike, NE.; dip, 80° SE.; 2 feet wide.	Mainly crystalline zincblende and argentiferous galena; said to carry ruby silver.
Hope	Fine-grained yellowish limestone; ore deposit in bedded masses; strike, E. and W.; dip, 32°; 4 to 9 feet thick.	Quartz, impregnated with black sulphurets of silver and carbonate of copper.
Scratch Awl	Limestone, white and crystalline, on the north wall; thinly bedded and slaty on the south wall. Vein: strike, E. 6° S.; dip, vertical; 2 feet wide.	Stained quartz, with oxides of manganese and copper, carrying silver.
M'CLELLAN'S GULCH DISTRICT.		
Deer Lodge	Diorite-granite. Vein: strike, N. 20 E.; dip, 20° W.; 1 to 2 feet wide.	Iron-stained quartz.
McClellan's Gulch lode	Diorite-granite. Vein: strike, NE.; dip, 20° S. E	Iron-stained quartz.

a In February, 1881, a portion of Deer Lodge county, including the Summit Valley district, was set off into a separate county, called Silver Bow.

LEWIS AND CLARKE COUNTY.

Mine.	Country rock and vein.	Ore and gangue.
SILVER CREEK DISTRICT.		
Albion	Dark slate. Vein: strike, E. 8½° N.; dip, 70° N.; 18 inches to 11 feet thick.	Quartz, with oxides of iron and manganese, little lead and copper, carrying gold and little silver.
Penobscot, Snowdrift, and Conrage.	Tough greenish slate, with imperfect bedding; small quartz veins. Vein: strike, E. and W.; dip, 70° N.; 4 to 18 feet wide.	Quartz, with oxides of iron and manganese; stibnite in pockets; carries gold and trace of silver.
Belmont	Slate at surface. No specimens. Normal granite in depth. Vein: strike, E. and W.; dip, S.; average width, 6 feet, with two branches.	Quartz, with some calcite, carrying gold and silver.
STEMPLE DISTRICT.		
Hickey and Bluebird	Dark compact slate, with imperfect bedding; ore bodies; strike, E. and W.; dip, 80° S.	Mixture of quartz and feldspar, carrying gold; gangue of fine, compact limestone in center of ore body in depth.
Mount Pleasant	Slaty limestone. Deposit: strike, E. and W.; dip, 80° S.; width, 5 feet.	Ore deposit like the former.
Sandford	Same character as Hickey and Bluebird, of which it is a continuation.	
Whip-poor-will	Slaty limestone. Vein: strike, E. and W.; dip, 75° N.; 3 feet wide.	Iron-stained quartz.
OTTAWA DISTRICT.		
Drumlommond	Syenitic granite, with a little quartz. Vein: strike, E. and W.; dip, 70° S.; 60 feet wide (40 feet long).	Mixture of quartz and feldspar, stained with azurite and iron oxide.
OWYHEE DISTRICT.		
Union lode No. 2	Diorite-granite, with biotite, hornblende, and augite. Vein: strike?; dip, 30° N.; 3 feet wide.	White gold-bearing quartz.

JEFFERSON COUNTY.

CATARACT DISTRICT.		
Boulder	Decomposed porphyry. Vein: strike, N. 70 W.; dip, 85° NE.; 7½ feet wide.	Iron-stained quartz, carrying gold.
Mantle	Syenite (?) containing a little quartz. Vein: strike, ENE.; dip, vertical; 4 feet wide.	Gold-bearing quartz, with pyrite; little silver.
CEDAR PLAINS DISTRICT.		
Keating	White homogeneous felsite, impregnated with pyrites. Vein: strike, N. and S.; dip, 85° W.; 3 feet wide.	Massive pyrite, carrying gold and silver.
ELKHORN DISTRICT.		
Alta	Compact felsitic porphyry. Vein: strike, NE.; dip, 60° NW.; 8 to 10 feet wide.	Quartz, carrying galena and pyrite, silver, and a little gold.
A. M. Holter	Limestone, thin bedded and compact on hanging wall; granular, resembling a sandstone on foot wall; ore body, dip 45° to the north with the stratification.	Quartz, with argentiferous galena, some native and horn-silver.
MOUNTAIN DISTRICT.		
Little Giant	Greenish eruptive rock; undeterminable. Vein: strike, E. and W.; dip, 80° S.; 4 to 6 feet wide.	Iron-stained mass, quartz and clay carrying gold.
DISTRICT NOT ORGANIZED.		
Bonanza Chief	No specimen. "Quartzose rock," "bedded mass in granite." Dip, 20° NE.	Iron-stained siliceous matter, containing gold and traces of silver.
SILVER STAR DISTRICT.		
Aurora Borealis	Fine-grained gneiss. Vein: strike, E. and W.; dip, 45° S.; 2 feet wide.	Gold-bearing quartz with galena; little carbonate of copper and iron oxide.
Broadway	Hanging wall dark impure limestone; foot wall granite. Deposit: strike, NW. and SE.; dip, 38° S.; thickness, 15 feet.	Yellow ferruginous jasper, with spots of hematite, chalcedony, and calcite in the fissures; carries gold.
Grasshopper and Cricket	Syenite(?), probably gneiss. No specimen. Vein: strike, E. and W.; dip, 50° S.; 5 to 6 inches wide.	Iron-stained gold-bearing quartz.
Grubstake	Even-grained gneiss. Vein: strike, NW.; dip, 45° NE.; 2 feet wide.	Decomposed yellow rock, probably gneiss carrying silver.

MADISON COUNTY.

HOT SPRINGS AND RED BLUFF DISTRICTS.		
Boaz	Gneiss. Vein: strike, NW.; dip, 45° E.; 2 feet wide	Crumbling, stratified rock, iron-stained, and carrying gold. Altered country.
Cordwainer	Fine-grained biotite-gneiss. Vein: strike, NW.; dip, 50° NE.; 2½ feet wide.	Crumbling, iron-stained gneiss, carrying gold; little copper.
Red Bluff	Gneiss. Vein: strike, E. and W.; dip, 41° N.; 3 to 6 feet wide	At surface red or blue jasper, with some pyrite and galena, carrying gold and silver. Below water level solid mass of pyrite and galena, with little quartz.
Red Chief	Granite (?). No specimens. Vein: dip, 48° NE.; 4 feet wide	Iron-stained quartz, carrying gold and silver.
MINERAL HILL DISTRICT.		
White Pine	Gneiss, with rhombic pyroxene. Vein: strike, E. and W.; dip, 45° S.; 18 inches wide.	Massive quartz, with some galena, carrying gold and silver.

BEAVER HEAD COUNTY.

Mine.	Country rock and vein.	Ore and gangue.
BANNACK DISTRICT.		
Dakota and Blue Grass	Hanging wall granite; foot wall limestone. No specimens. Deposit: strike, NE.; dip, 15° SE.; 8 feet thick.	Quartz, pyrite, and siliceous oxide of iron, carrying gold.
Excelsior	Hanging wall granite (?) and trap; foot wall limestone. No specimens. Deposit: strike, NW.; dip, 20° SE.; 8 feet thick.	Iron-stained quartz and pyrite.
French	Hanging wall granite (?); foot wall limestone. No specimens. Deposit: strike, E. and W.; dip, 15° S.; 15 to 40 feet thick.	Siliceous iron, with pyrite, carrying gold.
Golden Leaf	Same as French. Deposit: 10 to 80 feet; dip, 15° S.; strike, NE. and SW.; 10 to 50 feet thick.	Oxide of iron, free gold, argentiferous galena.
Springfield	Hanging wall granite (?); foot wall limestone. No specimens. Strike, NE.; dip, 15° S.; 5 feet thick.	Auriferous iron-stained quartz.
Washington	Like the preceding.	
BALD MOUNTAIN DISTRICT.		
Elkhorn	Granite. No specimens. Vein: strike, NE. and SW.; dip, 88° N.	"Zincblende, black copper, gray copper, chloride, and native silver." No specimens.
TRAPPER DISTRICT.		
Hecla	Dolomite, blue and gray. Ore deposit follows the stratification-planes. Strike, N.; dip, 10° W.; 2½ feet thick. Several bodies.	Contains galena, cerussite, calamine, and copper minerals. Gangue: white crystalline limestone.
Keokuk	Limestone, siliceous on hanging wall, crystalline on foot wall. Ore deposit following the stratification-planes. Dip, 35° SW.	Oxides, carbonates, and sulphurets of silver, lead, and copper. No specimens.

GEOLOGICAL SKETCH OF NEW MEXICO.

The territory of New Mexico, adjoining Colorado on the south, has a somewhat larger area, and is included between the one hundred and third degree of longitude west of Greenwich and the thirty-second west of Washington, and extends from the thirty-seventh degree of north latitude to the boundary of Mexico, which, except in the southwestern corner, is formed by the thirty-second degree of north latitude. Its climate is even drier than that of Colorado, which may be due to the fact that it has no concentrated high mountain mass to act as a condenser to the moisture-laden winds coming from the southwest. The mountain systems of Colorado end abruptly near its northern border, the Colorado range continuing with a gradually decreasing elevation as far south as Santa Fé, while the San Juan mountains, to the west of San Luis park, sink beneath the Cretaceous plains almost before the boundary is reached. Its surface is made up of an irregular series of detached mountain chains, stretching across the middle of the territory in a southwesterly direction, with a mesa country, belonging to the Colorado plateau region on the northwest, and broad arid plains, a continuation of those in northern Texas, stretching to the eastward. Across the middle of this area from north to south runs the Rio Grande river, whose valley presents many analogies with that of the famous Nile valley of Egypt. Its climate is warm and equable, and its alluvial soil, which occupies a comparatively narrow strip on either side of the river, in general not more than 2 miles in width, is of exceptional fertility. Like the Nile, it is subject to periodical overflows, and the area of its arable land can probably be increased by a more perfect system of irrigation than has been carried on by the Mexican population which at present occupies it. With the exception of this valley, there is little, if any, land in the territory which can be considered available for agriculture, not from any want of fertility of soil, but from the absence of water for irrigating purposes. The main wealth of the territory lies, therefore, in its grazing lands and its mineral resources.

Our geographical knowledge of this area is as yet extremely imperfect, being derived only from the meander lines made in early years by various government expeditions in exploring routes for a Pacific railroad and from detached maps of portions of the central and northern regions made by the explorations west of the 100th meridian under Lieutenant Wheeler.

In regard to its geology our information is equally fragmentary, being derived from the notes made by Professors Jules Marcou and J. S. Newberry, who accompanied the earlier railroad explorations, and of Messrs. G. K. Gilbert, E. E. Howell, and Professor J. J. Stevenson, who accompanied different parties of the Wheeler exploration. The census material with regard to this territory is also exceptionally incomplete, owing to the fact that Colonel Charles Potter, to whom was intrusted the duty of visiting and reporting on its various mining districts, was treacherously waylaid and killed by a party of seven Mexican robbers while in the discharge of this duty, and while his work, though nearly completed in the field, still needed his personal supervision to put it into an intelligible form.

GENERAL GEOLOGY.—The Archæan island which stretched through the state of Colorado from its northern to its southern boundary ended abruptly in New Mexico, its continuation to the southward being marked only by a series of more or less submerged reefs in the ocean, which covered this area until the close of the Cretaceous period. Up to this time, therefore, the waters of the ocean had free access to the Colorado plateau region, and at the present day the coal-bearing or Cretaceous rocks are known to extend over a great portion of the territory. Owing to the limited rainfall, the valleys and mountain slopes are much more heavily covered by Quaternary *débris* than those of Colorado, and the character of the underlying rocks is therefore more difficult to recognize. The Cretaceous formations are, however, known to extend from the plain country westward to the Rio Grande valley, and in the northwestern portion of the territory to connect with the Colorado plateau region, while they still form the surface rock over a very considerable area. In the latter region they are known to extend beyond its western boundaries, but in the mountain region, in the southwestern portion of the territory, they have either been entirely eroded off, or else, owing to some dynamic movement later than the Palæozoic period, as yet unproved, they were not deposited. Of eruptive rocks there is considerable development of quartz-porphyries and other Secondary rocks, especially in the southwestern portion of the territory; but no sufficient study has been made of them to determine definitely their age or relation to the Palæozoic beds in connection with which they are found. The only known Tertiary beds are those near San Ildefonso, which are supposed to be of Pliocene age. As yet, therefore, there is no record to determine the period at which the Tertiary eruptive rocks, which are so largely developed in the territory, were first poured out on the surface. Of these, as Mr. Gilbert shows, an immense crescent-shaped area extends through eastern Arizona and western New Mexico to the volcanic group of the San Francisco mountain at its northwestern point, and to that of Mount Taylor, in New Mexico, at its northeastern. They also cover considerable isolated areas to the east of the Rio Grande. That eruptive activity has continued until comparatively recent times is proved by the existence of numerous actual craters and cinder-cones in a region 35 to 40 miles southwest of Mount Taylor, from which streams of lava flowed out in every direction, extending at least 50 miles to the westward and to an unknown distance to the eastward. These recent lava flows are, according to Mr. Gilbert, all basaltic, while the mass of Mount Taylor consists of an older eruptive rock, described by him as something between a basalt and trachyte, and which, from analogy with other regions, may be supposed to be either andesite or a still earlier porphyrite. Professor Stevenson also describes extinct craters as existing to the east of Santa Fé near the Turkey mountains and flows of basaltic lavas filling the cañon of the Mora river. The northwestern part of the territory, therefore, which, from the Nacimiento range westward, belongs to the mesa region, and south of the Carboniferous anticlinal of the Zuñi range consists a broad belt of lava extending to the plains of San Augustin, is covered by rocks of too recent age to afford much promise to the prospector. It is in the mountain groups stretching across the territory to the southeast of this region that the principal developments have thus far been made. Among these Mr. Gilbert distinguishes two prevailing trends—a northwesterly and a north-and-south direction. The former, which is more common in the southwestern portion of the territory, he considers as belonging to a portion of the Basin range system, which stretches through Arizona in the direction of the Sierra Nevada; the latter he connects with the Colorado system. In these different regions the rocks thus far recognized are either Archæan or Palæozoic. Granite and gneiss are often found as a nucleus, and here, as elsewhere, are distinctly unconformable with the later beds of the Palæozoic formations, which consist of quartzites, sandstones, limestones, and shales. Fossil evidence has been found of the existence of the Cincinnati group of the Silurian, the Waverly or sub-Carboniferous, and the characteristic Carboniferous limestones of the Rocky Mountain region. Of Mesozoic formations the Trias is recognized in the northern portion, and is described by Professor Stevenson as being extremely thin or at times entirely wanting along the edge of the mountains northeast of Santa Fé. The aggregate thickness of the Cretaceous rocks, which consist, as elsewhere, of sandstones and shales, is given by Professor Stevenson at 2,000 feet. Mr. Gilbert states that coal is found throughout this entire formation, but only that of the middle is of economic importance. Professor Stevenson, on the other hand, makes the Galisteo beds, which have been practically developed in the northeastern part of the territory, belong to the Laramie group, or extreme upper member of the Cretaceous. Of the age of the coal-beds which have recently been developed in the neighborhood of the Rio Grande valley in the central and southern portion of the territory no information is available. In the succeeding description will be given the few facts it has been possible to obtain with regard to the geology of the mining regions thus far developed, following as far as possible the division by counties.

COLFAX COUNTY.

The western portion of Colfax county includes the southern end of the Rocky mountains, locally called the Taos and Baldy ranges, which consist of a nucleus of Archæan, overlaid by Carboniferous limestone and flanked by Mesozoic beds. Throughout the region there is a considerable development of eruptive rocks classed as trachytic, and on the adjoining plains, on either side, are recent flows of basalt. Partially included in the range is the longitudinal Moreno valley, whose Quaternary deposits are said to constitute rich gold placers. Besides the placers, gold veins are said to have been developed, but no working mines are reported. Specimens of gray copper ore, associated with coal, have been brought in from points along the eastern foot-hills of the mountains. Their geological position is not known The matrix is a sandstone resembling those of the Cretaceous formation, and it may be that they occur in connection with the singular longitudinal dike mapped by Professor Stevenson. Galena and considerable placer deposits occur in Taos county, adjoining Colfax on the west.

SANTA FÉ COUNTY.

The oldest mines of the territory, said to have been worked by the Spaniards when they first came here, over three centuries ago, are probably in Santa Fé county.

The Los Cerillos district embraces the Los Cerillos mountains north of the Galisteo river, and the Ortiz mountains to the south. In the former an eruptive rock, probably rhyolite or trachyte, breaks through the Cretaceous strata. In this are found irregular, thin deposits of galena and the celebrated turquoise mines, which have been worked for years both by Mexicans and Indians. This mineral occurs apparently as an impregnation along the cleavage faces of the country rock. Along the Ortiz mountains and the Placer mountains to the south are valuable placer deposits, which in places have been penetrated 60 feet without reaching bed-rock. But little is known of their extent or character, and, owing to the want of water, they have thus far been but little developed. The Placer mountains consist of Archæan rocks overlaid by Carboniferous limestone. Veins of auriferous pyrites are said to occur in the Archæan; also magnetic iron ore. In the limestones are deposits following the stratification and occurring in connection with what is called porphyry, which contain both auriferous pyrites and sulphurets of copper, more or less oxidized, carrying silver.

In Bernalillo county the Sandia mountains, which rise abruptly to the east of Rio Grande valley, are formed, according to Marcou, of Carboniferous strata dipping to the eastward, and have been apparently lifted to their present position by a fault. On their slopes occur also rich placer deposits. West of the Rio Grande copper has been obtained from the sandstones of the Trias in the neighborhood of Abiquiu. The ores are found as carbonates and oxides, replacing fossil plants.

SOCORRO COUNTY.

In the Socorro mountains, lying opposite the town of Socorro, on the Rio Grande river, according to Professor B. Silliman, (*a*) are several large veins of heavy spar running in a northeast and southwest direction and dipping 40° to the northwest, carrying chloride of silver and vanadium-bearing mimetite. The Magdalena mountains, 30 miles west of this, consist, according to the same authority, of slates, limestones, and quartzites, resting on gneiss and traversed by porphyritic eruptions. The Juniata lode is described as a vertical deposit of lead carbonates between porphyry and slates reaching a maximum thickness of 65 feet, but of low grade in silver. Galena and zincblende, with calamine and anglesite, are also found in the same deposit.

In the Oscuro mountains, to the east of the Rio Grande, are deposits of copper glance, azurite, and malachite, carrying a little silver and gold in a siliceous conglomerate. These ores, like those already mentioned, are associated with remains of fossil wood and various plants, and are said to carry from 10 to 60 per cent. of copper. This conglomerate, because of the resemblance of the deposits to those of Russia, which occur at this horizon, is regarded as of Permian age by Professor Silliman. The reason for such determination seems rather inadequate, in view of the fact that the Permian group has not yet been definitely recognized in the Rocky mountain system, to which these deposits belong, and that the beds in which similar deposits have been found in Colorado and New Mexico have hitherto been determined as Triassic.

The Negretta or Black range extends across Socorro county into Grant county, adjoining, and is apparently connected with the Miembres range. It is so called because of the dark-colored firs which cover it. According to Professor Silliman, this range is intersected by powerful lodes carrying gold, silver, copper, zinc, and lead, but no indication is given with regard to the character of the country rock, except that porphyry is mentioned as inclosing one vein. In the western portion of the county, at the head of the San Francisco river, is the Mogollon district, in which islands of Archæan granite, with Palæozoic rocks resting on them, occur on the southern border of the lava area already mentioned; and in the limestones of the latter are rich deposits of copper, in some cases carrying both gold and silver. No returns from individual mines are at hand.

LINCOLN COUNTY.

In Lincoln county, to the east of Socorro county, about 125 miles from the Rio Grande valley, is the White Oaks district, in a mountain group generally known as the Sierra Blanca. Gold ores are reported as discovered in this district, but no reliable data are at hand as regards either their value or the geology of the district.

DOÑA AÑA COUNTY.

In the Organ mountains, to the east of the Rio Grande, 15 miles from Las Cruces, argentiferous galena ores are reported. Near Hillsboro', on the west of the Rio Grande, are placer deposits, and gold veins are said to have been discovered.

The most important mining district of the county is Lake valley, which is on the eastern slope of the Miembres mountains. This range, according to Mr. Gilbert, has a core of Palæozoic limestone, with lava on the western slope. The ore bodies occur following the bedding-planes of limestone beds, which dip to the eastward. The foot wall is a heavy-bedded bluish-gray limestone, above which are thinly-bedded shaly limestones, carrying

a Trans. A. I. M. E., Feb., 1882.

fossils of the Waverly group. The ore consists of argentiferous galena and eerussite, with chlorides and chloro-bromides of silver in a gangue of red and brown hematite, with some oxide of manganese, and silica in the form of chert. Professor Silliman reports also the occurrence of vanadinite. The deposits apparently resemble in their manner of occurrence those of Leadville. Irregular masses and dikes of eruptive rocks are reported also as occurring in the region, but their lithological charaeter and direct relation to the ore deposits is not yet definitely known.

GRANT COUNTY.

Grant county has been the principal mineral producer of the territory, its most important mines being located within an area of which Silver City and Fort Bayard form the center. In the Miembres district, on the west slope of the Miembres mountains, to the east of Silver City, are argentiferous lead ores in limestones of Palæozoic age. The limestones are fossiliferous, and dip to the eastward; but it is not known whether they eorrespond to those of Lake valley on the east or to those in the neighborhood of Silver City on the west. The deposits follow the bedding, having a foot wall of limestone, with shale on the hanging wall. To the north of Silver City is the Pinos Altos mountain, which consists, according to Mr. Gilbert, of granite, with porphyry overlapping on one side and the lavas of the Diablo range on the other. The veins are quartz veins, carrying both gold and silver, having a general north and south strike, and standing at a steep angle. According to the census specimens, they occur in both diabase and quartz-porphyry. At Lone mountain, to the south of Silver City, are ferruginous deposits, carrying chlorides and sulphides of silver, following the bedding of limestones, which dip to the northeast.

The Burro mountains to the west of Silver City consist, aceording to Howells, of two bodies of Archæan granite, the one covered by heavily-bedded trachytes, the other by Palæozoic beds dipping to the northeast. In the latter occur argentiferous lead ores, with chlorides and sulphurets of silver. Those in the Chloride Flat district oecur between limestone beds, and those in the Silver Flat district between an overlying quartz-porphyry or diorite and an underlying limestone or dolomite. From the silver-bearing limestones Mr. Howells obtained characteristic fossils of the Cincinnati group.

In the Santa Rita mountains, according to Mr. Gilbert, argentiferous galena oeeurs in Carboniferous limestone, and veins carrying gold and eopper in porphyry. The famous Santa Rita mines are near the crest of the range at the contact of the Carboniferous limestone and an overlying porphyry. The Shakspeare or Virginia district is about 25 miles southwest of the Burro mountains, in the Pyramid range, which is made up, according to Mr. Gilbert, of basalt and trachyte, overlying an older lava, in which occur the quartz veins. The most prominent of these stand up above the weathered surface of the rock, while others less prominent carry argentiferous galena ores with chloride and native silver. The country rock most probably belongs to the older or Secondary type of eruptives, although Mr. Gilbert describes it as resembling the propylite of v. Richthofen.

SANTA FÉ COUNTY.

Mine.	Country rock and vein.	Ore and gangue.
LOS CERRILLOS DISTRICT.		
Marshall Bonanza	Supposed to be rhyolite. Vein vertical; strike, N. 38° E.; 2 feet wide.	Argentiferous galena and cerussite, with black oxide of manganese and minute crystals of wulfenite (?).
SILVER BUTTE DISTRICT.		
San Pedro and Cañon del Agua.	Quartzite and porphyry on hanging wall; limestone on foot wall. No specimens. Deposit with the formation. Strike, N. and S.; dip, 15° E.; 30 feet thick.	Iron-stained quartz, with pyrite, carrying gold; 7 to 8 feet thick on hanging wall; underlaid by deposit of azurite, malachite, chrysocolla, cuprite, chalcopyrite, and bournonite. No specimens.

GRANT COUNTY.

CHLORIDE FLAT DISTRICT.		
Bremen	Limestone; light-gray and crystalline on hanging wall, dark-blue and fine-grained on foot wall. Strike, N. 3° E.; dip, 13° E. Deposit in irregular bodies on foot wall.	Cerargyrite, argentite, and galena. Gangue: barite, fluorite, and argillaceous slate.
Providence	Dark-blue limestone or dolomite. Vein: strike, N. 40° W.; dip, 85° E.; average width, 2 feet.	Iron-stained quartz and limestone, carrying chlorides and sulphurets of silver.
LONE MOUNTAIN DISTRICT.		
Cosette	Dolomitic limestone; light brown, crystalline, and called porphyry, on hanging wall; reddish with conchoidal fracture on foot wall. Deposits with the bedding. Strike, NW.; dip, 21° E., in irregular bodies.	Siliceous hematite, carrying chloride and sulphide of silver. Gangue: altered foot wall.
MIEMBRES DISTRICT.		
Commercial	Dark carbonaceous shale; foot wall, fossiliferous limestone. No specimens. Deposit in irregular pockets with the bedding; dip, SE.	Argentiferous. No specimens.
McGregor	Dark carbonaceous shale; foot wall, fossiliferous limestone. No specimens. Deposit in irregular pockets with the bedding; dip, SE.	Chlorides and sulphurets of silver, with cerussite and carbonate of iron in altered limestone.
Naiad Queen	Dark carbonaceous shale; foot wall, fossiliferous limestone. No specimens. Deposit in irregular pockets with the bedding; dip, SE.	Chlorides and sulphurets of silver and carbonates (?) of iron; free milling.

GRANT COUNTY—Continued.

Mine.	Country rock and vein.	Ore and gangue.
PINOS ALTOS DISTRICT.		
Langston	Much altered diabase, called limestone. Vein: strike, N. 15° E.; dip, 70° SE.	Gangue cerussite, chlorides, and sulphides of silver carrying gold.
Mina Grande	Called quartzless granite, or trachyte. No specimens. Vein: strike, N. and S.; dip, 80° E.; 2 feet wide.	Auriferous quartz, with chlorides and sulphides of silver. No specimens.
Ohio	Decomposed quartz-porphyry. Vein: strike, N. and S.; dip, E.; 4 feet wide.	Galena, chalcopyrite, with barite in quartz, carrying gold and silver.
Pacific No. 2	Probably diabase. Vein: strike, N. and S.; dip, 75° E.; 2 feet wide.	Mixture of barite, quartz, pyrite, and galena, carrying gold and silver.
SILVER FLAT DISTRICT.		
Massachusetts and New Mexico.	Hanging wall light-colored quartz-porphyry; foot wall dark dolomite. Deposit with the bedding. Strike, N. 32° W.; dip, 85° E.; up to 15 feet thick.	Chlorides and sulphides of silver, with quartz and calcite.
Sherman	Hanging wall altered, eruptive rock, possibly diorite; foot wall dark-brown dolomite. Deposit with the bedding. Strike, N. and S.; dip, 15° E.	Galena, with chloride and sulphide of silver.

CHAPTER VI.—LEAD SMELTING AT LEADVILLE, COLORADO.

BY S. F. EMMONS.

PLANT.

INTRODUCTORY.—Although a very large amount of technical data on the various smelting works of the West was collected by the census experts, they were not found sufficiently complete to serve as the sole basis for a detailed description of the processes employed; nor do these works in general, as far as they are open to public inspection, present any features which are unusual or new to metallurgical science. At Leadville, however, where the numerous smelting establishments produce annually about $15,000,000 worth of argentiferous lead bullion, metallurgists have necessarily acquired an unusual amount of practical experience in the conduct of the operations of lead smelting and in the management of the business connected therewith. It has therefore been judged expedient to present a succinct account of the natural and economical conditions of smelting at this point, of the character of the plant, and of the processes employed. For this purpose recourse has been had to the MS. of a report by Mr. A. Guyard on the lead smelting of Leadville, which is to appear as an appendix to a monograph on the geology and mining industry of that district. An abstract of this report has been made by Mr. W. F. Hillebrand, and is supplemented by data obtained from census material and by himself and the writer personally, which appears in the following pages. In this the chemical investigations and calculations made by Mr. Guyard have been freely used, and the two illustrations which accompany it are taken from his plates; but all discussion as to the fitness or unfitness of methods employed, or of theoretical questions arising therefrom, has been avoided.

TOPOGRAPHICAL CONDITIONS.—An important condition in the disposition of smelting works, as well as of quartz-mills and other reduction works, is that the force of gravity may be used as an aid in handling the material to be treated, which is generally of a heavy and bulky nature. To such a disposition the surface character of the Leadville region is admirably suited by nature. The town itself is situated on a gently sloping mesa included between Evans gulch on the north and California gulch on the south, at the western base of the foot-hills of the Mosquito range, in which its ores occur. Along the high banks, which rise from the bottom of either of these gulches to the comparatively flat surface of the mesa, and at a sufficient elevation to allow room for the slag dumps below them, are located the various smelting works. They are thus situated so that from the mines an equally favorable grade leads either to the upper or the lower portion of the works, and the railroad which follows the surface of the mesa sends its branches on the level of or above the charging floor, and thus delivers its freight of fuel or of ore where it may descend through the various stages of the process until the final product, the bars of bullion, is obtained.

DISPOSITION OF THE PLANT.—No less than sixteen smelting works have been built at Leadville in the few years that have elapsed since its mines were opened. Of these, however, a number have been closed, some temporarily, others permanently. The general plan in these works is that adopted elsewhere, and involves the occupation of two principal floors. The lower of these floors is at such a height above the adjoining valley bottom as to afford a convenient opportunity for dumping slag and other waste. On this floor the furnaces are built, and room is also commonly provided for the blower and the engine by which it is actuated. The furnaces are usually placed in a row within a single inclosure, but sometimes they have a wall intervening between them. The upper floor is on a level with the feeding-door of the furnaces, from 12 to 14 feet above the lower, and affords space for ore-bins, fluxes, mixing-beds, and the operations connected with charging the furnaces, such as crushing and sampling. When the slope of the ground is great, however, the storage bins for ore and fuel are sometimes placed at a still higher level, with passages for wagons between. One roof generally covers the whole establishment, with the exception of the offices, laboratory, and scales, which commonly occupy detached buildings.

FURNACES.—Shaft furnaces only are employed in Leadville. Of these two varieties were in use during the census year, the one presenting a circular horizontal cross-section, sometimes called the Piltz furnace, while the other is rectangular; but in 1882 the latter had entirely replaced the former. While the circular section presents advantages in the regularity of the descent of the charges, it is more expensive in construction, and the diameter of the hearth is limited by the strength of the blast; indeed, with any ordinary blowing-engine a round furnace can be successfully worked only when it is of very moderate dimensions. The rectangular or Raschette furnace, on the other hand, may be constructed with a width at the tuyeres corresponding to the strength of the blast-engines, and the production may be increased by increasing the length of the cross-section. The horizontal elongation of the furnace has its limits, indeed, as has been proved by the history of the rectangular Raschette furnaces in Europe, but the capacity may nevertheless be increased considerably above that of a circular furnace of similar construction without deleterious effects upon the working. In lead smelting, and especially in smelting argentiferous lead ores,

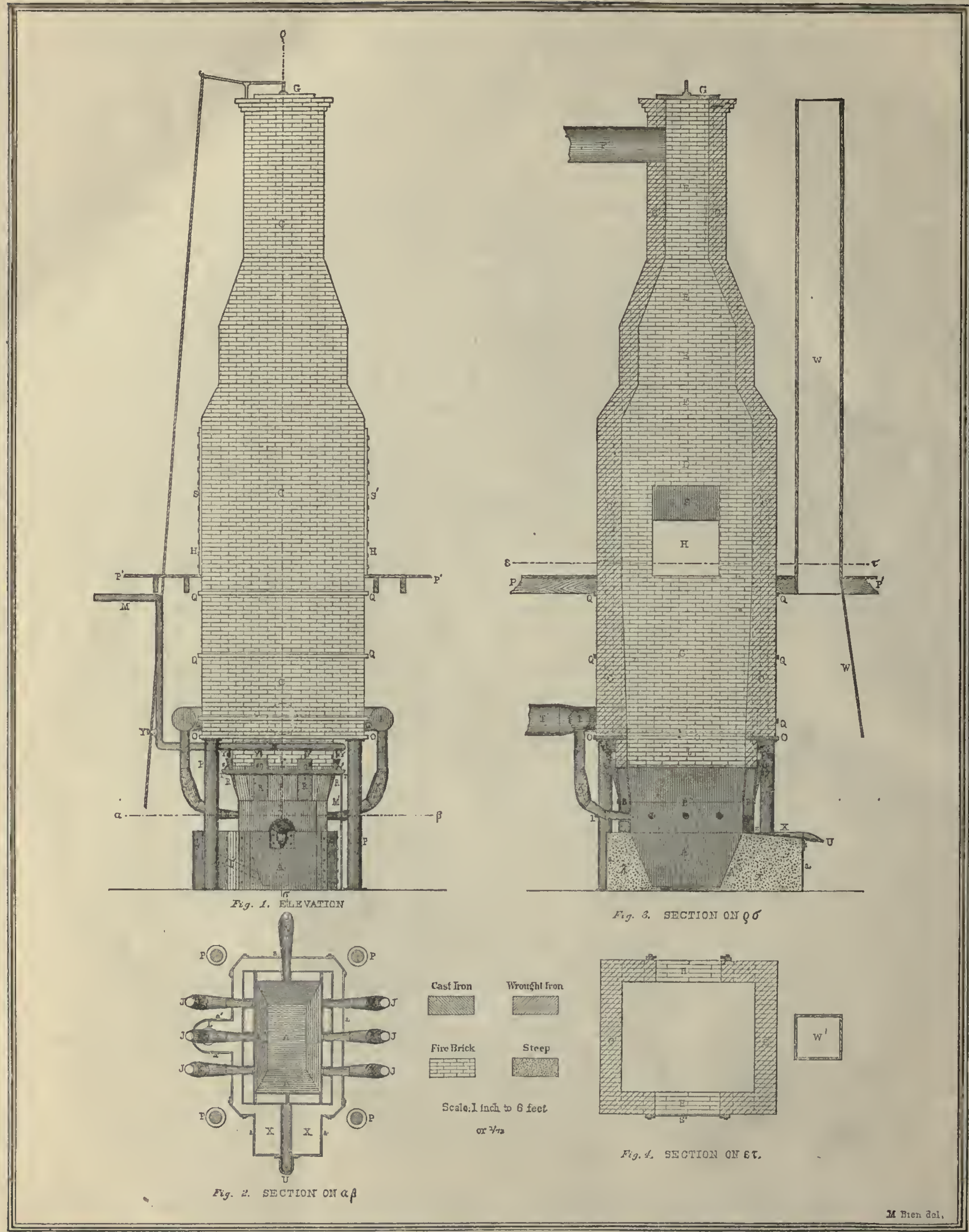


Fig. 1. ELEVATION

Fig. 2. SECTION ON αβ

Fig. 3. SECTION ON ρσ

Fig. 4. SECTION ON ετ.

RECTANGULAR FURNACE

it is very undesirable to employ the high-pressure blasts required by a circular furnace of large diameter, since the higher temperatures which result promote the production of fumes which are only imperfectly recovered and are always difficult of treatment.

The rectangular and the round furnaces of Leadville are constructed on the same general plan so far as height, method of support, water-jackets, tuyeres, etc., are concerned, but the sizes adopted vary greatly, the limits of capacity being from 15 to 40 tons in twenty-four hours.

Plate I, Fig. 1, represents a rectangular furnace in elevation drawn to a scale of 6 feet to the inch, and Fig. 2 the same furnace in horizontal section at the tuyere level. Fig. 3 shows a vertical section of the same furnace on its longer diameter, and Fig. 4 a horizontal section at the charging-doors. The masonry shaft (*C*) rests upon a cast-iron plate (*O*), supported by pillars (*P*), in order that there may be no unnecessary weight on the lower portion of the furnace. The walls for some distance above and below the tuyeres are formed of sectional water-jackets (*B*), constructed of cast or wrought iron or of steel. In the furnace illustrated the water-jackets are twelve in number, firmly bolted together and provided with openings for the insertion of the tuyeres (*N*). A cold-water pipe (*M*) runs around the furnace above the water-jackets, and water is admitted to each of them by a faucet (*Y*). Outlets (*M′*) for the hot water and gutters (*T*) for its removal are also shown in the illustrations. The interval (*b*) between the water-jackets and the plate on which the shaft of the furnace rests is filled with fire-brick, which can be readily removed in case of necessity. The lower ends of the water-jacket rest upon the hearth (*X*). This consists of cast-iron plates (*a*) bolted together and lined with a thick coating of fire-brick or of "steep" (brasque), a mixture of fire-clay and coke-dust, either in equal parts, or in the proportion of two of the former to one of the latter. The usual form of the hearth is shown in the illustrations; this, however, is modified in detail, according to the working of the furnace and the judgment of the manager or smelter, changes in it involving no modification of the iron plates.

The hearth plates include also the lead well *L* and the so-called "siphon tap". A similar device was long ago applied to the small charcoal-iron blast-furnaces of Silesia, to permit of the manufacture of castings without tapping the furnaces; it was not successful, however, the iron chilling too rapidly for the object in view, owing to its high melting point. This arrangement was introduced into lead smelting in Eureka, Nevada, by Mr. Albert Arents with great success, and has since been widely adopted both in this country and abroad. The lead rises through the oblique tap-hole *L′* shown in Fig. 1 to the same level in the well which it occupied in the furnace, and can be baled into the molds at leisure, and without the disturbance of the furnace-working incident to the old method of tapping at long intervals.

At the end of the furnace just above the hearth an opening (*V*) is left in the water-jacket to facilitate the tapping of slag. This opening is filled with clay, in which a hole can be pierced when required, allowing the slag to pass through an inclined gutter (*U*), shown in the illustrations, into a slag-buggy. A hood (*W*) is generally placed over the tapping-hole to draw off the fumes emitted during the tapping. The number of tuyeres varies with the size of the furnace, depending mainly on the length of the cross-section. A tuyere is always placed at the end of the furnace opposite the slag-tap, and sometimes also above it; this last, however, is somewhat in the way, and is often omitted. A sliding valve (*l*) at the elbow of the nozzle admits of the inspection of the interior of the furnace. The tuyeres are connected with the main blast-pipe (*I*) by canvas hose (*K*), the flexibility of which permits their withdrawal from the furnace when necessary. This convenient device is, of course, applicable only when cold air is supplied to the furnace, as is almost invariably the case in lead smelting. Feed-openings (*H*) on the upper floor are closed by sliding doors (*S*). The furnace terminates upward in a short chimney (*E*) and may, in case of need, be run without the dust-chambers, with which it is connected by a flue (*F*) indicated in the illustration.

As an example of recent construction, the furnaces in the works of Eddy, James & Grant, at Denver, may be cited. There are eight of these furnaces of the same pattern, all built in the spring of 1882. The height to the charging-door is 18 feet; the dimensions 3 feet below the charging-door are 60 by 102 inches; at the top of the jackets, 48 by 92½ inches, and at the tuyere level, 36 by 80½ inches. Each furnace has ten tuyeres, four on each side and one at each end. The capacity of each is about 30 tons. The waste gases and fumes are drawn from all these furnaces at a point below the charging-doors into large dust-chambers connecting with a single stack—a very convenient arrangement so far as the comfort of the workmen is concerned; whether it is accompanied by any ill effect upon the working of the ore is regarded as uncertain, but each furnace is provided with an independent stack, to be used in the event of its proving desirable to return to the ordinary practice.

Plate II shows a furnace with a circular horizontal section on the same scale as the rectangular furnace illustrated on Plate I, and a comparison will show that the general principles governing the construction are the same in both. A main point of difference is in the anchoring, which in the square furnace is necessarily effected by bars (*Q*), while the same object is more conveniently attained, when the section is circular, by a shell of sheet iron (*J*) composed of plates about a quarter of an inch in thickness. The diameter of round furnaces at the tuyere level is from 33 to 48 inches, and the capacity varies with this dimension.

DUST-CHAMBERS.—The appliances for catching flue-dust in the Leadville smelting works are generally very imperfect, but the reproach does not apply to Leadville alone, for, however extensive the system employed elsewhere, it fails to accomplish its purpose completely. It is said that some English lead works have dust-chambers no less than 5 miles in length, and yet fail to recover all the dust carried from the furnaces; some of the Leadville works, however, make no attempt to collect the flue-dust, a practice unworthy of imitation. The ordinary provision consists of brick chambers on or below the charging-floor, either divided into sections by walls and curtains or not. One such chamber is 75 feet long, 25 feet wide, and 15 feet in height, and another of the same length is only 4 feet wide and 6 feet high. The dust-chambers are sometimes built of iron instead of brick, and the circuitous direction given to the current by the interposition of walls and curtains in brick chambers is then often obtained by the use of adjoining vertical cylinders, the air and fumes entering the bottom of one and the top of the next.

BLAST-ENGINES.—The blowing engines employed are most commonly of the Baker rotary pattern, though at one establishment the Root blower is in use. The pressure of the blast furnished by these blowers varies from half an inch to 1½ inches of mercury, or say from one-fourth to three-fourths of a pound per square inch, the most usual tension being 1 inch of mercury, or about half a pound per square inch. Where several blowers are employed in furnishing blasts to more than one furnace the pressure is equalized, and the probability of an interference with the work through the stoppage of a blower is decreased by connecting them all with the same main blast-pipe.

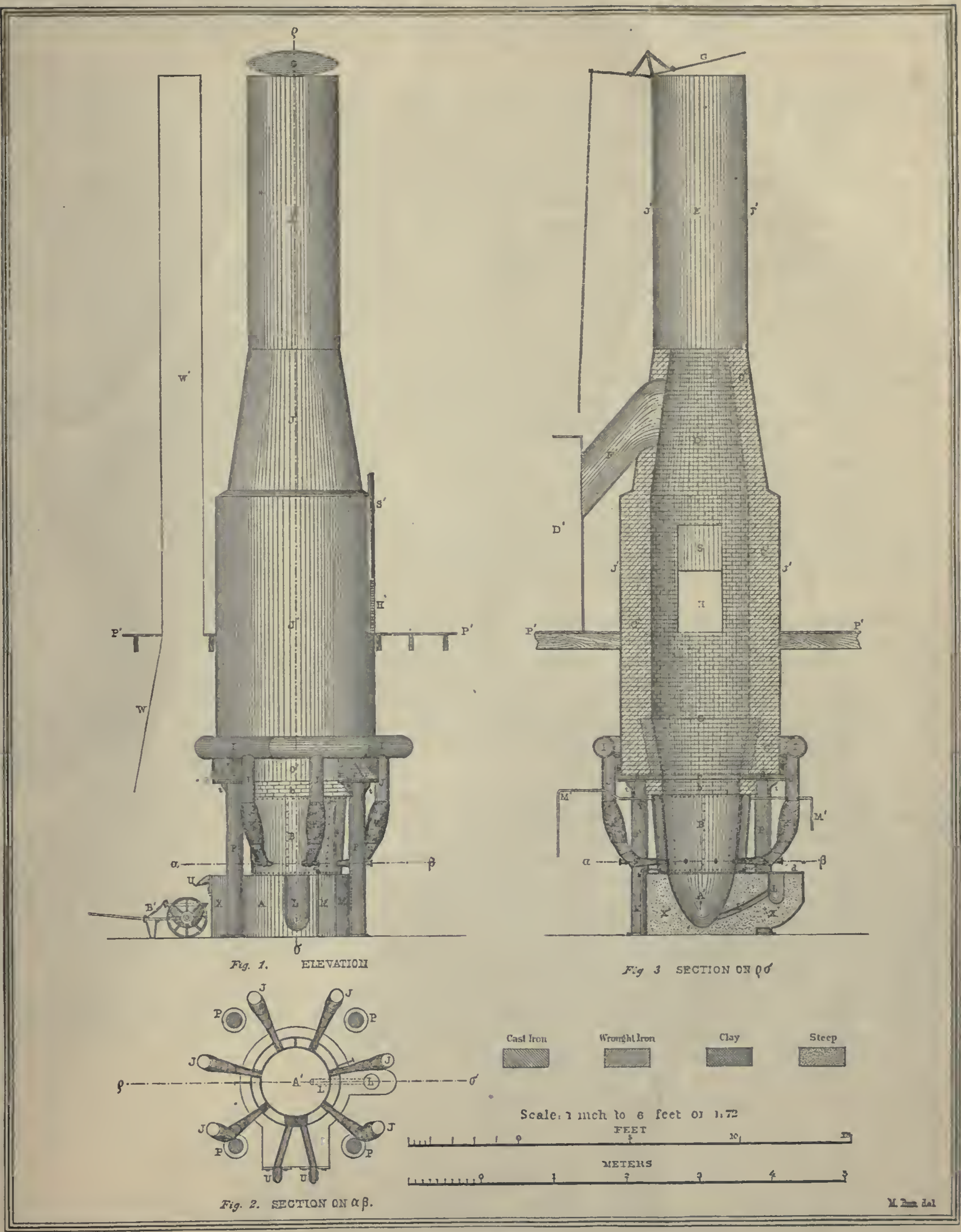
The iron work of the furnaces is sometimes made by Denver firms, but usually the entire plant is ordered from the East.

BARTLETT FILTER.—An experiment was made at one of the works with this arrangement for collecting flue-dust which gave some interesting results. The following is condensed from Mr. Guyard's description:

The stack of one of the square furnaces was connected with a Sturtevant fan by means of a sheet-iron flue, through which the fumes were drawn from the furnace and blown through a sheet-iron pipe 150 feet in length, which was connected, by means of two branch pipes, with two boxes of thin sheet iron. The dust was collected in the sheet-iron pipe as in an ordinary flue. Each branch pipe was provided with a damper, or valve, similar to those used in stovepipes, so that the fumes could be distributed to one or both of the boxes at pleasure. Each box consisted of a dust-chamber and a fireplace, the former being provided with sliding doors, placed at either extremity, and the fireplace with doors in front and sheet-iron pipes at the back, communicating with a stack. At the top of each of the dust-chambers were twenty-eight apertures, to each of which was fastened a cloth bag, 30 feet high, suspended to the beams of a light wooden structure, in which the apparatus was inclosed, and which was provided with very large openings for ventilation. When the apparatus is at work the fumes blown in distribute themselves in the dust-chambers and ascend the cloth bags, through which they are filtered. The gases come out perfectly colorless and free from any lead dust or even soot. The wind entering freely through the apertures of the building shakes the bags, and the dust with which they are charged falls back into the dust-chambers. When a sufficient quantity of this dust has been accumulated, the doors connecting with the fireplace are opened and a light wood fire is kindled. The soot soon catches fire and burns off, leaving the dust white. During a run of five days 3,030 pounds of calcined dust were caught in a Bartlett filter from one furnace. The experiment was not entirely satisfactory, owing to defects in the manner in which it was carried out; but the defect was one of arrangement, and by no means inherent in the filter. The furnace was worked without closing the feed-hole, as with an ordinary dust-chamber. The Sturtevant fan consequently drew in as much air as smoke, so that the chamber of the furnace had to be left half open, and about half the smoke escaped directly into the open air. The use of this arrangement was abandoned by the owners of the works partly on account of the expense involved and partly, as stated by them, on account of the large percentage of arsenic (15 to 20 per cent.) in the condensed matter and its low tenor in silver. As Mr. Guyard, in his analysis of this substance, found extremely little arsenic and much lead, chiefly combined with phosphoric acid, chlorine, and bromine, it is difficult to imagine on what ground the presence of arsenic in such quantity could be inferred. Mr. Guyard's analysis is supported by the fact that arsenic is present to but small extent throughout the district, while phosphoric acid exists in large quantities in many of the ores.

RAW MATERIAL.

ORES.—The ores of Leadville are remarkably pure argentiferous lead ores. They are locally divided into two general classes: the "sand carbonates", which are loose, sandy masses of carbonate of lead with chloride of silver, and the "hard carbonates", which are masses of porous siliceous material with a varying proportion of hydrated oxides of iron and manganese, carrying carbonates of lead and chlorides of silver, and sometimes containing a considerable proportion of unaltered argentiferous galena. As a rule, with the exception of mechanical mixtures of clay and varying proportions of iron and silica, they contain but few foreign ingredients. Intimately associated with the carbonates is generally a little pyromorphite or chloro-phosphate of lead, amounting in one exceptional case to 10 and in another to 30 per cent. of the whole. Sulphate of lead also occurs in small quantity, with small and variable amounts of oxidized compounds of copper, arsenic, antimony, and manganese. The latter is often abundant, and is associated with or replaces iron oxide. Ores which are rich in manganese are generally poor in silver. The galena is frequently covered by a coating of carbonate showing clearly the alteration of the sulphide, first to sulphate, and then to carbonate. In some few mines bismuth and vanadium ores have been found. But a small proportion of the ores smelted is furnished by districts outside of Leadville. Of this the greater part comes from Ten-Mile district, in Summit county, and especially from the Robinson mine, whose deposits carry much pyrite and zincblende. The silver in the oxidized ores is present in combination with chlorine, bromine, and iodine, either as chloride, chloro-bromide, or chloro-bromo-iodide, as the analyses on page 289 of specimens from several mines made in the laboratory of the United States geological survey at Denver show.



CIRCULAR FURNACE

	R. E. Lee mine.	Amie mine.	Big Pittsburgh mine.
Chloride of silver	21.589	15.755	99.965
Bromide of silver	77.986	84.091	None.
Iodide of silver	0.425	0.154	0.035

Large masses of chloride of silver, or horn-silver, have been found, and on several occasions tons of ore have been taken from the R. E. Lee mine assaying from 8,000 to 15,000 ounces of silver to the ton and almost entirely free from lead. According to Mr. Guyard, sulphide of silver is sometimes present in small quantity.

The Leadville ores in general contain little or no gold, its presence not being easily detected in the ore itself, but only being shown in the final product. The average daily output of the mines in 1880 is placed by Mr. Guyard at from 700 to 800 tons, and the total smelting capacity of the furnaces at 700 tons per diem.

FLUXES.—The fluxes used in Leadville are limestone and hematite. During the census year the limestone used was the blue dolomitic limestone (Lower Carboniferous), in which the Leadville ores occur, taken either from open quarries or from dead-work in some of the mines. In the latter case it often carried a small percentage of silver. Experiments showed that dolomite was a less favorable flux than pure carbonate of lime, and since the advent of the railroad limestone has been obtained from the beds of the Colorado Cretaceous formation at Cañon City, 117 miles distant, and more recently still from a bed in the Upper Coal Measures at Robinson, 16 miles distant by rail, where it costs $3 per ton f. o. b. Red hematite iron ore was at first exclusively used as a flux, being principally obtained from the Breece iron mine, where it occurs in large masses between the White and the Gray porphyry, and it is said to carry a small percentage of silver. More recently it has been the practice in many smelters to use the limonite which had collected on the dumps of the various mines, and which also carries a small percentage of silver. In many cases the ores themselves are so ferruginous that but little additional iron is required.

FUEL.—The fuels used are coke and charcoal. Previous to the advent of the railroad coke was scarce and dear, having to be brought 30 to 150 miles by ox or mule teams; hence charcoal was much more largely used than at present. This is furnished by the forests of spruce covering the neighboring mountain slopes. The charcoal produced from these woods varies greatly in quality, according to whether it has been burned in pits or in kilns. The pit-charcoal made in the neighborhood of Leadville is said to contain 2.5 per cent. of ash; a sample of kiln charcoal was found by Mr. Guyard to contain 1.62 per cent. of ash. One hundred and forty-two and one-half bushels of charcoal make 1 ton, the bushel weighing 14 pounds.

COKE.—The cokes used are brought from El Moro, in the southern part of the state, by the Denver and Rio Grande railroad, and from Como, in the South Park, by the Denver, South Park, and Pacific railroad. These cokes are made from coals of the Lignitic or Upper Cretaceous formation, and contain, according to determinations made at the smelting works of Messrs. Billings & Eilers, 22 per cent. of ash for the El Moro and 9½ per cent. of ash for the South Park coke. The composition of the ash of the El Moro coke is represented as being 84½ per cent. silica, 7.1 per cent. peroxide of iron, and 8.4 per cent. alumina, lime, etc. The ash of the South Park coke shows 29.1 per cent. silica, 47.8 per cent. peroxide of iron, and 23.1 per cent. alumina, lime, etc. About 40 pounds of coke make one bushel; hence, 50 bushels make one ton.

ORE BUYING.—Ore is purchased either directly from the mines themselves for cash or from sampling works, which either buy from the mines or act as their agents. Various considerations affect the price paid. From the assay value of the ore in silver a certain percentage is deducted for loss in smelting, which varies according to the nature of the ore, whether siliceous, ferruginous, or sulphureted, or according to a special arrangement made between the mine owners and the smelter owners. A further variable charge is made for cost of treatment, which is dependent on the nature of the ore and its tenor in lead. As a general rule, in regard to oxidized ores, the charge for treatment is lower the larger the percentage of lead they contain. When this tenor is between 5 and 30 per cent. the lead is paid for at from 15 to 45 cents a unit of 20 pounds; the higher the percentage of lead the higher the price paid per unit. When the ore contains less than a certain percentage of lead, which varies with the quality of the ore, the mine owner receives no remuneration for the lead contained in his ore, however rich it may be in silver. The following table gives a specimen of the rates charged for treatment of the ores of some of the best-known mines, the deduction made for loss of silver, and the price paid for each unit of lead above this certain percentage:

Name of mine.	Deduction for loss of silver in smelting.	Cost of treatment per ton of ore.	Price of lead per unit of 20 pounds.
	Per cent.		
Amie	10	$25	$0 25
Chrysolite	5	20	25
Dunkin	5	22	25
Carbonate	7½	20	25
Evening Star	7½	28	25
Morning Star	5	15	30
Iron	5	18	30
Tucson	5	21	25

These figures vary from month to month unless a time contract has been entered into, and are governed by the market quotations of silver and lead at New York and the prices of coke, charcoal, and fluxes at Leadville. Gold, when present in excess of one-tenth of an ounce to the ton, is paid for at the rate of $18 per ounce. The transportation of ore from the mines to the sampling or smelting works is paid for by the smelters at the rate of $1 to $1 85 per ton.

SAMPLING.—When the ore arrives at the sampling works, it is weighed in the wagon on scales generally occupying a detached building. It is then thrown into bins or piles in the open yard, every tenth shovelful as a rule being put into a wheelbarrow. The sample thus obtained is spread out on the sampling floor, and in the case of a sand ore is worked up directly to obtain a thorough mixture. Hard ores are first passed through Cornish rolls. When the ore is thoroughly mixed, it is repeatedly quartered till a sample convenient for drying has been obtained. After drying it is further crushed, mixed, and quartered, and a portion is then ground on the bucking plate by the bucker (*a*) until it passes through a sieve of 70 to 80 meshes to the linear inch. The sample is then divided into three portions, one of which is assayed at the smelter, and a second at the mine or by a public assayer who may be employed by the mine. If the results of the two assays agree closely, a mean is generally taken as the true value of the load; otherwise the third portion is sent for control to a third independent assayer. Sand ores require no crushing before charging into the furnace. For hard ores, slags, fluxes, etc., Blake, and occasionally Alden crushers, driven by steam-power, are employed.

SMELTING CHARGES.—The construction of ore-beds is carried on to a considerable extent at both smelting and sampling works. These beds average from 160 to 180 tons each in weight, and contain approximately equal parts (20 to 25 per cent.) of metallic lead, metallic iron, and silica, of which the proportion of lead is subject to the greatest fluctuation. The proportion of silver to lead is 1 ounce to about 6 or 8 pounds. Sulphureted ores are not roasted, but are thrown directly into the furnace, and are mixed in small quantities with the oxidized ores.

The charges vary so greatly in composition at the different smelters that it is hardly possible to give that of an average one. At first the aim seems to have been to produce a normal singulo-silicate slag, but a change has been gradually taking place to slags of a slightly more acid character, containing from 32 to 36 per cent. of silica. At one smelter the aim is said to have been to produce a slag in which the proportion of earthy base to metallic base should be as one to two, or to some even number. The following examples of different charges are taken from Mr. Guyard's report as specimens of their variable character:

	I.		II.		III.		IV.		V.	
ORE:	*Pounds.*		*Pounds.*		*Pounds.*		*Pounds.*		*Pounds.*	
Ore-bed mixture	100		200		123		500		......	
Unmixed ore	50		300		183		200		645	
Lead scraps	......		10		......		......		......	
		150		510		306		700		645
FLUX:										
Dolomite	10		50		90		80		62	
Hematite	10		......		7		170		......	
Slag	30		150		60		80		80	
		50		200		157		330		142
FUEL:										
Charcoal	15		80		50		95		80	
Coke	20		60		50		65		60	
		35		140		100		160		140
Total weight of charge		235		850		563		1,190		927

The proportions of charcoal and coke in the fuel vary, according to supply and cost and from other considerations, within the limits of three parts of the one to four of the other.

The table on page 291 gives the calculations made by Mr. Guyard from data obtained for the census year in eight of the principal smelting works of Leadville: First, the average proportion of flux to 100 parts of ore; second, the proportion of fuel to 100 parts of ore; third, the proportion of fuel to 100 parts of smelting charge. In the fourth rubric is given the number of tons smelted per twenty-four hours in each of these works. From these data he calculates the relation of actual to nominal smelting capacity as varying from 26 to 80 per cent. Furnace III is regarded as fulfilling most nearly theoretically perfect conditions.

a The bucking plate in ordinary use in assay offices in the West is a cast-iron plate measuring 2 by 1½ feet, with flanges on the long side rising half an inch above the surface; the latter is planed down, but not polished. The bucker or rubber is a rectangular piece of cast iron 7 by 5 inches, and from 1 to 4½ inches thick. On the upper surface is a socket for a long wooden handle, and the lower surface is curved (a portion of a large cylindrical surface) so that, as the operator pushes it to and fro on the plate to pulverize the ore, a slight rocking motion may be given at the same time, which brings the particles under the bucker instead of pushing them before it.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Proportion of flux to 100 parts ore	25.00	39.0	42.0	24.0	28.8	46.6	33.5	31.70
Proportion of fuel to 100 parts ore	45.33	33.0	33.8	18.5	25.0	46.2	25.0	25.54
Proportion of fuel to 100 parts charges	36.00	23.5	23.7	15.0	19.8	31.5	18.5	18.60
Tons of ore smelted per twenty-four hours	28.00	104.0	51.0	11.5	23.0	15.0	69.5	32.50

The proportions obtained by Mr. Guyard as an average for the entire camp during the census year are:

32.83 parts fuel to 100 parts ore.

23.65 parts fuel to 100 parts charges.

He calculates that 88 per cent. of the lead in the ore is extracted as bullion by direct smelting, the remainder going into the slag and escaping up the stack; also that 1½ parts of fuel are required for each unit by weight of bullion produced.

In the following table Mr. Guyard has calculated with regard to the same furnaces shown in the preceding table: First, percentage of lead extracted in smelting in the form of bullion; second, the percentage of silver extracted; third, the average charges for smelting per ton of ore at each establishment; fourth, the cost to the smelter of treating each ton of ore; fifth, the average assay of slags in ounces of silver per ton; sixth, the average assay of flue-dust in ounces of silver per ton:

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Percentage of lead extracted in smelting	85 to 88	86 to 91	88.0	85 to 95	85 to 90	90 to 03	87.0	90.0
Percentage of silver extracted in smelting	100	95 to 07	07.0	88 to 05	95.0	97.0	98.5	07.5
Charges for smelting per ton of ore	$15 to $30	$15 to $30	$15 to $30	$12 to $25	$16 to $30	$15 to $30	$15 to $30	$15 to $30
Cost for smelting per ton of ore	$12 to $18	$18 to $23	$10 to $15	$13 to $16	$15 to $18	$13	$13 68	$15
Average assay of slags in ounces of silver	2	4	0.5	1.5	1.5	1.5	1.5	4.0
Average assay of flue-dust in ounces of silver	36	37	36.0	35.0	35.0	36.0	36.0	37.0

The above table shows only the conditions which obtained during the year ending June 1, 1880. These have been varied since that time by a general reduction of the smelting charges, owing to competition and to the cheapening of supplies, and also by the reduced tenor of the ore in silver. The proportion of sulphureted over oxidized ores will also probably increase as time goes on.

GENERAL SMELTING OPERATIONS.

BLOWING-IN OF FURNACES.—The furnace is first dried by means of a slow charcoal or wood fire, whose temperature increases gradually for several days. When the drying is completed, the fire is allowed to burn out and the furnace left to cool. The crucible is then lined with steep or brasque; tamping, a simple lining of fire-clay, is sometimes put upon the dam, siphon, and siphon-tap. The furnace is then filled to the feed-hole with charcoal, the tuyere-holes, tympstone, and stack-damper being left open to create a draught. The charcoal gradually becomes incandescent to the very throat. When this zone has reached a low red heat the blowing-in begins. The tuyere-holes of the water-jacket, with the exception of from two to four of those nearest the front, are sealed with plugs of clay, and the wind-bags of the corresponding tuyeres are tied up with strings. Tuyeres are inserted in the holes left open; the tympstone is set in, and the blast then turned on at full pressure. A long flame issues from the siphon-tap, and the fire is kept steadily up until the lead-well becomes red hot. The remaining tuyere-holes are then opened and all the tuyeres are set in. The blast is regulated to the normal pressure, and the furnace is now ready for the filling of the crucible.

FILLING OF THE CRUCIBLE.—Bars of bullion kept in reserve for this purpose, in amount varying from 4 to 12 tons, according to capacity, are thrown in at the feed-door with more fuel, the proportion being three bars of bullion (300 pounds) to eight shovels of charcoal, or about 14 per cent. of fuel. From 100 to 150 bushels of charcoal, according to the capacity of the furnace, are consumed during the blowing-in. When molten lead makes its appearance in the lead-well, a few pieces of live charcoal are placed on it to prevent it from cooling, and the furnace is ready for charging.

CHARGING OF THE FURNACE.—Old slags are first of all thrown into the furnace as a test of its temperature, which is not ready until the slag is perfectly fluid. The head smelter or his assistant opens the tap-hole in the tympstone from time to time to observe their degree of fluidity, and the regular charging begins only when they run quite freely. The charges are disposed on the inside of the furnace next to the walls, a depression being left in the center for the fuel. This is the mode of charging generally adopted, but there are variations in the manner of mixing the materials forming the smelting charges. At some of the smelting works fuel is first thrown in, then old slags, above these the fluxes, and then the ore; at others fuel is mixed with the old slags and fluxes with the ores. The mode of proceeding generally adopted, however, is to mix slags, fluxes, and ore together and keep the fuel separate. At the most successful establishment the method of mixing fuels and old slags on the one hand and fluxes and ore on the other prevails. In either case the distribution of the materials in the furnace is the same; *i. e.*, fuel is thrown in the center and the charge is distributed around it.

TAPPING OF SLAGS.—The tapping of slag commences as soon as the furnace is in regular operation, and occurs generally every fifteen or twenty minutes, although a few works have adopted the method of continuous flow from the tap-hole. The tap-hole is closed by a lump of clay at the end of an iron tapping-rod. The slag is caught directly in a slag-buggy or conical cast-iron pot mounted on wheels, and is either allowed to solidify entirely in the pot and then thrown out and broken up, or it is wheeled to the edge of the slag heap and tipped over so that it runs in a half liquid state down the sides of the dump. A single smelter adopts the plan of allowing the slag to solidify partially in the pot, and of then making holes through the hardened crust and tipping the pot over so that the still molten material runs out, leaving a shell over 2 inches thick. This shell is easily broken up for re-smelting, it having been found that it is a little richer in silver than the center. Slag samples for assay are taken two or three times a day from the stream in the slag gutter, and their specific gravity and contents in lead and silver are determined in the assay office. Any speiss or matte that may be formed is run into the slag-pot with the slag, and is either thrown out with the latter upon the dump, or, after cooling, is detached from the slag and preserved separately. The proportion of speiss and matte at Leadville is generally very small.

LADLING OF BULLION.—As often as necessary the bullion is dipped out of the lead-wells with wrought-iron ladles and poured into cast-iron molds. At a single smelter a different method obtains. The bullion is tapped periodically from an opening in the clay lining of the lead-well into an iron pot mounted on a small stove, in which a light fire is kept burning. From this pot it is ladled into the molds. The advantages of this method are that the surface of the lead in the well is kept covered. The lead is therefore hotter, and the passage into the crucible is more readily cleaned. Moreover, the lead being drawn from below, the surface is free from skimmings, and the bars are smoother and cleaner.

The bars of bullion are then sampled, weighed, and marked. The sampling is done by taking with a scoop-chisel a piece from the top and a piece from the bottom of each bar. The samples from 200 bars, or 10 tons, which constitute a car-load, are sent to the assay office, where they are melted together and cast into a small bar, from which pieces are taken for an assay.

CONTROL OF SMELTING OPERATIONS.—From time to time the siphon-tap has to be cleared by the insertion of a curved iron rod, about 2 inches thick, previously heated to redness at the curved end.

The tuyeres must be watched from the sliding valve, and when dark rings of chilled slag are observed around them they are removed by iron rods inserted through the tuyere, and the temperature is raised by the addition of more fuel or by a reduction in the proportion of charge.

The water-jackets require constant watching, in order that the temperature of the water issuing from them may be kept as nearly as possible at from 50° to 60° C.

The blast also requires constant attention and regulating, the pressure being increased or diminished as the condition of the furnace, determined by observation from the tuyeres, may demand.

If semi-fluid slags or raw ore form accretions, which do not disappear by an increase of the temperature, the blast must be shut off, the tympstone removed, and the hearth cleaned by means of bars and sledges; after which a little fuel is thrown into the hearth, the tympstone is replaced, and the blast is turned on again. At one period ores rich in lead were scarce at Leadville, and the charges generally contained much less than the normal 20 to 25 per cent. of lead. The running of the furnace became, in consequence, a much more difficult matter, and the formation of obstructions of various kinds was of frequent occurrence.

When accretions form on the walls of the shaft, it is necessary to "bar it out" once in twenty-four hours, or once per shift, as the case may be. To accomplish this charging is interrupted until the contents of the furnace descend to the level of the accretion. The blast is then turned off, a long chisel-pointed bar is introduced into the feeding-hole of the furnace, and, being inserted between the accretion and the furnace wall, is struck with sledge-hammers until the accretion is detached, when the blast is turned on again and the charging resumed.

The Leadville furnaces are generally run with a dark top; *i. e.*, the zone at the throat is so dark that no flames issue from it, and only a black smoke is seen ascending the chimney. This appearance is an indication that the furnace is running properly.

SMELTING OF FLUE- AND CHAMBER-DUST.—Flue- and chamber-dust are mixed in general with lime, and the mixture may or may not be molded into bricks. It is then spread over the ore beds, so that a little of the flue-dust enters into the composition of the smelting charges.

BLOWING-OUT OF FURNACE.—This takes place when the furnace needs repairing, or when an accident, interfering with the regular working of the furnace, has occurred. It is done by suspending the charges and continuing the blast until the whole contents of the furnace are molten. The charge soon burns with a bright top, and the furnace emits torrents of heavy white fumes. When the whole charge has reached the level of the tuyeres the furnace is emptied of its fluid contents, first from the tap-hole, then the breast is removed, and the bullion is taken out of the crucible.

LENGTH OF RUN.—The smelting campaigns are seldom less than three weeks, and often reach six, eight, and even thirteen months.

FURNACE PRODUCTS.

BULLION.—The bullion of Leadville is generally very pure, its constituents other than lead and silver, though numerous, being present in very small quantity. The character of these impurities is shown in the following analyses made by Mr. Guyard, I being bullion from the La Plata smelter, II being a mixture of equal parts of bullion from nine different smelters:

	I.	II.
Lead (by difference)	99.0798210	98.492379
Silver	0.6112445	0.793417
Gold	0.0000888	0.000891
Copper	0.0479100	0.071450
Tin	A faint trace.	0.000897
Bismuth	A faint trace.	0.011791
Arsenic	0.0391365	0.219528
Antimony	0.2138940	0.347881
Iron	0.0063000	0.012600
Zinc	0.0016052	0.000232
Cadmium	A faint trace.	A faint trace.
Sulphur	None.	0.048934
	100	100
Ounces of silver to the ton	178.275	231.408
Ounces of gold to the ton	0.026	0.260

The presence of tin in the bullion seems rather singular, inasmuch as it has not been detected in any of the ores or fluxes of Leadville. It has been suggested that it owed its origin to the great number of preserved-fruit cans scattered about the place, some of which may have found their way into the furnace. It is indeed said that these cans were at one time used at one smelter, probably as a precipitant for the lead in the galena. As tin has also been found in other products at different times, it seems hardly probable that this source can be adopted as that from which it is in all cases derived.

The average assay of bullion shipped from Leadville during the early part of the census year was nearly 300 ounces to the ton, but during the month of December, 1880, it had fallen off to less than 200 ounces. Mr. Guyard estimates the average loss of silver in smelting at 4.115 per cent., and of lead at 11.68 per cent., part of which, however, is recovered from the chamber- and flue-dust. The bars of bullion weigh on an average 100 pounds each, 200 bars, or 10 tons, constituting a car-load. They are shipped to eastern refineries, and when sold direct the latter pay the cost of transportation, which varies from $27 to $35 per ton. The price of lead in bullion is subject to great fluctuation, and has varied between $30 and $78 per ton at Leadville, the average price being $60. Payments are made for bullion at New York quotations, deducting for the cost of refining 3 cents per ounce of silver, or sometimes $14 to $15 per ton of bullion. In other cases the charges are 3 ounces of silver and 5 per cent. of lead per ton.

SLAG.—The slags produced at Leadville are in some instances normal singulo-silicates, but in general rather more acid, the object in producing the latter being to insure a smoother run of the furnace, to require less constant watching and to avoid the formation of sows and accretions. They flow freely, and generally possess, when cold, a compact, fine-grained structure, though frequently well crystallized in parts. They are for the most part strongly magnetic; and Mr. Guyard has shown that this property is not due to any magnetic silicate of iron, but to magnetic oxide of iron, he having isolated these substances in a greater or less quantity and in a state of perfect purity from all slags investigated by him. As a means of judging whether the slag is normal in its composition and contains any excess of lead determinations are made daily at a few of the smelters by means of the Jolly spring-balance. Slags from a normal run carry from 2 to 4 per cent. of lead and from 2 to 4 ounces of silver to the ton, though by attention and careful charging these figures are sometimes greatly lowered. On the other hand, they frequently run much higher, both in lead and in silver, owing to the faulty composition of the charges or to careless regulation of the smelting process. Slags from the earlier campaigns of some furnaces have been found to contain as much as 15 to 20 per cent. of lead, and silver in proportion; in view of which it is hardly a matter of wonder that failures were frequent. Slags accidentally rich in silver, and whole slag heaps from some of the works first started are re-smelted with the ores.

MATTES.—Since the sulphide ores occurring in the region are not roasted, but thrown directly into the furnace, mixed in small proportion with the oxidized ores, a certain amount of matte is necessarily formed, which consists mainly of sulphides of iron and lead, with, as ascertained by Mr. Guyard, a large percentage of magnetic oxide of iron. These mattes carry from 40 to 90 ounces of silver to the ton, and are roasted in heaps preparatory to being re smelted.

SPEISS.—Speiss, which is found only in small quantity, is an iron sulph-arsenide, and seems to concentrate in itself all the molybdenum as well as most of the nickel, traces of which exist in the ores. It is further characterized by its very small percentage of antimony, and, according to Mr. Guyard, by the total absence of cobalt. It is a question, however, whether an examination of a large number of samples would justify the conclusion drawn by Mr. Guyard that a complete separation of nickel and cobalt is effected in the smelting process. He found cobalt without nickel in the skimmings from the lead-wells and nickel without cobalt in the speiss.

Its silver contents vary from 2 to 4 ounces per ton. It is not roasted or subjected to any further treatment.

ACCIDENTAL FORMATIONS IN THE FURNACE.—Among these iron sows are the most important, and have frequently been the source of much trouble, sometimes necessitating, as before mentioned, the blowing-out of a furnace in order to effect their removal. Besides ordinary hearth obstructions, different shaft accretions are found in varying quantity, which it is unnecessary here to discuss further, save to quote an instance, mentioned by Mr. Guyard, of a small, round furnace entirely lined from the water-jackets to within 6 inches of the feed-hole with one of these accretions a foot in thickness.

FLUE- AND CHAMBER-DUST.—Leadville being situated at an elevation of 10,000 feet above the sea, the volume of air blown into a furnace with a given blast-pressure is far greater than with the same pressure at sea-level; consequently the draught of the furnace is correspondingly increased, and the quantity of dust and fumes escaping by the stack is very large. This would seem to necessitate the employment of a very perfect system of condensing flues and chambers. In point of fact, however, as has been seen, these arrangements are, with one or two exceptions, very poor; consequently a large proportion of the dust and fumes is lost in the air. Their composition is extremely complicated, and is characterized by the presence, in considerable quantities, of chlorides, bromides, iodides, and phosphates. They carry from 25 to 60 per cent. of lead, the latter figure applying to the fumes condensed in the Bartlett filter before described, and from 30 to 40 ounces of silver to the ton, although the Bartlett filter fumes held but 4.3 ounces. The composition of the latter is otherwise remarkable in that they contain over 11 per cent. of phosphate of lead, 9 per cent. of chloro-bromo-iodide of lead, and 18 per cent. of sulphide of lead, and from the further fact, according to Mr. Guyard, that iron, zinc, and manganese exist in them entirely in the state of sulphides. It must be borne in mind, however, that these fumes were condensed at a distance of 200 feet from the furnace. Mr. Guyard has calculated the weight of calcined dust collected from one furnace of 30 to 40 tons capacity during twenty-four hours at 1,400 pounds, and estimates that, where the filter is not employed, the loss of lead equals half a ton and of silver 4½ ounces per day per furnace. On this assumption more lead is lost in the air than is collected in the dust-chambers. As already shown, the chamber- and flue-dust is mixed with lime and thrown over the ore-beds to be re-smelted. In one case, however, a furnace was specially constructed for the purpose of roasting the flue-dust, though with what object in view it is impossible to say, unless on the erroneous supposition that much arsenic is present. In point of fact, arsenic is found in it in only small quantities, and this roasting deprives the dust of the carbon which would otherwise suffice for the reduction of all the lead contained in it, besides occasioning the loss of some silver. In another smelter the flue-dust is prepared for re-smelting by melting down in a reverberatory furnace, at first with, and now without, the addition of slag. It is then run out, and after cooling it is broken up and mixed with the charges.

COST OF LABOR AND MATERIAL.

Below are given a few data relative to the prices paid for fluxes, fuel, and the average wages of employés during the census year at Leadville, which serve to give a fair idea of the economic conditions of smelting at that time:

Dolomite, per ton	$3 00 to $4 00
Hematite, per ton	8 00 to 11 50
Charcoal, per bushel	10 to 18
Coke, per ton	25 00 to 60 00
Pine wood, per cord of 2,000 to 3,000 pounds	4 50 to 5 00
Foremen, per shift of eight to twelve hours	3 00 to 6 00
Head smelters, per shift of eight to twelve hours	3 00 to 4 25
Slag wheelers, per shift of eight to twelve hours	2 50 to 4 00
Feeders, per shift of eight to twelve hours	3 00 to 4 00
Helpers, per shift of twelve hours	2 50 to 3 00
Day laborers, per shift of ten to twelve hours	2 50
Engineers, per shift of eight to twelve hours	3 50
Fuelmen, per shift of eight to twelve hours	3 00

CONCLUSION.—In conclusion, it may be said that lead smelting, as carried on in this region, while not entirely beyond criticism, has been brought to a relatively high degree of perfection, and is extremely creditable to American metallurgists. One of the most useful practical lessons that has been taught by the comparative success of the various smelting works is that this has been proportional to the more thorough training in scientific metallurgy of its managers, the completeness and accuracy with which they have gauged the operations of their furnaces by chemical tests, and the intelligence with which the results of these tests have been applied to the practical conduct of their business.

Could this lesson overcome the idea so common among us that the adaptability and "cuteness" of the American, which is in so many points acknowledged to be superior to that of other races, enable him to master the science of smelting as readily as he does any branch of trade, it might prevent an increase of the already very considerable number of abandoned smelters which dot our western hills and valleys, and save a portion of the capital which is annually wasted through gross ignorance in the various operations connected with mining.