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

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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 Neith 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, chlorobromide 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 porphyries. 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, 80° 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. 10° 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, and, 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.
Louella	Conglomerate, resting on Archæan, overlaid by sandstone. Dip, 30° E.; 7 feet thick.	Free gold in cement.
Ore Cash	Felsite-porphyry. Strike, NW.; dip, 30° NE.; ore belt 150 feet wide.	Gold-bearing hematite and limonite in quartz.
Pecche	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.
Ore 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.

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 16 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, bornite, 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.; 20 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, 60°; 20 to 40 wide; foot wall not found.	Largely chalcocite, carrying little silver.
Shonbar	"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, 30° 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 Courage.	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, 16° 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 cerussite, 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 character 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 correspond 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, according 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 occur 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 occurs in Carboniferous limestone, and veins carrying gold and copper 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. 88° 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.