DESCRIPTION OF THE TENMILE DISTRICT QUADRANGLE.

GEOPHYSICAL RELATIONS.

The area shown on the Tenmile district special map is included between the meridians 101° 8' and 106° 10' of longitude west from Greenwich and the parallels 39° 30' and 40° 30' of north latitude. It covers about 55 square miles, and adjoins on the northwestern portion of the area represented on the Mosquito Range, Sheet VI of the Leadville atlas, Monograph XII. This special district has immediately north of it, the Continental Divide, which runs east and west, connecting the Mosquito Range with the northeastern part of the Sawatch Mountains, and is bounded on the east by the steep western slope of the Mosquito Range. Immediately north of it is the little-known mountain group called the Gore Range. This divides the area into two sections, set off on an echelon somewhat to the westward, of the Mosquito Range.

The principal drainage is northward through Tenmile River, which flows around the northern end of the Mosquito Range into Blue River, the main source of the East River, which flows through the southern part of the Crooked River Range and enters the Ogden River. Situated as it is near the crest of the Rocky Mountains this district is one of the most dissected and broken sections in the State. The valleys are very narrow, the average being only about 100 feet wide, while the ridges, which are the summits of the peaks of the granite and schist massifs, are raised to a height of from 4000 to 7000 feet above sea-level.

The general character of the surface or topography of the area is one of extreme irregularity, the valleys being filled with large quantities of pyrite, and almost all the peaks show from their steep sides and abrupt summits large quartzose outcrops of various sizes. The surface is extremely rough and broken, and there are many great cracks, in some places with overhanging sides. The drainage is extremely irregular, the surface water runs off in small gullies and in large streams, and the greater portion of the surface is so broken that the various streams are entirely separated from each other by long barren sections.

In contrast with these rugged and steep slopes, which form only a narrow strip along the eastern edge of the area mapped, the rest of the region is characterized by smooth and rounded topographic forms, the surface being made up of gently dipping beds largely covered by glacial gravels and soil. The soil supports in places a considerable growth of grass, and on the more elevated areas near the lake, cedars, fir, and aspen. The surface is generally barren, with a few scattered trees here and there along the streams, and the general aspect is quite bleak and desolate.

The main valley of Tenmile River, which rises in a fine glacial amphitheater just south of this quadrangle, traverses the area from the north to the south, a distance of about 15 miles. The valley is very narrow, the average being only about 100 feet wide, while the ridges, which are the summits of the peaks of the granite and schist massifs, are raised to a height of from 4000 to 7000 feet above sea-level. The valley of Tenmile River is a typical dolomite, of bluish-gray or black color near the top, and lighter colored near the base. It is in general heavily bedded and of the dolomitic type. The greater part of the district is an extension of the Leadville limestone, which is about 200 feet thick, but it is sometimes considerably less, but nearly always present. The district north of the Leadville limestone is about 200 feet; it is sometimes considerable less, but nearly always present.

The lower part of the Leadville limestone is a fine grained dolomite, and then the overlying beds consist of the Carboniferous system, which is characterized by a series of layers of sandstone, with interbedded beds of siltstone, shale, and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of shale, and then by a series of siltstone beds, which are often very thin and discontinuous, and then by a series of thin layers of sandstone, with interbedded beds of siltstone and coal. The sandstone is generally fine grained, with a thin layer of coal at the base, which is succeeded by a series of thin layers of A
calcareous and argillaceous beds. This formation in the Tenmile district consists predominantly of coarse gray and red sandstones, in some places passing into conglomerates of small, irregularly developed beds of limestone. As contrasted with corresponding members of the Weber group, the following is typical of the beds in the district, though more abundant than in the beds of the next above, results not from the presence of pink feldspar, as in the Weber group, but from abundant quartzose, sometimes intergrading with the feldspar. Hence in depth, as shown in under-lying formations, the red color generally given way to a grayish gray. The strata in which the red color is most pronounced are fine grained and somewhat argillaceous in character, and the reddish areas in the thicker beds are conspicuously developed with parallel lamination. In some cases it was found that a mixture of one of these beds was covered by the other, and the second bed is represented in the district, the evidence of which has been noted. The red color of the sandstones, which is more common than in the lower formations, is produced by the development of thin argillaceous beds. Roth the Mountain region have, on fossil evidence, been noted. The red color of the sandstones, which is more common than in the lower formations, is produced by the development of thin argillaceous beds. Roth the Mountain region have, on fossil evidence, been noted. The red color of the sandstones, which is more common than in the lower formations, is produced by the development of thin argillaceous beds.
The Gold Hill porphyry is darker than the one previously described, owing to the development of smaller crystals of hornblende and biotite. The porphyry in the district contains quartz, biotite, and hornblende. The quartz, which constitutes the groundmass, is present in varying proportions throughout the district. The biotite is present in small amounts, and the hornblende is rare. The groundmass of the Gold Hill porphyry is composed of hornblende and biotite. The porphyry is characterized by the presence of large crystals of plagioclase feldspar and quartz, which are distributed throughout the mass. The porphyry is an example of a dike kontakt-metamorphosed rock, where the porphyry has been intruded into a pre-existing sedimentary or igneous rock, resulting in the formation of a metamorphosed porphyry dike. The Gold Hill porphyry is a good example of a dike-like body that has been intruded into a pre-existing sedimentary or igneous rock, resulting in the formation of a metamorphosed porphyry dike.
have a reverse dip of 65° E. These facts, and the general crumpling of the mass of the sedimentary beds, show that the faulting was accompanied by a compressive effect of granite and anesite. Enormous beds of almost solid sulphide of iron are found, generally by bismuthite, pyrite or marcasite. In some cases, however, in the form of pyrrhotite, or molybdenite. These ores are generally of low grade to pay for working them, but, however, or in bodies, there are extensive accumulations of galena and zinc blende carrying silver, and in some cases of copper ores, sulphides, molybdenum, and arsenides, which constitute the commercially valuable area of the region. The manganiferous schists and rhodochrosite are frequently associated with them, while quartz, calcite, and barite are the ordinary gangue minerals. These veins are found unaltered at a very short distance from the surface, showing that the oxidation by surface waters has penetrated to very slight depth. This is doublets, as in the more elevated portion of the Leadville district, to the great altitude of the deposits and the consequently short period in each year that surface waters are not impregnated by frost, and thus rendered inactive.

MIXES.

As shown by the workings of actually developed ore deposit in the region, whose character and manner of deposition will be best understood by a study of the principal mine in which each type is developed.

ROBINSON MINE.

History.—The various claims after consolidation into the Robinson mines were located in the summer of 1879, the principal prospectors in the employ of George B. Robinson, then Lieutenant-Governor of Colorado. In the following year, whilst awaiting the legal decision of adverse claims upon his property, Governor Robinson was shot by one of his own guards, who were holding armed possession of the claims. A posteriori, it was an important factor in the prosperity of the region. It has suffered, as have many other mines, from defects of management, one great mistake being the building of smelting works at the mine. As it changed hands several times, it has been quite impossible for them to obtain adequate data in regard to the amount or value of the ore that has been taken from it. Common report gives at about $6,000,000 the value of the final Robinson ore shoot.

Character of deposits.—The deposits on this property are narrow ore shoots having an average thickness of 3 feet, and no one central fracture, and minor fractures accompanied by some replacement on either sides, which define, approximately, the limits of the ore body. On the right or eastern side is a tendency of the strata to bend downward in a monocline. The fractures have not been traced below this level, and in the opinion of the writer the ore body is inclined, of an irregular, frequently somewhat wavy form shown by the diagram, and the fractures and the ore body have not been traced below this level for the reason that the topography has taught the miners that no ore could be expected below this level. The tunnel had passed through fissures parallel to the central one. The resulting ore bodies have widths of 10 to 100 feet, their greatest extension being at the upper part of the limestone. During the post-Cretaceous movement, in the line of contact of the nevadite with the Weber Formation, the Tenmile Valley, in Mayflower, Gold, and Carbondale, has been opened by the earlier explorers in the area along the Archean area. The Tenmile Valley, in Mayflower, Gold, and Carbondale, has been opened by the earlier explorers in the area along the general line of the narrow gorge of lower Tenmile River. As in most places only a single bed of limestone is 20 feet thick, is found, and farther northwest, along the strike, are several beds at the same horizon, direct connection being had with the rock fractures which abound in upper Carboniferous limestones. The White Quail limestone, at the end of Sheep Mountain Ridge, at the end of Fortune creek, both of which are nearly pure carbonate of lime, but lower portion is darker in color, some times almost black, and contains nearly 7 per cent of magnesium carbonate. On the crest of Sheep Mountain Limestone, the White Quail limestone is about midway in the formation, called, from the primitive mines whose southern shoulder of Jacque Mountain. Numerous pros-
the workings from the New York shaft, which is situated about 100 feet south of the Champion tunnel, the ore body was cut by a series of tunnel in the same geological formation, it was observed that they apparently make a sharp bend in strike to the southwestward under this valley; it appears probable that this bend is structurally controlled. In the Daughenbaugh shaft, on the west side of Robinson flat, a fault plane has been developed which appears to be a part of this same fault, or at least of this same system of faults.

Ore deposits in sedimentary beds extending along or parallel to stratification planes from cross fractures or fault planes outward are by no means uncommon. Such fractures have received the local name of “verticles,” as applied to the gold deposits in the Cambrian strata of the northern portion of the Black Hills of Dakota.

Quail Group.

History.—Soon after the discovery of the Robinson mine attention was called to the other workings on the crest of the southwestern end of Elk Ridge, just north of Kokomo Gulch, and by the summer of 1913 nearly all the main mining operations had been made extending nearly down to Kokomo Gulch. These were the White Quail (17), Afternoon (18), and Badger (20) inclines, the Eagle and Eagle (21) tunnel, and the Colonel Sellers (22) shaft and inclined. As finally developed, the White Quail tunnel, which started 350 feet vertically below the mouth of the White Quail incline, drained the ground above its mouth to a depth of about 250 feet. In addition, it is underlain by a sheet of fine-grained limestone, the ore being cut off both the limestone and the Mountain, the numerous and irregular intrusive beds. In like manner a sheet of black shale of black carbonaceous shale over the limestone, with a maximum thickness of 22 feet. There is generally a thin seam of galenaiferous and siliceous ores from that time, though but a limited proportion of the ore mined to that date has been taken from this level. An area in round numbers about 1500 feet across is the dip below its outcrop. Since the completion of this tunnel cut the Quail ore body 2100 feet on the west side of a shallow syncline, as shown in the diagram.

Characteristics of the ore.—The ore is mainly pyrite or marcasite, with small but varying amounts of siliceous and galena, more or less argentiferous, but the principal values occur with the latter mineral. The richer ores also carry some gold. Calcite and barite are found in a limited extent. Quartz in granular form also constitutes an important vein material. These materials occur, like the Robinson ore, as a replacement of the limestone, the line of contact often extending from its upper surface, or roof, irregularly downward, forming a thickness of 4 to 9 feet of ore. Later, layers, having a width of 50 to 80 feet, containing quartz and galena, have been worked, and the quartz vein is now being worked for the sake of the fillers.

In the unaltered zone from 10 to 50 feet, being often much richer in lead at right angles, or with a dip of 80° to 85° N. W. from the bedding, which has displaced the vein, throw back over the limestones. In the cross-cut drifts it was readily apparent that these changes were caused by the dipping past each other of alternate sheets of the structure. From the White Quail incline southeastward the Quail limestones have a regular cross-fault, striking N. 60° to 70° E., which is about the same as the dip of the Quail ore, from 25° to 17°, though the actual dip of the formation between the faults remains substantially constant.

Geological relations.—The outcoping rocks here consist of coarse sandstones, with some thin shale beds, of the Upper Carboniferous or Maroon (24) formation. These rocks are also known as “spar veins,” as they were called, were sometimes found in the lower levels of the mine. In the latter the sulphide of iron is largely in the form of pyrite.

Quinn of the West Group.

On the steep slope of the southeast spur of Quail Mountain, overlooking the town of Ekalaka, the Queen of the West and adjoining mines find their ore on a series of transverse fissures crossing the strata at right angles and having a strike N. 60° to 70° E., which is about the same angle as the strike of the flat from 10° to 20° from the bedding. In each of these cross-cut drifts were found one or more of a series of fracture planes parallel with the main fissure, the rock on either side of each plane being frequently different, and on many of these second fracture planes were found considerable developments of ore. Down to the sixth level the ore was mostly oxidized, but on the seventh or eighth level, the No. 4 flat, which was driven 800 feet below reaching the vein, found only sulphide ore which was so inferior both in bulk and quality that it was not found in the upper levels of the mine that the not long after closed down.

The sluiced ore was mostly galena, silver, and pyrite, with some sulphides and antimonials of silver. Calcite is the only prominent gangue mineral besides the altered country rock. The pyrite seemed to be largely a replacement of the country rock—pyrrhotite or pyrrhotous sandstone, as the case might be—but in the main or central fissure there was often found a vein, 1 to 2 feet thick, of crystalline calcite with curved faces, which was evidently the filling of a preexisting open cavity. Similar “spar veins,” as they were called, were sometimes found in the secondary fissures; but all such vein iron, which were bared of pay ore. In the oxidized zone from which the principal part of the pay ore was taken, metallic minerals could rarely be distinctly seen, the ore consisting of decomposed and iron-stained sandstone or pyrrhotite, as the case might be. In the mines workings the changes from decomposed sandstone to pyrite, and vice versa, were rare and frequent. In the cross-cut drifts it was readily apparent that these changes were caused by the dipping past each other of alternate sheets of pyrite and other minerals.
an inclination northward, and thus the drift passed gradually from a lower to a higher bed, in some cases from sandstone to porphyry, or vice versa. At the same time it might also have crossed one of the vertical fault planes, by which a change of country rock would also be brought about. It was assumed by some of those working the mine that the vein was following a porphyry dike, but no certain evidence of the existence of such a dike could be found, and the explanation here adopted seems to account for existing conditions in a satisfactory manner. This is that the alternating layers of sandstone and porphyry have been cut by a series of parallel and closely spaced fault planes of slight displacement, the average distance between which is about 10 feet and increases from the medial zone outward. The throw of the individual faults in this fault zone is in most cases downward on the southeast; it could not be determined whether this is universally the case. The mineral solutions have entered along these fault planes, more abundantly in the medial zone, and have filled the interstices and decomposed and, to a certain extent, replaced the country rock on either side. In fig. 4 is given a section across the vein, somewhat diagrammatic in its nature, though based on observations and measurements taken at the different levels of the mine. The figure also shows the horizontal faults made since the ore deposition, which apparently conform to the stratification planes, though, as represented in the section, they diverge slightly from them. As is usually the case with faults of this nature on a hillside, it is the upper part of the ground, nearest the surface, that has moved downhill relatively to the rock masses beneath. The positions of these horizontal faults as given on the elevation (fig. 3) are represented by broken lines, since they have been observed at only a few points on this plane, and their actual location between these points is more or less hypothetical. It is probable that the actual movement has taken place on some of the thin shale beds that occur between the sandstone strata, and is very possibly not confined to a single plane, as represented in the section. The movement of the lower fault is apparently much greater than that of the upper, and it is possible that the true continuation of the main ore-bearing fissures below this plane was not discovered, although considerable cross-cutting has been done on this level.

The evidence afforded by the mine workings thus shows that there have been two periods of faulting in the district, one previous to the ore deposition and one subsequent to it. During the first were formed the transverse fissures, which later became fissure veins where they traversed only sandstone and porphyry sheets, but which, when crossing limestone strata, merely served as water channels to admit the ore-bearing solutions that attacked and replaced the limestone. The evidence shows further that the deposits formed in the latter manner are by far the largest and most important ore bodies in the district; that these ore bodies have produced only a comparatively small proportion of ore which would yield a profit under previously existing conditions, and that enormous amounts of low-grade pyritic ore are still remain untouched in the mines, which it may yet be found profitable to work under improved methods of treatment.

It is to be remarked in a general way that, throughout this portion of Colorado, wherever there has been a considerable development of intrusive porphyries there has been a large concentration of metallic sulphides somewhere in the vicinity, and that the favorite locus of deposition of these minerals has been in the limestone strata, rather than in the less soluble sandstones and porphyries. In the neighboring districts of Leadville, Red Cliff, and Aspen, where the ores are both richer and in greater amount, this concentration has taken place mainly in the lower Carboniferous or Leadville limestones, and in some cases also in the beds immediately under it. In the greater part of the Telluride district, however, the Leadville limestone occurs at a depth of over 2500 feet from the surface, and it is questionable whether it would pay even to prospect for it with the diamond drill; for while this limestone may be mineralized to some extent, the probability that the drill would reach it where there are ore bodies is only one among a number of adverse chances, and if ore were found in this way, it would still be an open question whether it would pay to work it at so great a depth.

CONCLUSIONS.

The evidence afforded by the mine workings thus shows that there have been two periods of faulting in the district, one previous to the ore deposition and one subsequent to it. During the first were formed the transverse fissures, which later became fissure veins where they traversed only sandstone and porphyry sheets, but which, when crossing limestone strata, merely served as water channels to admit the ore-bearing solutions that attacked and replaced the limestone. The evidence shows further that the deposits formed in the latter manner are by far the largest and most important ore bodies in the district; that these ore bodies have produced only a comparatively small proportion of ore which would yield a profit under previously existing conditions, and that enormous amounts of low-grade pyritic ore are still remain untouched in the mines, which it may yet be found profitable to work under improved methods of treatment.

It is to be remarked in a general way that, throughout this portion of Colorado, wherever there has been a considerable development of intrusive porphyries there has been a large concentration of metallic sulphides somewhere in the vicinity, and that the favorite locus of deposition of these minerals has been in the limestone strata, rather than in the less soluble sandstones and porphyries. In the neighboring districts of Leadville, Red Cliff, and Aspen, where the ores are both richer and in greater amount, this concentration has taken place mainly in the lower Carboniferous or Leadville limestones, and in some cases also in the beds immediately under it. In the greater part of the Telluride district, however, the Leadville limestone occurs at a depth of over 2500 feet from the surface, and it is questionable whether it would pay even to prospect for it with the diamond drill; for while this limestone may be mineralized to some extent, the probability that the drill would reach it where there are ore bodies is only one among a number of adverse chances, and if ore were found in this way, it would still be an open question whether it would pay to work it at so great a depth.

SAMUEL FRANKLIN EMMONS.

Geologist.

July, 1896.