For short distances below the surface siderite and ferruginous calcite are common, both as massive stringers and as well-formed rhombic crystals lining small irregular vugs. The ores, which are locally called "sulphurets" and which consist usually of soft brown and black oxidized ores and somewhat similar appearing mixtures of these oxides with sulphide ores of secondary origin, are said to have been common near the surface.

The richest and largest bodies of ore were found between the third and fifth levels. It was from this locality that assays running several thousand ounces of silver to the ton were obtained from picked specimens. Good ore, however, running 200 to 400 ounces to the ton, has been taken from depths of more than 600 feet below the surface.

CENTRAL COLORADO LODE.

LOCATION AND DEVELOPMENT.

The Central Colorado vein, which is located on the northwest slope of Leavenworth Mountain, is developed by a series of tunnels. The main development being carried on at present is through a tunnel about 450 feet in length, which enters the hillside at an elevation of approximately 9,000 feet and intersects the vein about 400 feet from its mouth. About 225 feet of drifting has been done along the vein and some stoping has been begun.

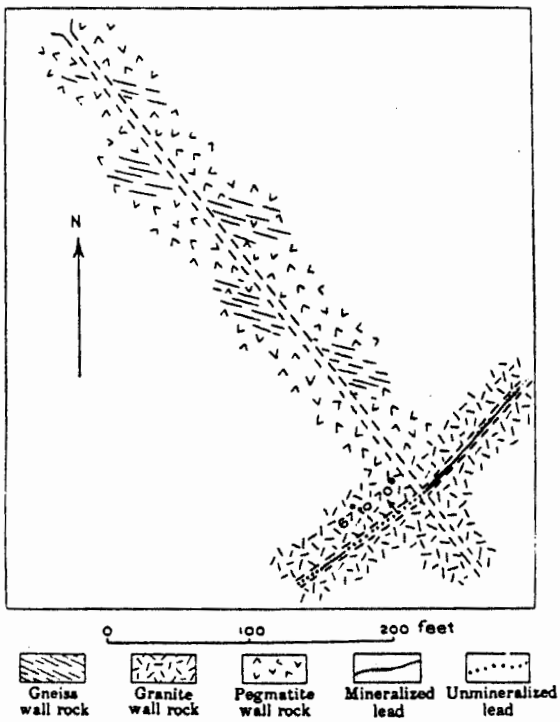


FIG. 101.—Geological plan of tunnel workings, Central Colorado vein.

NATURE OF WALLS.

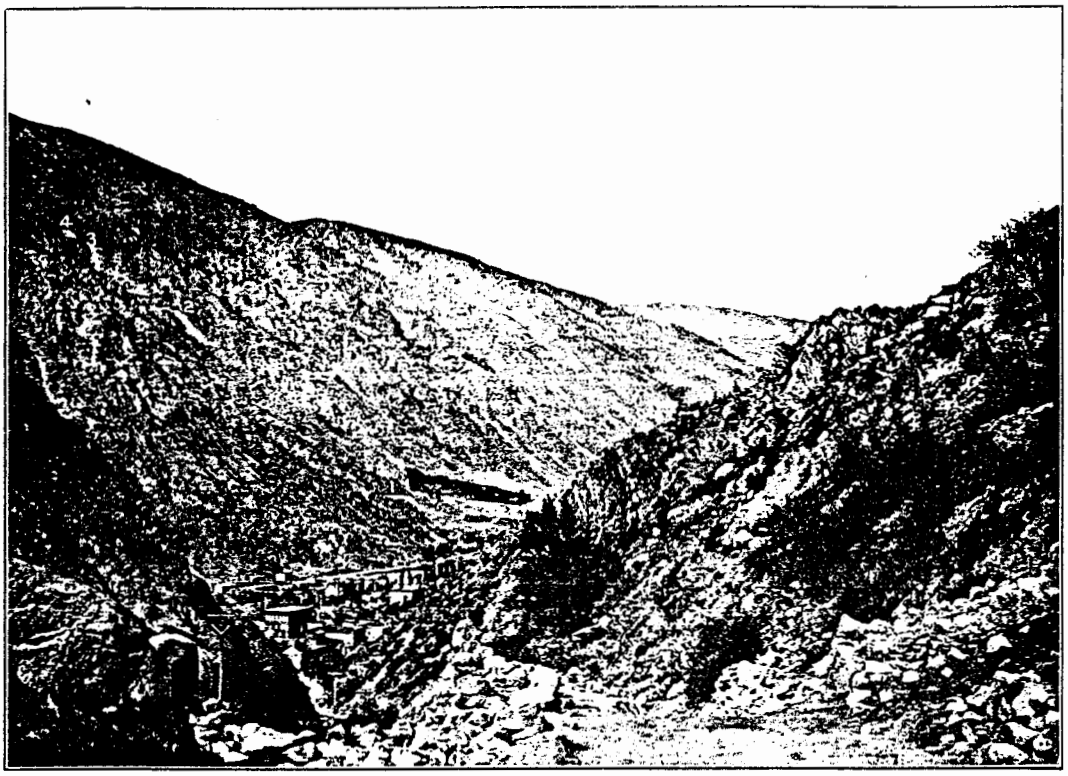
The country rock through which the tunnel (fig. 101) is driven is chiefly pegmatite with small patches of gneiss, usually of a hard granitic variety, inclosed within it. The walls of the vein, however, are mainly hard and comparatively fresh biotite granite. No porphyry was observed in the workings.

NATURE OF VEIN.

The vein usually consists either of a single narrow fracture or of a series of small or tight fractures traversing hard granite in a N. 45° E. direction. Very little movement has occurred along the vein, as gouge, slickensides, and other evidences of faulting and differential movement are almost entirely lacking. Gouge as thin selvage one-eighth to one-fourth inch thick occurs locally between the ore and the wall rocks, but as a rule the ore is "frozen" to the walls. In the vicinity of the small stope from which ore was being extracted the vein had the nature of a stringer lode, and consisted of a series of small mineralized veinlets running parallel to the strike of the vein and in places connected by a network of still finer veinlets.

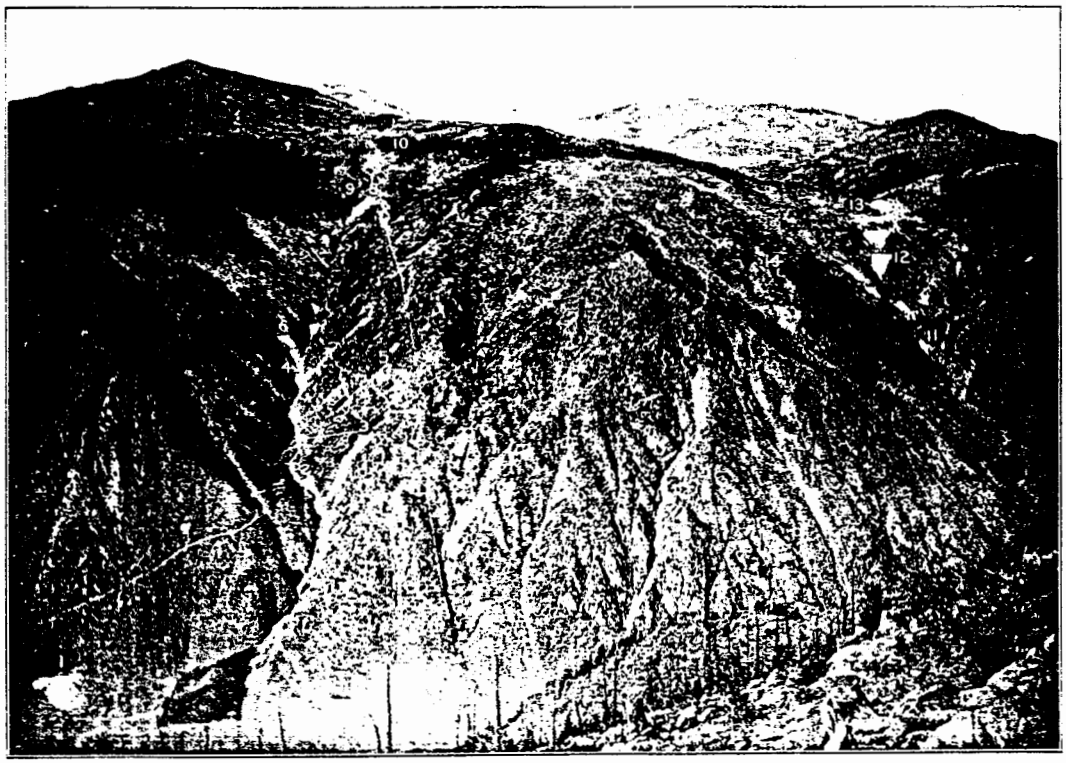
ORE.

The ore is mainly gold bearing and consists chiefly of pyrite, which is as a rule light in color, but in places carries so much copper that it verges on chalcopyrite. Thin seams or coats of zinc blende occur here and there between the copper-bearing pyrite and the wall rock, as if the zinc sulphide were of earlier origin than the cupriferous pyrite. The ore, which carries from a fraction of an ounce to 2 or 3 ounces of gold and practically no silver, occurs either as fairly well formed crystals of pyrite lining vugs or as massive cupriferous pyrite which adheres



A. GEORGETOWN AND REPUBLICAN MOUNTAIN, LOOKING NORTH IN SILVERDALE CANYON TO SOUTH CLEAR CREEK.

1, Kelly tunnel; 2, New Boston mine; 3, Beecher mine; 4, Muscovite mine



B. REPUBLICAN, DEMOCRAT, AND COLUMBIA MOUNTAIN MINES, LOOKING WEST FROM DUMP OF MAGNET MINE.

1, Kelly tunnel; 2, Moline tunnel; 3, New Boston mine; 4, Spartan tunnel; 5, Beecher mine; 6, Mineral Chief mine; 7, Muscovite mine; 8, Sceptre mine; 9, Queen mine; 10, Astor tunnel; 11, Cliff lowest level; 12, Junction lower level; 13, Edgar tunnel; 14, Buckeye tunnel.

tightly to the comparatively fresh wall rocks or is separated from these rocks by a thin selvage. In places where the ore adheres tightly to the walls the boundaries are rather irregular, owing to the replacement of more or less of the country rock adjoining the fracture. The chief gangue mineral is quartz, which in places shows comb structure. Small amounts of siderite and ferruginous rhodochrosite, as well as of barite, are also present.

WELCH LODE.

The Welch vein was actively developed in the early seventies and produced several shipments of very rich ore, but serious difficulty was encountered in exploration work owing to the discontinuous nature of the vein, due either to faulting or to irregularities in the vein fracture itself. At the time of visit no work had been done for years and practically all the workings were caved shut except a short tunnel and shaft located on the upper part of the west slope of the north spur of Leavenworth Mountain.

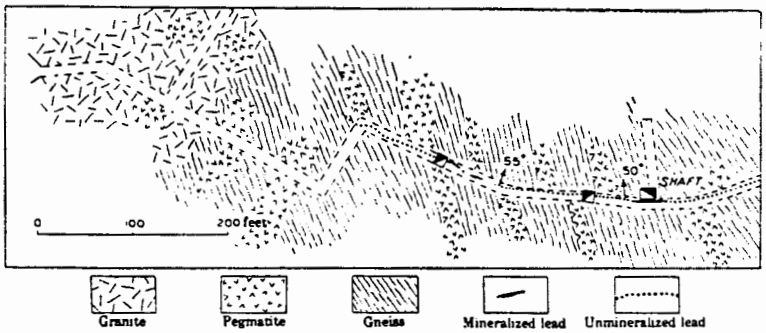


FIG. 102.—Geological plan of tunnel on Welch lode.

The country rock consists chiefly of soft micaceous gneiss with patches of pegmatite and granite. The strike of the gneiss is slightly to the west of north. In the tunnel (fig. 102) above mentioned the vein, which on the surface crosses the crest of Leavenworth Mountain ridge with a strike of S. 85° E., has a curved outline with the concave part of the curve facing north and the strike ranging from S. 62° E. to N. 70° E. It dips northward from 50° to 55° and consists of a clay and crushed rock lead which at certain points is replaced to some extent by quartz or by quartz and ore. Small stopes in the parts of the workings still open indicate that considerable ore was probably extracted from the mine.

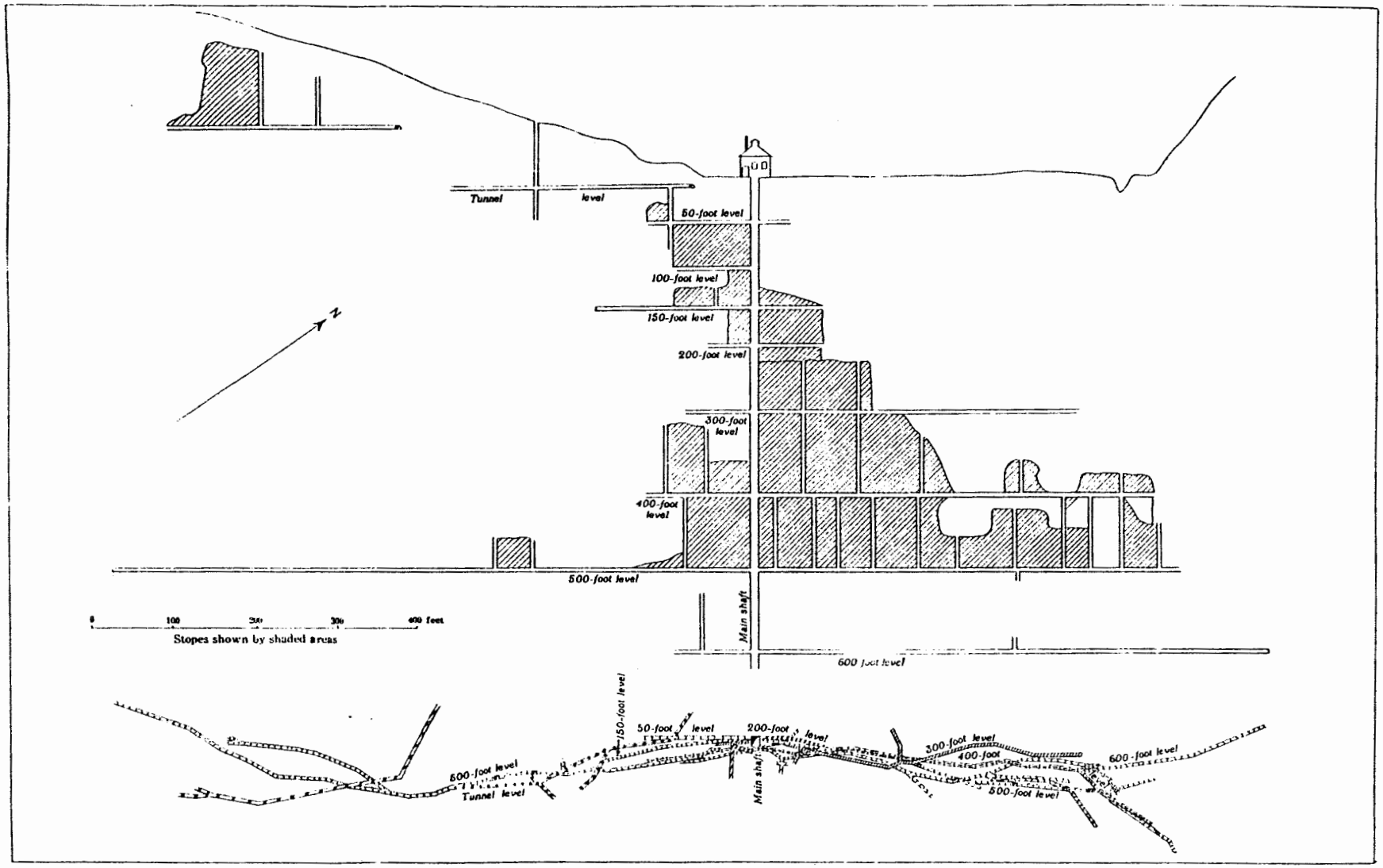
CENTENNIAL GROUP OF VEINS.

GENERAL DESCRIPTION.

The Centennial lode and its branches outcrop on the southern edge of the town of Georgetown and pass up over the northwestern shoulder of Leavenworth Mountain. The main or trunk vein, the Centennial, with a general strike of N. 40° E., passes on the northwest under the drift which here floors Clear Creek valley. Near the southwest end of the developed portion it gives off a number of branches, which strike S. 60° to 70° W. These branches are parallel and relatively close together, forming a zone a few hundred yards wide. The best known is the Burrel, on which, not far from its point of junction with the main Centennial vein, there is a shaft. Lying south of and parallel to the Burrel vein is the Big Indian vein, which appears to be a branch of the Burrel and to unite with it at the Burrel shaft. Another lode, lying not far north of the Burrel and parallel to it, joins the Centennial independently of the Burrel. The junctions either have not been encountered or are obscure in the accessible underground workings of the Centennial mine. All these veins are vertical or nearly so.

Taken all together, these lodes have been developed for a linear distance of more than half a mile. The main Centennial lode has been developed underground along a strike extent of upward of 1,400 feet.

The Centennial mine (Pl. XLIX) is reported to have produced ore to the value of $300,000. The Burrel is reported to have produced about $17,000, taken out mainly around the shaft, which is probably at the junction with the Big Indian vein and is not far from the junction of the Burrel with the Centennial.



VERTICAL AND HORIZONTAL PLANS OF CENTENNIAL MINE WORKINGS.

The Centennial vein is opened up by a shaft more than 600 feet deep, from which run various levels, as well as by some tunnels above the shaft. The Burrel vein was worked principally through a shaft. The Big Indian has a tunnel drift about 300 feet long on the vein.

ORIGIN OF VEIN.

Like the other veins of this region, the veins of the Centennial group have formed along a zone of fracturing and minor faulting. On the northeast end of the sixth level drift, striæ dip to the southwest at an angle of 32° from the horizontal, indicating the direction of differential movement. This fracture zone has been cemented by the vein materials. Little evidence of fissure filling appears. There is, however, much reason to suppose that the fracture zone may have been first decomposed and leached by waters, thus causing it to shrink and become porous, before mineralization. Where not mineralized the vein zone is still soft, but where it is mineralized it is cemented hard with quartz and sulphides.

STRUCTURE OF VEIN.

As seen on the 500-foot and 600-foot levels (Pl. L), the Centennial is a strong vein that branches and weakens at both ends. In the northeastern developed portion the branches open out to the northeast; in the southeastern portion to the southeast. The Centennial is opened up on these levels for about 1,300 feet. On the northeast end the branching and weakening of the vein takes place under the drift of Clear Creek, but on the southwest several of the branches, as above described, are visible on the surface and have been separately located and worked.

The plan of the fifth level (Pl. L) shows, near the southwest end of this level, a branching and reuniting of the vein, the two branches inclosing a horse of country rock. Similar features have been observed elsewhere in the district, as in the Dunderberg and Brown mines (figs. 84 and 81).

NATURE OF WALL ROCKS.

The country rock of the Centennial vein is chiefly black biotitic gneiss, generally massive, with some pegmatite. There is also a little porphyritic granite. The same gneiss also forms the principal wall rock of the Burrel vein and the other branches of the system which are parallel to it. The southwestern extensions of these branches, however, run into a mass of porphyritic granite. The wall rock of the Big Chief tunnel is entirely granite.

COMPOSITION OF VEINS.

The chief gangue of the Centennial vein is quartz, which is relatively abundant. Here and there the vein is made up mainly of quartz and carries very little sulphides. The principal metallic minerals are pyrite, cupriferous pyrite, chalcopyrite, and tetrahedrite. A little galena and blende occur, but not in sufficient quantities to yield more than traces of lead and zinc in large shipments of ore. The values in the ore consist of gold, silver, and copper, the silver content in the ore produced ranging from 20 to 30 ounces, the gold from 1 to 1½ ounces, and the copper from 4 to 8 per cent. The average value of the ore taken out between the 300-foot and 500-foot levels is stated at $18.60, of which about three-fourths was derived from the gold. The presence of gold in the ore seems to be dependent on that of copper. It is reported that where copper pyrite is present in the ore gold occurs in it and in the iron pyrite, but that where there is no copper in the pyrites they are poor in gold or barren. Some small portions of the ore run very high in gold, one assay of 522 ounces being reported from the 500-foot level. On the 600-foot level a small patch of tetrahedrite is said to carry $3 to the ton in platinum and iridium.

Occasionally druses lined with siderite are found. The Big Chief lode, which is probably a branch of the Centennial, shows different ore from that of the main vein. Here blende and galena are prominent, and chalcopyrite and pyrite are also present. Silver, gold, and copper are

although probably the best and most abundant ore occurred near the bottom of the shoot, at the 500-foot level.

Partial oxidation of the ore is reported to extend down 10 to 20 feet or more, but sulphides, chiefly pyrite, extend locally quite up to the surface. Typically there is about 10 feet or more of glacial drift covering the outcrop.

PRESENT WORK OF UNDERGROUND WATERS.

At present water is found dripping in all parts of the workings. This water contains sulphates of copper, as is shown by various occurrences. According to J. S. Randall, of Georgetown, crystallized hydrous cupric sulphate, chalcanthite, is found in the old workings of the Centennial mine. David Kennedy, owner and superintendent of the mine, reports that car rails in the mine get coated with metallic copper precipitated from the waters. The rust scale on the inside of a water pipe in the mine, assayed by Mr. Kennedy, yielded 11 per cent of copper. These facts show that the copper sulphides have been transformed into soluble sulphate by oxidation. Recognition of this fact indicates that a considerable enrichment in copper of some of the sulphides has been brought about by such waters as these, and the downward termination of the richer copper ores between the 500-foot and 600-foot levels suggests that this is the downward limit of the enriched ores, below which are the unaltered or only slightly altered pyritiferous ores. This suggestion, however, should be taken with some reservation. Although the influence of descending waters has probably been considerable in enriching the ore in the ore shoot, yet the irregularity of these ore bodies as shown in all the veins of the district is such as not to exclude the possibility that the ore shoot may have been in part original and formed previous to the enrichment.

MINES OF GRIFFITH AND SAXON MOUNTAINS.

COMET-ÆTNA LODE.

The workings of the Comet and Ætna mines, which lie high up on the northwest slope of Griffith Mountain (Pl. LI, *B*), due east of the town of Georgetown, were undoubtedly driven in order to develop the same lode. At the time of visit, however, none of the workings of the Ætna were accessible owing to caving.

COMET MINE.

LOCATION, DEVELOPMENT, AND PRODUCTION.

The Comet vein, which was worked extensively even previous to 1871, is developed by three shafts located at an elevation of nearly 11,000 feet above sea level, at the point where the trail from Georgetown to Highland Park reaches the crest of the slope, and also by a tunnel on the west side of Griffith Mountain about 450 feet lower down. This lower tunnel follows the J. A. Hawkes vein (a crushed rock and clay lead dipping 55° to 65° NW. and trending N. 52° E.) for about 500 feet to the point where it connects with a crosscut drift driven S. 65° E. to its intersection with the Comet lode, which lies parallel to the J. A. Hawkes vein and about 600 feet distant.

Not even a rough estimate of the production from the Comet vein was obtainable, but undoubtedly a great deal of ore was taken from the old shafts near the crest of the slope in the early days of mining about Georgetown. It is said that $60,000 was taken from a shoot of ore that was found a short distance above a level run from one of the shafts at a point 275 feet above the tunnel level.

NATURE OF WALL ROCKS.

The wall rocks consist of much altered pegmatite, granite, and gneiss, the last both granitic and micaceous. In the tunnel level the walls of the J. A. Hawkes vein consist chiefly of fairly hard altered granitic gneiss, with irregular patches of pegmatite interspersed throughout. Where distinguishable the strike of the gneiss is about N. 80° W. and the dip 45° N. In the crosscut to the Comet lode (Pl. LII) the first third of the distance was also through gneiss and pegmatite,

but in places these rocks are soft, from alteration, and are cut by small dikes of the variety of porphyritic granite locally termed "corn rock." The southeast portion of the crosscut is composed chiefly of granite cut by narrow masses of pegmatite and "corn rock." In the vicinity of the Comet lode itself and for a distance of 100 to 200 feet to the northwest of it the country rock is mostly a mixture of pegmatite and gneiss with small amounts of granite and "corn rock." In this belt, however, the alteration has been so intense that in many places it is difficult to distinguish one rock from the other.

Two veinlets of gray jasper-like or chalcedonic quartz intersect the crosscut from the J. A. Hawkes vein and run parallel to the Comet vein. This jasper-like quartz resembles porphyry in both texture and color, and also because of the presence of scattered small whitish rectangular specks that resemble altered feldspar phenocrysts embedded in a fine-grained groundmass. Under the microscope, however, a specimen of this rock exhibits a microgranular texture and appears to be composed chiefly of chalcedony, although a few small streaks cutting through the finer-grained matrix are composed essentially of minute angular fragments of quartz crystals, sericite and talc, and rarely shreds of muscovite and leached biotite. A couple of minute grains of zircon were also noted in one slide. These quartz veinlets contained no ore, although the microscope showed a little pyrite and magnetite. This rock is probably a finely crushed and highly silicified gneiss. No undoubted porphyry was found in the workings.

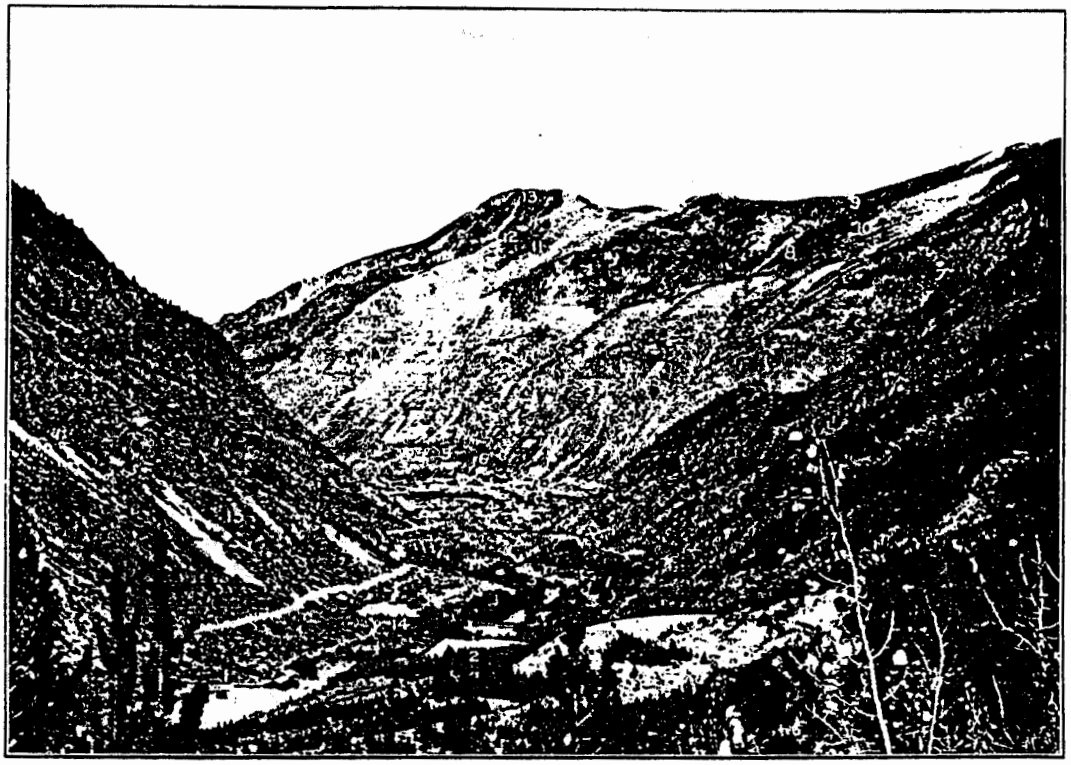
Small stringers of somewhat similar hard dark-gray jasper-like quartz occur reticulated through the whole belt of softened country rock for a distance of 100 to 200 feet northwest of the main vein, and led to the prevalent idea that the vein here was nearly 200 feet wide. However, the most of this quartz contained no values whatever, although in the vicinity of the Comet vein proper a little mineral occurred in stringers or in small isolated bunches of a quartz of similar appearance, but this probably represented simply a replacement of kaolin or gouge by silica along small slip zones.

NATURE OF VEIN.

The Comet-Ætna vein, which is a strong fracture with 5 to 8 feet of quartz and clayey materials, is isolated from the rest of the veins of the district. The nearest ore-bearing veins are separated from it by 3,000 to 5,000 feet of unexplored or unproved ground. Many people hold that the Comet-Ætna lode is an extension of the Colorado Central vein and this correlation is not without some foundation, for both of the lodes are very strong fractures which have the same general dip and strike. The dip of about 70° NW. could easily account for the northwestward swerving of the surface outcrops of the Comet and Colorado Central lodes as they cross the bottom of the valley of Leavenworth Creek. However, as there is fully a mile of territory between the two recognized ends of the veins, no definite statement to the effect that the two veins are the same can be made. It is possible that the Comet vein represents only one of several branches of the Colorado Central main trunk vein or that the two may be distinct veins which die out by branching as they approach one another.

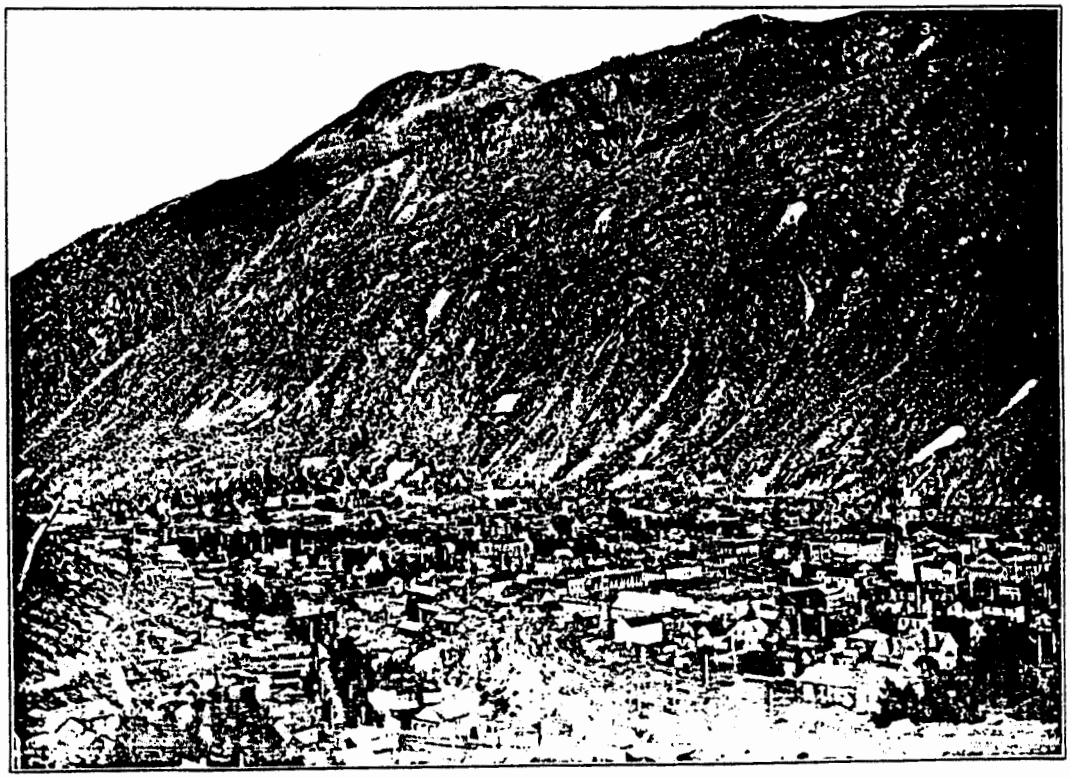
The Comet lode is very soft, and it is difficult to keep drifts open along it for any length of time. Consequently at the time of visit but little of the vein was exposed for study, as a result of the caving that had taken place during many years of comparative inactivity. From all appearances, however, the lode appears to be a single nonbranching one following two or more parallel planes of movement situated within a few feet of one another. It was not determined to what extent displacement had occurred along the fault planes, but discordances in the wall rocks on the two sides of the fractures were noted. That extensive movements have occurred is well shown not only by polished and slickensided surfaces, but by zones of crushed and pulverized wall rock, by banded friction clays, and by quartzose streaks which consist of well-rounded sandlike grains cemented together by a quartz matrix.

Considerable fracturing of the country rock probably accompanied the faulting which caused the vein fracture, as shown by the zone 100 to 200 feet wide which contains numerous quartz stringers. More or less sheeting of the wall rocks parallel to the main vein has taken place, as can be seen from the number of minor gouge leads occurring between and parallel



A. VIEW OF GEORGETOWN, LOOKING NORTHEAST FROM CEMETERY HILL, NEAR SILVER PLUME.

Lebanon group of mines in left foreground; Griffith Mountain and Saxon Mountain mines in background. 1, Lebanon tunnel; 2, Hall tunnel; 3, Georgetown loop; 4, Georgetown; 5, Annette-Griffith tunnel; 6, Capitol mine; 7, Ætna mine; 8, Comet tunnel; 9, Comet shafts; 10, Ruler tunnel; 11, Magnet mine; 12, Woodley mine; 13, Summit mine; 14, Iris tunnel; 15, Lebanon group of mines



B. GRIFFITH AND SAXON MOUNTAINS AND MINES EAST OF GEORGETOWN, FROM MOUTH OF CLEAR CREEK CANYON.

1, Annette-Griffith tunnel; 2, Capitol mine; 3, Comet tunnel; 4, Saxon Mountain.

to both the Comet and J. A. Hawkes veins. Two well-defined open fractures or "water breaks" also occur within this same space. One of these is an open fissure, in places nearly a foot wide, which furnishes a considerable flow of water and whose walls are heavily coated with the soft red and brown oxides of iron.

About 50 to 100 feet northwest of the Comet lode as exposed on the tunnel level is a connected series of leads with different strikes, forming a fairly persistent but irregular lead composed of 2 to 8 inches of crushed rock and gouge which in places grades into quartz or into quartz and ore sufficient in amount to have caused the miners to gouge up on the streak here and there and to put up a raise about 60 feet high in one place near the point where a small branch joins the Stranger lead.

STRUCTURE OF VEIN.

The vein where exposed on a level, connecting with one of the shafts at the crest of the mountain slope and located about 275 feet above the tunnel level, is extremely variable in width. One section of the vein (fig. 103) shows the foot wall, dipping 70° NW., to be somewhat altered granite. Resting upon this foot wall and separated from it by a narrow selvage is from 5 to 6 feet of very highly altered micaceous gneiss; above this is about 1 foot of yellow, brown, green, and blue fine-grained clay in alternating bands. This clay, which is very tough and putty-like, probably represents gneiss, pegmatite, and granite finely pulverized by extensive movements

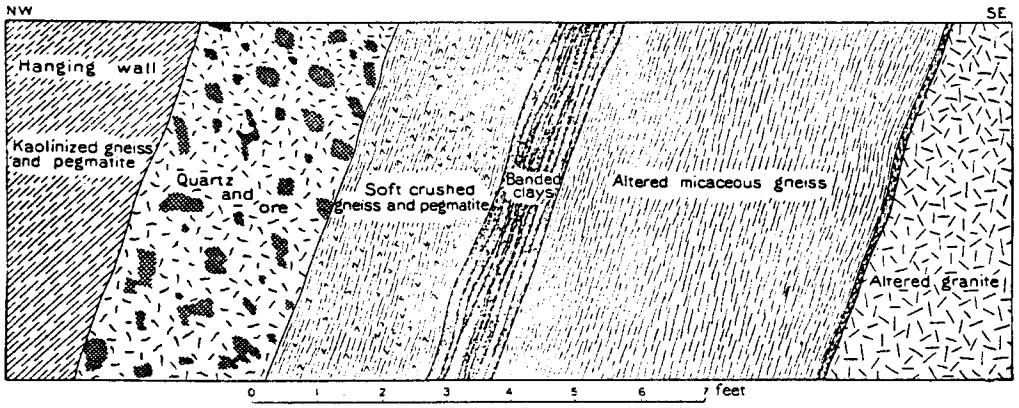
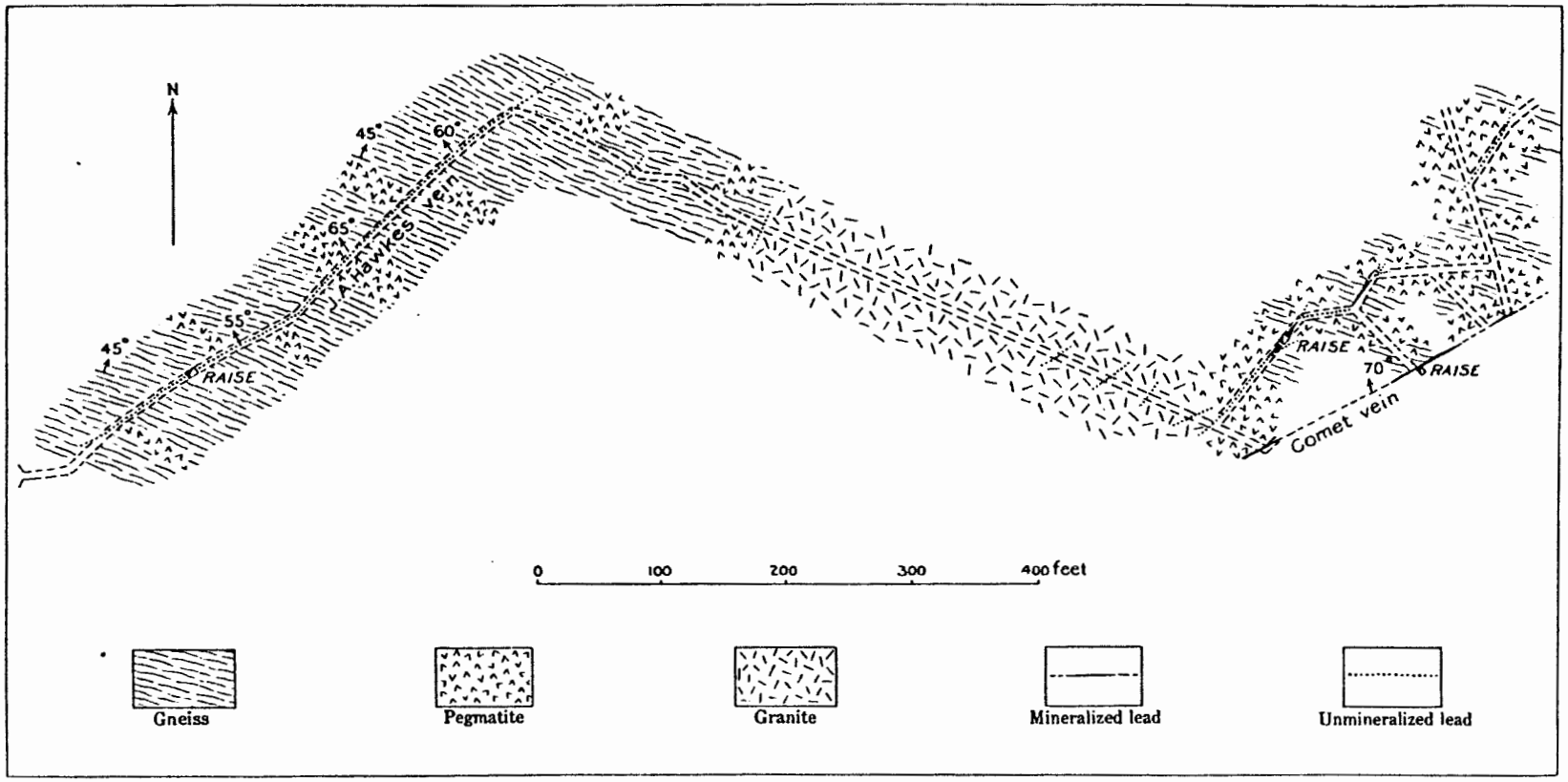


FIG. 103.—Cross section of Comet vein on level 270 feet above Comet tunnel level, showing the structure of the vein zone.

lengthwise of the vein or fault. Embedded in this clay are scattered fragments of pegmatite or granite with their long axes oriented parallel to the clay seams in such a manner as to give the clay belt the appearance of the banded flow structure commonly seen in contact phases of porphyry dikes.

Above and northwest of the alternating variegated clay bands are from 2 to 3 feet of soft, crushed, altered gneiss and pegmatite containing a considerable amount of kaolin or "gouge." Still farther northwest 2 to 4 feet of low-grade ore was noted. This ore zone consists mainly of quartz, which in places either partially or entirely fills cracks in highly fractured gneiss and pegmatite or else coats the fragments of gneiss and pegmatite with a layer of dark-gray jaspery quartz one-eighth to one-fourth inch thick, closely resembling the widely separated veinlets of jaspery or chalcedonic quartz that traverse the belt of altered country rock for 100 to 200 feet to the northwest of the Comet vein.

This dark-gray vein quartz is practically massive, with here and there a small pegmatite or gneiss inclusion that is not so much altered and replaced as to make it impossible to recognize the original rock, although it is highly silicified and its irregular boundaries grade into the mass of jaspery quartz gangue. The ore in this silicified zone occurs mainly in narrow vuglike openings in the partially filled cracks in the fractured gneiss and pegmatite, but also lining irregular-shaped cavities, many of which show crustification but no comb quartz, and which are probably cavities of dissolution resulting from the action of the mineralizing waters. Small bunches of ore are also found sparsely disseminated through the quartz mass.



GEOLOGICAL PLANS OF COMET TUNNEL AND ANGLO-SAXON EXTENSION LOWEST TUNNEL.

The northwest or hanging wall, in contact with the quartz and ore belt, consists of a zone of kaolinized and somewhat silicified gneiss and pegmatite 100 to 200 feet wide. The structure of the vein, however, is not constant; for near the shaft, on the level where the above-mentioned section was observed, the ore streak changes to a belt over 10 feet wide of fractured and in places brecciated pegmatite and gneiss, recemented by dark-gray jasper-like quartz which carries practically no ore. Between this broad zone and the putty-like banded clay strip is 6 to 8 inches of rock which appears to be a greenish-gray porphyry, but which on microscopic examination proves to have a groundmass ranging from cryptocrystalline to a fine-grained aggregate of crushed quartz grains with irregular outlines and wavy or undulose extinction. In this groundmass are embedded larger rounded grains of quartz that in the hand specimen look like phenocrysts. This same rock section, moreover, shows that small cracks and rectangular open cavities formerly existed, and that subsequently these were first lined with a coating of carbonates and then the remaining space was filled with kaolin. In some of the stringers filling the cracks, the carbonates, especially where they completely filled the minute veinlets, were associated with small amounts of the contemporaneous ore-bearing minerals, pyrite, zinc blende, and galena, the last appearing to be of slightly more recent origin than the pyrite.

ORE.

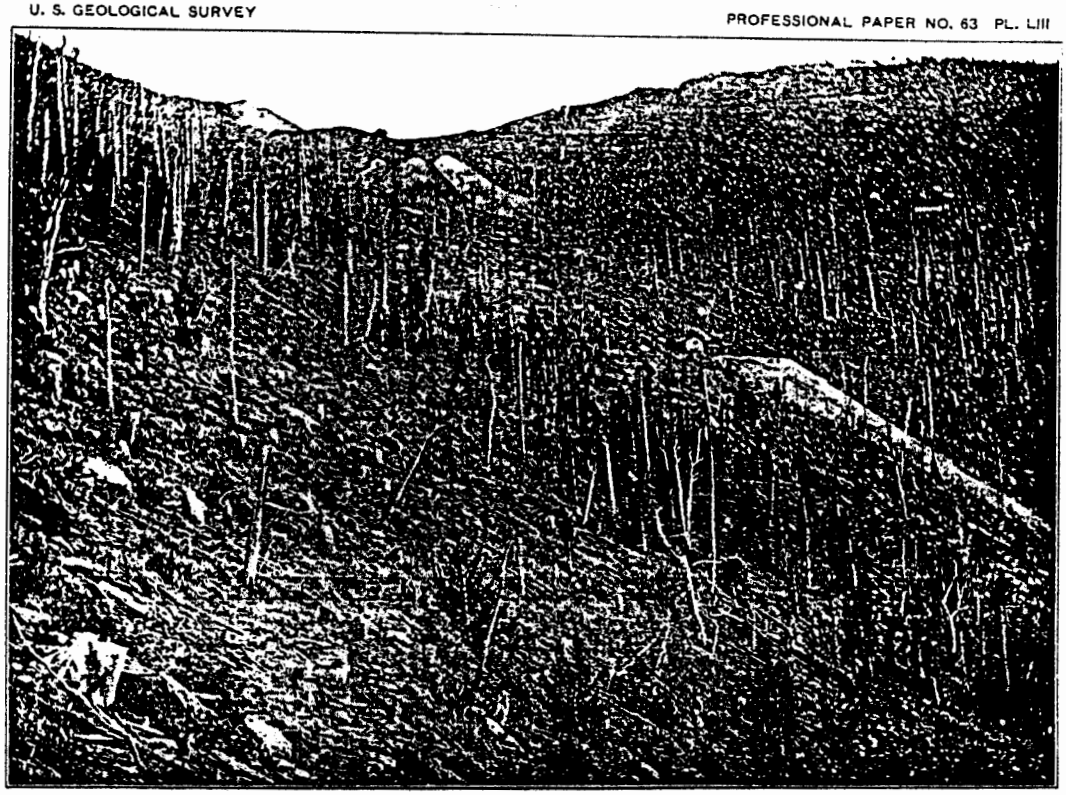
The ore noted consisted mainly of well-formed crystals of galena, zinc blende, and a little cupriferous pyrite associated with some siderite or ankerite. This ore occurred generally lining narrow slitlike vugs along fractures or in irregularly shaped dissolution cavities lined with drusy, jasper-like, dark-gray quartz. Some of the blende was of a resinous nature and ranged in color from a light yellow or greenish yellow to a dark brown; other varieties were black and had a dark metallic luster. The ore exposed at the time of visit was of low grade owing to the predominance of the quartz gangue, but a large northeastward-pitching shoot of high-grade ore is said to have been stoped out at a point about 60 feet higher. The ore near the surface was also much richer.

The siderite and ankerite where present have the nature of porous coats on drusy quartz. In places a white earthy substance is found incrusting the crystals of galena and blende in vugs. A chemical analysis by W. T. Schaller shows this to be chiefly an alumina-bearing mineral resembling kaolinite, which contains some zinc but no carbonates. The zinc is probably in the form of a sulphide and the white substance may be either a physical mixture of finely powdered blende with the kaolinite, or kaolinite containing a small amount of the soft white amorphous form of zinc sulphide described by Dana.[a]

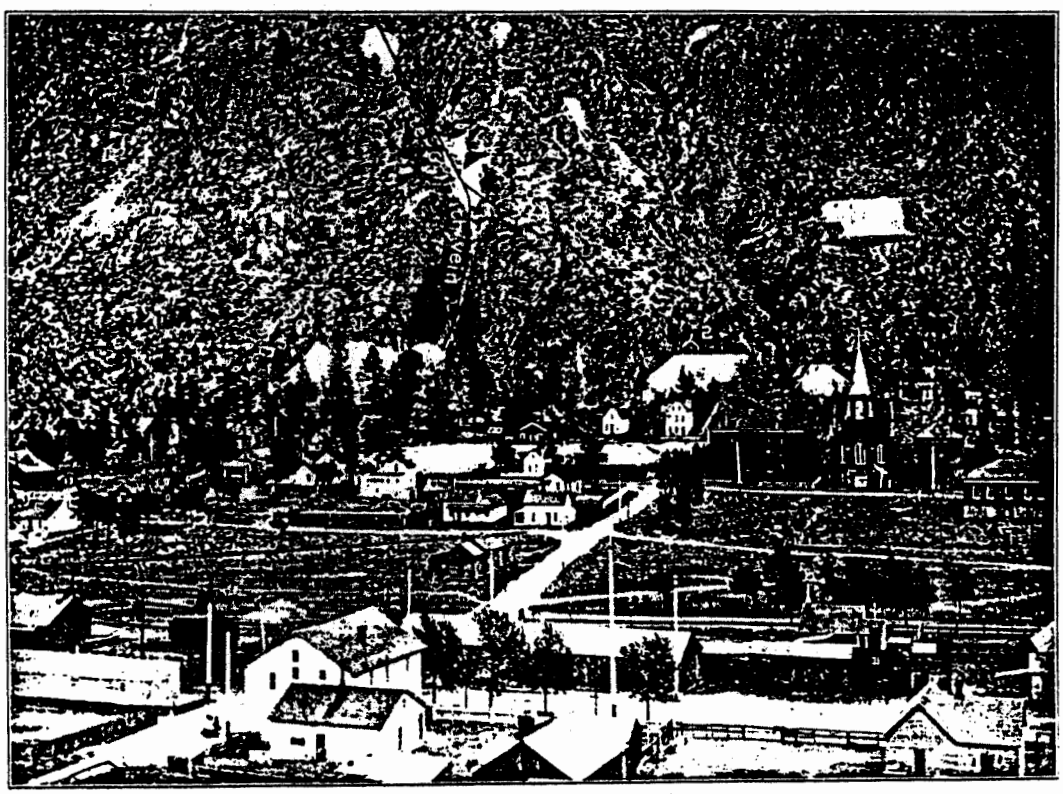
ÆTNA MINE.

The Ætna mine, which is situated high up on the west slope of Griffith Mountain, was first located in 1867. The vein is undoubtedly the southwestern extension of the Comet lode, for it has been opened up by three short tunnels, one above another, run into the hillside and extending almost to the limits of the Comet property. At the time of visit all these tunnels were caved shut. At present, however, a tunnel, now 1,900 feet in length, is being run by the Capital Mining and Tunnel Company from a point in the valley just east of Georgetown and south of the Griffith mine, with the purpose of intersecting the Comet-Ætna vein at a depth of about 1,500 feet below the proved surface outcrops. It has been estimated by the owners that this tunnel will cut the vein at a point about 2,600 feet from the mouth. The vein is broad and soft and is said to resemble the Comet lode in every respect. Small shipments of ore that have been made from the mine have carried between 35 and 300 ounces of silver to the ton, but it is said that assays as high as 1,600 ounces in silver have been obtained from picked specimens. The ore consists chiefly of galena and zinc blende, with a small quantity of iron sulphide carrying considerable copper. A specimen of vein material picked up on one of the mine dumps showed specks of galena, greenish-yellow resin blende, and pyrite sparsely scattered through a ground-

[a] Text-book of mineralogy, p. 291.



A. MAGNET MINE, ON SAXON MOUNTAIN, LOOKING SOUTHEAST.



B. ANNETTE-GRIFFITH VEIN AND MINE OPENINGS, LOOKING EAST FROM SLOPE OF REPUBLICAN MOUNTAIN.

1, Annette-Griffith tunnel. 2, Capitol mine.

mass of finely crushed granite and gneiss containing a few larger fragments of pegmatitic milky quartz and vein quartz, the whole recemented by silica. This well-indurated vein material, which closely resembles a solid igneous rock, is very similar in nature to the portion of the Comet lode which resembles porphyry.

SPORTING TIMES MINE.

The Sporting Times mine is located at an elevation of about 9,900 feet on Alpine Mountain, three-fourths of a mile south-southwest of Georgetown. It is developed by two tunnels. The lower one, which is the only one accessible at present, is driven on the vein and is about 850 feet in length. The wall rocks consist almost entirely of micaceous gneiss cut by intrusive pegmatite and granite. At a point about 600 feet from the mouth of the lower tunnel, however, porphyry forms the south wall of the vein for a distance of 50 feet, and a patch of porphyry about 15 feet in length also occurs on the north side. This porphyry mass was too much altered to allow its variety to be determined. The vein (fig. 104) consists of a soft clay, quartz, and pyrite lead, which here and there gives place to quartz, and of sphalerite and galena ore. The

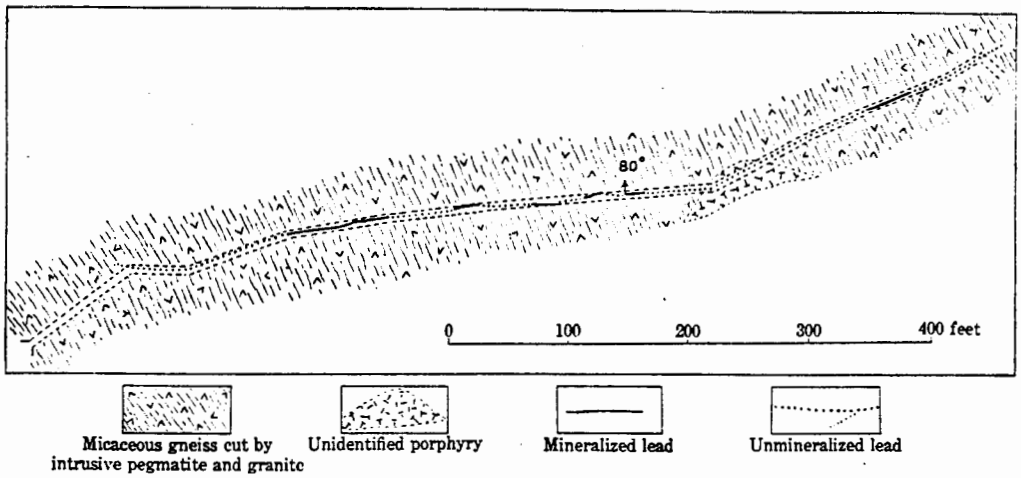


FIG. 104.—Geological plan of Sporting Times lower tunnel.

ore in places is comprised of breccia fragments of galena and sphalerite embedded in a matrix of pyritiferous quartz or silicified crushed rock. No stopes occur on the lower level, but small quantities of ore are said to have been produced by the upper workings.

MAGNET LODE.

LOCATION AND DEVELOPMENT.

The Magnet mine (Pls. LIII, *A*; LIV), which produced small lots of rich ore prior to 1871, is situated near the head of the steep gulch extending from the valley of Clear Creek to the draw between Saxon Mountain and Woodchuck Peak. The development consists of a comparatively shallow shaft located at an elevation of over 11,000 feet and a series of five tunnels in the gulch to the west, the lowest one of which is more than 500 feet below the collar of the shaft. The tunnels and drifts aggregate over 6,000 feet in length, and although the mine has not been very actively worked for a number of years, yet most of these workings are still open.

NATURE OF WALL ROCKS.

In the vicinity of the principal ore bodies the walls of the vein are comprised chiefly of porphyritic biotite granite. On following the main vein to the northeast, however, a mixture of pegmatite and granitic gneiss is encountered, and still farther northeast soft biotite gneiss with a few small patches of pegmatite. Gneiss also forms the walls of a clay and crushed rock lead,

followed by tunnel No. 4 for the first 300 feet. The schistosity of the gneiss is variable but as a rule has a strike ranging from northeast to nearly due east. Granite forms the southern half of the long crosscut to the south near the breast of tunnel No. 4.

The wall rocks near the vein are in many places much altered, the gneiss becoming locally soft and kaolinized and the granite changing to a decomposed or friable mass. No porphyry dikes are found in the present workings.

NATURE OF VEINS.

The main vein follows a strong line of movement, marked usually by a single fault line or narrow fractured zone from which a few minor fractures branch. The vein, where unmineralized, is a strong clay, crushed rock, and quartz lead where it passes through granite, pegmatite, or granitic gneiss; but on entering soft biotitic gneiss, as it does toward the northeast, it changes to a much narrower clay and crushed gneiss lead which tends not only to be deflected from its normal trend but to grow less marked and to branch into a series of slips, owing to the fact that the movement was probably taken up in part along the schistosity planes. Besides the evidence of movement furnished by gouge and crushed rock, there are also well-developed movement striæ, which range in dip from 30° to 63° SW. The Magnet vein varies greatly from point to point both in strike and dip, and this characteristic has caused considerable annoyance in exploration, especially on the lower levels (Pl. LV). In the southwest or principal ore-bearing portion of the workings, the vein ranges in strike from N. 45° E. on tunnel No. 1 level to N. 72° E. on tunnel No. 3 level. The strike in the soft gneiss on these levels was N. 77° E. and N. 55° E., respectively. On the main vein the dip was also flatter as a rule in the southwestern ore-bearing portion than at the northeast end. In the southwestern section the dip was about 45° to 55° NW.; at the northeast end it ranged from 60° to 75° in the same direction.

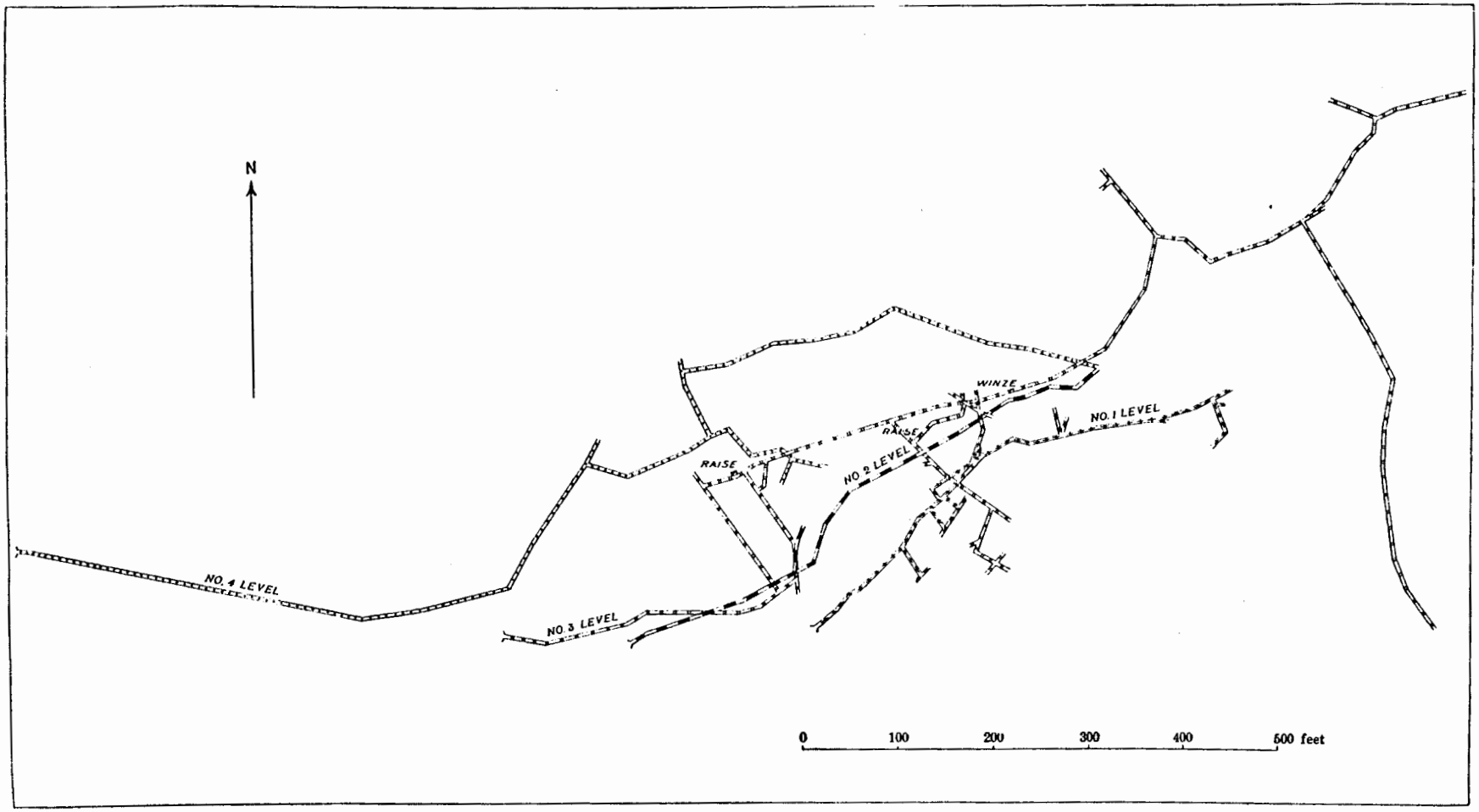
Where mineralized, the vein may consist of a single seam of solid ore, but more commonly it is a stringer lode in granite or other hard rock, or consists of a fractured zone in which most of the rock fragments have been extremely altered and many of them wholly or partly dissolved away and their place taken by quartz or by gangue minerals and ore. However, evidences of the extensive solvent action of the underground waters is still seen in the porous nature of the vein filling and in the numerous irregular openings, which have every appearance of being cavities of dissolution.

In a number of places where the vein has only one wall the mineral-bearing solutions have penetrated for some distance into the country rock on either side of the fracture, and impregnated it with ore minerals in sufficient quantities to make the extraction of the whole mass for a width of several feet pay well. Locally, however, where the vein is broad, the proportion of quartz in the vein filling is so great that, even though polybasite and tetrahedrite are found associated with the galena and blende present, the latter are in such minor quantities that the whole mass yields small values on mining.

About 250 feet from the mouth of tunnel No. 1 two well-mineralized veins converge toward the east and join the Magnet vein, the one northwest of the main vein coming from the S. 57° W. and the other branch from the S. 28° W. These branches, which are rather obscure right at the junction with the main vein, are heavily mineralized a few feet away, but within a short distance diminish in size again as they recede from the main vein.

The Sequel vein is a somewhat parallel vein, also dipping to the northwest, which trends slightly toward the Magnet vein and is thought by some of the miners to make a union with it; but no evidence of such a junction was noted. Several minor, slightly mineralized veins were also observed trending at high angles to the course of the main vein. However, these were rather isolated fractures whose relations to the main vein were indeterminable and which were not recognized on more than a single level.

An unmineralized fault line called the De Meli lode cuts across the Magnet vein on tunnels Nos. 1, 2, and 3. It is a strong barren clay and gouge lead 6 inches to 1½ feet wide which



HORIZONTAL PLAN OF MAGNET MINE WORKINGS.

trends N. 58° W. It intersects the Magnet vein on tunnel No. 1 about 300 feet north from the mouth, but is found 50 feet or so farther northeast on No. 2 level, owing to its dip of 55° NE. On tunnel level No. 3 its dip changes to 70° NE.

COMPOSITION OF VEINS.

The gangue material is chiefly quartz, but barite is also common. Carbonates are sparingly present. The quartz is mainly of the dark-gray chalcedonic variety. The barite is most prevalent as well-formed crystals in vugs, but also occurs massive, interspersed through the quartz and metallic minerals.

The metallic minerals consist as a rule of galena, blende, polybasite, tetrahedrite, and some cupriferous pyrite or chalcopyrite.

The ore is relatively high in both silver values and in the percentage of zinc. The amount of zinc present is commonly about twice as great as that of the lead. The zinc, which occurs chiefly as greenish-yellow blende but in part as the brown variety, is in places so abundant as to detract from the value of the ore. The amount of silver as a rule is greater the less the quantity of zinc present in the ore. However, small shipments have been made of ore averaging 400 to 500 ounces of silver per ton in which the zinc content ranged from 15 to 20 per cent. The reason for this is that the main silver values probably lie in the polybasite and tetrahedrite, which are very common in all the best ores of the mine. These two argentiferous minerals occur in the massive form, associated with irregular masses of galena, sphalerite, and chalcedonic quartz, or as rough crusts and poorly formed crystals lining irregular-shaped openings which are probably mainly cavities of dissolution.

The pyrite and chalcopyrite where present are generally associated with the tetrahedrite, polybasite, and chalcedonic quartz.

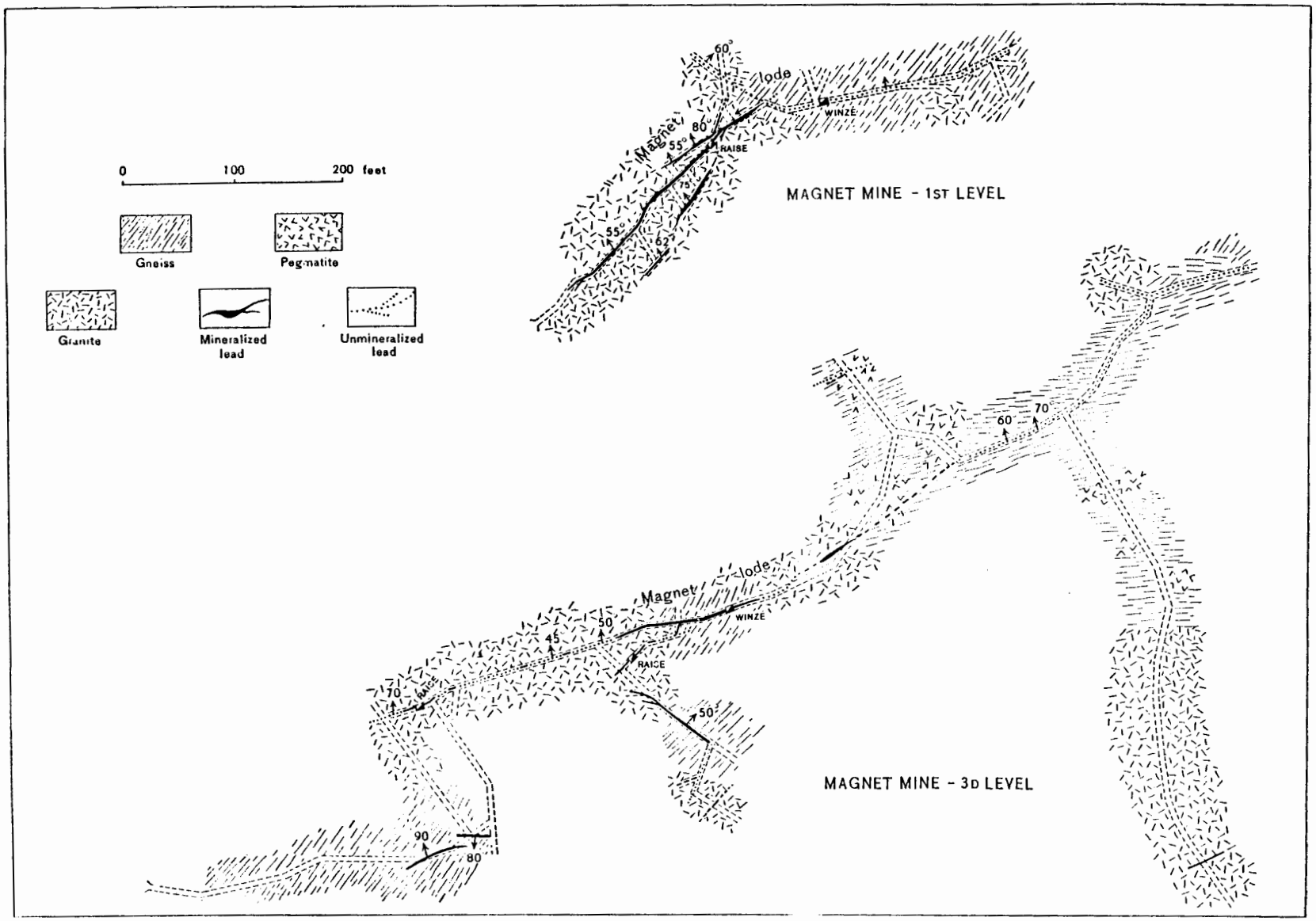
About 0.05 ounce of gold is usually present. Near the surface considerable soft oxidized ore carrying some copper carbonates was found, and this soft ore was also in many places associated with the soft pulverulent black sulphides rich in silver which are common near the surface in many other parts of the district. Assays from different parts of the vein range from 35 to 600 or 700 ounces of silver to the ton. Some of the small stringers on the Sequel vein gave assays as high as 1,400 ounces in silver. The average ore shipped, however, carries from 150 to 300 ounces of silver to the ton.

OCCURRENCE OF ORE.

On tunnel No. 1 level ore was encountered about 50 feet from the mouth of the tunnel and extended continuously for nearly 250 feet, to a point within 10 or 15 feet of the barren De Meli cross lode. Near its east end the vein is joined on both sides by short but strong branch veins, which diverge to the southwest and contain small but well-developed ore shoots. The southern of these branches is probably represented on the level below by a similarly located vein carrying small streaks of ore. The main ore shoot on No. 1 level pitches about 60° E., and was stoped from the surface continuously to tunnel level No. 3, on which ore also commenced 10 or 15 feet southwest of the De Meli lode, but extended for only about 125 feet. The values in this ore shoot, which was the largest in the mine, however, do not seem to go much below level No. 3, a depth of 235 feet below the surface. An ore shoot due to the junction of minor leads also occurs to the northeast of the De Meli lode, and starts in about 10 feet from the cross lode. This ore body, which was only about 40 feet in length, also pitched eastward and extended between levels No. 2 and No. 3 and for 12 to 15 feet below No. 3. At the time of the visit a crosscut drift to the south was being run toward the vein at this point from a winze sunk to a depth of 65 feet below No. 3 level. A small ore body was also found on No. 3 level on the N. 55° W. vein in the drift located to the southwest of the large ore body west of the De Meli lode.

The Sequel vein carries but few small stringers, and these are composed of very rich ore.

All the main ore bodies seem to be confined to the areas of comparatively hard rocks such as granite, pegmatite, and granite gneiss, rather than to the areas of soft biotite gneiss. The reason for this probably lies in the fact that the rocks first named, being harder and more



GEOLOGICAL PLANS OF SEPARATE LEVELS, MAGNET MINE.

brittle, under movement would result in more open fractures than the soft biotite gneiss, and so the mineralizing solutions would have a better chance to operate. Vein junctions, although in some cases obscure at the immediate point of union, also probably have a beneficial influence on the ore deposition; and a flattening of the dip of the veins appears to have further influenced the precipitation.

PRODUCTION.

The Magnet vein produced small quantities of ore as early as 1871, and according to Fossett[a] had yielded $50,000 up to 1875. According to some of the old lessees on the property, $70,000 worth of ore was taken from the large stope to the southwest of the De Meli lode, and about $50,000 was obtained from the ore body to the northeast of the same lode. A few sacks of very rich ore were also yielded by the Sequel vein.

GRIFFITH LODE.

GENERAL DESCRIPTION.

The Griffith is a straight and strong lode, at present operated principally by two mines, the Griffith and the Annette, the former exploiting the southwestern portion, near the town of Georgetown, and the latter the northeastern portion, farther into Griffith Mountain (Pls. LIII, *B;* LVI). The vein has in general a strike of N. 50° E. and a vertical dip. In the longest level, the Annette No. 1, the lode is developed for 1,900 feet in a straight line. The older levels, which are higher up on Griffith Mountain, are mostly worked out and are now usually inaccessible. The main levels run into the mountain but little above the level of Clear Creek. The Griffith lode has the same general strike and dip as the Centennial, and the two lodes have certain features in common, together with very sharp differences.

NATURE OF VEIN.

The Griffith lode has formed along a fracture zone, of which some parts are unmineralized, some are slightly altered, with vein and gangue material in thin seams, and others have been mineralized so as to form wide and important ore deposits. The vein shows the usual phenomena of branching, and on the Annette No. 1 level it forks and reunites—a condition which was also observed in the Centennial (Pl. L). The east end of the Griffith lode, as developed underground in the Annette No. 1 level, shows only a weak mineralized slip which at the breast of the tunnel lies in soft gneiss and is barely perceptible. This suggests that the actual end of the lode is very near.

Some of the phenomena of branching at least are probably due, as will be explained, to two distinct periods of vein formation, the veins of the second period being superimposed upon those of the first. The crossing of the main lode by a minor vein zone near the northeast end of the Annette No. 1 level is an unusual occurrence in lodes of this district, and is due in this case to the two periods of vein opening.

Near the southwest end of the developed lode a branch diverges from the south side, opening out to the east. This is called the Sonora vein, and has a southeast strike and a dip of 70° NE. On the surface some high-grade ore carrying from 700 to 800 ounces in silver is said to have been taken from this vein; but where it joins the main Griffith lode, as seen in the Griffith No. 1 level, the vein contains only a small streak of pyrite and has not produced any pay ore.

NATURE OF WALL ROCK.

The wall rocks include gneiss of several varieties, pegmatite, alaskite, and some hornblendite. Usually these rocks are all well mingled, though in some places gneiss and in others pegmatite and alaskite are predominant.

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[a] Fossett, Frank, Colorado, 1880, p. 316.

INFLUENCE OF WALL ROCK.

A mixture of gneiss with alaskite and pegmatite has resulted in a rigid rock that has fractured well and formed a good medium for the slips along which the vein has formed. Locally, where soft gneiss predominates, as in the outer or southwestern part of the Griffith No. 1 level, the vein becomes weak or pinches out almost entirely and is unmineralized. Where the vein fracture passes into granite, on both sides of the gneiss, the vein immediately becomes strong again.

COMPOSITION OF VEIN.

The character of the ores in different parts of the vein is very different, largely on account of the two distinct periods of ore deposition. To take all parts of the vein together, it may be stated that the vein materials include considerable pure galena, some blende, pyrite, and chalcopyrite, with brown carbonates, including siderite, rhodochrosite, and magnesite, as the chief gangue minerals. Pure kaolin occurs in the vein at many places and is locally abundant. It is evidently a chemical precipitation, as was determined to be the case in the Colorado Central mine. A peculiar feature of this mine, not determined in other mines of the district, is the presence of gold and silver telluride. This mineral has been described by Richard Pearce,[a] who notes that C. A. Martine, of Georgetown, discovered the presence of tellurium in the mineral and sent it to him for investigation. Doctor Pearce found that the mineral occurred in small quantities, associated with pyrite, galenite, and chalcopyrite, in a matrix containing a little magnesite.

The color is dark gray, with a bright metallic luster; hardness about 3. An analysis was made by Mr. F. C. Knight on carefully selected material, but, owing to its intimate association with the minerals named above, it was impossible to obtain the mineral in a pure form. The result of the analysis is as follows:

Ag	50.65
Te	18.80
Pb	9.34
Cu	4.65
Fe	4.00
Bi	1.16
S	8.06
$MgCO_3$	1.95
Alloy of Au and Ag	.48
Insoluble residue	1.07
	100.16

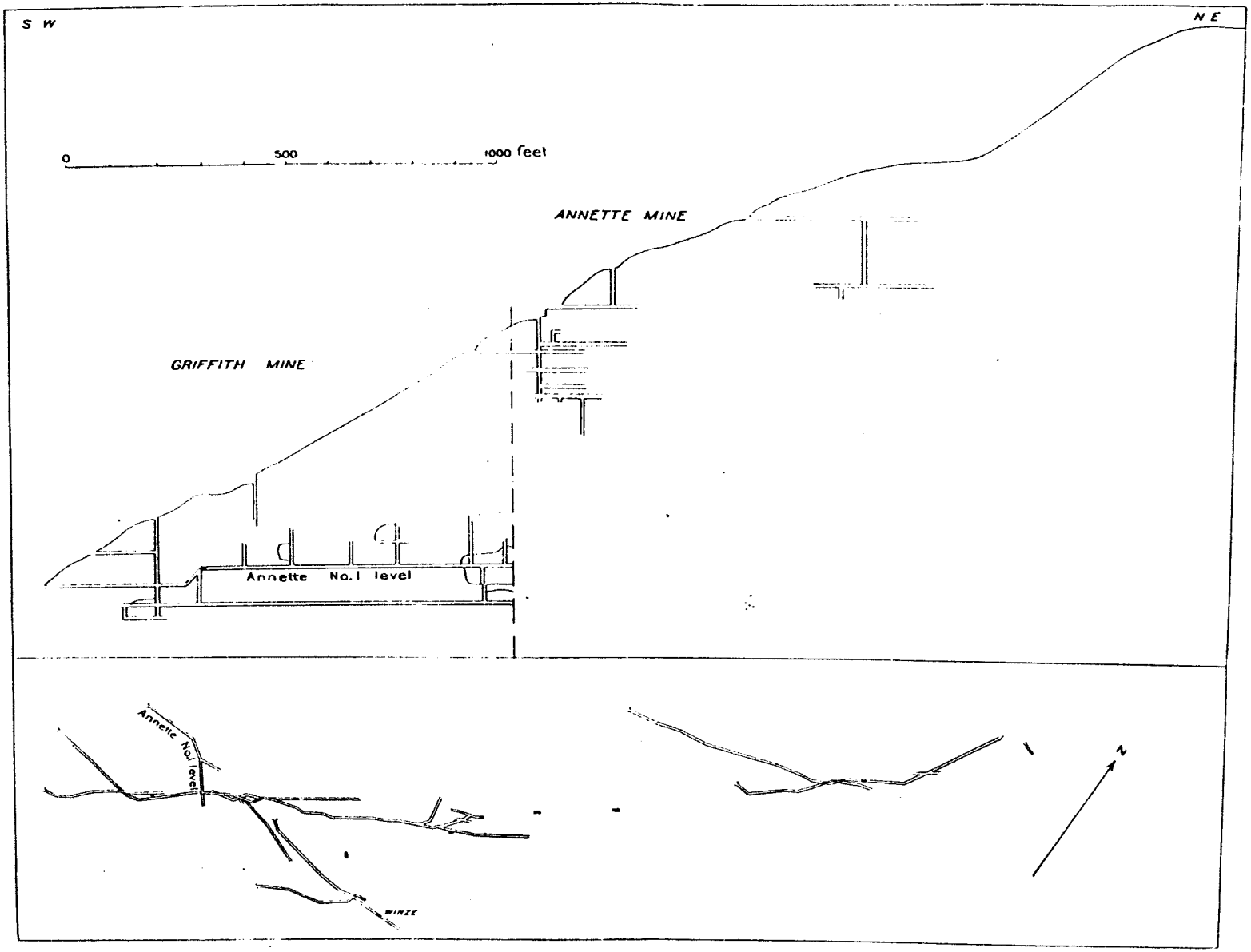
It was supposed by Mr. Martine that the gold present in the mineral was combined with tellurium; the results of my investigations show, however, that the gold exists in the form of a rich alloy of Au and Ag. One small piece of the mineral showed distinctly a coating of gold and silver alloy on its cleavage plane. On treating the powdered mineral with nitric acid the residue showed no indication whatever of brown sponge gold, which would have been the case if this metal was combined with tellurium. On the other hand, the residue contained the gold only in the form of a bright pale-yellow alloy which proved to be 0.725 fine, the rest being silver.

The mineral, judging from the above analysis, may be said to consist of a mixture of hessite and argentite, Ag_2Te and Ag_2S, associated with other minerals in the following proportions:

Hessite	51.22
Argentite	20.93
Cu_2S } (chalcopyrite probably)	5.82
FeS } (chalcopyrite probably)	6.28
PbS (galenite)	10.78
Bi_2S_3	1.42
Au and Ag alloy	.48
$MgCO_3$	1.95
Insoluble residue	1.07
	99.95

It is interesting to note that the relation between the hessite and the argentite corresponds closely to the formula $2(Ag_2Te) + Ag_2S$.

[a] Proc. Colorado Sci. Soc., vol. 5, 1894-1896, pp. 242-243.



VERTICAL AND HORIZONTAL PLANS OF WORKINGS ON GRIFFITH VEIN COVERED BY GRIFFITH AND ANNETTE MINES.

Annette workings incomplete; other workings less so.

A specimen of this telluride was assayed by H. K. Miller, of Georgetown, who found 17.478 ounces of silver and 1.970 ounces of gold to the ton, with 13.75 per cent of lead and 5.80 per cent of copper. Another specimen given to the senior writer by the owners of the Griffith mine was submitted to W. F. Hillebrand, of the United States Geological Survey, who found in it qualitatively the elements reported by Doctor Pearce, and remarked that the evidence afforded by a partial analysis supported his conclusion as to the presence of a mixture of hessite, argentite, and other minerals. This telluride occurred in the Griffith vein, in a shoot of ore which extends from the surface downward almost vertically.

In general the ores of the mine may be divided into two groups—the galena ores associated with blende, chalcopyrite, and some pyrite, and the carbonate ores associated with pyrite and some barite. These two classes of ore were deposited at distinctly different periods. In general the carbonate ore is not profitable for mining, the average content being stated at $2 to $3 in gold and 10 to 12 ounces in silver, with little or no lead. It is, however, reported that one stope of carbonate ore containing pyrite yielded 20 to 25 ounces in silver and $6 to $10 in gold. A specimen of typical carbonate-pyrite ore was taken by the senior writer from the more northern of the two branches near the northeast end of the Annette No. 1 level, 60 to 70 feet from the breast of the branch. A seam of ore here was a few inches thick, with no traces of galena, but the ore was rather soft and crumbling, as if decomposed by circulating waters. An assay made by R. H. Officer & Co., of Salt Lake City, yielded 0.16 ounce of gold and 63 ounces of silver to the ton.

In the ores of the galena class in the Griffith mine the values are chiefly in lead, next in silver, and $4 to $5 in gold. It is reported that farther into the mountain on the same vein, in the Annette mine, the values run more in gold, silver, and copper and less in lead. In both mines it is these masses of galena ore which are sought for and mined. These lead ores are subordinate in quantity to the carbonate ores above discussed. They are reported to contain on an average about 40 ounces of silver and $8 to $9 in gold. As a rule the copper is not present in large enough quantity to be paid for by the smelter, although one shoot yielded the exceptional amount of 1 to 1½ per cent of copper.

Owing to the origin of the two classes of ore at different periods, mixtures of the two generations of vein materials in all proportions are found at many places. Such mixed ore was seen, for example, in the Annette No. 1 level a few hundred feet from the entrance and was reported to yield 20 ounces of silver and 0.05 to 0.10 ounces of gold. Similarly, about 300 feet in on the Griffith No. 1 level is a small body of rich ore in a low-grade vein. This ore is reported to yield 300 ounces in silver, $2 to $3 in gold, and some copper. A specimen of this ore taken by the senior writer and examined by E. C. Sullivan, of the Survey, was found to contain a sulphantimony compound of silver.[a] Sphalerite was also present and smaller quantities of copper, cadmium, lead, arsenic, etc.

STRUCTURE OF VEIN.

The vein shows plainly two distinct periods of fissuring and cementation by vein materials.

The result of the first dislocation of the rocks along this line was a strong fissure, in part open for a considerable width, as is shown by the angular fragments of wall rock that occur in and are cemented by the vein materials which were deposited subsequent to this dislocation. These angular fragments of wall rock indicate an original rubble-filled fissure, like that now occupied by portions of the Mendota and similar veins. The filling of this fissure was also similar to veins of the class mentioned. The first deposition was a line of comb quartz, and the interior of the fissure was filled with solid sulphides, practically without gangue, consisting of galena, blende, pyrite, and chalcopyrite. The abundance of chalcopyrite is distinctive of this vein, in contrast with the Mendota and other similar veins referred to.

Subsequent to the formation of this sulphide vein there was another dislocation, resulting in much larger openings than the first disturbance produced. The new fissure in general

[a] Probably tetrahedrite or polybasite.—J. E. S.

followed along the line of the old one, splitting the older vein and breaking it up in various ways. On account of the greater brittleness of the original sulphide filling, as compared with that of the wall rocks, the new fissure split the vein in the middle at many points, leaving a layer of sulphides clinging to each wall, a result which, after the new fissure was cemented with the carbonate ore of the second period, gave a false appearance of crustification. In numerous other places the older vein was broken into angular fragments, which rested in the new-formed fissure in the shape of rubble (fig. 105), precisely as the fragments of country rock had filled the original fissures. These angular fragments of sulphide ore now appear as inclusions in the later carbonate ore in varying amounts and degrees of coarseness.

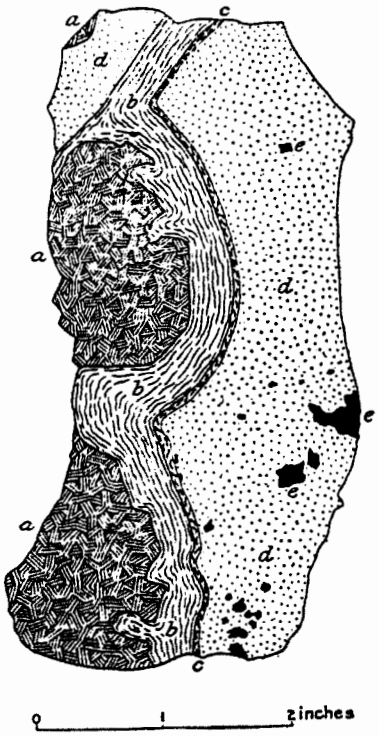


FIG. 105.—Sketch of specimen from Griffith vein, showing cementation of fragments of galena (*a*) belonging to the first period of deposition by a crustified material belonging to the second period and deposited in the following order: 1, Finely banded (crustified) brown carbonates (*b*); 2, a thin crust of quartz with sulphides (*c*); 3, mingled brown carbonates and fine quartz (*d*) containing some pyrite (*e*) and a little galena (*a*).

Elsewhere the new fissure departed locally or completely from the course of the original one (fig. 106). Thus on the Annette No. 1 level, where the composite Griffith vein splits and reunites, the two branches inclosing a horse of country rock, it is probable that one of the branches was formed during the first period of vein deposition and the other after the second period. It seems highly probable also that certain of the branches diverging from the trunk vein were formed entirely during the second period of vein deposition. Near the northeast end of the Annette No. 1 level are two branches separating from the trunk vein on the north side and striking almost due north. The ore in these branches is entirely the carbonate-pyrite ore characteristic of the second period. The more northeastern of the two branches crosses the trunk vein and has been explored for a considerable distance in both directions. The probability that this branch is due to the subsequent period of fissuring explains the otherwise unusual phenomenon of crossing.

Where, as is usual, the path of the earlier and the later fissures practically coincided, the proportion of the vein filling belonging to the two periods varies greatly (fig. 107). In general, however, the spaces afforded by the reopening of the fissure, and consequently the amount of ore now present in the vein as a result of cementation of this reopened fissure, are estimated to be many times as great as in the first period. In places the earlier sulphide ore may form the bulk of the present vein, constituting what is locally (though perhaps not correctly from a technical standpoint) known as an ore shoot.

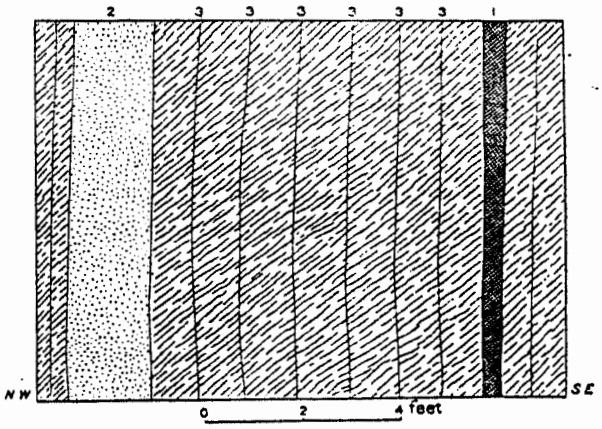


FIG. 106.—Vertical cross section of Griffith vein, Griffith No. 1 level, showing veins of two distinct periods running side by side and parallel in the same drift. 1, Vein of earlier period consisting of blende, galena, and a little pyrite; 2, vein of later period consisting of brown carbonates with pyrite; 3, sheeting in gneiss country rock, parallel with vein.

PARAGENESIS OF MINERALS.

The principal minerals of the ores belonging to the first period are galena, blende, chalcopyrite or cupriferous pyrite, and some iron pyrite. Copper-bearing pyrites seem to be invariably associated with this earlier vein material, but nowhere in any quantity with the material of the second period. Examinations of hand specimens and thin sections of this earlier sul-

phide ore show that the various sulphides are almost contemporaneous, but in detail they have crystallized out in the following order: (1) Pyrite, (2) chalcopyrite, (3) galena. The relative age of the blende has not been observed, though it seems to be very nearly contemporaneous with the galena. In various places galena was noted filling cracks in chalcopyrite. The earliest formation in the veins of this first period was comb quartz, which lined the open spaces. Tetrahedrite was noted along cracks in chalcopyrite and distinctly subsequent to it.

In the vein material belonging to the second period of deposition the pyrite, which is abundant, is contemporaneous with the more abundant carbonates, whereas the sulphides of the first formation, where they are included in the carbonate gangue, occur in broken and angular fragments. Microscopic examination, however, indicates that a small amount of chalcopyrite, galena, and blende was deposited contemporaneously with the carbonate gangue.

A specimen of the carbonate in the later ore, submitted to E. C. Sullivan, of the United States Geological Survey, proved to be mainly ferriferous rhodochrosite, with some magnesite and traces of calcite. Doctor Pearce, quoted above, mentions magnesite as a gangue material. According to J. S. Randall, of Georgetown, the carbonate gangue of the Griffith mine is largely siderite, with some magnesite. It is probable that the brown carbonate is a mixed carbonate of iron, magnesite, manganese, and lime, as in other mines of the region.

Typically small contemporaneous crystals of quartz are scattered in the massive carbonate. As a rule also the deposition of quartz has persisted longer than that of carbonate, for abundant geodes and druses, which are found in the carbonate ore, are lined with crystals of quartz. With this predominant quartz there is also here and there some lesser amount of brown carbonates, and even small and scanty crystals of sulphides, such as chalcopyrite, galena, and blende. Barite also is very commonly found lining the druses as the last mineral to crystallize, and kaolin occurs under the same conditions.

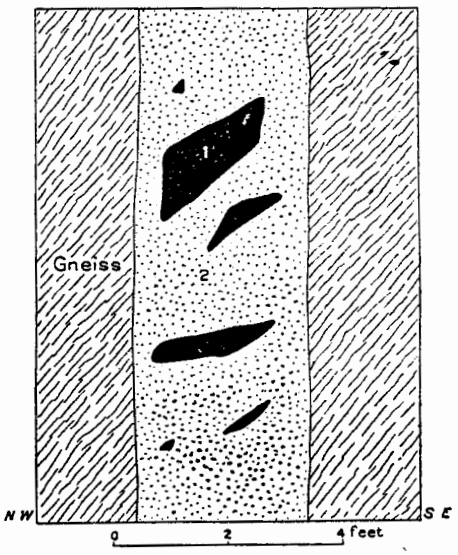


FIG. 107.—Vertical sketch section of Griffith vein, Annette No. 1 level, about 1,600 feet from mouth, showing ore of two periods of vein formation. 1, Coarse galena ore of first period; 2, carbonate-pyrite ore of second period inclosing broken angular fragments of No. 1. The wall rock is gneiss.

In some places the gangue may be mainly quartz, with a subordinate amount of intercrystallized carbonates. In other mines of this region, such as the Mendota, Dunderberg, Bismarck, Wisconsin, Pay Rock, and Colorado Central, brown carbonates of iron, manganese, etc., with contemporaneous pyrite, have been found to be in general later than galena and blende, but nowhere on such a scale as is found in the Griffith mine. In the other mines mentioned also this carbonate-pyrite ore has usually a very evident connection with the present topographic surface, but the somewhat similar ore of the Griffith has no such connection.

INFLUENCE OF DEPTH.

On considering the influence of depth on the ores of the first period, it appears probable that the action of surface waters has brought about some local concentration and impoverishment. As is usual in mines of this district, the surface ores were very rich, and according to Raymond[a] contained sufficient gold to repay sluicing. It is reported by those familiar with the mine that there was more copper on the upper levels than in those more remote from the surface. The occurrence of tetrahedrite along cracks in chalcopyrite, like that noted in the Centennial mine, suggests the secondary nature of the tetrahedrite and descending ground waters as the depositing agency. It is also reported that these upper ores contained more silver and gold and less galena.

[a] Mines and mining west of the Rocky Mountains: Ex. Doc. No. 207, 41st Cong., 2d sess., p. 368.

It appears probable that this action of shallow descending waters had some enriching influence on the subsequent carbonate-pyrite ore, for it is reported that in the upper levels much of the ore of this class was rich enough to pay.

POSTMINERAL FAULTING.

On the Griffith No. 1 level, 100 feet from the mouth, the Griffith vein is cut by a transverse fault striking N. 43° W. and dipping 76° NE. At the point where the lode is cut it is a composite lode, the result of the two periods of vein cementation. It is offset about 10 feet to the northwest on the northeast side by the fault. It is reported that this same fault is found all the way down from the surface, but that the offset diminishes in depth. For example, 60 feet above this level the offset is 15 feet, but 25 feet below it is only 5 or 6 feet. Near the surface the fault is marked by a water course filled with bowlders.

PRESENT UNDERGROUND WATERS.

In the southwestern, or outer, portion of the Annette No. 1 level coatings were observed on the drift walls, in some places stained with copper. Water drips from the rocks and vein at intervals all along these drifts. On the Annette No. 1 level water was observed from the mouth for 1,200 feet in, to a point having an estimated vertical distance from the surface of 650 feet. From this point to the end of the level, which is about 1,900 feet from the surface, at an actual depth of about 1,050 feet, the rocks were quite dry.

ANGLO-SAXON LODE.

ANGLO-SAXON MINE.

HISTORY, DEVELOPMENT, AND PRODUCTION.

The Anglo-Saxon lode is located on the northwest slope of Saxon Mountain and runs north-northeastward up the slope to an elevation of 10,500 feet. In 1867 it caused much excitement on account of the extremely rich ore found along it. The developments consist of four levels with numerous crosscuts and shafts, but all these workings are at present caved shut.

According to Burchard[a] the Anglo-Saxon mine had yielded about $700,000 previous to 1883. But little ore has been extracted since that time, although small quantities of rich "float ore" are at present occasionally found scattered through the loose surface material along the trend of the vein.

NATURE OF ROCKS.

As all the workings were closed by caving, the exact nature of the rocks occurring along them is unknown, but the surface rocks in the vicinity of the vein consist chiefly of much-altered friable granite and pegmatite. Granitic and biotitic gneiss also occur. The gneiss has a general strike of N. 40° W. and a dip of 20° NE.

VEIN AND ORE.

The Anglo-Saxon vein on the surface has a general strike of N. 70° E. and a dip ranging from vertical to a slight inclination toward the north. Where the vein crosses a spur of Saxon Mountain, at an elevation of about 10,300 feet, the wall rocks for some distance on either side of the vein consist of yellowish altered and friable granite. Running through this soft granite, much of which is probably not in place, are irregular branching seams of loose material in which are embedded here and there nodular masses or nuggets of very rich ore. These masses consist either of yellowish and greenish light-colored oxidized ore, or of rounded lumps of a black sectile waxy substance, high in silver values, which W. T. Schaller found by chemical analysis to be argentite (Ag_2S), or silver glance. Argentite occurs also as small stringer-like masses in the sandy matrix, which resembles loose surface material. These stringers may represent the portions of displaced surface croppings of the vein, for the seams have been successfully followed for only a few feet in depth.

[a] Burchard, H. C., Precious metals in the United States, 1883, p. 277.

In all probability the rich sulphide ore is the result of the secondary action of surface waters and has originated since the formation of approximately the present topography. These sulphides which are residual in the oxidized ores are much the richest of the ores in the mine and in respect to their high content of the precious metals are very similar to ores noted at Monte Cristo, Wash.,[a] by Spurr, and also at Leadville[b] by Emmons, who stated that it was "evident that the action of the surface waters has been to concentrate the silver in the sulphide ore, not in the oxidized product."

Small shipments of high-grade ore obtained near the surface have brought returns ranging from 1,000 to several thousand ounces in silver to the ton.

No active work has been done on this mine for years, although at present a few sacks of ore are being obtained from surface pits by picking out the rich pieces of ore which are sparsely scattered as nodules or irregular seams in the friable granite and wash.

ANGLO-SAXON EXTENSION VEIN.

LOCATION AND DEVELOPMENT.

The Anglo-Saxon Extension vein, which is probably either the continuation of the Anglo-Saxon vein or one of its branches, is located to the west and south of the old Anglo-Saxon workings and is opened by a series of tunnels which aggregate over 2,500 feet of drifting. Most of the upper workings are inaccessible. The lowest, or seventh, level, the longest one in the mine, was about 825 feet in length at the time of visit, but was being extended. The first part of the lowest tunnel, the mouth of which is located 600 or 700 feet above Clear Creek, is a crosscut run through fractured biotite granite and pegmatite. The rest of the level and the vein itself are entirely in gneiss, which as a rule strikes to the northwest.

VEIN AND ORE.

The vein on the lowest level has a strike of N. 73° E. and a slight dip to the northwest. It is for the most part a crushed gneiss and clay lead, from a few inches to 2 feet wide, which is in many places highly colored by iron and copper salts. That the vein is along a fault line is well shown by the gouge and the putty-like clay, which represent country rock finely pulverized as a result of movement, and also by slickensides and movement striæ dipping 65° NE. In a few places the clay and crushed rock lead changes to quartz or to a low-grade ore, or "mill dirt," consisting of a mixture of quartz and decomposed pegmatite and gneiss over a foot wide with specks of galena all through the mass, which also carries a little lead carbonate and some copper compounds, as shown by the presence of copper sulphate, and the carbonates, azurite and malachite.

This lean ore is said to carry values ranging from $10 to $18 per ton. Some portions of the vein nearest the surface carry a porous or honeycombed mass of quartz which shows leaching by descending surface waters. The presence of iron oxides in abundance shows that the lower workings are still in the oxidized zone.

Most of the ore produced by this mine was found between the Blacksmith Shop level and the seventh level, which are about 225 feet apart. The greater part of the ore was from shoots which are said to have dipped to the northeast.

PRODUCTION.

Little information was obtainable about the production of the Anglo-Saxon Extension mine, but the Director of the Mint reports the production for 1889[c] as $2,017.60, divided as follows: Gold, $880; silver, $768; lead, $250.80; copper, $118.80. In the report for 1890[d] the yield was given as $3,955, divided thus: Gold, $1,100; silver, $2,246; lead, $609.

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[a] Spurr, J. E., Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 2, 1901, p. 777-865.
[b] Emmons, S. F., Secondary enrichment of ore deposits: Trans. Am. Inst. Min. Eng., February, 1900, p. 7.
[c] Leech, E. O., Production of gold and silver in United States, 1889, p. 144.
[d] Idem, 1890, p. 130.

MINES OF REPUBLICAN, DEMOCRAT, AND COLUMBIA MOUNTAINS.

REPUBLICAN MOUNTAIN GROUP.

EXISTENCE OF A ZONE OF MINERALIZATION AND INTRUSION.

The so-called Republican Mountain group of veins occupies a definite east-west zone which extends from Clear Creek on the east westward up the valley of Silver Creek nearly to the summit of the mountain ridge. (See Pl. LVII.) The difference of elevation of the surface along various parts of this zone amounts to about 3,000 feet. The separate veins in this zone have a generally eastward trend corresponding with that of the zone as a whole, but also vary from that direction to the southeast and the northeast.

This vein zone is also a zone of porphyry intrusion. The principal dike runs east and west along the Sunburst-Sceptre vein. Farther east, what may be the same dike is encountered near the Boston vein, in some places forming one or both of the walls of this vein. Smaller dikes have also been noted in this zone. The porphyry is definitely earlier than the formation of the vein zones.

It is evident that an east-west zone of weakness existed here previous to the intrusion of the porphyry. The first dislocations were probably followed by the igneous intrusion. Subsequently, the stress continuing, renewed movement took place, producing fault zones which in part followed along or near the older dike. These later openings were in part cemented by vein material. Later still movement was again resumed, also on an important scale. The result was that the principal vein of the zone, the Sunburst-Sceptre, was reopened and fissured in the same way as the Griffith vein on Saxon Mountain. The fissures in the reopened veins of Republican Mountain were subsequently cemented by the same materials as in the Griffith vein, namely, brown carbonates with pyrite. Subsequent to this cementation the Sunburst-Sceptre vein was again reopened and the fissures were cemented with chalcedonic quartz. Thus fissuring and subsequent cementation have taken place repeatedly during a period of time probably beginning in the late Cretaceous[a] and lasting to a recent date, or very likely to the present day.

PRINCIPAL VEINS OF THE GROUP.

The principal vein in the western portion of this zone is the Sunburst-Sceptre. The Queen lode is a smaller vein near and parallel to the Sunburst-Sceptre, and the Astor is a similar nearly parallel vein. At the east end of the zone the chief veins are the Boston and the Mineral Chief, with a number of smaller ones, such as the Muscovite, Spartan, and Beecher. The connection between these veins has not been well established, but it is possible that some of those which go by different names may be in reality parts of the same lode. For example, the Spartan is probably the northeastern continuation of the Mineral Chief, and the western continuation of the Mineral Chief is commonly held to be the Smith & Wesson. Similarly it is possible, as is held by many, that the Spartan-Mineral Chief vein may be the continuation of the Boston vein. The Muscovite vein may be the continuation of the Beecher, which is a branch of the Boston, although no connection has been traced either on the surface or underground.

CHARACTERISTICS OF VEIN FILLING.

The lodes of this zone contain ores which possess characteristic distinctions from those of other groups of veins. Those near the foot of the mountain or at the east end of the zone, such as the Boston, Mineral Chief, Beecher, Spartan, and Muscovite, all contain ore of the same kind, marked in many places by large amounts of pure galena, a variable amount of very dark blende, and considerable pyrites, with a low content of silver and very little gold. Siderite and a little kaolin also occur. When sorted this material forms a good grade of commercial lead ore. It resembles in many ways the Griffith ore of the first period of deposition, even containing the same peculiar dark-colored zinc blende. The lodes farther up the mountain, at the west end of the zone, are similar to the others, being usually of low grade in respect to silver. However,

[a] See p. 109.