Garrey's report on the mine.[22] The main ore bodies all lie in the "Blue limestone" at its contact with the overlying "Dolomitic limestone." These beds strike about N. 30° W. and dip 22°-40° NE. As shown in figure 3, there were several rich ore shoots, which ranged from 30 feet to several hundred feet in length and 10 to 60 feet in width. Burchard[23] gives the thickness of the ore bodies as 1 to 7 feet, averaging about 42 inches. They had a general pitch to the northeast. There are in the workings numerous nearly vertical fissures of north and northeast trends, which do not as a rule contain sufficient ore to be productive but which Garrey believes to be "the fractures through which the hot mineralizing solutions spread out along the favorable contacts or ore horizons."

The valuable metals in the Gold Cup ore are silver, lead, and gold. In 1890 the ratio of these metals in the ore was about 1 ounce of gold and 247 ounces of silver to the ton to 23 percent of lead. The abundant primary ore minerals are galena and pyrite, accompanied by small amounts of chalcopyrite, sphalerite, and gray copper. The silver is chiefly associated with the galena, and the gold with the pyrite. The secondary ore minerals are cerussite, anglesite, cerargyrite, limonite, and malachite. Azurite, chrysocolla, and calamine are sparingly present. Foster[24] mentions silver bromide in addition to the cerargyrite. The cerargyrite is so intimately intergrown with the cerussite that it cannot be distinguished with the naked eye. Most of the ore found on the dump and most of that shipped was oxidized ore. At least partial oxidation extends to a depth of more than 500 feet.

The ore consists of sugary or jaspery quartz, usually mixed with abundant limonite, which contains irregular masses and seams of dark-gray cerussite and anglesite. In

[22]Garrey, G. H., Unpublished report on the Gold Cup mine, in the Tincup mining district, Gunnison County, Colo., 1928.

[23]Burchard, H. C., Report of the Director of the Mint for 1883, pp. 312-313.

[24]Foster, E. L., op. cit., p. 46.

many places the cerussite surrounds and veins small masses of galena. Pyrite is very scarce. Malachite, chrysocolla, and calamine fill fractures and cavities but are not abundant. Sphalerite is locally present in small spots. Some of the ore consists of large masses of coarsely cellular quartz coated with limonite. In places limonite is so intimately mixed with the quartz that the mass has the appearance of a brown jasper. Some of the ore on the dump has a cindery appearance due to black limonite or manganese oxide stain. A light-brown chert has been deposited later than the ore and forms seams in it. Many cavities are filled with prismatic quartz crystals. Calcite appears to be the latest mineral deposited. In one specimen found on the dump minute crystals of wulfenite were observed in a cavity.

In recent years a tunnel has been driven from the west side of the Willow Creek Valley S. 60° W. into Gold Hill for a distance of about 2,200 feet. This tunnel, whose altitude is about 10,700 feet, was driven for the purpose of intersecting the contact of the "Blue limestone" and the "Dolomitic limestone" at about 125 feet below the bottom of the inclined shaft. The contact, as exposed at the breast of the tunnel, is cut and offset by a N. 70° E. fault, the displacement being about 30 feet eastward on the south side. In the contact plane adjacent to the fault there is about 1 to 1½ feet of gougy limonitic, siliceous material, which contains a small amount of ore. The fault zone is 2 to 3 feet wide and consists of sheared and brecciated limestone, which is stained with limonite and contains calcite seams. Throughout the last 360 feet of the tunnel there are several brecciated bedding planes and numerous nearly vertical fissures of northeast trend which contain quartz, limonite, and small amounts of ore, but there are no ore bodies of commercial size. It is a distinct possibility, however, as pointed out by Garrey, that commercial ore bodies may be encountered in raising from the tunnel breast along the "Blue limestone" and "Dolomitic limestone" contact to intersect the lower levels of the inclined shaft.

The tenor of the Gold Cup ores apparently ranged from 30 to 1,800 ounces in silver and 0.5 to 4 ounces in gold to the ton. Burchard[25] in 1881 stated: "The ore is said to run 240 to 1,800 ounces to the ton." In 1882[26] he stated that a body of ore was struck in October which ran 264 ounces in silver to the ton. In 1883[27] he gave the tenor as ranging from 30 to 1,000 ounces in silver and 0.5 to 4 ounces in gold to the ton, and stated that "The average grade of the present output is 168 ounces in silver and 1½ ounces in gold per ton." The 800 tons shipped during 1883 had a value of $88,000, or an average of $110 a ton. The daily output during that year was 8 to 15 tons. The Colorado Mining Directory for 1883[28] stated that the Gold Cup ore, when sorted, assayed $50 to $150 a ton. Foster[29] in 1884 gave the tenor as ranging from 150 to 175 ounces in silver and 0.5 to 2.5 ounces in gold to the ton.

Tincup Group

The Tincup, Robert E. Lee, and Drew mines are located in a compact group on the east side of Tincup Gulch, 3 miles south of Tincup and half a mile south of the Gold Cup mine, at an altitude of about 11,575 feet. The geology and ore deposits are very similar in these mines.

Tincup.—The Tincup mine is the largest of the group and ranks third in production among the mines of the district. It is opened by a vertical shaft and, 150 feet farther south, by an inclined shaft, both of which were inaccessible in 1932. To judge from the size of the dumps, the workings connected with the vertical shaft amount to about 800 feet and those connected with the inclined shaft about 300 feet.

The ore deposits are of about the same size, shape, and character as those of the Gold Cup mine. However, the

[25]Burchard, H. C., Report of the director of the Mint for 1881, p. 395.

[26]Burchard, H. C., Report of the Director of the Mint for 1882, p. 465.

[27]Burchard, H. C., Report of the Director of the Mint for 1883, p. 313.

[28]Corregan, R. A., and Lingane, D. F., Colorado Mining Directory, 1883, pp. 333-334.

[29]Foster, E. L., op. cit., p. 46.

chief ore bodies in the Tincup mine occurred in the "Granular limestone" at its upper and lower contacts. Garrey states that there were also supposed to be good stopes on the contact of the "Blue limestone' 'and the "Dolomitic limestone" at the north end of the claim. The formations appear to have about the same strike and dip as at the Gold Cup mine. The "Big fault" of the Gold Cup workings, described by Garrey, is said by Frank Korn, of Tincup, to continue south through the Tincup workings and to cut off the ore on the east side.

The Tincup ores are reported to carry more silver and lead and less gold than the Gold Cup ores. However, in 1890 the ratio in the ore shipped was 1 ounce of gold and 248 ounces of silver to the ton to 23 percent of lead, which was about the same as the ratio in the Gold Cup ore for the same year. The ore minerals are about the same in both mines. The ore on the Tincup dumps contains the same sugary and limonitic quartz and the limonitic jaspery material, but cerussite and galena are more abundant and in larger masses than at the Gold Cup mine. Malachite, chrysocolla, and calamine are more abundant in the Tincup ore, filling seams and cavities. They are all later than the cerussite, and the order of deposition seems to be malachite, chrysocolla, calamine, and drusy quartz, for in several of the cavities they occur in that order. Minute crystals of wulfenite occur on the drusy quartz in some cavities.

The inclined shaft evidently explores the contact of the "Blue limestone" and the "Dolomitic limestone." There is considerable good cerussite-galena ore on the dump, associated with white, gray, and brown sugary quartz. There is also considerable of the black cindery material on the dump.

The tenor of the Tincup ore is not as variable as that of the Gold Cup and on the average is higher. Burchard[30] stated that 450 tons shipped in 1881 averaged $180 a ton. The next year 450 tons shipped had a value of $80,000, or $178 a ton.[31] A small shipment of picked ore ran $6 a pound.

[30]Burchard, H. C., Report of the Director of the Mint for 1881, p. 395.

[31]Burchard, H. C., idem for 1882, p. 465.

In 1883[32] Burchard gave the tenor as 75 to 380 ounces of silver to the ton and about 60 percent of lead. Shipments of 400 tons brought $60,000, or $150 a ton. The Colorado Mining Directory for 1883[33] gave the tenor of the Tincup ore as 50 to 70 ounces of silver to the ton.

Robert E. Lee.—The Robert E. Lee mine is 250 feet southeast of the Tincup shaft. The mine is opened by a vertical shaft, and the size of the dump indicates about 1,000 feet of workings, which were inaccessible in 1932. The shaft collar is in the "Dolomitic limestone." According to Garrey the ore bodies in this mine were also in the "Granular limestone" at its upper and lower contacts and were very similar in size, shape, and character to the Tincup ore bodies. The ore minerals are the same as those at the Tincup mine. On the dump the brown jaspery material predominates and contains irregular spots and seams of cerussite and anglesite. Soft yellow limonite is very abundant.

The Robert E. Lee ore contains very little gold. The ore shipped in 1888 had a ratio of .09 ounce of silver to the ton to 1 percent of lead. In 1890 the ratio was about 2.2 ounces of silver to the ton to 1 percent of lead. No data are available as to the tenor of the ore.

Drew.— The Drew mine is 300 feet south of the Tincup shaft and consists of a 200-foot inclined shaft and more than 500 feet of total workings. The ore-bearing zones, the shapes of the ore bodies, and the character of the ore are the same as at the Tincup mine. Burchard[34] gives the thickness of the replacement ore body as 5 feet.

In 1881[35] a shipment of 7 tons gave returns of 82, 127, and 676 ounces of silver to the ton for the three classes of ore. Single assays ran as high as 3,454 ounces. In 1882[36] a

[32]Burchard, H. C., idem for 1883, p. 318.

[33]Corregan, R. A., and Lingane, D. F., op. cit., p. 359.

[34]Burchard, H. C., Report of the Director of the Mint for 1883, p. 318.

[35]Burchard, H. C., idem for 1881, p. 395.

[36]Burchard, H. C., idem for 1882, p. 465.

shipment of 25 tons assayed $200 a ton. In 1883[37] a shipment of 87 tons returned $8,700, or an average of $100 a ton. The Colorado Mining Directory for 1883[38] gave the mill run of the ore when sorted as 50 to 150 ounces of silver to the ton and 20 percent of lead.

El Capitan

The El Capitan mine is on the west side of West Gold Hill, 2 miles south of Tincup at an altitude of about 11,500 feet. According to Burchard[39] the mine produced $60,000 to $80,000 to the end of 1883. The workings consist of two parallel shafts, 20 feet apart and inclined 18° S. 80° E. The dump indicates about 800 to 1,000 feet of workings. The workings are in the top of the Fremont limestone, which here strikes about N. 15° W. and dips 18° E. About 150 feet to the west of the shaft collar the large dike of hornblende diorite porphyry cuts through the hill, almost parallel in strike to the beds but dipping more steeply.

The ore bodies of the El Capitan are blanket deposits replacing the Fremont limestone along its contact with the overlying "Fairview shale." According to the Colorado Mining Directory[40] the ore bodies were 4 to 10 feet in thickness, but no data are available as to their extent.

The ore yields gold, silver, and lead. Burchard[41] stated that the ore carried very little lead but a great deal of silver and some gold. The primary ore minerals are galena and pyrite, and the secondary ore minerals are cerussite, anglesite, malachite, limonite, calamine, and free gold. Burchard[42] mentions "a great deal of silver glance, horn silver, and silver sulphide." These minerals are probably associated with the galena, and the gold with the pyrite. Quartz

[37]Burchard, H. C., idem for 1883, p. 318.

[38]Corregan, R. A., and Lingane, D. F., op. cit., p. 351.

[39]Burchard, H. C., op. cit. for 1883, p. 314.

[40]Corregan, R. A., and Lingane, D. F., op. cit., p. 329.

[41]Burchard, H. C., op. cit. for 1883, p. 314.

[42]Burchard, H. C., idem for 1882, p. 465.

and silicified limestone constitute the gangue. Much of the vein material on the dump consists of silicified limestone breccia cemented by vuggy vitreous quartz in which the cavities are lined with long prismatic quartz crystals. The ore occurs in seams 2 to 5 inches wide, many of which are bordered with gouge. On the side of these seams there is a sugary quartz, which contains considerable soft limonite. The central zone of the seam is composed of gray cerussite, which surrounds small residual spots of galena. Lenticular cavities in the cerussite contain a thin coating of malachite and are partly filled with a fibrous greenish-white calamine.

At 230 feet N. 25° W. of the inclined shaft there is a vertical shaft about 50 feet deep in Fremont limestone, and monzonite porphyry at the bottom. Apparently just above the porphyry there is a small ore body 6 inches to 1 foot thick, composed of sugary quartz, limonite, cerussite, and a small amount of malachite.

Burchard in 1882[43] gave the tenor of the El Capitan ore as $50 to $700 a ton. In 1883[44] shipments of 100 tons of ore brought $10,000, thus averaging $100 a ton, and Burchard stated that there were 250 tons of ore on the dump which contained 50 ounces of silver to the ton. The Colorado Mining Directory for 1883[45] stated that the ore "mill-runs 1 ounce of gold per ton."

West Gold Hill

The West Gold Hill mine is on the west slope of West Gold Hill, about one-third of a mile northwest of the El Capitan and 2¼ miles south of Tincup, at an altitude of about 11,200 feet. The workings, as shown in figure 2, consist of a 360-foot tunnel extending due east into the hill and an inclined stope on the ore body 300 feet long. These workings are in the Manitou limestone about 30 feet above

[43]Burchard, H. C., op. cit. for 1882, p. 465.

[44]Burchard, H. C., idem for 1883, p. 314.

[45]Corregan, R. A., and Lingane, D. F., op. cit., p. 329.

the top of the Sawatch quartzite. The beds strike N. 15° W. and dip 15°-22° E. No data are available on production, but the size of the only stope in the mine indicates that about 2,500 tons of ore was removed.

Gold was the principal metal produced by the West Gold Hill mine, although there may have been small amounts of silver, lead, and copper. The ore is all oxidized, and the chief ore mineral is limonite, which is abundant and probably contains free gold, cerussite, and malachite, in small amounts. The gangue consists of quartz and silicified limestone.

The underground workings of the West Gold Hill mine were the only ones in the blanket deposits of the district that were accessible to the writer in 1932, and therefore the ore body and its geologic setting are described in some detail. These features seem to be typical of the district as a whole, and thus the West Gold Hill ore body serves as a type for the Tincup blanket deposits.

The ore body (see fig. 2) is a blanket deposit of lenticular shape, which lies parallel to the bedding. It has an east-west length of about 300 feet, a width of 20 to 25 feet, and a thickness of 10 to 15 feet. The ore has replaced parts of two beds of limestone along a bedding plane and in places breaks across bedding planes into upper and lower beds.

Four normal faults or fracture zones cross the ore body. The easternmost of these is a relatively strong fault which has a displacement of about 15 feet down on the west side. The others show only a few inches of displacement. These fissures are earlier than the ore and are apparently the channels through which the mineralizing solutions came up and spread out along the bedding planes. The ore body tends to widen out or thicken along them. These faults range in strike from N. 25° W. to N. 5° E. and dip 58°-77° W. They are 1½ to 2½ feet wide and consist of limestone breccia or fractured limestone cemented with quartz and limonite. Irregular vuggy seams of late calcite cut the breccia, and in places in the fault zones there are open fissures from 1 to 6 inches wide.

There has also been notable displacement along the bedding plane followed by the ore body. Considerable breccia occurs along it, and in places there are fragments of diorite porphyry, which must have been dragged in from the large dike about 100 to 200 feet to the east. Thus a thrust movement is indicated, and, as it took place before the vertical faulting, it is probably related to the Tincup thrust fault. This brecciation evidently determined the horizon of the ore body, and its extent and amount probably determined the size and shape of the ore body.

The ore is a more or less intimate mixture of quartz and limonite; in some places a porous quartz with soft yellow limonite, in others a solid sugary quartz with large masses of hard brown limonite. Small amounts of cerussite are mixed with the quartz. Malachite and crysocolla occur in small amounts as veinlets and small cavity fillings in the ore.

Silver-Lead-Gold Vein Deposits

Jimmy Mack

The Jimmy Mack mine is on the west slope of Gold Hill, overlooking West Fork, 3¾ miles south of Tincup, at an altitude of about 11,760 feet. The deposit was discovered in 1878 by Thomas Maher. The workings consist of a 420-foot shaft, inclined 70° E., and six levels which range from 150 to 350 feet in length. The Blistered Horn tunnel has been driven from the bottom of the West Fork Valley eastward into Gold Hill for 1,800 feet and intersects the Jimmy Mack vein about 750 feet beneath the surface. A raise connects the tunnel with the shaft workings. The shaft collar is in the "Siliceous limestone" of the Chaffee formation, and the workings cut all the formations down to and including pre-Cambrian.

According to the Mint reports,[46] the Jimmy Mack produced 300 to 500 tons of ore a year in 1881, 1882, and 1883. During 1882 and 1883 more than $26,000 worth of ore was

[46]Burchard, H. C., Report of the Director of the Mint for 1881, p. 395; idem for 1882, p. 465; idem for 1883, p. 313.

taken out. The maximum daily output was about 6 tons. This ore averaged $100 to $150 a ton.

The valuable metals in the Jimmy Mack ores are silver, lead, and copper. Gold is very scarce. The primary ore minerals, named in the order of their abundance, are pyrite, argentiferous galena, and chalcopyrite. Foster[47] also mentions argentite and some native silver. The secondary minerals are limonite, cerussite, anglesite, malachite, chrysocolla, cerargyrite, and calamine.

The Jimmy Mack vein strikes N. 25°-30° E. and dips 70°E. It cuts the pre-Cambrian granite gneiss and the Cambrian, Ordovician, and Devonian formations, but the chief ore bodies are in the limestones of the Manitou, Fremont, and Chaffee formations. At the shaft collar the wide dike of hornblende diorite porphyry lies 5 feet east of the hanging wall of the vein, but the dike and the vein diverge with depth. The vein ranges from 3½ to 6 feet in width.

Practically all the ore taken out through the shaft was oxidized. It consisted of porous sugary quartz and brown jaspery material (a fine-grained mixture of limonite and quartz), which contained irregular masses and stringers of cerussite and anglesite and small residual masses of galena. Limonite is abundant in all the ore. The wall rock is apparently considerably altered. Some of the material on the dump consists of a greenish banded material resembling serpentine, which appears to be altered limestone.

The Blistered Horn tunnel cuts the granite gneiss and the Sawatch quartzite, and the raise passes through Manitou limestone. The tunnel cuts several northeast veins of steep dip, but apparently none of them are of economic importance. The tunnel was inaccessible to the writer. Both oxidized and unoxidized vein material appears on the dump. The primary ore consists of sugary and coarsely crystalline quartz, which carries abundant coarse-grained pyrite and less abundant coarse-grained galena in irregular masses and veinlets. Chalcopyrite and sphalerite are pres-

[47]Foster, E. L., Report of the State geologist, 1883-84, p. 46, 1884.

ent as small spots in the quartz. Gray copper, rarely present, is associated with galena. The order of deposition of the vein material was (1) quartz, pyrite, and chalcopyrite, (2) galena and gray copper, (3) quartz, and (4) sphalerite. The oxidized ore carries abundant limonite, much of it pseudomorphs after pyrite, irregular seams and masses of cerussite, and small amounts of malachite, chrysocolla, and calamine.

The tenor of the Jimmy Mack ore ranged from about $60 to $130 a ton. The highest assay ever obtained, according to Burchard,[48] was 6,385 ounces of silver and 0.5 ounce of gold to the ton. In 1881[49] Burchard gave the tenor of the Jimmy Mack ore as $130 a ton; in 1883,[50] from $60 to $125 a ton. Ore shipped in 1883 was 500 tons, which brought $55,000, or an average of $110 a ton.

Indiana

The Indiana mine is on Gold Hill 3 miles south of Tincup and three-quarters of a mile north of the Jimmy Mack, at about the same altitude as the Jimmy Mack. It has shipped a small amount of good-grade ore which carried silver, lead, and a small amount of gold. The mine is opened by a shaft 250 feet deep.

The vein strikes N. 35° E. and dips 55° W. It cuts the large hornblende diorite porphyry dike and the underlying Dyer limestones. The ore on the dump shows a limonitic quartz containing a small amount of cerussite.

Deacon

The Deacon mine is half a mile northwest of the Jimmy Mack, just west of the road, at an altitude of about 11,700 feet. It is a small mine but has shipped some good silver-lead-gold ore. The Deacon vein, which is 2 to 3 feet wide,

[48]Burchard, H. C., op. cit. for 1883, p. 313.

[49]Burchard, H. C., idem for 1881, p. 395.

[50]Burchard, H. C., idem for 1883, p. 313.

cuts the Manitou limestone, strikes about N. 5° E., and has a nearly vertical dip. It is opened by a shaft about 150 feet deep.

The ore consists of limonitic sugary quartz containing abundant cerussite. The average tenor is $50 a ton, but some of the ore has run as high as 6 ounces of gold to the ton.

LITTLE ANNA

The Little Anna mine is on the crest of the ridge of Anna Mountain, 4½ miles S. 20° W. of Tincup and half a mile due west of Gold Hill Pass, at an altitude of about 12,200 feet. The workings consist of a shaft on the vein about 60 feet deep and a tunnel about 150 feet long, which runs west into the hill and apparently intersects the bottom of the shaft. The mine is on the north side of a large stock of quartz monzonite porphyry, at its contact with the granite gneiss. The ore contains silver and gold, of about equal value, and less lead. The chief primary ore minerals are pyrite and galena, and the secondary minerals are limonite, cerussite, and cerargyrite.

The Little Anna vein strikes N. 58° E. and is nearly vertical. It cuts both the porphyry and the granite gneiss about at right angles to the contact, but there appears to be very little ore in the porphyry. The vein is about 4 feet wide, of which 16 inches is pay ore. The vein material consists of milky quartz containing disseminated small cubes of pyrite and galena. The quartz is very vuggy, and the vugs are filled with interlacing quartz crystals. Chalcopyrite occurs sparingly in small irregular masses. Most of the ore is partly oxidized, the pyrite being changed to limonite, and the galena surrounded by veins of cerussite. Malachite and sooty chalcocite fill a few small cavities. The wall rock is altered (mostly sericitized) for 1½ to 2½ feet on each side of the vein.

According to the Colorado Mining Directory for 1883[51] the Little Anna ore contained 100 to 200 ounces in silver and $100 in gold to the ton.

[51]Corregan, R. A., and Lingane, D. F., op. cit., p. 342.

Anna Dedrika

The Anna Dedrika mine, which is mentioned in several of the Mint reports, appears to be on the northeastern extension of the Little Anna vein. It was not visited by the writer, but the following data have been taken from the Mint reports.[52]

The Anna Dedrika vein cuts the granite gneiss and crops out for 2,000 feet along the ridge of Anna Mountain, which strikes about N. 55° E. The vein is opened by three shafts. It averages about 4 feet in width and contains a pay streak 6 inches to 2 feet wide. The ore consists of galena, cerussite, and cerargyrite.

Assays on the ore have ranged from 24 to 1,640 ounces in silver to the ton. In 1882 shipments of 25 tons of ore averaged 188 ounces of silver and 1.5 ounces of gold to the ton and 22 percent of lead. In 1883 shipmens tof 80 tons of ore had a value of $7,000, or an average of $88 a ton. The lowest mill run was 105 ounces of silver, and the highest was 1,046 ounces of silver and 1.5 ounces of gold.

Molybdenum-Tungsten Vein Deposits

Ida May

The Ida May mine is on the crest of Gold Hill, the divide between Willow and Quartz Creeks, 4½ miles due south of Tincup and about 1,500 feet west of the point where the Pitkin road goes over Gold Hill Pass. The altitude of the mine is about 12,250 feet. The workings consist of a shaft about 300 feet deep, a short crosscut tunnel, and several open pits.

The Ida May was originally a gold-silver mine. In 1889[53] it produced $500 in gold, $272 in silver, and $228 in lead. When the World War began, the mine was exploited for tungsten, and during 1917-18, according to Frank Korn,

[52]Burchard, H. C., Report of the Director of the Mint for 1881, p. 395; idem for 1882, p. 465; idem for 1883, p. 317.

[53]Smith, M. E., Report of the Director of the Mint for 1889, pp. 148-149.

2 or 3 cars of ore were shipped which averaged 11 percent of tungsten. Since the war very little work has been done on the property.

The Ida May vein is entirely within pre-Cambrian granite gneiss. It is about 1½ to 2 feet wide, strikes about N. 30° E., and dips 70°-80° W. The granite gneiss is silicified for about 2 to 3 feet. On the west side of this vein, within a zone of 150 feet, there are three or four roughly parallel veins, which strike N. 30°-56° E. The Ida May vein and one other contain both tungsten and molybdenum; the rest carry only molybdenum.

The ore minerals of these veins, named in the order of their abundance, are hübnerite, molybdenite, pyrite, chalcopyrite, sphalerite, galena, and gray copper. The gangue consists of sugary and coarse vitreous quartz and silicified granite gneiss. The order of deposition of the vein material appars to have been (1) hübnerite and vitreous quartz, (2) molybdenite and sugary quartz, and (3) sulphides (pyrite, chalcopyrite, and small amounts of galena and gray copper). The evidence for this paragenesis is as follows: The vitreous quartz that contain hübnerite is cut by veinlets of the sugary quartz that contains molybdenite, although no molybdenite cutting hübnerite was found; veinlets of chalcopyrite cut cleanly across zones of disseminated molybdenite, and elsewhere the chalcopyrite is intergrown with the other base-metal sulphides.

The Ida May vein seems to be made up of two distinct seams, one of vitreous quartz containing hübnerite in tabular crystals half an inch long and an eighth of an inch wide and one of sugary quartz containing molybdenite in scattered flakes and fine disseminations. The sulphides, consisting of pyrite, chalcopyrite, and small amounts of galena and gray copper, occur in irregular seams and intergrown masses in both kinds of quartz. Molybdite coats late fractures in the quartz and covellite coats the sulphide grains.

The shipments of sorted ore from the Ida May averaged 11 percent of tungsten. The crude ore as a whole probably averages less than 1 per cent. In the whole Ida May vein system molybdenum is considerably more abundant than tungsten.

Mammoth

The Mammoth vein is about 2,000 feet west of the Ida May, on the east slope of the West Fork Valley, about 250 feet from the top of the divide. The altitude is about 12,000 feet. It is a recent discovery (since 1925), and very little development work has been done on it. In July, 1932, a tunnel was being started on the vein, and there were numerous open pits along the outcrop. Molybdenum is the

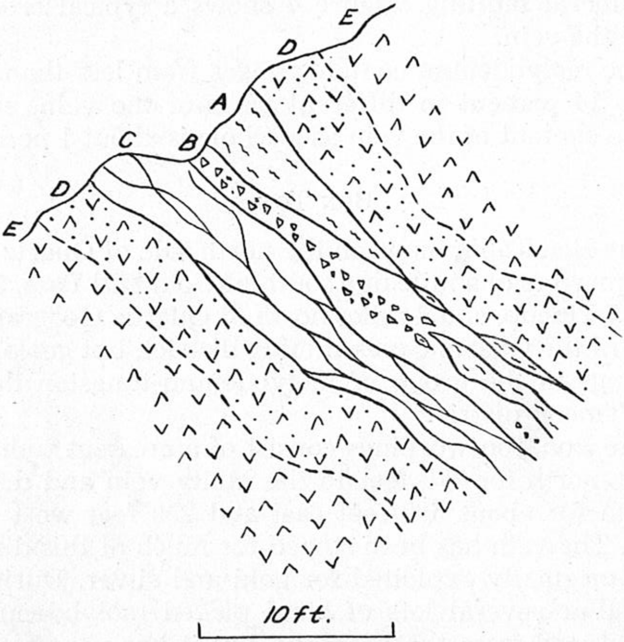

Figure 4. Sketch of the Mammoth molybdenum vein as exposed in an open cut. A, milky quartz containing short irregular seams and lenses of fine granular and flaky molybdenite and a few small grains of pyrite; B, gouge containing irregular rounded fragments and small particles of molybdenite-bearing quartz; C, soft sericitized granite gneiss containing numerous small interlacing veinlets of molybdenite-bearing quartz; D, slightly sericitized granite gneiss; E, unaltered granite gneiss.

only valuable metal in the vein. Molydenite and some molybdite occur in a gangue of quartz. Pyrite is scarce.

The Mammoth is a strong, well-defined vein in granite gneiss. It strikes N. 71° E. and dips 38° SE. and can be traced for about 1,500 feet along the surface. There are three other veins that are parellel to and of the same type as the Mammoth, one at 250 feet to the northwest and the others at 60 and 150 feet to the southeast.

The Mammoth vein is typical of the group. The total width of the vein material is fairly uniform, ranging from 6 to 8 feet, but the molybdenite-bearing quartz thickens and thins rapidly from a few inches to several feet, due to post-mineral faulting. Figure 4 shows a typical cross section of the vein.

The molybdenum content ranges from less than 1 percent to 14 percent in different parts of the vein, and the average content of the vein as a whole is about 1 percent.

Bon Ton

The Bon Ton mine is on the north side of Quartz Creek three-quarters of a mile due south of Gold Hill Pass, 5 miles south of Tincup, and 4 miles north of Quartz. Geographically it is in the Quartz Creek mining district, but geologically it belongs in the group of molybdenum-tungsten deposits of the Tincup district.

The Bon Ton workings consist of a crosscut tunnel extending north for 270 feet to the Molly vein and drifts on the vein for about 600 feet east and 200 feet west of the tunnel. The vein has been stoped for much of this distance. It was originally exploited for gold and silver. During the World War several lots of hand picked molybdenum ore were shipped from the property, but it has now been idle except for a little development work for several years.

The Molly is a strong vein, from 3 to 5 feet wide, in granite gneiss. It strikes N. 68°-72° E. and dips 37°-42° SE. The chief ore minerals are molybdenite and pyrite. Chalcopyrite is present but seems to be in small amount. Worcester[54] reports considerable chalcopyrite and says that copper with some gold and silver were the chief products of the mine up to 1917. Quartz is the chief gangue mineral. The bulk of the pyrite is clearly later than the molybdenite. Massive pyrite surrounds breccia fragments of molybdenite-bearing quartz, and small pyrite veinlets cut across molybdenite seams.

The Molly vein consists of coarse vitreous to milky quartz that contains veinlets and small lenticular masses of moderately fine-grained molybdenite. The footwall side of the quartz vein has been brecciated and recemented by coarse-grained massive pyrite, which makes up 50 to 80 percent of this zone. At 390 feet east of the crosscut tunnel the vein is well exposed and shows a typical cross section. On the hanging wall there is 1½ feet of molybdenite-bearing quartz. Next to this is a 2- to 3-inch zone of almost solid pyrite containing small fragments of the quartz. Bordering this is a 6-inch seam of molybdenite and quartz, then 3 feet of breccia of wall rock and quartz, which contains both pyrite and molybdenite, cemented by gouge. There is 1 to 2 inches of gouge on the hanging wall.

At 110 feet west of the crosscut the Molly vein is cut by a postmineral fault that strikes N. 16° W. and dips steeply to the east. Slickensides on the wall of this fault dip 58° S., and the drag on the Molly vein indicates that the west side moved up and to the north, but the vein is displaced 10 feet to the south and on the west side. To the west of this fault the Molly vein turns to S. 85° W. and is rather barren. At the west breast of the drift the vein is merely a 3-foot shear zone containing pyrite seams.

According to Worcester[55] the molybdenum ore mined from the Bon Ton mine assayed 1 to 3 percent MoS_2. The vein is said to average $5 in gold to the ton, but assays made in 1932 gave only 60 cents in gold to the ton for the full width.

[54]Worcester, P. G., Molybdenum deposits of Colorado: Colorado Geol. Survey Bull. 14, p. 60, 1919.

[55]Worcester, P. G., op. cit.

Molybdenite

The Molybdenite mine is 1,000 feet N. 70° W. of the Bon Ton. The workings consists of a crosscut tunnel running N. 33° W. for 140 feet and a drift on the vein 85 feet long. A few shipments of molybdenum ore were made from this property during the World War, but there has been little development since.

The country rock consists of granite gneiss containing small lenticular areas of schist. The schist strikes N. 60° W. and dips vertically. The ore minerals are molybdenite and pyrite in a gangue of quartz.

The Molybdenite vein strikes N. 78° W. and dips 57°-60° S. It may continue east far enough to join the Molly vein, but it could not be traced because of cover. The vein ranges in width from a few inches to 1½ feet and consists of vitreous quartz containing molybdenite, which is abundant in places and scarce in others. Near the west breast of the drift the vein splits into a series of quartz stringers in schist and is finally cut off by a N. 36° W. fault that dips 31° NE.

According to Worcester[56] the vein averages 4 feet in width on the surface and dips 45° S., but "this vein proved to be very disappointing when it was prospected at some depth."

Iron Deposits

Cumberland

The Cumberland mine is on Gold Hill, 4 miles south of Tincup, half a mile south of the Jimmy Mack, and just east of the road. It is opened by a tunnel more than 97 feet long. The Colorado Mining Directory for 1883[57] gave the following information: The ore body is a blanket deposit in limestone, 38 feet thick. It consists of magnetite and red hematite, contains considerable gangue, and assays 64 per-

[56] Worcester, P. G., op. cit., p. 61.

[57] Corregan, R. A., and Lingane, D. F., op. cit., p. 327.

cent of iron, with 6 ounces of silver and 2 ounces of gold to the ton. In 1883[58] the mine produced 530 tons of ore, which had a value of $13,250.

M. C. R. R.

The M. C. R. R. mine is in the vicinity of the Cumberland. Buchard[59] in 1883 gave the following data: The mine is entirely in porphyry. The ore body is a "dike" of solid "iron" 17 feet wide, which crops out along the surface for 84 feet. It consists of very pure hematite, which runs 65 to 78 percent of iron and 8 to 12 ounces of silver to the ton.

Mines on Cross Mountain

Gold Bug

The Gold Bug mine is in a hanging valley on the east side of the ridge that runs north from Cross Mountain, about a mile due north of the peak, at an altitude of about 11,450 feet. The deposit was discovered in 1906 or 1907. The workings consist of a shaft on the vein about 300 feet deep and a crosscut tunnel about 400 feet long that cuts the vein 300 feet west of the shaft. Another crosscut tunnel was started 700 feet S. 60° E. of the first and 150 feet below it and was driven for about 300 feet, but it did not reach the vein. All these workings are now caved.

The Gold Bug ore deposit is a fissure vein that strikes about N. 40° E. and is nearly vertical. The vein cuts Cambrian quartzite, Manitou limestone, Harding quartzite, and Fremont limestone on the north limb of the steep syncline. The beds strike N. 70° W. and dip 70° SW. A sill of monzonite porphyry about 30 feet thick lies in the Manitou limestone 70 feet above the Cambrian quartzite. The shaft is in quartzite, and the tunnel is in limestone.

The valuable metals in the Gold Bug are gold and

[58]Burchard, H. C., Report of the Director of the Mint for 1883, p. 308.

[59]Idem, p. 313.

copper. Chalcopyrite is the only primary ore mineral of economic importance, and the gold is apparently associated with it. The oxidized ore shows abundant limonite and considerable malachite. According to Frank Korn, of Tincup, practically all the ore shipped consisted of porous limonitic quartz carrying free gold.

The ore on the dumps indicates a quartz vein from a few inches to 2 feet wide. The primary ore consists of sugary to medium coarse-grained vitreous quartz containing abundant chalcopyrite in irregular masses and veinlets. The chalcopyrite is surrounded and seamed with limonite, and malachite fills cracks and cavities. The oxidized ore consists of granular porous quartz containing abundant limonite in soft yellow or hard brown masses. On the shaft dump there is quartzite breccia cemented with quartz and some quartzite containing chalcopyrite.

Wahl

The Wahl lode is on the east side of Cross Mountain about a quarter of a mile east of the peak, at an altitude of 12,200 feet. It was named after C. H. Wahl, now deceased. The lode was discovered by Charley Gorman in 1891, and the first ore was packed out by burros to Ohio City. In 1895 an amalgamation mill was constructed near Lottis Creek, and this operated until 1896. The workings consists of three tunnels in the mountain side 100 feet apart, which run S. 15° W., S. 85° W., and S. 30° W.

The ore body is a blanket replacement deposit in the Fremont limestone at its contact with the overlying "Fairview shale." which here consists of shaly thin-bedded limestones. At 10 feet above the top of the Fremont limestone there is a 10-foot sill of hornblende monzonite porphyry. The beds strike N. 35° W. and dip 20° NE.

Gold is the chief metal produced, but there is some copper. The gold occurs free, and, according to Frank Korn, some of it was coarse enough to be visible. The ore is all oxidized, but in some specimens small spots of pyrite and chalcopyrite can be seen. The secondary ore minerals are limonite and malachite. Quartz is the chief gangue, but there is some calcite.

The Wahl lode consists of a group of small, flat, lenticular ore pockets in the Fremont limestone. The entire lode extends for about 700 feet up the dip, according to Frank Korn, and for about 350 feet along the strike.

The middle tunnel is accessible for 50 feet and gives a good picture of the character of the lode. The tunnel shows several small ore pockets, grouped along a fracture that strikes N. 10° W. and dips 70° W. These pockets are 10 to 15 feet long, 3 to 6 feet wide, and 1½ to 3 feet thick. Apparently the fracture served as a channel for ore-forming solutions, and the shales and porphyry served as a dam, thus causing deposition in the Fremont limestone. There are probably numerous other north-south fractures in the Wahl lode, and many of the ore bodies are probably larger than those described, for the other dumps are much larger.

The ore piles on the dumps closely resemble piles of coke or clinkers. The ore consists of finely cellular quartz that contains abundant black and brown limonite. This is coated with bluish-black manganese oxide. Mixed with the quartz are large masses of hard dark-brown limonite and almost black siderite. A few specimens showed small residual cores of pyrite and chalcopyrite in limonite. Malachite fills cavities in some of the cellular quartz. White calcite, later than the ore, coats some of the cavities in the quartz.

According to Eric Norloff, of Tincup, much of the ore of the Wahl lode was of very high grade.

Future Possibilities

The ore deposits of the Tincup district are very similar in character and composition to those of the Leadville[60] and

[60] Emmons, S. F., Irving, J. D., and Loughlin, G. F., op. cit., pp. 187-272.

Aspen[61] districts, 25 to 30 miles to the north. In each of these districts the chief production has come from lead-silver blanket deposits that occur along certain bedding planes in the Paleozoic sediments at their contact with prominent pre-ore faults. The chief difference between the Tincup district and the larger districts is in the extent and amount of faulting. In the Leadville and Aspen districts there are networks of strong pre-ore faults, which are of great extent and in many places form wide broken zones. These faults furnished large trunk channels for the free circulation of the ore solutions and were undoubtedly important factors in the concentration of ore in large bodies. In the Tincup district the faults and fractures in general are of small extent and displacement and do not appear to form any extensive network. Thus the circulation of ore solutions was confined to narrow channels, and the resulting deposits were small compared with those of the Leadville and Aspen districts. Because of this difference in structural conditions it seems probable that the Tincup district will always be a small district and that there is little possibility of finding ore bodies much larger than those already exploited.

However, there is a distinct possibility of finding new ore bodies in the Tincup district comparable to those already exploited. In some of the larger mines, such as the Gold Cup and the Tincup group, there has apparently been no exploration of the lower potential ore horizons (horizons 1, 2, and 3 as listed on pages 566-7. It is possible that ore may have been formed at some of these lower horizons along the fault fissures that influenced the formation of ore bodies at the upper horizons. There is also the possibility of finding new ore bodies at favorable horizons along fault fissures that have remained undiscovered or have not shown evidence of being associated with ore bodies.

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[61]Spurr, J. E., Geology of the Aspen mining district, Colo.: U. S. Geol. Survey Mon. 31, pp. 224-236, 1898. Knopf, Adolph, Recent developments in the Aspen district, Colo.: U. S. Geol. Survey Bull. 785, pp. 14-24, 1926. Vanderwilt, J. W., Revision of structure and stratigraphy of the Aspen district, Colorado, and its bearing on the ore deposits: Econ. Geol. Vol. 30, pp. 223-41, May, 1935.

The West Gold Hill ore body apparently showed no surface indication of its existence and the faults with which it was associated were apparently inconspicuous. It is probable that a careful survey of the district will uncover numerous pre-ore fault fissures which at present are unknown or little understood but which may be associated with ore bodies at favorable horizons beneath the surface. Thus future exploration in the Tincup district may be carried on along two lines—(1) exploration of lower favorable horizons along fault fissures known to be associated with ore bodies in upper horizons; (2) exploration for additional pre-ore fault fissures and along known fissures that show no surface indication of ore but may contain ore at favorable horizons at depth. In this exploration diamond drilling and geophysical prospecting would undoubtedly be of considerable aid.

The future possibilities of the molybdenum-tungsten veins depend largely on metallurgical treatment and on market conditions. The tungsten minerals in these veins seem to be scarce, but molybdenite is consistently present. There seem to be numerous molybdenum veins on the western part of the crest of Gold Hill that as yet have been little explored. Also these veins appear to occupy some of the most extensive fault fissures in the district. If the mining and metallurgical problems could be worked out so as to compete against other producers the Tincup deposits could produce an important quantity of molybdenum.