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COPPER ORES OF THE LA PLATA DISTRICT, COLORADO, AND THEIR PLATINUM CONTENT

by

EDWIN B. ECKEL[2]

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ILLUSTRATIONS

[1]Published by permission of the Director, Geological Survey, United States Department of the Interior, of the Colorado State Geological Survey Board, and of the Colorado Metal Mining Fund.

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Abstract

Small but appreciable amounts of platinum and palladium have been discovered in random samples of disseminated chalcopyrite ore from the Copper Hill mine, one-half mile west of the town of La Plata. The area described here is characterized by the presence of one monzonite and two syenite stocks. The rocks that surround these stocks comprise most of the sedimentary formations that occur in the district. In addition, there are many bodies of diorite-monzonite porphyry, some of them very large.

Between 1911 and 1917 the Copper Hill mine shipped to the Durango (Colo.) smelter 2,336 tons of crude ore, which carried 4,478 ounces of silver and 223,865 pounds of copper. All of the ore was taken from a small glory hole. A long tunnel was driven at a lower level, but no ore was taken from it.

The deposit is situated near the edge of the larger syenite stock in a metamorphic rock composed essentially of alkali feldspars and augite. Chalcopyrite, hematite, magnetite, and some pyrite are disseminated throughout the rock and also occur as veins that reach a maximum observed width of about 2 inches. Oxidized minerals are rare. Gangue is subordinate to metallic minerals in the veins and is made up chiefly of garnet, ankerite, fluorite, and quartz.

The results of assays of two random samples of ore from the Copper Hill dump relatively high in chalcopyrite are summarized. In addition to copper, they contain appreciable quantities of platinum, palladium, and silver. The gold content is very small, and osmium, iridium, rhodium, and ruthenium are present only in negligible quantities. Any statement as to tenor of the ore in place is highly speculative, since no representative samples were taken. Careful consideration of all known factors makes it seem possible that the ore in place will be found to contain valuable metals in something like the following order of abundance:

Copper	2 to 4 percent
Platinum	0.02 to 0.06 ounce per ton
Palladium	0.02 to 0.04 " " "
Silver	0.14 to 0.76 " " "

The deposit is evidently not a bonanza, but provided a large body of ore of the tenor shown here can be developed, it should be workable under favorable conditions. It is impossible to make reliable estimates of the extent or shape of the Copper Hill deposit. Much of the area is covered by glacial debris and exposures are poor in general. Logical reasoning indicates, however, that a large area in the vicinity of the Copper Hill mine may be worthy of rather intensive exploration.

In addition to the Copper Hill deposit, several other low-grade copper deposits are described. None of them is known to contain platinum metals and all of those described contain less copper than the one on Copper Hill. Geologic conditions are so similar, however, and exposures are so poor that all of the rock in and near the syenite stocks seems to warrant further prospecting.

Introduction

Small but determinable amounts of palladium and platinum were recently discovered in certain disseminated copper ores during a resurvey of the La Plata mining district in southwestern Colorado. Early in the field work vague rumors were encountered that these metals were present in the area, but it is not known that they had been recognized. Present data are insufficient to provide a basis for definite statements as to the possible commercial value of the deposits. They indicate clearly, however, that a comparatively large area in the district is worthy of prospecting. It is believed that the interests of the public will be best served by immediate publication of the data in hand, rather than by waiting until the full report on the district is completed.

Deposits of gold and silver were first discovered in the La Plata (or California) mining district in 1873. From 1873 through 1937 the mines have produced $5,766,992, according to records of the Bureau of Mines. In terms of recovered metals the production has been as follows:[3]

Gold, fine ounces	202,898.45
Silver, fine ounces	2,021.286
Copper, pounds	283,876
Lead, pounds	736,183

It is a pleasure to acknowledge the invaluable advice of A. C. Spencer, who was associated with the party during the 1936 and 1937 field seasons. Others who took part in the field work in the district, but who played little direct part in the study of the deposits described here, were F. W. Galbraith, R. S. Moehlman, V. H. Steele, and J. S. Williams. E. T. Erickson, of the U. S. Geological Survey's chemical staff, deserves credit for the actual discovery of platinum metals in samples of ore originally submitted to him for assay of the gold and silver content and for much painstaking work in the quantitative determination of the precious metals.

[3]Henderson, C. W., personal communication.

GEOGRAPHY

The La Plata district lies within the La Plata Mountains and includes parts of La Plata and Montezuma Counties (fig. 1). The principal known copper deposits, one of which has been found to contain platinum metals, are situated on the west side of the La Plata River, between the town of La Plata and the divide between the East Mancos and La Plata drainage systems (fig. 2). None of the deposits is accessible by road but nearly all of them can be reached by good trails. Hesperus, 8½ miles from La Plata and 16 miles from Durango, is the nearest shipping point on the Rio Grande Southern Railway, a narrow gage line which connects with the Denver & Rio Grande Western Railway, also narrow gage, at Durango. A spur line, unused for many years, connects May Day, at the mouth of the La Plata Canyon, with the main line. Most of the ores shipped from the district in recent years have been carried by truck to Durango, 21 miles from the town of La Plata over present

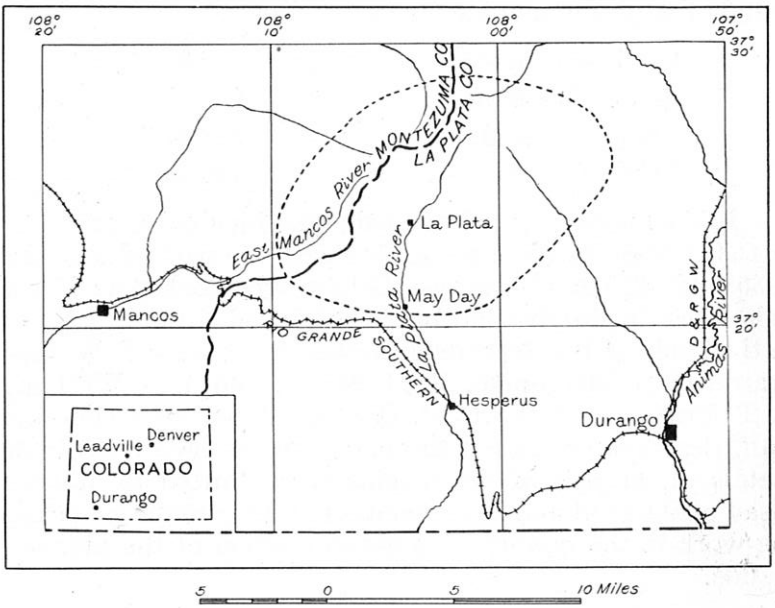

Figure 1.—Index map, showing location and extent of the La Plata district.

roads. A power line runs from Hesperus to the Gold King Mill, 1½ miles above La Plata. Coal is obtainable from mines at Hesperus.

As shown in figures 2 and 3, the district is characterized by comparatively gentle and accessible slopes near the La Plata River and extremely rugged and steep slopes near the headwaters of the tributary streams. The river is 9,200 feet above sea level at La Plata; the lowest points on the divide at the heads of the creeks are nearly 12,000 feet.

The climate is rigorous, and like that of other southwestern Colorado mining camps at similar altitudes. Boren, Bedrock, and nearby creeks are small streams, and it is probable that none of them could supply sufficient water

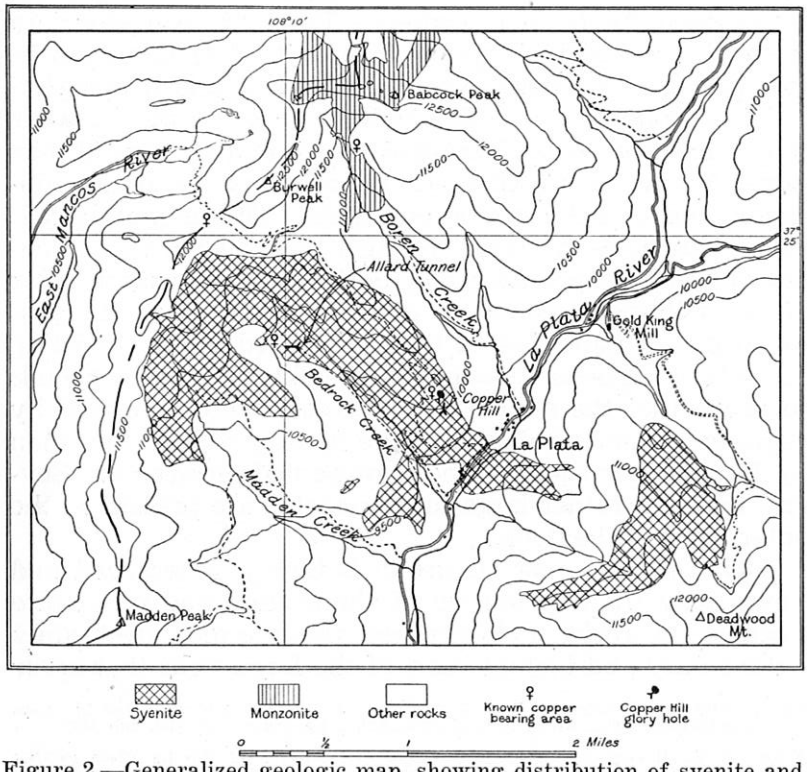

Figure 2.—Generalized geologic map, showing distribution of syenite and of the principal known copper deposits, some of which are known to contain platinum metals.

for large milling operations. The La Plata River is a perennial stream and except for two or three months during the winter it commonly has a flow of several second-feet of water. A large part of the area is heavily timbered (fig. 3). Aspen is most abundant, but spruce is plentiful in places.

GENERAL GEOLOGY

The geology and ore deposits of the district have been briefly described by Cross[4] and by Eckel.[5] The La Plata Mountains have been carved from a domal uplift of sedimentary rocks that were intruded by numerous stocks, dikes, and sills of igneous rock. In general, the strata dip away from the central higher areas. The sedimentary rocks are much altered in the central part of the district, but are essentially fresh elsewhere. The igneous rocks vary widely in composition and in form but all of them can be grouped in two general types—porphyritic and nonporphyritic. Porphyry, most of which is intermediate between diorite and monzonite in composition, is more abundant than any other igneous rock type. It occurs as essentially contemporaneous sills, stocks, and dikes. The nonporphyritic rocks, which are in general younger than the porphyry, consist of syenite, monzonite, and diorite and occur as irregular stocks with many associated dikes. These bodies cut across all formations and few of them disturbed the pre-existing attitude of the beds. A summary of field evidence that tends to prove that the nonporphyritic rocks were emplaced by replacement or assimilation of the country rocks rather than by forcible intrusion has been presented elsewhere.[6] Several faults of rather large displacements are present in the outer parts of the dome.

The geologic map, figure 2, is highly generalized and shows only the distribution of the syenite and monzonite stocks. The rocks that surround these bodies are mainly sedimentary and include most of the formations that occur

[4]Cross, Whitman, Spencer, A. C., and Purington, C. W., Description of the La Plata quadrangle, Colo.: Geol. Survey Geol. Atlas, La Plata folio (no. 60), 1899.

[5]Eckel, E. B., Resurvey of the geology and ore deposits of the La Plata mining district, Colo. (prelim. rept.): Colorado Sci. Soc. Proc., vol. 13, no. 9, pp. 508-546, 1936.

[6]Eckel, E. B., Mode of igneous intrusion in La Plata Mountains, Colo.: Am. Geophys. Union Trans., 18th Ann. Meeting, pp. 258-260, 1937.

Figure 3.—Copper Hill and vicinity from a ridge east of La Plata. The chief known platinum-bearing copper deposit is situated on the lower part of Copper Hill, just below where it bends sharply to the left. Bedrock Creek is on the extreme left; Boren Creek is to right of the center. The highest point on the divide is Babcock Peak.

in the La Plata district. Many bodies of diorite-monzonite porphyry, some of them very large, are associated with the sedimentary strata. None of the porphyry bodies are shown on figure 2, however, as their distinction from the sedimentary rocks has no practical bearing on the present subject. The details of the areal geology are better shown on the map that accompanied the preliminary report.[7] It should be noted, however, that, as a result of further field studies, some of the rocks shown on that map, notably the "porphyry" at the head of Bedrock and Madden Creeks, and the "diorite" on the ridge between those streams, have now been grouped with the syenite.

The syenite is altered in many places, and this fact, together with poor exposures and varying degrees of replacement of the intruded rocks, make its relation to other rocks obscure and difficult to map. It is rarely possible to find two specimens of syenite that possess the same appearance or texture. In general the rock is gray or pinkish and crystalline. It is sufficiently different from other igneous rocks to make it possible to distinguish it and map it separately in most places, although elsewhere there seem to be almost insensible gradations that make accurate mapping impossible. Alkali feldspars predominate in most of the rock classed as syenite. Augite is the chief dark mineral and is locally very abundant. Quartz is present in very small amounts throughout the rock.

Ore Deposits

Copper Hill mine

Location and history.—The Copper Hill mine, which explores the only known platinum-bearing deposit, is situated on the ridge between Boren and Bedrock Creeks at an altitude of about 10,250 feet. Several good horseback trails and an abandoned wagon road connect the workings with the town of La Plata, one-half mile distant. There are no patented claims on the hill but some of the ground is covered by unpatented claims, the names of which are not known.

[7]Eckel, E. B., op. cit., pl. 1.

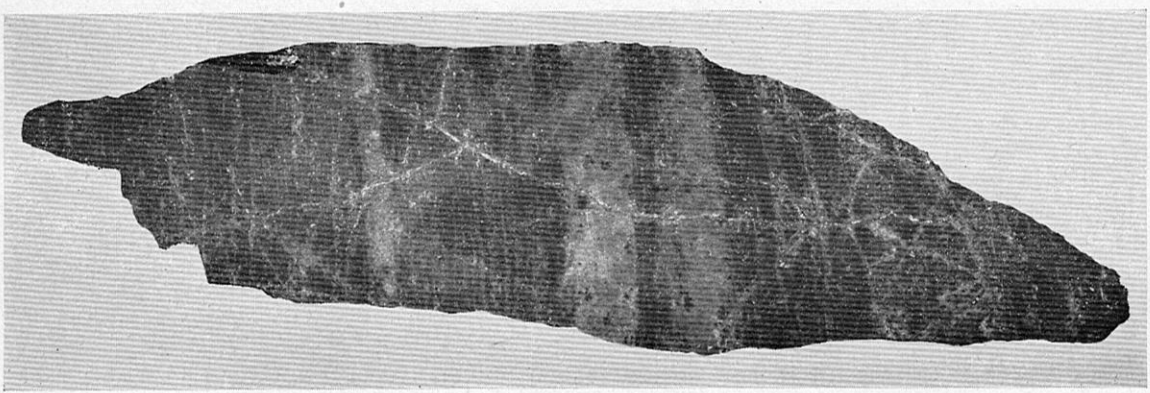

Figure 4.—Polished slab of low-grade copper-bearing metamorphic rock from Copper Hill glory hole. The veins are largely chalcopyrite, as are the disseminated white grains. Two-thirds natural size.

Little is known of the history of the mine. As early as 1902, two claims, the Gold Eagle and the Deleware, had been located in the vicinity of the present mine but no production has been recorded. The Copper Hill mine was worked by the Copper Hill Mining Co. from 1911 through 1917, and considerable copper ore was produced. Thereafter, it apparently remained idle until some time between 1927 and 1932, when the La Plata Mines Co., operators of the Gold King mine, took up a large group of claims on Copper Hill. This company erected a steam power plant at the mouth of Bedrock Creek, designed to supply part of the power for both the Copper Hill and Gold King workings. Part of the machinery has since been removed but some of it was still in a good state of repair in 1937. This company did some development work on Copper Hill but produced no ore.

Development and production.—The chief mine workings consist of a small glory hole and a 600-foot tunnel. The location of the glory hole is shown on figure 2. It is a rudely oval open pit, roughly 50 by 75 feet in greatest dimensions and 30 to 50 feet deep. The flat floor of the pit is about 150 feet below the crest of the ridge. Short tunnels have been driven at different altitudes into the walls of the pit in several places. Ore was removed from the pit through a tunnel about 75 feet long at the altitude of the pit floor.

Between 500 and 700 feet southeast of the open pit, and 250 feet lower, there is a tunnel which was evidently intended to serve as a low level haulage way for ore from the glory hole. The tunnel trends N. 80° E. for about 255 feet, where it turns to N. 10° E. and continues a distance of about 365 feet. A raise of unknown height, fitted with an ore chute, is 120 feet from the breast. About 700 feet east of the glory hole there are several caved tunnels, which may possibly have been located on the old Deleware claim. They are not shown on figure 2. In addition to the workings described above, there are several short adits, most of which are caved, and a few small open cuts scattered over the hill.

The recorded production of the Copper Hill mine is as follows.[8]

[8]Henderson, C. W., personal communication.

Production of Copper Hill mine

(Smelting ore in terms of original content)

Year	Ore (dry tons)	Gold (fine ounces)	Silver (fine ounces)	Copper (wet assay) (pounds)
1911	464	.....	1,271	73,133
1912	36	11.62	54	82
1913	1,347	.....	2,468	110,602
1914	235	0.18	295	13,503
1915-16	No production			
1917	254	0.46	390	26,545
Totals	2,336	12.26	4,478	223,865

Geologic features and ore deposits.—The deposit is situated within the larger syenite stock near its northeast border, as shown on figure 2. The geologic features are in large part obscured by moderately heavy timber and by soil, talus, and glacial debris, which covers most of the hill. As seen in the excellent exposures afforded by the glory hole, the host rock is not normal syenite but a dark, greenish brown to gray, massive metamorphic rock that resulted from partial replacement of sedimentary rocks by syenite. It is hard and tough, with a somewhat greasy luster, and in places shows distinct layering (fig. 4). The rock is composed of rather distinct layers of finely to coarsely crystalline feldspar which alternate with layers of augite that occurs as small bladed crystals. Grains and crystals of quartz, apatite, and titanite occur in subordinate amount, but all are much more abundant than in the more typical syenite.

Small irregular grains and masses of chalcopyrite, specular hematite, and magnetite are abundantly disseminated through the rock. Chalcopyrite is much more abundant than hematite or magnetite. In addition to the disseminated metallic minerals, the rock is cut by innumerable closely-spaced veinlets. These trend in all directions but the dominant trend seems to range from north to northeast. The veinlets range in width from mere irregular films to elongated lenses that are more than 2 inches wide in places. They are composed in large part of chalcopyrite but in places hematite, magnetite, and pyrite are intimately inter-

grown with the chalcopyrite. Microscopic examination of a few polished specimens indicates that the iron oxides are the oldest of the metallic minerals, and were followed by pyrite. Chalcopyrite was the latest ore mineral to form.

In the veins nonmetallic minerals are much less abundant than metallic minerals. Garnet, ankerite, and some quartz are the chief gangue minerals. A little fluorite is present locally.

The deposits have undergone only slight oxidation. Thin green and blue films of malachite and azurite and veinlets of hydrous iron oxide, or limonite, are the chief products of weathering.

Microscopic examination of a few polished sections of ore rich in chalcopyrite, made by F. W. Galbraith and the writer, has failed to disclose the mode of occurrence of the platinum group of metals. They may exist in solid solution in the chalcopyrite or they may form discrete particles intergrown with the chalcopyrite or with the iron oxide minerals.

Tenor of Copper Hill ore.—The tenor of the ore shipped from the Copper Hill mine, calculated from the figures cited above, is shown in the following table. The character of the gold ore shipped in 1912 was obviously different from that of the copper ore produced in other years and is not included in this table.

Tenor of crude ore shipped from Copper Hill mine

Year	Silver (oz. per ton)	Copper (percent) (wet assay)	Ratio by weight Silver : Copper
1911	2.74	7.9	1:887
1913	1.83	4.1	1:653
1914	1.25	2.9	1:665
1917	1.54	5.2	1:982

The ratio of silver to copper by weight in the ore shipped was of the same order of magnitude for each of the four years of record, and averaged 1.97 ounces of silver to 4.8 percent copper.

During this investigation, a sample of relatively high-grade chalcopyrite ore from the Copper Hill dump was submitted to E. T. Erickson for assay determination of gold and silver. Cupellation yielded a metallic button that had the characteristics of one that contained metals of the platinum group, that is, the button had a peculiar frosted appearance and showed a tendency to flatten out toward the close of cupellation. The determination of gold and silver in this button by special methods left a balance that was at first thought to represent platinum metals. Platinum was identified but the content of platinum indicated by difference was later found to be too high, owing to the fact that cupellation had failed to remove all of the lead from the button. This behavior is characteristic of buttons that contain relatively high proportions of the platinum group of metals. Spectrographic examination of this sample by George Steiger, of the Survey laboratory, however, confirmed the presence of platinum and also showed the presence of palladium.

Although samples representative of the dump as a whole had not been collected, the same material mentioned above and a second large sample from the same dump were studied further. The second sample consisted of many small pieces and chips of ore that contained comparatively large amounts of chalcopyrite and probably fairly represents the better grade of copper ore that could be recovered by careful hand sorting. Copper was determined in the usual way. in a separate assay, silver was separated as silver chloride from the other constituents that remained after cupellation, and was reduced to a button and weighed as metallic silver. Gold was removed by solution of its chlorides in ethyl acetate, and found to be about 0.01 ounce per ton.

For determination of the platinum metals, separate samples were assayed in the regular way, except that they were scorified to lower the copper content. For cupellation, 3 milligrams of silver was added. The final button was heated for a long time in aqua regia. The silver was removed by precipitation as chloride, and any remaining silver chloride that separated from the combined filtrates overnight was also filtered off. The filtrate, worked down to a

very dilute hydrochloric acid solution, was yellow, indicating platinum metals of the order of some tenths of an ounce per ton. Palladium was determined by precipitation with dimethylglyoxine under control conditions in which the effect of platinum would be eliminated. Platinum metals were then precipitated by formic acid and ammonium formate and platinum was determined colorometrically. By separate assay, the other metals of the platinum group—osmium, iridium, rhodium, and ruthenium—were determined to be present only in negligible quantities. The results of the determinations are summarized below.

ASSAYS OF SELECTED SAMPLES RICH IN CHALCOPYRITE FROM COPPER HILL MINE DUMP

[E. T. Erickson, analyst]

Sample no.	Copper (percent)	Platinum (ounces per ton)	Palladium (ounces per ton)	Gold (ounces per ton)	Silver (ounces per ton)
1	17.66	0.24	0.30[1]	0.04[2]	1.21
2	13.1	0.14	0.12[3]	0.01	2.52

[1]Platinum and palladium determined on one-half assay ton sample.
[2]Maximum, possibly considerably too high.
[3]Platinum and palladium determined on 1 assay ton sample.

Thus far, no confident statement as to the tenor of the ore in place can be made as representative samples have not yet been taken. In order to form tentative conclusions, the following observations can be brought to bear on the problem:

(1) Direct estimate of copper content of ore now exposed in the glory hole.

(2) Comparison of ore in place with samples taken from dump for assay.

(3) Comparison of exposed ore with that exposed in the Allard tunnel. As described below, it is reliably reported to contain an average of 0.8 percent copper.

(4) The ore mined from 1911 through 1917 was hand sorted over a grizzly and shipped crude. The concentration ratio was probably not much more than 2:1.

Careful consideration of all the above factors make it seem highly probable that the ore now exposed in the Copper Hill glory hole will be found to range from 2 to 4 per-

cent copper. If this is true, and if the ratio of platinum metals to copper falls within the range indicated by available determinations, then it seems possible that the crude ore in place will be found to contain valuable metals in about the following order of abundance:

ESTIMATED TENOR OF COPPER HILL CRUDE ORE IN PLACE

Copper	2 to 4 percent
Platinum	.02 to .06 ounce per ton
Palladium	.02 to .04 ounce per ton
Silver	.14 to .76 ounce per ton

A brief examination of the lower tunnel south of the glory hole shows that the entire length traverses metamorphic rock like that at the upper workings. The rock contains much disseminated chalcopyrite and some pyrite but the average copper content is probably considerably lower than that at the glory hole. No samples were available for determination of copper or platinum metals.

Possible extent of Copper Hill deposits.—Conditions are such that it is impossible to make reliable estimates of the extent or shape of the Copper Hill deposit. The glory hole workings show that the ore body of better grade is at least 150 feet in diameter and 50 feet deep. The tunnel southeast of the glory hole shows that ore of the same type but of probably lower grade covers a much larger area and extends to considerably greater depths. Only intensive exploration can serve to reveal whether the ore beneath the glory hole is richer or leaner.

OTHER COPPER DEPOSITS

In addition to the deposit on Copper Hill, which is known to contain metals of the platinum group, chalcopyrite is widely distributed in the central part of the La Plata district. Every specimen collected during this investigation from the two syenite stocks contains a little chalcopyrite, which is present in disseminated grains or as threadlike veinlets. In several areas chalcopyrite is relatively abun-

dant. Available scanty data indicate that these deposits contain little or no platinum and less copper than the Copper Hill deposit. They resemble it in many respects, however, and thus appear to warrant further examination.

Deposits on Bedrock Creek

General relations.—Except near its mouth, the rocks along the lower parts of Bedrock Creek are poorly exposed and there is little available information regarding possible ore deposits. Scattered exposures and a few short tunnels serve to indicate that the creek is crossed by several fairly strong shear zones that trend from north to northeast. Veins of quartz, with pyrite, chalcopyrite, and galena, occupy fissures in some of the zones. The two caved tunnels 700 feet east of the Copper Hill glory hole were apparently driven to explore the northward extension of one of these veins.

Near the headwaters of the creek, between the Allard tunnel and the divide (fig. 2), there is a large area that appears to be worthy of further prospecting for disseminated copper deposits.[9] The area was more or less thoroughly prospected for gold deposits in the early days of the district and many claims were staked. The results of prospecting were not encouraging, however, and there has been no activity for several years. Apparently in 1937, all of the ground was open for location with the exception of the patented Copper Age claim.

Allard tunnel and vicinity.—The Allard tunnel provides a good exposure of the rocks and ores on Bedrock Creek, which are described below. The tunnel is situated near the bank of a tributary of Bedrock Creek at an altitude of about 10,250 feet. An abandoned wagon road of uniform grade connects the workings with La Plata, 1¼ miles to the east. The tunnel was driven prior to 1921 on an unpatented claim by the Allard Mining Co. No ore was ever produced. The main tunnel extends 740 feet in a N.31°W. direction. Five hundred feet from the portal a side drift trends S.74°W. for a distance of 100 feet, where it turns to N.45°W. and continues 90 feet.

[9]Toll, R. H., La Plata Mountains, Colo.: Mining and Sci. Press, vol. 97, p. 744, 1908.

Geologic features and ore deposits.—Between the Allard tunnel and the divide the slopes are rugged and in general exposures are better than in most other parts of the district. The bedrock is completely bare over large areas near the tunnel.

Most of the rock exposed is somewhat porphyritic and is easily mistaken for diorite-monzonite porphyry. Near the borders of the syenite stock the intruded sedimentary rocks are strongly brecciated in places. Elsewhere the contact is vague and indistinct, largely because of incomplete replacement of country rock by syenite. Much of the syenite contains fragments of sedimentary rock.

Pyrite and chalcopyrite are widely disseminated through the syenite. In addition, the rock near the Allard workings is traversed by innumerable veins and dikes. They trend and dip in all directions but many of the strongest trend from northeast to east and dip steeply. The most impressive veins or dikes consist of coarsely bladed dark-green augite, intergrown with feldspar (microcline). Coarsely crystalline calcite, white to clear crystalline quartz, and blue chalcedony fill the central parts of many of the veins. Considerable chalcopyrite and some pyrite occur in irregular masses interstitial to the nonmetallic minerals. Individual veins range from less than an inch to 2 feet or more in width. Many of them can be traced for several hundred feet; others pinch out within short distances. The largest composite vein or dike seen is 15 feet wide and consists of seven alternating bands of medium-grained syenite and of coarsely crystalline feldspar and augite. Those of medium-grained syenite are from 6 inches to 3 feet wide and are cut by many small quartz veins, most of which contain chalcopyrite. Individual crystals of feldspar and augite in the coarse-grained bands range from less than ½ inch to more than 6 inches in length. The coarse-grained zones contain much quartz, chalcedony, calcite, chalcopyrite, and some pyrite.

In addition to the dikelike bodies described above, there are many quartz veins that contain chalcopyrite and pyrite. There are also numerous discontinuous veins of fluorite,

which range from one-sixteenth inch to 5 inches in thickness and are made up almost wholly of dense, siliceous fluorite, intergrown with more or less coarsely crystalline quartz. Freshly broken fluorite is dark-blue to purple but it weathers to pink or magenta shades. Some of it contains a few grains of pyrite. Veins or lenses of galena are reliably reported to occur near the Allard tunnel.

Weathering and oxidation have made more headway near the head of Bedrock Creek than on Copper Hill. Much of the pyrite in the rocks has been altered to limonite and the outcrops are prevailingly red or yellow to brown in color. In places the primary copper minerals have been converted to malachite, azurite, and chrysocolla, and large rock surfaces are coated with films of these green and blue minerals. The Copper Age mine, situated near the present Allard tunnel, exploited a vein rich in red copper oxide, cuprite, and native copper.[10] No cuprite was found in place in 1937, but a few pieces derived from veins one-fourth inch to three-fourths inch wide were found in the stream beds.

Tenor and extent of deposits.—According to R. D. McCausland,[11] who had access to samples from each round while the Allard tunnel was being driven, the average copper content of the rock traversed by this 700-foot tunnel was 0.8 per cent. He further states that a northeasterly-trending zone along the side drift averaged 5 percent copper over a width of 30 feet. The same type of mineralization extends at least 1,500 feet westward from the Allard tunnel and to altitudes of 400 to 500 feet above the portal. It seems probable that the bulk of the rock will be found to have an average copper content near that of the rocks cut by the mine workings. It is to be expected that certain zones may be found to contain much more copper than others.

Five specimens representative of different types of material in and near the Allard tunnel were submitted to Erickson for assay. The character of the specimens was as follows:

[10]Wallace, J. P., La Plata County, in Burchard, H. C., Report of the Director of the Mint, 1883, pp. 368-376, 1884.

[11]McCausland, R. D., personal communication.

Sample No. 3. Nearly pure pyrite.

Sample No. 4. Augite, with a little chalcopyrite and quartz.

Sample No. 5. Nearly pure chalcopyrite.

Sample No. 6. Intergrowth of feldspar, quartz, and fluorite, with some sulphides.

Sample No. 7. Red copper oxide, cuprite.

The samples were treated precisely like those from Copper Hill, noted above. It was found that platinum and palladium, if present, each amount to less than 0.01 ounce per ton.

Deposits at head of Bedrock and Boren Creeks.—Near the crest of the divide, at the head of Bedrock and Boren Creeks, the geologic features and ore deposits are similar in general to those near the Allard tunnel. In places, the rocks contain considerable chalcopyrite, both disseminated and in quartz veins. In most of this area, however, pyrite is much more abundant than chalcopyrite. The area as a whole is, therefore, considerably less attractive than the Copper Hill and Allard deposits.

SUMMARY

The existence of determinable quantities of platinum and palladium in the disseminated copper ores from the Copper Hill mine is shown by results of assays of random samples. It seems clear that the deposit is not a bonanza and will not be amenable to the mining and milling methods heretofore employed in the La Plata district on high-grade telluride ores of gold and silver. If a large deposit of ore whose tenor is comparable to that indicated by the U. S. Geological Survey's investigations can be shown to exist, however, there is reason to believe that large-scale operations might be successful. A large area near the Copper Hill workings is covered with glacial drift, talus, and soil. Scattered exposures indicate that the geologic relations are similar to those near the known deposit, and that exploration, possibly by means of drilling, is therefore worthy of consideration.

The deposits exposed in the vicinity of the Allard tunnel contain less copper than those of Copper Hill, and available data indicate that little or no platinum and palladium are associated with the copper. Nevertheless, the geologic relations are so similar to those on Copper Hill that the deposits appear to deserve thorough study as possible reserves of copper ore. Furthermore, all of the area in and near the syenite stocks is characterized by the presence of small amounts of the copper minerals and it seems possible that other deposits of commercial size and grade may be uncovered by thorough prospecting methods.