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Occurrence of Native Copper Near Jefferson City, Montana

Terence G. Kirkland

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OCCURRENCE OF NATIVE COPPER
NEAR
JEFFERSON CITY, MONTANA

BY
TERENCE G. KIRKLAND

MONTANA SCHOOL OF MINES LIBRARY
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A Thesis

Submitted to the Department of Geology
in Partial Fulfillment of the
Requirements for the Degree of
Bachelor of science in Geological Engineering.

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MAY 15, 1947

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Introduction

Sometime prior to 1870, a group of prospectors made what was believed to be a "rich strike" on one of the tributaries of Prickly Pear Creek in Jefferson County, Montana. After laboriously packing their "fortunes" cross-country to Fort Benton, the nearest shipping point about 120 miles distant, it was discovered that their nuggets were native copper rather than gold. Instead of striking it rich, they had uncovered a native copper deposit, worthless to them because of its limited extent and remote location, but now of much interest to the geologist, and to the mining engineer because of its possible commercial value.

The native copper deposit occurs in the muck which accumulated in a pond produced by a beaver dam across one of the gulches that drains into Beavertown Creek. It lies on the C. J. O'Connell

property, and the gulch was appropriately given the name of Copper Gulch. As shown on Plate 4, the exact location is in Sections 23 and 24, T. 7 N., R. 4 W., in Jefferson County, Montana between Jefferson City and Boulder, and it is about one ^{1/2} mile from U. S. Highway 91.

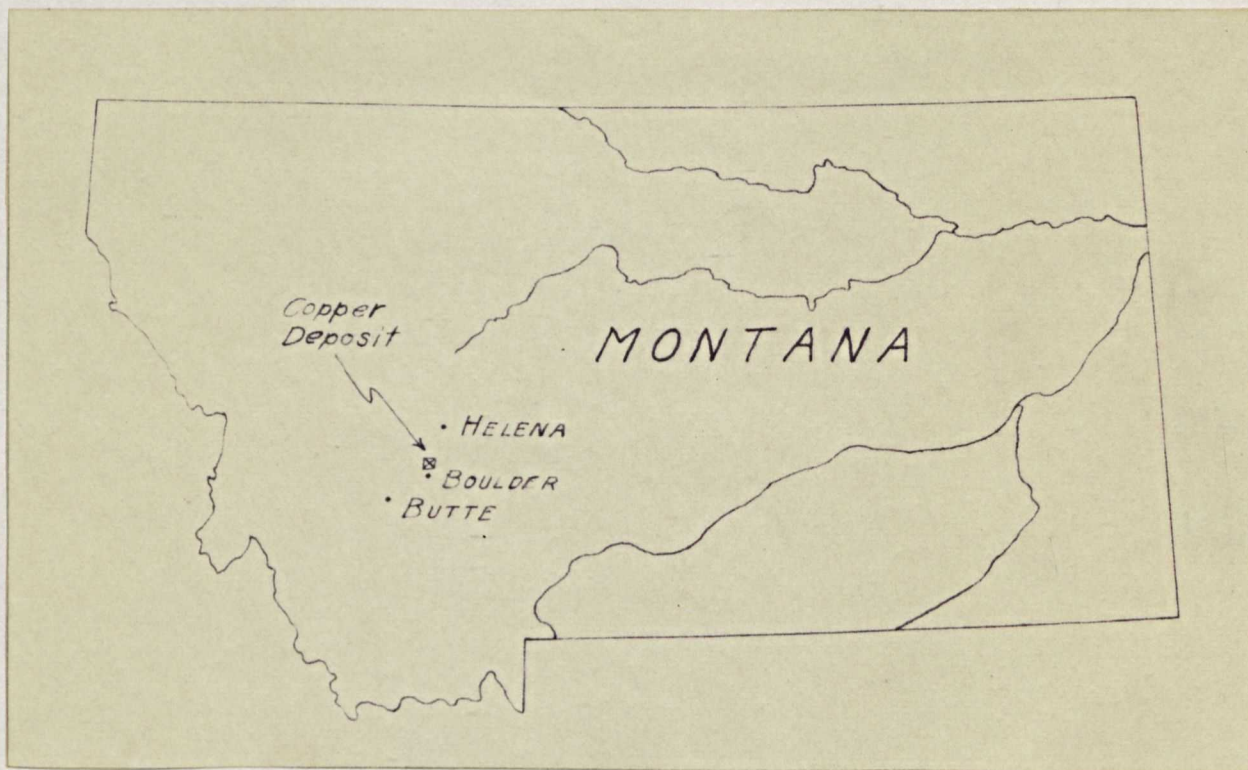


Figure 1. Index map of Montana.

The copper was first brought to the author's attention while looking at a silver deposit near there. The deposit presented many interesting problems as to origin and mode of occurrence; and it looked like a good project for a thesis, one of the requirements

for a Bachelors degree in Geological Engineering at the Montana School of Mines. The solution of some geologic problem through either library, laboratory or field work is required, and the copper deposit brought forth problems in the latter two categories.

Due to the unusual weather that persisted through the fall of 1946, most of the work for this report was accomplished during the spring of 1947.

I wish to express my appreciation to Dr. E. S. Perry and Dr. E. W. Heinrich for their valuable assistance in the laboratory, and in the actual writing of the report. Also the writer appreciates aid given by Clinton L. Miller, Bruce W. Emerson and Tom Manuel in their help in mapping and sampling, and to Mrs. Loretta B. Peck, librarian, for her assistance in finding references. The Erickson family, ranchers in the vicinity of the deposit, were very helpful in giving directions.

History

The early prospectors, who had discovered the deposit during the "gold rush" in Montana, abandoned their "strike" when they discovered no gold was present, but not until after they had driven several tunnels into the peat-like muck, one of which is said to have been over one thousand feet long. In 1886 and 1887 (3), the American Smelting and Refining Company reputedly obtained iron flux from the area for their East Helena smelter, but the amount of mining

was inconsequential.

Mr. O'Connell first became interested in the deposit as a boy, and did quite a bit of work on the property throughout the many years that he was ranching in the area. However there are no records available showing commercial ore shipments, and it is unlikely that any copper was ever marketed.

Mr. J. D. Forrester (3) made a detailed field study of the deposit for the Anaconda Copper Mining Company in 1939. He took auger core samples, both for assay and examination as well as several samples of the water for analysis. His studies consisted of laboratory tests by the potentiometer method. The conclusions reached in this manner were that most of the copper was precipitated by iron oxide, the carbonaceous material having however kept some copper in solution. No action was taken as a result of this report.

During World War II the U. S. Bureau of Mines sampled the deposit; however their report has not been published, and it was not available to the author.

Physiography

The area is one of rugged relief, the elevation ranging from 4500 feet to over 6000 feet within a distance of a mile from the deposit. Timber is quite irregular but plentiful, some of the crests and slopes being heavily timbered where others are bare. The immediate area of the deposit is relatively free of trees and

Plate 1.

- A. View of one of the pits, looking west up the gulch.
- B. View from the portal of the main tunnel, looking west up the gulch.
- C. View of the plane table and alidade, also the shack at the portal of the main tunnel. Snow covered south ridge in background.



A.



B.



C.

Plate 1. Photographs showing physiography of area.

Plate 2.

- A. View of the shack and portal of the main tunnel, looking west
- B. View from the top of one of the ridges near Copper Gulch, looking south.



A.



B.

Plate 2. Photographs showing physiography of area.

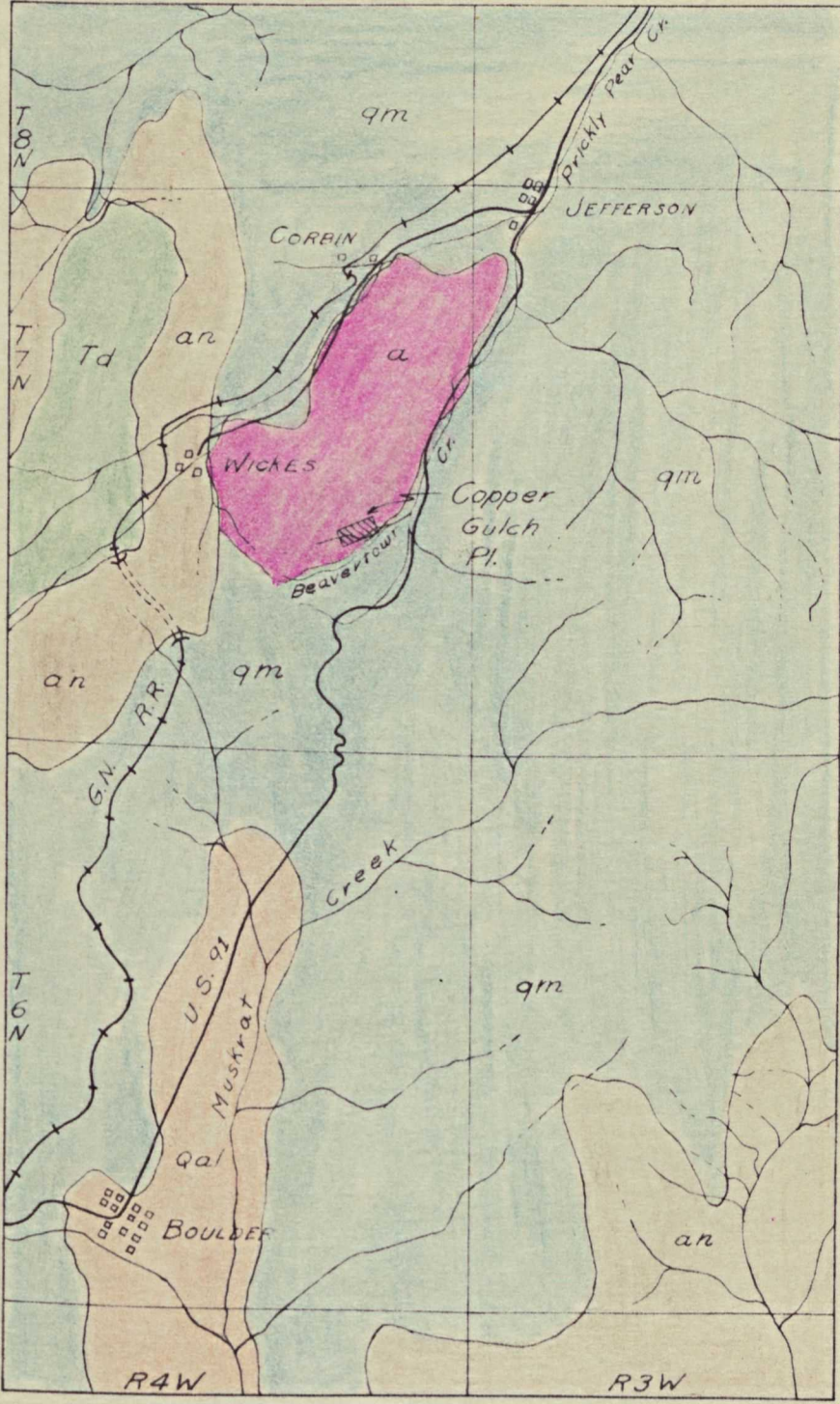
brush, the slopes being covered with bunch grass, and some marsh grass occurs along the creek.

Copper Gulch Creek, whose gradient is about 5 feet per 100 feet, contains running water at the surface only during the spring and fall. Its total length is about 2 miles.

The road leading to and past the deposit is only a trail, but there was no difficulty in traversing it with a pick-up truck. It joins U. S. Highway 91 near the foot of the hill at the head of Beavertown Creek. The region is served by the Great Northern Railroad with stations at Wickes, Jefferson City, and Boulder.

General Geology

The deposit lies in the northern half of the Boulder batholith, a quartz monzonite intrusion of late Cretaceous or early Tertiary age. The quartz monzonite of the batholith has been intruded by late Cretaceous or early Tertiary dacite, aplite and andesite, and locally extrusive phases of these rocks cap the monzonite. Beavertown Creek forms the southeast contact of one of the larger masses of aplite, roughly 2 miles by 5 miles in extent, and Copper Gulch lies in the southwestern half of the aplite mass. This relationship can be seen on Plate 3. The aplite as well as the surrounding quartz monzonite has been cut by small, narrow acidic dikes that are probably related to igneous activity in the highly mineralized Wickes-Corbin mining district which lies along the northwest contact of the aplite 2 miles away.

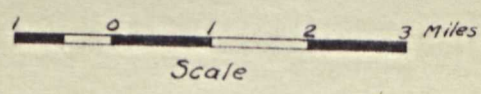


- LEGEND**
- SEDIMENTARY ROCKS**
- qal
Alluvium
- IGNEOUS ROCKS**
- Td
Dacite
 - a
Aplite
 - qm
Quartz Monzonite
 - an
Andesite and Latite Breccias, Tuffs and Lavas

After U.S.G.S. Bull. 527

MAP SHOWING
GENERAL GEOLOGY OF AREA
OF COPPER OCCURRENCE

T.G. KIRKLAND, 1947



Origin and Occurrence of Native Copper

The Lake Superior district affords the most outstanding example of the occurrence of native copper. Although the conditions which brought about the formation of these deposits in no way resemble the conditions responsible for the native copper of the deposit described in this report, they bring forth one of the accepted theories for the deposition of this metal from ascending solutions whereby the action of iron in the form of one of its oxides was a precipitating agent. This action of iron must be accepted as a possible cause of precipitation for this deposit, and will be discussed as such in the report.

Paralleling the Lake Superior deposits are many small deposits of native copper in lavas elsewhere, and they serve to show that deposition of native copper is not too rare a phenomenon.

Among copper deposits considered to be of sedimentary origin are the so-called "red beds" type (1) scattered throughout the United States, given that name because of their common association with red sedimentary rocks of clastic continental origin. However in few of these deposits does the copper occur in the native state, most of it being in the form of bornite, chalcopyrite, covellite, malachite or azurite. These deposits all show association of the copper minerals with compressed and carburized plant remains, in most cases in the form of high rank coal. This brings forth the concept that the presence and state of the carbonaceous material in the sediments may have

something to do with the character of the precipitated minerals.

In the vicinity of Cooke City, Montana is a deposit of native copper quite similar to the deposit north of Boulder. It presents a very interesting study of the precipitation of native copper by organic matter. Again native copper occurs in material accumulated in an ancient bog formed by a beaver dam; and the bog in which the metal was deposited occurs at an abrupt change in stream gradient, with several bodies of pyritic copper ore cropping out above the bog. Most of the material is made up of layers of sand and gravel with a few thin beds of black muck between the coarser sediments, the black muck consisting largely of clay and organic remains. The copper occurs in these interspersed black layers. Mr. T. S. Lovering (4) conducted many experiments on the copper containing material, based on the theory that bacteria caused the precipitation. His experiments, wherein he used both the black clayey muck and introduced bacteria, were successful in producing metallic copper. Although he reached no definite conclusions as to the type of organic matter, he did conclude that the copper was precipitated by the organic remains contained in the black layers.

Description of the Deposit

The surface geology, positions of the old workings, and some of the physiography are shown on Plate 4 which is a detailed map of the area. The mapping was accomplished with a plane table and telescopic alidade using a standard stadia rod for reading distances, elevations were not recorded. The south side of the gulch was fairly well covered with snow at the time of the mapping, April 13th and 20th, which obscured surface geology.

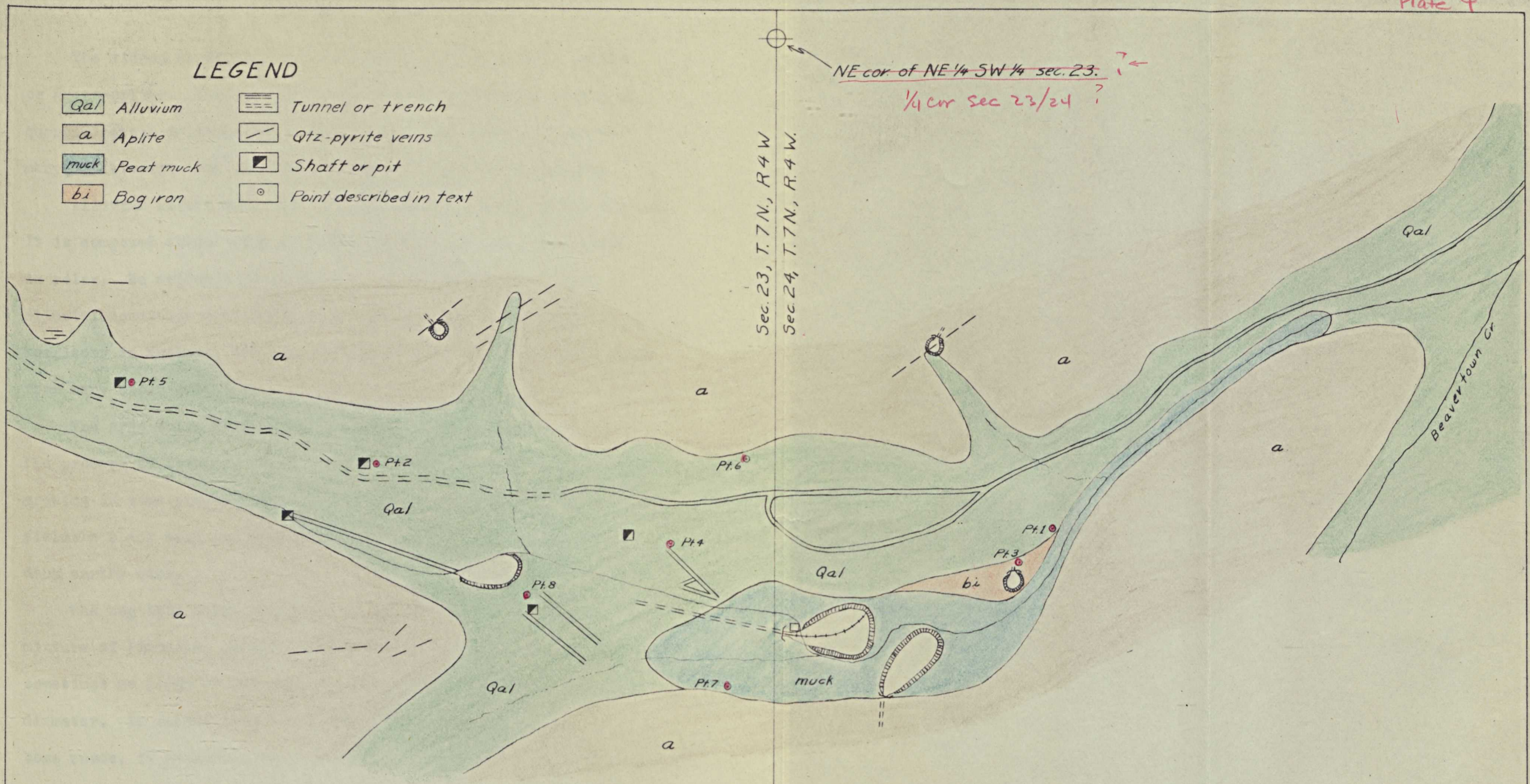
The physiography of the deposit, described in a general manner in the earlier part of the report, has many smaller details that may lead to the solution of the origin of the copper.

As can be seen on the map, Plate 4, there are three main gulches draining into Copper Gulch, and in addition there are many smaller ones. The immediate area of the deposit is fairly flat, and the bog iron outcrop at Point 1 gives evidence of its having been much more flat at an earlier time, for the bog iron crops out about 15 to 20 feet above the present creek bed. This outcrop places the beaver dam perhaps 25 feet farther east, although the creek bed now has cut through many feet of the sediments laid down there.

The creek channel is well confined in the center of the valley at both the east and west sides of the map, however in the center of the map, it gives evidence of having changed its course many times through or above the pond filling since the disintegration of the beaver dam. At times it runs through the old workings.

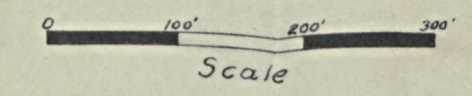
LEGEND

- | | |
|---|-------------------------|
| Qal Alluvium | Tunnel or trench |
| a Aplite | Qtz-pyrite veins |
| muck Peat muck | Shaft or pit |
| bi Bog iron | Point described in text |



GEOLOGIC MAP
OF
COPPER GULCH, JEFFERSON CO., MONT

T. G. KIRKLAND, 1947



The ridges on either side of the deposit are largely aplite or grano-aplite. The rock is light colored, consisting mainly of quartz, potash feldspar and some biotite. The aplite is cut by many small veins that will be referred to later in the report.

Alluvium covers most of the area between the two valley slopes. It is composed essentially of weathered feldspar and sand, light in color. No evidence of copper is in this top layer. This alluvial condition predominates in most gulches in mountainous territory in Montana, and in this manner does not differ materially from many other gulches.

The area shown in blue on the map is one in which peat is in the process of forming. It is very black in color with marsh grass growing in some places. The soil is almost entirely organic matter, yields a black oozy mud when compressed in the hand, and exudes a dank earthy odor.

The bog iron shown in orange on the map is a well cemented mixture of limonite, quartz and feldspar with inclusions of aplite sometimes as large as one inch or one and one-half inches in diameter. It ranges from brick red to dark brown in color. In some cases, it resembles rock of igneous origin very closely, however, due to its position, and its structural and compositional characteristics, it is definitely detrital. *

From samples taken and recorded by Mr. Forrester (3) copper occurs definitely between Points 2 and 3, ranging from 0.005% to

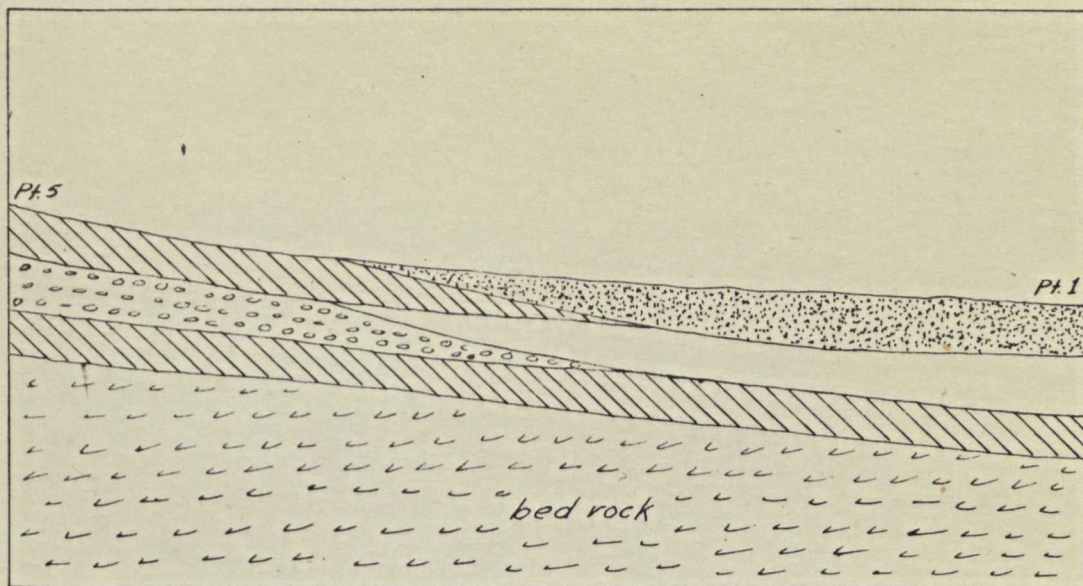
0.07% respectively and points inbetween assay as high as 8.340%. However as the bog iron extends west of these boundaries, it is possible that the copper also occurs there, probably in such minute quantities as to escape detection. These figures could not be verified by the writer due to excess water from melting snow.

Four cross-sections, both ideal and actual, are shown on Plates 5 and 6.

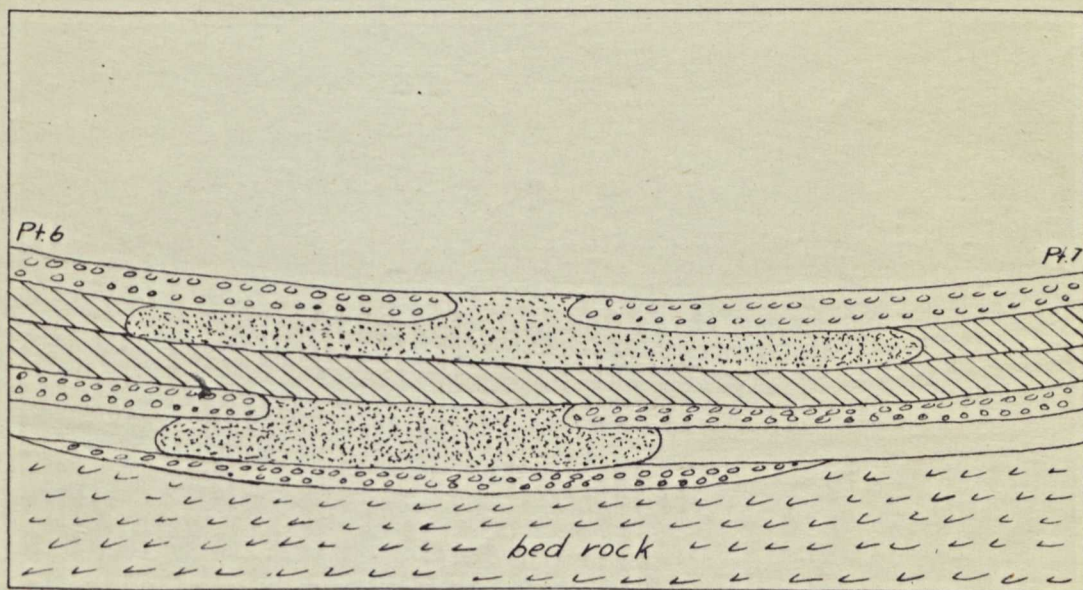
Plate 5, A, shows an ideal west-east cross-section from Point 5 to Point 1. The slope in the bed of bog iron to the west is due to the decrease in stream gradient caused by the beaver dam. The height of the beaver dam is concluded from the height of the outcrop at Point 3.

Plate 5, B, shows an ideal north-south cross-section west of the probable position of the beaver dam. This cross-section illustrates the way in which the various strata may have been laid down. The material having been deposited from the sides of the gulch as well as from upstream would account for the fact that the layers differ in composition within a few feet in all directions.

A and B on Plate 6 are actual cross-sections. A was taken at Point 4 and consists of 3 layers, the top one and one-half feet being a sandy light-colored material with very little organic matter contained in it. The next eight inches is black clay muck, at least 50% organic matter in fairly late stages of decomposition. The organic matter ranges from very small ferns to twigs a half-inch or more in

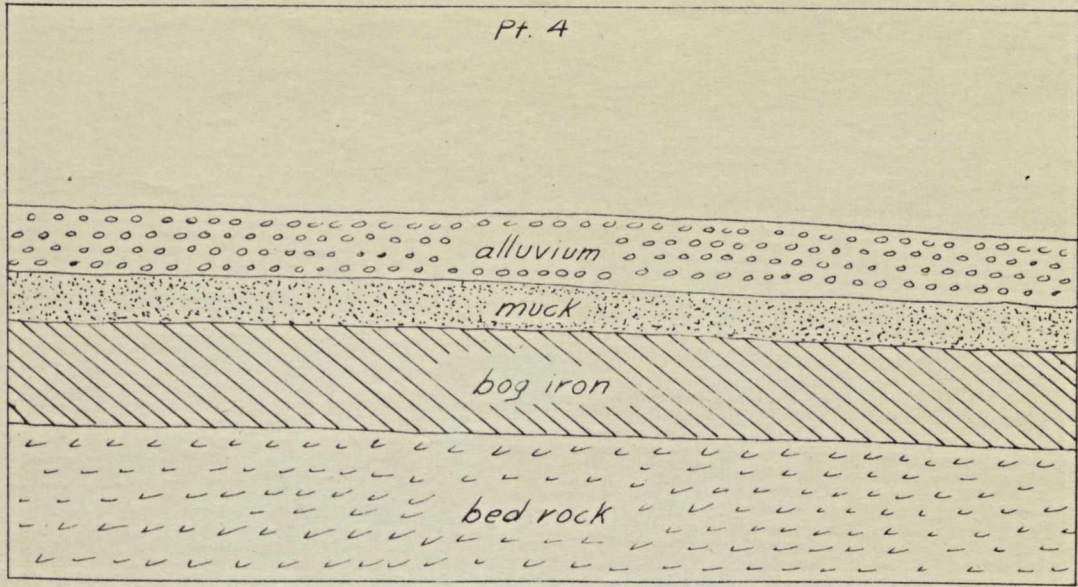


A.

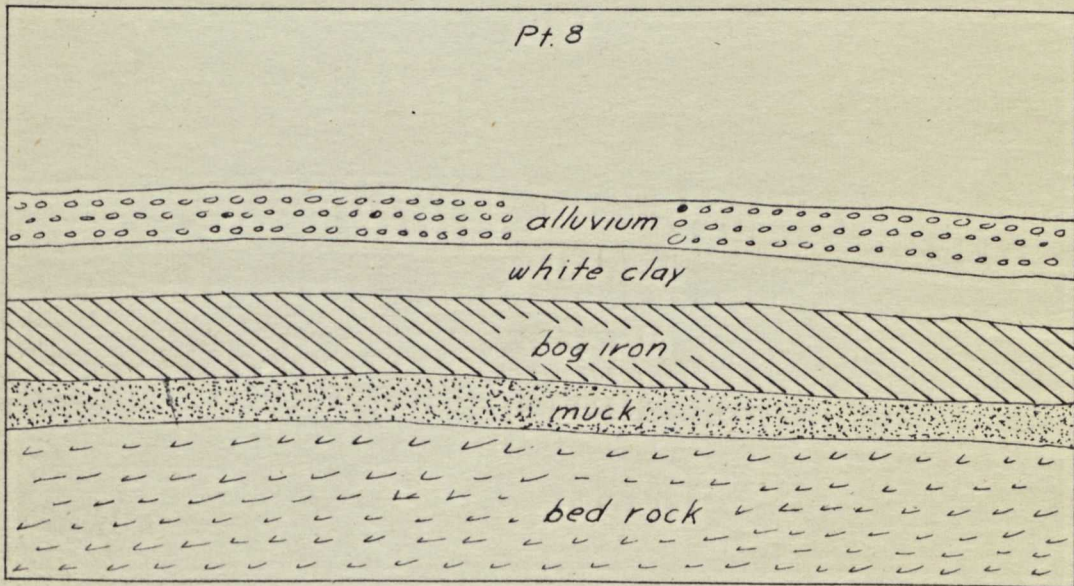


B.

Plate 5. Ideal cross-sections illustrating stratification.



A.



B.

Plate 6. Actual cross-sections illustrating stratification.

diameter. This material was undoubtedly formed under the same conditions as the peat muck shown on the map and formerly described. Below this was approximately 2 feet of bog iron essentially the same as that which crops out to the east. Samples were taken from the section when it was first exposed and did not show any copper by laboratory tests, however, when the author visited the property about two weeks later, the face of the black layer was lightly coated with a greenish blue material which due to its taste and color was determined to be copper sulphate.

The cross-section, B, was taken at Point 8. This cross-section shows the same layers with the exception of one, a white clay layer second from the top, composed of very light and very fine silicates. Also the layers occur in a different sequence, the black layer being below the bog iron.

As is the case with most beaver dams, this one was probably destroyed and built up again many times. This and the fact that cloud-bursts, spring run-offs and the normal flow of the creek carry material, ranging widely in size and weight, would account for the varied layers and their relative positions.

Both the early prospectors and Mr. O'Connell explored the deposit with the result that many adits, shafts and trenches remain as evidence of their work. The trenches might once have been adits that have since caved. The shafts are all caved so that their former depths cannot be determined. The only adit that remains in fairly

good condition is one driven by Mr. O'Connell. The author explored this adit for about 100 feet from the portal, but the depth of the water made it impossible to proceed any further. The creek runs through the adit for a good portion of its length. These workings are all shown on the map, and the portal of the adit just described stands near the shack in about the center of the map. Track is still in place and runs out of the adit to the edge of the dump, and a one ton mine car still remains on the track.

There are many pits and short adits into the aplite and granopelite, some of them following small veins and others driven into barren rock.

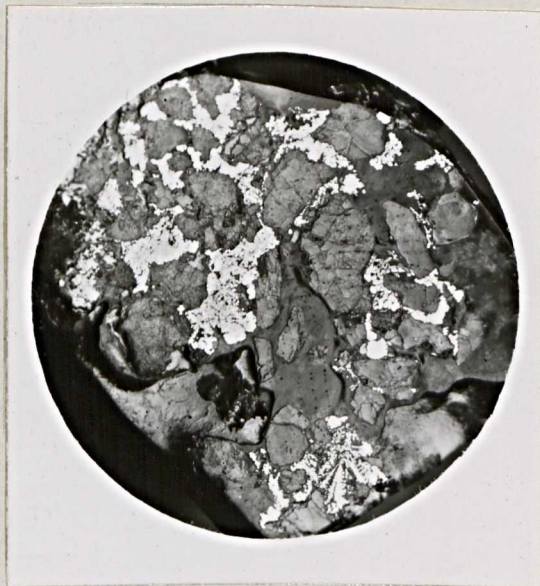
Mineralogy

The mineralogy of the deposit is simple. Native copper and limonite occur embedded in muck, and filling interstices in coarse or fine detrital material. No evidence of replacement of country rock was observed, but some copper may have replaced wood. No signs of veining was observed. The copper shows concretionary shapes, in the form of small clusters of globules. Following are descriptions of photographs showing copper occurrence. The loose friable specimens were first impregnated with lucite before being cross-sectioned and polished for photographing.

Photograph A, Plate 7, shows the association of copper with organic material. The two largest white triangular particles are



A. X $2\frac{1}{2}$



B. X $2\frac{1}{2}$



C. X $2\frac{1}{2}$



D. X 13

Plate 7. Photomicrographs showing occurrence of native copper.

quartz inclusions, while the rest of the white material is copper. The small stringlets throughout the sample are minute twigs with copper deposited on them. The largest of them, in the upper center of the photograph, is almost completely coated with copper. The black areas are copper which is just below the polished surface. The sample was obtained from the main adit, and occurred in one of the black muck layers similar to the one previously described.

Photographs B and C show the association of copper with quartz, feldspar and limonite which occurs as a breccia. In this case the copper was probably precipitated by the iron oxide for there is no evidence of organic matter, the associated material being quartz and small grains of feldspar. The sample was taken from a layer similar to the bog iron layer described formerly except that the limonite was much less abundant.

Photograph D is an enlargement of a portion of photograph C. The picture is interesting because of the similarity in structure between the copper precipitated by natural causes in the deposit and that precipitated by electrolysis in the electrolytic refining of copper. The radial structure is often seen on the edges of copper sheets when they are taken out of the tanks. Photograph A, although it does not show a radial pattern, does show the nodular effect that is also evident on the edges of copper sheets. This conforms to Forrester's idea that the potential of the solution would affect the deposition.

It is concluded that a very peculiar action has taken place in the past and is probably taking place now, the reaction being the replacement of native copper by limonite. This relationship is illustrated by Figure 2, the limonite shown in blue and the copper in orange.

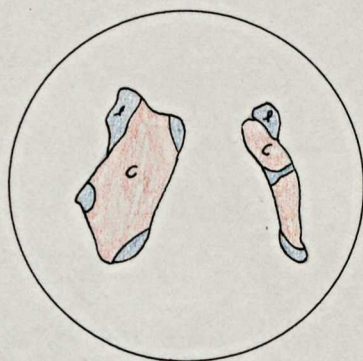


Figure 2. Replacement of copper by limonite, X 30.

Origin of the Deposit

There are at least two possible solutions for the origin of the copper; (1) weathering of exposed veins, and (2) ascending solutions. However, neither of them can be stated as positive in this report due to a lack of field evidence to support them.

(1) Weathering of exposed veins would be the most logical solution for the origin of the deposit. However, there is no evidence of a vein large enough, and with sufficient sulphide content, to have that amount of copper leached out. There are many

small veins cutting the aplite such as those shown on Plate 4, and some of these veins do show copper sulphides. They are seldom over a few inches in thickness and composed mainly of quartz and pyrite.

It is not to be construed that this solution is impossible however, as a large vein could lie on the bottom of the gulch, covered with sediments. The only method by which detection of such a vein is possible is by digging a trench to bed-rock, and continuing this trench the full length of the gulch. Another deduction is that a large vein maybe along the sides of the gulch and has been overlooked, although this is quite unlikely.

(2) Ascending solutions is another supposition that is entirely possible, but difficult to establish. Solutions containing copper might have percolated up through some form of fracture in the bed-rock upstream from the location of the beaver dam, perhaps escaping as a spring. If this were true, there should be some evidence of deposition at the place where these solutions came to the surface. Again, this fracture might be in the bottom of the gulch and covered by sediments. If it were on the sides of the gulch, it would undoubtedly have been detected.

The length of time that copper was being deposited is very difficult to determine, and would have been left to the judgement of the reader except for one interesting discovery. This was a ten gallon milk can, found lying in Copper Gulch Creek a short distance from where it runs into Beavertown Creek. The can had a

distinct coating of copper which appeared to be fresh. Assuming 25 years as the maximum time that this type of can has been in use in that area, this means that the stream was still carrying copper until approximately 1920. The length of time that the can has been submerged is undeterminable, it may have been less than 25 years, but that figure would appear to be a reasonable deduction.

Likewise, the observation that a fresh cut in limonite cemented detrital material developed a copper sulphate precipitate within a period of a month shows that there is a copper content to the water in the muck at the present time.

This does not necessarily mean that the stream was carrying copper such as that leached from a vein at this time. If limonite is now replacing the native copper it might be this replaced copper which has been deposited on the milk can, or which was observed in the cut.

Precipitating Agents

Both iron oxide and organic material are commonly known for their abilities as precipitating agents of metallic copper. Drill steels, in various stages of replacement by native copper, can be found in practically any copper mine in the country. Lovering's (4) experiments prove definitely that organic materials act as precipitating agents, and the occurrence of the "red beds" (1) deposits also substantiates this theory.

This particular deposit seems to have seen action by both agents as indicated by the polished sections. The action of both agents is not too difficult to understand, for at various stages in the history of deposition, different beds would be in immediate contact with the stream. This could be due to either the destruction and rebuilding of the beaver dam, or to the different stages of weathering caused by the flash floods and spring run-offs, or by percolation of water through the deposit. For example: after a period of little stream activity, organic matter in the form of grass, leaves and twigs may have formed a black mucky layer such as the one described, and the copper solution could have attacked this layer. Conversely, after a period of intense weathering a layer of quartz, feldspar, etc., may have accumulated. The limonite cementing material may have come from the same source as the copper, and have been deposited first and then replaced by copper.

Another possible means by which the solution might attack either substance is variation and differences in electrolytic potentials. However, the proof of such a cause is beyond the scope of this report.

Conclusions

A native copper deposit of the type found in Copper Gulch presents many interesting problems to the geologist such as origin, precipitating agent, cause of precipitation in the particular locale, and commercial possibilities. The following conclusions, in the author's opinion, would seem to solve these problems to a reasonable degree.

The copper has been leached from a vein, containing copper sulphides, which has not been discovered at the present date.

The precipitating agents were either or both iron oxide and carbonaceous material, depending upon factors involved.

A beaver dam causing a change in stream gradient and also giving rise to the accumulation of the precipitating agents was the cause of precipitation in this particular district.

The deposit has no commercial possibilities at the present time. This latter conclusion is based in part on the sampling program conducted by Mr. Forrester (3).

Bibliography

1. Butler, R. D., A "red beds" type copper occurrence, Wyoming County, Pennsylvania: Econ. Geology, vol. 33.
2. Clarke, F. W., The data of geochemistry: 5th ed., U. S. Geol. Survey Bull. 770.
3. Forrester, J. D., A native copper deposit near Jefferson City, Montana: Econ. Geology, vol. 37.
4. Lovering, T. S., Organic precipitation of metallic copper: U. S. Geol. Survey Bull. 795.
5. Wells, R. C., Chemistry of deposition of native copper from ascending solutions: U. S. Geol. Survey Bull. 778.