UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

GEOLOGY AND ORE DEPOSITS OF THE MOFFET-JOHNSTON PROPERTY
Madison County, Montana

by

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ILLUSTRATIONS
(In folio)

SUMMARY

The Moffet-Johnston property in the Tidal Wave mining district, Madison County, Montana, was examined by Roy P. Full and Frank C. Armstrong during a ten-day visit to the area in July and August of 1944. The district has been prospected since 1864, but only a small amount of copper ore has been produced from the Moffet-Johnston property. The property has been developed by two main adits, one from the south side of the hill and the other from the north side and 507 feet higher. Other workings consist of an inclined shaft and numerous shallow openings. Chalcopyrite, the principal hypogene ore mineral, occurs in tactite, which has been formed at the contact of a massive bluish-gray limestone with a quartz monzonite stock. The quartz monzonite has been correlated with that in the Boulder batholith, and has invaded the sediments, partly along and partly across the bedding. Certain beds in the limestone have been converted to hornfels. The predominant metamorphic rock is the tactite that formed along the quartz monzonite-limestone contacts. Copper oxides have been mined from the weathered zone, but the deposit has been prospected to develop the sulfide mineralization at depth. Several shipments of ore have been made, though the irregular nature of the deposit does not permit the calculation of ore reserves. Exploration and production records show that the property should be given no further consideration as a possible source of strategic minerals.

INTRODUCTION

An examination of the Moffet-Johnston property was made by Roy P. Full and Frank C. Armstrong during a ten-day visit to the area in the latter part of July and early August of 1944. The examination was made to evaluate a reported large tonnage of readily accessible copper ore.

From April, 1944, until October, 1944, U. S. Bureau of Mines Project 1464, under the supervision of R. N. Roby, operated at the property. Ten diamond drill holes, totaling 1101 feet, were drilled from the surface and underground workings; 111 drift and surface trench samples were cut; four bulldozer trenches were cut across mineralized ground and a transit survey was made of all accessible workings after cleaning out a caved area in the Johnston level.

Thanks are due to R. N. Roby and E. W. Newman of the Bureau of Mines for an interchange of information.

The property consists of a group of 14 patented claims (see Plate 2) and a patented millsite which are now under lease and option by H. R. Hakes and associates of Sheridan, Montana. Originally the claims were controlled by two separate owners; the Johnston holdings comprising one group of 10 claims and a millsite; the Moffet interests holding 4 claims.

The new organization was formed under the name of the Allied Copper Company.

LOCATION

The Moffet-Johnston property is in secs. 2 and 3, T. 3 S., R. 5 W., in the Tidal Wave mining district, Madison County, Montana, and lies within the Dillon quadrangle. The mine is reached from Twin Bridges, a town on a branch line of the Northern Pacific Railroad. Nine miles of gravel road connect the mine with state highway No. 34 at Twin Bridges.

The property lies a short distance above the mouth, and on the north side, of Bear Gulch Creek, a small stream which enters the Jefferson River valley from the west slopes of the Tobacco Root Mountains. Elevations range from 6300 to 7450 feet above sea level.

HISTORY AND PRODUCTION

The exact date of location of the claims in the Johnston and Moffet properties is not known, but prospecting in the Tidal Wave mining district was reported as early as 1864 1/. At that date, however, the principal interest was in deposits carrying free gold.

On August 19, 1904, Horace V. Winchell made a report on this property, at which time the Johnston adit and Stella shaft were near their present state of development. The Moffet adit, however, represented only about 350 feet of workings and went just through the first contact zone . (See Plate 5.) Other workings were limited to small prospect pits and trenches.

Small mining operations were carried on in the Moffet workings during 1916, at which time 638.29 tons of ore were shipped to the East Butte Smelter at Butte, Montana 2/. The average assay for the shipments was 2.32 percent copper, 0.39 ounces silver, and 0.018 ounces gold.

Eight cars of ore were shipped to the Anaconda Copper Mining Company at Butte during 1944. The dates, grades, and tonnages of the shipments are shown in Table 1. The first two shipments were made from ore which had been mined at some earlier date from the Stella shaft and had been left in a bin near the collar of the shaft. The ore in the first four cars shipped on October 2 was mined from the area marked "Open Cut" on Plate 1. The greater portion of that in the last two cars was mined from surface openings in the tactite body which is cut by the road west of the Stella shaft. The remainder of these last cars came from the Stella ore bin.

1/ Winchell, A. N., Mining Districts of the Dillon Quadrangle, U. S. Geological Survey Bull. 574, p. 145, 1914.

2/ U. S. Bureau of Mines, War Minerals Report 159, p. 7, 1944.

TABLE I

Date	Dry Tons	% Cu	Oz. Ag	Oz. Au
1-28-44	50.70	5.40	1.30	0.060
1-28-44	52.89	2.63	1.00	0.035
10-2-44	56.22	1.44	0.25	0.010
10-2-44	59.80	1.54	0.30	0.015
10-2-44	58.07	1.38	0 35	0.015
10-2-44	48.22	1.54	0 30	0.015
10-2-44	46.84	3.50	0.75	0.030
10-2-44	34.51	5.34	1.20	0.030

DEVELOPMENT

The Moffet-Johnston property is developed by two main adits, an inclined shaft, and numerous shallow openings.

The Johnston adit, which is the lowest level on the property, opens into Bear Gulch at an elevation of 6350 feet. It consists of 2325 feet of crosscut and 3 short drifts. (See Plate 6.)

The Moffet adit, 507 feet above the Johnston adit, was driven from the north or Spring Gulch side of the hill. This level consists of 1478 feet of drifts and crosscuts which are for the most part at or near the contact of a limestone block with the quartz monzonite. (See Plate 5.)

At the time of the examination, the Stella shaft was open only to the short sublevel about 70 feet below the collar of the shaft. (See Plate 3.) Maps accompanying H. V. Winchell's report of 1904 show that the shaft continues at 45 degrees to a vertical depth of 185 feet below the collar. Two short levels have been driven at 151 feet to 180 feet below the collar of the shaft. A total of 316 feet of drifts and crosscuts was driven from the shaft. Two short adits on the Bear Gulch side of the hill were driven for a total of 345 feet along a limestone-quartz monzonite contact (lower half of Plate 3).

Other openings on the property consist of numerous small shafts and drifts, all of which were inaccessible at the time of the examination.

GEOLOGY

Near the mouth of Bear Gulch, a massive bluish-gray limestone, which strikes north and dips steeply to the west, forms the west slope of the Tobacco Root Mountains. A short distance above the mouth of the canyon, the limestone is intruded by a small quartz monzonite stock which is probably of the same age as the Boulder batholith 3/. The intrusion came in both along and across the bedding,

3/ Winchell, A. N., Mining Districts of the Dillon Quadrangle, U. S. Geol. Survey Bull. 574, p. 145, 1914.

leaving blocks of limestone isolated in the quartz monzonite. At the contact of the quartz monzonite the limestone has been converted to tactite, with which the copper mineralization is associated. Favorable beds in the limestone have been converted to hornfels.

Sedimentary rocks

The only sedimentary rock in the mapped area is limestone, which has been correlated with the Madison formation of Mississippian age 4/. It is a massive, bluish-gray formation which shows only minor folding, and which weathers to very rough, irregular outcrops. The limited area observed may not be representative of the general structure of the formation. The beds in general strike to the north with a westerly dip of from 45 degrees to 80 degrees. Several isolated blocks of limestone show strikes which deviate considerably from the general trend, but this may be explained by rotation of the blocks during the intrusion. The limestone is fairly uniform in character, but the presence of several types of metamorphic rock suggests that the composition of the beds varies considerably.

Igneous rocks

The only igneous rock exposed was mapped as quartz monzonite. The composition is not uniform, and considerably more basic areas were observed.

The quartz monzonite, studied only in the hand specimen, appears to be made up of nearly equal amounts of quartz and orthoclase and considerably more plagioclase than either of the other two minerals. Both feldspars show subhedral forms with the orthoclase at times as much as one-half inch in diameter and the plagioclase appearing in lathe-shaped form up to a quarter of an inch in length. Anhedral quartz cements the earlier formed minerals. Biotite and hornblende make up the greater part of the mafic minerals, with hornblende greatly subordinate to the biotite.

The more basic part of the intrusive rock appears to fall into two groups. Several large areas were observed underground and on the surface. The second group consists of numerous small xenolithic bodies.

The larger bodies which are a hundred or more feet across show a gradational transition zone from the two-feldspar, monzonitic rock to a single feldspar dioritic rock. The change is from a rock high in plagioclase, orthoclase, and biotite to a rock composed principally of hornblende and plagioclase. The nature of the transition zone and the composition of the rocks suggest that these more basic areas are the product of magmatic segregation.

The second and smaller bodies of basic inclusions are quite widely distributed, but are more numerous along the east edge of the mapped area than at any other place. They are from a few inches to a

4/ Tansley W.; Schafer, P. A.; Hart, L. H.; General Reconnaissance of the Tobacco Root Mountains, Madison County, Montana, State of Montana Bureau of Mines & Geology, Memoir No. 9, p. 15, 1933.

foot in diameter and give the quartz monzonite a spotted appearance. On close examination their angular borders can often be observed; in most cases, however, they have been assimilated to the extent that their fragmental characteristics are destroyed. Most of the inclusions have lost their original identity, although a few were observed that still retained the gneissoid or schistose structure of the original rock. It appears quite evident these rocks are the remains of partly assimilated foreign material which was introduced into the magma during its molten state.

Metamorphic Rocks

Marble has been formed along many of the quartz monzonite-limestone contacts, and may be present even several hundred feet from known contacts. In general, the marble is white and coarsely crystalline, though in places the material is fine-grained and still retains the blue color of the limestone.

Irregular shaped bodies of tactite occur along many of the intrusive contacts. These bodies range in width from a few inches to over a hundred feet, and form sharp contacts with the marble. In general, the contact between the tactite and the intrusive is sharp, though in a few places the quartz monzonite shows evidence of partial replacement by the contact minerals. The tactite is composed mainly of massive to granular brown garnet, with fine-grained light green diopside in some places. Epidote, wollastonite, and green garnet are found in smaller amounts.

Two types of hornfels have resulted from contact action between the quartz monzonite and the limestone. A massive, light green diopside hornfels was observed in the Johnston level and on the surface near the east edge of the area. The rock consists almost entirely of diopside with only minor amounts of other contact silicates. The formation ranges in thickness from 100 feet to 200 feet, and in both places observed, it strikes north with a westerly dip. Good bedding was observed in the limestone near the diopside contact. All observed evidence suggests that the diopside member was formed from a bed of favorable composition in the limestone. The sequence of rocks above and below the diopside hornfels suggests that the rock in both places was formed from the same bed, though observed dips show that there is no connection now between the surface exposure and the occurrence on the Johnston level. Apparently the intrusion broke across the bedding, moving the surface exposed block to the east. As the limestone-diopside contact is approached from the west, the limestone becomes progressively more recrystallized to marble and is replaced by an increasing amount of garnet in numerous small grains up to a quarter of an inch in diameter. The garnet gives the marble near the contact a characteristic spotted appearance.

Directly below and to the east of the diopside rock is a 10-foot bed of siliceous hornfels. This rock is a dark, fine-grained, siliceous material that appears to have been formed from an impure limestone. East of this member there is a second band of siliceous hornfels which is 40 feet to 60 feet wide, and which nearly parallels

the other hornfels members. It is separated from them by a band of quartz monzonite, which apparently came in along bedding planes. Dips observed in the road cuts conform with the westerly dips of the other hornfels. The rock in this band is not as altered in appearance as that just below the diopside hornfels, though it bears little resemblance to limestone. The banded appearance and some relic bedding show it was derived from impure limestone by contact action.

ORE DEPOSITS

The ore deposits on the Moffet-Johnston property are of the contact metamorphic type, in which the mineralization is confined almost entirely to the tactite zones. The principle hypogene ore mineral is chalcopyrite, which is found associated with garnet and magnetite and less widely distributed pyrite, and diopside. Much of the tactite rock is not mineralized or only weakly so. The localization of the tactite and mineralization appears to be controlled by sheared zones along or near the contact of the intrusive. Very little displacement is evident along the shears, and it is believed that they are the results of adjustments during the cooling of the intrusive. The magnetite and chalcopyrite are closely associated, and both appear to have formed by replacement of the garnet. The sulfides, in general, are disseminated through the tactite, but in a few places they have formed as stringers in shear zones.

Supergene mineralization is common near the surface in the tactite bodies. The oxidized zone is not deep, but azurite, malachite, and chrysocolla have been deposited along shears and fractures. Small high grade stringers of oxide ore have been formed.

ORE RESERVES

No attempt has been made to calculate ore reserves for two reasons. First, the sporadic mineralization in irregular tactite zones makes it impractical to project ore any distance from known occurrences; and second, it is questionable if the hypogene ore could be economically mined even at the present premium prices of copper, considering the lack of a mill and the expense of mining and shipping. Previous shipments and assays suggest that this deposit does not contain ore of a sufficiently high grade to be shipped directly to a smelter.

It is quite possible that a few hundred tons of smelting grade supergene ore could be mined from surface openings, though reserves of such ore would be difficult to calculate.

CONCLUSIONS

Though this deposit has not been fully explored, it is the belief of the authors that sufficient work has been done to show what can be expected from it.

Records of ore mined from the surface show quite conclusively that no large tonnage of oxide ore of shipping grade can be expected. Undoubtedly, the four cars of ore mined from the open cut were shipped at a loss to the operators. The average grade was 1.47 percent copper.

The sulfide ore from the Moffet level, though sufficiently high in grade for mill feed in a few places, does not show the continuity or tonnage to justify the construction of a mill. It is very questionable if ore under 2 percent copper could be economically mined in this type of deposit where exploration and development cost will be exceptionally high per ton of ore mined.

As far as can be determined, the possibility of finding ore along any of the known contacts in the Johnston level is very small. The tactite bodies are not well developed, and mineralization is very weak at all exposed points. If other contact zones were encountered at this level there is no reason to believe that the mineralization would be any more continuous, or of higher grade than that exposed in other workings on the property.

In the opinion of the authors, the property is of too low grade to become a profitable enterprise, and it is felt that as far as the Strategic Mineral program is concerned, no further consideration should be given this property by the U. S. Geological Survey.