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FILE MEMO

MOFFEET - JOHNSTON MINE, Madison County, Montana

One day was spent on this property by J. K. Jones during the reconnaissance trip to Montana in July, 1971. Mineralization occurs along a ~~[illegible]~~ narrow, elongate tactite zone on a quartz monzonite - limestone contact. If the reported figure of about 290,000 tons at 1.5% oxide copper is correct, 9 million pounds of copper are available. Because of the narrow, elongate shape of mineralization it must extend to considerable depth to produce ~~[illegible]~~ a large tonnage.

In the latter part of July the mill mentioned in Hollingsworth's letter was in a very preliminary stage of construction, so its existence as a workable entity should be questioned.

Information currently ~~[illegible]~~ available suggests that the Moffet Johnston ore body may be too small to be of interest to ESSEX. However, this is an interesting prospect and justifies several more days field work and a review of drilling results and other geologic information.

PAUL: looks too small, but worth a little longer look. Datasheet not up to date.
Ken

J. K. Jones
August 30, 1971

COUNTY:	COUNTRY:	STATE:	NAME OF PROPERTY:
MADISON	USA	MONTANA	JOHNSTON-MOFFET MINE

DISTRICT OR AREA:	METALS:	ACCOUNT NUMBER:	NUMBER:
Tidal Wave	Cu, Pb, Ag, Au	M003	98

GENERAL DESCRIPTION:
Contact metamorphic deposits at contact of quartz monzonite with limestone.

EXAMINED BY:

DATE:

BRIEFED BY: J.K. Jones

DATE:

STATUS: Letter from JKJ to Harve Nelsonasking for more information 5-12-71

TYPE OF DEPOSIT:
Contact metamorphic

GEOLOGY
Steep west dipping Paleozoic limestone and quartzite overly preCambrian gneiss and schist and are intruded by large, north-trending quartz monzonite dikes.

LOCATION: In Bear Gulch about 8 miles northeast of Twin Bridges.

ELEVATION: 7000 to 8000 feet

LAT: 45° 40' ± **LONG:** 112° 15' ±

ACCESS:

DEVELOPMENT:
2400 foot adit, inclined shaft

MINERALIZATION:
300 to 400 foot wide skarn zone contains magnetite, hematite, copper oxides and sulphides.

PROPERTY & OWNERSHIP:
Lee Hepfler, Ne-Mont Enterprises, Box 160, Melrose, Montana 59743

GEOPHYSICS:

AERIAL PHOTOGRAPHS:

GEOCHEMISTRY:

TOPOGRAPHIC MAPS:

MAPS & REPORTS:
See references

MINERAL PROSPECT DEPOSIT DATA SHEET

ESSEX INTERNATIONAL, INC.
1704 WEST GRANT RD., TUCSON, ARIZONA 85705
PHONE (602) 624-7421

BY: J. K. Jones

DATE: May 12, 1971

NAME OF PROPERTY:
JOHNSON-MOFFET MINE

NUMBER:

REFERENCES:
U.S.G.S. Bull. 574, pages 145-158

PRODUCTION & RESERVES District production several hundred thousand dollars in Au, Ag, Pb, Cu. Reserves several hundred thousand tons at a little more than 1% Cu, also some sulphide potential

SAMPLES:

METALLURGY:

ENGINEERING:
Engineering studies made by Harve P. Nelson, Univ. of Nevada, Reno, Nevada.
Address: 1245 Palisade Dr., Reno, Nevada 89502. Home phone: (702) 323-7603
office phone: 784-6935
or: 784-6691

FACILITIES:
Leaching plant reportedly under construction.

EXPLORATION POSSIBILITIES:
Possibility of large contact-metamorphic copper deposit should be investigated.

ADDITIONAL INFORMATION OR SKETCH MAP:

Prospect not formally presented to Essex. Owners interested in finding a market for cement copper production expected during summer of 1971.

May 12, 1971

Mr. Harve P. Nelson
1245 Palisade Drive
Reno, Nevada 89502

Dear Harve:

I made an inquiry about the possibility of Essex buying cement copper from the Johnston-Moffet Mine in Montana. At the present time we do have an unfilled contract for cement copper, but there is some possibility we will be using this contract for our own cement copper later in the year. If we are able to take your copper it would require shipment out of Montana, but this might be economically feasible under some circumstances.

Please let me know when you plan to be in production, and how many tons of copper as cement copper you plan to produce per day. Do you expect to be able to maintain a 12-month per year operation, or will you have to shut down in the winter? Any technical information you can provide on the plant would be of interest to us.

I hope to be able to make a trip to Montana sometime this summer and would like to see the operation while in the area.

Sincerely,

J. K. Jones
Chief Geologist

ESSEX INTERNATIONAL, INC.

JKJ:td
cc: H. Lanier ✓

FILE MEMO October 7, 1971

OXIDE PROSPECTS AT TWIN BRIDGES, MONTANA

Abe Linton of Micro Corporation called to advise that he had seen an oxide property that we may be interested in. The property is located at Twin Bridges near Butte, Montana, and consists of 16 patented claims. The owners have recently made a number of cuts and placed a number of shallow drill holes indicating an estimated 400,000 tons of 1.6% copper. He indicates that there is evidence that the vein, which is 50-60' wide and 1500' long, extends as deep as 500'. He states there may be 4 or 5 million tons of 1½-2% ore.

A group of owners have about $175,000 in the work to date and they are anxious to locate someone who would be willing to develop.

Linton claims the property does have sulfide potential as well as oxide which has been indicated to date.

The man to contact is Don McFerrin at Sparks, Nevada.
Phone: (702) 358-0997.

NOTE: Micro has sold their small property to Keystone-Wallace, who are presently producing about 17,000 lbs. of cement copper per day which is being shipped to Kennecott, McGill.

H. Lanier

COUNTY:	COUNTRY:	STATE:	NAME OF PROPERTY:
MADISON	USA	MONT.	JOHNSTON-MOFFET MINE

DISTRICT OR AREA:	METALS:	ACCOUNT NUMBER:	NUMBER:
TIDAL WAVE	Cu, Pb, Ag, Au		

GENERAL DESCRIPTION:
Contact metamorphic deposits at contact of quartz monzonite with limestone

EXAMINED BY:

DATE:

BRIEFED BY: JKJ

DATE:

STATUS: Letter from JKJ to Harve Nelson asking for more information 5-12-71

TYPE OF DEPOSIT:
Contact metamorphic

GEOLOGY
Steep west dipping Paleozoic limestone & quartzite overly pre Cambrian gneiss and schist and are intruded by large, north-trending quartz monzonite dikes.

LOCATION: In Bear Gulch about 8 mi. northeast of Twin Bridges Sec. 2, unsurveyed T.3 S, R.5 W.

ELEVATION: 7000 to 8000 feet

LAT: 45°37' ± **LONG:** 112°11' ±

ACCESS:

DEVELOPMENT:
2400 foot adit, inclined shaft;

MINERALIZATION:
300 to 400 foot wide skarn zone contains magnetite, hematite, copper oxides and sulphides

PROPERTY & OWNERSHIP:
Lee Hepfler, Ne-Mont Enterprises, Box 160, Melrose, Montana 59743.

GEOPHYSICS:

AERIAL PHOTOGRAPHS:

GEOCHEMISTRY:

TOPOGRAPHIC MAPS:
USGS 1:62,500 WATERLOO, MONT. Quadrangle

MAPS & REPORTS: See references.

MINERAL PROSPECT DEPOSIT DATA SHEET

ESSEX INTERNATIONAL, INC.
1704 WEST GRANT RD., TUCSON, ARIZONA 85705
PHONE (602) 624-7421

BY: J. K. JONES

DATE: May 12, 1971

NAME OF PROPERTY: JOHNSTON-MOFFET MINE

NUMBER:

REFERENCES:
U.S.G.S. Bull. 574, pages 145-158

PRODUCTION & RESERVES: District production several hundred thousand dollars in Au, Ag, Pb, Cu. Reserves several hundred thousand tons at a little more than 1% Cu, also some sulphide potential

SAMPLES:

METALLURGY:

ENGINEERING:
Engineering studies made by Harve P. Nelson, Univ. of Nevada, Reno, Nevada. address: 1245 Palisade Drive, Reno, Nevada 89502. Home phone: (702) 323-7603
office phone: 784-6935 or 784-6691

FACILITIES:
Leaching plant reportedly under construction

EXPLORATION POSSIBILITIES:
Possibility of large contact-metamorphic copper deposit should be investigated.

ADDITIONAL INFORMATION OR SKETCH MAP:
Prospect not formally presented to Essex. Owners interested in finding a market for cement copper production expected ~~the~~ during summer of 1971.

P.P. Paul-Should this be checked.

EBH

for Ken Jones

FILE MEMO

October 7, 1971

OXIDE PROSPECTS AT TWIN BRIDGES, MONTANA

Abe Linton of Micro Corporation called to advise that he had seen an oxide property that we may be interested in. The property is located at Twin Bridges near Butte, Montana, and consists of 16 patented claims. The owners have recently made a number of cuts and placed a number of shallow drill holes indicating an estimated 400,000 tons of 1.6% copper. He indicates that there is evidence that the vein, which is 50-60' wide and 1500' long, extends as deep as 500'. He states there may be 4 or 5 million tons of 1½-2% ore.

A group of owners have about $175,000 in the work to date and they are anxious to locate someone who would be willing to develop.

Linton claims the property does have sulfide potential as well as oxide which has been indicated to date.

The man to contact is Don McFerrin at Sparks, Nevada.
Phone: (702) 358-0997.

H Lanier

NOTE: Micro has sold their small property to Keystone-Wallace, who are presently producing about 17,000 lbs. of cement copper per day which is being shipped to Kennecott, McGill.

H. Lanier

Paul Brown

ASSOCIATES
ALFRED H. OSBORNE
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DENNIS J. HEALY, JR.
ARTHUR T. NICHOLLS

PETER ECHEVERRIA
ATTORNEY AND COUNSELLOR AT LAW
555 SOUTH CENTER STREET
RENO, NEVADA 89501
TELEPHONE 323-8678

August 13, 1971

Sleeper Handle

Mr. Howard Lanier
Essex International
1704 West Grant Road
Tucson, Arizona

Dear Mr. Lanier:

Mr. Raymond Robinson, consulting geologist, informed the undersigned that your company was interested in acquiring mineral deposits containing copper oxide ore which could be mined by open pit methods.

Enclosed is a memorandum report prepared by Harve P. Nelson, concerning a group of 14 patented mining claims which is situate 7 miles from Twin Bridges, Montana and embraces a deposit containing approximately 300,000 tons of oxide ore averaging over 1.5% copper. Drilling operations conducted subsequent to Nelson's report indicate that the probable oxides of 83,484 tons shown in the report should be added to the proven oxides of 207,036 tons.

As can be further determined from the report, the deposit also contains a large tonnage of mixed oxide-sulfide and sulfide copper ore which also averages over 1.5% copper.

A gravity-flotation mill with a capacity of 500 tons per day is owned by our clients and is situate on a mill site adjoining the property.

If you have any interest in this property, please contact the undersigned and arrangements will be made for your examination of the property and acquisition of further information concerning it. The owners are willing to lease and/or sell said property and mill upon reasonable terms and conditions.

Thank you for your attention to this matter.

Sincerely yours,

E.A. Hollingsworth

E.A. Hollingsworth

EAH:em
Enc.

PHONES: Area Code 702
Office: Direct Line — 784-6935
Leave Message — 784-6691
Home — 323-7603

HARVE P. NELSON
P.E., B.S., E.M., Ph.D
CONSULTING MINING ENGINEER
1245 PALISADE DRIVE
RENO, NEVADA 89502

22 July 1971

EVALUATION OF THE MOFFET-JOHNSTON MINE

The following report is submitted as confirmation of the extensive evaluation of the Moffet-Johnston mine. Upon first seeing the exposed portions of the ore bodies my opinion was that the deposit had a high potential value and could be economically exploited.

Shortly thereafter the U. S. Bureau of Mines Report #3939 was discovered which disclosed adequate information to assign tonnage and acceptable grades as follows:

PROVEN ORE: 66,000 tons of copper oxide ore with a value of 1.33% Cu. conveniently located for surface mining.

PROBABLE ORE: 500,000 tons of oxide-sulfide mixture with a value of 1.3% Cu.

POSSIBLE ORE: 500,000 tons of sulfide ore of unknown value.

Subsequent to the time that Ne-Mont Enterprises obtained a lease on the two groups of claims extensive drilling, dozing, and a thorough examination of the exposures in the Moffet tunnel have increased the ORE RESERVES to the following tonnage and value:

ORE RESERVES

PROVEN OXIDES:	main and new ore bodies weighted assays - 1.57% Cu	207,036 Tons	
PROVEN OXIDE-SULFIDE:	total ore body weighted assays - 1.87% Cu	69,012 Tons	
PROVEN TONNAGE.			276,048 Tons
PROBABLE OXIDES:	between ore bodies weighted assays - 1.58% Cu	83,484 Tons	
PROBABLE OXIDE-SULFIDE:	total ore body weighted assays - 1.77% Cu	27,826 Tons	
PROBABLE SULFIDES:	total ore body weighted assays - 1.49% Cu	1,348,136 Tons	
PROBABLE TONNAGE			1,459,446 Tons
POSSIBLE SULFIDES:	below Moffet tunnel		28,200 Tons
TOTAL:	PROVEN, PROBABLE, AND POSSIBLE TONNAGE		1,798,200 Tons

With reference to the attached base map, 31 exploratory holes have been drilled from the surface. Four of which were drilled to check whether the area for waste dumps was truly barren or not. Three were in waste but hole No. 16 hit what is now known as the New orebody. Only a relatively small amount of waste talus will need to be removed to confirm my belief that this orebody connects solidly with the older, so-called Large orebody.

Assays from the drill cuttings have been used along with the U. S. Bureau of Mines assays of core and sluge from their drill holes plus results from their channel samples chipped from the floors of the dozer cuts and from the walls and back of the Moffet tunnel to calculate the tenor of the ore reserves.

MINING METHODS

Open cut (pit) mining will be practical to a depth of 200 feet on the wider (plus 50 ft.) ore bodies. Because of minimum waste to handle by using angle drilling with pre-splitting on the monzanite side, and nearly vertical walls on the limestone side, 10 ft. wide ore bodies can be mined to 35 ft. depth; 15 ft. wide ore bodies to 80 ft. depth; 30 ft. wide to 120 ft. depth; and, 40 ft. wide to 150 ft. depth. By using a backhoe even 5 or 6 ft. wide steeply dipping veins can be mined to a depth of about 12 feet. Thus, surface showings of relatively narrow ore structures can be economically exploited, thereby, giving an unlimited tonnage range for exploration of the Moffet-Johnston claims and the adjacent claims which probably can be optioned at this time, if desired, for very little outlay of capital.

Underground mining costs will approach those incurred from the working of the surface areas provided adequate funds are made available from early profits. These funds will provide proper development and preparation of the deep ore bodies for stoping. Main entry ways already exist. Both walls are strong and the ore will stand over great widths to permit use of a modified long blasthole method.

PROSPECTIVE ORE

The face of the Moffet tunnel workings barely reaches underneath the down-hill edge of the large (upper) ore body, thereby, giving a big target for long-hole drilling from which to explore the large extremely favorable area underlying the now known sulfides of this deposit.

The many pendents of dolomite located on the property, in particular, on the Johnston claims, give unlimited contact areas between the sedimentary rock and the igneous quartz monzanite for the formation of tactite contact material which is extremely favorable for the deposition of copper minieral. As there are a number of outcrops showing copper on the Johnston claims which increases the possibility of additional ore, reference to the mining methods section of this report clearly indicates the economic feasibility of exploiting such areas even if they should remain relatively small after final determination. The foregoing possibilities plus the road site position enhances the value of the Johnston claims.

Throughout the property a high content of magnetite (a magnetic iron mineral) occurs in the areas that carry a good grade of copper. The presence of magnetite in these favorable areas provides an easy target for geophysical prospecting for locating additional reserves. Rumors have it that a Canadian mining company found a rather large and favorable anomaly by geochemical exploration but unfavorable demands by the owners of the property at that time prevented an optioning and further pursuit of the claims.

BY-PRODUCTS

Panning tests and microscopic observation of the minerals indicates that approximately one fifth of the total material is magnetite which is the main source of iron for steel furnaces. Separation of this mineral from an oxide composite produced a concentrate weighing exactly 20% of the material. Contact

has been made with two of the nearest consumers. Favorable negotiations are presently going on with the U. S. Steel Corporation for the Geneva Plant near Salt Lake City, Utah. Freight cost is the determining factor in gaining a profit. It is estimated that one railraod car load of the by-product magnetite could be produced each day.

Garnet is another probable by-product. Its main use is in sand-blasting and on safety strips such as those glued to step surface to combat slipping.

Respectfully submitted,

Harve P. Nelson

Harve P. Nelson, PhD.
Registered Professional Engineer
22 July 1971

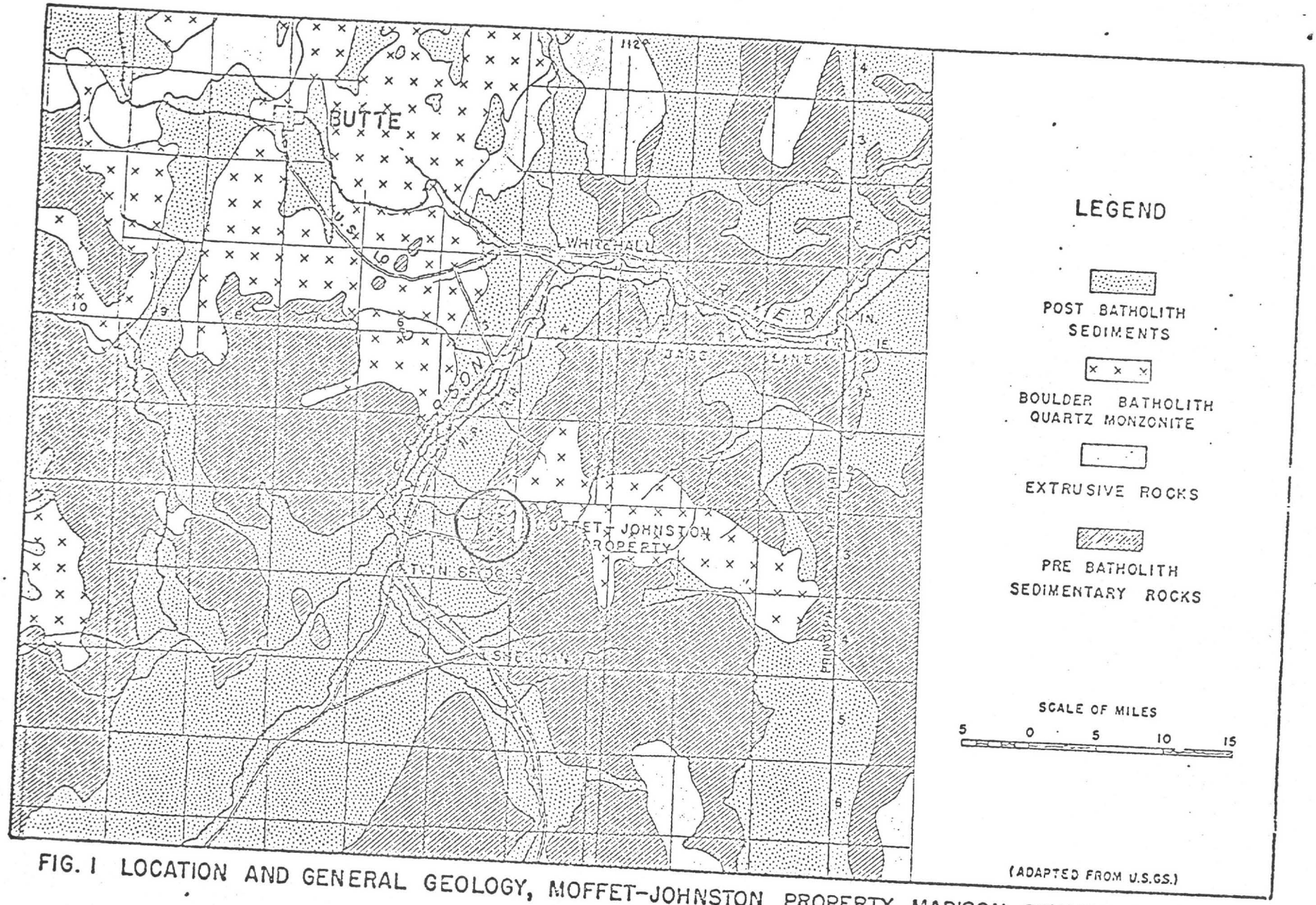

FIG. 1 LOCATION AND GENERAL GEOLOGY, MOFFET-JOHNSTON PROPERTY, MADISON COUNTY, MONTANA

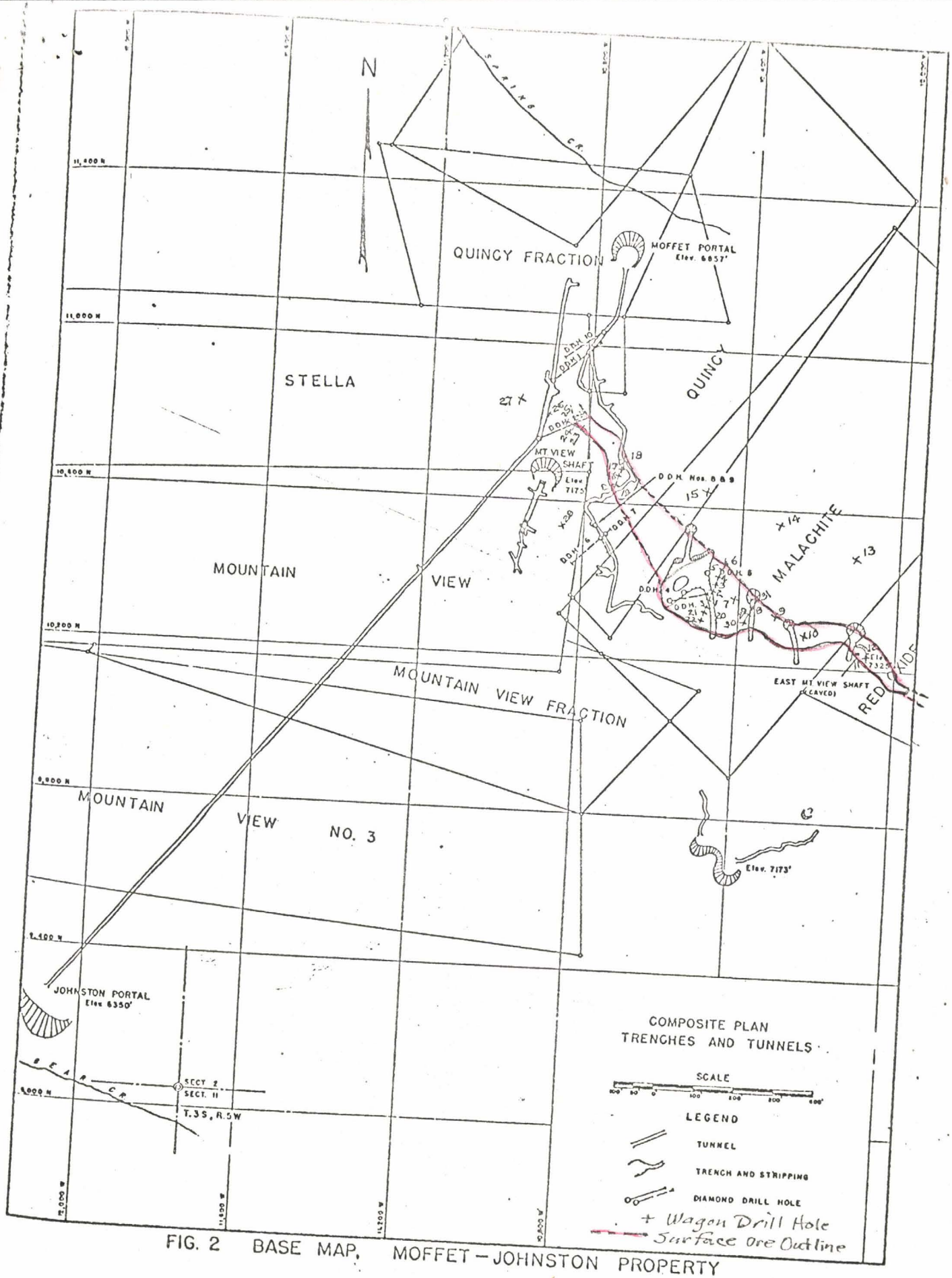

FIG. 2 BASE MAP, MOFFET – JOHNSTON PROPERTY

SKETCH MAP

JOHNSTON-MOFFAT MINE

TIDAL WAVE DISTRICT

MADISON Co., MONT.

N

1" = 200' approx.

7-26-71

JKN

SALT LAKE BLUE

FORM 1006

USGS Bull 574

To go with Johnston-Moffet Mine, Madison Co. Mont. file

Twin Bridges, of Blacktail Creek from Dillon southeastward for 20 miles, and of Divide Creek and the northward-flowing water across the divide from its head. A valley, probably once occupied by a single large river, extends from Silver Bow through Feely to Divide, and is followed by the wagon road to Melrose and by McCarthy and Nez Perce creeks to the region of Twin Bridges. The history of this old through valley, which crosses the Continental Divide at an elevation of 6,300 feet, has not yet been deciphered.

With the exception of a small area in the northwest part of the region, south and west of Butte, the quadrangle is drained by Jeffer-

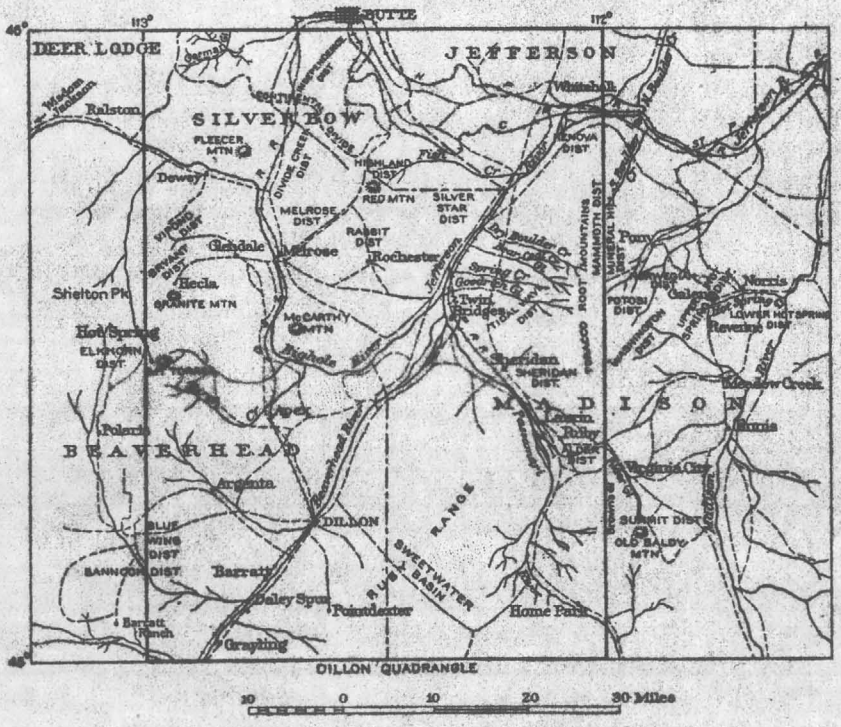

FIGURE 2.—Sketch map of the Dillon region, showing location of mining districts.

son River, which unites with Madison and Gallatin rivers to form Missouri River in the northern part of the Threeforks quadrangle. Jefferson River is formed by the junction of Beaverhead and Bighole rivers near the center of the Dillon quadrangle. German Gulch and Basin and Blacktail creeks, in the northwest part of the quadrangle, flow northward into Clark Fork, locally known as Silver Bow Creek, and thence to Columbia River and the Pacific Ocean.

Physiographically the Dillon quadrangle is a portion of the Rocky Mountain province of the United States. It includes a portion, about 50 miles long, of the main Continental Divide, which enters

TIDAL WAVE DISTRICT.

LOCATION AND HISTORY.

The Tidal Wave district, one of the largest districts in the region, lies east of Twin Bridges, extending about 7 miles north and south and about 5 miles east and west. It is named from a mine on the ridge north of Dry Georgia Gulch, but includes half a dozen gulches from mouth to head along the western slope of the Tobacco Root Mountains. Its elevation ranges from less than 6,000 to more than 10,000 feet above sea level.

The district was prospected as early as 1864, but at that time little attention was paid to ores other than those carrying free gold. Within a decade, however, the importance of argentiferous lead ores was demonstrated at Argenta and later at Hecla and the mines of the district were rapidly located. The Tidal Wave and High Ridge mines were among the first to be developed. Nearly all the mining in the district has been carried on by owners or lessees operating on a small scale without large investments of capital.

The names of some of the gulches in this district are incorrectly given on the editions of the topographic map of the Dillon quadrangle issued by the United States Geological Survey in 1893 and 1909. The stream shown on that map as Coal Creek is Dry Boulder Creek; the next creek to the south is Coal Creek; the first gulch north of Spring Creek is Bear Gulch; and the stream shown as Bear Canyon Creek is Goodrich Creek. (See fig. 2, p. 13.)

GEOLOGY.

In a general way the west flank of the Tobacco Root Mountains as far south as Dry Georgia Gulch is occupied largely by Paleozoic limestones resting upon quartzites, schists, and gneisses, with some interbedded layers of crystalline limestone. In part of the central region, west of Jefferson Peak, the underlying siliceous rocks are replaced by granitic rocks similar in type to the Butte quartz monzonite or "granite." It seems quite possible that this granitic intrusion is of the same age and source as the Boulder batholith. Though referred to in places in this report as "granite," it is probably really a quartz monzonite with local dioritic phases.

The rocks underlying the Paleozoic limestones were mapped as Archean in the Threeforks folio, but the presence of interbedded quartzites and limestones makes this correlation improbable. On the other hand, they correspond well with the beds described by Peale as the Cherry Creek and assigned by him to the Algonkian and they will be provisionally classified as Cherry Creek in this report. It is possible that the Archean occurs beneath them in some places, but its existence there has not yet been established.

ORE DEPOSITS.

The ore deposits of the Tidal Wave district are of three types. The first type is confined to the region along Bear Gulch, where granitic intrusives come in contact with limestone and produce typical contact deposits containing copper and lead and subordinate gold and silver. The second type occurs at the head of Bear Gulch, and perhaps to some extent in other gulches of the district, in vein deposits in gneiss or schists or, more rarely, in "granite," all closely associated with intrusions of "granite" or of differentiation products from the granitic magma, such as aplite. The veins carry chiefly gold, with some lead, silver, and copper. The third type is found on Dry and Wet Georgia creeks and on Goodrich Gulch, in vein deposits in gneiss or schists, in many places closely associated with igneous intrusions, apparently unrelated to the granitic magna and of much earlier date. Ore deposits of the first type are clearly due to the mineralizing action of gases and liquids escaping from the great magma now consolidated to the granitic intrusive mass extending from Bear Gulch across the Tobacco Root Mountains to the vicinity of Norris, Mont. Ore deposits of the second type were probably due to mineralization produced in more siliceous country rock by the same agencies. Ore deposits of the third type were probably due, at least in part, to mineralization from other intrusive igneous bodies perhaps even before the deposition of the Paleozoic limestone, in the post-Cherry Creek erosion interval.

PRODUCTION.

No statistics of production during the earlier years of mining in the Tidal Wave district are available, but it is probable that the production during the latter part of the nineteenth century was frequently greater than the average annual production during the period (1904–1912) for which records are available. The records of the United States Geological Survey show the production from 1904 to 1912.

Production of metals in the Tidal Wave district.

Year.	Ore.	Gold.		Silver.		Copper.		Lead.		Total.
	Tons.	*Fine oz.*		*Fine oz.*		*Pounds.*		*Pounds.*		
1904	21	39.67	$820	140	$80	.....	.....	8,000	$160	$1,060
1905	114	752.92	15,564	17,742	10,823	309	$48	59,485	2,691	29,126
1906	178	234.34	4,844	4,775	3,199	3,766	727	68,066	3,879	12,649
1907	184	370.17	7,652	2,026	1,337	.....	.....	55,636	2,949	11,938
1908	1,454	577.35	11,935	6,866	3,639	3,935	520	144,689	6,077	22,171
1909	468	754.44	15,596	10,056	5,229	882	115	155,942	6,705	27,645
1910	677	746.09	15,423	7,459	4,028	2,307	293	118,551	5,216	24,960
1911	400	596.70	12,335	6,415	3,400	2,205	275	146,802	6,606	22,616
1912	242	379.26	7,840	2,600	1,599	3,673	606	42,573	1,916	11,961
	3,738	4,450.94	92,009	58,179	33,334	17,077	2,594	799,744	36,199	164,128

The ore deposits and geologic features of the Tidal Wave district are not sufficiently uniform to render further general description useful. Numerous facts of interest, however, are brought out in the following descriptions of the several gulches:

DRY BOULDER CREEK.

Dry Boulder Creek occupies the northern part of the Tidal Wave district, its mouth being about 8 miles northeast of Twin Bridges and about 5 miles nearly due east of Iron Rod. Its waters maintain their identity in a surface channel for about three-fourths of the distance across the sands and gravels of the bench lands on their way from the Tobacco Root Mountains to Jefferson River.

The western slope of the Tobacco Root Mountains at Dry Boulder Creek is occupied by upturned Paleozoic limestones and some interbedded shales, and the central portion of the mountains is occupied by "granite" and gneiss. In general the line of contact between "granite" and limestone runs north and south, but in detail it is very irregular, and may be complicated by the presence of minor igneous intrusions.

Numerous deposits of ore lie along this contact. Some fill fissures in the "granite," but most of them are irregular bunches and chimneys in the limestone adjoining the "granite." Some ore bodies are associated with faults, but there is no evidence of extensive movement either in or across the ore deposits.

The writer did not visit the Copper Queen group of claims, but according to R. H. Sales, chief geologist for the Anaconda Copper Mining Co., copper ores occur there in irregular contact deposits in limestone, the chief ore minerals being malachite and azurite, with possibly some black oxide of copper. The ore is evidently a replacement of limestone along the contact and increases in quantity from the bottom to the top of the raise from the middle tunnel. A vein in "granite" is filled with iron oxides and some quartz and a few specks of iron pyrites. The veins and contact deposits have been extensively leached, but the existence of commercially important enriched ore deposits, due to precipitation below the zone of leaching, has not yet been established.

BEAR GULCH.

LOCATION.

Bear Gulch is in the northern part of the Tidal Wave district, the mouth of the gulch being about 7 miles northeast of Twin Bridges, and about 5 miles east-southeast of Iron Rod. Its waters flow rapidly, but within less than 2 miles from the mouth of the gulch they lose themselves in the sand and gravel of the Jefferson Valley.

GEOLOGY.

An interesting succession of rocks is to be found in Bear Gulch. At its mouth Paleozoic limestone striking north and dipping steeply west is cut by the westward-flowing creek. Less than half a mile up the canyon the limestone gives place to an intrusive granitic rock, which has invaded the limestone partly as sills and partly by breaking across the bedding. The ores are in close association with this intrusive, both as typical contact deposits and as fissure veins, which are usually farther from the contacts but which presumably extend downward to the granitic mass, whence their filling was probably at least in part derived. At the contact with the igneous rock the limestone is converted into lime-silicate rock containing garnet, epidote, zoisite, titanite, and diopside. A pale-green resistant rock lying along one contact consists chiefly of fine-grained granular diopside. The corundum which occurs on the Atlantic claim on the ridge between Bear Gulch and Coal Creek must have been produced by the contact metamorphism of a highly aluminous bed in the limestone, for it forms a band about a foot wide with garnet-epidote rock above and below it. A short distance farther up the gulch wholly or nearly isolated beds of limestone, approximately parallel and showing contact zones on their upper and lower surfaces, occur in the "granite." The approximately vertical walls of the canyon expose these relations to a depth of more than 1,000 feet, and show that some of the beds of limestone are cut off by "granite" on the dip, and that others extend below the creek level. The section as followed upstream shows repeated alternations of "granite" and limestone to a point where a bed of limestone rests on shaly sandstone grading downward into pure sandstone. Below this the "granite" occurs again, metamorphosing the sandstone much less than it does the limestone, though indurating it along the contact into a compact quartzite, which usually contains more or less orthoclase and muscovite. Farther east, up the gulch, limestone occurs again, underlain by quartzite which overlies gneiss, irregularly cut by "granite" masses. (See figs. 11 and 12.) The granitic intrusive here penetrates gneiss, quartzite, and limestone. Associated with the granite are some dikes of aplite and pegmatite.

PETROGRAPHY.

The "granite" is not uniform in composition but is spotted by patches of darker color, which are sometimes explained as due to segregation or differentiation in the magma before or during crystallization. In Bear Gulch no evidence of any such differentiation could be found. On the contrary, the patches themselves furnish evidence of a different origin. They consist largely of hornblende and plagioclase with subordinate titanite, apatite, and calcite.

Some of them have on their borders epidote and zoisite, and in places the epidote seems to have formed at the expense of biotite.

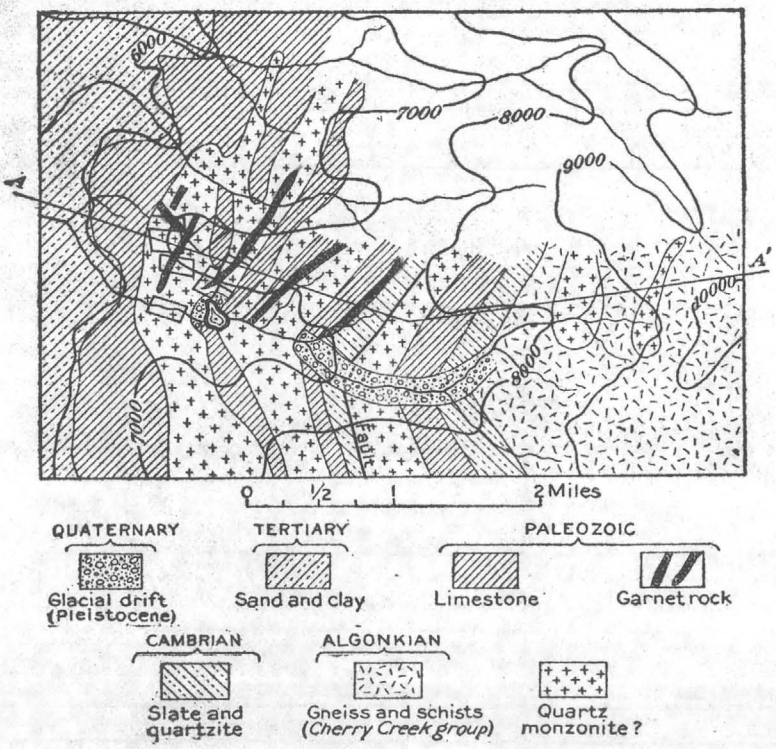

FIGURE 11.—Geologic sketch map of Bear Gulch in the Tidal Wave mining district, Mont.

Calcareous minerals are thus especially abundant. In other spots quartz and feldspar are unusually plentiful. Finally, some spots

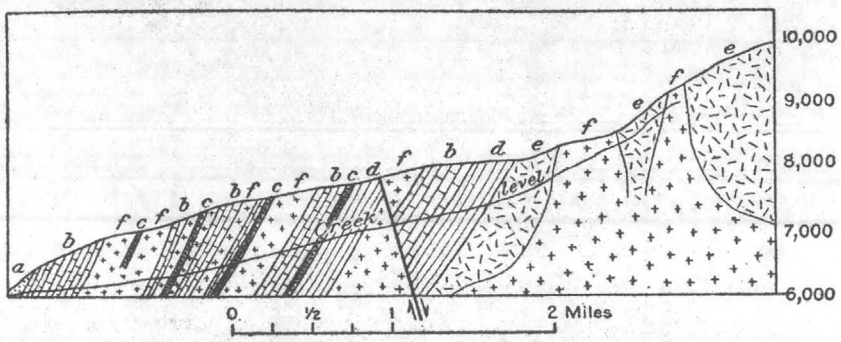

FIGURE 12.—Geologic vertical section of Bear Gulch in the Tidal Wave mining district. *a*, Sand and clay (Tertiary); *b*, limestones (Paleozoic); *c*, garnet rock (Paleozoic); *d*, slate and quartzite (Cambrian); *e*, gneiss and schist (Cherry Creek group, Algonkian); *f*, quartz monzonite (?).

are clearly banded. Spots of the first type are found most abundantly near the limestone contacts, those of the second type near

the quartzite contact, and those of the third type near the "granite" and gneiss contact. The first and second types occur in the lower (western) end of the gulch and the third type is confined chiefly to the upper (eastern) end. In a few places the various types are mingled in a single mass of "granite." Both from their composition and mode of occurrence, it seems probable that these spots in the "granite" are not differentiation products, but represent the incompletely absorbed fragments of the country rock. All stages in the process of assimilation are visible; in some spots the fragments or xenoliths are sharply angular (Pl. VI, *A*), in others the gneissoid or schistose structure of the included rock is still visible (Pl. VII, *B*), and in still others the angular outlines and the structure are more obscured or are obliterated entirely (Pls. VI, *B*, and VII, *A*) and the difference in composition between the xenolith and the inclosing "granite" is slight.

In the upper canyon of Bighole River, between Divide and Dewey, in Beaverhead County, similar xenoliths occur in an igneous rock, which is probably the quartz monzonite of the Boulder batholith. In this locality the xenoliths are wonderfully abundant; within 3 miles east of Dewey there are thousands of them of all sizes, some being as large as a small house. (See Pls. VI to VIII.)

It is believed that the facts stated indicate that these spots are not differentiation products, but are the remains of foreign rocks incompletely assimilated by the intruding "granite." It seems that the fragments of adjoining rocks which become inclosed in the "granite" are gradually absorbed by it. If heat and time are insufficient the fragment may be very little modified, especially if it was originally siliceous. Such a fragment is easily recognized as a xenolith, especially if the schistose structure is present. If the fragment was originally limestone and was small, heat and time appear to have been invariably sufficient to expel the carbonic acid completely and to produce silicates of lime. With more heat and longer time the fragments lose their original outlines, and doubtless the constituents of the magma become diffused into the xenolith, and those of the xenolith into the magma. Thus the chemical composition of the two tends to become the same. But as the chemical composition becomes more alike the process of diffusion becomes less active. If the xenolith is completely dissolved diffusion appears to be able so to equalize the composition that the absorption of foreign material produces no perceptible effect on the color or texture. If the xenolith is only partly dissolved diffusion may considerably reduce the differences in composition between the xenolith and the inclosing magma. At any particular place diffusion begins to modify the composition before solution occurs, but uniformity of composition is rarely, if ever, attained through the operation of diffusion

alone. On the other hand, approximate uniformity of composition through small volumes is reached rather easily by diffusion when solution-fusion also occurs.

Benedicks and Tenow[1] have recently published an interesting description, with photographic illustrations, of assimilation textures, some of them orbicular, produced by partial fusion of suitably prepared mixtures of graphite or other material in paraffin.

GLACIATION.

A glacier extended down Bear Gulch to a point about a mile above the mouth, where a small terminal moraine crosses the gulch and produces a small lake. This lake has the peculiarity of filling in the spring to a certain height, at which it begins rather suddenly to discharge through the moraine. By autumn the lake is small, or wholly dry.

Instead of the ordinary rounded and considerably mixed bowlders and sand the morainic material in Bear Gulch consists of bowlders practically free from sand, in places very uniform in composition, and remarkably angular in shape. That the bowlders are morainic and were not deposited by a landslide is indicated by the surroundings, there being no probable local source for the material, and also by the occurrence of similar and more typical morainic bowlders for a distance of 3 to 4 miles up the gulch, which heads in several small glacial cirques of normal type.

The peculiar characteristics of the terminal moraine are probably due to special conditions existing in the gulch during the period of glaciation. It seems probable that the terminal moraine consists of material that was carried by the glacial ice exclusively on its upper surface, probably for the most part from the walls of cirques about 3 miles east of the moraine, which are composed largely of the same materials. Detritus which sank to the base of the glacier or far enough into it to undergo considerable wear and rounding probably did not reach the terminal moraine but was deposited farther up the gulch.

It is believed that conditions which would favor the transportation of material on the upper surface of the glacier existed in this region during glaciation. It is evident that these conditions are (1) an abundant supply of material falling upon the glacier from inclosing rock walls, (2) a snowfall so deficient that such superglacial material would not be covered with névé or ice, and (3) a valley steep enough to cause rather rapid glacial movement in spite of the deficiency in the supply of ice.

The present state of the walls of the small glacial cirques at the head of Bear Gulch shows that an abundant supply of material

[1] Benedicks, C., and Tenow, O., Geol. Fören. Förhandl., vol. 33, p. 105, 1911.

must have fallen upon the glacier from the inclosing rock walls. A similar cirque at the head of Mill Creek about 10 miles southeast of the head of Bear Gulch (see Pl. V, p. 136) contains abundant talus accumulated since glacial time.

That the snowfall was light in this region during glacial time is indicated, first, by the fact that rainfall is deficient in the region and there is no evidence of a change in precipitation, and, second, by the fact that although local glaciers were abundant throughout southwestern Montana, none of them extended far from the mountainous centers of accumulation. Many of them, in fact, like the one in Bear Gulch, did not even emerge from the mountainous region into the valleys.

The Bear Gulch valley has a total fall of 2,000 feet in 3 miles—nearly 700 feet to the mile, or about 12 per cent—a fall sufficient to facilitate rapid movement of the glacier in spite of deficient snowfall.

ORE DEPOSITS.

In the lower (western) end of Bear Gulch the ore deposits are chiefly of the contact type and occur in limestone near "granite" intrusions. They are characterized by the presence of epidote, garnet, diopside, zoisite, titanite, and hornblende in the metamorphosed zone, and by magnetite, hematite, cuprite, melaconite, native copper, malachite, azurite, chrysocolla, chalcopyrite, bornite, pyrite, and, rarely, films of chalcocite in the ores. Aside from minerals that are the result of weathering the others contained in the primary ore show the characteristic association of oxides and sulphides illustrated by the presence of magnetite with pyrite.

Along the same contact in the next gulch to the north, locally known as Coal Creek, the ores are chiefly argentiferous galena with practically no copper.

The most development work in this part of Bear Gulch has been done on the Johnston-Moffet group of claims, about 8 miles from Twin Bridges. These claims are from 6,000 to 7,000 feet above sea level and extend from the gulch over the ridge to the north. The limestone has been changed to garnet, epidote, and other calcium and magnesium-aluminum silicates for a distance of 300 or 400 feet from the "granite." Since the first deposition of these ores surface waters have produced oxides and carbonates. The most important ores of this type include some bodies of malachite, with subordinate azurite, cuprite, melaconite, chrysocolla, and native copper. But, probably owing to the small rainfall, oxidation has not penetrated deeply and below 100 feet from the surface the rocks become rapidly harder.

The principal shaft, an incline on the contact, is in the northeast corner of the Mountain View claim. For the first 100 feet the ore

body resembles a vein in shape and continuity. Below this for 25 feet or more is black shaly material formed from altered limestone. At a depth of 125 to 150 feet chalcopyrite and pyrite appear in small particles and streaks and in some solid lenses. The 200-foot level about 150 or 160 feet vertically below the surface, is developed by crosscut with east-west drifts on ore streaks. No large bodies of sulphide ore have yet been found. The principal mine opening in this part of Bear Gulch is an adit about 2,400 feet long, which enters the south side of the ridge north of Bear Gulch not far above the creek and extends to a point below another tunnel (called the Moffet tunnel) on the north side of the ridge. The long tunnel penetrates "granite" for about 1,400 feet and then passes into limestone. There is no ore at the contact, but some chalcopyrite and bornite, with a little chalcocite, which may represent the beginning of enrichment, was found below the Moffet tunnel. This ore occurs from 160 to 170 feet south of the face of the tunnel, which appears to be approaching another contact, the limestone probably being inclosed by "granite."

The rocks in this tunnel are hard and unoxidized except near the face, where there is a little oxidized ore containing malachite and native copper associated with pyrite and magnetite in garnet rock.

The Moffet adit starts in "granite" on the Quincy claim and runs southward for about 230 feet to the north contact of the limestone with "granite." At the contact a drift has been run about 100 feet to hard limestone and garnet rock through copper ore, consisting of a mixture of oxides and sulphides, which seems to have been rearranged and rudely banded by the action of surface waters. At other points near the surface on this group of claims small bodies of high-grade oxidized copper ores have been found, but so far as known no large bodies of profitable ore have been uncovered.

North of Bear Gulch, about 2 miles east of the Johnston-Moffet property, limestone occupies the summit of Smelter Hill, so called from an old smelter near its base. This limestone is partly inclosed and apparently underlain by "granite." Along the contact occur lead ores, consisting chiefly of argentiferous galena. The mines and smelter are abandoned.

A cyanide plant which was built at the mouth of Little Bear Gulch (the main tributary of Bear Gulch from the south) for the purpose of treating gold ores occurring on that gulch was closed in the fall of 1909 after running about six months.

At the head of Bear Gulch the "granite" is in contact with gneiss, schists, and black slate. In this region the ores occur in well-defined veins, and, like the contact deposits, are with little doubt genetically connected with the granitic intrusion. Their different character is probably due to the difference in the country rock. When "granite"

intrudes limestone the escaping ore-bearing solutions penetrate the limestone irregularly and produce ore bodies of correspondingly irregular form. On the other hand, when "granite" invades quartzite, gneiss, schists, or similar rocks, the escaping solutions are forced to follow fissures, fault planes, or similar openings. Limestone may be more porous before the intrusion than the other intruded rocks, and, whether it is or not, the heat of intrusion may drive off its carbon dioxide, rendering it more porous and giving it an affinity for silica and water. The effect of heat upon other intruded rocks is commonly to make them less porous. Furthermore, limestone is much more soluble than most rocks. Thus, ores from a common source may form contact deposits in limestone and vein deposits in siliceous rocks.

Near the surface the veins at the head of Bear Gulch have undergone some oxidation and concentration, but some unaltered sulphide ore usually remains, and this may even extend to the surface. The veins occur in "granite," in gneiss, or along the contact between the two. Thus, in the Pritchett mine, at an elevation of about 9,000 feet, a crosscut penetrates "granite" for about 200 feet southward to dikes of aplite and fault veins, which strike northeast and dip steeply southeast. The ore shoot, which is near a contact of "granite" with slate or fine-grained black gneiss, pitches about 75°. One shoot, which carries pyrite and galena, considerable gold, and some silver, has been mined from the tunnel level to the surface. Extremely little oxidation is apparent, though water is now going through rather abundantly. The mine has a 5-stamp mill with a plate and a Wilfley table. The high-grade ore and concentrates are sacked and hauled by wagon to Twin Bridges, whence they go by rail to one of the smelters of the region.

The Royal Bear, Aurora, and Peter claims adjoin the Pritchett property on the south, on the other side of a spur between two glacial cirques. Several tunnels, which run very irregularly northward along stringers of pyrite and galena in "granite" near the contact with gneiss, have found pockets of high-grade gold ore but no large ore bodies. These workings reach an important fault, striking about east and dipping about 80° S., which shows 5 to 8 feet of gouge but no ore. In this mine the pyrite is said to carry $300 to $400 and the galena about $20 in gold to the ton, with very little silver. Sulphide ores extend to the surface, where they are mixed with a little cerusite. They include a little chalcopyrite and sphalerite, but the important constituent is the auriferous pyrite.

On the Blue Jay and Jay Gould claims, to the west, two kinds of ore occur. One consists of chalcopyrite, tetrahedrite, and bornite, with auriferous pyrite in a gangue of quartz, barite, siderite, and calcite. The other consists of auriferous pyrite without copper minerals. The first kind of ore has been enriched in both gold and

copper to a depth of about 75 feet. The second kind has not been much modified by weathering, though it contains a little free gold in the shallow oxidized zone. The vein strikes about east and west and dips about 20° N. It varies from 1 to 2 feet in thickness.

GOODRICH GULCH.

GEOLOGY.

Goodrich Gulch opens into the Jefferson Valley about 5 miles east-northeast of Twin Bridges. Near its mouth the creek has taken advantage of faults in cutting across the Paleozoic limestone flank of the Tobacco Root Mountains. To the north a hard dark-blue limestone dips about 20° W., and to the south yellow to gray limestones dip 35° S. to SW. A short distance above its mouth the course of the gulch is offset nearly a mile to the north, probably by another fault. In going up the gulch one crosses the geologic formations in descending order. Beneath the limestones lie shales, quartzite, and gneiss. Near the head of the gulch these formations are underlain and cut by intrusive "granite" of the same type as that so abundant along Bear Gulch. Associated with the "granite" are broad aplitic dikes, consisting of a fine-grained matrix of quartz and orthoclase containing a few phenocrysts of orthoclase, which are commonly altered to sericite, kaolinite, quartz, hematite, chlorite, and titanite.

The matrix in places shows a eutectic intergrowth of quartz and orthoclase. These dikes occur on the divides between Goodrich Gulch, Little Bear Gulch, and a tributary of Wisconsin Creek. One dike, running northwest and southeast, is 600 to 800 feet wide; another, extending northeast and southwest, is about 1,000 feet wide.

ORE DEPOSITS.

The Schmidt property is located at the extreme head of Goodrich Gulch, some of the workings being about 1,000 feet above running water. About 800 feet below the divide at the head of the gulch a vein, opened by a tunnel cutting shale for about 120 feet, dips about 70° E., increasing to 80° at the face of the tunnel. The ores are oxidized and are rich in gold, but the underlying sulphides are of low grade.

Although the important constituent is gold, cerusite, malachite, cuprite, chrysocolla, bornite, chalcopyrite, pyrite, and sphalerite are also present.

On the Red Bell claim, about half a mile below Schmidt's camp, is a tunnel penetrating gneiss for about 350 feet. About 150 feet from the mouth it cuts ore in a zone of crushed ground, with much talc running in all directions. The ore here is auriferous pyrite and argentiferous galena with a little sphalerite.

About 2 miles below the head of Goodrich Gulch is a group of claims, the Carolina, Topeka, Little Goldie, and Nettie, which are being worked more or less regularly by lessees. They are on the south side of the creek well up on the ridge between Goodrich and Georgia gulches. The Carolina, which is about 800 feet above the creek and 7,700 feet above sea level, has a vein striking N. 30° W. and dipping 32° SW. The ore is chiefly auriferous pyrite. The mine is opened by an inclined shaft 125 feet deep and a tunnel about 760 feet long. The tunnel cuts at least two veins, one striking N. 25° E. and dipping about 30° NW. and the other striking about north and dipping about 60° E. The latter is cut about 400 feet and the former about 700 feet from the mouth of the tunnel. These veins cut slate and quartzite underlying Paleozoic limestone of either Cambrian or pre-Cambrian age. At this place the apparent thickness of the slate and quartzite is about 200 feet. It is underlain by gneiss, apparently belonging to the Cherry Creek group. The ore deposits are in the upper part of the slate and quartzite series near the base of the overlying limestone.

DRY AND WET GEORGIA GULCHES.

LOCATION.

Two gulches 4 and 5 miles nearly due east of Twin Bridges are known as Dry Georgia and Wet Georgia, respectively. Their waters flow southwestward from the westernmost part of the Tobacco Root Mountains. Even in the wet season the water in Dry Georgia Gulch is so scanty that it sinks into the sands and disappears completely within a mile or two of the mountains.

Mining has been carried on in the vicinity from the early days of quartz mining in the territory. The Tidal Wave mine, on the ridge between Dry Georgia and Goodrich gulches, was known in the sixties. The High Ridge mine, on the southwestward face of the mountains between Dry Georgia and Wet Georgia gulches, was operated by Dahler & Elling early in the eighties, and for the last 20 years has been worked more or less continuously by lessees.

GEOLOGY.

The westward-dipping Paleozoic limestones forming the western flank of the Tobacco Root Mountains may be followed southward along their strike from the steep cliff near Renova to Dry Georgia Gulch, where they disappear. The same Paleozoic limestones form the western flank of the Ruby Range, and it is possible that the two areas of limestone are continuous beneath the gravels of the Passamari Valley. But the surface distribution indicates the probability of faulting in this valley, and the continuity of the limestones is uncertain. In the region of the Georgia gulches the limestone rests in gen-

eral upon schists and gneiss, which contain some beds of limestone and quartzite and which probably belong to the Cherry Creek group. These underlying beds are considerably metamorphosed and are cut by dikes of andesite and aplite. On the Buckeye group of claims in Dry Georgia Gulch the surface of the schists and gneiss immediately below the limestone seems to be considerably weathered, and the great difference in the degree of metamorphism exhibited by the underlying schists and gneiss and the overlying limestones is further evidence of an unconformity at this point. The meager evidence obtained concerning the strike and dip of the schists points to the same conclusion.

ORE DEPOSITS.

The ore deposits of the two Georgia gulches are chiefly in veins cutting the schists and gneiss of the Cherry Creek group. They are in general closely associated with dikes or sills of various types of intrusive rocks, chiefly aplite and andesite. There seem to be at least two sets of veins in this region. One set carries gold as its most important constituent with important amounts of silver and some lead. The other set carries silver and lead as the chief metals, with minor quantities of gold.

In the region of the Georgia gulches enrichment extends to a much greater depth than it does in the Bear Gulch area (p. 152), and it seems possible that this is due to the greater age of the ore deposits of the Georgia gulches. If these deposits existed in the schists and gneisses of the Cherry Creek group before the deposition of the Paleozoic limestones, enrichment may have occurred chiefly during the erosion interval represented by the unconformity above the Cherry Creek group. It is entirely in harmony with this view that the veins of the Georgia gulches nowhere extend upward into the Paleozoic limestone, although in places they extend practically to the base of the limestone.

In the Buckeye group of claims on Dry Georgia Gulch gold ore occurs in gneiss just below the contact with the overlying limestone. The ore, so far as opened by a shaft 200 feet deep and an incline 600 feet long, reaching a depth of about 300 feet, is all oxidized. The gneiss is much folded and faulted.

The High Ridge mine, on the mountain side between Dry and Wet Georgia gulches, is in gneiss about 400 feet below the limestone. The ore carries chiefly silver and lead, with some gold. The vein dips about 20° NE.

The Democrat mine, which adjoins the High Ridge on the southwest down the slope, shows oxidized gold ore in a quartz vein in gneiss. Tunnels run in 200 to 400 feet without reaching sulphide ore.

The Empire and Bay State properties on Wet Georgia Gulch are in gneiss about 500 feet below the limestone.

The Keynote mine is in gneiss 1,000 to 1,200 feet below the limestone. One vein which strikes about east and dips about 75° S. is closely associated with a pegmatite dike rich in orthoclase. It carries chiefly gold and silver. Another vein which strikes about north and has a flat dip, first to the west and then to the east, carries chiefly lead and silver, with some gold.

The Ella mine, on Wet Georgia Gulch, is in gneiss about 500 feet below the limestone. An andesite dike about 100 feet wide strikes northeast and dips about 30° NW. The quartz vein dips about 10° N. and carries chiefly lead and silver, with some gold. Oxidation on this vein is less advanced than elsewhere, and some sulphides (galena and pyrite) occur even to the surface, but they are mixed with oxidized ores (cerusite and iron-stained quartz) at all depths opened.

The Argenta mine, which is nearly on the divide between the head of Wet Georgia and Goodrich gulches, is in gneiss just below the limestone. The ore is auriferous pyrite and galena in a quartz vein along the footwall of an aplite dike, as seen in the main tunnel. The dike strikes about north and dips about 15° W. The limestone on the ridge at the head of the gulch strikes nearly east and dips north.

On the Buckeye group, in Dry Georgia Gulch, a vein of oxidized manganese ore (pyrolusite) lies parallel with the banding in gneiss and locally attains a thickness of 10 feet. This manganese ore, so far as exposed, is not in the same veins as the gold ore, but is so closely associated with them that it may have played an important part in the process of concentration. It has been shown by Emmons [1] that manganese is important in the concentration of gold, not only in causing the solution of gold by producing nascent chlorine, but also in preventing the reprecipitation of gold by keeping sulphated iron in the ferrous state. In harmony with this view is the fact that placers have never been commercially important in Dry Georgia Gulch, though they have been actively worked in many other gulches of the southwestern slope of the Tobacco Root Mountains. The veins have not yet been opened to sufficient depth to determine whether the gold is notably concentrated, but the conditions seem to be favorable for concentration.

VIRGINIA CITY DISTRICT.

LOCATION.

Virginia City is situated near the upper end of Alder Gulch, in the central part of Madison County, at an altitude of about 6,000 feet, in a gulch which cuts deep into the heart of the Tobacco Root Mountains. The nearest railroad station is about 9 miles west, at Alder, the terminus of the Ruby branch of the Northern Pacific Railway. Alder Creek rises along the northern base of Old Baldy Mountain, flows north about

[1] Emmons, W. H., Am. Inst. Min. Eng. Bull. 46, pp. 768-831, 1910; Jour. Geology, vol. 19, pp. 15-46, 1911.