R. I. 3952

October 1946

UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
R. R. SAYERS, DIRECTOR

REPORT OF INVESTIGATIONS

EXPLORATION OF THE JUMBO BASIN IRON DEPOSIT
PRINCE OF WALES ISLAND, SOUTHEASTERN ALASKA

BY

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CONTENTS

INTRODUCTION

Preliminary and detailed exploratory examinations of iron and copper ores on Prince of Wales Island have been conducted by the Bureau of Mines from early in 1942 until the end of 1944. Among these investigations was that of the Jumbo magnetite deposit, which was visited by Stephen P. Holt, an engineer of the Bureau of Mines, during a preliminary examination of the Copper Mountain and Jumbo properties September 15 to 18, 1943. During the months of June, July, and August 1944, a more detailed examination, which consisted essentially of mapping and sampling, was made by the authors working in conjunction with George C. Kennedy of the Geological Survey. Geological, topographical, and dip-needle contour maps were made of the area, and 97 channel samples were cut.

ACKNOWLEDGMENT

In its program of exploration of mineral deposits, the Bureau of Mines has as its primary objective the more effective utilization of our mineral resources to the end that they make the greatest possible contribution to

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Report of Investigations 3952."
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national security and economy. It is the policy of the Bureau to publish the facts developed by each exploratory project as soon as practicable after its conclusion. The Mining Branch, Lowell B. Moon, chief, conducts preliminary examinations, performs the actual exploratory work, and prepares the final report. The Metallurgical Branch, R. G. Knickerbocker, chief, analyzes samples and performs beneficiation tests. Both these branches are under the supervision of Dr. R. S. Dean, assistant director.

Special acknowledgment is made to R. D. Stewart, Territorial Commissioner of Mines and former general manager, and to Duncan Campbell, Ketchikan, Alaska, former mine superintendent of the Jumbo mine. Acknowledgment is also due to George C. Kennedy of the Federal Geological Survey for extending cooperative assistance in topographical mapping, dip-needle surveying, and geological study of the deposits. Further acknowledgment is made to C. Travis Anderson, chief, Rolla Division, Metallurgical Branch, and other members of that division for conducting beneficiation tests on Jumbo Basin ores.

LOCATION AND ACCESSIBILITY

The Jumbo group of claims is on the west slope of a ridge between Mount Jumbo and Copper Mountain on Prince of Wales Island, Alaska, at latitude 55° 15' north, longitude 132° 38' west. The property is 1-1/2 miles east of Hetta Inlet, a deep embayment connected to the Pacific Ocean through Cordova Bay off the west coast of the southeast end of the island, as shown in figures 1 and 2. Hetta Inlet is navigable by steamships to a point at its head near the site of the abandoned mining camp of Sulzer. At one time Hetta Inlet was connected at its head with Cholmondeley Sound by a 4-mile road over which light freight and mail from Ketchikan were delivered to Sulzer and Coppermount. Ketchikan, the nearest city and source of hardware, fuel, and lumber, is 120 miles by water and 40 miles by airline east of the property. By arrangement, a mail boat will make weekly delivery of supplies to Jumbo Harbor, as it does to Hydaburg, a small fishing village 8 miles west.

The old Jumbo workings, once connected to the beach by an aerial tram, can be reached only by a foot trail about 2 miles in length. A new trail constructed by the Bureau of Mines branches from the old trail about 3/4 mile from the beach and leads northwest to the main magnetite deposit. This deposit lies at an elevation of 1,600 feet, half a mile north of the old Jumbo copper mine, which was the main source of production of the Alaska Industrial Co., the original operators. At an elevation of 3,400 feet, half a mile southeast of the old Jumbo mine, is the upper Copper Mountain workings, property of the Copper Harbor Co. The Jumbo group of patented claims, with a total of 860 acres, extends from the beach to a point near the ridge crest, as shown in figure 3. The Jumbo property is in the Ketchikan Mining District and consists of 55 patented claims of the following survey numbers:

- 26 mining claims of Survey No. 562-A
- 1 mining claim and 5 mill sites of Survey No. 562-B
- 5 mining claims of Survey No. 1542
- 6 mining claims of Survey No. 1545
- 10 mining claims of Survey No. 1596
- 2 mill sites of Survey No. 1599

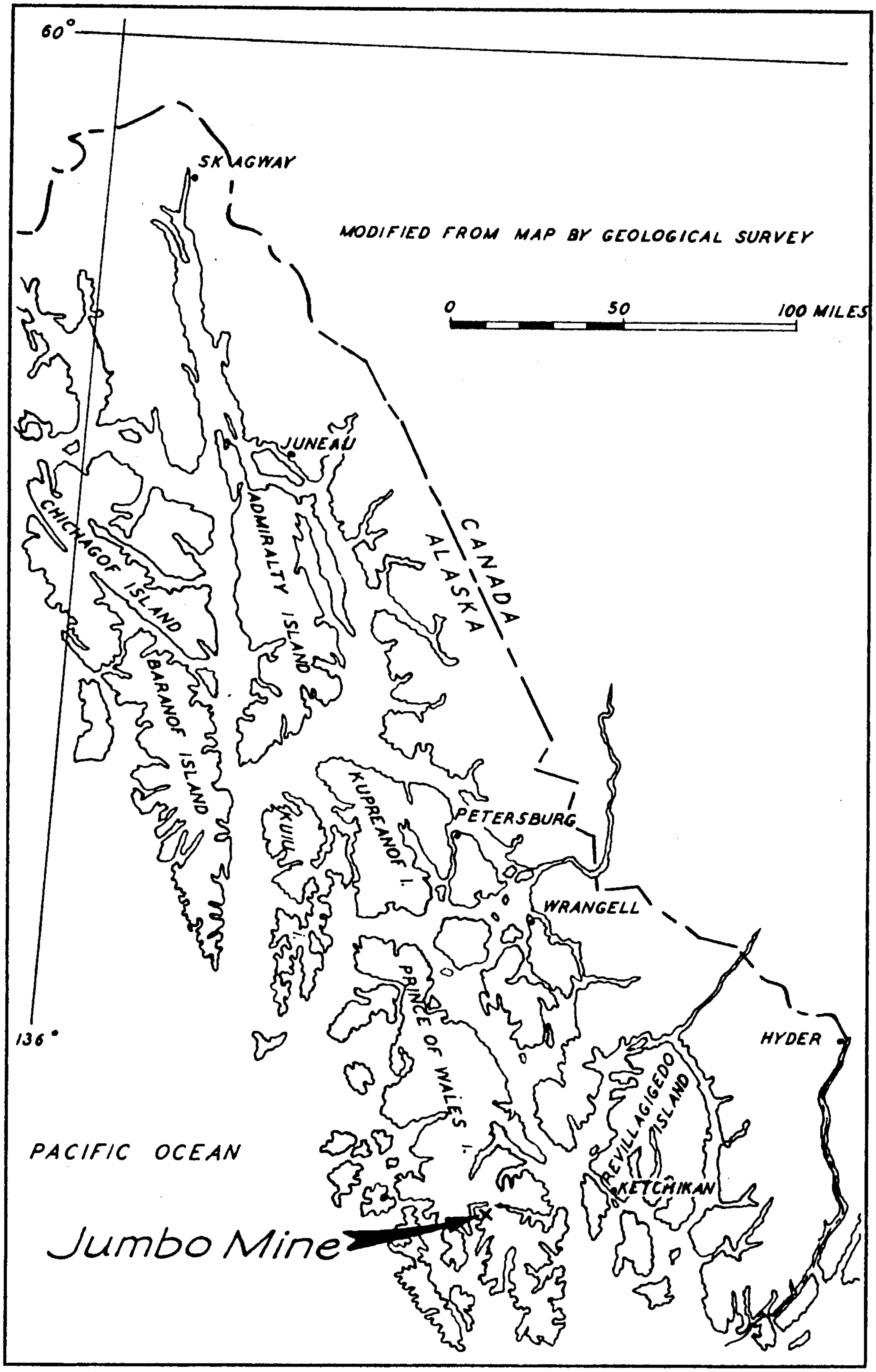


FIG. 1 INDEX MAP — SOUTHEASTERN ALASKA

The freight rate from Ketchikan to Seattle on ore worth \$60 or less is \$4.50 a ton plus a 16 percent surcharge, which is effective only during the war. If cargo is transshipped at Ketchikan, the wharfage is \$2.20, and at Seattle it is \$1.40 if cargo is transferred to open railroad cars. At one time marble was transported by barge from Dall Island to Seattle at \$0.90 a ton.

PHYSICAL FEATURES AND CLIMATE

The west shore line of Prince of Wales Island is broken by many bays and inlets, which are protected from the Pacific Ocean by small seaward islands. The topography of the island is not as rugged as that of the mainland but is characterized by rounded mountains, deep stream channels, U-shaped valleys, and a few jagged peaks. The Jumbo property lies on the steep slope of a U-shaped basin resembling a cirque. The basin faces Hetta Inlet, from which slopes rise gently for three-quarters of a mile and increase gradually from 20 to 50 degrees to the crest of an arc-shaped ridge at altitudes of 2,500 to 3,800 feet. Jumbo Creek, originating in snow-covered areas above timber line, forms a series of falls and rapids in its descent to the valley. This creek, as well as two lakes on the east and southeast sides of Copper Mountain are potential sources of power for mining. Lake Josephine, 1-1/4 miles long and half a mile wide, is three-quarters mile east of Copper Mountain at an altitude of 1,840 feet. Lake Mellen, a smaller body at 876 feet, is half a mile south of Copper Mountain and 1 mile east of Copper Harbor, a 1 mile embayment on the east side of Hetta Inlet.

Precipitation in the area probably closely approximates the recorded annual average of 150.89 inches at Ketchikan. Even in midsummer, mist and fog usually enshroud the rim of Jumbo Basin, where snow remains on the north-facing slopes the year around. The climate is mild, as winter temperature rarely is low as 0° F. and summer temperature seldom reaches 90° F.

Below 2,000 feet the ground is covered with a heavy growth of spruce, hemlock, and cedar, all of which make suitable mining timbers. An abundance of ferns, alders, and berry bushes forms a dense undergrowth in the valley.

LABOR AND LIVING CONDITIONS

The labor supply, though normally plentiful, is scarce at this time (1945) by reason of war-emergency demands. Fishing, the principal occupation in this part of Alaska, affords employment in the summer months for all available workmen. Prevailing hourly wage rates exceed prewar rates by roughly 25 percent. In 1943, the following basic wage rates were established by the War Labor Board for the Territory of Alaska:

	Per hour
Blacksmith	\$1.565
Carpenter	1.50
Drill runner	1.315
Foreman drill runner	1.45
Laborer, unskilled	1.015
Miner	1.40
Motorman	1.315
Tractor operator	1.75

Time and one-half must be paid for work over 8 hours a day and 40 hours a week, and double time is paid for the seventh consecutive day.

Except for two small one-story cottages on the beach, there are no living quarters on the property. Water for domestic purposes is available in numerous small streams.

HISTORY AND OWNERSHIP

Mineral deposits were discovered at Jumbo Basin in 1897 by Aaron Shellhouse, and in the following spring claims were recorded. In 1899 William Sulzer, recognizing the value of the deposits because of their copper content, organized the Alaska Industrial Co. to develop them. The company held 29 claims in the Jumbo group and located 14 on Green Monster Mountain. Exploration and development on the Jumbo group was begun in 1902 and continued in succeeding years with the driving of adits and sinking of test pits. Most of the work was done on claims 1, 1A, and 2 on the west flank of the Jumbo-Copper Mountain ridge at 1,500 to 1,900 feet, and on claims 4 and 14 at 1,700 and 2,050 feet altitude, respectively. An aerial tram 8,250 feet long was erected for the transportation of ore to the beach where ore bins of 4,000 tons capacity and a wharf with a 150-foot frontage were built also. The company made its first shipment of ore to the Tyee smelter in British Columbia in 1907, and operated intermittently in the following years until 1919, when a low copper price and lack of ore reserves caused them to close the mine. The total value of copper and gold produced at the property is not known, but it is reported to exceed $1,000,000. All claims of the Jumbo and Green Monster groups formerly held by the Alaska Industrial Co. now belong to the estate of William Sulzer, of which Mrs. Clara Sulzer, 6479 Morris Park Road, Overbrook, Pa., is administratrix.

GEOLOGY

A granitic mass in the form of a batholith occupies the central portion of an area roughly 5 miles square east of Hetta Inlet and south of Portage Bay. The main rock type in this mass is a hornblende diorite, though at some places monzonite and diorite are found. Surrounding the intrusive body is an almost unbroken belt of intensely folded limestone and greenstone schists. The surface geology of the area is shown in figure 2. An inclusion of limestone and schists forms the upper 400 feet of Copper Mountain and extends northwest into the Jumbo Basin area. Tongues of the granitic intrusive extend into the schists, and in some places small igneous bodies are isolated in the older formations. Near the intrusive contacts in Jumbo Basin, the schists are silicified and garnetized and the limestone is marmarized. The belt of contact metamorphic rocks ranges in width from 0 to 500 feet and is very irregular in outline. The principal minerals in the contact rocks are garnet, amphibole, pyroxene, epidote, and calcite.

The dip of the intruded rocks, except in a few places, conforms to the attitude of the contact surface of the batholithic mass, about 70 degrees. Jointing planes in the diorite have nearly vertical dips, and no faults or structural breaks were found within the intrusive mass. The stratified deposits are intensely compressed and folded.

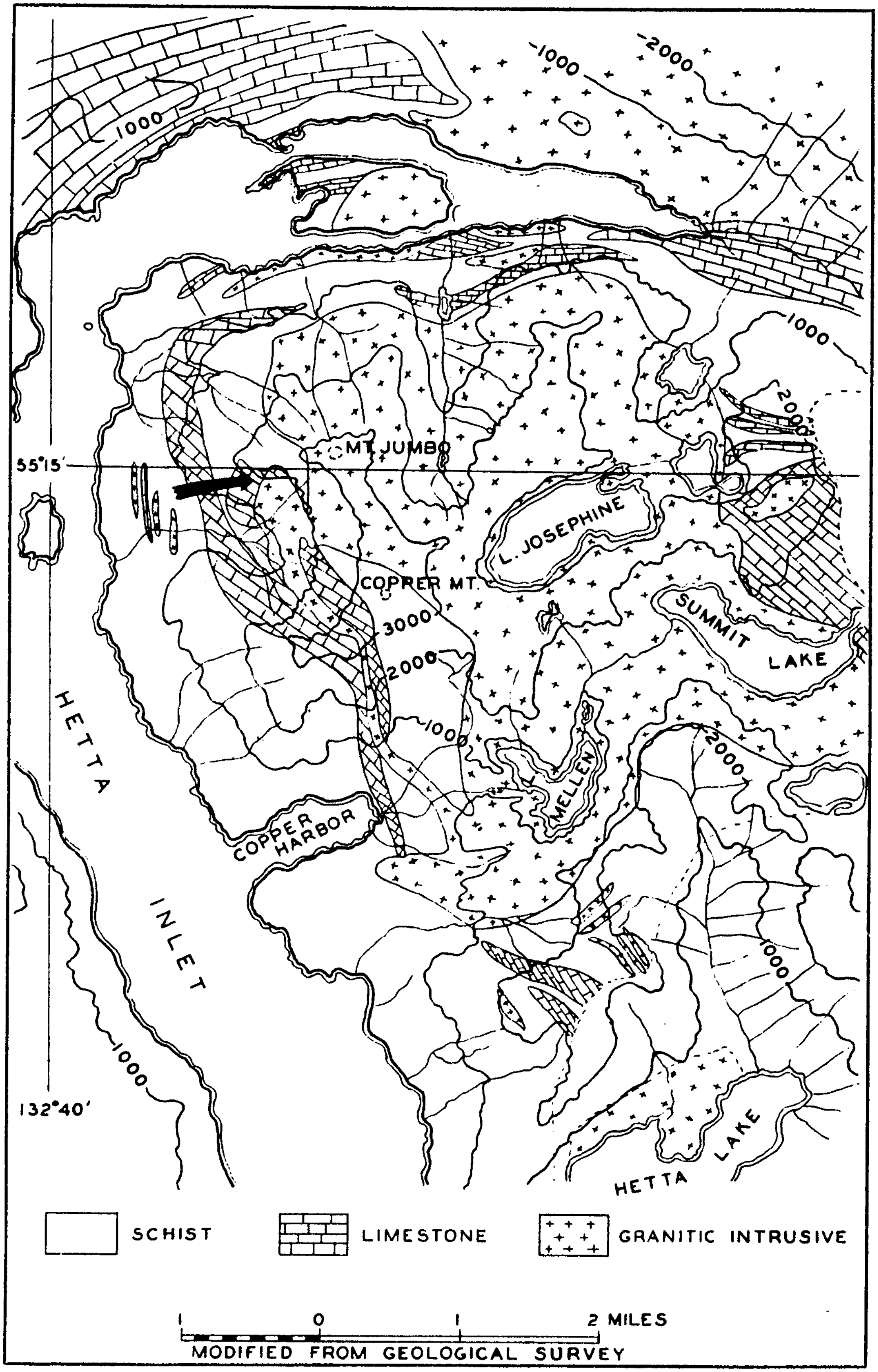


FIG. 2 MT. JUMBO AREA PRINCE WALES ISLAND ALASKA

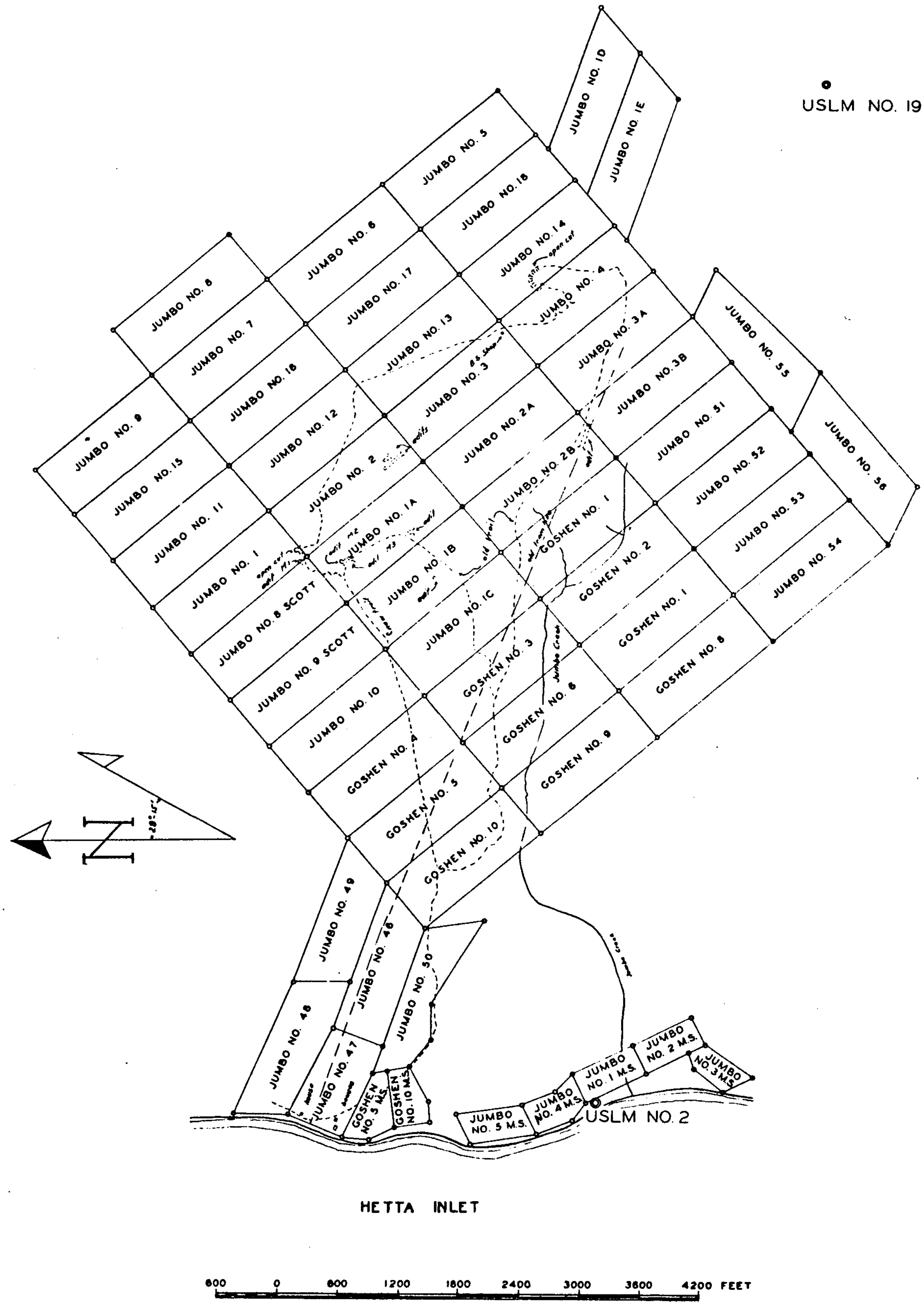


FIG. 3 CLAIM MAP - JUMBO BASIN

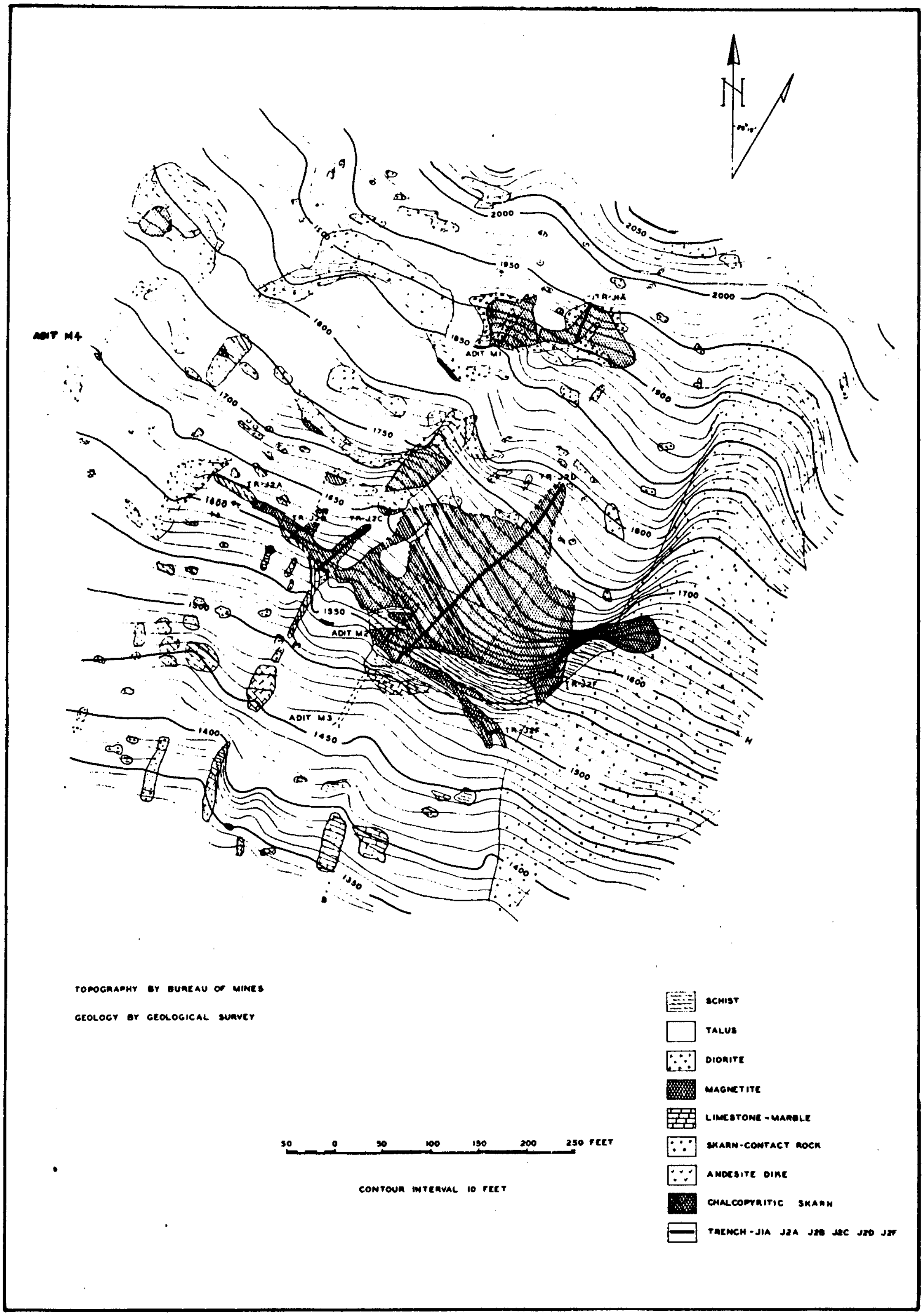


FIG. 4 GENERAL TOPOGRAPHIC AND GEOLOGIC MAP

ORE DEPOSITS

Ore deposits in the Jumbo Basin belong to the contact type and may be divided, on the basis of mineral composition, into two classes - (1) the chalcopyrite group and (2) the magnetite-chalcopyrite group. The chalcopyrite deposits were exploited extensively before 1919 by the Alaska Industrial Co., which left no ore of this class in the old stopes. The part of the contact zone in which these deposits were found has been explored by drifts, crosscuts, raises, and winzes. Scattered patches of disseminated chalcopyrite and pyrite remained in No. 3 adit, and a small remnant of massive chalcopyrite was observed in the roof of No. 2 adit near the portal, though ore in minable quantity was not found. On the surface near the portal of No. 2 adit a small amount of molybdenite is exposed in irregular pattern in close association with secondary silicates. Garnet, epidote, calcite, diopside, hornblende, and pyroxenite are the principal gangue minerals.

The magnetite-chalcopyrite deposits on which all Bureau of Mines exploring was done, are situated above an elevation of 1,400 feet on Jumbo claims 1, 1A, and 2, as may be seen by reference to figures 3 and 4. The main ore body, a lenticular mass with two sides almost entirely exposed, overlies the diorite intrusive on a slope of 52 degrees. Exposure of formations at the surface and in adit M3 suggests that the lower part of the ore body is overlain by limestone (see fig. 8, sec. A-B). Irregular in outline, the exposed portion is roughly 300 feet wide by 270 feet long, measured on the slope, and, including three narrow branches of the main body, has an area of roughly 90,000 square feet. An unreplaced band of greenstone schist between elevations 1,550 and 1,610 appears to separate the ore body almost completely into two blocks. At the base of the outcrop, where the magnetite appears to dip under the white marmarized limestone, the contact is very sharp.

On the southeast, the magnetite outcrop is bordered by a band of diorite fully exposed for a width of 200 feet and for a slope distance of several hundred feet. On this side, a portion of the magnetite body appears to have broken apart from the existing block leaving an almost vertical wall 20 to 70 feet high. The average thickness of the deposit on this side is 28 feet. It is assumed that glacial action has forced a portion of the magnetite body apart from the remaining mass, carried it away, and left the underlying diorite exposed. Further evidence of glacial action is the broad, slightly dish-shaped gulch in this area.

About midway of the ore body, at an altitude of 1,540 feet, adit M-2 exposes the following material: 19.5 feet of magnetite ore containing 47.5 percent iron and 0.57 percent copper, 4.75 feet of greenstone schist, 24.75 feet of magnetite ore containing 36.0 percent iron and 0.24 percent copper, and 3.5 feet of diorite.

Projecting these distances normal to the dip, the two ore sections are separated by 3.75 feet of greenstone and have a combined thickness of 35 feet. At an altitude of 1,460 feet, a 62.5-foot adit, M-3, exposes 53 feet of limestone and 9.5 feet of magnetite. The west half of the drift face shows hornblende, garnet, and a low percentage of magnetite. Geological structure and dip-needle readings indicate that one lens of ore lies beyond this face and, in this area, extends a short distance downward. This is illustrated in figure 8, section A-B.

Surface trenching and outcrops indicate that the ore body is progressively thinner west and northwest of adit M-2. Beyond the limits of the main ore body are found intermingled patches of skarn, marble, greenstone, diorite, and magnetite. The contact minerals forming skarn are abundant in this area, particularly at the contact of the diorite dikes with the greenstone.

The upper or northeast side of the deposit is likewise wedgeshaped and at one place extends in a narrow, thin neck 100 feet up the mountain side. A much thicker band of magnetite, having a length of 85 feet and a width of 50 feet, branches from the main body on the east.

On the north, a small lens of magnetite is separated from the main body by a 40-foot band of diorite. On the opposite side, it is in contact with a small isolated limestone outcrop. This deposit, though only 50 feet wide, is believed to have formed along the contact of a spur of the main dioritic intrusive and extends downward a considerable depth, as suggested by section A-B, figure 8.

Farther up the slope, between 1,850 and 1,950 feet, is a small outcrop of magnetite in contact with chalcopyrite-bearing skarn. An adit, M-1, 52 feet long penetrates chalcopyrite-bearing skarn a distance of 38 feet and exposes only 14 feet of magnetite-chalcopyrite ore, which can be assumed to extend downward a distance equal to the difference in elevation of the highest outcrop and the adit, or about 100 feet. The magnetite outcrop here is 100 feet wide and 50 feet long on the slope.

One-half mile east, a few outlying magnetite cappings are scattered over a comparatively large area, but all are small. (See fig. 6.) A dip-needle survey of the area is shown in figure 7.

Dip-Needle Survey

Numerous dip-needle readings were taken in the contact zone in an attempt to find a continuation of the main ore body or unexposed outlying deposits. Fairly strong negative anomalies were recorded at the upper and lower limits on the west side of the main outcrop. It is partly because of the greater magnetic intensity in these areas that ore shoots are assumed to extend to moderate depths beneath them. (See fig. 5 and fig. 8, sec. A-B.) Lesser readings were recorded as much as 250 feet beyond the northwest limits of the outcrop, but trenching in this area showed these to be caused by shallow, isolated, magnetite cappings. The main area of positive anomalies is on the north side of the large outcrop, as would be expected, but it is interesting to note that few of the needle deflections are as much as 30 degrees. Greater deflections were obtained in a few small areas where it is believed minor deposits are covered by skarn, limestone, or greenstone. One such area is in the southeastern corner of the large outcrop, where the magnetite appears to dip under the limestone. The positive anomalies here are taken as criteria that the magnetite extends to a moderate depth along the contact at this point.

Dip-needle readings were taken over the entire upper area, and, with the exception of one small spot, deflections were obtained only in the vicinity of magnetite cappings. The readings indicated no important ore bodies in this area.

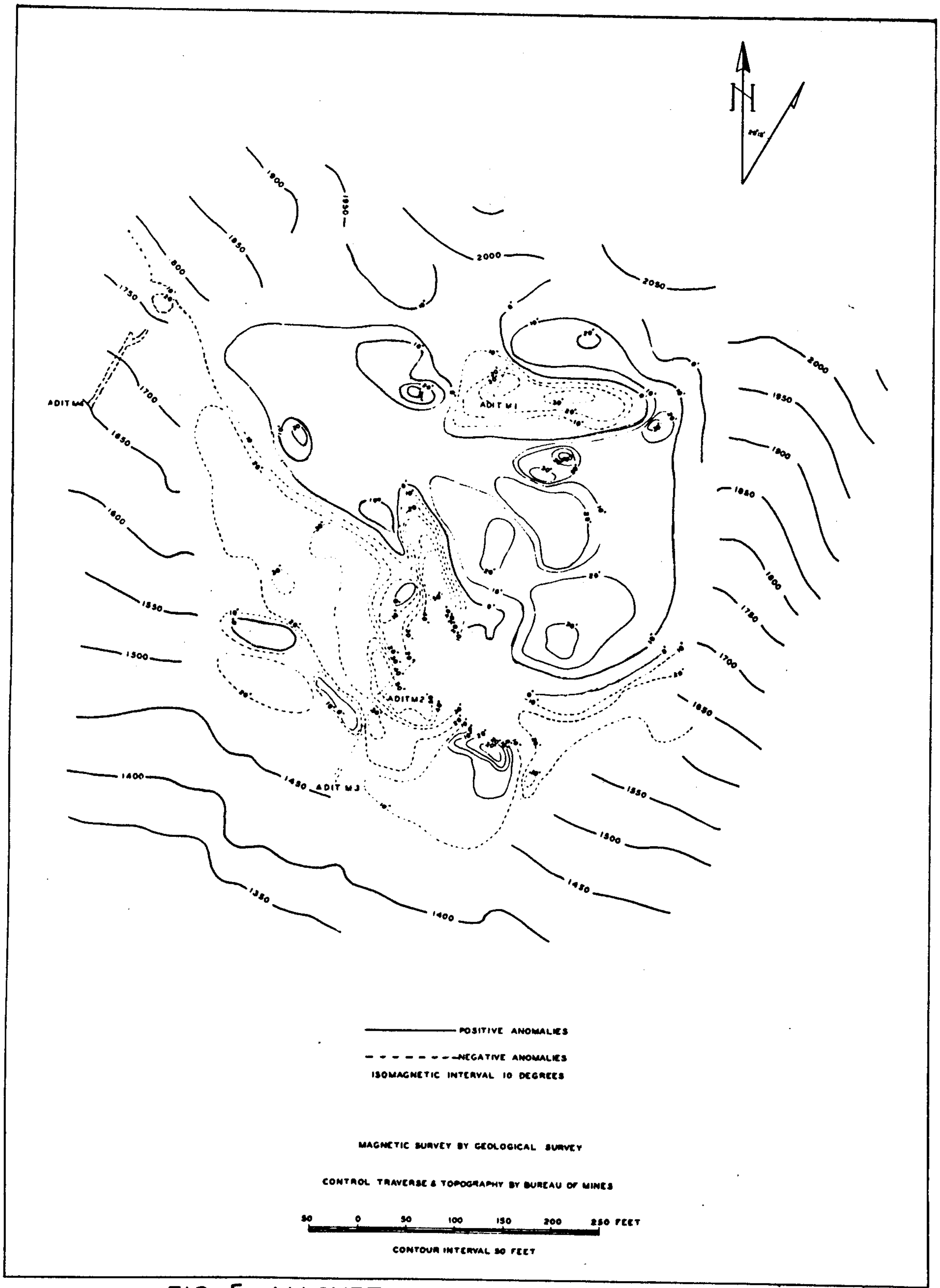


FIG. 5 MAGNETIC SURVEY OF MAIN AREA

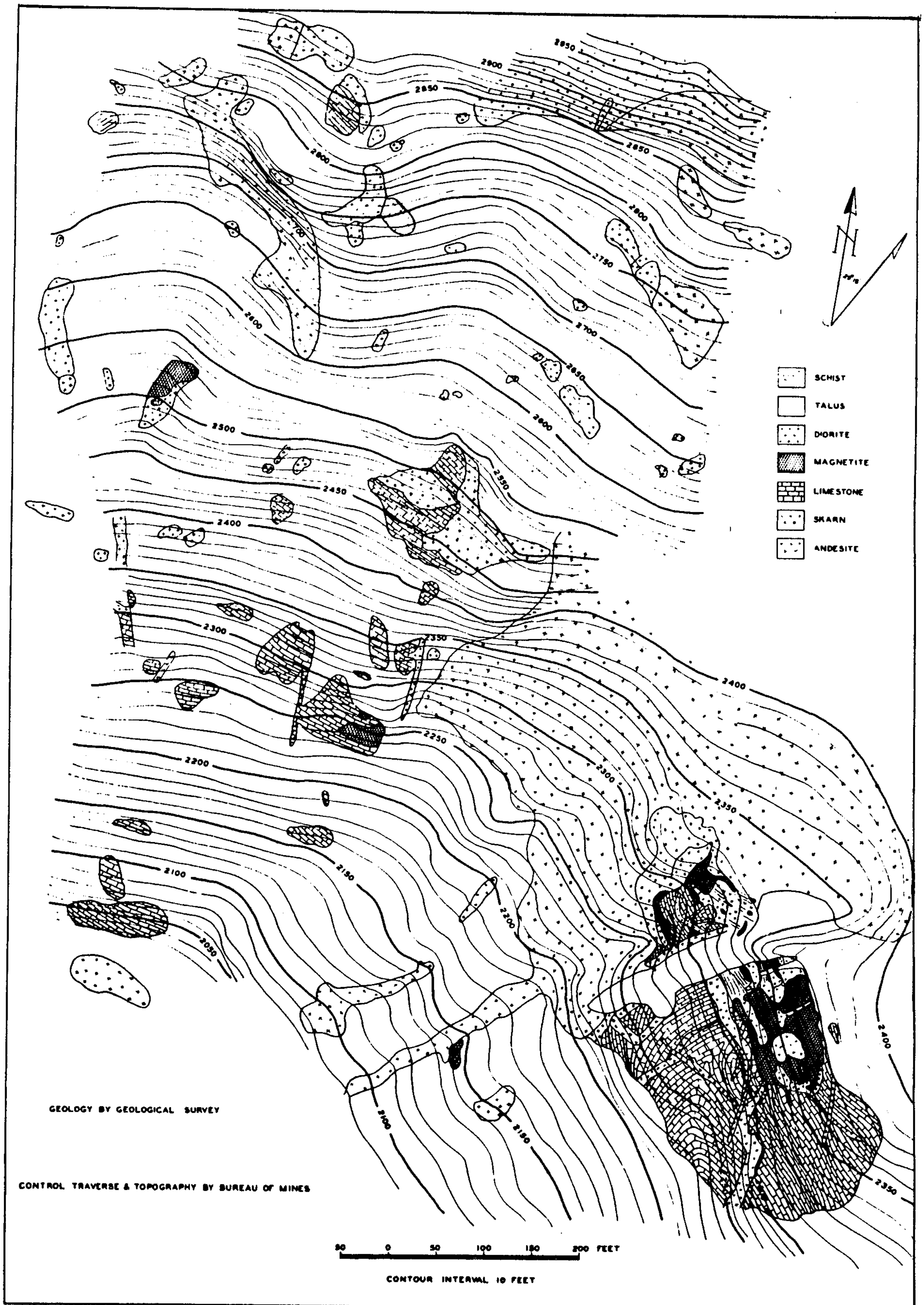


FIG. 6 MAGNETITE OUTCROPS UPPER AREA

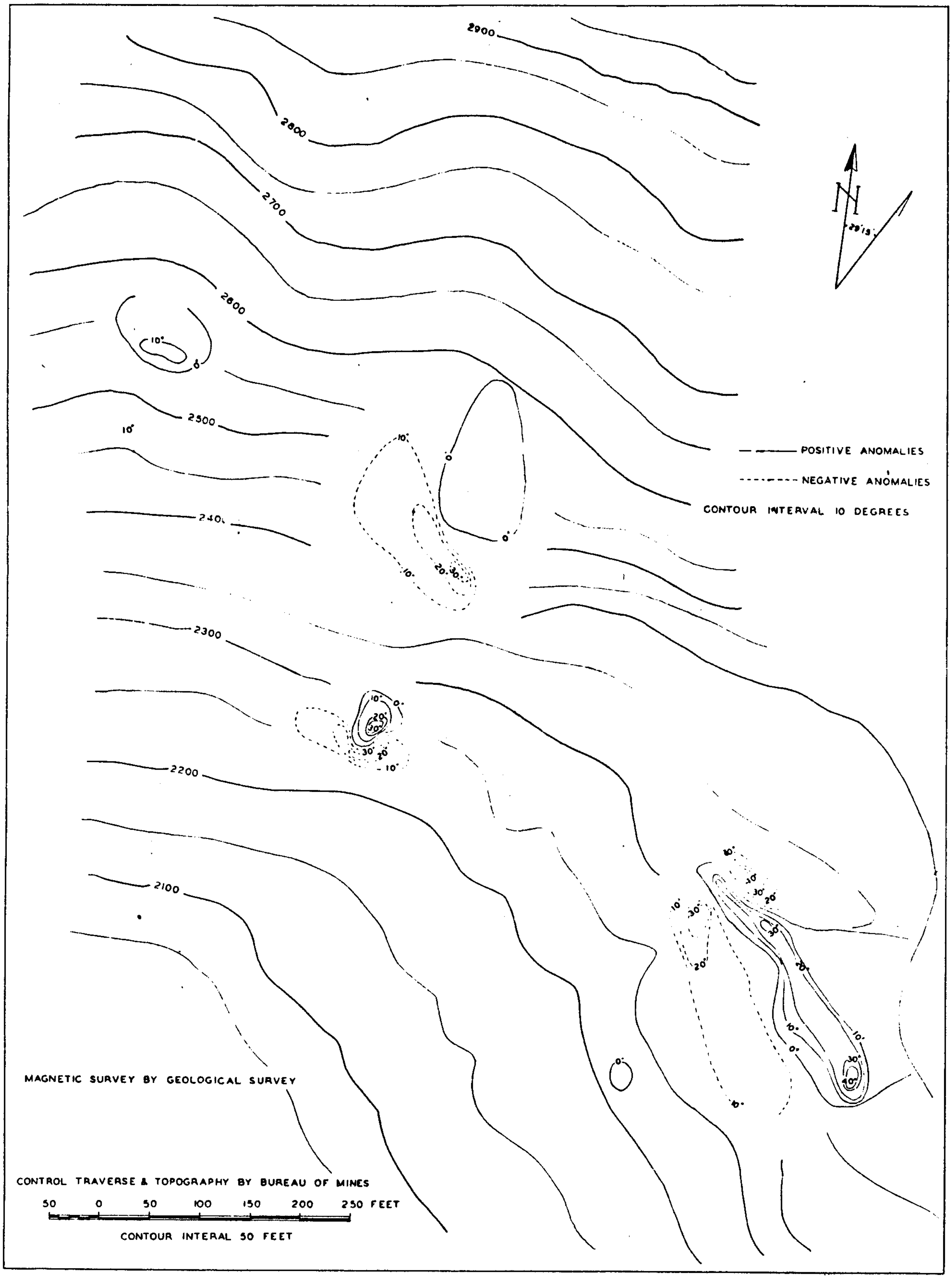
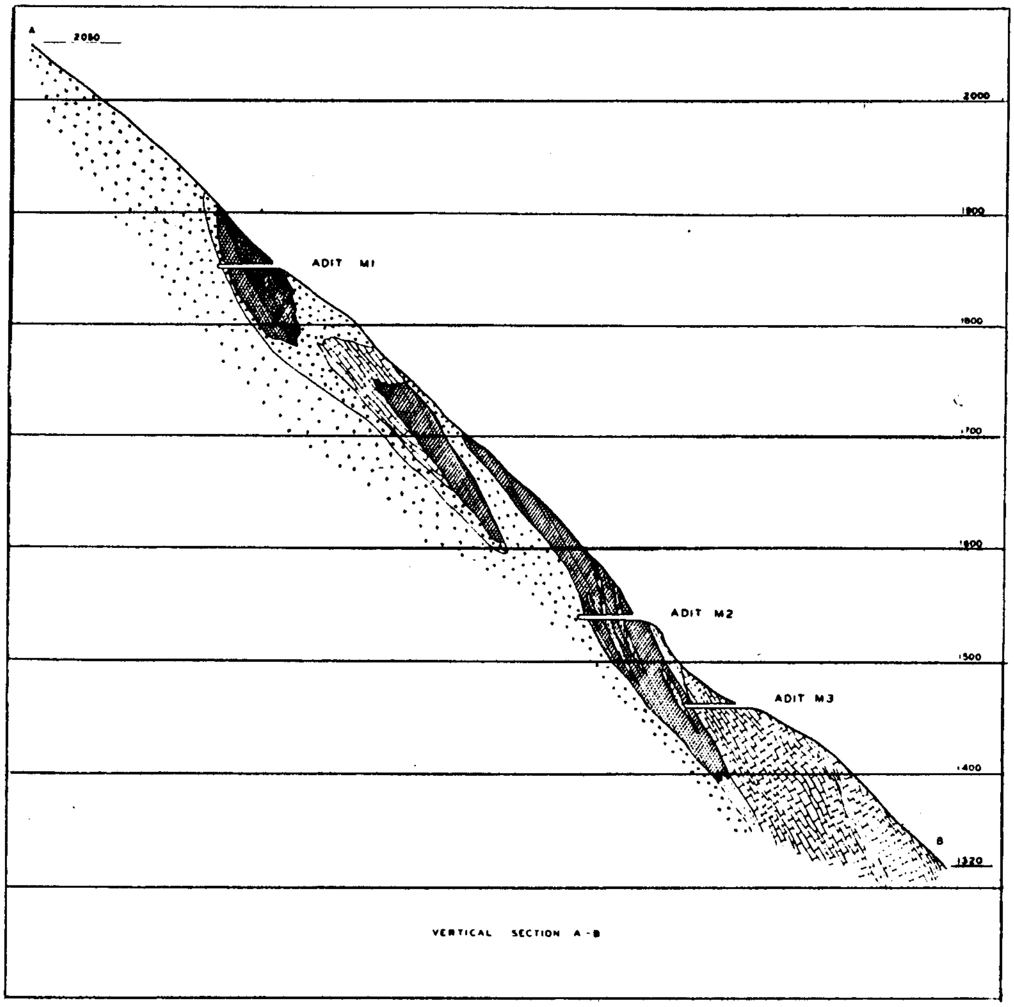


FIG. 7 MAGNETIC SURVEY OF UPPER AREA



JUMBO PROPERTY
PRINCE OF WALES ISLAND

CONTROL TRAVERSE BY BUREAU OF MINES - GEOLOGY BY GEOLOGICAL SURVEY

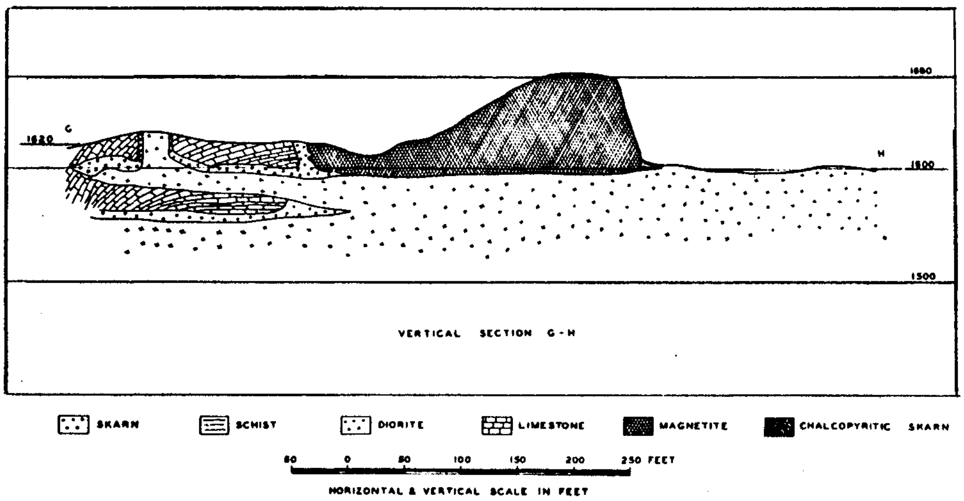


FIG. 8 SECTIONS A-B AND G-H

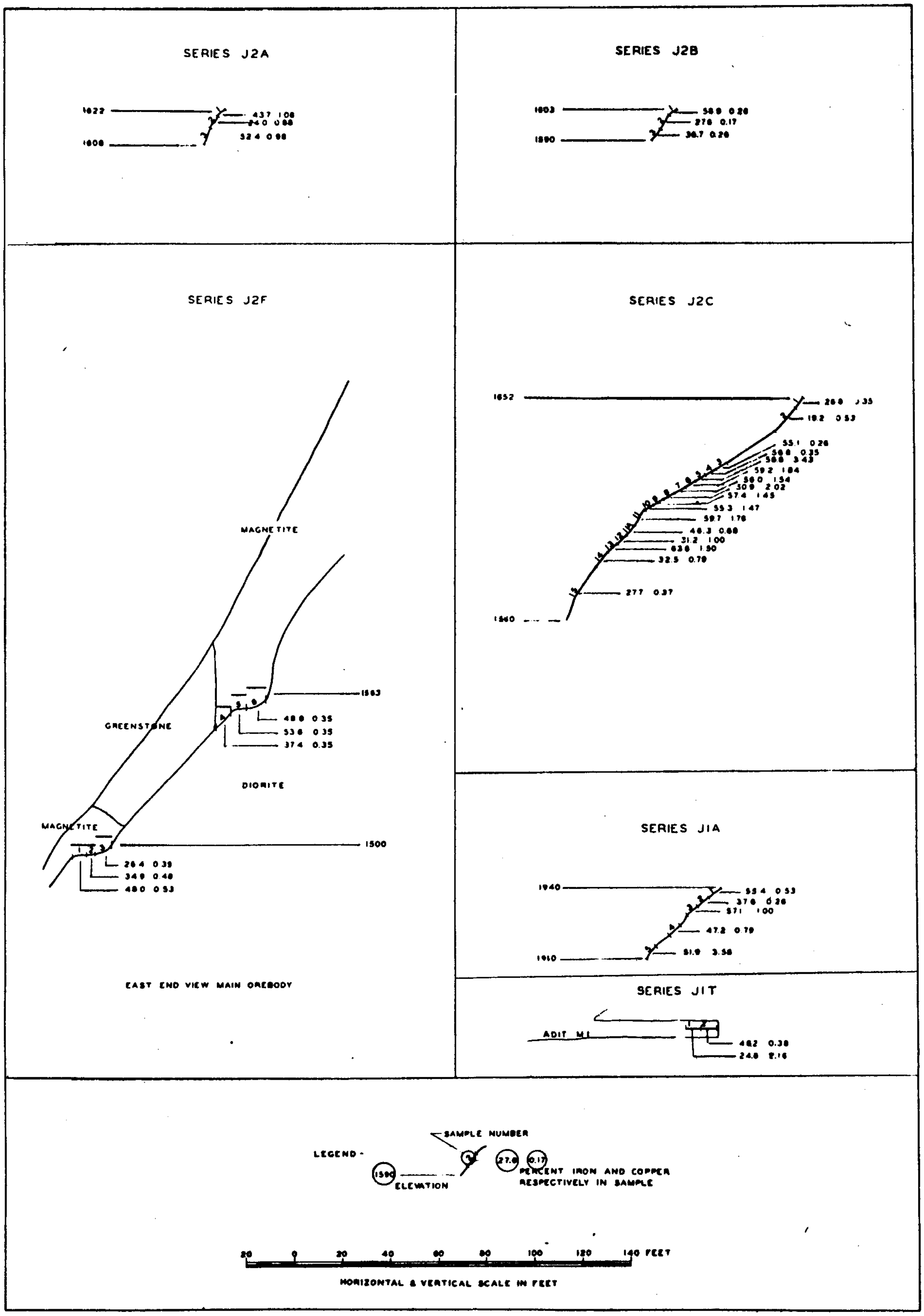
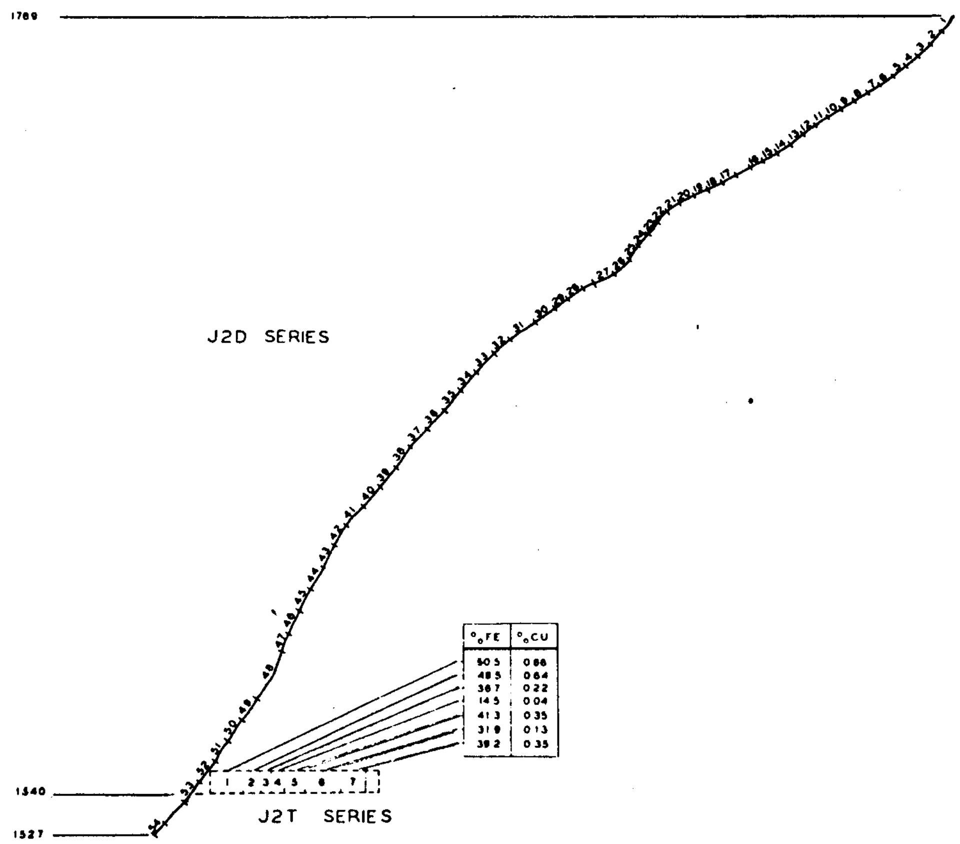


FIG. 9 PROFILES OF CHANNEL SAMPLING-SERIES J2A, J2B, J2C, J2F, J1A



SAMPLE NO	%FE	%CU		SAMPLE NO	%FE	%CU
1	33.1	0.19		28	57.3	0.02
2	26.4	4.27		29	48.2	0.32
3	21.2	0.53		30	57.1	1.63
4	26.4	0.15		31	57.8	1.96
5	32.8	0.22		32	57.1	1.36
6	38.6	0.22		33	58.8	1.38
7	54.8	0.06		34	27.9	0.27
8	33.8	0.17		35	51.4	0.92
9	53.0	0.10		36	55.5	1.00
10	52.7	0.10		37	57.0	1.89
11	41.9	0.04		38	53.8	1.26
12	38.1	0.09		39	35.7	1.00
13	35.8	0.11		40	46.7	1.75
14	30.3	0.07		41	58.5	1.05
15	40.9	0.04		42	52.9	1.17
16	43.7	0.04		43	55.3	0.88
17	45.1	0.02		44*	31.5	0.22
18	56.8	0.04		45	50.0	0.53
19	61.0	0.02		46	52.7	0.66
20	63.0	0.02		47	44.1	0.57
21	61.8	0.09		48	13.0	0.22
22	61.7	0.18		49	60.3	1.32
23	55.2	0.02		50	52.0	1.26
24	58.9	0.02		51	62.3	0.44
25	64.0	0.04		52	51.0	0.57
26	65.2	0.04		53	37.4	1.00
27	62.6	0.04		54	48.2	1.13

FIG. 10 PROFILE OF CHANNEL SAMPLES J2D J2T

SAMPLING AND ASSAYING

The main ore body does not have an exposed face normal to the main axis that can be sampled safely. The nearest approach to the desired condition is found in adit M-2, which lies 38 degrees off of the normal position. Loose, overhanging slabs prevented sampling the upper east face, but on the lower east face sample channels were staggered in "stair-step" pattern to obtain the equivalent of a continuous channel across the vein. (See fig. 9.) Aside from these two series, all channels on the main ore body were cut from top to bottom of the slope. In cutting most of these channels, the samplers used pulley blocks, ropes, and chairs with underslung, canvas-covered platforms. All samples were cut as 2- by 6-inch channels and ranged in length from 3 to 10 feet, depending on the iron content of the material. A few breaks occurred in the continuity of the channels where diorite dikes or bands of greenstone lay across the line of samples. (See fig. 10.) It is assumed that by selective mining and sorting this material can be kept out of the ore.

The ore body lying 270 feet up the slope from the main deposit was sampled by one channel (J-1-2) on the surface and by two samples (J-1-T-1 and J-1-T-2) in adit M-1. No other samples were taken outside the main ore body.

All samples were dried, crushed in a laboratory jaw crusher to minus 1/4-inch size, and passed through a Jones splitter. One portion of each sample from the splitter was submitted for iron and copper analysis to the assay office of the Territorial Department of Mines at Ketchikan. The other portion was again split into two parts, one of which was combined with samples of the same series to form a composite. The other part was retained for future analysis, if necessary. There were 97 cut samples and 10 composites. The average lime, insoluble, phosphorus, titanium oxide, sulfur, gold, and silver content of the ore is based upon a weighted average of the 10 composites, as shown in table 1.

TABLE 1

Composites, series	Length, feet	Percentage							Oz/per short ton	
		Cu	Fe	CaO	S	P	Insol.	TiO_2	Au	Ag
J-1-A	31	1.67	54.0	4.50	2.20	Tr.	11.66	Tr.	0.02	0.90
J-2-A	18	.83	43.4	10.44	5.4	Tr.	18.94	Tr.	Tr.	.70
J-2-B	17	.20	40.6	9.95	2.46	Tr.	28.1	Tr.	0.01	.80
J-2-T	44	.50	45.8	4.00	2.04	Tr.	25.4	Tr.	Tr.	.90
J-2-C	137	1.32	41.7	9.60	2.36	Tr.	23.3	Tr.	0.01	.90
J-2-D 1-16	80	.40	37.4	3.33	.86	0.01	34.97	Tr.	.02	.80
J-2-D 17-31	89	.29	58.9	.30	.35	Tr.	13.4	Tr.	.01	.70
J-2-D 32-47	126	1.17	49.1	.20	1.32	Tr.	23.0	Tr.	.01	.70
J-2-D 47-54	45	.75	50.3	.35	2.80	Tr.	21.6	Tr.	.01	.70
J-2-F	36	.57	42.9	.20	.76	Tr.	33.7	Tr.	.01	1.00
Weighted average		1/ 0.67	1/ 43.4	2/ 3.74	2/ 1.67	2/ Tr.	2/ 21.6	2/ Tr.	3/ 0.012	3/ 0.90

1/ Weighted on the basis of represented ore reserves.
2/ Weighted on the basis of series lengths.
3/ Long-ton average.

DEVELOPMENT

Adit M-1, with a bearing N. 26° E., penetrates the skarn and magnetite of the J-1 ore body a distance of 42 feet at an altitude of 1,850 feet. Aside from a very small amount of surface excavation, no other work was done in this area.

Adit M-2, at an altitude of 1,540 feet and 54 feet in length, extends across the main ore body on a bearing N. 40° E. and exposes the underlying diorite. Adit M-3, 80 feet lower, is 62.5 feet long and bears N. 30° E.

Adit M-4 is 300 feet northwest of the main ore body at 1,650 feet. It bears N. 31° E. for 88 feet, but at 78 feet from the portal a 20-foot branch to the right has a bearing N. 50° E. The adit penetrates limestone and skarn but no magnetite.

These four adits comprise the workings on Jumbo claims 1, 1A, and 2. The ore and country rock are hard and firm. No faults or seams were observed, and timbers had been used only at the portal of adit M-3.

EQUIPMENT

The powerhouse at the beach contains a Felton water wheel belted to an electric generator. The wheel is equipped with a regulator and appears to be in good condition. It is considered suitable for the development of 100 horsepower at 2,300 volts, but the wooden pipe line has deteriorated, and there is no dam in Jumbo Creek for impounding water.

A 2-stage compressor is inside No. 4 adit of the old copper mine. Its condition could not be determined, as it was surrounded by water, but its size suggests a capacity for delivering about 800 cubic feet of free air a minute.

No other usable equipment was found on the property.

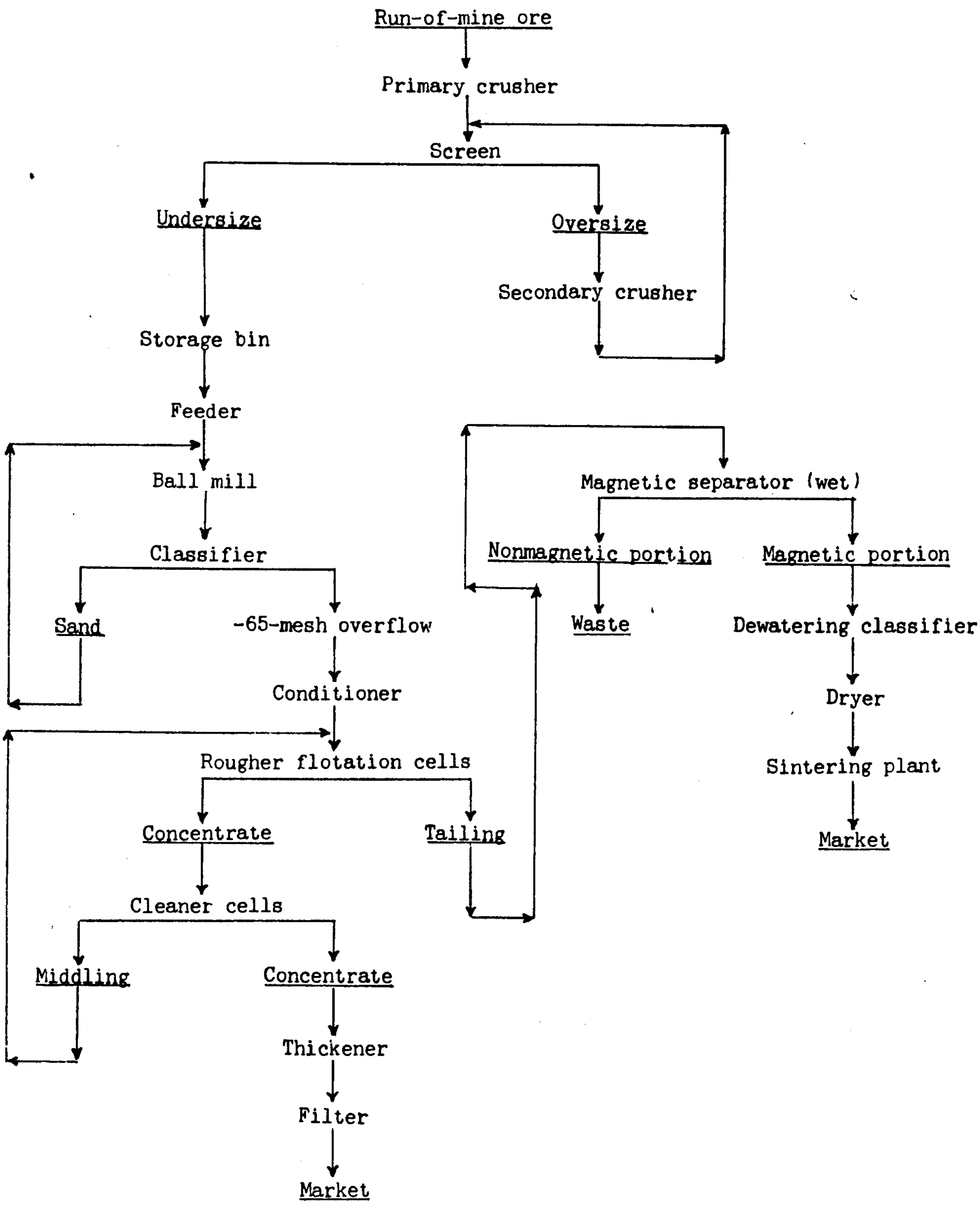
BENEFICIATION

A beneficiation test was made in the Rolla laboratory of the Bureau of Mines on a composite of equal weights of five samples of ore taken from the Jumbo magnetite deposit at the time of the preliminary examination. The analysis of the composite sample was as follows:

Analysis, percent

Fe	Cu	S	P	SiO_2	Al_2O_3	CaO	TiO_2	Mg
38.39	0.38	1.19	0.039	16.05	3.02	2.28	0.55	1.12

The sample was divided into four parts, which were ground to minus 8-, minus 28-, minus 100-, and minus 200-mesh, respectively. Portions of the various fractions were roasted for 30 minutes in hydrogen gas at 550° C. Roasted and unroasted samples were treated in a Davis-tube magnetic separator to determine if a reducing roast prior to magnetic separation would increase iron recovery. Results indicate iron recovery is not increased materially by a reducing roast.



Suggested flow sheet for recovering iron and copper.

The magentic and nonmagnetic products from the unroasted material of -28- and -100-mesh sizes showed the following analyses, weights, and recoveries:

Product	Weight, percent	Analyses, percent					Percent of total				
		Fe	Cu	S	P	SiO_2	Fe	Cu	S	P	SiO_2
-28-mesh magnetic	56.8	63.2	0.05	1.0	0.02	3.7	93.6	8.6	50.3	46.7	12.8
-28-mesh nonmag.	43.2	5.7	.70	1.3	.03	33.2	6.4	91.4	49.7	53.3	87.2
-100-mesh magnetic	53.3	68.6	.05	.87	.03	1.1	93.8	7.3	42.7	40.6	3.6
-100-mesh nonmag.	46.7	5.2	.72	1.33	.05	33.6	6.2	92.7	57.3	59.4	96.4

Treatment of minus 8-mesh unroasted material produced a 59.2 percent iron concentrate. The test demonstrates the improvement in grade of the magnetic product with finer grinding, though it is doubtful whether the advantage of a 68.6 percent iron concentrate over one containing 63.2 percent iron would be worth the cost of grinding all material to pass 100-mesh.

A sample of ore was ground to minus 100-mesh and floated with 0.125 pound a ton of potassium pentasol xanthate and 0.12 pound per ton of methyl amyl alcohol. The rougher concentrate was cleaned twice. The tailing from this test was passed through the Davis tube to concentrate the magnetite. Results of flotation followed by magnetic concentration of the tailings are as follows:

Product	Weight, percent	Analysis, percent					Percent of total	
		Fe	Cu	S	P	SiO_2	Fe	Cu
Copper concentrate	1.63	35.2	19.8	-	-	-	1.48	84.94
Copper middling	2.54	2.83	1.12	-	-	-	1.82	7.49
Magnetic concentrate ...	51.63	69.0	.03	0.61	0.05	0.90	92.20	4.08
Nonmagnetic tailing	44.20	3.9	.03	.17	.07	43.5	4.46	3.49
Composite	100.00	38.6	0.38	0.41	0.06	20.5	100.00	100.00

The foregoing tests indicate that magnetic concentration of 100-mesh material before flotation pulls 7.3 percent of the copper into the magnetic material. In the test in which the material was first treated by flotation and the magnetite tailing was concentrated in the Davis tube, only 4.08 percent of the copper was contained in the magnetic concentrate. This is a serious consideration in an ore of 0.63 percent copper content, hence a more advantageous flow sheet would probably be one in which flotation preceded magnetic separation. Though the test was made on minus 100-mesh material, the grain size of the chalcopyrite indicate that the grade of the copper concentrate and the copper recovery would not be greatly impaired if the material were floated at minus 65-mesh size.

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