Alaska Southeastern Alaska Iron

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

BUREAU OF MINES
R. R. SAYERS, DIRECTOR

REPORT OF INVESTIGATIONS

EXPLORATION OF POOR MAN IRON DEPOSIT
KASAAN PENINSULA, PRINCE OF WALES ISLAND
SOUTHEASTERN ALASKA

BY

S. P. HOLT AND ROBERT S. SANFORD

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INTRODUCTION

The wartime demand for iron ore and alloy steel on the west coast revived interest in iron reserves in western United States and Alaska. Magnetite was known to have been the most abundant metallic mineral at some of the old copper mines on Prince of Wales Island. In the summer of 1942, the Bureau of Mines began a program of preliminary investigation followed by core-drilling two magnetite deposits on the island.

The Poor Man iron deposit on Kasaan Peninsula, Prince of Wales Island, Southeastern Alaska, was examined in August 1942 by Robert L. Thorne, associate mining engineer of the Bureau of Mines, and John C. Reed and E. N. Goddard, geologists of the Federal Geological Survey. In September 1942 the area was mapped geologically and a magnetic survey was made by the Geological Survey. In October and November 1942, a more thorough preliminary examination, which included cleaning out and sampling old adits and trenches, was made by the senior author, Robert L. Thorne, and Aner W. Erickson, engineers of the Bureau. J. G. Shepherd, a consultant of the Bureau, spent two weeks in March and April 1943 investigating the Poor Man and other deposits on Kasaan Peninsula. Core drilling was completed in June 1943.

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 3956."
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L. A. Warner, of the Geological Survey, examined all cores and interpreted structural data revealed by the drilling.

ACKNOWLEDGMENTS

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 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 C. Travis Anderson, chief, Rolla Division, Metallurgical Branch, and to A. L. Howard, Erick Lindeman, and James Coleman for cooperation and assistance.

LOCATION AND ACCESSIBILITY

The deposit is at latitude 55° 53' north, longitude 132° 26' west on the north side of Kasaan Bay on Prince of Wales Island, Southeastern Alaska. It is 2 miles northwest of the village of Kasaan by Forest Service trail and 35 miles northwest, by water, of Ketchikan. The general location is shown on figure 1.

Kasaan has one store, a post office, an elementary school, and a cannery. Except when the cannery is operating during the salmon-fishing season in July and August, the community consists of less than 50 persons, mostly native Indians.

Ketchikan, a city of about 6,000 people, is a seaport on the inside-passage waterway 750 miles north of Seattle and has regular and frequent steamer service by the Alaska Steamship Co., Northland Transportation Co., Canadian Pacific Railway Co., Steamship Service, and Canadian National Lines.

Ketchikan is the best source of food and mining supplies, timber, and labor. From Ketchikan, regular weekly trips are made to Kasaan by the motorship "Eureka", which carries mail, passengers, and freight. During the fishing season there is regular radio-phone service from Kasaan to outside points via Ketchikan.

There are no roads on the Peninsula. A Forest Service trail from Kasaan to Salt Chuck passes the south end of the Poor Man property.

Airplane service from Ketchikan to Kasaan or from Kasaan to Ketchikan, if previously arranged, is available on regular trips by small seaplanes of the Ellis Airways from Ketchikan to points on the west coast of Prince of Wales Island. The fare is $10 a passenger if set off or picked up on a regular trip. Charter trips at greater cost may be arranged.

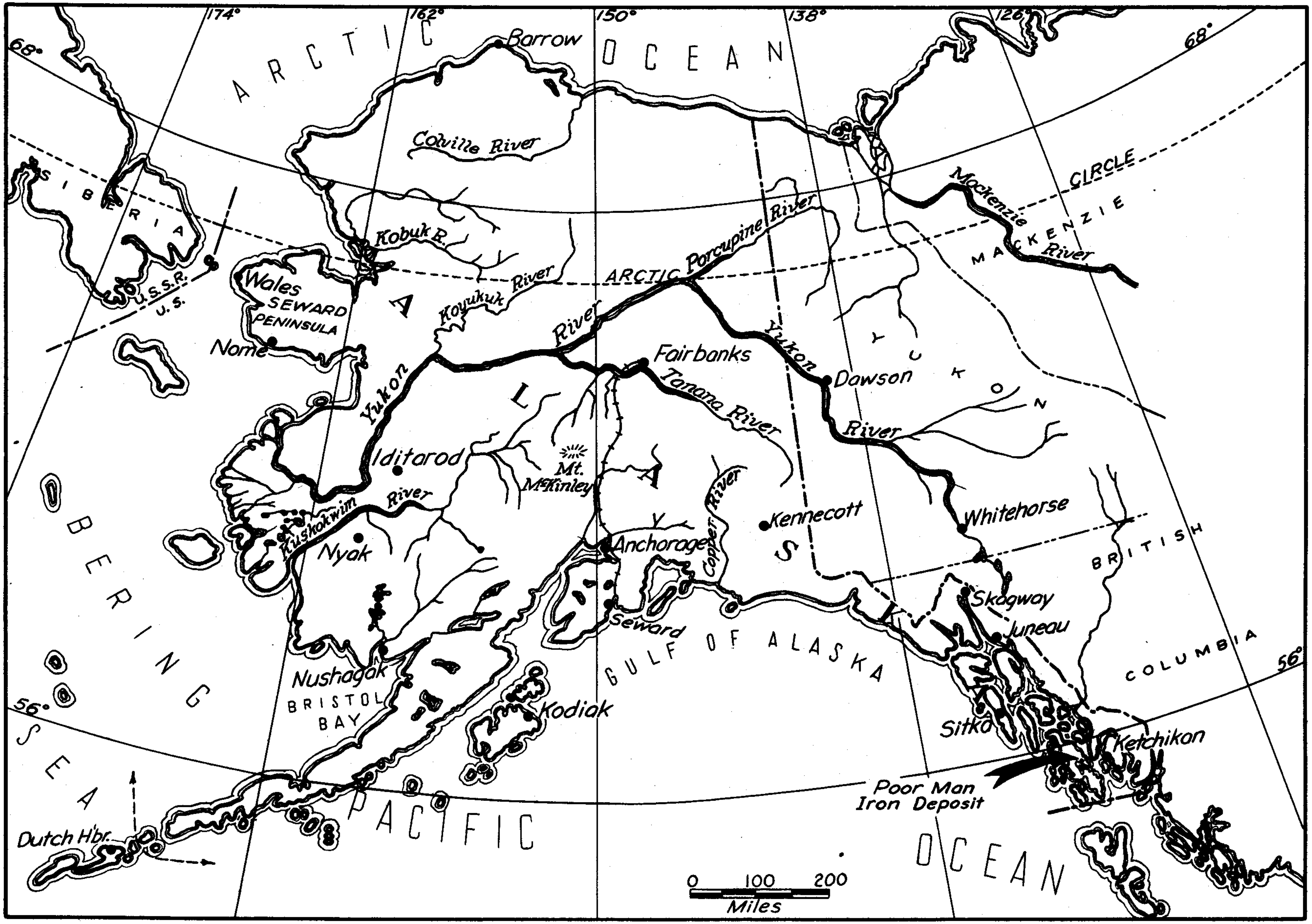


FIG. 1-INDEX MAP, SHOWING LOCATION OF POOR MAN IRON PROSPECT

There is a fair-weather anchorage for sea-going vessels directly offshore from the property. The nearest harbors safe for small ships in heavy storms are at Long Island, 4-1/2 miles to the southeast. Safe harbors for larger vessels are at Coal Harbor or Twelve Mile Arm, 4 miles southwest.

PHYSICAL FEATURES AND CLIMATE

The ore deposit lies on a heavily wooded flat 1,500 to 3,000 feet inland from the beach at altitudes of 50 to 200 feet. Poor Man Creek, a small stream flows along the west side of the deposit, and has a branch from the northeast. During the driest part of the summer of 1943, this creek carried ample water for mining and camp use.

The climate is typical of southeastern Alaska, the temperature rarely dropping to 0° F. in winter or rising above 90° F. in summer. Precipitation is heavy, approaching the average of 151 inches a year of rainfall reported at nearby Ketchikan. Most of it is in the form of rain as snowfall seldom is more than 3 feet a year. The winter of 1942-43 was said to be unusual, with 8 inches of snow at sea level and 24 inches at an altitude of 400 feet in December, and temperatures at or below 0° F. for 10 day periods.

Mining can be done throughout the year if proper housing is provided. Shipping to and from Seattle continues throughout the year on vessels that move along the ice-free inside passage.

Vegetation is luxuriant; dense undergrowth occurs near sea level, and there are fine stands of spruce, hemlock, and some yellow cedar, all of which provide enough timber for any reasonable mining use or camp construction.

LABOR AND LIVING CONDITIONS

Under peacetime conditions, labor is reported to have been plentiful and wages reasonable. At present (January 1946) skilled labor is scarce and all wages are high. Common labor is paid $1.015 an hour; mechanics, miners, and carpenters receive $1.30 to $1.60 an hour for 40 hours weekly and time and one-half for work over 40 hours. Kasaan is a nearby source of labor and will furnish a limited number of native workers, some of whom are skilled carpenters and mechanics, except during the fishing season. This native labor has been found satisfactory.

Because of the mild climate, living conditions are good, although the excessive rainfall is trying for men working outdoors. As there are no buildings on the property except two small occupied cabins, and no housing is available nearby, camps would have to be built to house workmen in any contemplated exploitation of the deposit.

HISTORY AND PRODUCTION

James Coleman, one of the owners, reports that the property was located in 1903 by Jack Kirman. Kirman relinquished his title to Billy Anderson, who turned the property over to Coleman. During the early 1900's a stock company trying to develop a copper mine did considerable work, including driving three short adits and sinking three shallow shafts. A surface tramway from the beach to the deposit and a small dock were built. This enterprise failed when it became apparent that, owing to its grade, the copper would not support the operation. No iron ore has been shipped, except one small lot for testing, results of which are not available.

PROPERTY AND OWNERSHIP

The property consists of three unpatented claims registered with the United States Commissioner at Ketchikan. Of these, Iron King No. 1 covers a small, isolated copper deposit; Iron King No. 2 is located to cover the beach, Coleman's residence, and trail north to the iron deposit; and Iron King No. 3 covers the iron outcrops.

James Coleman, who lives on the property, Erick Lindeman, Ketchikan, Alaska, and A. L. Howard, 7018 Brooklyn Avenue, Seattle, Wash., are joint owners of the property.

ORE DEPOSIT

The Poor Man iron deposit has been traced for a distance of 1,500 feet along the strike and for a maximum surface width of 150 feet. It is of the contact-metamorphic type, the principal ore minerals being magnetite, chalcopyrite, and pyrite in a gangue of epidote, garnet, hornblende, quartz, and calcite. Country rock is the Kasaan greenstone, a dense gray and greenish rock, possibly of volcanic source, now highly metamorphosed, silicified, and epidotized, especially near the ore body. There are included lenses of limestone, metamorphosed to coarsely crystalline gray and white marble.

The ore occurs in a breccia zone in the greenstone. No clearly defined bedding planes were seen either in the ore or country rock, though many small seams roughly parallel to the ore contacts were observed. The eastern or footwall contact of the ore, as determined by core drilling, dips 50° to 70°, and averages 60° westerly. The western or hanging wall is steeper and more irregular, dipping generally from 70° westerly to 90° and averaging 80°. Strike of the ore body is approximately north-south.

The south end of the ore body is covered by alluvium. Dip-needle surveys by the Bureau of Mines and the Geological Survey indicate that the ore continues 50 to 100 feet farther south and there pinches out or pitches steeply downward. The former condition appears more probable. No ore is seen at the surface as far north as No. 4 shaft, which is down 10 feet in alluvium and glacial till. Dip-needle surveys indicate that ore continues 10 to 15 feet farther north, where it is cut off abruptly, possibly by a concealed fault that strikes easterly against a wall of gray and white marbleized limestone. No abnormal dip-needle readings were observed beyond this point.

Several dikes of syenite occur within the ore at the surface. (See figure 2.) Dikes of syenite, andesite, and diabase also were intersected in drill holes. The Federal Geological Survey estimated that the volume of waste rock included within the ore may be as much as 20 percent of the total. Estimates based upon the results of drilling indicate that waste included in the

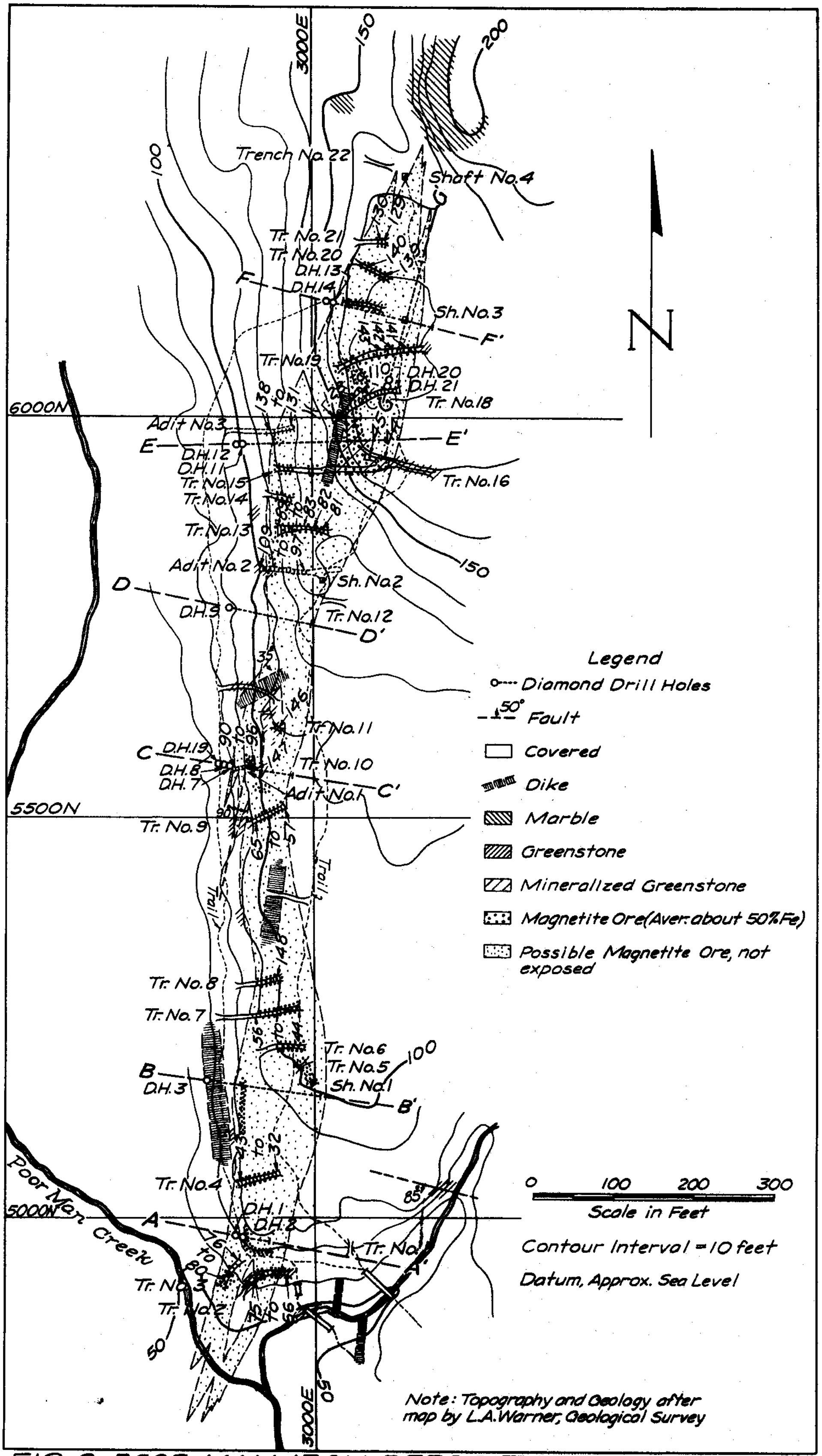


FIG. 2, POOR MAN IRON DEPOSIT, KASAAN, ALASKA

TRENCH NO. 4

Sample No.	%Cu	%Fe
32	Nil	58.40
33	Nil	60.20
34	Nil	58.80
35	Nil	60.50
36	0.05	60.10
37	Nil	61.20
38	Tr.	61.00
39	Nil	61.60
40	Nil	52.60
41	Tr.	61.00
42	Nil	57.80
43	Nil	49.40

TRENCH NO. 7

Sample No.	%Cu	%Fe	Composits
44	Tr.	52.7	Au-0.03 oz./ton
45	0.09	54.8	Ag-0.05 oz./ton
46	0.10	57.3	Insol.-12.59%
47	Tr.	57.3	S-1.16%
48	Nil	54.0	P-0.05%
49	Nil	60.9	Mn-0.05%
50	Nil	37.9	Ti-Trace
51	0.05	41.2	
52	0.10	12.0	
53	0.09	33.75	Au-0.01 oz./ton
54	0.05	27.25	Ag-Trace
55	Tr.	24.8	Insol.-39.60%
56	Nil	16.7	

TRENCH NO. 9

Sample No.	%Cu	%Fe	Composits
57	Nil	60.5	Au-0.02 oz./ton
58	0.02	50.4	Ag-0.03 oz./ton
59	Tr.	50.3	Insol.-9.86%
60	Tr.	43.5	S-1.53%
61	0.07	61.5	P-0.03%
62	0.04	50.5	Ti-0.06%
63	0.01	58.5	
64	0.01	55.6	
65	0.01	59.4	

TRENCH NO. 2

Sample No.	%Cu	%Fe	Composits
66	0.01	29.5	
67	0.03	38.6	
68	0.02	39.0	Au-0.04 oz./ton
69	0.17	38.0	Ag-0.10 oz./ton
70	0.45	22.88	Insol.-13.00%
71	0.57	42.3	S-1.36%
72	0.32	56.2	P-0.06%
73	0.11	60.0	Ti-0.01%
74	0.03	29.9	
75	0.02	26.1	

TRENCH NO. 3

Sample No.	%Cu	%Fe
76	0.09	57.6
77	0.05	58.0
78	0.04	58.5
79	0.12	53.7
80	0.07	52.0

TRENCH NO. 13

Sample No.	%Cu	%Fe	
			Au-0.06 oz./ton
81	0.39	37.2	Ag-0.18 oz./ton
82	0.50	57.5	Insol.-18.95%
83	0.15	49.4	Au-0.05 oz./ton
84	0.09	54.8	Ag-0.12 oz./ton
85	0.05	48.3	Insol.-11.10%
86	0.22	45.7	S-0.97%
87	0.13	49.2	P-0.01%
88	0.49	42.1	Ti-Trace
89	0.11	47.8	

ADIT NO. 1

Sample No.	%Cu	%Fe	Composits
90	0.15	55.0	Au-0.02 oz./ton
91	0.39	38.5	Ag-0.05 oz./ton
92	0.34	34.8	Insol.-9.52%
93	0.51	49.6	S-5.28%
94	1.00	37.8	P-0.03%
95	0.38	51.3	Ti-Trace
96	0.36	49.1	

ADIT NO. 2

Sample No.	%Cu	%Fe	Composits
97	0.51	53.0	Au-0.05 oz./ton
98	0.69	41.8	Ag-0.14 oz./ton
99	0.65	34.4	Insol.-21.17%
100	0.51	31.2	S-6.49%
101	1.04	26.1	P-0.02%
102	1.70	36.8	Mn-0.02%
103	0.81	42.9	Ti-0.15%
104	0.61	44.4	
105	0.21	24.8	
106	0.35	24.8	
107	0.57	22.1	
108	0.89	21.7	
109	0.93	5.2	

TRENCH NO. 18

Sample No.	%Cu	%Fe	Composits
110	0.22	55.5	
111	0.12	60.1	
112	0.14	61.25	
113	0.19	58.6	
114	0.18	62.0	Au-0.02 oz./ton
115	0.28	59.35	Ag-0.04 oz./ton
116	0.35	56.5	Insol.-7.94%
117	0.25	48.5	S-1.46%
118	0.52	51.5	P-0.02%
119	0.04	59.6	Mn-0.03%
120	0.17	62.75	Ti-0.10%
121	0.09	55.75	
122	0.09	15.78	
123	0.18	58.55	
124	0.11	57.95	Au-0.02 oz./ton
125	0.11	57.25	Ag-0.03 oz./ton
126	0.01	58.6	Insol.-16.72%
127	0.05	51.4	
128	0.06	7.54	

TRENCH NO. 21

Sample No.	%Cu	%Fe
129	0.60	38.95
130	0.01	59.25

ADIT NO. 3

Sample No.	%Cu	%Fe	Composits
131	Nil	54.1	
132	0.03	59.2	Au-0.03 oz./ton
133	0.02	49.35	Ag-0.06 oz./ton
134	0.04	53.5	Insol.-16.00%
135	0.08	49.35	S-1.35%
136	0.14	50.45	P-0.01%
137	0.04	41.95	Ti-Trace
138	0.02	35.5	

TRENCH NO. 20

Sample No.	%Cu	%Fe
139	Nil	55.2
140	Nil	49.4

TRENCH NO. 19

Sample No.	%Cu	%Fe
141	0.01	57.9
142	Tr.	55.0
143	0.01	56.4

TRENCH NO. 16

Sample No.	%Cu	%Fe
144	0.02	53.1
145	Nil	57.0

TRENCH NO. 11

Sample No.	%Cu	%Fe
146	1.14	35.2

TRENCH NO. 10

147	0.17	59.35

TRENCH NO. 8

148	0.04	56.0

FIG. 2A-ANALYSES, POOR MAN IRON DEPOSIT

Average Analysis for portion of Hole in Ore (Percent)

Hole No.	Fe	Cu
1	56.88	0.15
2	60.28	0.12

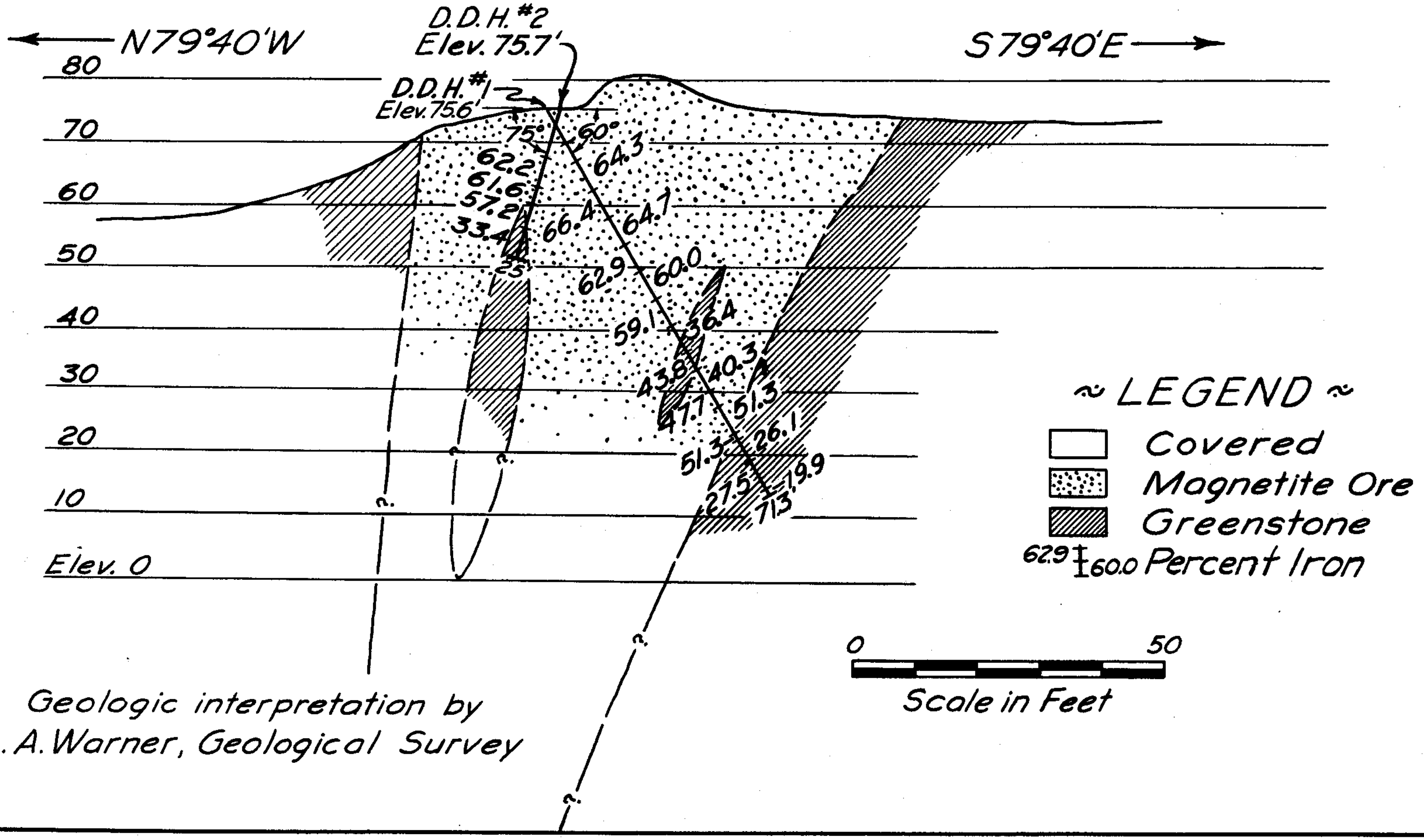
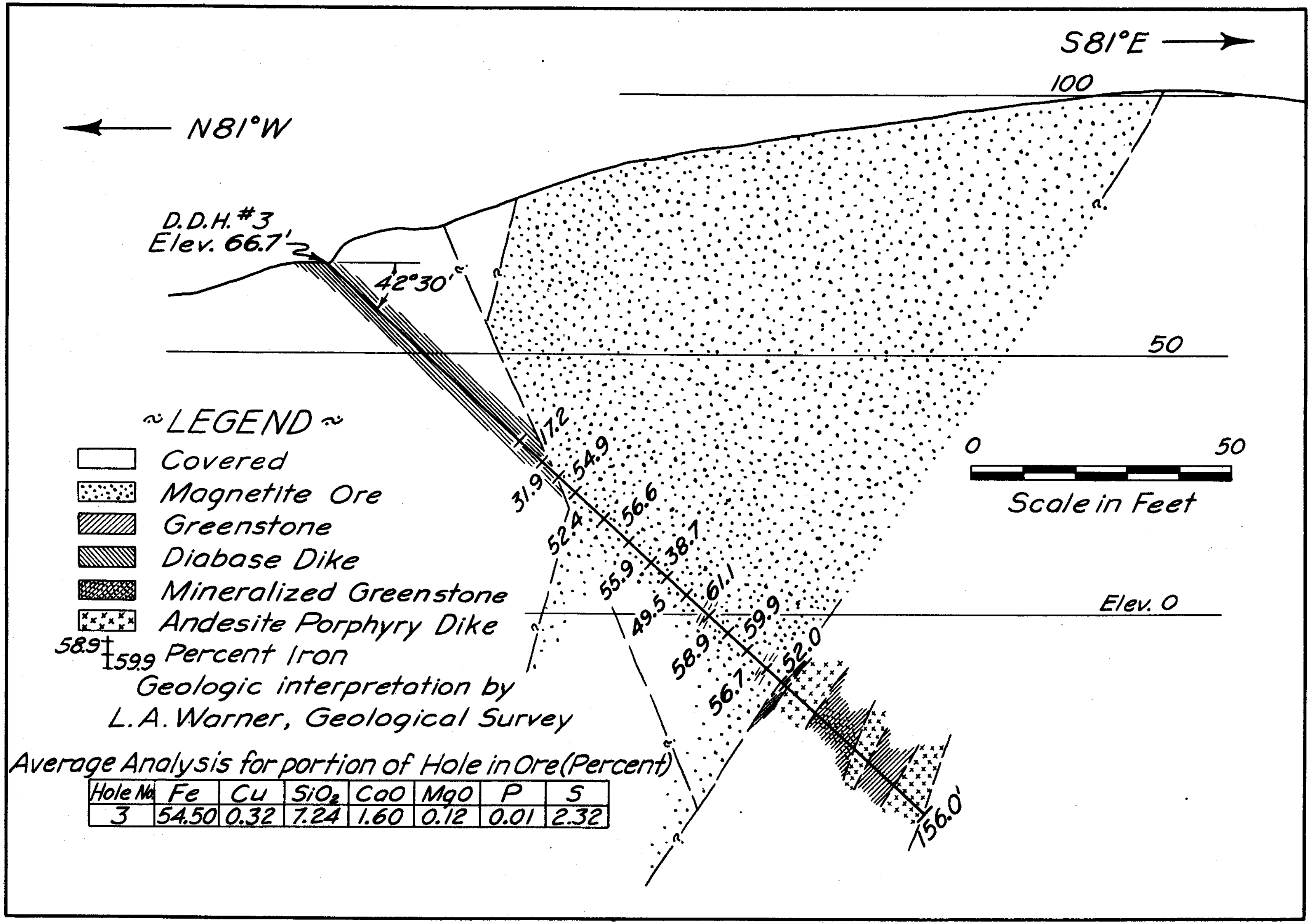


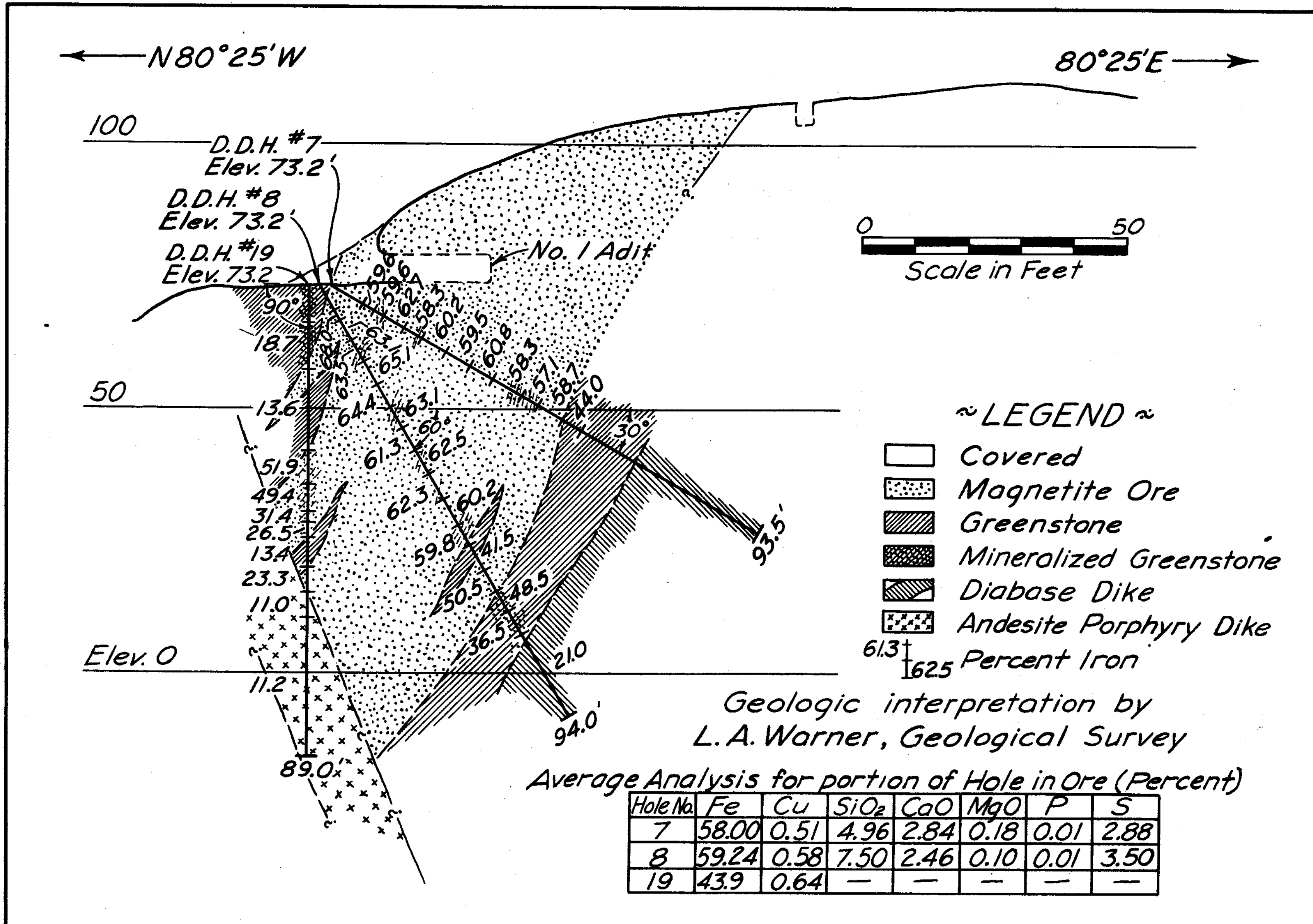
FIG. 3-SECTION A-A', ON LINE OF HOLES 1 AND 2



Average Analysis for portion of Hole in Ore (Percent)

Hole No.	Fe	Cu	SiO_2	CaO	MgO	P	S
3	54.50	0.32	7.24	1.60	0.12	0.01	2.32

FIG. 4 – SECTION B-B' ON LINE OF HOLE 3



Average Analysis for portion of Hole in Ore (Percent)

Hole No.	Fe	Cu	SiO_2	CaO	MgO	P	S
7	58.00	0.51	4.96	2.84	0.18	0.01	2.88
8	59.24	0.58	7.50	2.46	0.10	0.01	3.50
19	43.9	0.64	—	—	—	—	—

FIG. 5 - SECTION C-C', ON LINE OF HOLES 7, 8, AND 19

Average Analysis for portion of Hole in Ore (Percent)

Hole No.	Fe	Cu	SiO_2	Al_2O_3	CaO	MgO	P	S
9	46.83	0.21	11.76	1.48	5.54	3.32	0.02	2.89

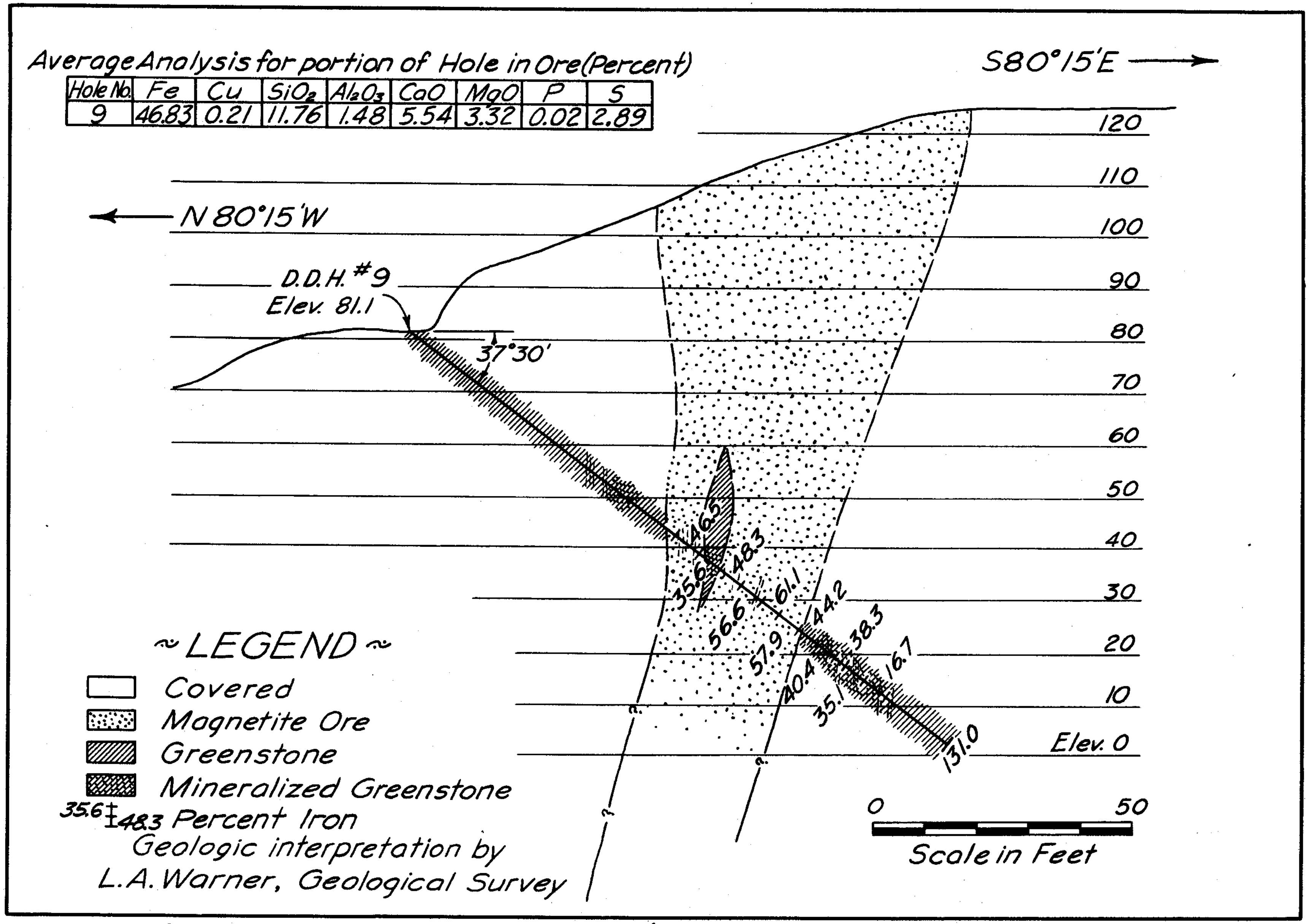


FIG. 6 - SECTION D-D' ON LINE OF HOLE 9

Average Analysis for portion of Hole in Ore (Percent)

Hole No.	Fe	Cu	SiO_2	CaO	MgO	P	S
11	48.55	0.33	17.90	2.86	0.14	0.01	0.80
12	52.66	0.16	12.94	3.90	0.62	0.01	1.02

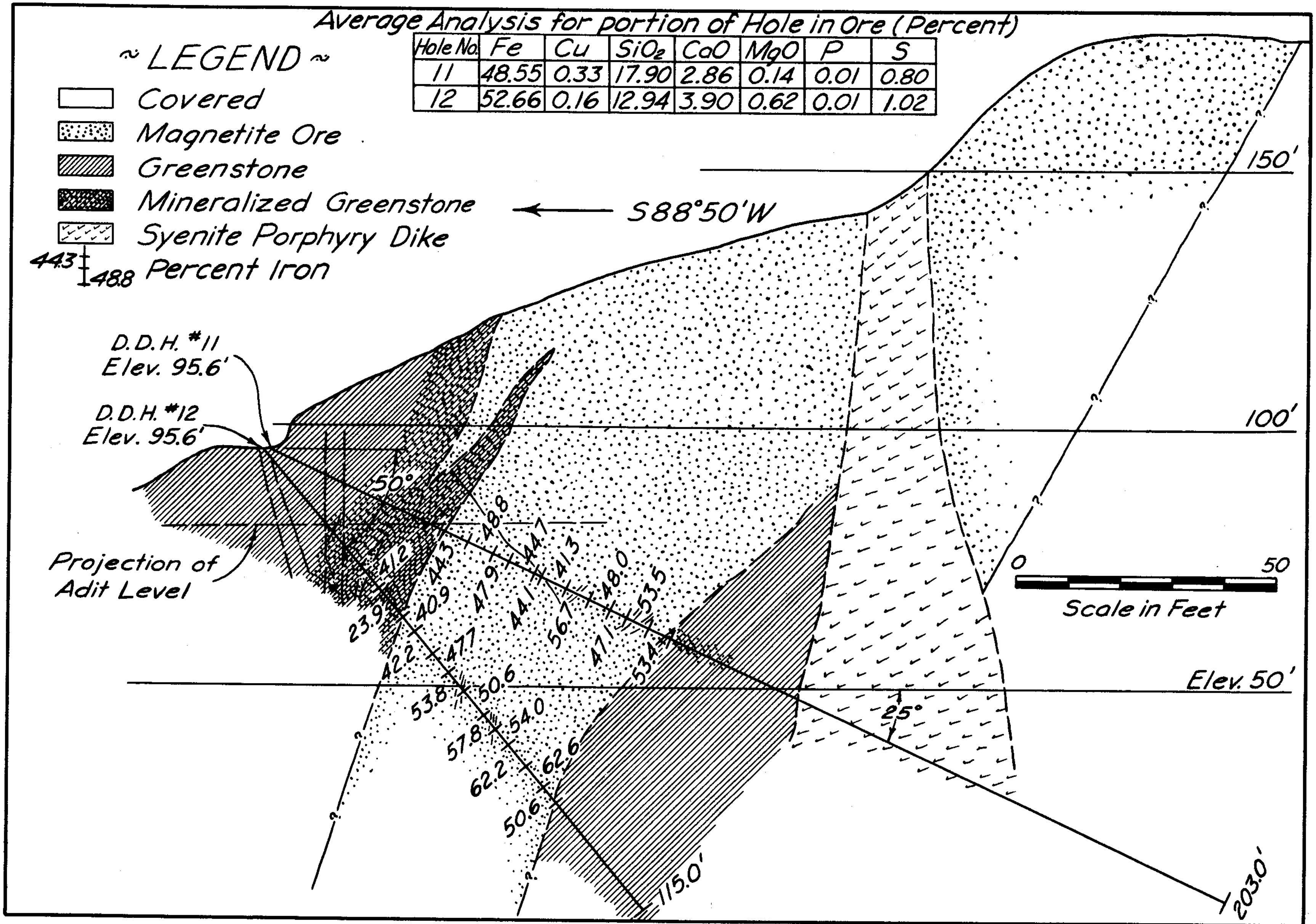
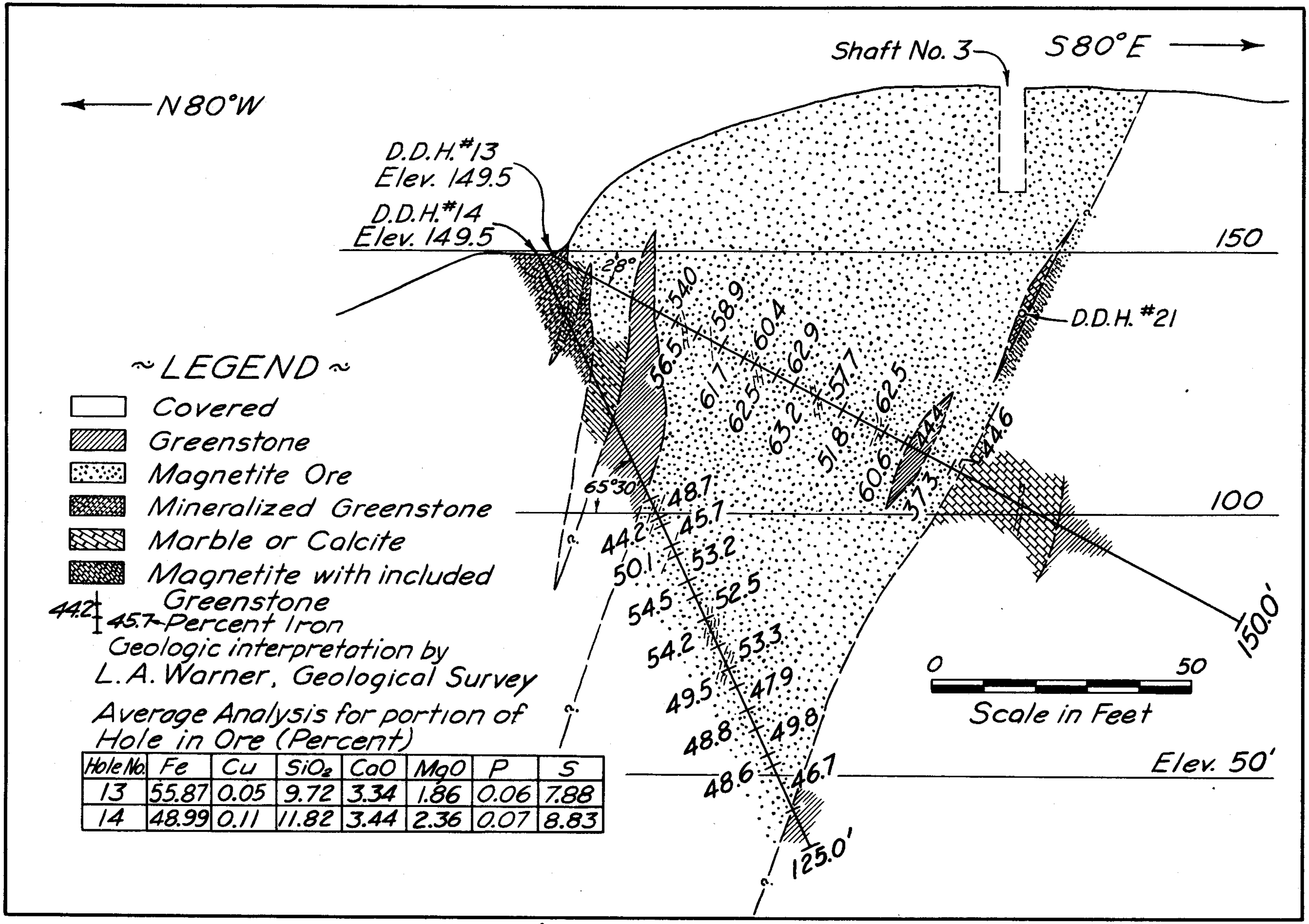
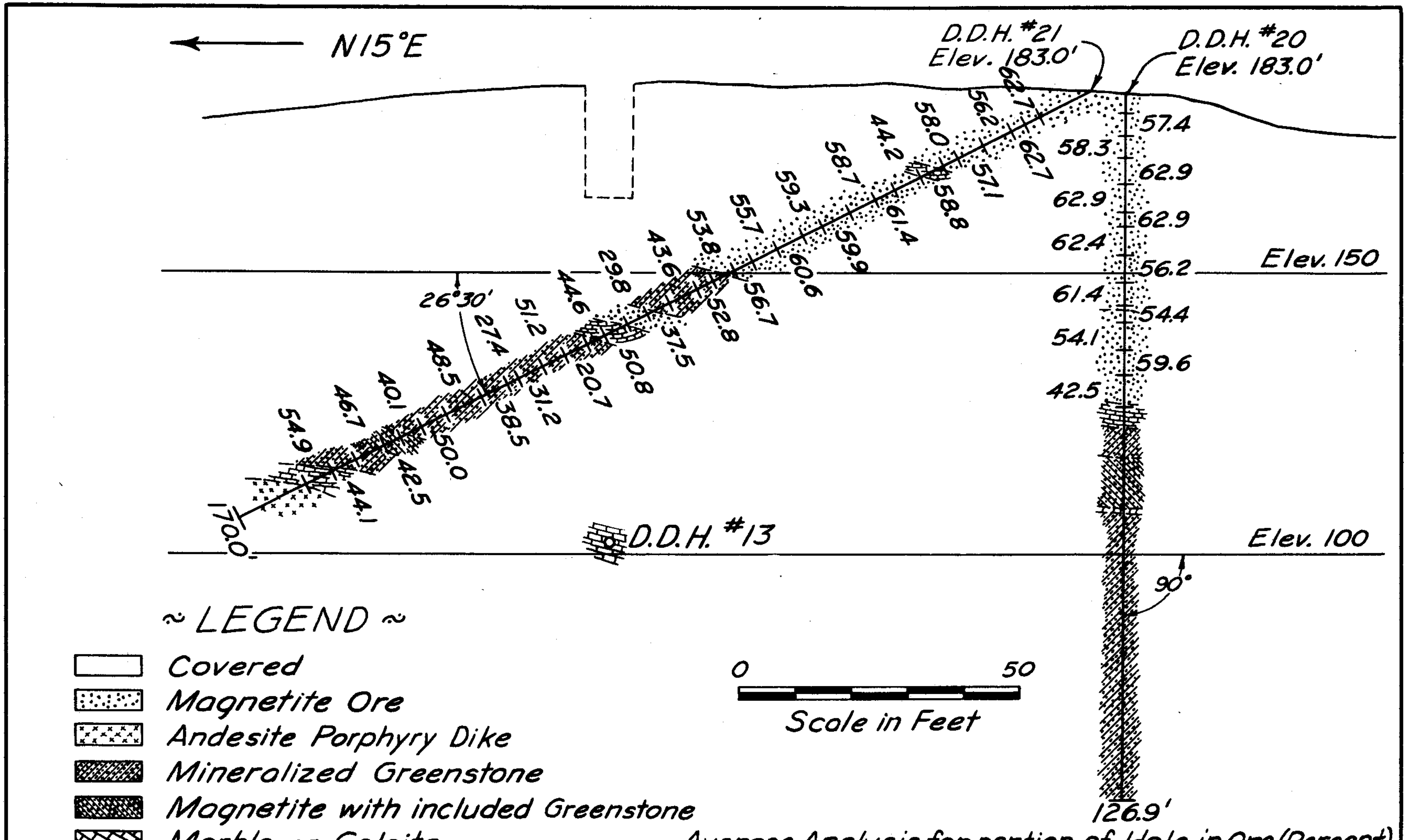


FIG. 7-SECTION E-E' ON LINE OF HOLES 11 AND 12



Hole No.	Fe	Cu	SiO_2	CaO	MgO	P	S
13	55.87	0.05	9.72	3.34	1.86	0.06	7.88
14	48.99	0.11	11.82	3.44	2.36	0.07	8.83

FIG. 8-SECTION F-F' ON LINE OF HOLES 13 AND 14



Average Analysis for portion of Hole in Ore (Percent)

Hole No.	Fe	Cu	SiO_2	Al_2O_3	CaO	MgO	S	P
20	52.21	0.14	11.46	—	1.90	1.72	8.23	0.07
21	49.15	0.23	7.88	1.30	3.68	1.04	3.35	0.03

FIG. 9 - SECTION G-G' ON LINE OF HOLES 20 AND 21

ore body amounts to 4.49 percent of the whole by volume, or 3.09 percent of the whole by weight.

Chalcopyrite and pyrite occur, apparently in larger amounts, at and near the margins of the ore body, although they also occur scattered irregularly throughout the ore. Chalcopyrite is found mostly along cracks and seams, pyrite mostly disseminated through the magnetite. Results of the Bureau's sampling indicate that the total sulfides included in the iron ore amount to 7.0 percent.

SAMPLING AND ANALYSIS

During October and November 1942, the Bureau cleared out 14 old trenches and took from them and the walls of the three adits 103 channel samples and 13 chip samples. The chip samples were taken only in ore apparently uniform in grade. Location of these samples is shown on figure 2, and results of analyses on figure 2-A.

Between April and June 1943 the Bureau drilled 13 diamond drill holes, which ranged in depth from 25 to 203 feet. The total length of hole drilled on the Poor Man iron deposit was 1,549.7 feet. Locations of these holes are shown on figure 2, and sections on line of holes, with analyses of samples, on figures 3 to 9, inclusive.

Sludge from core drilling was carefully collected, dried, and split. Sludge was analyzed by the Territorial Assay Office, Ketchikan, Alaska. Cores were split and analyzed by a private concern in the States.

Sludge and core analyses were adjusted by the Longyear method. Both individual and average analyses for iron shown on figures 3 to 9 are adjusted from individual core and sludge analyses. The copper analyses are likewise adjusted, but the average analyses for other metals are derived from composites of core samples only.

Adjusted and weighted average of all samples indicate that the ore content is as follows:

	Percent
Iron	52.40
Copper	.25
Insoluble	12.10
Alumina	1.38
Lime	3.13
Magnesia	1.22
Phosphorus	.03
Sulfur	3.72
Manganese	.03
Titanium	.04
Gold (ounce per long ton)	.032
Silver (ounce per long ton)	.071

Two spectrographic examinations made on composite samples of cores from hole 3 and the first part of hole 7 and from holes 8 and 19 and the lower part of hole 7 were as follows:

Element	Approximate quantity (Holes 3 and 7, upper part)	Approximate quantity (Hole 7, lower part, 8 and 19)
Iron	Major constituent	Major constituent
Silicon) Calcium)	Intermediate constituent	Intermediate constituent
	Minor constituents, percent	Minor constituents, percent
Aluminum	1.0	1.0
Copper	.5	.5
Magnesium	.1	.1
Sodium	.1	.1
Titanium	.05	.05
Manganese	.05	.05
Zinc	.01	Trace
Cobalt	.01	0.01
Nickel	.001	.001
Strontium	.001	.001
Chromium	.001	.001
Vanadium	.001	.001

DEVELOPMENT

Development consists of 19 trenches 10 to 120 feet in length, generally crosscutting the ore; 3 short adits, 35, 100, and 90 feet in length, also crosscutting ore; and 4 shallow shafts, 15, 60, 20, and 10 feet in depth. Of these shafts, the second connects with No. 2 adit and extends about 30 feet below the adit track level. All shafts were filled with water and, because of the absence of pumping equipment, were not unwatered during the course of the Bureau's examination. Appearance of the dumps seems to confirm the report that Nos. 1, 2, and 3 shafts were generally in ore to the bottoms and that No. 4 shaft encountered only alluvium and glacial till.

The ore is hard and firm. Country rock, mostly greenstone, is also firm, with only small cracks and seams. Several faults were noted, none of which were large enough to cause trouble in mining. No timbering has been done, except at shaft collars, and none is believed to be necessary in mining.

Because of the heavy rainfall in the district, considerable water is encountered in the mine workings close to the surface, but no trouble is expected from water in open-cut mining. As mining progresses below natural drainage, pumps will be necessary; but pumping lifts will never be over 100 feet, and the amount of water will be only the amount of rain falling into the area of the pit plus a certain amount of seepage.

No equipment is on the property. An old rail tram from the beach to the No. 3 adit has rotted out entirely and the dock is gone.

Topography, shape of the ore body, the physical characteristics of the ore, and wall rock favor open-pit mining.

BENEFICIATION

Results of tests at the Bureau's Rolla Laboratory on samples of ore from surface trenches on the Poor Man deposit indicate that the ore is amenable to beneficiation by magnetic separation or by flotation followed by magnetic separation of flotation tailing. Magnetic separation of coarsely ground ore (10-mesh) was not successful, because particles of magnetite and silicious material were locked and not completely freed at grinds coarser than 65-mesh.

Best results were obtained by flotation of comparatively coarsely ground, 35-mesh, ore and magnetic separation of tailing from flotation. Ore of the following analysis was used in these tests.

Analysis, percent

Fe	SiO_2	Insol.	S	Cu	P
52.4	12.3	14.2	2.07	0.09	0.09

The first tests were made in a wet, low-intensity, magnetic separator on portions of the ore ground to pass 10-mesh, 48-mesh, and 65-mesh screens. Concentration of 10-mesh material was negligible. At 48-mesh, a high-grade magnetic product low in silica and phosphorus was obtained, but the sulfur content was above the maximum allowable for iron ores. At 65-mesh the sulfur content of the magnetic portion was 0.09 percent, half of that at 48-mesh, but still considerably in excess of the maximum of 0.04 percent.

A portion of the ore was stage-ground in a pebble mill to pass 35-mesh and floated at 25 percent solids in a mechanical-type cell to remove the sulfides. The sulfide rough concentrate was cleaned once, and the cleaner tailing was combined with the rougher tailing. This material was reserved for magnetic separation tests. Examination of the sulfide concentrate showed it to be chiefly sulfides of iron, together with calcite; no oxides of iron were noted. The selective flotation of the small amount of copper-bearing minerals was not successful.

Flotation results

Product	Weight, percent	Chemical analysis, percent					Percent of total				
		Fe	S	SiO_2	P	Cu	Fe	S	SiO_2	P	Cu
Concentrate.	4.7	42.9	41.7	0.4	0.01	1.0	3.8	89.5	0.2	0.6	71.2
Tailing	95.3	53.9	0.24	11.1	.09	.02	96.2	10.5	99.8	99.4	28.8
Heads calculated.	100.0	54.4	2.19	10.6	.09	.07	100.0	100.0	100.0	100.0	100.0

Operating data

Reagents	Pounds per ton of ore		
	Conditioner	Rougher	Cleaner
Sodium ethyl xanthate	0.10		
No. 5 pine oil (General Naval Stores Co.)..	.18		
Time, minutes	3	2	1

Magnetic separation of the tailing was made in a wet, low-intensity, magnetic separator. The iron recovered substantially represents the recovery of magnetite.

Magnetic-separation data

	Weight, percent	Analysis, percent				Percent of total	
		Fe	S	SiO_2	P	Fe	S
Magnetic concentrate	76.8	66.8	0.02	5.3	0.03	94.3	6.2
Non-magnetic tailing	23.2	13.4	1.00	-	-	5.7	93.8
Feed calculated	100.0	54.4	.25	-	-	100.0	100.0

Another flotation and magnetic-separation test was made as described above, except that the ore was ground through 65-mesh. Further unlocking of the deleterious constituents was evident from the magnetic-concentrate analysis, which was 67.1 percent iron, 0.003 percent sulfur, 4.9 percent insoluble, and 0.008 percent phosphorus. Iron recovery was 93.9 percent.

Finer grinding of the crude ore followed by magnetic separation probably would produce an acceptable magnetic concentrate. However, the flotation procedure at the relatively coarse mesh seems desirable for three reasons: (1) the ease with which flotation is accomplished, (2) the removal of the sulfides also reduces the amount of material to be magnetically treated, (3) the flotation concentrate is a potential source of sulfuric acid and iron sinter, and grinding costs would be considerably reduced, probably offsetting the cost of flotation.

Samples taken from core drilling contain a higher percentage of copper, and there is less oxidation than in material used in the tests described above.

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