R. I. 4182 January 1948

UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. Krug, Secretary

BUREAU OF MINES
James Boyd, Director

REPORT OF INVESTIGATIONS

YAKOBI ISLAND NICKEL DEPOSIT
SITKA MINING DISTRICT, ALASKA

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By J. H. East, Jr.,[2] W. M. Traver Jr.,[3] R. S. Sanford,[4]
and W. S. Wright[5]

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ILLUSTRATIONS

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[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 4182."

[2] Mining engineer, Bureau of Mines, Washington, D. C.

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[5] Mining engineer, Bureau of Mines, Juneau, Alaska.

ILLUSTRATIONS (Cont'd.)

INTRODUCTION

This report describes the results obtained from a diamond-drill exploration project performed by the Bureau of Mines on the nickel deposits of the Yakobi Island, Alaska.

The Federal Geological Survey[6] completed a detailed geologic study and mapped the area during the summer of 1940, and a Bureau of Mines examining engineer[7] made a preliminary examination of the deposits in June 1941, at which time core drilling was suggested as the logical means of determining the extent and grade of the deposits.

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[6] Reed, J. C., and Dorr, J. Van N., II, Nickel Deposits of Bohemia Basin and Vicinity, Yakobi Island, Alaska: Geol. Sur. Bull. 931-F, 1941, pp. 105-138.

[7] Spangler, Ricker, senior mining engineer.

Equipment and supplies were unloaded on the beach at Yakobi Island on October 21, 1941. The drills were moved to Bohemia Basin, where actual drilling operations were begun under the direction of a Bureau of Mines engineer[8] on November 7, 1941. Two core-drill holes were completed on December 7, 1941. Upon the request of the drilling contractor, operations were recessed owing to severe winter conditions. Work on the project was resumed April 27, 1942, under the direction of another Bureau of Mines engineer[9] and was completed August 15, 1942. During the 1942 season, 13 core-drill holes were completed, and 10 surface pits and a tunnel were sampled. A total of 5, 191 feet of core-drill hole was drilled in 15 holes during the entire project. The results of drilling and sampling form the basis of this report.

The Federal Geological Survey maintained a field party[10] on the island during the drilling and collaborated with the Bureau of Mines engineer in logging diamond-drill cores and interpreting geologic data obtained in the course of the work.

ACKNOWLEDGMENTS

This paper is one of many reporting on various aspects of the Bureau of Mines program initiated in August 1939 by passage of the Strategic Minerals Act, the scope of which was greatly expanded by subsequent legislation.

Some of these papers were published as war mineral reports; others are issued as bulletins, technical papers, reports of investigations, and information circulars of the Bureau of Mines or in technical journals.

In its program of investigation 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 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, Oliver C. Ralston, chief, analyzes samples and performs the beneficiation tests.

The Yakobi Island project was part of a program for the investigation of mineral deposits in Alaska under the general supervision of R. S. Sanford, acting division chief. From October 1941 to March 1942 the project was under the supervision of J. H. East, Jr.; William M. Traver, Jr., was project engineer from March until the project was completed in August 1942.

Acknowledgment is made to J. A. McAllister, former metallurgist, Salt Lake City Division, Metallurgical Branch, for beneficiation and analytical tests on the ore.

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[8] J. H. East, Jr., mining engineer.

[9] W. M. Traver, mining engineer.

[10] George O. Gates, assistant geologist, and George C. Kennedy, junior geologist.

Acknowledgment is also made to J. C. Reed, J. V. N. Dorr II, W. T. Pecora, George O. Gates, George C. Kennedy, and Matt S. Walton, Jr., of the Geological Survey for their detailed geologic map of the area and the interpretation of geologic data from drill cores.

LOCATION

Yakobi Island is the northernmost island of the Alexander Archipelago of southeastern Alaska. (See fig. 1.) It is in the extreme northern part of the Sitka mining district at a latitude 58° N. and longitude 136° 25' W. The island is about 100 miles airline west from Juneau and 76 miles north of Sitka, as shown in figure 2. Lisianski Strait, one-half mile in width, and Lisianski Inlet separate it from Chicagof Island. Yakobi Island is 18 miles long, and its greatest width is 6 miles. Pelican City, the nearest settlement, is a fishing village located on Chicagof Island in Lisianski Inlet and is about 7 miles from the beach camp on Yakobi Island.

The specific area to which this report refers is Bohemia Basin, the local name applied to the valley of Bohemia Creek. It is located on the east side of Yakobi Island (fig. 3) and is roughly midway between the north and south points of the island. Six showings of mineralization are known to exist and are located on figure 3. The area south of the Bohemia Basin camp is the largest in extent and is the one upon which the exploration was concentrated. The deposits are 2-1/2 miles by trail southwest of the mouth of Bohemia Creek, but the airline distance is only about 1-1/2 miles. The trail is the only means of access to the deposits. Bohemia Creek empties into Lisianski Strait 2-1/4 miles southwest of Miner Island, which is a conspicuous landmark.

ACCESSIBILITY

Yakobi Island is extremely inaccessible. A motorship makes a weekly scheduled trip between Juneau and Sitka but does not travel the route through Cross Sound (fig. 2). It does, however, on alternate weeks, connect at Hoonah with a contract mail boat which receives and delivers mail to Pelican City.

The main steamer route to the west from Juneau passes through Cross Sound north of the island. None of the steamers on the run now make regular stops at Pelican City; merchandise and passengers must be routed to Juneau and arrangements made for delivery from there.

Alaska Coastal Airways makes periodical trips from Juneau to Pelican City. Passengers, on request, are landed at Bohemia Basin Camp on Yakobi Island at the same fare ($20.88 including tax).

The island can readily be reached by small motorboats from either Juneau or Sitka, but the former is preferred because the route from that point is by inside, safer waters. Diesel boats average 15 hours for the trip. Flying time is 45 minutes.

When available on regular schedules, boat fares from Juneau to Pelican City are $18.00. Freight rates with independent boatmen, on indefinite schedules, average $10.00 a ton.

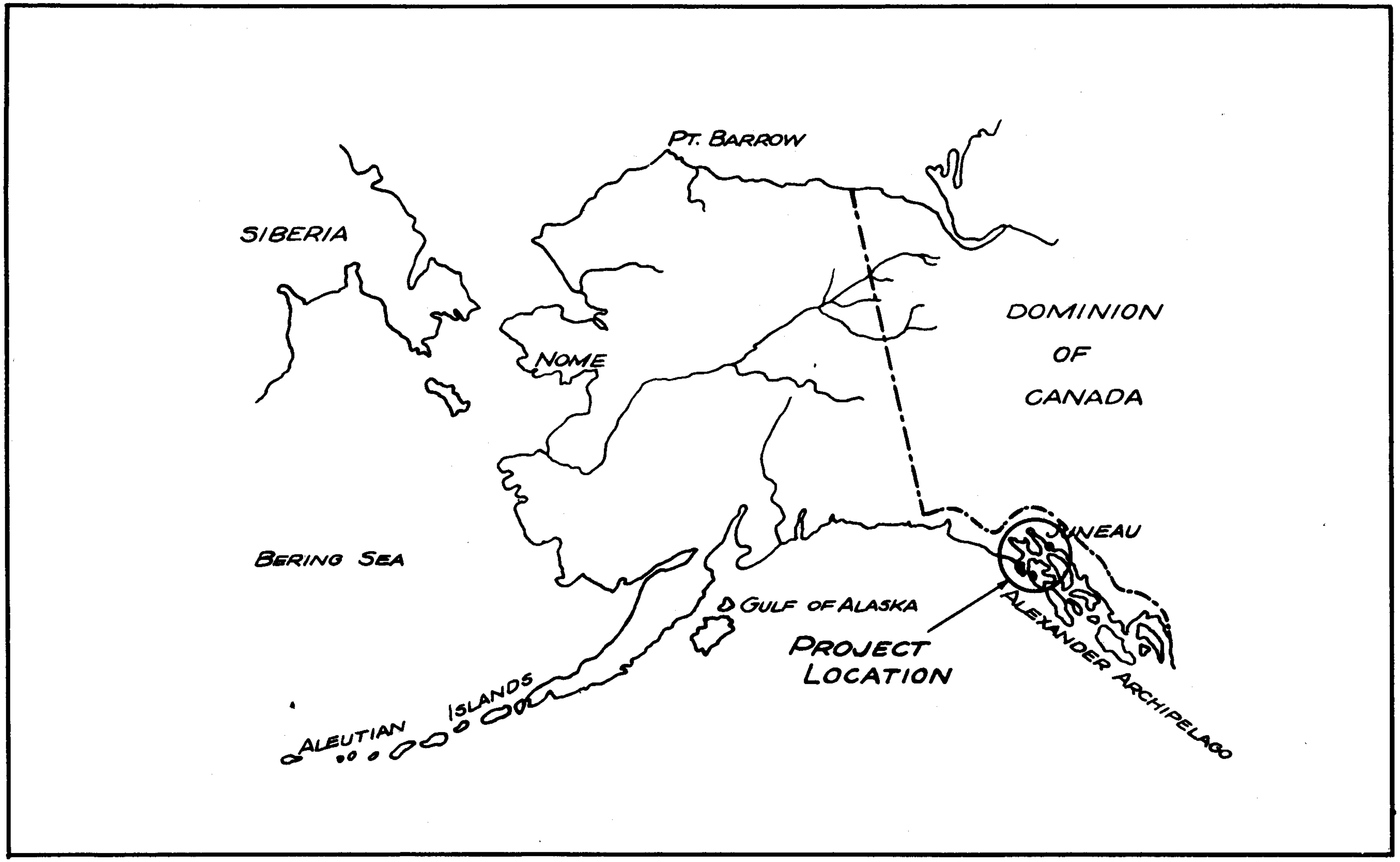

Figure I. - Territory of Alaska index map, Yakobi Island.

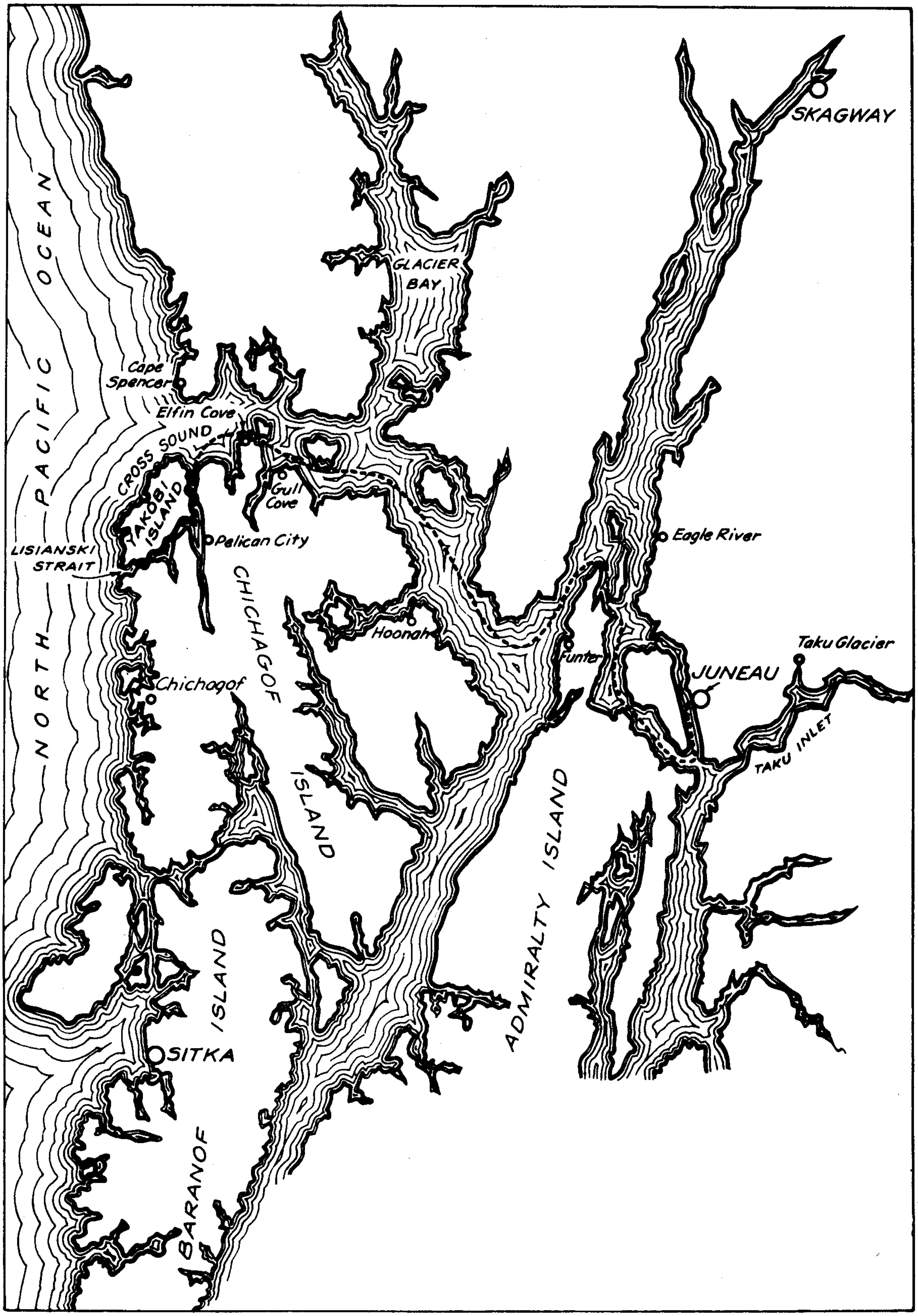

Figure 2. - Yakobi Island and vicinity; Bohemia Basin nickel deposit.

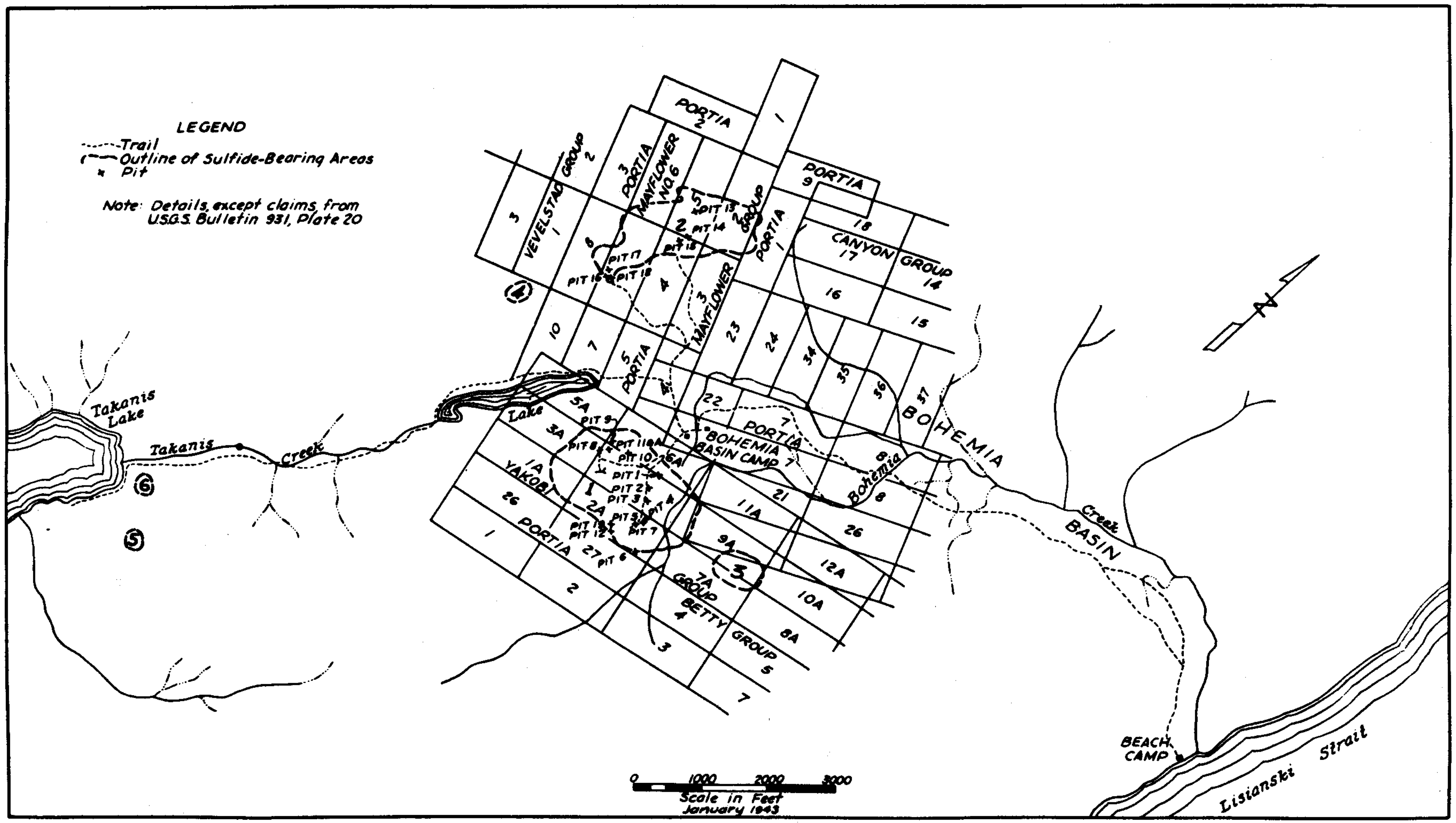

Figure 3. - Location and claim map, Bohemia Basin.

Tides are a factor in the islands' accessibility, especially important when dock construction and operation are considered. They are about the same as for Sitka, as shown in the Tide Tables published by the Coast and Geodetic Survey of the United States Department of Commerce, with a maximum of about 15 feet.

TOPOGRAPHY AND CLIMATE

Yakobi Island, like most of the islands of the Alexander Archipelago, is very rugged, and altitudes range from sea level to 2,500 feet. The terrain rises abruptly on the northwest side of Bohemia Creek, but the relief to the southeast is moderate. Flat areas along the basin are covered with as much as 7 feet of muskeg that is completely saturated, except in very infrequent dry periods.

The climate is similar to that of all southeastern Alaska; extremely heavy precipitation, chiefly rain, can always be expected. Snow is reported to reach a depth of 12 feet on the level at the higher altitudes during the winter. An average annual precipitation of 120 inches, a maximum temperature of 57° F. and a minimum of 30° F. were recorded at Kimshan Cove, the closest Government weather station, for the period August 1940-July 1942.

TIMBER

Spruce, pine, hemlock, and cedar grow abundantly over a great portion of the island up to altitudes of 1,500 to 2,000 feet. The height, diameter, and soundness vary in different localities, but a sufficient amount of timber for limited mining operations appears to be available. Wood suitable for heating and cooking is available in the section adjacent to the Bohemia Basin camp.

WATER POWER

Water for domestic purposes and for concentrator operation can be supplied by Bohemia Lake, 1/4-mile west of the deposits, or Takanis Lake, 2 miles southwest.

Measurements were not made of the flow of water from Takanis Lake, but from the drainage area and amount of rainfall, it is estimated that it would not provide more than 20 percent of the water required to operate a hydroelectric plant to furnish power necessary for mine and concentrator plants.

OWNERSHIP

The controlling interests in the ore deposits of Bohemia Basin are largely owned by S. H. P. Vevelstad, Hon. David Sholtz, and associates. Figure 3 shows the claims thought to cover the main mineral areas. Data for the location of the claims shown on figure 3 were furnished by Carl Vevelstad, one of the owners, as was the following list of the 124 unpatented claims with the recorded ownership. Claims are all 600 feet by 1,500 feet, many of them overlapping.

Mayflower group	1 - 6,	inclusive	- S. H. P. Vevelstad, trustee.
Do.	7 - 20,	do.	- Do.
Do.	21 - 44,	do.	- Carl Vevelstad.
Yakobi group	1A - 15A,	do.	- Nickel Corp. of America.
Portia group	1 - 10	do.	- S. H. P. Vevelstad, trustee.
Do.	16 - 22	do.	- Nickel Corp. of America.
Do.	24 - 27	do.	- Do.
Canyon group	1 - 6	do.	- S. H. P. Vevelstad, trustee.
Do.	7 - 24	do.	- Carl Vevelstad.
Vevelstad group	1 - 12	do.	- Do.
Betty group	1, 4, 5, 8		- Do.

All core drilling by the Bureau of Mines was on claims 2A and 4A of the Yakobi group.

HISTORY, PRODUCTION, AND DEVELOPMENT

S. H. P. Vevelstad is credited with discovery of the nickel-copper ores on Yakobi Island in 1921. Since that time many claims have been added to those originally staked until they cover practically all of Bohemia Creek and the west shoreline of Lisianski Strait. In 1939 the ore bodies herein referred to as area 1 (fig. 3), which is just south of the Bohemia Basin camp, were segregated in the Yakobi group, and those of the two Takanis bodies (area 2, fig. 3) were included in the Mayflower and Portia groups. Some of the ground was restaked in 1940 by a prominent mining company, on agreement with Vevelstad, but were not recorded.

Little authentic historical information is available concerning the property.

No ore shipments have been made.

Soon after location, the Bohemia tunnel was started on the "Tunnel ore body" and has been advanced from time to time, probably to fulfill the requirements of annual assessment work, until at present it has a total length of 160 feet. The various other ore bodies have been prospected by 20 open surface trenches or pits. The lower ore bodies are covered by muskeg. They have been sampled by removing the muskeg from prominent ridges and blasting a fresh face in the solid formation exposed. The pits on the higher bodies expose fresh faces on the outcrops. In the tunnel, as well as in the open pits, there is evidence that an effort has been made to follow the richest mineralization wherever possible.

GEOLOGY[11]

The oldest stratified rocks of Yakobi Island are Upper Triassic and in part Lower Cretaceous, largely volcanic rocks and graywacke. Two intrusions

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[11] Reed, J. C., and Dorr, J. Van N., II, Nickel Deposits of Bohemia Basin and Vicinity, Yakobi Island, Alaska: Geol. Survey Bull. 931-F, 1941, pp. 105-138; Buddington, A. F., Mineral Investigations in Southeastern Alaska: Geol. Survey Bull. 773, 1925, 267 pp.; and Kennedy, George C. and Walton, Matt S., Jr., Nickel Investigations in Southeastern Alaska: Geol. Survey Bull. 947-C, 1943 and 1944, pp. 39-64.

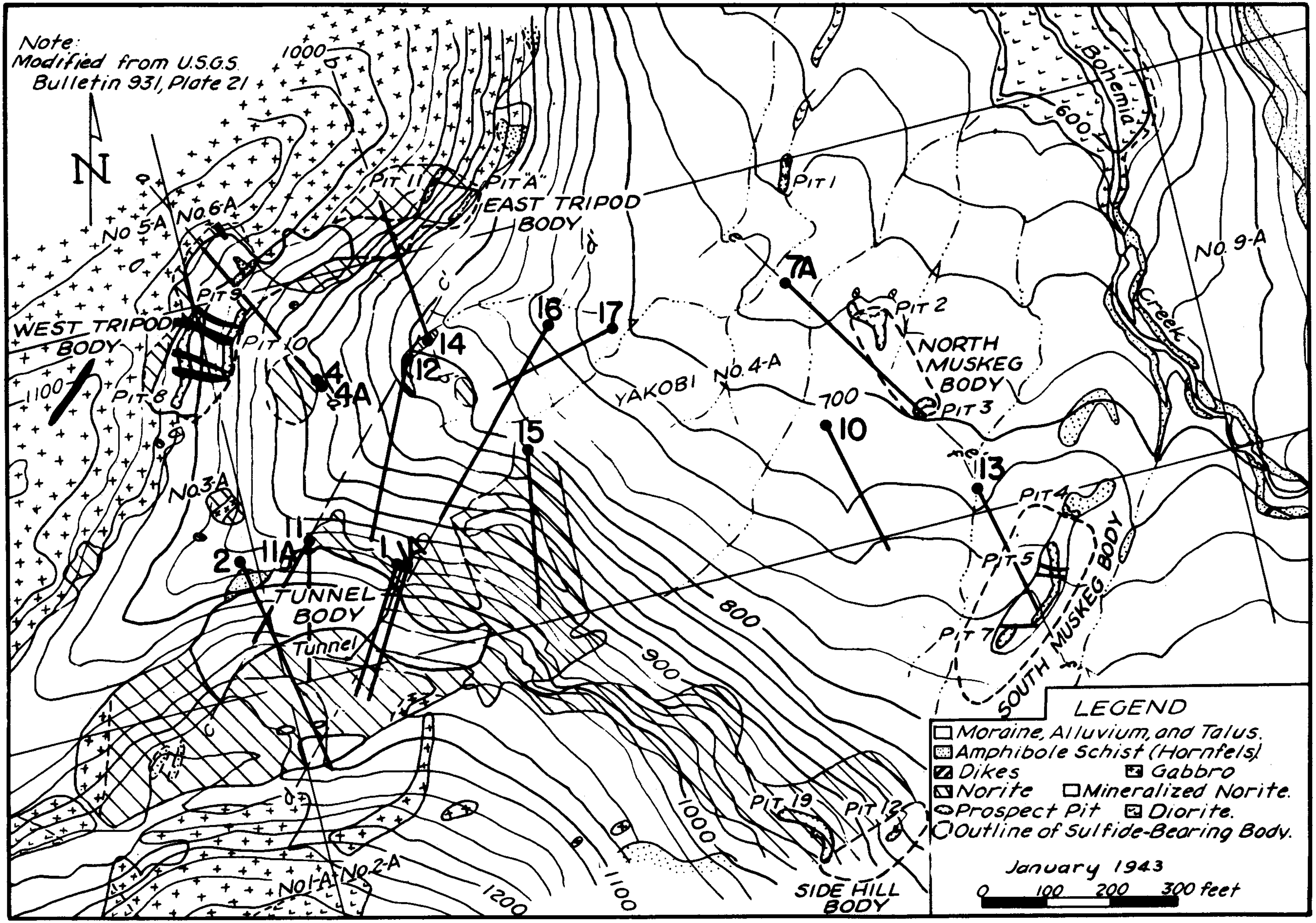


Figure 4. - Geologic and topographic map, Yakobi Island.

into the stratified rocks are identified - an earlier one related to the Coast Range batholith, mostly albite granite gneiss and amphibolite, and a later stoc of unfoliated intrusives, norite, gabbro, diorite, and quartz diorite. Metamorphism was extensive as a result of both intrusions, and in places inclusions of amphibole schists have been metamorphosed to hornfels.

It is the rocks of this later stock, particularly the norite, with which this report is concerned, for the sulfide-bearing bodies are almost entirely confined to this one rock type. Ore bodies are thought to be the result of magmatic segregation, mainly pyrrhotite, pentlandite, chalcopyrite, and magnetite, and are considered among the last minerals to crystallize from that part of the magma which formed the norite. Alteration of the minerals is very slight, even close to and at the surface. While the mineralization is confined almost entirely to the norite, the greater part of the norite is barren.

Many dikes, mostly andesite, cut the rocks of the area. Some are presumed to be related to the intrusive gneiss and some to the later stock.

There are also a large number of small faultings, both pre- and post-intrusions, but none were found to affect the ore bodies measurably.

The names of the ore bodies outlined by the Geological Survey Bulletin 931-F are adhered to on the plan map, figure 4. Six of the eight bodies exposed by 1,500 feet of trenches or pits and one tunnel 160 feet long, are in the area explored; these are the West Tripod, East Tripod, Tunnel, North Muskeg, and Side Hill.

No drilling was done on the Side Hill body, and drill hole 14 proved the West and East Tripod bodies to be continuous.

The outline of the various bodies where no magnetic prospecting has been done is more or less arbitrary, especially in the case of the lower bodies, which are completely covered by muskeg. The upper bodies are more readily delineated, since the contact between mineralized and unmineralized zones in in part exposed.

ORE

The minerals pyrrhotite, pentlandite, chalcopyrite and magnetite occur in the norite and form the ore.

The sulfide content of the ore, as shown in trenches and diamond drill holes, is erratic. Sampling proved that practically all nickel and copper values are confined to the sulfide zones.

A sample of about a ton of the ore, mined from the Bohemia tunnel, was tested in the Bureau of Mines metallurgical laboratory. The analysis of the ore, which is given below, showed that no metals of economic importance, other than nickel and copper, were present:

Analysis, percent											Ounce per ton		
Ni	Cu	Fe	Insol.	SiO_2	S	CaO	MgO	Zn	Co	Pb	Ag	Au	Pt
0.34	0.20	2.9	83.8	46.4	1.3	10.9	14.1	Trace	0.01	0.05	0.1	Trace	Nil

CORE DRILLING

Drilling was done by a private contractor under the direct supervision of a Bureau of Mines engineer. Standard portable rotary drills, powered with model T Ford motors, were used, and cores were recovered through double core barrels obtaining solid cores of standard "BX", "AX", and "EX" sizes.

Sleds were built to haul rods, pipe, etc., using green timber for runners. The drills were winched up the trail pulling three sleds behind each of two drills.

Figure 4 is a geologic and topographic plan of the area, showing the location of the various ore bodies drilled and the position of core-drill holes with respect to these bodies. Holes 4, 4A, and 14 (see figs. 5 and 6) are on the Tripod body; 11, 11A, 1, 1A, 12, 16, 2, 15 and 17 (figs. 7 through 14) in the Tunnel body; and 7A, 10, and 13 (figs. 15, 16, and 17) in the North and South Muskeg bodies.

Table 1 gives collectively significant data regarding the drill holes.

TABLE 1. - Diamond-drill-hole data

Hole	Collar elevation, ft.	End elevation, ft.	Bearing	Inclination	Length, ft.	Ore, ft.	Core recovery, percent
			Tripod ore body				
4	890	890	N. 41° W.	0°	289.5	124.8	94.8
4A	885	567	N. 41° W.	-70°	338.6	216.8	92.5
14	793	572	N. 20° W.	-45°	312.9	106.4	87.6
			Tunnel ore body				
11	945	830	South	-26° 30'	258.1	180.4	89.2
11A	944	761	S. 30° W.	-45°	258.5	125.8	93.9
12	806	514	S. 12° W.	-45°	413.2	302.4	93.9
1	938	718	S. 17° W.	-45°	310.4	122.5	95.4
1A	941	941	S. 17° W.	0°	220.7	188.2	94.3
16	731	392	S. 30° W.	-45°	479.3	125.0	92.7
2	964	964	S. 24° E.	0°	352.8	40.9	89.2
15[1]	814	465	S. 8° E.	-55°	425.8	-	87.9
17[1]	703	224	S. 65° W.	-67°	520.3	-	94.2
			North Muskeg body				
7A	678	386	S. 47°39'E.	-45°	413.3	154.5	92.0
10[1]	708	492	S. 27°39'E.	-45°	305.0	-	84.1
			South Muskeg body				
13	710	503	S. 25°30'E.	-45°	292.5	104.0	89.0

[1] Not considered in ore zone.

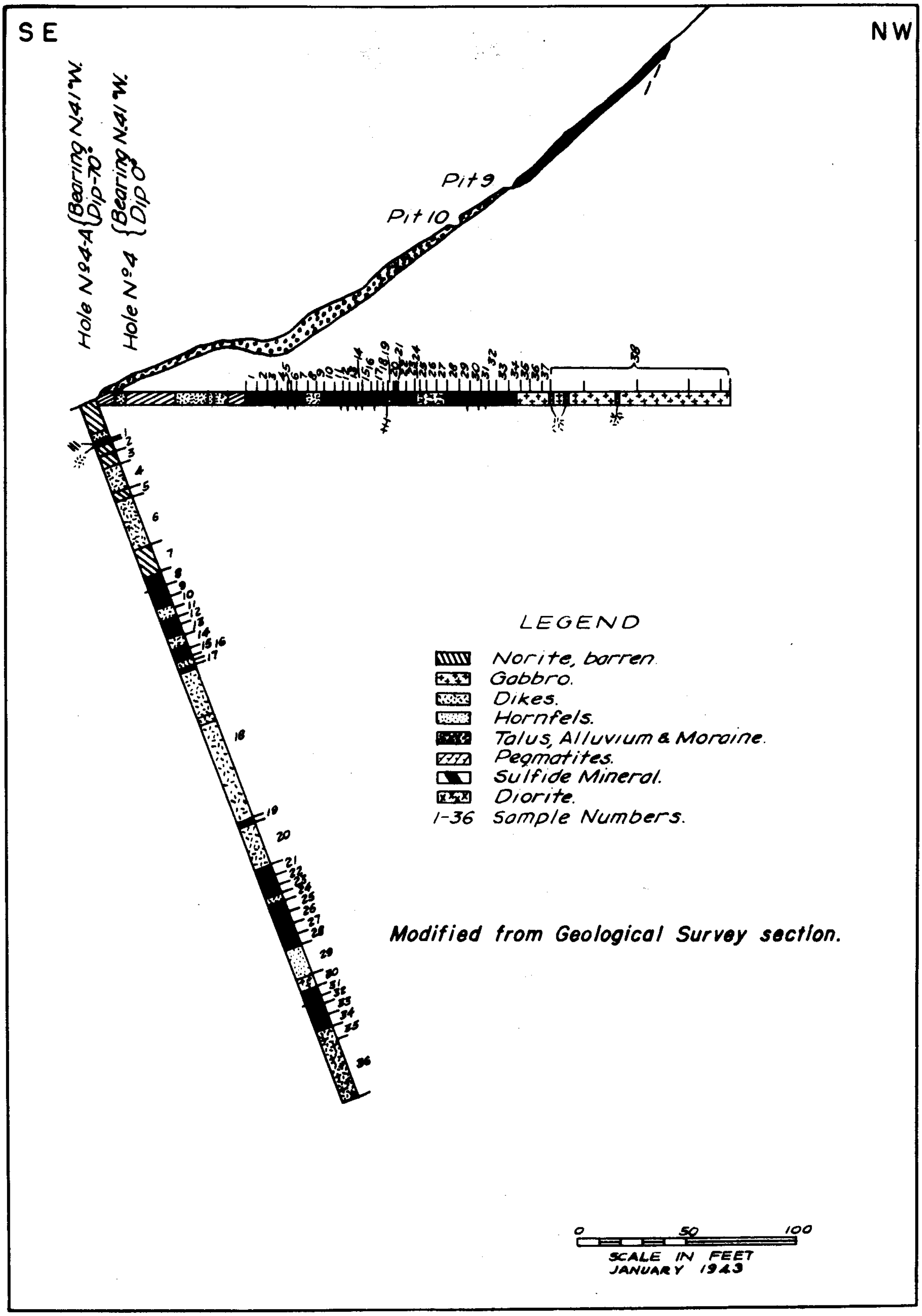
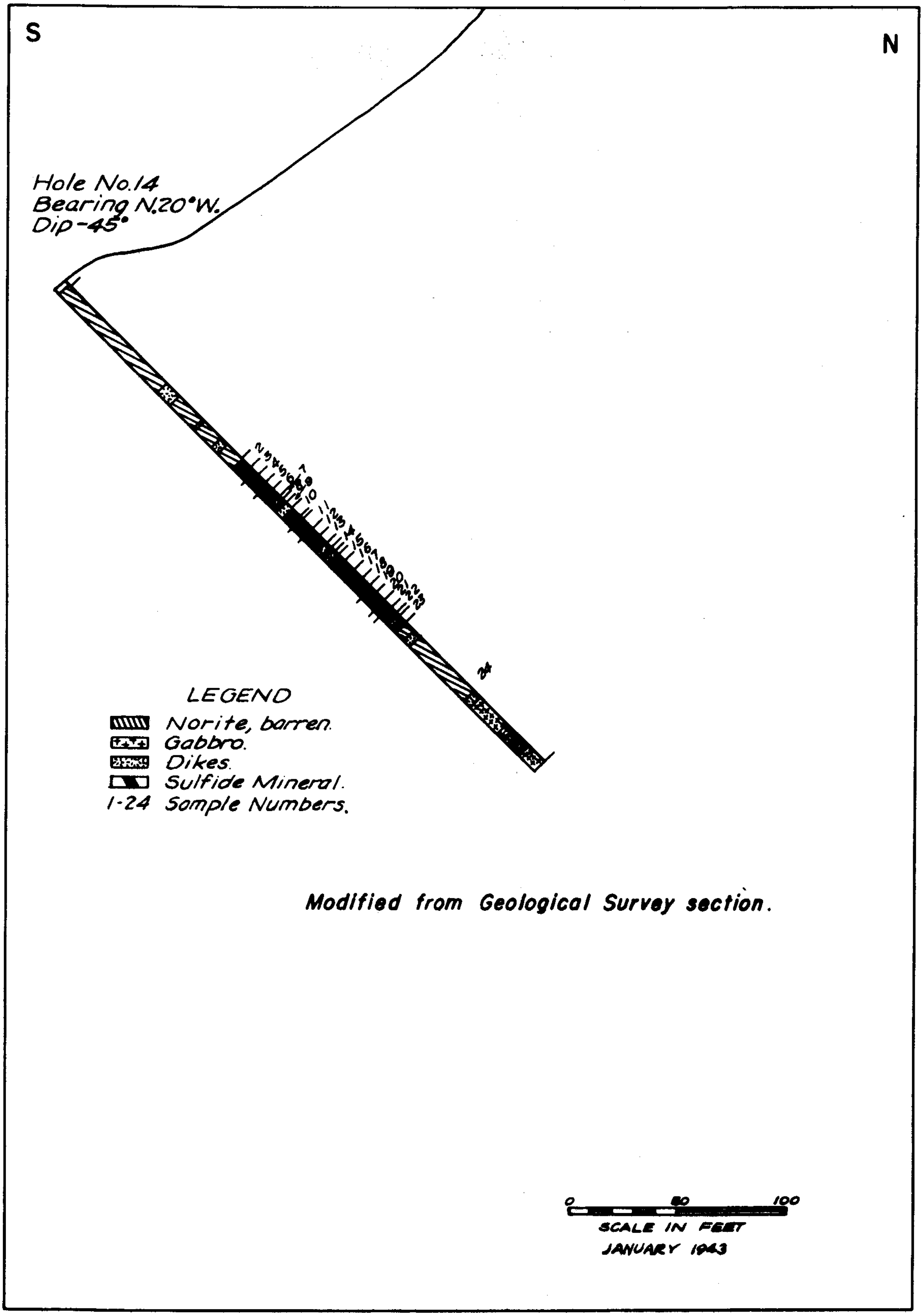


Figure 5. - Tripod ore body; surface profile, section, and assay plan, diamond-drill holes 4 and 4A.



Modified from Geological Survey section.

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Figure 6. - Tripod ore body; surface profile, section, and assay plan, diamond-drill hole 14.

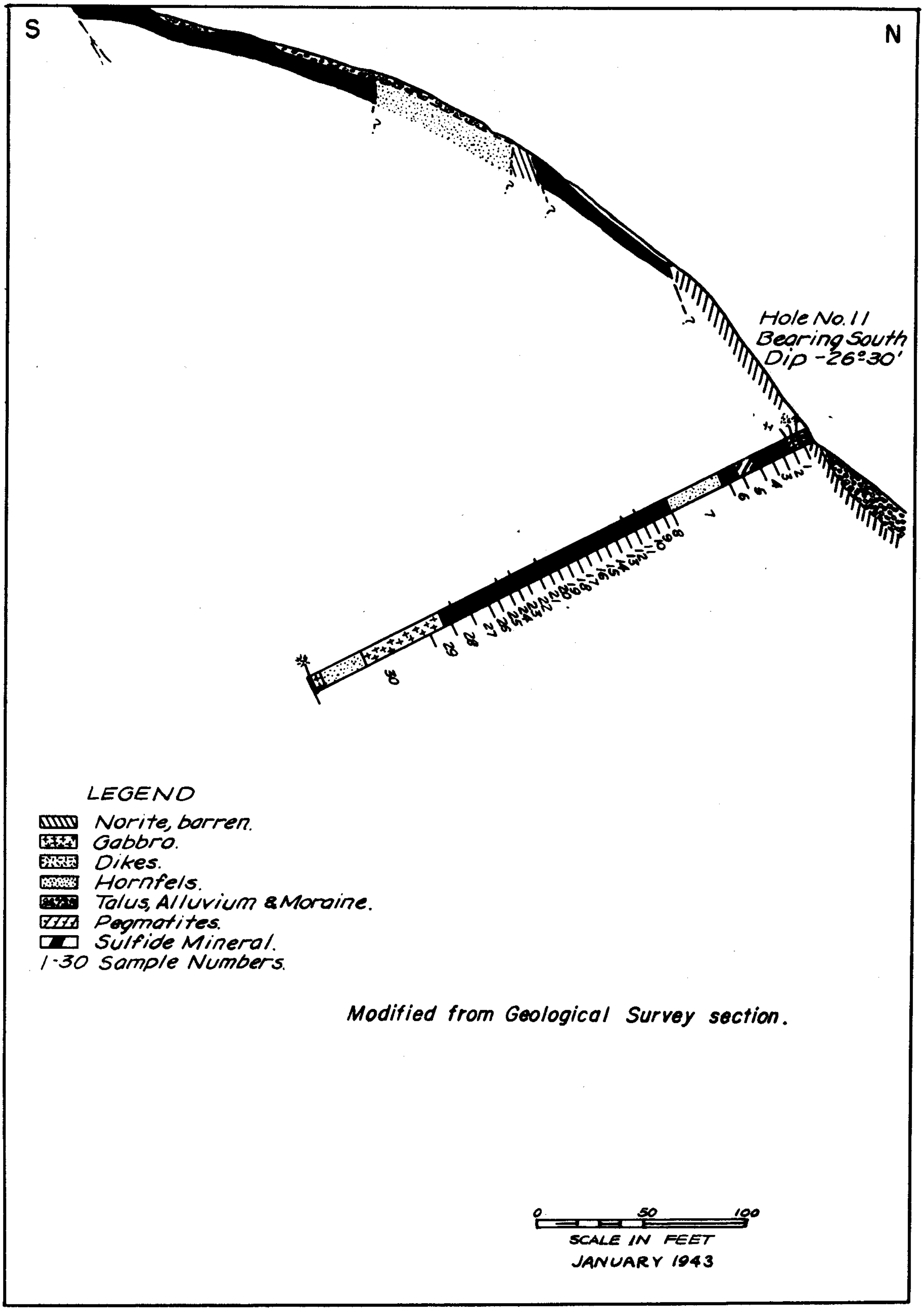

Figure 7. - Tunnel ore body; surface profile, section, and assay plan, diamond-drill hole 11.

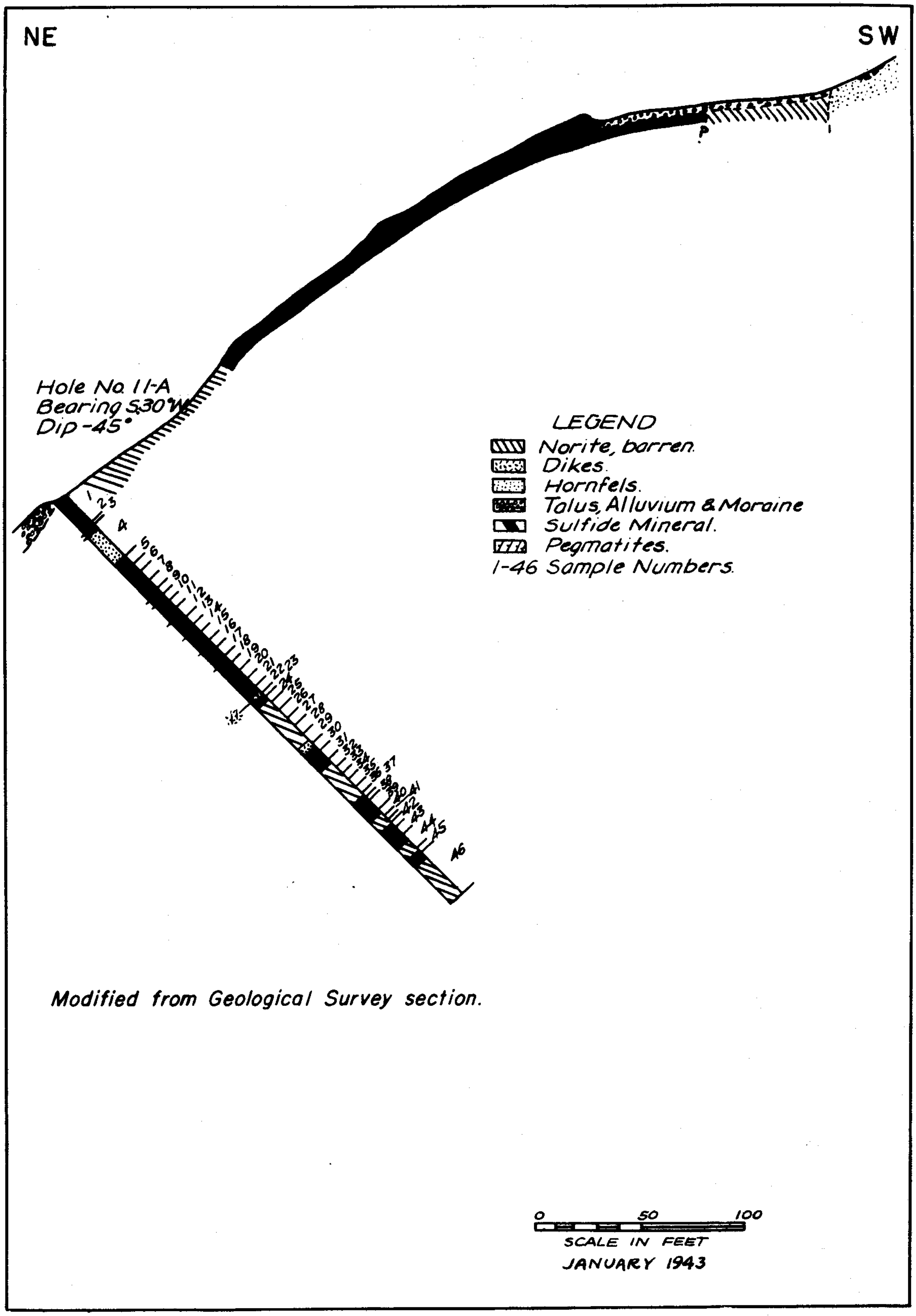

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Figure 8. - Tunnel ore body; surface profile, section, and assay plan, diamond-drill hole 11A.

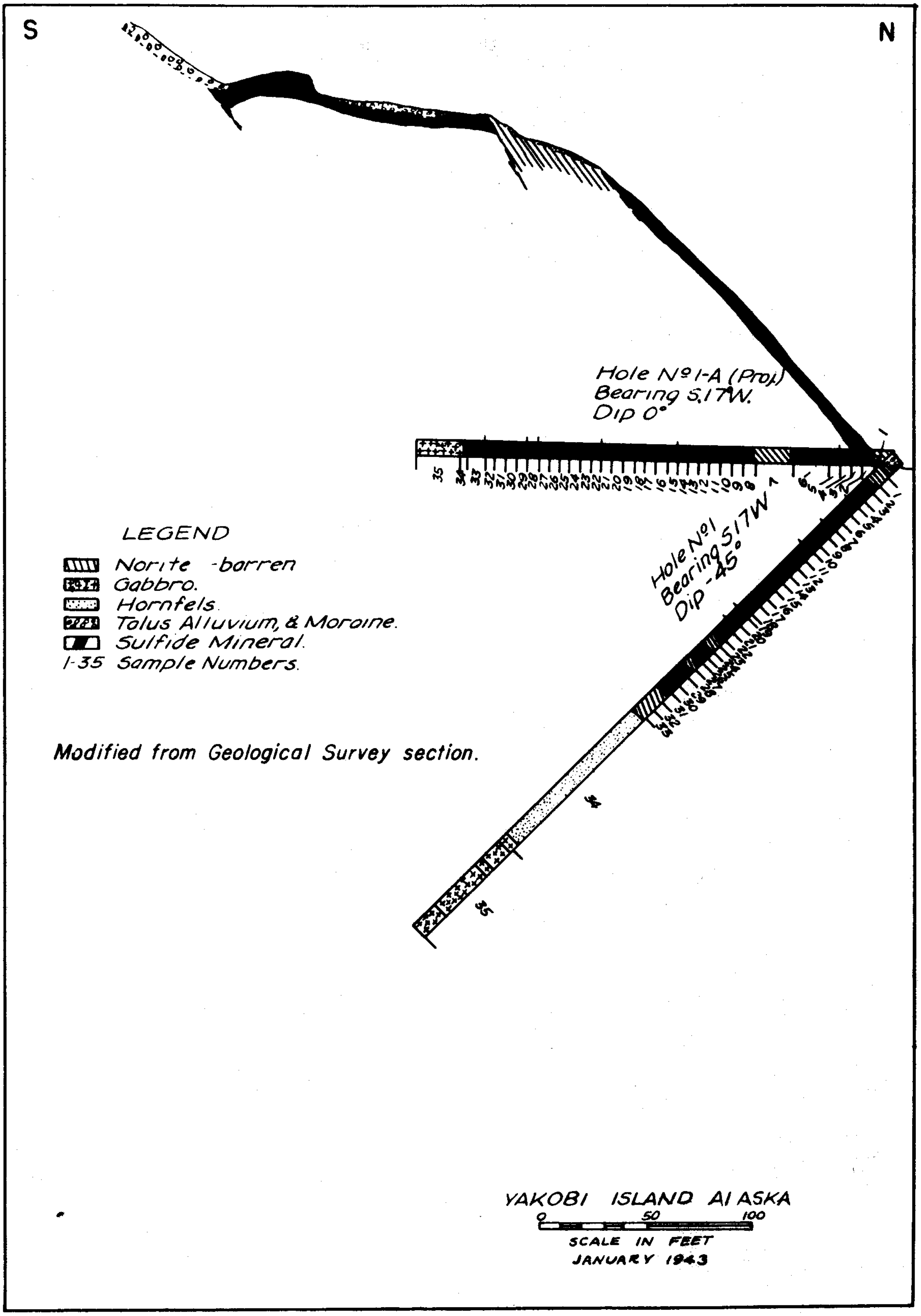

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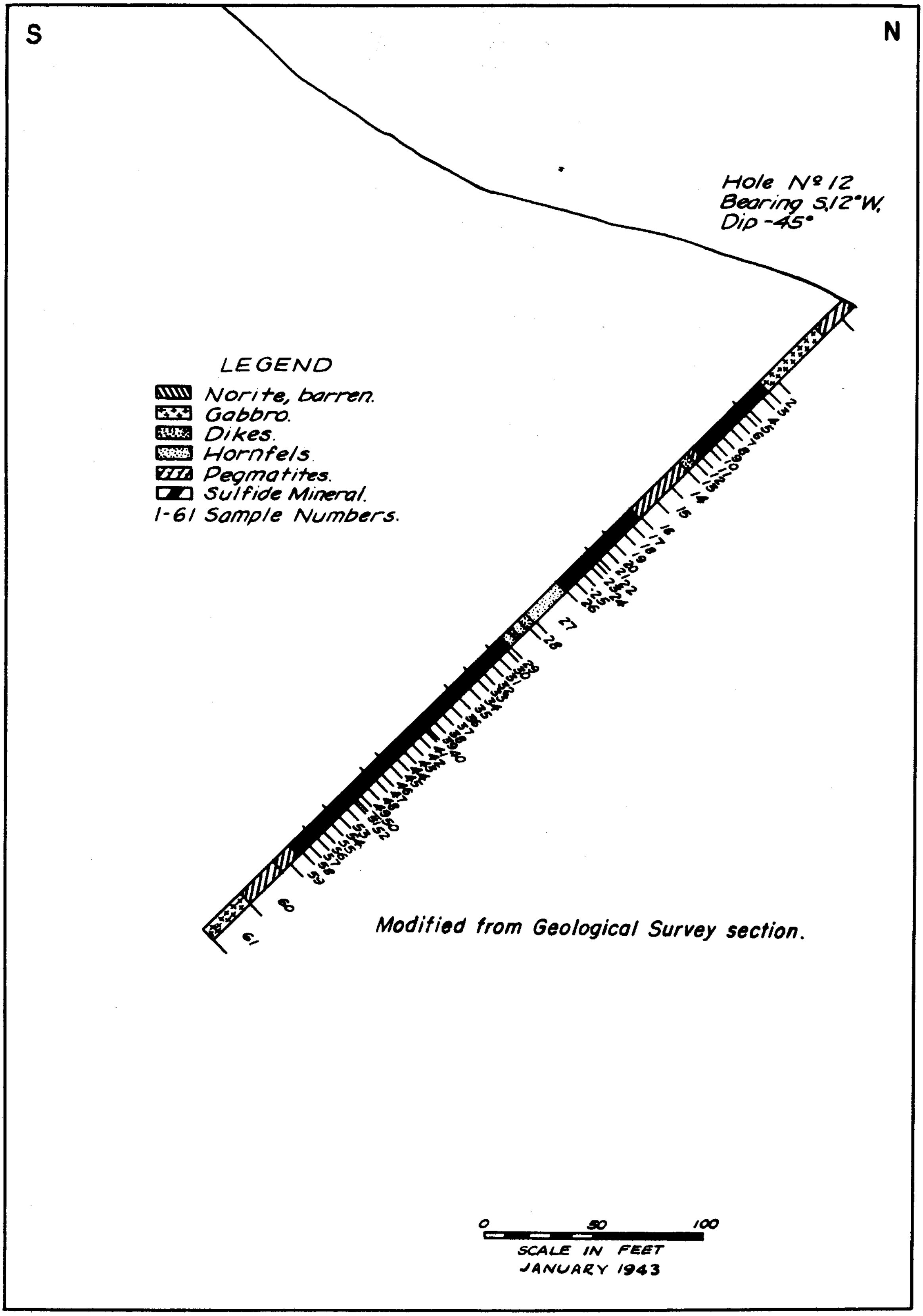
Figure 9. - Tunnel ore body; surface profile, section, and assay plan, diamond-drill holes 1 and 1A.



Modified from Geological Survey section.

Figure 10. - Tunnel ore body; surface profile, section, and assay plan, diamond-drill hole 12.

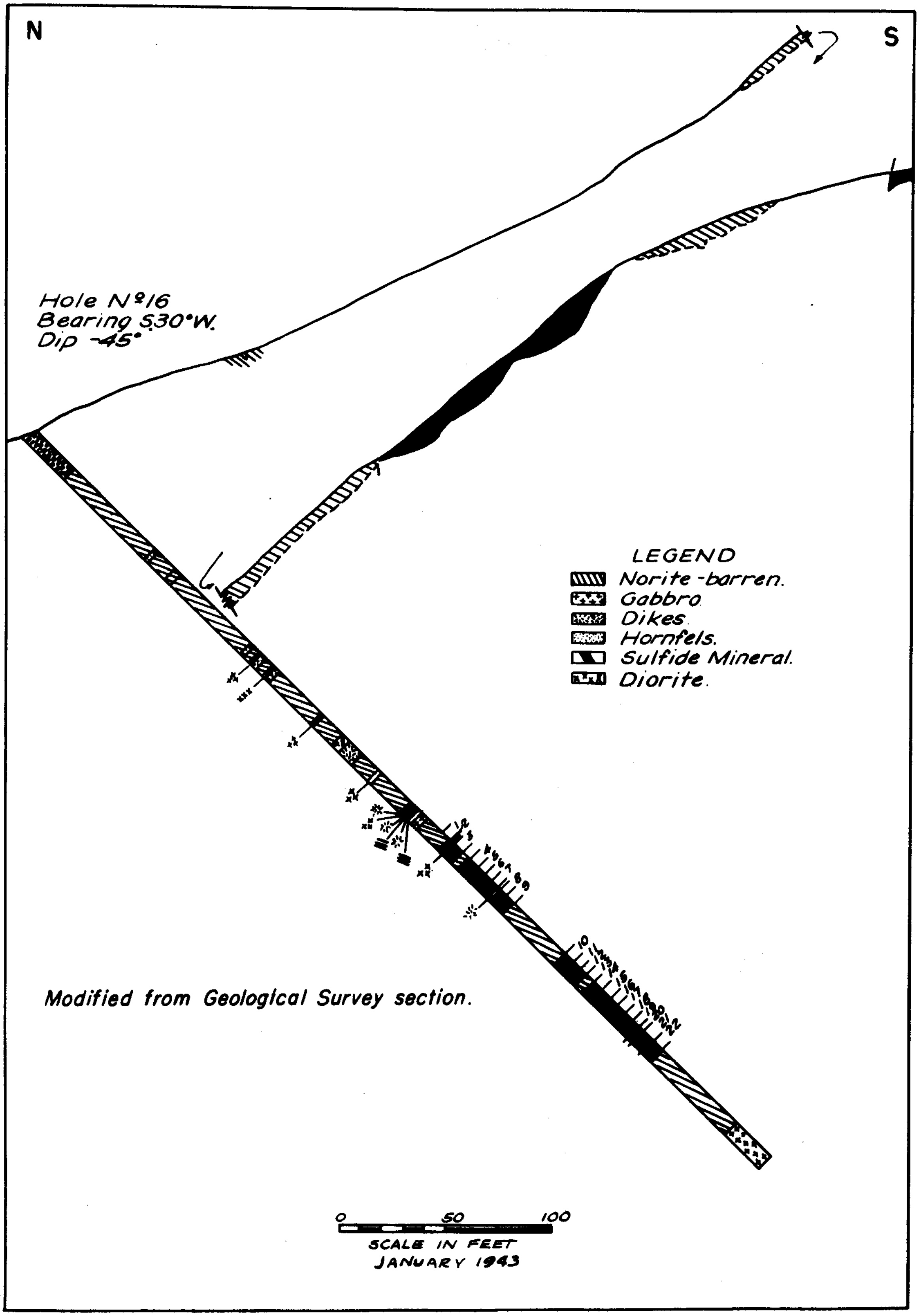


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Figure 11. - Tunnel ore body; surface profile, section, and assay plan, diamond-drill hole 16.

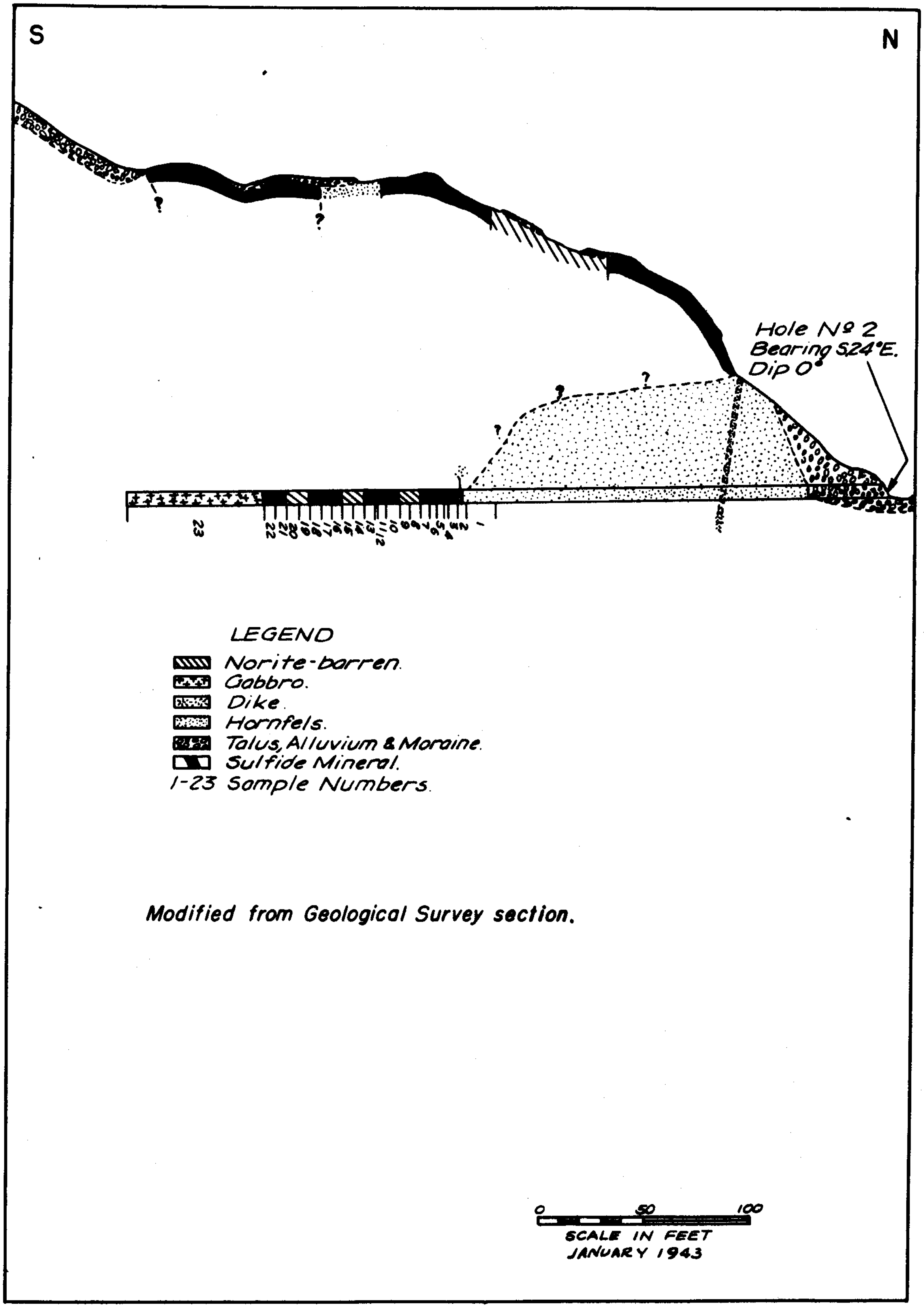

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Figure 12. - Tunnel ore body; surface profile, section, and assay plan, diamond-drill hole 2.

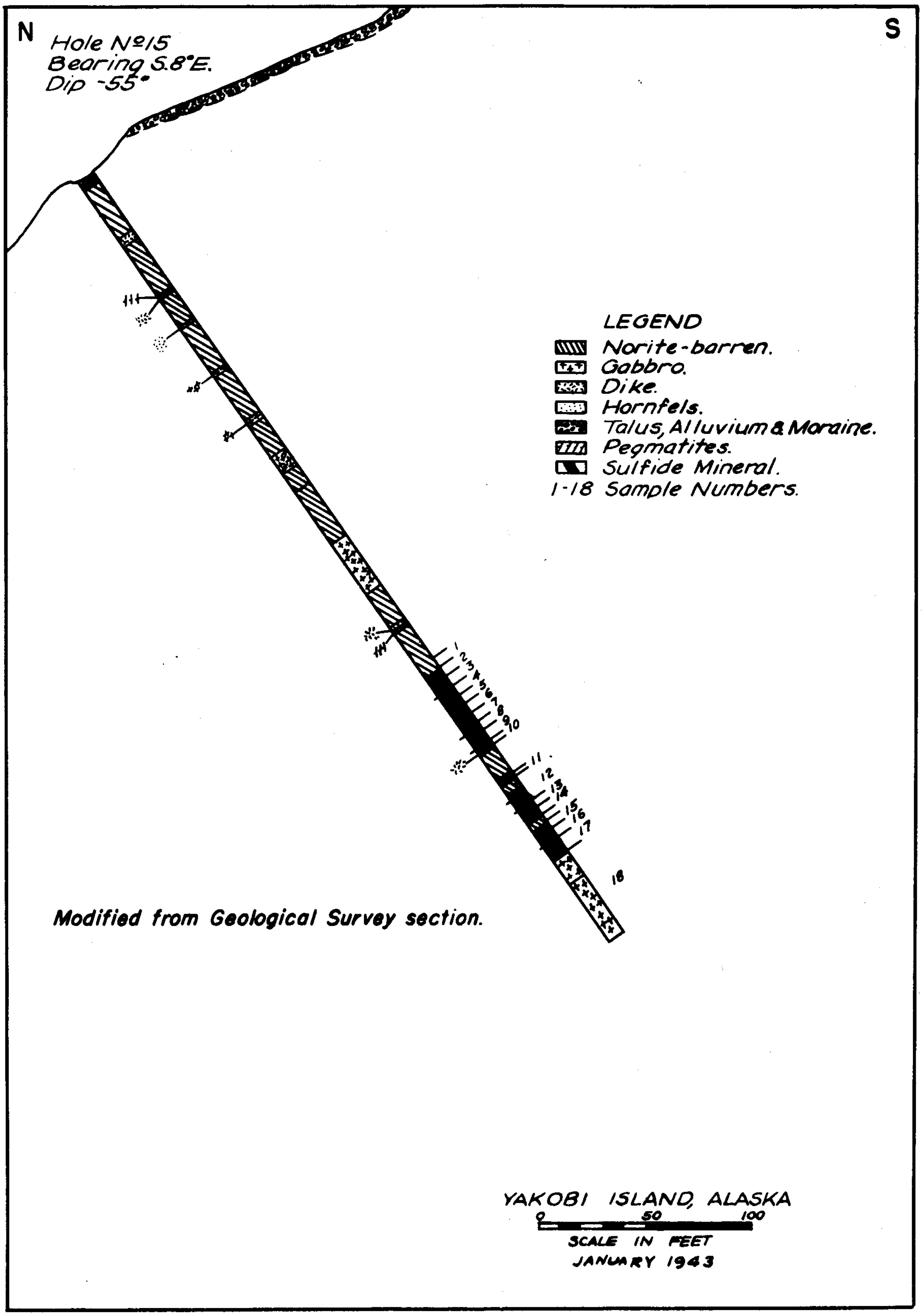

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Figure 13. - Tunnel ore body; surface profile, section, and assay plan, diamond-drill hole 15.

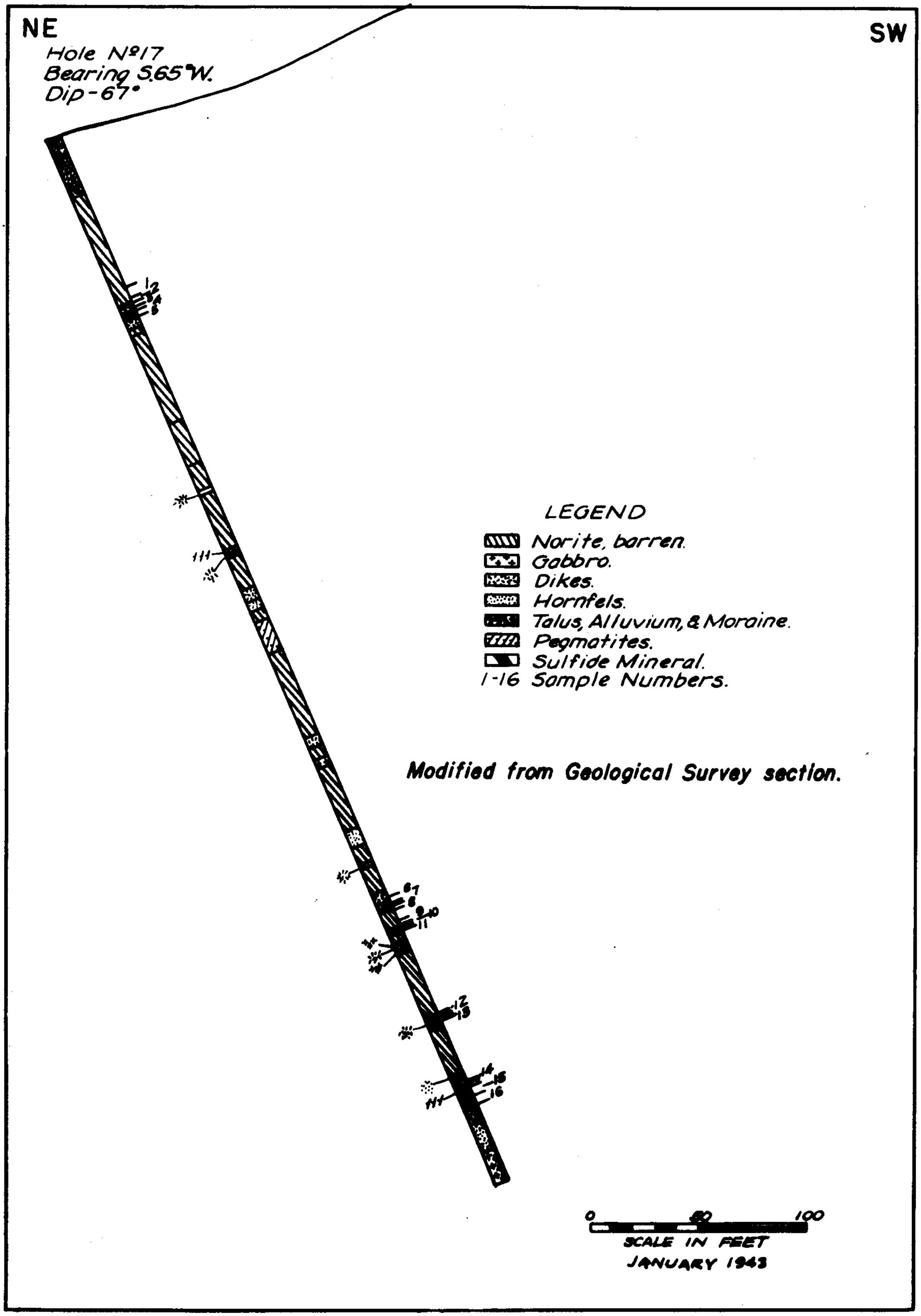

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Figure 14. - Tunnel ore body; surface profile, section, and assay plan, diamond-drill hole 17.

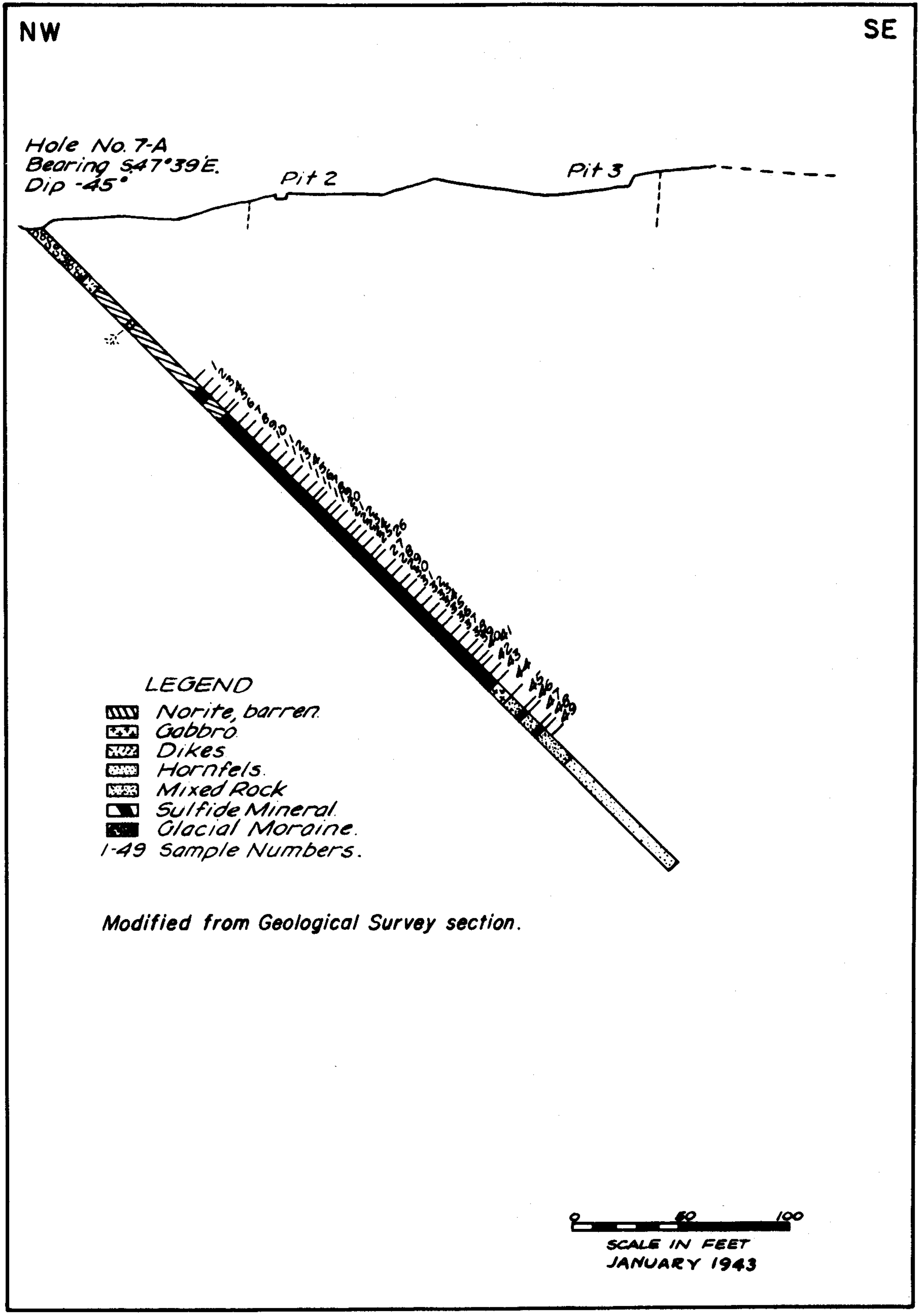

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Figure 15. - North Muskeg ore body; surface profile, section, and assay plan, diamond-drill hole 7A.

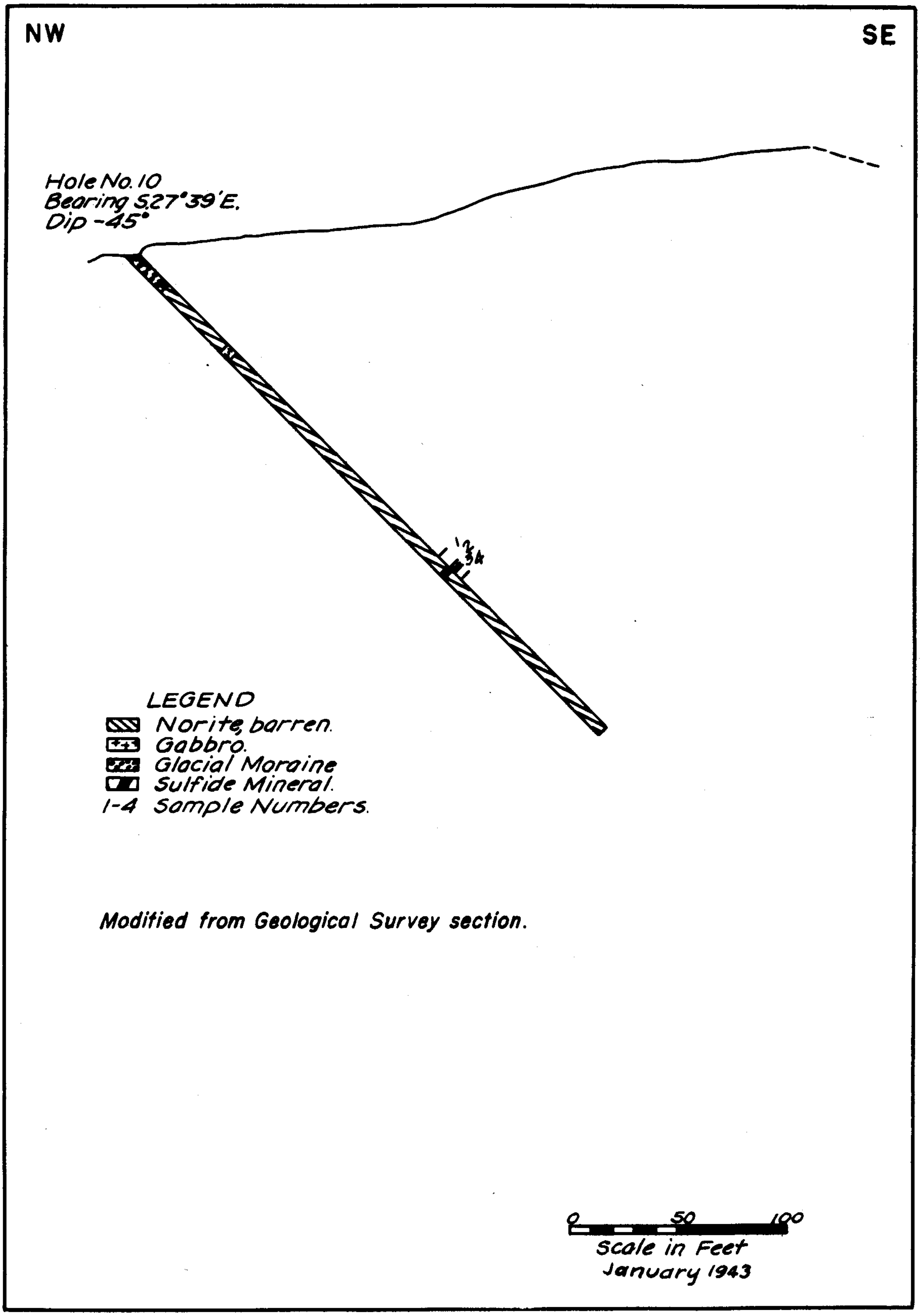
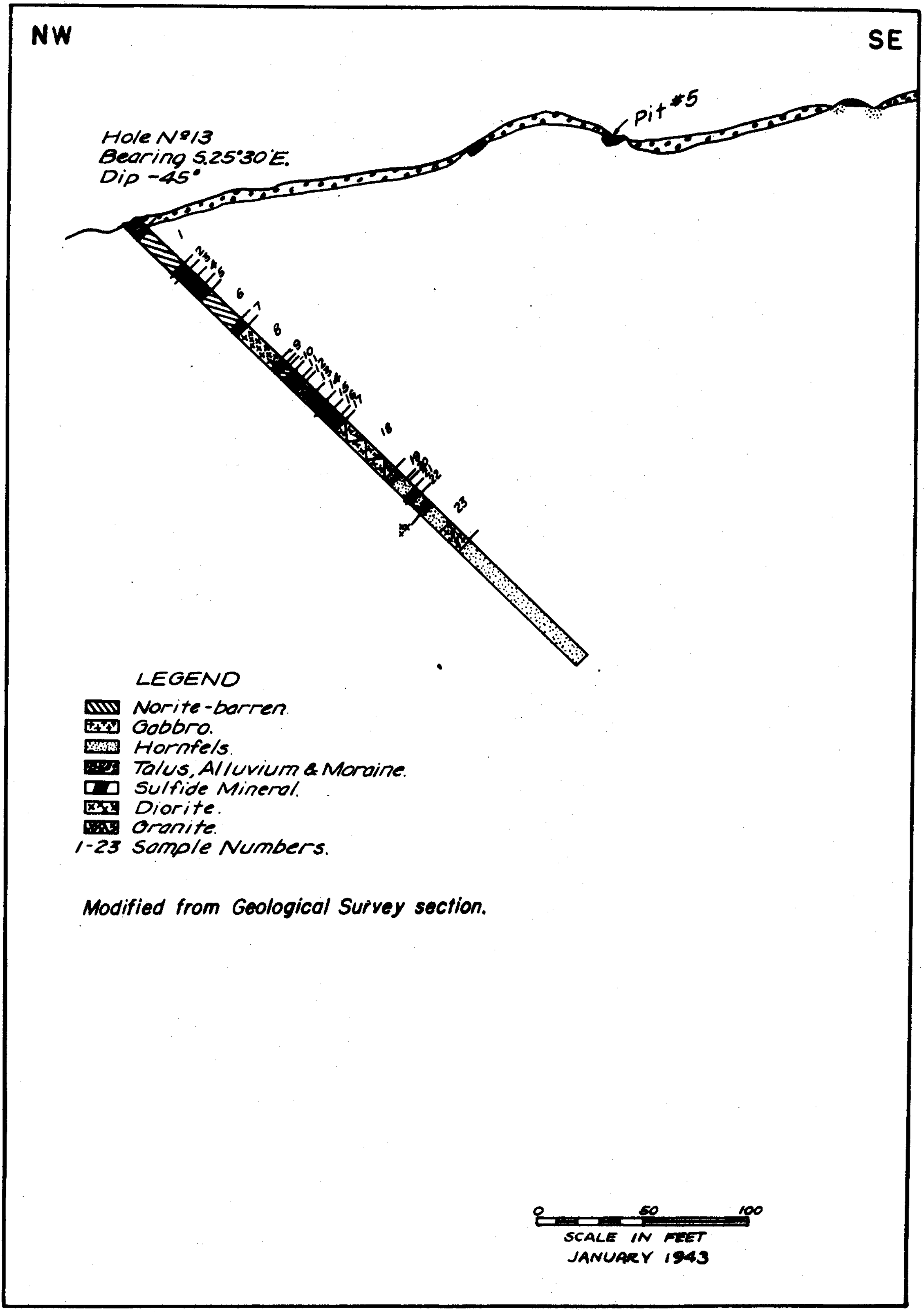


Figure 16. - North Muskeg ore body; surface profile, section, and assay plan, diamond-drill hole 10.



Modified from Geological Survey section.

Figure 17. - South Muskeg ore body; surface profile, section, and assay plan, diamond-drill hole 13.

DIAMOND-DRILL SAMPLING

Standard metal "sludge tanks" were used, and the cuttings were recovered from all holes while ore was being drilled. Since a high core recovery was obtained, the cuttings were discarded when the core was removed from the hole. Only six cutting samples were sent for analysis, and although the results were recorded, they were disregarded in calculations.

Cores were filled in wooden core boxes with metal dividers until logged, after which they were split longitudially, one half going for assay and the duplicate retained at the project for use in case of lost shipments, or for a check on results if required.

In all, 467 core samples and 113 pit and tunnel samples were shipped to the Bureau of Mines laboratory at Reno, Nev., for analysis; in addition, a sample of more than 1 ton was mined in the tunnel and sent to the Bureau of Mines laboratory at Salt Lake City, Utah, for metallurgical testing.

Tables 2 to 14, inclusive, show sample lengths and core analyses.

TABLE 2

Tripod ore body
drill hole 4

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent	
			Ni	Cu
1	71.5	4.8	0.19	0.15
2	76.8	5.3	.15	.13
3	81.0	4.2	.18	.12
4	85.5	4.5	.02	.02
5	86.5	1.0	.06	.03
6	89.7	3.2	.27	.12
7	94.5	4.8	.01*	.03
8	99.3	4.8	.01*	.02
9	102.0	2.7	.01*	.04
10	107.0	5.0	.40	.18
11	111.3	4.3	.67	.20
12	114.3	3.0	1.77	1.13
13	118.2	3.9	.49	.24
14	120.0	1.8	.37	.10
15	124.0	4.0	.69	.29
16	126.7	2.7	.74	.76
17	129.3	2.6	1.91	.92
18	131.7	2.4	.44	.43
19	134.3	2.6	.09	.10
20	135.5	1.2	.50	.40
21	135.9	0.4	5.85	.04
22	139.4	3.5	.62	.52
23	144.2	4.8	.64	.34
24	146.2	2.0	1.32	.25
25	149.0	2.8	.01*	.02*
26	153.8	4.8	.01*	.02*
27	158.7	4.9	.01*	.02*
28	163.7	5.0	.34	.23
29	168.6	4.9	.16	.08
30	173.8	5.2	.33	.17
31	177.6	3.8	.01*	.02
32	181.3	3.7	.41	.24
33	186.5	5.2	.55	.52
34	191.5	5.0	.25	.25
		124.8	.384	.222
35	196.5	5.0	.04	.04
36	201.5	5.0	.01*	.02*
37	206.3	4.8	.01*	.02*
38	289.5	83.2	.01*	.02*

*Less than.

No sample taken, 0 - 66.7 ft.; barren formations.

Composite sample, 206.3 - 289.5 ft.

Tripod ore body
drill hole 4A

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent	
			Ni	Cu
1	17.5	0.6	0.01*	0.02*
2	22.5	5.0	.01*	.02*
3	28.3	5.8	.01*	.02*
4	40.8	12.5	.01*	.02*
5	44.0	3.2	.01*	.02*
6	68.5	24.5	.01*	.06*
7	81.8	13.3	.01*	.02*
8	88.3	6.5	.08	.05
9	93.5	5.2	.18	.14
10	98.1	4.6	.37	.13
11	103.2	5.1	.01*	.02*
12	106.6	3.4	.10	.02*
13	111.6	5.0	.67	.24
14	117.6	6.0	.01*	.02*
15	122.3	4.8	.72	.40
16	123.8	1.5	.01*	.02*
17	126.0	2.2	.39	.09
18	202.0	76.0	.01*	.02
19	204.0	2.0	.57	.16
20	224.9	20.9	.01*	.12
21	230.0	5.1	1.40	.42
22	235.0	5.0	.51	.51
23	238.6	3.6	1.10	.43
24	242.7	4.1	.01*	.02
25	248.0	5.3	.94	.48
26	253.0	5.0	.94	.44
27	258.0	5.0	.77	.36
28	264.6	6.6	.47	.37
29	279.0	14.4	.01*	.02*
30	285.0	6.0	.01*	.02*
31	290.6	5.6	.18	.05
32	293.6	3.0	.21	.04
33	298.6	5.0	1.04	.45
34	305.0	6.4	1.04	.86
		216.8	.256	.150
35	311.0	6.0	.03	.04
36	338.7	27.7	.02	.02

*Less than.

No sample taken, 0 - 3.7 ft.; overburden.

No sample taken, 3.7-16.9 ft.; barren norite.

Composite sample, 311.0 - 338.7 ft.

TABLE 3. - Tripod ore-body drill hole 14

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent Ni	Core analysis, percent Cu
1	115.6	112.6	0.01*	0.02*
2	120.6	5.0	.41	.21
3	125.6	5.0	.20	.10
4	130.6	5.0	.29	.19
5	135.6	5.0	.30	.19
6	140.6	5.0	.16	.19
7	142.0	1.4	.04	.02
8	144.0	2.0	.40	.27
9	148.6	4.6	.04	.02
10	153.0	4.4	.41	.15
-**	154.7	1.7	-	-
11	161.0	6.3	.19	.09
12	166.0	5.0	.82	.34
13	171.0	5.0	.59	.25
-**	172.7	1.7	-	-
14	175.0	2.3	.38	.20
-**	177.6	2.6	-	-
15	182.6	5.0	.27	.16
16	187.6	5.0	.35	.19
17	192.6	5.0	.38	.15
18	197.6	5.0	.36	.21
19	202.6	5.0	.35	.19
20	207.6	5.0	.52	.21
21	212.6	5.0	.47	.23
22	216.6	4.0	.48	.24
-**	218.0	1.4	-	-
23	222.0	4.0	.48	.18
		106.4	.339	.170
24	312.9	90.9	.01*	.03

* Less than.
**No sample taken.
No sample, 0 - 3.0 ft.,; overburden.
Composite sample, 3.0 - 115.6 ft.

TABLE 4. - Tunnel ore-body drill hole 11

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent	
			Ni	Cu
1	11.5	6.1	0.01*	0.02*
2	17.5	6.0	.09	.02
3	21.6	4.1	.15	.11
4	28.8	7.2	.15	.10
5	38.3	9.5	.18	.08
6	45.0	6.7	.44	.23
7	74.0	29.0	.08	.04
8	78.2	4.2	.78	.30
9	83.2	5.0	.62	.23
10	88.1	4.9	.86	.22
11	93.1	5.0	.32	.10
12	98.0	4.9	.51	.10
13	103.0	5.0	.99	.30
14	108.0	5.0	.88	.21
15	113.0	5.0	.46	.14
16	118.0	5.0	.52	.20
17	123.0	5.0	.91	.38
18	128.3	5.3	.86	.34
19	133.0	4.7	.68	.31
20	137.8	4.8	.93	.44
21	142.8	5.0	.29	.18
22	147.8	5.0	.05	.08
23	152.9	5.1	.15	.12
24	157.8	4.9	.09	.11
25	162.8	5.0	.29	.18
26	167.9	5.1	.22	.07
27	178.0	10.1	.11	.05
28	188.2	10.2	.20	.11
29	197.9	9.7	.30	.18
		180.4	.366	.154
30	258.1	60.2	.08	.05

*less than.

No sample taken, 0 - 5.4 ft.; overburden.

TABLE 5. - Tunnel ore-body drill hole 11-A

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent		Sample	Depth, ft.	Sample length, ft.	Core analysis, percent	
			Ni :	Cu				Ni :	Cu
1	13.5	7.5	0.13	0.06	24	136.1	4.3	0.07	0.05
2	18.5	5.0	.20	.11	25	141.1	5.0	.10	.06
3	19.5	1.0	.45	.31	26	146.1	5.0	.06	.08
4	40.7	21.2	.08	.06	27	151.0	4.9	.05	.06
5	45.7	5.0	.61	.41	28	156.6	5.6	.05	.02
6	50.7	5.0	.72	.76	29	161.7	5.1	.01	.03
7	56.0	5.3	.33	.24	30	166.7	5.0	.47	.34
8	61.3	5.3	.61	.26	31	172.5	5.8	.54	.43
9	64.5	3.2	1.18	1.04	32	177.0	4.5	.05	.06
10	69.5	5.0	.55	.11	33	182.0	5.0	.08	.06
11	74.9	5.4	.64	.32	34	186.1	4.1	.09	.08
12	80.0	5.1	1.13	3.18	35	191.1	5.0	.05	.02
13	85.1	5.1	3.60	3.13	36	194.5	3.4	.04	.04
14	90.1	5.0	.08	.13	37	197.7	3.2	.45	.19
15	95.1	5.0	.15	.10	38	199.5	1.8	.01	.05
16	100.0	4.9	.43	.16	39	204.6	5.1	.12	.07
17	105.0	5.0	.27	.18	40	209.6	5.0	.05	.02
18	110.3	5.3	.84	.71	41	212.1	2.5	.08	.05
19	115.3	5.0	.99	.23	-	213.2	1.1	-	-
20	120.0	4.7	1.30	.36	42	217.4	4.2	.18	.13
21	125.4	5.4	1.56	.94	43	221.6	4.2	.30	.12
22	129.3	3.9	.01	.04	44	229.7	8.1	.05	.04
23	131.8	2.5	1.30	.45	45	233.3	3.6	.36	.16
		125.8	.649	.514			101.5	.146	.099
					46*	258.5	25.2	.02	.05

*Composite sample, 233.3 - 258.5 ft.

No sample taken, 0 - 6.0 ft.; overburden.

TABLE 6. - Tunnel ore body, drill holes 1 and 1-A

Drill hole 1

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent	
			Ni	Cu
1	15.3	4.6	0.01*	0.02*
2	20.3	5.0	.01*	.05
3	25.5	5.2	.14	.16
4	29.0	3.5	.05	.08
5	34.0	5.0	.20	.11
6	39.0	5.0	.53	.24
7	43.7	4.7	.24	.11
8	48.7	5.0	.13	.10
9	53.7	5.0	.29	.19
10	57.8	4.1	.03	.02
11	63.0	5.2	.42	.27
12	68.0	5.0	.35	.23
13	73.0	5.0	.27	.17
14	78.0	5.0	.29	.17
15	83.0	5.0	.29	.16
16	87.5	4.5	.25	.20
17	92.5	5.0	.27	.13
18	97.5	5.0	.37	.23
19	101.1	3.6	.37	.30
20	106.0	4.9	.79	.42
21	111.0	5.0	.72	.28
22	116.0	5.0	.62	.24
23	119.0	3.0	.09	.04
24	122.5	3.5	.42	.19
25	126.5	4.0	.45	.20
26	130.1	3.6	.44	.18
27	135.0	4.9	.09	.06
28	140.0	5.0	.53	.14
29	145.0	5.0	.17	.67
30	151.5	6.5	.12	.10
		122.5	.337	.200
31	156.5	5.0	.01*	.04
32	161.5	5.0	.01*	.02
33	167.0	5.0	.05	.02*
34	253.0	86.0	.01*	.02*
35	310.4	57.4	.01*	.02*

*Less than.

No sample taken, 0 - 10.7 ft.; overburden and mine dump.

Composite samples: 167.0 - 253.0 ft.
253.0 - 310.4 ft.

Drill hole 1-A

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent	
			Ni	Cu
1	10.3	4.6	0.01*	0.02*
2	15.5	5.2	.30	.12
3	20.5	5.0	.66	.32
4	25.5	5.0	.47	.29
5	30.5	5.0	.22	.16
6	47.5	17.0	.05	.05
7	65.0	17.5	.01*	.02
8	70.7	5.7	.04	.03
9	75.7	5.0	.16	.05
10	80.6	4.9	.17	.10
11	85.6	5.0	.31	.11
12	90.5	4.9	.45	.19
13	95.5	5.0	.49	.24
14	100.5	5.0	.44	.16
15	105.5	5.0	.44	.27
16	110.5	5.0	.43	.20
17	115.5	5.0	.48	.30
18	120.5	5.0	.39	.18
19	125.5	5.0	.41	.16
20	130.5	5.0	.23	.19
21	135.5	5.0	.34	.15
22	140.5	5.0	.72	.48
23	145.5	5.0	.67	.31
24	150.0	4.5	.85	.19
25	155.0	5.0	.63	.45
26	160.0	5.0	1.04	.40
27	164.0	4.0	.56	.30
28	169.5	5.5	.10	.10
29	174.5	5.0	.26	.12
30	179.5	5.0	.53	.29
31	184.5	5.0	.37	.33
32	188.5	4.0	.33	.17
33	198.5	10.0	.16	.06
		188.2	.338	.176
34	201.0	2.5	.08	.03
35	220.7	19.7	.09	.05

*Less than.

No sample taken, 0 - 5.7 ft.; overburden.

Composite sample, 201.0 - 220.7 ft.

TABLE 7. - Tunnel ore-body drill hole 12

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent	
			Ni	Cu
1	49.4	46.4	0.07	0.03
2	54.9	5.5	.10	.09
3	59.5	4.6	.36	.14
4	67.3	7.8	.14	.05
5	70.3	3.0	.28	.14
6	75.3	5.0	.69	.27
7	80.2	4.9	.55	.24
8	85.2	5.0	.39	.22
9	90.2	5.0	.47	.19
10	92.7	2.5	.33	.12
11	98.8	6.1	.37	.19
12	102.4	3.6	.09	.03
13	107.3	4.9	.01*	.03
14	118.5	11.2	.01*	.03
15	127.0	8.5	.02	.03
16	138.0	11.0	.04	.03
17	143.0	5.0	.39	.22
18	148.0	5.0	.32	.18
19	154.8	6.8	.30	.19
20	159.3	4.7	.30	.17
21	164.8	5.3	.14	.10
22	167.3	2.5	.05	.05
23	170.4	3.1	.06	.04
24	175.4	5.0	.25	.16
25	180.4	5.0	.16	.13
26	185.8	5.4	.15	.08
27	206.0	20.2	.07	.06
28	210.0	4.0	.02	.05
-	221.9	11.9	-	-
29	224.1	2.2	0.18	0.15
30	229.1	5.0	.41	.13
31	234.1	5.0	.17	.14
32	239.1	5.0	.20	.14
33	243.5	4.4	.20	.12
34	249.0	5.5	.19	.12
35	255.5	6.5	.20	.11
36	260.8	5.3	.52	.26
37	265.8	5.0	.80	.38
38	271.0	5.2	.44	.33
39	275.5	4.5	.61	.24
40	276.6	1.1	.06	.05
41	280.5	3.9	.68	.30
42	285.5	5.0	.93	.45
43	290.5	5.0	1.19	.38
44	295.5	5.0	1.10	.28
45	299.8	4.3	1.02	.53
46	304.8	5.0	.43	.33
47	309.0	4.2	.66	.43
48	313.5	4.5	.27	.22
49	318.6	5.1	.28	.20
50	321.6	3.0	.18	.05
51	322.8	1.2	.03	.04
52	327.8	5.0	.46	.25
53	332.8	5.0	.55	.26
54	337.8	5.0	.45	.31
55	342.8	5.0	.44	.23
56	347.0	4.2	.55	.40
57	352.0	5.0	.49	.28
58	357.3	5.3	.17	.19
		302.4	.318	.169
59	363.5	6.2	.10	.11
60	390.0	26.5	.07	.05
61	413.1	23.1	.03	.03

*Less than.

No sample taken, 0 - 3.0 ft.; overburden.

No sample taken, 210.0 - 221.9 ft.; barren formations.

Composite samples: 3.0 - 49.4 ft.
263.5 - 390.0 ft.
390.0 - 413.1 ft.

TABLE 8. - Tunnel ore-body drill hole 16

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent Ni	Cu
1	270.3	5.3	0.01*	0.02*
2	271.7	1.4	.08	.02*
-	272.7	1.0	-	-
3	278.7	6.0	.11	.03
-	283.0	4.3	-	-
4	288.0	5.0	.25	.16
5	293.0	5.0	.27	.11
6	298.0	5.0	.27	.07
7	302.0	4.0	.44	.07
-	303.0	1.0	-	-
8	307.0	4.0	.35	.14
9	312.0	5.0	.37	.17
-	345.0	33.0	-	-
10	350.0	5.0	.26	.17
11	355.0	5.0	.23	.15
12	358.7	3.7	.26	.13
13	364.1	5.4	.10	.02*
14	369.0	4.9	.25	.10
15	374.0	5.0	.27	.16
16	379.0	5.0	.20	.09
17	384.0	5.0	.33	.20
18	389.0	5.0	.12	.06
19	393.5	4.5	.25	.14
20	396.0	2.5	.12	.09
21	402.3	6.3	.19	.07
22	408.0	5.7	.17	.07
		125.0	.179	.082

*Less than.

No sample taken, 0 - 29.5 ft.; overburden.
No sample taken, 29.5 - 265.0 ft.; barren formations.
No sample taken, 271.7 - 272.7 ft.; barren gabbro.
No sample taken, 278.7 - 283.0 ft.; barren norite.
No sample taken, 302.0 - 303.0 ft.; barren dike.
No sample taken, 312.0 - 345.0 ft.; barren norite.
No sample taken, 408.0 - 479.3 ft.; barren formations.

TABLE 9. - Tunnel ore-body drill hole 2**

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent	
			Ni	Cu
1	196.3	159.7	0.01*	0.03
2	198.8	2.5	.16	.40
3	203.8	5.0	.22	.25
4	206.3	2.5	.53	.27
5	209.5	3.2	.46	.38
6	213.0	3.5	.11	.11
7	217.0	4.0	.27	.25
8	222.4	5.4	.01*	.03
9	227.5	5.1	.03	.02
10	232.5	5.0	.48	.25
11	237.2	4.7	.36	.14
	(2 - 11)	40.9	.245	.188
12	238.0	0.8	.06	.03
13	242.8	4.8	.27	.09
14	247.8	5.0	.08	.03
15	252.8	5.0	.08	.02
16	257.8	5.0	.13	.02
17	262.8	5.0	.12	.02
18	268.2	5.4	.12	.02
19	273.4	5.2	.08	.02
20	278.5	5.1	.08	.05
21	283.5	5.0	.15	.12
22	289.0	5.5	.27	.02
	(12 - 22)	51.8	.137	.040
	(2 - 22)	92.7	.184	.105
23	352.8	63.8	.01*	.02*

*Less than.

**Hole located between ore sections.

No sample taken, 0 - 36.6 ft.; slide rock.

Composite sample, 36.6 - 196.3 ft.; barren hornfels.

Composite sample, 289.0 - 352.8 ft.; barren hornfels.

TABLE 10. - Tunnel ore-body drill hole 15**

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent	
			Ni	Cu
1	277.7	5.0	0.01*	0.04
2	282.7	5.0	.18	.08
3	288.0	5.3	.26	.15
4	293.0	5.0	.22	.10
5	298.0	5.0	.15	.12
6	303.0	5.0	.10	.13
7	308.0	5.0	.15	.12
8	313.0	5.0	.10	.09
9	318.4	5.4	.04	.04
10	320.5	2.1	.15	.14
-	336.7	16.2	-	-
11	338.6	1.9	.10	.10
12	352.0	13.4	.02	.05
13	356.0	4.0	.24	.18
14	360.0	4.0	.15	.14
-	363.8	3.8	-	-
15	368.0	4.2	.18	.14
16	373.0	5.0	.30	.16
17	381.0	8.0	.16	.05
		103.3	.116	.082
18	425.8	44.8	.01*	.02*

*Less than.

**Hole located outside of ore sections.

No sample taken, 0 - 3.0 ft.; overburden.

No sample taken, 3.0 - 272.7 ft.; barren formations.

No sample taken, 320.5 - 336.7 ft.; barren norite.

No sample taken, 360.0 - 363.8 ft.; barren norite.

Composite sample, 381.0 - 425.8 ft.

TABLE 11. - Tunnel ore-body drill hole 17**

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent	
			Ni	Cu
-	75.2	47.7	-	-***
1	80.2	5.0	0.04	0.04
2	82.9	2.7	.29	.19
3	85.0	2.1	.01*	.02
4	86.5	1.5	.20	.11
5	89.0	2.5	.03	.02
-	380.0	291.0	-	-***
6	383.7	3.7	.01*	.03
7	384.3	0.6	.17	.13
8	386.5	2.2	.01	.04
-	391.5	5.0	-	-***
10	394.1	0.8	.12	.11
11	396.7	2.6	.02	.04
-	438.3	41.6	-	-***
12	439.5	1.2	.05	.10
-	440.8	1.3	-	-***
13	441.8	1.0	.10	.09
-	471.8	30.0	-	-***
14	473.0	1.2	.13	.09
-	474.0	1.0	-	-***
15	479.0	5.0	.01*	.06
16	483.7	4.7	.01*	.05
-	520.3	36.6	-	-***

*Less than.

**Hole located outside ore sections.

***No sample taken; barren formations.

No sample taken, 0 - 27.5 ft.; overburden.

TABLE 12. - North Muskeg ore-body drill hole 7-A

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent		Sample	Depth, ft.	Sample length, ft.	Core analysis, percent	
			Ni	Cu				Ni	Cu
1	103.2	4.7	0.01*	0.02	26	216.1	3.1	0.20	0.19
2	108.4	5.2	.18	.14	27	221.8	5.7	.22	.17
3	112.6	4.2	.01	.01	28	225.6	4.8	.14	.15
4	118.3	5.7	.01*	.02	29	230.8	4.2	.11	.10
5	119.7	1.4	.01*	.03	30	235.1	4.3	.18	.10
6	126.6	6.9	.15	.19	31	240.9	5.8	.22	.15
7	131.4	4.8	.21	.14	32	245.9	5.0	.09	.07
8	136.2	4.8	.01*	.03	33	251.1	5.2	.14	.01*
9	141.3	5.1	.59	.37	34	254.9	3.8	.12	.05
10	146.5	5.2	.37	.28	35	258.8	3.9	.25	.09
11	151.6	5.1	.27	.24	36	264.6	5.8	.10	.01*
12	156.8	5.2	.30	.15	37	269.8	5.2	.26	.15
13	161.0	4.2	.22	.16	38	275.0	5.2	.18	.10
14	166.1	5.1	.26	.15	39	278.3	3.3	.51	.15
15	170.9	4.8	.35	.31	40	281.4	3.1	.25	.07
16	175.7	4.8	.30	.23	41	285.5	4.1	.23	.25
17	177.7	2.0	.67	.28	42	290.7	5.2	.39	.04
18	183.1	5.4	.39	.14			154.5	.241	.145
19	186.3	3.2	.34	.12					
20	190.6	4.3	.18	.14	43	295.8	5.1	.07	.03
21	196.2	5.6	.13	.08	44	304.9	9.1	.05	.03
22	199.2	3.0	.06	.08	45	313.0	8.2	.01*	.02
23	203.2	4.0	.10	.11	46	314.8	1.8	.01*	.01
24	208.2	5.0	.13	.08	47	323.7	8.9	.01	.03
25	213.0	4.8	.17	.23	48	325.9	2.2	.05	.10
					49	330.7	4.8	.02	.04

*Less than.

No sample taken, 0 - 3.0 ft.; overburden.

No sample taken, 3.0 - 98.6 ft.; barren formations.

No sample taken, 330.7 - 413.3 ft.; barren formations.

TABLE 13. - North Muskeg ore-body drill hole 10**

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent Ni	: Cu
-	195.4	175.4	-	-
1	203.5	8.1	0.01*	0.01
2	204.0	.5	.01*	.02
3	205.0	1.0	.01*	.02
4	209.6	4.6	.01*	.03

*Less than.
**Hole located outside ore section.
No sample taken, 0 - 20.0 ft.; overburden.
No sample taken, 20.0 - 203.5 ft.; barren formations.
No sample taken, 209.6 - 305.0 ft.; barren formations.

TABLE 14. - South Muskeg ore-body drill hole 13

Sample	Depth, ft.	Sample length, ft.	Core analysis, percent Ni	: Cu
-	9.0	3.0	-	-
1	33.0	24.0	0.08	0.02
2	37.0	4.0	.24	.03
3	42.0	5.0	.44	.30
4	47.0	5.0	.41	.24
5	50.6	3.6	.20	.15
6	70.0	19.4	.09	.08
7	74.0	4.0	.36	.23
8	96.0	22.0	.07	.05
9	99.0	3.0	.17	.15
-	101.0	2.0	-	-
10	104.0	3.0	.08	.06
11	109.0	5.0	.21	.14
12	111.0	2.0	.56	.20
13	118.0	7.0	.05	.02
14	124.5	6.5	3.08	.90
15	129.5	5.0	.68	.41
16	134.0	4.5	.77	.37
17	137.0	3.0	.51	.21
		104.0	.407	.183
18	169.4	32.4	.01*	.02
19	176.0	6.6	.01*	.05
20	177.2	1.2	.01*	.07
21	181.9	4.7	.01*	.04
22	185.0	3.1	.01*	.05
23	292.5	107.5	.01*	.03

*Less than.
No sample taken, 0 - 6.0 ft.; overburden.
No sample taken, 99.0 - 101.0 ft.; barren norite.
Composite sample, 137.0 - 169.4 ft.
Composite sample, 185.0 - 292.5 ft.

TUNNEL AND PIT SAMPLING

The character of the rock made hand sampling difficult and complete sampling would have been impossible in the short working season with inexperienced samplers. A total of 127.7 feet of channel samples, taken in 2- by 3-inch grooves, were cut along the sides of the Bohemia tunnel. (See fig. 18.)

In pits 8, 9, 10, 11, and A on the Tripod body representative channel samples of mineralized sections were taken and applied in the formula on page 23 to determine the grade. The assumption that the unmineralized exposures were barren was justified by a study of assay returns previously received on core drill samples which proved that the dike rock, hornfels, or norite which make up these zones and in which no sulfides were discernable, were obviously so lean as to be considered barren of nickel or copper. (See fig. 19.)

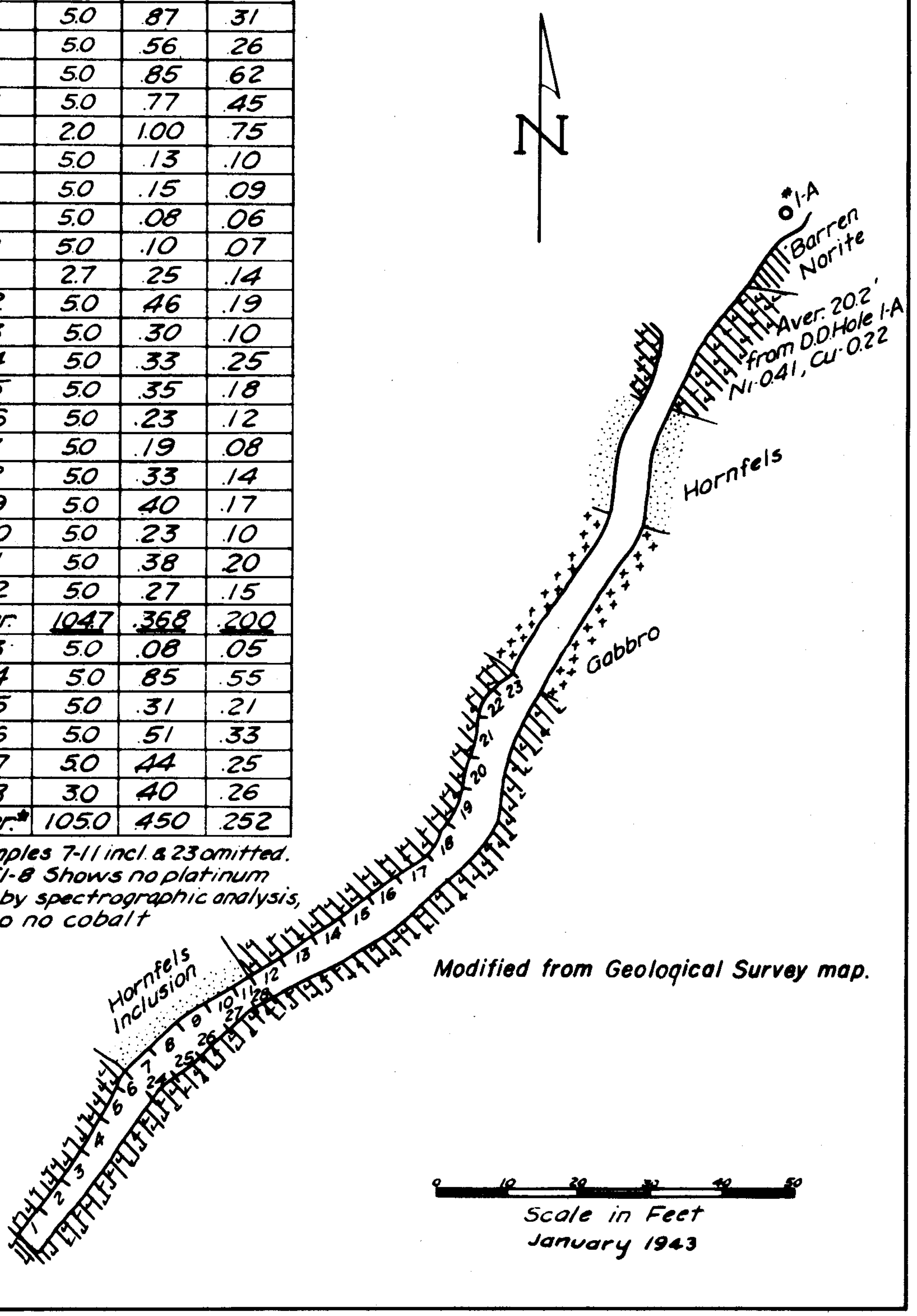
Pits 2 and 3 on the North Muskeg body (fig. 20) and pits 4, 5, and 7 on the South Muskeg body (fig. 21) were sampled in the same manner, except that a larger number of samples were taken and they were chips instead of channels.

Tables 15 to 18 show analyses of channel and pit samples.

CHANNEL SAMPLES

Sample No.	Length, Ft.	Percent Ni.	Percent Cu.
1	5.0	0.19	0.18
2	5.0	.87	.31
3	5.0	.56	.26
4	5.0	.85	.62
5	5.0	.77	.45
6	2.0	1.00	.75
7	5.0	.13	.10
8	5.0	.15	.09
9	5.0	.08	.06
10	5.0	.10	.07
11	2.7	.25	.14
12	5.0	46	.19
13	5.0	.30	.10
14	5.0	.33	.25
15	5.0	.35	.18
16	5.0	.23	.12
17	5.0	.19	.08
18	5.0	.33	.14
19	5.0	40	.17
20	5.0	.23	.10
21	5.0	.38	20
22	5.0	.27	.15
Aver.	1047	.368	.200
23	5.0	.08	.05
24	5.0	85	.55
25	5.0	.31	.21
26	5.0	.51	.33
27	5.0	44	.25
28	3.0	40	.26
Aver.*	105.0	450	.252

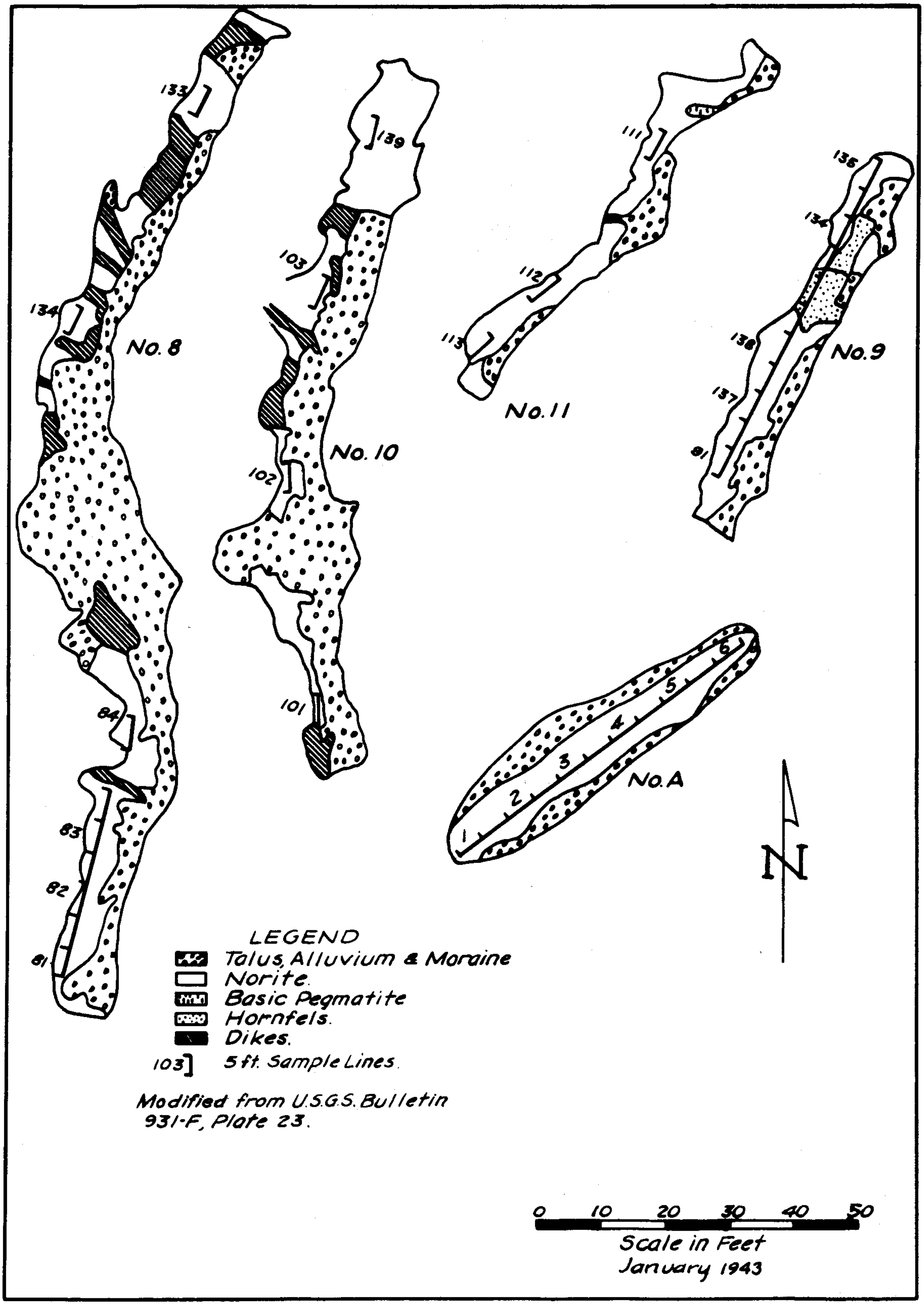
* Samples 7-11 incl. & 23 omitted.
Comp. #1-8 Shows no platinum metals by spectrographic analysis, and also no cobalt



Modified from Geological Survey map.

Scale in Feet
January 1943

Figure 18. - Tunnel ore body; geologic and assay plan, Bohemia tunnel.



Modified from U.S.G.S. Bulletin 931-F, Plate 23.

January 1943

Figure 19. - Tripod ore bodies; geologic and assay plan; pits 10, 11, 9, A, and 8.

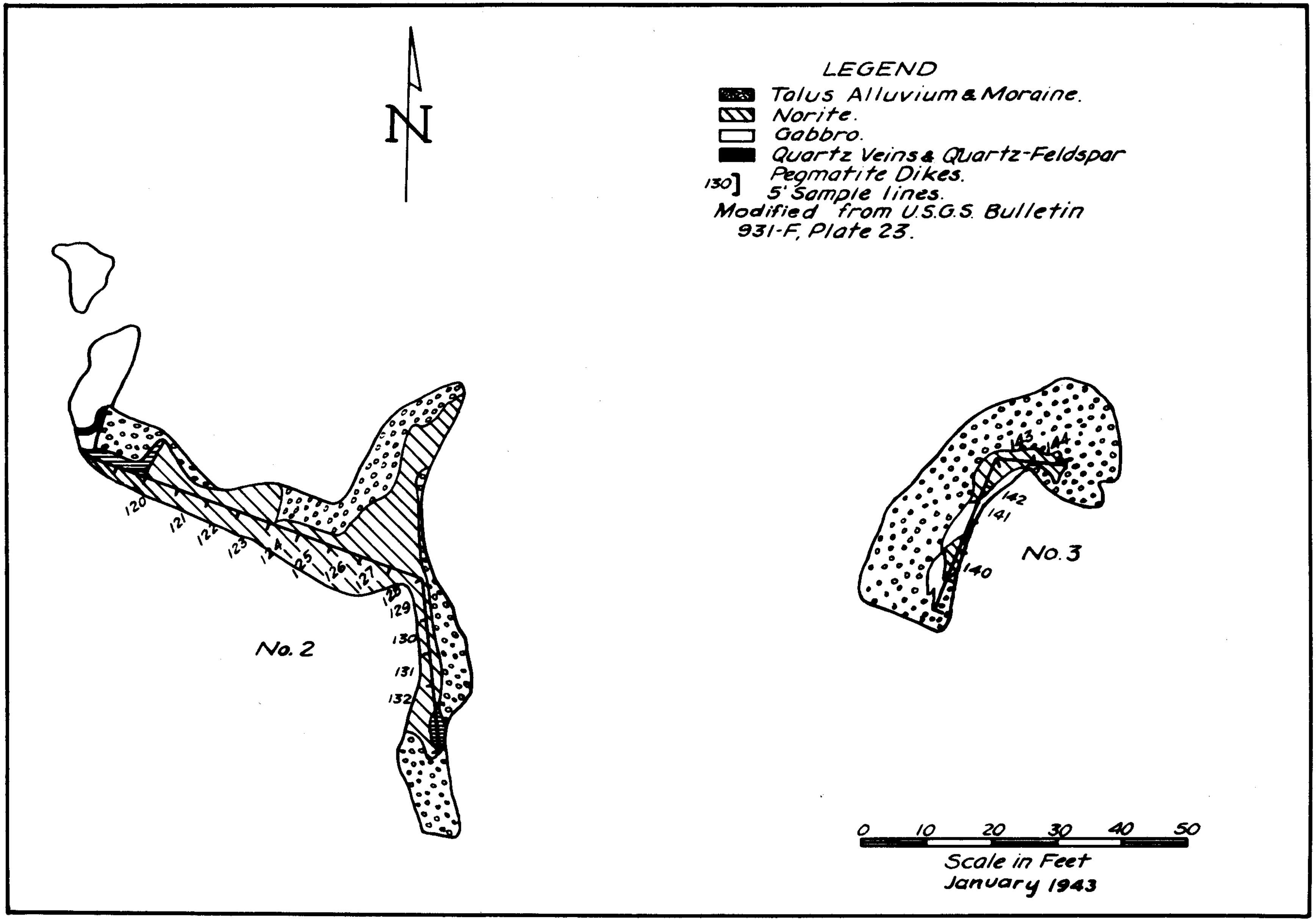


Figure 20. - North Muskeg ore body; geologic and assay plan, pits 2 and 3.

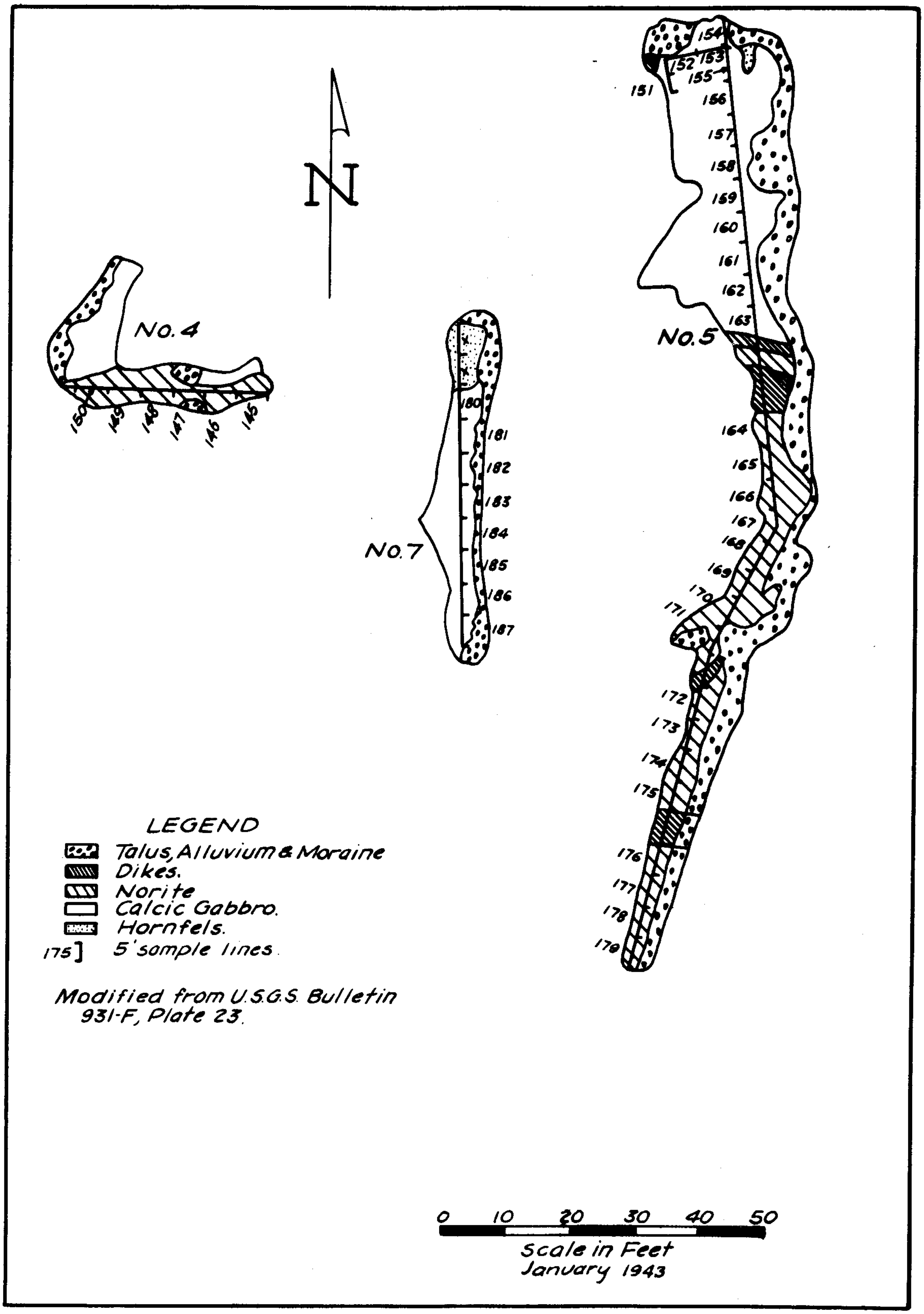


Figure 21. - South Muskeg ore body; geologic and assay plan, pits 4, 5, and 7.

TABLE 15. - Tripod ore-body; analysis of pit samples and 5-foot channel samples

Pit 8

Sample	Analysis, percent Ni	Analysis, percent Cu
81	0.52	0.45
82	1.00	.97
83	.46	.58
84	.68	.45
133	.26	.16
134	.38	.36
Av.	.550	.495

Pit 11

Sample	Analysis, percent Ni	Analysis, percent Cu
111	0.49	0.26
112	.62	.80
113	.67	.37
Av.	.593	.477

Pit 9

Sample	Analysis, percent Ni	Analysis, percent Cu
135	0.61	0.59
136	.62	.32
137	.45	.19
138	.29	.17
91	.95	.46
Av.	.584	.346

Pit A

Sample	Analysis, percent Ni	Analysis, percent Cu
1	0.65	0.76
2	.60	.52
3	.97	.74
4	.57	.28
5	.25	.22
6	.26	.10
Av.	.550	.436

Pit 10

Sample	Analysis, percent Ni	Analysis, percent Cu
101	0.42	0.17
102	.35	.39
103	.49	.26
139	.15	.14
Av.	.352	.240

Pits	8	9	10	11	"A"	Total
	Feet					
Exposed formation	138	64	100	70	55	427
Mineralized	100	55	75	48	55	333

Nickel average: $$\frac{100 \times 0.550 + 55 \times 0.584 + 75 \times 0.352 + 48 \times 0.593 + 55 \times 0.550}{427} =$$

0.403.

Copper average: $$\frac{100 \times 0.495 + 55 \times 0.346 + 75 \times 0.240 + 48 \times 0.477 + 55 \times 0.436}{427} =$$

0.312.

TABLE 16. - North Muskeg ore-body analysis of pit samples

5-foot chip samples

Pit 2

Sample	Analysis, percent	
	Ni	Cu
120	0.70	0.36
121	.81	.84
122	.76	.34
123	.42	.33
124	.33	.25
125	.29	.20
126	.47	.27
127	.25	.25
128	.64	.24
129	.66	.55
130	.26	.20
131	.62	.51
132	.59	.45
Av.	.523	.369

Pit 3

Sample	Analysis, percent	
	Ni	Cu
140	0.29	0.18
141	.15	.04
142	.18	.04
143	.37	.27
144	.75	.52
Av.	.348	.210

Pit	2	3	Total
Exposed formation	80 ft.	35 ft.	115 ft.
Mineralized	65 ft.	25 ft.	90 ft.

Nickel av. $\frac{65 \times 0.523 + 25 \times 0.348}{115} = 0.371.$

Copper av. $\frac{65 \times 0.369 + 25 \times 0.210}{115} = 0.254.$

TABLE 17. - South Muskeg ore-body analysis of pit samples

5-foot chip samples

	Analysis, percent	
Sample	Ni	Cu
145	0.26	0.40
146	.23	.50
147	.15	.28
148	.32	.27
149	.40	.38
150	.10	.08
Av.	.243	.318

	Analysis, percent	
Sample	Ni	Cu
151	0.17	0.24
152	.25	.40
153	.27	.30
154	.20	.25
155	.07	.15
156	.24	.20
157	.29	.25
158	.59	.36
159	.30	.52
160	.18	.41
161	.57	.57
162	.42	.27
163	.40	.33
164	.17	.29
165	.22	.37
166	.17	.24
167	.16	.23
168	.22	.30
169	.15	.19
170	.21	.14
171	.19	.16
172	.29	.20
173	.43	.33
174	.45	.58
175	.27	.35
176	.39	.62
177	.46	.49
178	.40	.46
179	.40	.34
Av.	.294	.329

	Analysis, percent	
Sample	Ni	Cu
180	0.48	0.45
181	.46	.27
182	.39	.24
183	.35	.15
184	.22	.15
185	.32	.17
186	.45	.24
187	.29	.19
Av.	.371	.232

Pits	4	5	7	Total
Exposed formation	34 ft.	165 ft.	50 ft.	249 ft.
Mineralized	30 ft.	145 ft.	40 ft.	215 ft.

Nickel av. $\frac{30 \times 0.243 + 145 \times 0.294 + 40 \times 0.371}{249} = 0.260.$

Copper av. $\frac{30 \times 0.318 + 145 \times 0.329 + 40 \times 0.232}{249} = 0.267.$

TABLE 18. - Tunnel ore-body tunnel channel samples

Sample	Sample length, ft.	Analysis, percent Ni	Cu
1	5.0	0.19	0.18
2	5.0	.87	.31
3	5.0	.56	.26
4	5.0	.85	.62
5	5.0	.77	.45
6	2.0	1.00	.75
7	5.0	.13	.10
8	5.0	.15	.09
9	5.0	.08	.06
10	5.0	.10	.07
11	2.7	.25	.14
12	5.0	.46	.19
13	5.0	.30	.10
14	5.0	.33	.25
15	5.0	.35	.18
16	5.0	.23	.12
17	5.0	.19	.08
18	5.0	.33	.14
19	5.0	.40	.17
20	5.0	.23	.10
21	5.0	.38	.20
22	5.0	.27	.15
	104.7	.368	.200

BENEFICIATION

The beneficiation test indicated that two treatment procedures would be satisfactory. One was the bulk flotation of a sulfide concentrate containing the nickel and copper that could be subsequently smelted to produce a nickel-copper matte. In the bulk flotation of this ore, 69.8 percent of the nickel and 84.4 percent of the copper were recovered. The other treatment was the selective flotation of both a copper and nickel concentrate. By this procedure a copper concentrate containing 78.3 percent of the copper was recovered, and subsequently a nickel concentrate was recovered that contained 68.1 percent of the nickel. The latter methods, however, would necessitate a more complex flow sheet. Typical tests using both procedures are reported herewith.

Bulk Flotation of Copper and Nickel

The ore used in the beneficiation tests was ground with an equivalent of 0.08 pounds of Minerec B (Denver Equipment Co., Denver, Colo.) for each ton of ore. The ground flotation feed was 57 percent minus 200-mesh. The conditioning reagents were 1.5 pounds of copper sulfate, 0.14 pound of pine oil, 0.20 pound of Z-3, and 0.20 pound of Z-6 for each ton of feed. (Z-3 and Z-6, also from Denver Equipment Co.) The conditioning time was 5 minutes and the flotation time 12 minutes. The pulp density used in conditioning was 50 percent solids, and the density in the flotation was about 25 percent solids. The pH in the roughing circuit was 7.8. The reagents used in the cleaner were 0.1 pound of sulfuric acid and 0.1 pound of sodium silicate for each ton of feed.

Metallurgical data

Product	Percent, weight	Analysis, percent				Recovery, percent			
		Ni	Cu	Insol.	Fe	Ni	Cu	Insol.	Fe
Bulk cleaner concentrate	4.8	4.82	3.5	38.6	29.2	69.8	84.4	2.2	48.4
Bulk cleaner tailing.	3.7	.98	.6	79.4	5.8	10.9	11.1	3.5	7.3
Bulk rougher tailing.	91.5	.07	.01	87.8	1.4	19.3	4.5	94.3	44.3
Calculated head	100.0	.33	.20	85.1	2.9	100.0	100.0	100.0	100.0

The concentration ratio was 21:1.

Differential Flotation of Copper and Nickel

The size of grind and the pulp dilution were the same as in the bulk-flotation tests. The other pertinent details of the test are:

Reagents and data

Grind		Ni conditioner		Cu conditioner		Ni cleaner		Cu cleaner	
lb./ton		lb./ton		lb./ton		lb./ton		lb.	
Lime	4.0	H_2SO_4	3.0	Z-3	0.03	H_2SO_4	0.25	H_2SO_4	0.25
Minerec B	0.04	$CuSO_4$	.5	Amyl alcohol	.10	Sodium silicate	.50	Sodium silicate	.50
		Z-6	.2	50 percent Solids		pH	7.6	pH	8.2
		Alcohol	.05	pH	11.2				
		pH	7.9						

Metallurgical data

Product	Percent, weight	Analysis, percent				Recovery, percent			
		Ni	Cu	Insol.	Fe	Ni	Cu	Insol.	Fe
Cu cleaner concentrate	0.7	0.08	20.21	28.4	22.5	0.3	78.3	0.2	5.7
Cu cleaner tailing.	1.1	.55	.62	82.2	4.6	2.0	3.9	1.0	1.8
Ni cleaner concentrate	2.8	7.39	.54	33.6	31.8	68.1	8.4	1.0	31.9
Ni cleaner tailing.	3.1	1.18	.25		8.3	12.2	4.4	2.7	9.3
Rougher tailing ...	92.3	.057	.01		1.6	17.4	5.0	95.1	51.3
Calculated head ...	100.0	.30	.18		2.8	100.0	100.0	100.0	100.0

Although the low head assay would not seem to warrant the more complex selective flotation treatment, its installation might be advised because of the fewer complications involved in the subsequent smelting and refining operations, to produce separate nickel and copper metals. These might also be produced commercially from the bulk flotation matte by a combined electrothermal and electrolytic process.[12]

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[12] Koster, J., and others, Recovery of Nickel, Copper, and Precious Metals from Domestic Ores by a Combined Electrothermal and Electrolytic method: Bureau of Mines Rept. of Investigations 3483, 1939, 28 pp.

A proposed bulk-flotation flow sheet is shown in figure 22.

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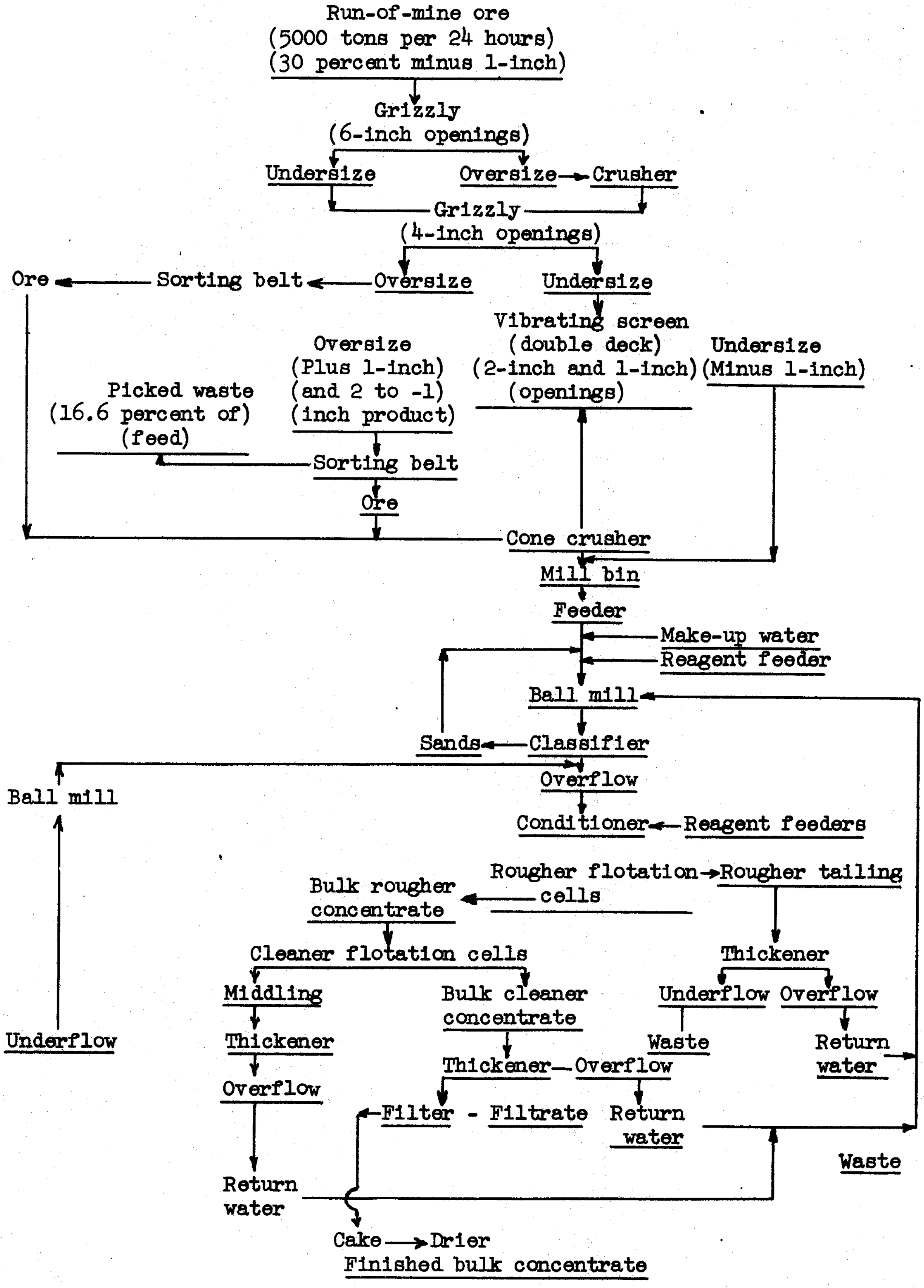

Figure 22. - Proposed bulk flotation flow sheet for Yakobi mill.