UNITED STATES
DEPARTMENT OF THE INTERIOR
Geological Survey
Washington

THE GEOLOGY AND NICKEL-COPPER DEPOSITS OF YAKOBI ISLAND, SOUTHEASTERN ALASKA

by George C. Kennedy and Matt S. Walton, Jr.

INTRODUCTION

This report briefly describes the nickel-copper deposits of Yakobi Island, southeastern Alaska, as well as the general geology of the island. It also interprets and summarizes the geological data obtained during drilling tests in 1941 and 1942 by the Bureau of Mines and magnetometer exploration in 1943 by the Geological Survey of the nickel-copper deposits. These deposits have been described by Reed and Dorr 1/ and much detail has been omitted from this report, as it is available in their bulletin.

Geography

Yakobi Island is a small island off the northwest corner of Chichagof Island, at latitude 58° N. and longitude 136° W. (see fig. 1). The island is about 18 miles long and 10 miles wide at its widest part. It is bounded by Lisianski Strait on the east and by the Pacific Ocean on the west. The nearest settlement, Pelican, which contains a cold storage plant, general store and post office, is about five miles east of Yakobi island on the northeast side of Lisianski Inlet.

The nickel-copper deposits of Yakobi island are a short distance east of the geographic center of the island. They are about 2 miles from tidewater near the head of Bohemia Basin, the local name for the open valley of Bohemia Creek. The deposits are relatively accessible as Lisianski Strait and Inlet have protected anchorages for boats of any tonnage and the deposits can be easily reached from the beach by way of the valley of Bohemia Creek. There is at present no regular means of transportation to Yakobi Island, but it can be reached by small boat from Juneau, 130 miles by water to the east, or from Sitka, 80 miles to the south.

The climate is, in general, mild with temperatures rarely lower than 15° F. or higher than 70° F. Precipitation is heavy, principally in the form of rain. At Sitka the mean annual temperature is approximately 44° and the average annual precipitation about 86 inches.

1/ Reed, J.C. and Dorr, J.V.N. 2nd, Nickel deposits of Bohemia Basin and vicinity, Yakobi Island, Alaska: U. S. Geol. Survey Bull. 931-F. 1942.

Yakobi Island consists of two topographic belts, a coastal belt and a mountainous belt (see fig. 2).

The coastal belt is on the west side of the island and is from 1 to 4 miles wide. It has a maximum relief of about 400 feet. Eastward the mountains rise abruptly from the coastal belt and reach altitudes of more than 2000 feet.

Field Work

The nickel-copper deposits of Bohemia Basin were studies during the summer of 1940 by John C. Reed and J. V. N. Dorr, 2d. of the Geological Survey. Their results, with detailed geologic and topographic maps, were called to the attention of the Bureau of Mines, and have been the basis for subsequent work by both the Geological Survey and the Bureau of Mines.

Diamond drilling of the Bohemia Basin deposits by the Bureau of Mines began in November 1941, but after the completion of two holes, was interrupted by inclement weather. Drilling was resumed in May 1942, and the project was completed the following August.

During the latter part of the drilling in the fall of 1941, and until late June 1942, George O. Gates represented the Geological Survey on the project. During July and August 1942, George C. Kennedy visited the project for 2 or 3 days each week. These men gave such assistance as comes within the field of the Geological Survey, including logging of the cores, making of visual estimates of the grade of material in the cores, marking of the units of core to be sampled and advising as to the location and length of holes.

During the summer of 1942 a Geological Survey field party, consisting of George C. Kennedy and R. E. L. Rutledge mapped the western portion of Yakobi Island in the hope of finding sulfide-bearing deposits in addition to those described by Reed and Dorr. 2/

Late in June 1943, Matt S. Walton, Jr. and George C. Kennedy spent a week in the Bohemia Basin tracing a sulfide-bearing body under covered areas by means of a magnetometer survey. At this time eight traverses were made with an Askania vertical-intensity magnetometer.

GEOLOGY

Regional geology

The oldest rocks on Yakobi Island consist of a thick sequence of pre-Triassic (?) greenstone, believed to be originally basalt flows, with some intercalated graywacke (see fig. 2). The greenstone occupies the northeastern part of

2/ Reed, J.C., and Dorr, J.V.N. 2d., op. cit.,

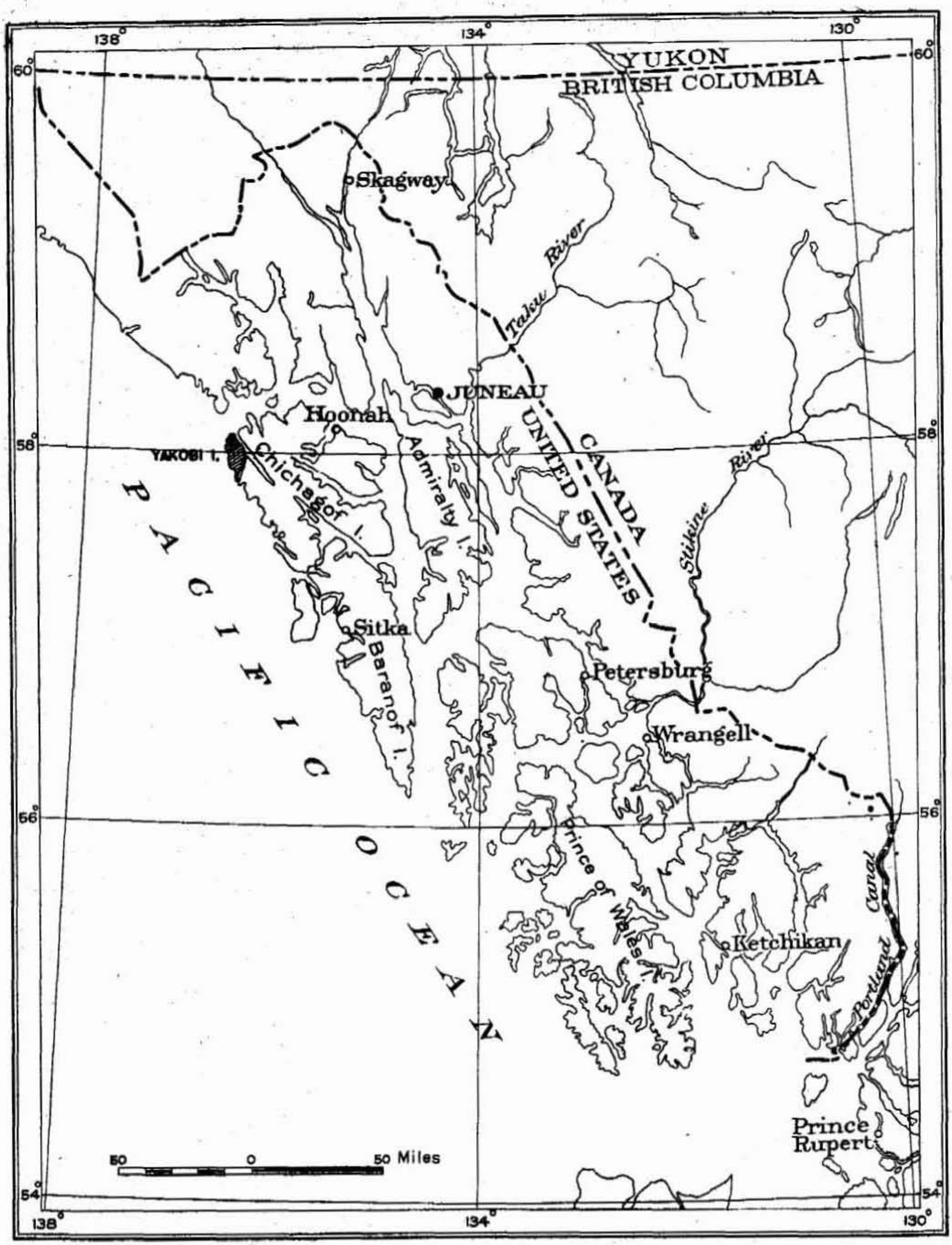

FIGURE I.-- INDEX MAP SHOWING LOCATION OF YAKOBI ISLAND, SOUTHEASTERN ALASKA

37082

Yakobi Island. The greenstone has been tentatively correlated with the greenstone schist mapped by Reed and Coats 3/ in the Chichagof mining district. This correlation is based on lithology and structural relations.

Overlying the greenstone are Triassic (?) rocks, which form an almost continuous belt 1 to 2 miles wide extending for about 13 miles through the island. The Triassic (?) sequence is composed of graphitic schist, greenstone, graywacke, chert and limestone. In general the amount of volcanic material in these rocks increases from south to north and the lower strata contain more volcanic material than do the upper. A few lenses of limestone extend for short distances.

The southern portion of Yakobi Island adjoining Lisianski Strait is underlain by Cretaceous (?) graywacke. The graywacke is made up largely of clastic sedimentary material with considerable amounts of volcanic material. The graywacke is metamorphosed over much of its extent to biotite-quartz schist. Included volcanic material has been metamorphosed to amphibole schist and amphibole-epidote-chlorite schist.

The stratified rocks strike northwesterly and dip steeply eastward. The steep eastward dips suggest that the beds have been isoclinally folded and overturned.

In Cretaceous (?) time plutonic rocks intruded the stratified rocks. These plutonic rocks are believed to be related to the Coast Range batholith. Igneous invasion was accompanied, and followed by metamorphism and shearing of both the stratified and plutonic rocks. The intrusive rocks were altered to albite granite gneiss and to amphibole gneiss. The amphibole gneiss has been included in the map unit with the albite granite gneiss (see fig. 2). There is some evidence that much of the amphibole gneiss is metamorphosed greenstone.

Most of central and western Yakobi Island is occupied by a large composite stock. This stock is unfoliated and was intruded after metamorphism. The rocks of the stock have been separated into a quartz diorite group and a gabbro group.

The rocks of the quartz diorite group range from granite to diorite, though most of the rocks are biotite-quartz diorite and hornblende-quartz diorite. The percentage of dark minerals in these rocks ranges widely and abruptly. Darker phases of the quartz diorite are cut by lighter phases.

Available evidence indicates that the stock was emplaced quiescently. The field relations and a study of thin sections indicate that much of the quartz diorite, at least around the margins of the stock, was formed by granitization, or some related process. Contacts are gradational, and igneous textures have, in many places, developed in the stratified rocks surrounding the quartz diorite. Near the margins of the stock much of the diorite contains numerous inclusions. These inclusions are partially digested sedimentary and volcanic rocks, and locally constitute more than half of the mass. The stratification of many inclusions is parallel to relict stratification structures in the quarts diorite and the inclusions are apparently patches of partially granitized stratified rocks surrounded by more completely granitized material. Other inclusions are randomly oriented.

3/ Reed, J.C., and Coats, R.R., Geology and ore deposits of the Chichagof mining district, Alaska: U. S. Geol. Survey Bull. 929, 1941.

The rocks of the gabbro group range in composition from gabbro to norite and pyroxenite. Norite, though it constitutes a relatively small proportion of the rocks of this group, contains all the known nickel-copper deposits on the island.

Geology of Bohemia Basin

The largest known nickel-copper deposits on Yakobi Island and the most intensively prospected bodies are in Bohemia Basin.

These deposits are in a norite body of elliptical outcrop, part of the much larger composite stock (see fig. 3). Around the western part of the norite body, gabbro is in contact with norite, whereas, around the eastern part, amphibole schist and quartz diorite bound the norite. The norite has altered the amphibole schist to hornfels for a short distance away from the contact.

The norite ranges widely in texture and proportions of constituent minerals. Within a few feet, the rock ranges from fine- to coarse-grained, and the feldspar content from about 70 percent to almost none. Actually the unit mapped as norite includes not only norite but some gabbro, amphibolite, hypersthenite, and basic pegmatite. These rocks are gradational local differentiates of the norite and show no systematic arrangement within the norite body.

Inclusions of hornfels as much as 100 feet thick are present within the norite mass. Some evidence indicates that they tend to be oriented parallel to the contacts of the norite.

The norite is cut by numerous fine-grained andesitic dikes as much as 30 feet thick. Swarms of dikes locally cut the norite, and, over some areas of a few hundred feet square, may quantitatively exceed the norite.

NICKEL-COPPER DEPOSITS

History

The nickel-copper deposits of Bohemia Basin are reported to have been discovered in 1921 by S.H.P. Vevelstad. The first claims were staked in that year, and additional claims have been staked from time to time since then. The bodies called the North Takanis and the South Takanis are believed to be included in the Mayflower and Portia group of claims, and the North Muskeg, South Muskeg, Side Hill, Tunnel, East Tripod and West Tripod bodies are believed to be included in the Yakobi, formerly the Bohemia, group of claims. There are probably more than a hundred claims in the district. The ownership of the claims is very involved and some controversies are understood to have arisen as to titles and options on some of the claims. At an early date a tunnel was started in the Tunnel body. This has been lengthened from time to time until in 1943 it was 166 feet long.

No ore has been shipped from the district.

General features

The nickel-copper deposits of Bohemia Basin are sulfide-bearing portions of norite masses. The explored bodies lie in two main groups. One of these, the Takanis group, includes the North Takanis and the South Takanis bodies. The other group of bodies (see fig. 3) includes the Tunnel, East and West Tripod, North and South Muskeg and Side Hill bodies. Deposits of this group have been explored by diamond drilling and magnetometer prospecting. These deposits are in the western part of Bohemia Basin in an area about 1,800 feet long in an east-west direction and about 1,200 feet wide in a north-south direction. The western portion of this area, which embraces a small valley where the drilling was concentrated and where the greatest reserves of mineralized material are indicated, contains the East Tripod, the West Tripod and the Tunnel bodies. These bodies, actually believed to be part of a single deposit, crop out around this small valley.

Richer concentrations of sulfide minerals cannot be correlated with any particular unit of the norite group. Amphibolitic, gabbroic and other types are all locally as mineralized as the more typical norite. Coarse-grained basic pegmatite is the only member of the group in which no appreciable quantities of sulfide minerals have been found.

Mineralogy

The only metallic minerals present in appreciable quantities within these deposits are pyrrhotite, pentlandite, chalcopyrite and magnetite. Although Buddington 4/ reports small amounts of bravoite, ((Fe, Ni) S_2), all significant quantities of nickel are believed to be in pentlandite.

An average of 4.6 percent of sulfides by weight was contained in 61 samples collected by Reed and Dorr 5/. Of this, 48 percent was pyrrhotite, 35 percent was pentlandite, and 17 percent was chalcopyrite. These data are believed to be representative of the entire district.

The sulfide minerals form small blebs erratically distributed within the norite. Abrupt changes in the percentage of sulfide minerals in the bodies are typical.

Structure of the deposits

The known nickel-copper deposits of Yakobi Island lie near the margins of norite bodies, and appear to parallel those margins. The deposits in Bohemia Basin which have been explored by diamond drilling and magnetometer prospecting (see fig. 3 and 7) are marginal portions of a norite mass of elliptical outcrop.

4/ Buddington, A.F., op. cit. pp. 103-105, 1925.

5/ Reed, J.C., and Dorr, J.V.N. 2nd, op. cit., p. 119, 1942.

The evidence from drill cores and from magnetometer prospecting, though not conclusive, indicates that the bottom of the norite mass is basin-shaped, that the deposits, dip inward toward a common center at angles ranging from 45 to 70 degrees. Essentially all of the sulfide-bearing norite lies within 250 feet of the norite contact. This norite body is underlain by gabbro and amphibole schist, and is believed to be a later differentiate from the magma of the composite stock rather than the underlying gabbro.

In the western part of the norite body the deposits appear to form a blanket, 100 feet to 200 feet thick, above the base of the norite body with as much as 40 feet of barren norite between the mineralized norite and the underlying gabbro.

Origin of the deposits

The available evidence indicates that these deposits were formed by late-magmatic separation of immiscible sulfide droplets from a cooling norite magma. The sulfide droplets were concentrated by gravity in the lower parts of the norite.

Such an origin is similar to that inferred for deposits at the base of noritic and gabbroic bodies elsewhere.

Separation of the sulfide droplets from the norite magma is believed to have taken place so late in the consolidation period of the norite that most of the silicate minerals had crystallized. The sulfide droplets apparently separated from the residual magma and influenced by gravity, migrated downward through the interstices between the crystals of the largely consolidated norite until the droplets of sulfide became trapped in the lower parts of the body. The sulfide minerals did not entirely crystallize until after the norite had consolidated sufficiently to permit a little fracturing to take place. These late fractures, in both the norite and adjacent rocks, are commonly filled with sulfide minerals.

The sulfide content of the sulfide-bearing portions of the norite ranges widely and abruptly. The differences in grade may perhaps be due to differences from place to place in the permeability of the norite, which is a function of grain size, degree of consolidation, and other factors at the time when the sulfide droplets were settling out from the ov-rlying norite. The sulfides would accumulate in that norite, which, during the period of sulfide-separation and settling had a permeability great enough to permit the sulfide drops to enter the lower layers of the partly crystallized norite, but not great enough to permit most of them to pass through into the norite below.

Descriptions of sulfide-bearing bodies

Tunnel and Tripod bodies: The East and West Tripod bodies are believed to be outcropping parts of one limb, and the Tunnel body of the other limb, of a single trough-shaped deposit of mineralized norite, which plunges northeasterly (see fig. 4). Not enough diamond drilling has been done to prove conclusively that the two limbs join at depth or that the trough is complete, with no barren gaps between the bodies.

The outcrop and drill holes 4 and 4-A, indicate that the West Tripod body dips southeasterly at about 65 degrees. Drill holes in the Tunnel body show that it dips northeasterly at about 45 degrees. Drill holes which were directed to intersect the inferred synclinal structure near the bottom of the trough indicate that the bottom of the trough plunges northeasterly at about 35 degrees.

Barren dikes and hornfels inclusions locally constitute a large proportion of these bodies. Drill hole 4a, in the West Tripod body, (see figs. 3 and 6), passed through a dike swarm which amounted to 60 percent of the material encountered within the sulfide zone. Hornfels inclusions generally constitute less than 10 percent of a drill core from the mineralized zone. However 150 feet of drill hole 2 in the Tunnel body, (see figs. 3 and 5) was in hornfels and only a fraction of the nickeliferous material expected was penetrated by this hole.

Muskeg and Side Hill bodies: In the eastern portion of the norite body, where exposures are relatively scarce and where only three holes have been drilled, the continuity of a sulfide-bearing zone above the base of the norite, here underlain by hornfels, is inferred largely from magnetic data.

The results of the magnetometer traverses are plotted graphically on the cross sections along the traverse lines as shown on figure 7. The corrected magnetic values are listed in the following table.

Table I - Vertical intensity anomalies in gammas
(regional intensity approximate)

Station No.	Traverse							
	1	2	3	4	5	6	7	8
1	-33	46	10	45	39	24	28	69
2	5	90	51	44	58	162	17	135
3	-53	63	74	120	378	392	213	240
4	-35	78	102	136	354	12	546	262
5	-91	161	178	-5	81	24	190	164
6	-11	233	29	-32	34		-130	155
7	-35	117			-44		-9	167
8		0					-9	185
9								80
10								184
11								164
12								181

The readings show that rocks which contain pyrrhotite affect the local vertical magnetic intensity more than do rocks that are pyrrhotite free.

Traverses 2 to 7 inclusive strongly indicate that the sulfide-bearing zone is a continuous body in the area between these traverses, for in each of the traverses a significant increase in vertical intensity was recorded along a trend compatible with available geologic information on the probable structure and position of the sulfide zone and the norite mass.

The magnetic profile along traverse 1 shows only minor fluctuations and those not in alignment with the trend shown by the other traverses. All but one of the readings along traverse 1 are approximate regional values of vertical intensity. The sulfide-bearing zone apparently is not present beneath this traverse. The traverse indicates that the sulfide zone of the Muskeg bodies is not continuous with the East Tripod body. The trend established by traverses 2, 3 and 4 suggests that the zone of the Muskeg bodies passes north of traverse 1. It cannot extend much farther west, however, as it is not present in the well exposed area north of the area shown in figure 7. An offset, therefore, is indicated between the zone of the Muskeg bodies and that of the East Tripod body. Whether or not this offset is caused by faulting or is an original discontinuity is not known.

Traverse 8 indicates that the Muskeg bodies are not connected with the Side Hill body. The values along this traverse are all higher than the assumed regional value of vertical intensity. The norite between the Tunnel and Side Hill bodies contains appreciable pyrrhotite but too little to designate it a sulfide-bearing body. The high vertical intensity values along traverse 8, although inconclusive, suggest that the zone of the Muskeg bodies may widen and merge with the zone of sparsely disseminated pyrrhotite just mentioned.

An inward, westerly dip of about 75 degrees for the North Muskeg body and about 45 degrees for the South Muskeg body as exposed had already been indicated by one drill hole in each and by the inferred position of the contacts at the surface.

The magnetic profiles, except 1 and 8, show not only the continuity and extension of the Muskeg deposit but also an abrupt change in vertical intensity near the outer ends of the profiles away from the norite mass and a more gradual change inward. Thus the profiles are consistent with a general inward dip of the whole body unless the norite itself has a higher magnetic susceptibility than the surrounding rocks.

The magnetic traverses, the outcrops, and 2 drill holes fix the position of the outer (lower) contact of the body within fairly narrow limits. The inner contact of the sulfide zone cannot be placed as closely because the profiles show a relatively gradual change in magnetic intensities over the inner contact of the zone. The width of outcrop of the sulfide body as inferred from the magnetic profiles is sketched on figure 7.

The thickness of the zone at the North Muskeg body from drill hole 7a and from the magnetic data is calculated to be about 80 feet. Similarly the zone at the South Muskeg body is calculated to be about 100 feet. The zone northwesterly from the North Muskeg body is, from the magnetic data, about as wide as at the North Muskeg body.

Assuming that the susceptibility of the barren norite and the surrounding rocks are approximately similar, and knowing that the deposit dips inward, the fact that the relatively abrupt change in magnetic intensity is on the outward end of magnetic profiles 2 to 7 indicates that the deposit is substantially greater in vertical extent than its width on the surface. The two drill holes in the Muskeg bodies prove that the deposit, at those two places, extends down the dip at least 180 feet.

The fact that the magnetic intensity changes so abruptly near the inferred contact of the sulfide-bearing zone indicates that the cover of moraine and muskeg over the deposit is not more than a few tens of feet thick. If the deposit were buried by a much greater thickness of cover the magnetic effects of the deposit would be dampened and the abrupt change in magnetic intensities as revealed by the profiles would not be present.

Takanis bodies

The Takanis bodies have not been explored by diamond-drill holes or magnetometer prospecting, although their surface features have been described by Reed and Dorr 6/. For the most part, these bodies are marginal to a norite mass, and it is believed that exploration might reveal structural relationships analagous to those described at the Tunnel, Tripod, Side Hill and Muskeg bodies.

Other bodies

At least six other unprospected bodies of sulfide- bearing norite are present on Yakobi Island. Four of these have been described by Reed and Dorr 7/ and no additional information about these deposits is available.

Sulfide-bearing norite was observed at two localities in the western part of Yakobi Island. These localities are marked A and B on the accompanying geologic map (see fig. 2). At both of these places rock exposures are poor, and the size of the deposits could not be estimated.

Reserves

On the basis of surface sampling and mapping of outcrops, Reed and Dorr estimated for the entire district 5,800,000 tons of sulfide-bearing material with a nickel content of 0.36 percent and a copper content of 0.27 percent. The prediction was made that further development and exploration would probably increase

---

6/ Reed, J.C., and Dorr, J.V.N. 2d., op. cit., pp. 125 and pl. 22, 1942.

7/ Reed, J.C., and Dorr, J.V.N. 2d., op. cit., pp. 125-126, 1942.

the estimated tonnage in these bodies, but that there was no reason to believe that any additional tonnage would have a metallic content of a different order of magnitude from the material they sampled. This prediction has been found correct.

Tripod and Tunnel bodies

Grade: Analyses for nickel and copper were made by the Bureau of Mines of the diamond-drill cores. The lengths to be analyzed were selected by the Geological Survey but when these lengths exceeded 5 feet the Bureau of Mines divided the lengths into 5-foot segments. The analyses were furnished the Geological Survey and, averaged by holes, provided the data for table 2. In table 2, the data in columns 2 through 5 refer to the sulfide-bearing deposit as a whole, whereas the data in columns 6 through 9 refers to the richer parts only. The data from two holes in the Muskeg deposit, 7a and 13, are included in this table. These holes are discussed in the section on reserves in the Muskeg deposit.

For locations of the drill holes see figure 3. Column 2, the lengths of the holes in the sulfide-bearing deposit, shows the distances between the place where material with significant sulfide minerals was first encountered and the last place where material with significant sulfide minerals was cut.

Low-grade material and small local concentrations of sulfide minerals border the mineralized body, and the determination of its exact limits is therefore largely arbitrary. Generally material with a nickel content of less than 0.15 percent has been considered to lie outside the deposit.

In calculations of grade and determination of the length of each hole in the sulfide-bearing deposit, barren norite, dikes, and hornfels inclusions, lying within the deposit have been calculated as parts of the deposit. These barren zones decrease the average grade and increase the total tonnage of material within the deposit. Smaller tonnages of higher grade material would be available if the barren zones within the deposit were eliminated.

Calculations of tenor of material for each drill hole have been made (columns 8 and 9) on the arbitrary assumption that barren zones, here generally considered as zones containing less than 0.25 percent of nickel, within the deposit 10 feet or more thick would be excluded and that sulfide-bearing masses 10 feet or more thick would be included, in mining. The exclusion of barren material in layers more than 10 feet thick decreases the lengths of the drill holes in the deposit as shown by the comparison of the data in column 6 with the data in column 2.

The average nickel content of the deposits as calculated from the data cited in the table is 0.37 percent and is remarkably similar to the average as calculated by Reed and Dorr 8/ from analyses made by R. C. Wells, F. S. Grimaldi, J. G. Fairchild, J. M. Axelrod, M. Fleischer, and K. J. Murata of the Geological Survey (0.36 percent). However, the copper content as indicated by different groups of analyses ranges widely and most of these differences appear to be due to differences in analytical method of technique. The nickel content of the deposits,

---

8/ Reed, J.C., and Dorr, J.V.N., 2nd., op. cit., p. 129.

Table 2 - Data from diamond - drill holes in Bohemia Basin nickel-bearing deposits.

Hole	Length in feet of hole in sulfide-bearing body	From - To (feet from collar)	Percent of nickel	Percent of copper	Length in feet of hole in body, barren material excluded	From - To (feet from collar)	Percent of nickel, barren material excluded	Percent of copper, barren material excluded
1	122.5	29-151.5	.337	.202	87	29-44	.392	.212
						58-130		
1-A	133	65-198	.466	.202	123	65-188	.501	.214
2	93	196-289	.188	.105	22	198-209	.395	.235
						227-238		
4	125	66-191	.413	.205	68	102-146	.700	.348
						158-168		
						177-191		
*4-A	216	82-305	.216	.139	97	82-126	.422	.266
						225-265		
						292-305		
7-A	171	119-90	.230	.145	65	136-186	.353	.221
						275-290		
10								
11	116	74-190	.482	.208	66	74-140	.700	.265
11-A	194	40-234	.415	.334	91	40-85	.875	.710
						95-131		
						161-172		
12	336	54-390	.288	.149	147	70-98	.516	.247
						138-165		
						255-347		
13	127	10-137	.385	.166	68	10-50	.610	.212
						109-137		
14	107	116-222	.348	.171	107	116-222	.348	.171
15	104	277-381	.125	.087				
16	125	283-408	.245	.114				
17	100	383-483						

* For reserve calculations hole 4-A was assigned relatively little weight as it intersects a zone of dikes, not believed to be representative of the body.

therefore, seems much better established than the copper content. The average copper content of the deposits as calculated by Reed and Dorr is 0.27 percent whereas, calculated from the Bureau of Mines data, as given in the table, is 0.20 percent. Analyses by the Territorial Assay Office 9/ in Ketchikan of 90 feet of channel samples cut in the tunnel in the Tunnel Body indicate an average of 0.63 percent of nickel and 1.21 percent of copper. Samples cut in the same tunnel and in essentially the same places, by Reed and Dorr show an average of 0.52 percent of nickel and 0.30 percent of copper. Analyses of core from a drill hole parallel to and only a few feet from the tunnel indicate an average nickel content of 0.50 percent and a copper content of 0.214 percent.

The Geological Survey samples, cut by Reed and Dorr, except those taken from the tunnel, were taken from the surface. The difference between the average copper content as determined from the Geological Survey analyses and as determined from the Bureau of Mines analyses possibly reflects a small amount of secondary enrichment of copper, although no secondary copper minerals were seen. That there has been appreciable leaching of nickel appears doubtful because analyses of fresh core material show almost the same nickel content as analyses of material from surface cuts. Furthermore, the area has been so recently glaciated that striae are abundant and fresh sulfides are common on natural exposures.

Tonnage: The number of tons of mineralized norite present in each limb of the trough-shaped deposit has been estimated. The deposit has been arbitrarily limited on the east by a vertical plane connecting the most easterly exposures of the East Tripod and the Tunnel bodies. (See figure 3). On the west the deposit is similarly limited by a plane connecting the most westerly exposures of the West Tripod and the Tunnel bodies.

Drill holes 15, 16, and 17 (see figs. 5 and 6) show diminished nickel content immediately east of the eastern limiting plane. There is no drill data for the part of the body lying west of the western plane, but a few exposures indicate that the body probably continues little, if any, west of the plane.

The tonnage of sulfide-bearing material which is known completely enough to be called measurable is relatively so small that it is not estimated here. The sulfide-bearing material in the trough between the outcrops of the Tunnel body and the Tripod bodies, and limited by the arbitrary bounding planes is classed as indicated material.

The outcrop length of each of the two limbs of the deposit was determined by direct measurements from the map and it was assumed that each of these lengths is the average for the corresponding limb, although this is only approximately true, (see fig. 3). Each of the two limbs of the deposit was projected beyond the drill information to the inferred bottom of the trough where the limbs meet, and the average distance down the dip determined from the projections.

The average thickness of the body, within the limiting planes, was determined geometrically from drill and some outcrop information. In the following calculations, two average thicknesses for each limb were used - one including

9/ East, J. H., Jr., Interim Report, Bohemia Basin nickel deposit, Yakobi Island, Alaska: U. S. Dept. of the Interior, Bureau of Mines, 1942.

dikes, hornfels inclusions, and barren norite (see table 2, col. 2), the other including only the richer material (see table 2, col. 6). In all tonnage calculations the specific gravity of the material is assumed to be 3.

The grade data from each hole have been weighted according to the approximate proportional part of the limb of the body the hole represents.

Table 3 – Tonnage and grade of material in the Tunnel and Tripod bodies, Bohemia Basin.

Barren and low-grade material included.

East and West Tripod bodies

(north limb of trough)

Average thickness	124 feet
Outcrop length	700 "
Average distance down dip	510 "
Tons of material	4,400,000
Average grade	0.38 percent of nickel
	0.19 percent of copper

Tunnel body

(south limb of trough)

Average thickness	147 feet
Outcrop length	570 "
Average distance down dip	760 "
Tons of material	5,900,000
Average grade	0.37 percent of nickel
	0.21 percent of copper

Barren and low-grade material excluded

East and West Tripod bodies

(north limb of trough)

Average thickness	88 feet
Outcrop length	700 "
Average distance down dip	510 "
Tons of material	2,900,000
Average grade	0.44 percent of nickel
	0.23 percent of copper

Tunnel body

(south limb of trough)

Average thickness	90 feet
Outcrop length	570 "
Average distance down dip	760 "
Tons of material	3,600,000 -
Average grade	0.57 percent of nickel
	0.31 percent of copper

The total tonnage of sulfide-bearing norite in this trough-shaped deposit, from the above data, is 10,300,000 tons of indicated material with an average grade of approximately 0.37 percent of nickel and 0.20 percent of copper, or 6,500,000 tons of material with a grade of 0.51 percent of nickel and 0.27 percent of copper.

The lengths of holes in the bodies as shown in columns 2 and 6 of table 2, and the lengths within the limits of the deposit as shown in figures 5 and 6 do not in every case agree. The sulfide content of the core alone determines the lengths recorded in columns 2 and 6, of table 2 whereas geologic information is used in determining the generalized limits of the deposit as recorded in figures 3, 5, and 6.

Muskeg and Side Hill bodies

Grade: The Muskeg bodies have been tested by both diamond-drill holes and channel samples 10/ in the Muskeg and Side Hill bodies, aggregating 399 feet, indicate an average grade of 0.25 percent of nickel and 0.25 percent of copper. Drill cores, holes 7a and 13 (see table 2) in the Muskeg deposits aggregate 298 feet and indicated an average grade of 0.293 percent of nickel and 0.154 percent of copper. The analyses of nickel from the channel samples and from the drill cores are comparable, but it is difficult to explain the wide differences in the copper analyses. The highest grade material encountered in the entire drilling program was in hole 13 in the South Muskeg body where a 6.5-foot length of core contained 3.08 percent of nickel and 0.9 percent of copper.

The magnetic data used in this report do not, in themselves, yield information on the nickel-copper content of the deposit. Observed anomalies, where the deposit is not exposed, appear consistent with those where the deposit is exposed and with the theoretical anomaly calculated on the basis of an average pyrrhotite content for all of the deposit of 2.2 percent and on simplified assumptions of its shape and extent based on geology.

The ratio of the sulfide minerals, pentlandite, chalcopyrite, and pyrrhotite, is remarkably constant. Therefore, the grade of material indicated solely by magnetometer traverses is presumed to be comparable to that indicated in the better known parts of the deposit by analyses of drill cores and channel samples.

10/ Reed, J. C., and Dorr, J.V.N. 2d., op. cit.

Tonnage: Information obtained from the magnetic observations and from the few exposures of the Muskeg deposit indicates a band of sulfide-bearing norite continuous for about 1500 feet, from the western-most exposure of sulfide-bearing material in the Side Hill body to a point half way between traverses one and two, arbitrarily assumed to be the northwestern limit of the Muskeg deposit. The assumption is made, in this estimate of length of the outcrop of the deposit, that the high magnetic anomalies observed along traverse eight, between the Side Hill body and the South Muskeg body indicates a local area of sparsely distributed sulfide minerals connecting the two bodies, and not an actual discontinuity in the deposit. Tonnage estimates have been reduced by 10 percent as an allowance for this and presumably other low-grade or barren parts of the deposit. Data obtained from surface exposures, diamond-drill holes, and the magnetometer traverses indicate that the average thickness of the deposit is about 80 feet. No evidence is available concerning the maximum dip length of the deposit. For purposes of tonnage calculations a dip length of 750 feet, one-half the strike length of the deposit, has been assumed.

There are thus approximately 8,100,000 tons of sulfide-bearing material in the Muskeg deposit (includes the Muskeg and Side Hill bodies).

Takanis bodies

Reed and Dorr 11/ have estimated 2,400,000 tons of sulfide-bearing material in the Takanis bodies. These bodies have not been drilled by the Bureau of Mines or explored by any geophysical method and no revisions of these earlier estimates are possible. By analogy with the deposits described, additional exploration might well greatly increase this estimated tonnage.

Summary of reserves

In summary, the present estimate of the amount of sulfide-bearing material available on Yakobi Island, principally in Bohemia Basin, is 10,300,000 tons of indicated material in the Tunnel and Tripod bodies, 8,100,000 tons of inferred material in the Muskeg and Side Hill bodies, and 2,400,000 tons of indicated material in the Takanis bodies a total of 20,700,000 tons. The average grade is about 0.33 percent of nickel and 0.21 percent of copper. Approximately 35 percent of the material included in these estimates of tonnage is probably virtually barren, and, if excluded by some process of selective mining, the grade would be increased to about 0.45 percent of nickel and 0.28 percent of copper.

Certain features of these deposits should be emphasized as they would affect any scheme of mining.

The deposits are large. Rough calculations indicate that the removal of approximately 4,000,000 tons of barren norite and overburden from the trough above the western portion of the deposit would expose about 9,000,000 tons of the 10,300,000 tons of indicated sulfide-bearing material.

11/ Reed, J. C., and Dorr, J.V.N., 2nd., op. cit., p. 129.

A few small, high-grade bodies of material were encountered in the drilling with a nickel content up to as much as 3.08 percent. However, these high-grade bodies have no known regularity and cannot be projected from one drill hole to the next.

Other factors pertaining to the general economies of exploitation and operation have been discussed by Reed and Dorr 12/.

RECOMMENDATIONS FOR FURTHER EXPLORATION

Enough exploratory work has been done to form a reasonably safe basis for analysis of the various factors that require preliminary consideration as to whether or not the deposits are worth development. If prospecting is to be continued in the Bohemia Basin, the norite near its contact with the underlying rocks is the most hopeful zone to test. A better idea of grade of material in the covered areas may be obtained from pits or short drill holes through the moraine. However, exploration in areas covered by moraine is difficult. The ground is saturated so that pits rapidly fill with water. The thickness of morainal cover ranges widely and predictions of thickness are difficult.

There is no reason to believe that any additional tonnage which might be located would have a nickel or copper content significantly higher than that of the material already indicated.

April 1944

12/ Reed, J. C. and Dorr, J. V. N., 2nd., op. cit., pp. 130-132.