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NICKEL CONTENT OF AN ALASKAN BASIC ROCK

BY

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CONTENTS

ILLUSTRATION

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ABSTRACT

A nickel-bearing sill, about 126 feet thick, lies in a thick sequence of greenstone schists, graphitic phyllites, and quartzites near the north end of Admiralty Island not far from Juneau, Alaska.

Petrographic measurements show that volumetrically the rock is made up of about 62.07 percent labradorite, 34.22 percent olivine, 2.42 percent pyroxene, 0.79 percent pyrrhotite, 0.21 percent magnetite, 0.14 percent chalcopyrite, and 0.06 percent pentlandite.

By weight the rock contains about 0.20 percent chalopyrite and 0.10 percent pentlandite. The copper content in chalcopyrite therefore is about 0.067 percent and the nickel content in pentlandite about 0.025 percent.

Chemical analyses of representative samples show the rock as a whole to contain about 0.350 percent copper and 0.344 percent nickel. The differences between the petrographic and the chemical results are believed to be due only in part to the fact that the few thin and polished sections studied may not be representative of the rock. The large differences appear to indicate that much of the nickel is present in the rock in some other mineral than pentlandite, presumably in olivine.

LOCATION AND GENERAL FEATURES

Several nickel-bearing deposits are known in southeastern Alaska,[1] although no significant quantities of nickel have been produced from Alaskan ores. The deposits have many features in common and are similar to many nickel-bearing deposits throughout the world.

This paper deals with a nickel-bearing sill known at the outcrop as the "Mertie lode," near the north end of Admiralty Island (fig. 11) not far from Juneau.

The country rocks of the vicinity comprise a thick sequence of greenstone schists, graphitic phyllites, and quartzites and several bodies of diorite or gabbro. The principal structural feature of the area is a large anticline that pitches about 30° SE. The nickel-bearing sill lies high on the anticline but somewhat to the east of its apparent axis. Outcrops near the sill are poor, and the only natural

[1] Overbeck, R. M., Geology and mineral resources of the west coast of Chichagof Island: U. S. Geol. Survey Bull. 692, pp. 125–133, 1919. Kerr, P. F., A magmatic sulphide ore from Chichagof Island, Alaska: Econ. Geology, vol. 19, pp. 369–376, 1924. Buddington, A. F., Alaskan nickel minerals: Econ. Geology, vol. 19, pp. 521–541, 1924; Mineral investigations in southeastern Alaska: U. S. Geol. Survey Bull. 773, pp. 95–113, 1925; Mineral investigations in southeastern Alaska: U. S. Geol. Survey Bull. 783, p. 46, 1926. Buddington, A. F., and Chapin, Theodore, Geology and mineral deposits of southeastern Alaska: U. S. Geol. Survey Bull. 800, pp. 348–351, 1929.

exposures are an outcrop along a small stream and another very small outcrop about 40 feet east of the stream. The deposit has been prospected by a tunnel 110 feet long and by several diamond-drill holes.

At the outcrop along the stream the hanging wall is light-colored siliceous schist, about 20 feet thick, overlain by graphitic phyllite. The footwall is greenstone schist.

The sill is about 126 feet thick, strikes N. 15° W., and dips 38° E. The rock is very dark, almost black, coarse grained, and contains

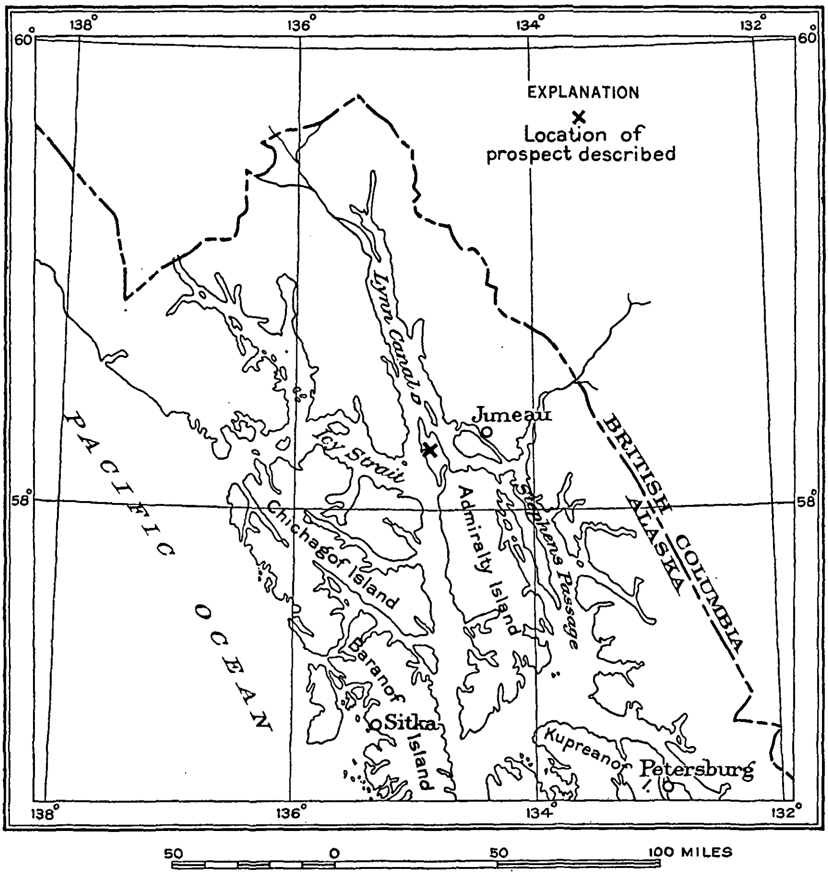

FIGURE 11.—Index map showing location of nickel-bearing sill on Admiralty Island.

sporadic finer-grained masses as much as several inches across. Numerous joints cut the rock in the tunnel. These joints trend about N. 10° E. and dip about 50° W. Many of them form channels for the passage of water, and near the face are filled with as much as an inch of hydrated oxides of iron. Near the portal the joints are very conspicuous, and some of them contain several inches of limonite. Also near the portal weathering has spread widely from the joints and has produced characteristic boulderlike forms. The weathered rock is stained with limonite. Careful examination of the rock in the tunnel failed to reveal any flow bands or any finer-grained border rock near the footwall, the only wall exposed in the tunnel. The absence of fine-grained chilled borders and the coarse grain of the rock suggest that the sill may be only a small part of a much larger body.

PETROGRAPHIC STUDIES

The rock of the sill has been classified by Buddington as troctolite. Buddington[2] found the rock to contain 55 percent labradorite, 39 percent olivine, 4 percent pyroxene, and 2 percent magnetite.

This paper is largely based on the study of five thin sections and three polished sections cut from the sill. Three of the thin sections are from material collected by Buddington.

The secondary minerals comprise a complex assemblage that includes sericite, carbonates, brown hornblende, serpentine, talc, biotite, and chlorite. The opaque minerals include magnetite, ilmenite, pyrrhotite, chalcopyrite, and pentlandite.

The approximate mineral constitution of the rock at each of the places from which a thin section was available was determined by making about six measured traverses in different directions across each thin section. From these were calculated the volumetric proportions of plagioclase, olivine, pyroxene, combined alteration products, and combined opaque minerals given in the table below.

Volumetric percentages of principal constituents, alteration products, and opaque minerals of specimens from a sill on Admiralty Island

Specimen	Plagioclase	Olivine	Pyroxene	Alteration products	Opaque minerals	Total
A	37.1	18.4	2.5	30.0	11.7	99.7
B	62.8	30.0	2.6	3.4	1.0	99.8
C	66.9	6.7	1.3	24.1	1.0	100.0
D	53.5	32.2	2.6	10.0	1.6	99.9
E	29.0	29.7	13.5	9.6	18.3	100.1
Average of B, C, and D	61.07	22.97	2.17	12.50	1.20	99.91

Specimen E was collected from the part of the lode richest in sulphides, so far as seen. It was therefore not used in calculating the average constitution of the sill. Similarly specimen A, which was collected by Buddington, was left out of the same calculation because it contains a far larger proportion of opaque minerals than the average rock. The remaining specimens, B, C, and D, were then averaged to reach an approximation of the average rock of the sill as exposed and as represented by the thin sections.

[2] Buddington, A. F., Mineral investigations in southeastern Alaska: U. S. Geol. Survey Bull. 783, p. 46, 1926.

It was estimated from the study of the thin sections that about 90 percent of the alteration products were formed at the expense of olivine, about 8 percent at the expense of plagioclase, and about 2 percent at the expense of pyroxene. The alteration minerals were then assigned to the plagioclase, olivine, and pyroxene in proportion to the estimated ratios, and the original constitution of the average rock, as represented by specimens B, C, and D, was calculated. Similarly the original constitutions of the rocks represented by specimens A and E, were calculated as shown in the following table.

Original volumetric percentages of principal constituents and combined opaque minerals of specimens from a sill on Admiralty Island

Specimen	Plagioclase	Olivine	Pyroxene	Opaque minerals	Total
A	39.5	45.4	3.1	11.7	99.7
Average of B, C, and D	62.07	34.22	2.42	1.20	99.91
E	29.8	38.3	13.7	18.3	100.1

Traverses were next made across the three polished sections, and the approximate relative volumetric proportions of pyrrhotite, magnetite, chalcopyrite, and pentlandite were determined for each of the sections as shown below.

Volumetric percentage of combined opaque minerals furnished by each opaque mineral in specimens from a sill on Admiralty Island

Polished section	Pyrrhotite	Magnetite	Chalcopyrite	Pentlandite	Total
1	80.1	5.1	9.5	5.2	99.9
2	63.6	12.9	15.9	7.5	99.9
3	54.8	33.2	8.8	3.2	100.0
Average	66.2	17.1	11.4	5.3	100.0

The average percentage of each opaque mineral among the combined opaque minerals was assumed to hold for the sill as a whole and was then used in calculating the volumetric percentage of each opaque mineral in specimens A and E and in the average of B, C, and D from the percentage of combined opaque minerals that had already been determined. (See table below.)

Volumetric percentages of minerals from specimens of a sill on Admiralty Island

Specimen	Plagioclase	Olivine	Pyroxene	Pyrrhotite	Magnetite	Chalcopyrite	Pentlandite	Total
A	39.5	45.4	3.1	7.75	2.00	1.33	0.62	99.7
Average of B, C, and D	62.07	34.22	2.42	0.79	0.21	0.14	0.06	99.91
E	29.8	38.3	13.7	12.11	3.13	2.09	0.97	100.1

The volumetric percentages of the chalcopyrite and of the pentlandite in the average rock (average of specimens B, C, and D) were then converted into percentages by weight. In the calculations the following specific gravities of the minerals were used: For labradorite, 2.7; for olivine, 3.5; for pyroxene, 3.4; for pyrrhotite, 4.6; for magnetite, 5.2; for chalcopyrite, 4.2; and for pentlandite, 5.0. The specific gravity of the average rock may be about 3 and the rock may carry about 0.20 percent chalcopyrite and 0.10 percent pentlandite by weight.

Chalcopyrite contains about 34.5 percent copper, and the average rock of the sill, with 0.20 percent chalcopyrite, should therefore contain in chalcopyrite 0.067 percent copper. The composition of pentlandite is not fixed, but A. H. Phillips analyzed pentlandite from Yakobi Island in southeastern Alaska for Buddington [3] and found it to contain 24.65 percent nickel. If this amount approximates the nickel content of the pentlandite from the sill on Admiralty Island, the sill may contain in pentlandite about 0.025 percent nickel. The rock therefore may carry in these two sulphides about 2¾ times as much copper as nickel.

CHEMICAL ANALYSES

The table following lists the results of chemical analyses made by R. C. Wells of six samples taken from the 110-foot prospect tunnel.

Percentages of copper and nickel in samples from a sill on Admiralty Island

	1	2	3	4	5	6
Copper	0. 26	0. 27	0. 36	0. 25	0. 61	0. 45
Nickel	. 28	. 24	. 34	. 25	. 61	. 30

1. Chip sample along the inner 28 feet of the tunnel.
2. Channel sample from 6-foot vertical cut at center of tunnel face.
3. Channel sample from 7-foot vertical cut on right side of tunnel, 100 feet from the portal.
4. Channel sample from 7-foot vertical cut on left side, 100 feet from the portal.
5. Channel sample from 7-foot vertical cut on right side, 75 feet from portal.
6. Channel sample from 7-foot vertical cut on right side, 39 feet from portal.

Sample 6 in the table above was cut from weathered material to find out if weathering produced any notable differences in the amounts or proportions of copper and nickel present.

The average content of copper and nickel in the rock as a whole as exposed in the prospect tunnel is probably closely approximated in the averages for each metal in the samples above. The values for sample 6 are omitted from the calculations because sample 6 was weathered material. Thus the average rock probably contains about 0.350 percent copper and 0.344 percent nickel.

[3] Buddington, A. F., Alaskan nickel minerals: Econ. Geology, vol. 19, p. 523, 1924.

CONCLUSIONS

The petrographic studies reveal much smaller quantities of copper and nickel in the rock of the sill than is shown by chemical analyses. That some differences between the results reached by the two methods should appear is to be expected. The samples submitted for analysis are probably much more representative of the rock than are the thin and polished sections. It is hardly to be expected that five thin sections and three polished sections would correctly represent a rock mass as large as that exposed in the tunnel.

Nevertheless, some inferences can be drawn from a comparison of the two sets of results. Chemical analyses show about five times as much copper as does the petrographic work. The petrographic results counted only the copper present as chalcopyrite. Perhaps some of the copper found by analysis is present in one or more of the other minerals.

Similarly, the petrographic studies counted only the nickel present in pentlandite. In the case of nickel the divergence between the two sets of results is even greater than in the case of copper. Thus the chemical work reveals nearly 14 times as much nickel as the microscope.

While the petrographic results are admittedly not so reliable as the chemical results in their absolute values, still the relative amounts of copper and nickel as determined by both methods should be about the same, provided the two metals are present only in chalcopyrite and pentlandite. By chemical analysis the ratio of copper to nickel is found to be almost exactly 1 to 1. By petrographic determination the ratio is about $2\frac{3}{4}$ to 1.

Thus it is inferred that a considerable part of the nickel is present in some other mineral than pentlandite. Some copper other than that in chalcopyrite may also be present. That the other nickel mineral may be the abundant olivine is thought likely, although this has not yet been proved. Nickel in olivine has been reported from many localities. Ross,[4] Shannon and Gonyer tabulate analyses of olivine from North Carolina that show several tenths of a percent of nickel. The same paper tabulates published data that show comparable amounts of nickel in olivines from New Caledonia, Oregon, the Urals, Hawaii, and Germany.

[4] Ross, C. S., Shannon, E. V., and Gonyer, F. A., The origin of nickel silicates at Webster, N. C.: Econ. Geology, vol. 33, No. 5, pp. 528-552, 1928.