NICKEL DEPOSITS IN THE LOWER COPPER RIVER VALLEY.

By R. M. Overbeck.

INTRODUCTION.

Nickel is one of the few metals for which the United States now depends on other countries. Its importance has been shown by the extensive uses to which it was put during the war, and consequently the discovery of deposits of nickel ore would be welcome additions to the knowledge of the mineral wealth of the United States. The purpose of the present investigations of the nickel deposits of Alaska is to accumulate data about the extent to which the United States can be independent of other countries for its supply of nickel. Such data are valuable, even if the deposits are never worked, because they may prescribe limits to the monopoly held by other countries. Unless a strong demand for nickel on the Pacific coast should arise through the establishment of industries in which nickel is used, the present known nickel deposits of Alaska probably could not compete, for their nickel content alone, with the deposits of Sudbury, Canada.

The nickel deposits near Spirit Mountain, in the lower Copper River valley, were visited in August, 1917, by the writer, who spent about one and a half days in examining the prospects. An occurrence of nickel in southeastern Alaska has been described in a previous report.[1]

LOCATION.

The Spirit Mountain nickel deposits are near the head of Canyon Creek, a small westward-flowing stream that enters Copper River about 8 miles below the mouth of Chitina River. (See fig. 1.) The mouth of the creek, which is nearly opposite mile 121 on the Copper River & Northwestern Railroad, is about 9 miles south of the town of Chitina. Although Canyon Creek is only 12 miles long, it is fed by several large glaciers and consequently at times carries much water. Canyon Creek flows northeastward for 3 miles and, making a right-angled bend, northwestward for the remaining distance. The lower course of the stream lies in a narrow box canyon. The principal nickel deposit is on the west side of the creek about 1½ miles southwest of the right-angled bend and about the same distance from the head

[1] Overbeck, R. M., Geology and mineral resources of the west coast of Chichagof Island: U. S. Geol. Survey Bull. 692, pp. 91–136, 1919 (Bull. 692–B).

of the creek. The main exposure is on a steep hillside several hundred feet above stream level, or approximately 4,000 feet above the sea.

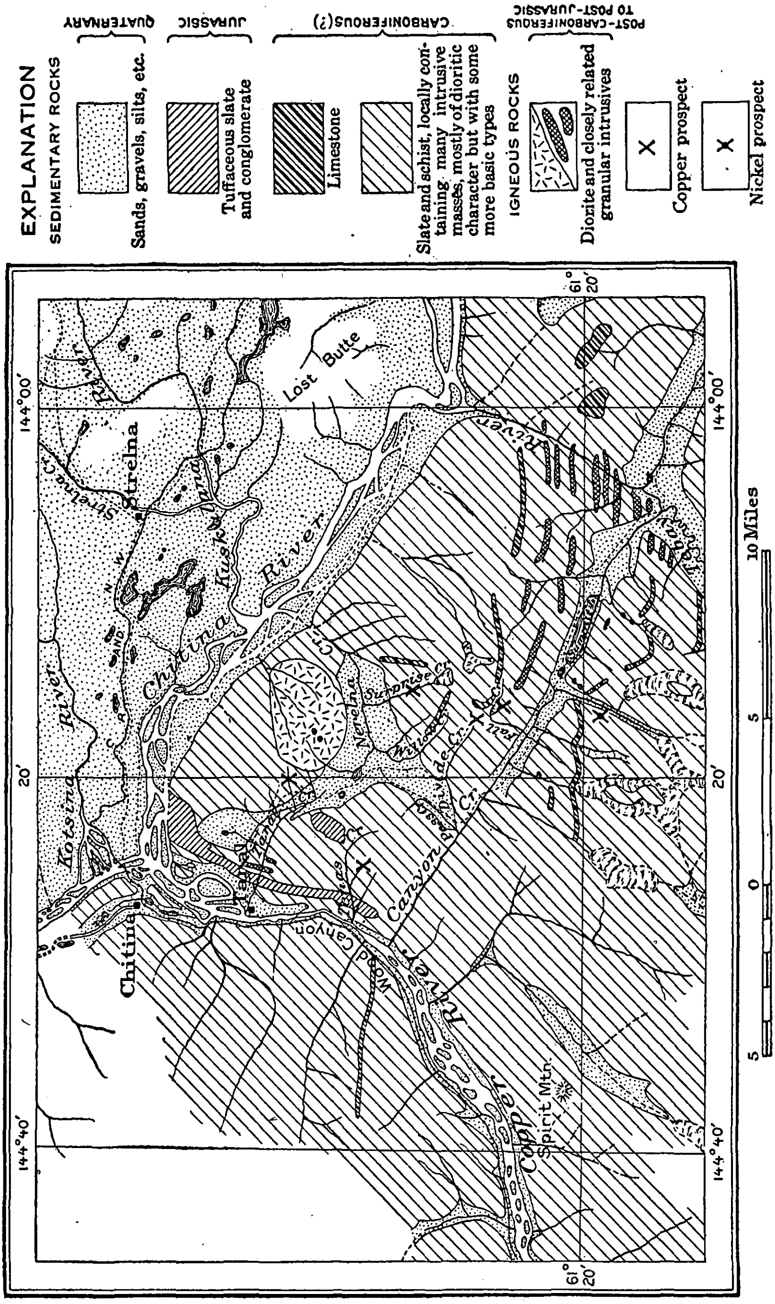

FIGURE 1.—Geologic reconnaissance map of Canyon Creek and vicinity.

The deposits, though they derive their name from the prominent peak on Copper River known as Spirit Mountain (elevation 7,270 feet), lie about 12 miles east of the peak.

The claims can be reached from Chitina by two trails. One trail leaves the east side of Copper River at Taral; the other, at a point a short distance below the mouth of Canyon Creek. The Canyon Creek trail is the one most used now, for it is reported to be in somewhat better condition than the Taral trail. The Canyon Creek trail is steep, rising 2,000 feet in a little over a mile, but at the time of visit the footing for horses was good in all except one place. The distance to the claims from the river is about 12 miles. By either trail a crossing of Copper River is necessary, but boats and Indian boatmen can usually be hired for the trip. Horses have to swim, as the river is narrow and swift at both crossing places.

The nearest town to the deposits is Chitina, which lies near Copper River, opposite the mouth of Chitina River, about 9 miles above the mouth of Canyon Creek. Supplies can be obtained at Chitina, or from Cordova, the nearest seaport and the coast terminus of the Copper River & Northwestern Railroad, 130 miles from Chitina.

The region is extremely rugged. Copper River has an elevation of 400 feet just below the mouth of Canyon Creek, but the mountains on either side of the river rise steeply to elevations of 6,000 feet or more. Many of the streams flow through deep canyons just before entering Copper River, and most of them are fed by glaciers. Timber line averages 2,500 feet above sea level. The Spirit Mountain deposits are several miles from the nearest timber. A more detailed discussion of the geography of the region is given by Moffit.[1]

GEOLOGY.

The following notes on the geology of the region in which Canyon Creek lies are quoted or abstracted from the report by Moffit [2] on the Hanagita-Bremner region:

> Two groups of sedimentary rocks occupy most of the area under consideration. The oldest consists of schist, slate, and limestone, which form the chief rocks of the mountains between Hanagita Valley and Chitina River and of those south of the Hanagita Valley eastward from Copper River for nearly 30 miles. These sedimentary beds are folded, faulted, and much metamorphosed. Furthermore, they are intruded in a most complicated manner by igneous rocks and sills, which are chiefly dioritic but include granitoid rocks of a more basic kind. * * *
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> The second group of sedimentary beds consists of interstratified slate and graywacke, here classed as early Mesozoic (?) (Valdez group). It adjoins the group first mentioned on the south. * * * These sedimentary rocks are folded and faulted but are less metamorphosed than the schist and limestone beds bounding them on the north. They are cut by numerous light-colored dikes of quartz monzonite.

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[1] Moffit, F. H., Geology of the Hanagita-Bremner region, Alaska: U. S. Geol. Survey Bull. 576, p. 8–17, 1914.

[2] Idem., pp. 17–18, 32–33.

Igneous rocks are common throughout this district. Diorite and closely related types are the most common, but more basic intrusive rocks are found in several places. The dioritic rocks doubtless belong to several periods of intrusion. Some of them are light colored, coarse grained, and almost unaltered; others are fine grained and dark colored. Diorite is especially common in the vicinity of Taral and is in places so greatly altered that it can not be readily distinguished from the altered diabase associated with it. The greenstone so abundant east of Taral is derived from diorite and diabase. A very few basic dikes having the composition of peridotites were found in this vicinity. The small area between Canyon Creek and Chitina River is in large part a complex of intrusives in which large masses of sedimentary rock have been inclosed. Diabase is the prevailing type, but diorite is common and presents a varied appearance. A dike of peridotite consisting of pyroxene and much-altered olivine with metallic sulphides was found near the head of Canyon Creek. The surrounding rocks are schist and limestone, very much folded and extensively faulted.

The country has been extensively glaciated.

THE DEPOSITS.

Up to the time of the writer's visit in 1917 sixteen nickel claims had been located in the Canyon Creek valley. Some of these claims were staked as early as 1907 or 1908. Moffit, who in 1911 visited the deposits on the west side of the creek, has described them briefly, and apparently little development work has been done on them since that time. The 16 claims, which are consolidated, are held by three or four men. Six of these claims are on the west side of Canyon Creek near its head, 4 on the east side, 4 just over the ridge on the east side, and 2 opposite the mouth of Fall Creek on the ridge along the south side of Canyon Creek. The principal development work has been done on the claims west of Canyon Creek. At the time of visit in 1917 no work was being done on any of the claims.

The country rock of the Canyon Creek valley is schist of probable Carboniferous age. The numerous bodies of igneous rock that have intruded the schist are conspicuous because of their rusty-looking croppings. The shapes of these bodies are irregular, but the irregularity is probably due in part to faulting which took place after intrusion. The slickensided surfaces found along the contact between schist and igneous rock indicate that such faulting has occurred, and a fault trace shows prominently on the face of a cliff on the west side of Canyon Creek. The intrusive bodies range from acidic rocks, such as quartz monzonite, to basic rocks, such as peridotites. Quartz stringers are also rather abundant in the schist.

The most promising of the exposures and the one on which the most development work has been done is on the west side of Canyon Creek about 500 feet above the bed of the creek, or 4,100 feet above sea level. Some shallow pits have been sunk on the outcrop, and a 50-foot tunnel has been driven in an attempt to undercut the ore body. Several other holes have been put down to find the continuation of the body up the hill. The outcrop of the body is plainly visible from the creek, for one end of it is cut off by a cliff, and the face of this cliff is stained a bright yellowish brown and green. As exposed at the surface the ore body is an irregular mass about 25 feet wide, which strikes about N. 65° W. and apparently dips very steeply to the north. The westward extension of this body can be traced only a short distance on the surface, and its eastward extension is cut off within a short distance by a steep cliff. The section of the body outlined on the cliff face has a width of about 25 feet for possibly 50 feet down the cliff and is there cut by a fault. An iron-stained streak a foot or more wide follows the fault trace down the cliff. At the bottom of the cliff a tunnel has been driven into a crushed zone about a foot wide which includes with the crushed material a little mineralized basic rock. The face of the cliff is inaccessible, and so absolute measurements of the exposures there could not be made.

The country rock in which the nickel-bearing body occurs is light-gray limy and quartzose schist, striking N. 84° W. and having a vertical dip, into which peridotite has been intruded. The peridotite is rather strongly mineralized in places with sulphides, and it is with these sulphides that the nickel is associated. This schist, which is a recrystallized impure limestone, is seen under the microscope to consist chiefly of coarse calcite crystals separated by flakes of biotite, chert, hornblende, muscovite, and zoisite. Along the hanging wall of the ore body lies a light-colored igneous rock that may represent an acidic differentiation product of a magma of which the nickel-bearing basic rock along the footwall is the other extreme. This acidic rock is very light colored and medium grained and contains a few scattered garnets. A thin section shows that it consists chiefly of quartz, orthoclase, and altered plagioclase. The quartz and orthoclase together are about equal in amount to the altered plagioclase. Some garnet and a few flakes of biotite and muscovite are present. The altered feldspar has been so far changed that its original composition could not be determined, although traces of plagioclase twinning can still be detected in some of the crystals. The alteration product of the feldspar is very fine grained and can not be determined definitely, but a considerable part of it seems to be sericite. The quartz and orthoclase are closely intergrown and in some parts of the slide show graphic intergrowth. Attention is called to this graphic intergrowth because, although it is extremely common in the acidic rocks, it has been noted at a number of places where nickel ores are associated with extremely basic igneous rocks. Relatively the rock is not greatly altered, nor does it show the effects of having undergone any intensive squeezing. As the specimen was taken from a surface outcrop, much of the alteration may be due to weathering. Stringers of chlorite are rather common, but these too may be the result of weathering.

The quartz stringers, which are fairly abundant near the outcrop of the basic rock, may represent products of differentiation—a step farther than that of the acidic dike.

The rock in which the nickel-bearing sulphides occur is a highly altered coarse-grained peridotite. It appears to have consisted originally of olivine and pyroxene, but it has been so greatly altered that none of the olivine and almost none of the pyroxene remains. The olivine has been altered with characteristic mesh structure to serpentine, talc, and opaque minerals. The pyroxene is now hornblende. Some epidote and several large flakes of biotite were noted. Stringers of carbonate that may be in part calcite and in part magnesite are very abundant in the slide. Chlorite is present in considerable quantity. The rocks as a whole, however, have been so greatly altered that only a part of the minerals can be definitely determined. The opaque sulphide minerals in the slide occur partly as grains and partly as stringers that cut across the silicates. Although the sulphides seem to be later than the silicates, their deposition seems to have been controlled to some extent by the presence of the silicates. In other words, they are for the most part interstitial between the grains of the silicates and to a rather minor extent cut across the grains. Although the type of rock is different from that of the southeastern Alaska nickel deposit, the texture of the polished surface of the ore rock is very similar in appearance. Chalcopyrite and pyrrhotite can be recognized in a thin section of the ore rock.

The more heavily mineralized portion of the dike is along its footwall side. In places the mineralized rock is massive sulphide, but at most places where it has been mineralized the sulphides are interstitial in the coarse-grained igneous rock. The minerals in the massive ore have been acted on extensively by the weather and now represent rather an agglomeration of original minerals and minerals that are the result of weathering. The only mineral that can be definitely determined on a polished surface of the ore is chalcopyrite. The section is cut by numerous stringers of a bluish mineral that may be in part chalcocite and in part hematite. The most abundant minerals in the slide have some resemblance to pyrrhotite, but comparison with polished surfaces of known pyrrhotite show there is a decided difference in color. The most abundant mineral, next to pyrrhotite, in most of the specimens is light colored and has roughly equidimensional surfaces that show cubic cleavage. This mineral occurs also in slender stringers cutting though the pyrrhotite. The pyrrhotite is very strongly magnetic; the unknown mineral is nonmagnetic.

The sulphides are so brittle and so badly weathered that a good polished section on which the relations of the opaque minerals can be seen is difficult to get. Stringers of a bluish mineral that seems in part to be hematite are abundant in the section. These stringers are later than the other minerals in the section. Marked cleavage occurs in the pyrrhotite, and in places the bluish mineral follows these cleavage lines. With high powers of the microscope minute parallel cleavage lines can be seen starting out on either side of the cracks that cut the polished surface. Chalcopyrite is scattered through the slide and varies in amount in different specimens. The order of deposition of the three minerals can not be told from the highly polished specimens. The unknown mineral seems to be present both as crystals and as stringers.

An attempt was made to determine the two principal minerals that were observed on a polished surface of the ore. In order to get material, if possible, that would be homogeneous a piece of the ore was cut into many thin slices. The slices were polished on both sides so that the minerals could be recognized and picked out. After the material was selected in this way it was ground very fine, and a further separation was made with a magnet. The result of the chemical analysis is as follows:

Analyses of minerals from nickel ore of Spirit Mountain deposits.

[W. T. Schaller, analyst.]

	1	2
Insoluble in aqua regia	1.2	0.9
Soluble in HCl:		
Cu	.2	.3
Fe	9.8	53.2
Ni	3.2	2.2
Insoluble in HCl:		
Cu	.5	.3
Fe	18.6	.9
Ni	16.4	.0
S (by difference)	50.1	42.2
	100.0	100.0

Mn, Zn, Co, and As absent. 1, Supposed nickel mineral; 2, supposed pyrrhotite.

The above analysis shows that both specimens, notwithstanding careful mechanical separation, are mixtures. Specimen 2 consists essentially of iron and sulphur and is probably pyrrhotite, as was originally supposed. Nickel and copper are probably impurities. That the presence of copper would be shown in the analysis was expected, for, as stated above, chalcopyrite and chalcocite (?) were determined in the hand specimen. Some of the iron, too, is undoubtedly derived from hematite and limonite. In specimen 1 there are apparently two kinds of nickel minerals, one soluble in hydrochloric acid and the other insoluble. Their formulas and consequently their names can not even be surmised, for the extent to which impurities have entered into the analysis is not known; nor is it possible to determine the influence of the ferric chloride that was formed when part of the material went into solution on the solubility of the material not in solution.

The iron-stained outcrops on the east side of the creek reach 100 feet in width, but their outline is irregular. They occur in a country rock of schistose impure limestone. Such outcrops can be traced intermittently up the hillside and over the ridge, and they may have at one time belonged to a single body that has since been broken by faulting. At several places in these croppings shots have been put in, but there are no satisfactory exposures of the fresh underlying rock. Some stringers of pyrrhotite were found at places, but analysis of this pyrrhotite showed only a trace of nickel.

It is reported that the best assay returns obtained from the Canyon Creek claims showed about 11 per cent of nickel and about 2 ounces of silver to the ton. A selected specimen of the sulphide ore was analyzed in the laboratory of the Survey and reported to contain 7.23 per cent of nickel and a trace of cobalt. One of the principal things to be determined about the deposit is whether the nickel is a surface concentration or whether the tenor holds or increases with depth. To determine this point further development work and additional assays are necessary. All the specimens that are now available show the effects of extensive surface alteration.

The amount of development work done on the claims is so small that assay returns as to the amount of nickel in the ores may be misleading. Weathering, for example, may have leached and carried away much of the nickel, or it may have concentrated the nickel under the leached surface cropping. Most very basic dikes, such as peridotite dikes, carry a small percentage of nickel, and surface leaching and reconcentration of this nickel may cause an enrichment near the surface that would give an erroneous idea of the true tenor of the body. Some fresh pyrrhotite taken from one of these dikes was tested for nickel and showed only the most minute trace. The deposits in New Caledonia represent the type of nickel deposit which is formed from the surface enrichment of basic igneous rocks. Such deposits, to have economic value, must be rather large and so disposed that surface stripping could be carried on easily.