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**GEOLOGY OF THE JUMBO MOUNTAIN
NICKEL DEPOSIT
SNOHOMISH COUNTY, WASHINGTON**

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GEOLOGIC SETTING OF THE NICKEL OCCURRENCES ON JUMBO MOUNTAIN, WASHINGTON

by JOSEPH W. MILLS

In 1956 the discovery of nickel on Jumbo Mountain, Snohomish County, Washington, focused attention on this part of the Cascade Range, far more renowned for its timber than for its mineral resources. Hand specimens assaying as high as 13 pct Ni encouraged Discovery Mines Inc. of Mount Vernon, Wash., to stake 12 claims in Township 31 North, Range 9 East of the Willamette Meridian. The property was leased to Climax Molybdenum Co. in January 1957. Trenching, sampling, and geologic studies were carried out during the late summer of 1957 when most of the snow had disappeared. Although the deposits are only about four miles south of the logging town of Darrington and about two miles, as the crow flies, southeast of the end of a good gravel road from that town, all camp supplies and equipment were air-dropped, owing to the extremely rugged nature of the terrain.

GEOLOGY

The rocks of Jumbo Mountain comprise a series of folded Tertiary sediments forming a belt one half to three quarters of a mile wide, trending northwest about parallel to the strike of the beds. This belt is sandwiched between two extensive intrusives—gabbro on the northeast and quartz diorite on the southwest—and has been intruded by dikes of fresh and serpentinized dunite. Shear zones

follow many of the dunite-sedimentary rock contacts, and in these the nickel mineralization is concentrated. A few transverse faults offset the sediments and ultrabasics.

Sedimentary Rocks: Two kinds of quartzite make up the greater part of the sedimentary section. One is dark purplish gray, very fine-grained, and thin-bedded; the other is light gray to white, medium-grained, and well-bedded. Locally the light-colored quartzites contain grit and conglomerate horizons, rich in pebbles of white chert and very fine-grained quartzite. Intercalations of dark argillites near the summit of the mountain give many of the cliffs a striking banded appearance. Dark gray to black, aphanitic, thin-bedded argillites occur throughout the entire sedimentary belt. Beds vary from a few inches to a few tens of feet thick and some, near the summit, contain numerous fossiliferous (willow?) leaves. Only the thicker beds were mapped.

The sediments are quite fresh on the northeastern side of the belt and become more metamorphosed (hornfelsed) toward the southwestern side. Brown biotite is present in the metasediments in increasing amounts as the quartz diorite is approached. Near the intrusion, porphyroblasts of plagioclase, up to 1 in. across, testify to the soaking of sedimentary rocks by solutions emanating from the quartz diorite.

Most of the sediments mapped lie along the southwestern limb of an anticline, the axis of which follows the crest of the mountain and plunges at a low angle to the northwest.

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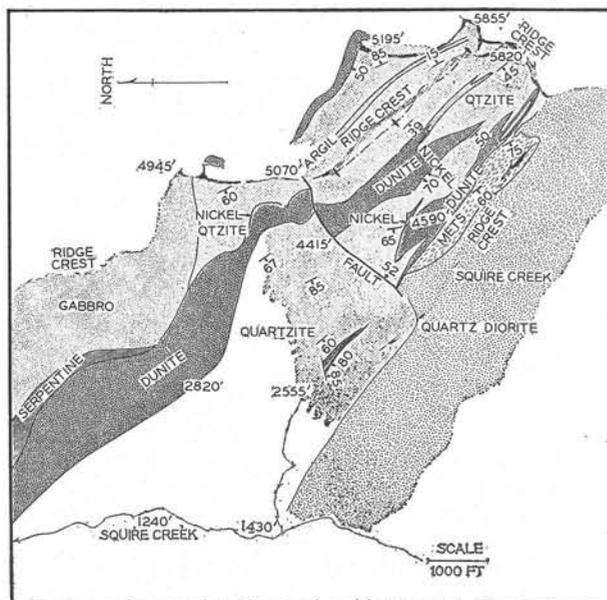


Fig. 1.—Geologic plan of Jumbo Mountain.

Vance¹ correlates the sediments of Jumbo Mountain with the Swauk formation and points out:

The Swauk formation . . . is part of a long, narrow north-northwest-trending belt of continental sediments extending over 50 miles with several gaps from the type area south of Mt. Stuart to the present area, thence almost 50 miles farther with a few more breaks to the Bellingham area where the same unit has been called the Chuckanut formation. . . . The Swauk appears to owe its preservation in this narrow belt to faulting and in part to sharp downfolding.

Ultrabasic and Basic Igneous Rocks: Intrusive into the sediments are numerous dikes of fine-grained, black to grayish green, coarse-grained dunite, composed almost entirely of iron-poor olivine or its alteration products, talc, tremolite, and serpentine. Commonly the rock weathers a characteristic orange-brown color. Dikes vary from a few feet wide and a few hundred feet long to great tabular bodies several hundred feet wide and miles long.

Within the map area there are three large persistent dikes of dunite, all striking about parallel to the sedimentary rocks. The eastern one was not mapped in its entirety; it lies to the east of the fold axis and dips southwesterly directly across the sedimentary beds. This dunite dike is fine-grained and dark green-gray to black. It contains abundant talc and serpentine, together with less than 1 pct of exceedingly small pyrrhotite grains. Although the dike is quite schistose, especially along its margins, no promising nickel mineralization has so far been found in it on this side of the mountain. The dike transects the folded early Tertiary sediments and is itself truncated to the northwest by the gabbro intrusive.

The other two major dikes, lying southwest of the anticlinal axis, strike and dip about parallel to the sediments, though locally they cut across the bedding at low angles. They differ in size but are quite similar in other respects—characteristically they are somewhat darker and finer-grained along the margins than at their centers, invariably they contain a sprinkling of very small pyrrhotite grains, and frequently they are crisscrossed by thin films of

crystalline talc. Locally, they are schistose for a few feet from their contacts, and it is these schistose zones which are mineralized with pyrrhotite and pentlandite. The dikes die out along the strike and up and down the dip by branching and intertonguing with the sediments.

The southwest dike, the smaller of the two, pinches out to the southeast just a few feet from the summit, cropping out again on the southeast (unmapped) side of the mountain at about the same elevation. The implication is that this and probably other dunite bodies are tabular-lenticular branching bodies which, like the folds, have low angles of plunge.

The central portion of the dunite dike that lies south of the gabbro intrusive is exceedingly coarse-grained. Differential weathering has removed the finer-grained matrix and left striking euhedral crystals of olivine, up to an inch long, projecting from the weathered rock surface.

At least locally and to a minor degree, all the dikes show alteration of the dunite to serpentine. This is more pronounced along the borders where schistosity has been developed. The area between the gabbro and the largest dunite dike is noteworthy for a volume of serpentine at least a mile long and more than 200 ft wide, composed entirely of glossy, moderately schistose serpentine. It is not known whether this rock is the product of dynamic metamorphism of the dunite or the product of contact metasomatism by solutions that originated in the gabbro mass.

Gabbro: The belt of sedimentary rocks on Jumbo Mountain is bordered on its northeast side by one or more basic intrusions. The northwest end of the mountain is made up of a green, medium to coarse-grained, massive gabbro. The truncation of the dunite dike and of the sediments at the south end of the gabbro body is interpreted as indicating a post-dunite and hence a Tertiary age for the gabbro. It has been intruded along the anticlinal fold axis.

A thin section shows this rock to be composed of about equal amounts of rather basic (An 65) saussuritized plagioclase and fibrous uralitic hornblende, with its alteration products, epidote, silica, and chlorite. Minor amounts of very fine-grained secondary silica and talc were visible under the microscope, as well as numerous grains of sphene and/or ilmenite.

Acid Igneous Intrusives: Bordering the sedimentary belt on the southwest, and intruding into



Fig. 2—Crest of Jumbo Mountain, looking southeast.

it, is a light-colored, medium to coarse-grained quartz diorite composed of plagioclase, hornblende, brown biotite, and minor quartz. This is the northern limit of a great stock, called by Vance¹ "the Squire Creek Quartz Diorite," which occupies an area of some 30 sq miles. According to Vance, "the stock is a roughly elliptical body, the larger axis of which trends about N 30 W, approximately parallel to the structural trend of the adjacent country rocks." He considers the stock "to be of igneous origin . . . indicated by the uniformity of the quartz diorite and by its universally sharp contacts. . . . Textures are dominantly magmatic." Within the map area the stock probably dips at a very steep angle to the south.

Light gray to white fine-grained aplite dikes are found cutting the quartz diorite and the metasediments. Seldom more than a foot wide, these dikes cannot be shown on a map the scale of this study. The aplite is a differentiation product of the quartz diorite magma.

Faults: The faults are either longitudinal or transverse. Longitudinal faults occur along and just within the borders of the dunite dikes; the schistosity, developed as a result of fault movement, is further discussed below. Transverse faults are characterized by narrow, clean-cut surfaces of dislocation which cut across the sedimentary belt, strike from east to a few degrees north of east, and dip steeply southeast. Two transverse faults have been recognized, each offsetting dunite dikes in the central part of the map area. The largest dunite dike has been offset at least a couple of hundred feet on the larger fault, the north side apparently having moved east. The actual net slip on the transverse faults is unknown. They contain no sulfide mineralization.

NICKEL DEPOSITS

In all three principal dunite dikes, minute disseminated grains of pyrrhotite are to be seen in the fresh rock in amounts less than 1 pct. Traces of nickel have been reported from many such specimens. Nickeliferous pyrrhotite is the principal nickel-bearing mineral, although olivine contains very minor amounts of nickel in solid solution, substituting for magnesium and iron. Such occurrences are of no economic significance.

Nickel analyses of possible economic significance (up to 3 pct Ni) have been returned from samples taken near the margins of the two large western dunite dikes. These samples were from schistose zones along and within the dike walls. The mineralized shear zones, up to 30 ft wide, strike N 30 W and dip from 65° to 90° west. They consist of layers of hard, fresh, green-gray dunite, mineralized with finely disseminated pyrrhotite. These layers alternate with layers of soft, black, oxidized schistose dunite up to 1 ft wide, well mineralized with pyrrhotite and tabular-fractured pentlandite in crystals up to 1/4-in. diam.

Sulfides identified in polished sections were chiefly pyrrhotite and pentlandite, with much smaller amounts of chalcopyrite. There are two varieties of pyrrhotite. One develops a fine polish and conforms to published descriptions. The other is slightly darker and browner, does not polish as well, and displays flamelike growth or intergrowth structure when etched with nitric acid fumes. Pyrrhotite and pentlandite crystallized contemporaneously in the form of veins in the olivine and as fillings of the interstices of euhedral olivine crystals. Chalcopyrite replaces the other sulfides.

The most striking feature of the deposits is their occurrence in intimately fractured and schistose zones in the dunite where faulting has been localized along the contacts of the sediments and the dunite dikes. Though far too little detailed work has been done to be certain, there appears to be a higher concentration of sulfides in the shear zones along the margins of dike apophyses, sediment reentrants, and strike and dip irregularities.

Much more study would be required in order to submit a plausible theory of formation of the nickel deposits, supported by laboratory and field evidence. Results of the present study, especially localization of the metals by fracturing, certainly indicate that the nickel concentrations were brought about by precipitation of nickel sulfides from fluids that used the fractures as a means of ingress. Studies of nickel sulfide deposits throughout the world have demonstrated that such sulfides were deposited at considerable depths and at temperatures of several hundred degrees. This would rule out the possibility of groundwater as the transporting medium. The two possible sources of hot nickel-bearing fluids are quartz diorite and gabbro. The first possibility is that large volumes of fluids, expelled from the quartz diorite magma during its crystallization, obtained a supply of nickel by altering the nickeliferous olivine of the dunites. The likelihood of this process is lessened by the recognition that, although the dunites show some alteration to serpentine, talc, and tremolite, they are for the most part remarkably fresh outside the schistose zones. The worldwide association of nickel with basic rocks, together with the presence of pyrrhotite in thin films on joint planes of the gabbro on Jumbro Mountain, favors the gabbro source.

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REFERENCE

¹ J. A. Vance: The Geology of the Sauk River Area in the Northern Cascades of Washington. Doctoral dissertation, University of Washington, 1957.

Discussion of this article sent (2 copies) to AIME before April 30, 1960, will be published in MINING ENGINEERING.