MISCELLANEOUS PAPER 20

INVESTIGATIONS OF NICKEL IN OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
DONALD A. HULL, STATE GEOLOGIST

1978

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INVESTIGATIONS OF NICKEL IN OREGON

INTRODUCTION

Purpose and Scope of this Report

This report contains pertinent data on nickel deposits in Oregon gathered in recent studies by the Oregon Department of Geology and Mineral Industries in cooperation with the U.S. Bureau of Mines. Summaries and references of essentially all previously published reports on nickel deposits in the State are also included. Much of the detailed information is new and not available in any previous publications. The report is, however, of a preliminary nature, resulting from reconnaissance field investigations of a large number of occurrences that have had little or no previous exploration or development.

The report is designed to supply basic resource data to various groups and agencies interested in the State's nickel potential and to land use planners. Maps (scale 1:250,000) of southwestern and northeastern Oregon (Plates 1 and 2, folded, in pocket) show the distribution of ultramafic rocks and locations of nickel mines, deposits, and prospects. The location, geology, history of exploration, and extent of development of individual deposits are discussed in the text. Large-scale maps of southwestern Oregon deposits are also included in appropriate places in the text.

Acknowledgments

During the summer of 1975, while working on the nickel laterite investigations project funded by the U.S. Bureau of Mines, the writer was ably assisted by Bruce C. McNeal, geology student, Southern Oregon State College; Norman V. Peterson, District Geologist, Oregon Department of Geology and Mineral Industries, Grants Pass field office; and Howard C. Brooks, Resident Geologist, Department's Baker field office, who did all of the preliminary investigations on reported nickel occurrences in northeastern Oregon. Geologists from the U.S. Bureau of Mines, including Tom Hillman and Fred Williams, have also been of assistance. Ruth E. Pavlat, secretary-receptionist for the Grants Pass field office, prepared the bibliography, conducted office research, and typed the manuscript and camera-ready copy. Editing of the manuscript was done by Beverly F. Vogt and Ainslie Bricker, Department's Portland office. Members of the Siskiyou National Forest staff have been very helpful, particularly E. Eileen Blakely, who loaned color infrared aerial photographs and assisted in obtaining base maps. Private-company geologists Boies Hall, Allan D. Wood, and Winthrop A. Rowe provided some data for this report. Chemical analyses were done by Gary L. Baxter, Department assayer-spectroscopist.

U.S. Nickel Industry

The U.S. and world nickel supply-demand relationships for 1975 are shown in Figure 1 and for the period 1966-76 in Table 1. The entire U.S. primary production of nickel during this period has been from the Hanna Mine at Nickel Mountain near the town of Riddle, Douglas County, Oregon. This mine has been producing from 4 to 8 percent of the nation's total industrial demand over the last 10 years. Imports, recovered secondary metal, government stockpile excess shipments, and industry stocks on hand supply the remainder. Figure 1 shows that in 1975 about 62 percent of our imported nickel was derived from Canada.

The Nickel Mountain deposit was put into production on completion of the smelter in 1954. Annual production of nickel from this smelter has increased from about 5,692 tons in 1956 to about 13,030 tons in 1976 (Table 4).

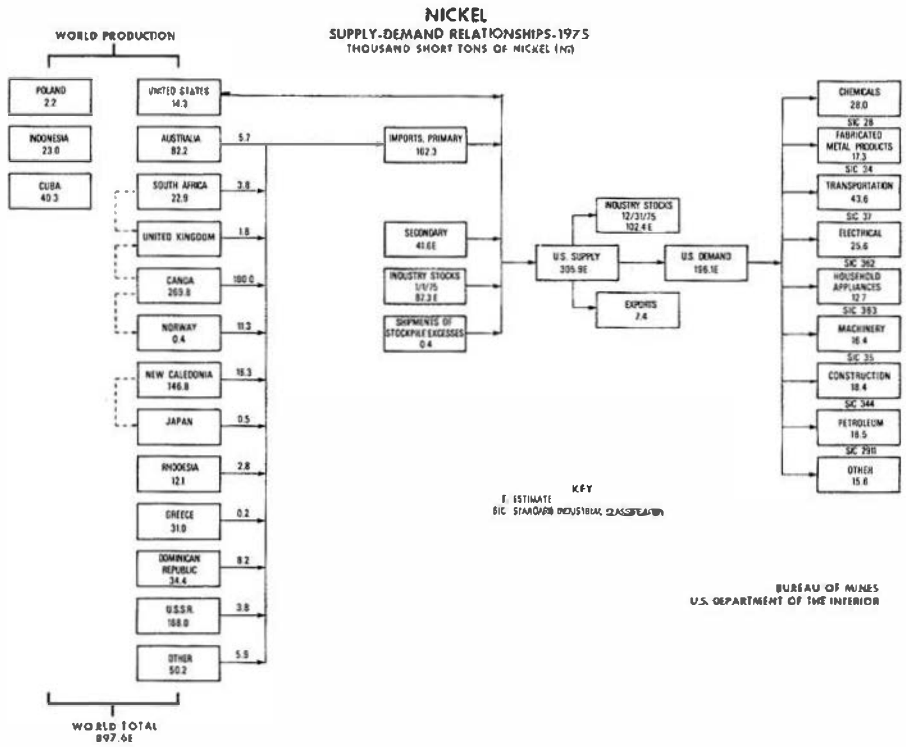

Figure 1. Supply-demand relationships for nickel. (U.S. Bureau of Mines, 1977)

Table 1. Nickel supply-demand relationships, 1966–76 (Thousand tons) (U.S. Bureau of Mines, 1977)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976[p]
World mine production:											
United States[1]	13.2	14.8	15.2	15.8	15.6	15.6	15.7	13.9	14.1	14.3	13.9
Rest of World	426.9	480.2	532.9	516.9	676.8	685.0	666.2	707.7	809.1	883.3	906.1
Total	440.1	494.8	548.1	532.7	692.4	700.6	681.9	721.6	823.2	897.6	920.0
Components of U.S. supply:											
Domestic mines	13.2	14.6	15.2	15.8	15.6	15.6	15.7	13.9	14.1	14.3	13.9
Secondary	63.1	52.3	36.6	71.0	48.7	63.1	67.5	65.9	64.5	41.6	47.0
Shipments of Government stockpile excesses	103.6	22.3	3.2	4.3	2.1	14.9	1.8	1.0	4.6	.4	0.5
Imports	141.0	143.0	148.0	129.3	166.3	142.2	173.9	195.1	220.7	162.3	188.6
Industry stock, Jan. 1	14.1	44.5	39.6	37.2	31.9	24.7	57.3	77.9	71.3	87.3	102.4
Total U.S. supply	335.0	277.7	242.6	257.6	254.6	260.5	316.2	349.8	375.2	305.9	352.4
Distribution of U.S. supply:											
Industry stock, Dec. 31	31.3	34.6	37.3	31.9	24.7	57.3	77.9	71.3	87.3	102.4	123.4
Exports	11.8	8.0	6.5	2.3	6.5	4.6	3.0	5.0	4.3	7.4	15.8
Industrial demand	291.9	235.1	198.8	223.4	223.4	198.6	235.3	273.5	283.6	196.1	213.2
U.S. demand pattern:											
Chemicals	21.4	26.0	22.4	34.3	33.4	29.7	36.2	41.2	43.0	28.0	31.1
Petroleum	11.7	14.1	12.4	17.3	17.8	17.9	21.3	24.7	26.1	18.5	18.6
Fabricated metal products	2 .7	40.3	25.0	18.7	21.3	20.3	23.6	27.5	26.1	17.3	18.7
Transportation											
Aircraft	30.4	16.5	24.3	14.9	13.4	13.9	16.2	19.2	17.0	11.8	18.1
Motor vehicles and equipment	36.4	24.0	22.1	23.4	26.7	21.8	28.4	30.2	29.4	21.5	22.7
Ship and boat building and repairs	11.7	7.3	9.2	8.6	6.6	6.1	6.8	8.4	13.4	10.2	8.7
Total	78.5	47.8	55.6	46.9	46.7	41.8	49.4	57.8	59.8	43.6	49.5
Electrical	34.7	20.2	20.7	30.0	28.8	25.7	30.8	35.8	34.4	25.6	28.9
Household appliances	28.9	18.4	18.7	13.7	14.5	13.6	16.5	19.2	21.7	12.7	15.1
Machinery	42.6	12.9	13.1	18.3	16.5	13.7	16.5	19.2	23.0	16.4	18.2
Construction	13.8	11.0	10.8	18.1	21.3	17.9	21.3	24.7	28.8	18.4	19.8
Other	31.6	44.4	20.1	30.1	23.1	18.0	20.9	23.6	21.0	15.6	17.5
Total industrial demand	291.9	235.1	198.8	223.4	223.4	198.6	235.3	273.5	283.6	196.1	213.2
Total U.S. primary demand[2]	228.8	182.8	162.2	152.4	174.7	135.5	167.8	207.6	219.1	154.5	166.2

[1] Refined metal from domestic ores.
[2] Industrial demand less secondary.
[p] Preliminary

GEOLOGY OF LATERITE DEPOSITS

Previous Work

Nickel-bearing laterites of southwestern Oregon were investigated by the Department beginning in 1943. The results of these preliminary investigations were published by Libbey and others (1947); Dole and others (1948); and Mason (1949). The Department's work on laterites followed publication of a study of the Nickel Mountain deposit by the U.S. Geological Survey (Pecora and Hobbs, 1942).

The U.S. Bureau of Mines conducted a drilling program and did smelter testing of ore from Red Flat in Curry County; results were reported by Hundhausen and others (1954). Hotz (1961) compared the chemistry of a section of soil, saprolite, and fresh peridotite from Nickel Mountain and Eight Dollar Mountain. Hotz (1964) presented a fairly complete discussion of nickeliferous laterites in southwestern Oregon and northwestern California. His work was used often during preparation of this report.

A recent paper by Rowe and others (1976) on the geology of the Nickel Mountain Mine contains some pertinent information summarized in this report. Several other reports on nickel deposits are referred to in this paper and listed in the bibliography.

Ultramafic Rocks

Composition

Various types of ultramafic rocks occur in Oregon; the most common are harzburgite (a variety of peridotite also called saxonite) and serpentinite derived from harzburgite. Among other varieties of peridotite are dunite, wehrlite, lherzolite, and pyroxenite. Serpentinite derived from one or more of these varieties of peridotite is the predominant ultramafic rock type in most areas of the State. Nickeliferous lateritic soils in Oregon are derived exclusively from ultramafic rocks rich in olivine. Rocks of this type have been widespread in southwestern Oregon, but a large percentage of them are now altered almost completely to serpentinite (Plate 1, in pocket).

Distribution

Peridotite is generally restricted to the larger ultramafic bodies away from shear zones and contacts with other rocks, particularly later intrusives. Relatively unserpentinized peridotite seems to be more prevalent at higher elevations on ridge tops and often appears to be underlain by serpentinite, which generally has inferior resistance to erosion. Many areas of ultramafic rock in southwestern Oregon occur as upper plates in fairly low-angle thrusts, and the thrust zones enclose abundant sheared serpentinite underlying relatively unaltered peridotite.

Sheared serpentinite occurs as narrow elongate bodies that mark relatively high-angle fault zones of considerable crustal movement. A few narrow exposures of sheared serpentinite with outcrop patterns roughly following topographic map contours mark relatively low-angle thrust faults. These may represent major tectonic events between two crustal plates or minor intraformational events such as those that occurred in Curry County, where serpentinite penetrates shears in the Dothan-Otter Point Formation.

Structure

The tectonic history of the Klamath Mountains province of southwestern Oregon and northern California is complex and not well known in detail. The structure of the Blue Mountains province in northeastern Oregon is similarly complex. It is generally believed that the ultramafic rocks represent the basal part of an ophiolite assemblage, including gabbros, volcanic rocks, and sediments originating on and beneath an ocean floor. In the Klamath Mountains province, these rocks, which have been transported into their present positions as a result of impinging oceanic and continental plates, have been subjected to crumpling, folding, shearing, and thrusting, as well as lateral and vertical adjustments along high-angle faults.

The Klamath Mountains province in southwestern Oregon was largely near or below sea level during the Cretaceous and early Tertiary time; but since late Tertiary, the entire area has been uplifted. Remnants of the late Tertiary erosion surface, named the Klamath peneplain by Diller (1902), occur at a fairly uniform elevation of about 4,000 ft. Extensive stream erosion coupled with alpine glaciation of areas with elevations at or above 4,000 ft have removed most of the Tertiary soil horizon and sediments deposited on this former erosion surface. The youthful topography developed in the uplifted area is often characterized by oversteepened slopes, and landsliding has been commonplace.

The scattered, nickeliferous laterite deposits occur as erosional remnants on the old upper weathered surface and as landslide deposits. Some deposits on lower slope benches include transported or downslope creep of soil and rock debris.

Geochemistry of Nickel

The average amount of nickel in the earth's crust is about 80 g/ton or 0.008 percent. The earth's core is believed to contain about 7 percent Ni in an iron-nickel alloy. Rocks of the earth's mantle between the crust and core, estimated to be about 2,900 km (1,800 mi) thick, are believed to contain 0.1 to 0.3 percent Ni. Ultramafic rocks presumably derived from the upper mantle and tectonically emplaced in the earth's crust also have an average nickel content of about 0.2 percent.

Nickel and cobalt are close geochemical relatives of iron. Nickel is concentrated in early magmatic sulfide segregations of the pyrrhotite-pentlandite assemblage. These sulfides are the principal nickel ore minerals mined throughout the world.

In ultramafic rocks devoid of sulfides, nickel is found in the lattices of silicate minerals, principally olivine, where it can substitute for magnesium, which has a similar ionic radius. Rankama and Sahama (1950, p. 683) state that olivine may contain up to 0.5 percent Ni. Nickel also occurs in other silicate minerals, especially orthorhombic pyroxenes. Lower amounts are found in clinopyroxenes, amphiboles, and biotite.

During weathering, nickel remains largely in the solid products of disintegration and is deposited in the hydrolyzate sediments. During lateritic weathering of nickel-bearing silicate minerals and serpentine, nickel may accumulate to form nickel-silicate veins or become enriched in the insoluble residue of silica, nickel hydrosilicates, and oxides of magnesium and iron. These chemically complicated hydrosilicates form a group of claylike nickel-bearing chlorite minerals such as pimelite, $(Ni, Mg)_3 Si_4O_{10} (OH)_2 \cdot 4H_2O$ (Rankama and Sahama, 1950, p. 683-684).

Chemical Weathering of Peridotite

Although some of the oldest laterites may have formed in a Tertiary tropical environment, the younger soils and saprolites undoubtedly formed under temperate climatic conditions that have existed since Pleistocene glaciation.

The weathering process involves a gradual chemical breakdown of minerals in the rock along all surfaces exposed to air and water. Access into the rock is gained along fractures, shears, and cracks of any kind. During the winter, frost wedging enlarges and extends these cracks. Slightly acid rainwater and snow meltwater act slowly to break down olivine and pyroxene in the peridotite. The more soluble elements such as magnesium, calcium, and silica dissolve more rapidly than less soluble elements such as iron and nickel. Olivine is unstable under atmospheric conditions and tends to break down rapidly during weathering; pyroxenes (enstatite and diopside) break down somewhat more slowly (Hotz, 1964, p. 368).

Secondary and intermediate hydrous, magnesium-rich clay minerals and serpentine minerals form during the weathering process. Some of these minerals, e.g. montmorillonite, are not stable endproducts of weathering (oxidation and leaching) but are only a step in the overall process (Rudmann, 1970).

Serpentine minerals present in the parent rock are relatively stable during weathering. Chromite and magnetite are also resistant to any change during weathering and are residual minerals in the saprolite and lateritic soils.

The soil profile

The typical section of soil and weathered peridotite may be divided into five parts. From the surface downward, they are (1) dark, reddish-brown soil with minor organic residue and abundant to minor amounts of iron oxide pellets and chromite grains (variable amounts of relatively unweathered peridotite boulders are nearly always intermixed and concentrated as surface lag); (2) yellow-brown soil with variable amounts of partly weathered peridotite; (3) yellow-brown soft saprolite; (4) greenish-brown, slightly weathered peridotite or hard saprolite, sometimes with supergene silica boxwork and garnierite occurring as fracture- and joint-fillings; and (5) fresh peridotite.

The thickness of the soil profile and of each of its various segments is highly variable and dependent on several factors including age of the laterite, amount of erosion or surface movement to which it has been subjected, degree of fracturing and alteration of the parent rock, the history of precipitation in the area, vegetative cover, and composition of the parent rock.

A thick cover of iron pellets is believed to indicate an older, well-developed laterite on which erosion from wind and water has left a surface concentration of the heavier magnetite, chromite, maghemite, and limonite and/or goethite pellets. The dark, reddish-brown surface soil zone may be only about 1 ft thick or may be nearly 10 ft thick, as at Nickel Mountain (Pecora and Hobbs, 1942, p. 214). Hotz (1964, p. 367) reports that this upper section is the least variable segment of the soil profile and is commonly from 1 to 3 ft thick.

A few landslide deposits such as the north ore deposit at Nickel Mountain seem to lack the usual color stratification and are a heterogenous mixture of soil and saprolite. Older slide deposits or those which have had less internal disruption display a fairly normal soil profile.

A few areas of abundant surface peridotite boulders may have a fairly well-developed soil profile under the boulder veneer. Abundant silica boxwork float debris may indicate either a deposit disrupted by landsliding or a history of rather severe erosion which has depleted all but the roots of a once more extensive deposit.

The underlying yellow-brown soil and soft saprolite (zones 2 and 3), the most important part of the deposit, have the highest nickel content when a supergene silica-garnierite deposition is absent. The thickness of zones 2 and 3 varies from 2 or 3 ft to as much as 50 ft or more in the better deposits.

Even in the thicker deposits, the fresh, unweathered peridotite surface is highly irregular; and knobs and reefs of fresh peridotite may crop out at the surface. Such reefs may be protecting residual soil deposits from destructive erosion.

Mineralogy

Nickeliferous nontronite, the ferric iron member of the montmorillonite clay mineral series, is the major alteration mineral in saprolite derived from dunite (Rudmann, 1970; Rowe and others, 1976). Nontronite is generally subordinate to remnant serpentine in saprolite derived from harzburgite (saxonite). Analysis of clay separations from saprolites derived from dunite shows 3.7 percent Ni; analysis of clay fractions of saprolite derived from peridotite indicates 3.5 percent Ni. The crude saprolite from dunite assays 1.73 percent Ni, from peridotite 1.37 percent Ni.

Rowe and others (1976) state that goethite is the dominant mineral in the near-surface soil zone at Nickel Mountain and suggest that, although no discrete nickel minerals have been identified in this zone, some nickel hydroxide occurs mixed with the goethite. Other minerals in the soil zone include maghemite, silica boxwork fragments, residual enstatite, chromite, spinel, ilmenite, magnetite, and small amounts of chlorite and clay minerals including montmorillonite, kaolinite, gibbsite, and diaspore. The presence of these alumina-rich minerals is surprising since the parent rock has a very low alumina content (generally less than 2 percent). By X-ray diffractometer, Hotz (1964, p. 369-371) identified montmorillonite, chlorite, and talc in the clay fraction of lateritic soils at Eight Dollar Mountain. Talc and chlorite are more prominent in the surficial zone, and montmorillonite is more plentiful at deeper levels.

Rowe and others (1976) divide Nickel Mountain ores into three groups: soil, saprolite, and boxwork, with over 70 percent of the reserves classified in the saprolite group. Nickel is concentrated in saprolite by replacement of magnesium in hydrous silicate minerals formed during the weathering process. Most of the nickel in saprolite is believed to occur in nickeliferous nontronite. Additional nickel is concentrated in thin fracture fillings of gornierite between blocks of saprolite. Some nickel is probably also present in serpentine, chlorite, and talc, where it proxies for magnesium (Hotz, 1964, p. 371).

The mineralogy of silica boxwork includes supergene chalcedony, hydrous nickeliferous magnesium silicates (gornierite group), and minor hydrous iron oxides. X-ray diffraction work by Hotz (1964) and Rowe and others (1976) indicates that the garnierite group at Nickel Mountain consists of o mixture including a serpentinelike mineral, o tolcose mineral, and lesser amounts of sepiolite and chloritelike minerals.

The term "garnierite group" is suggested by Pecora and others (1949) and Faust (1966) as a field term for all hydrous nickel-magnesium silicate minerals. Pecora and others (1949) recognize a direct relationship between color, density, index of refraction, specific gravity, and nickel content. The dark-green varieties of garnierite may contain as much as 34 percent Ni. Better grade material overages about 15 percent Ni (Rowe and others, 1976, Table IV).

Prospecting Guides and Techniques

All nickel laterite occurrences in southwestern Oregon are situated on ultramafic rocks, preferentially on relatively unserpentinized peridotites, mainly horzburgite and dunite. Areas of relatively gentle slope such as ridge tops and benches are more likely to have accumulations of lateritic soil. Areas of steep, rugged terrain ore generally devoid of soil covering. A significant number of known deposits are in relatively old landslides, where weathering processes progress somewhat more rapidly because the rock is quite broken.

Most deposits were discovered during ground reconnaissance and have been known for a good many years. A few deposits were discovered by air reconnaissance and the use of color aerial photographs. For this study, color infrared aerial photographs with an approximate scale of 1:16,000 taken in 1973 for the Siskiyou National Forest (Project Number 41033) were particularly helpful; most areas of anomalous color observed by this technique have some lateritic soil cover. The dark-red soils of areas underlain by nickeliferous laterite deposits show up as yellowish-tinted areas on the color infrared photographs, and the normally green vegetative cover appears as various shades of red. Areas of red soil with foirly dense vegetative cover of brush and scrub pine trees are brownish-red in color. Bright green, dense vegetation over nonultramafic features such as dikes and inclusions is readily distinguishable.

During preliminary on-the-ground field investigation, visual estimations were mode of the relative abundance of unweathered surface rock. Sampling was usually done with a hand-operated soil-augering tool. The depth of sampling was limited by the depth of soil, chunks of hard rock encountered, length of available extension rod, and strength of the operator's bock. Depths of 7 to 10 ft were commonly attained; depths greater than 15 ft were seldom achieved. A fair ideo of the potential grade con be obtained at depths of 3 to 5 ft. Without the use of geophysical instruments or power equipment, depth can only be estimated. Although not done in this study, follow-up exploration may involve use of o portable seismograph to measure depth to unweathered bed rock; a backhoe for bulk sampling and more accurate determination of the percentage of intermixed unweathered rock; and/or a power drill capable of penetrating soil, loose boulders, and bed rock. Because they ore versatile, relatively inexpensive, and efficient, the seismograph and backhoe hove become the most popular tools for laterite exploration (Figure 2).

Figure 2. Backhoe sampling, Rough and Ready outwash deposit near O'Brien and U.S. 199.

OTHER TYPES OF NICKEL DEPOSITS

The two other types of nickel prospects in Oregon are in nickel sulfide deposits and silica-carbonate rocks. Their modes of occurrence are described below.

Nickel Sulfide Deposits

Deposits in Oregon

Two deposits of nickel-bearing sulfide minerals have been described in the State: the Shamrock Prospect in southwestern Oregon and the Standard Mine in northeastern Oregon. Nickel is a minor metal at the Standard.

The Shamrock Prospect is developed by about 1,500 ft of underground workings but has had no production. Mineralization consists of pyrrhotite, pentlandite, and chalcopyrite in a small norite sill. The ore contains some nickel, copper, cobalt, and minor platinum metals.

The Standard Mine has produced about 10,000 tons of ore containing gold, silver, copper, cobalt, nickel, and antimony from quartz fissure veins in porphyritic andesite (greenstone) that has been intruded by dikes of granodiorite and diabase. The Standard vein, which penetrated a fault zone, varies from a few inches to 4 ft thick. Ore minerals occurring in a gangue of quartz with some ferriferous dolomite and calcite are pyrite, chalcopyrite, arsenopyrite, cobaltite, glaucodot, bismuthinite, native bismuth, galena, and sphalerite. Secondary ore minerals include erythrite, annabergite (?), jarosite, and malachite. In 1915, the total length of underground workings at the Standard Mine was about 3,800 ft.

Other areas

Sulfide deposits having significant amounts of nickel associated with copper and cobalt are generally found in or related to mafic or ultramafic igneous rocks such as the Sudbury Complex, Ontario; Duluth Gabbro Complex, Minnesota; and the Stillwater Complex, Montana. Sulfides of the Duluth Gabbro Complex occur in a troctolite phase just above the base of the complex (Snyder, 1968, p. 269). Disseminated to massive sulfides occur as layers, lenses, and pods of pyrrhotite, pentlandite, and chalcopyrite in the basal norite zone of the Stillwater Complex (Page and Nokleberg, 1974). Many other examples of similar geologic occurrence are known in the world; and it appears logical that areas of gabbro, olivine gabbro in particular, may be favorable locations to prospect for nickel- and copper-bearing sulfides.

Prospecting techniques

Preliminary prospecting techniques for sulfide deposits may involve geochemical sampling of stream silts followed by wide-grid soil sampling in areas of anomalous nickel and copper. Certain geophysical techniques such as magnetometer and induced polarization (I.P.) have also been successful in indicating areas of sulfide mineralization. A continuing exploration program to develop sulfide deposits may eventually involve core drilling to establish reserves.

Silica-Carbonate Deposits

Pods and lenses of silica-carbonate rock, an alteration product of serpentinite, are apparently localized along major faults in northeastern Oregon. These rocks consist of silica in the form of chalcedony, quartz and/or opal, and varying amounts of granular carbonate, i.e. iron-rich dolomite, that is close to ankerite in composition. Accessory minerals include chromite, mariposite (?), or fuchsite (?). The latter green minerals have been mistaken for nickel-bearing minerals of the garnierite group which may also be present as minor accessory minerals in some of these altered rocks. The silica-carbonate rocks probably formed as low-temperature, carbon dioxide-rich hydrothermal (hot spring or fumerolic) alteration of serpentinite. Similor rocks are described as host rocks to quicksilver deposits in the New Idria District in California (Eckel and Myers, 1946; Linn, 1968).

The silica-carbonate rocks do not appear to have been enriched in nickel, retaining approximately the same nickel content (0.10 to 0.34 percent) as the serpentinites from which they have been altered. Some minor residual enrichment of nickel occurs during weathering of the silica-carbonate rocks, as at the Red Elephant Prospect, for example, where surface weathered material in an 8.6-ft auger sample of soil assays 0.41 percent Ni.

These rocks are discussed in this text only because several reported "nickel prospects" in northeastern Oregon are found in them, and occasional selected "high grade" samples have been assayed as much as 0.50 percent Ni. The Berry Prospect near John Day has a few, very small lenses or pods of chrysoprase. The average nickel content of all samples at the Berry Prospect is about 0.18 percent, essentially the same as the surrounding serpentinite. Since similor grades are found in other occurrences of this type, they cannot be considered an important potential nickel resource.

DISTRIBUTION OF LATERITE DEPOSITS

The laterite deposits in southwestern Oregon are grouped into four general areas. Most deposits occur in southwestern Josephine and southeastern Curry Counties in the Josephine ultramafic sheet extending from Eight Dollar Mountain in a southwesterly direction to the California line. A second group occurs in isolated erosional remnants of an upper thrust plate of peridotite in Curry County east of Gold Beach and south of the Rogue River. The other two areas are the deposits of Nickel Mountain in southern Douglas County and minor occurrences on Iron Mountain along the border of Coos and Curry Counties.

Nickel Mountain Deposits (1, Plate 1) *

The most important deposits in southwestern Oregon are those at Nickel Mountain near Riddle (Figure 3). The Hanna Nickel Mine, located on these deposits, is the only current source of primary nickel in the United States.

Location

The Nickel Mountain deposit (Figure 4) is situated about 4 mi west of Riddle, a small town on the Southern Pacific Railroad. A siding and spur serve the Hanna Mining Company nickel smelter, situated at the south base of the mountain.

Figure 3. Aerial view of Nickel Mountain, looking from northeast to southwest.

* Numbers refer to deposits whose locations are shown on either Plate 1 or Plate 2, in pocket.

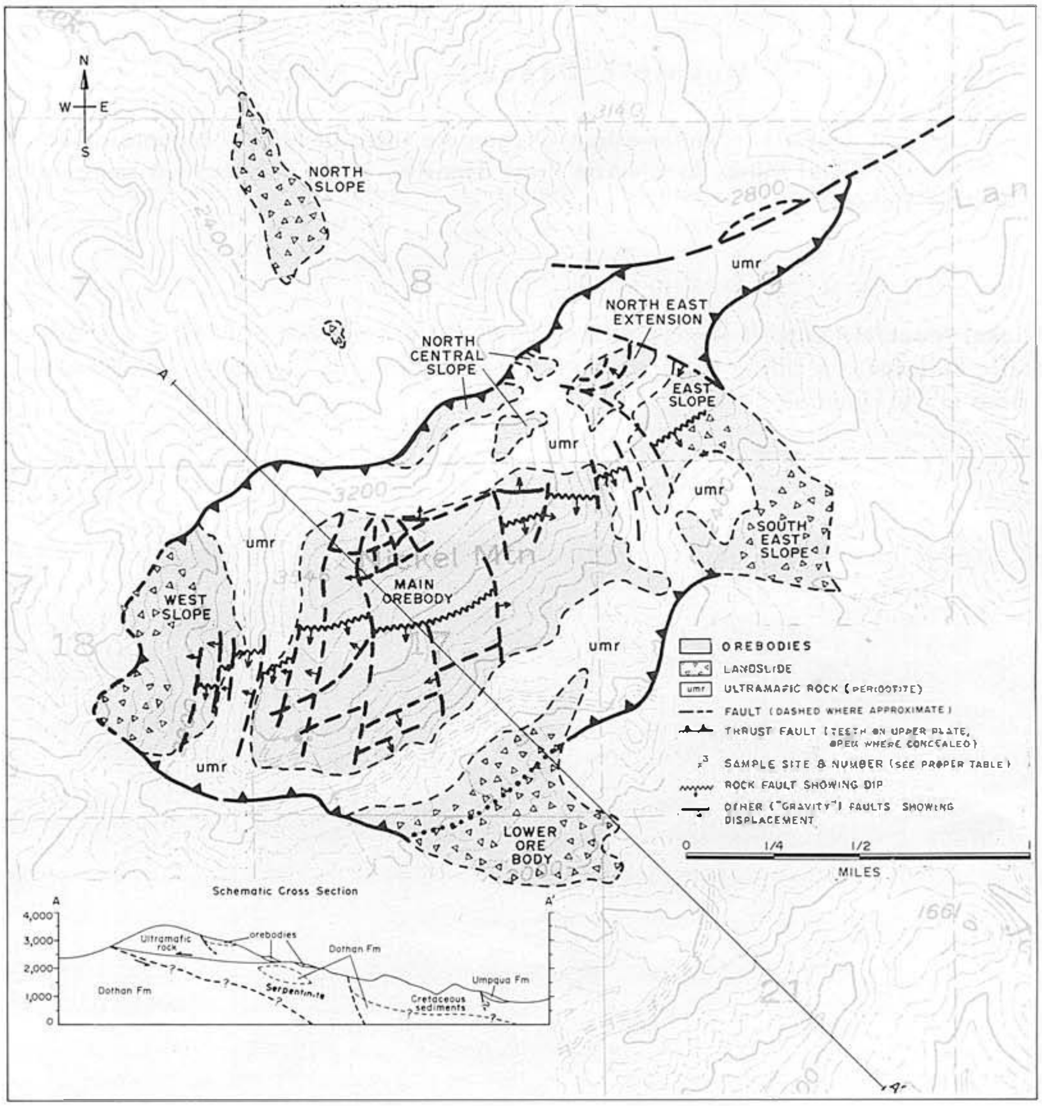

Figure 4. Geologic map and cross section of Nickel Mountain deposit showing upper peridotite thrust plate and outlines of orebodies. (Modified from Rowe and others, 1976)

Geology

Much has been written on the geology and deposits of Nickel Mountain including Clark (1888); Austin (1898); Kay (1907); Diller and Kay (1924); Pecora and Hobbs (1942); Dole and others (1948); Pecora and others (1949); Oregon Department of Geology and Mineral Industries (1953); Foster (1957); Hotz (1964); Cumberlidge (1965); Cumberlidge and Chace (1968); Chace and others (1969); Hotz and Romp (1969); Rudmann (1970); Cornell (1971); Romp (1972); and Rowe and others (1976). Starting in 1952, this writer has mode many visits to the area and has done some large-scale geologic mapping of the immediate area of the mine. In 1968, Al Wood, geologist formerly with the Hanna Mining Company, assisted with mapping.

The upper 500 to 1,200 ft of Nickel Mountain is underlain by relatively unserpentinized peridotite (harzburgite) and dunite (labeled "umr" in Figure 4). On the south and east slopes, this peridotite is underlain by sheared serpentinite and sheared lenses of sediments and volcanic rocks of the Dothan Formation. On the northwest slopes of the mountain, peridotite is underlain by sediments of the Dothan Formation, which are somewhat younger than the ultramafic rocks. The overall structure is not well understood, but it appears that the peridotite is an erosional remnant of an overthrust sheet (see cross section, Figure 4). The source of this peridotite thrust plate is uncertain, and no nearby correlative segments have been recognized. Similar geologic relationships ore found in Curry County, however, as in the vicinity of Snow Camp Mountain. The relative ages of rocks in the area ore shown in Table 2.

Table 2. Stratigraphy of the Nickel Mountain area

System	Group	Formation	Intrusive rocks
Tertiary	Umpqua	Lookingglass	
Early Cretaceous	Myrtle	Days Creek Riddle	
Late Jurassic Jurassic (?)		Dothan	 Gabbro and related dikes Serpentinite Peridotite

Ore deposits

The various orebodies (areas of lateritic red soil and nickel enrichment) were mopped by Cumberlidge and Chace (1968) and Rowe and others (1976). Orebodies mopped by Rowe and others are shown in Figure 4. The total area of the various ore deposits is about 790 acres. Cumberlidge and Chace (1968) reported 500 acres with on overage depth of 50 ft. The thickness of deposits reportedly varies from 5 to 200 ft. The profile of soil and weathered rock in the main orebody at Nickel Mountain contains all of the phases shown in Table 3.

The ore is classified into three groups: soil, saprolite, and boxwork. Cumberlidge and Chace (1968) report that the soil accounts for approximately 20 percent of the ore reserve. Average soil thickness is 10 ft, ranging from no soil at all to as much as 40 ft thick. The soil is rich in hydrous iron oxides and clay minerals and contains scattered fresh peridotite boulders and occasional irregular fragments of leached chalcedony boxwork. The gradational transition from red to yellow soil generally occurs within a few inches to 1 ft and reportedly reflects the change from predominantly ferric to ferrous compounds. The surface horizon of red soil is generally about 1 to 3 ft thick. A maximum of 9 ft is reported by Pecora and Hobbs (1942, p. 214). Nickel content of the soil zone varies from about 0.1 percent at the surface to as much as 2 percent at relatively shallow depths in the yellow-brown soil.

Table 3. Classification characteristics of ore types at Nickel Mountain Mine
(Modified from Rowe and others, 1976)

Group	Ore type	Classification characteristics	Approximate Ni content (%)
Soil	Red soil	Fe - 12%; soil texture; brick-red color	0.1-0.8
	Yellow soil	Fe - 16%; soil texture; yellow to brown color	0.6-1.5
Saprolite	Soft saprolite	MgO - 24%; saprolite texture; less than 20% fresh peridotite	1 -2.5
	Hard saprolite	MgO - 24-34%; saprolite texture; 20-50% fresh peridotite	0.8-1.5
	Soprolized peridotite	MgO - 34-40%; saprolite texture; 50-75% fresh peridotite	0.5-1
	Peridotite	MgO - 40-45%; saprolite to fresh peridotite texture	0.2-0.3
Boxwork	Boxwork	SiO_2 - 50% (veins also present in saprolite); boxwork veins, massive chalcedony veins, or chalcedony bands; more than 75% fresh peridotite	1.5-5+

The soils contain goethite as a dominant mineral, minor clay minerals, maghemite in the upper part of the red soil horizon, and chemically resistant minerals such as silica boxwork fragments, enstatite, chromite, spinel, ilmenite, and magnetite (Rowe and others, 1976).

Soil mineralogy

The saprolites of Nickel Mountain are classified by their MgO content or by their degree of weathering. The three types are soft saprolite, hard saprolite, and soprolized peridotite. Thoroughly weathered, soft saprolite contains from about 15 to 25 percent MgO; hard saprolite contains from about 25 to 35 percent MgO; and saprolized peridotite contains from about 35 to 40 percent MgO. The unweathered peridotite at Nickel Mountain contains from about 40 to 45 percent MgO. According to Rowe and others (1976), over 70 percent of the ore reserves at Nickel Mountain can be classified in the saprolite group. The saprolite mineralogy includes montmorillonite and serpentine, with lesser quartz, hydrous iron oxides, olivine, enstatite, amphibole, and tolc. Serpentine, olivine, and enstatite are residual minerals from the peridotite.

The boxwork ores hove over 50 percent SiO_2 and ore deposited by supergene processes along faults or other open channelways for percoloting ground water. These chalcedony-rich ores charocteristicolly have multiple breccia textures apparently formed in fault zones that were active during supergene silica deposition (Rowe and others, 1976). Boxwork ores ore generally quite porous. They are the highest grade of the various ores due to the deposition of garnierite-group minerals including sepiolite and nickel-bearing chlorite. Specimens of garnierite ore may assay 20 percent Ni or more, but the boxwork ore is more commonly in the range of 1.5 to 2 percent Ni. Pecora and others (1949) note that darker green varieties of garnierite have a higher nickel content, lower magnesium content, higher specific gravity, and higher index of refraction. Their samples vary in content from 2 to 29 percent Ni. The 2 percent Ni sample contains 36.36 percent MgO; the 29 percent Ni sample has 5.28 percent MgO. The silica, iron, and water content of garnierites varies less significantly.

Boxwork ores at Nickel Mountain probably accounted for nearly 10 percent of the total ore reserves, but much of this high-grade material has been depleted in mining of the main orebody. Cumberlidge and Chace (1968, p. 1658) describe numerous, thin, gornierite-cholcedony-serpentine veinlets, rarely exceeding 5 percent of the total weight of the ore, filling fractures in saprolite and fresh peridotite. They also describe zones of predominantly gornierite-cholcedony boxwork ore as much as 40 ft thick occuring along the hanging wall of Rock Fault. They distinguish three varieties of boxwork ore:

"(1) True boxwork veins. These vary in thickness from a few inches to more than 15 ft and ore composed of thin-walled chalcedony boxes, 1 to 5 cm square, commonly filled or portly filled with hydrous Ni-Mg silicates including gornierite and minor amounts of limonitic earth.

"(2) Chalcedony veins, massive or bonded. These ore up to 10 ft thick, ore composed essentially of chalcedony in shades of white, gray, and brown, and may contain up to 75 percent SiO_2. Occasional bonds or partings of gornierite ore common, and some green chalcedony (chrysoprose) is also found. However, this ore is generally of lower grade than other types of boxwork.

"(3) Breccia veins. These consist of fragments of peridotite, saprolite, serpentine, early chalcedony, or early gornierite, cemented by later chalcedony, serpentine, and gornierite. Fault grooving and striae, often coated with later gornierite and cholcedony, ore very common. Thin portings of soft, plostic, white or greenish sepiolite also occur with the breccia veins and may represent a fault gouge or mylonite."

Structure

Jointing and faulting has obviously influenced the concentration of ore at Nickel Mountain. A strong east- to northeast-striking, 35 to 45° south-dipping, normal fault called "Rock Fault" is the most important structure. It marks the north edge or footwall of the main orebody with depth. The main high-grade boxwork ores ore along Rock Fault. The thick boxwork is vuggy and cavernous, implying deposition in open fractures (Cumberlidge and Chace, 1968, p. 1663). The footwall of Rock Fault is usually fresh peridotite. Several semiporollel faults that enter, cross cut, or parallel Rock Fault ore mopped as "gravity faults" by Rowe and others (1976) and ore shown on Figure 4. It appears that most of these faults ore truly gravity faults.

At Nickel Mountain, fairly lorge areas of slumping appear to hove occurred in the lower, west slope, and southeast slope orebodies. The north slope deposit is a completely detached mudflow-type slide in which soil, saprolite, and rock debris are fairly well mixed. The time of sliding is not known. It may hove occurred from a few hundred to a few thousand years ago. Although the satellite orebodies hove not moved for from their original positions, they hove probably sustained very gradual gravity slumping movement over on extensive period of time. Accompanying fracturing and opening of joints in the slump areas have helped establish more channelways for chemical leaching of the peridotite by ground water and have thus accelerated the formation of soil and saprolite.

Mining and metallurgy

Mining at Nickel Mountain has been done by open-cut level benches with maximum 20-ft vertical intervols and minimum 50-ft width. The benches ore connected by haulage roods with 10 percent maximum grade. Most of the ore is dug without blasting, but occasional vertical 6½-in. blast holes ore drilled and loaded with a fertilizer fuel-oil explosive mixture. Loading is done with 3½- and 5½-yd diesel shovels, and hauling to the screening and tram-loading plant is done with 60-ton diesel trucks. Lorge boulders of unweathered peridotite ore rejected in both the mining and screening operations. In recent years, approximately one-half of the mined rock is rejected.

Ore is transported down the mountain to the smelter on on aerial tram for a distance of about 8,300 ft and vertical drop of about 2,000 ft. The tram has a maximum capacity of 250 short tons/hr and utilizes 50-cu ft cable-suspended tram cars. Two 300-hp induction generators maintain the speed of 500 ft/min. The braking action of these generators produces about 500 hp used to operate the mine facilities at the top of the mountain.

The average grade of smelter feed at the mine has gradually dropped from a high of about 1.5 percent Ni during the first few years of operation to about 1 percent (?) in 1977.

Table 4. Mine and smelter production summary *

Year	Crude tons mined	Nickel production (pounds)
1954	129,000	319,000
1955	423,000	6,505,000
1956	614,000	11,383,000
1957	1,087,000	18,122,000
1958	1,243,000	21,234,000
1959	1,287,000	20,794,000
1960	1,426,000	22,229,000
1961	1,422,000	20,650,000
1962	1,395,000	21,139,000
1963	1,480,000	21,448,000
1964	1,813,000	22,473,000
1965	1,898,000	25,333,000
1966	1,691,000	24,533,000
1967	1,672,000	26,070,000
1968	1,898,000	26,252,000
1969	1,781,000	26,172,000
1970	2,137,000	25,349,000
1971	2,215,000	25,934,000
1972	2,254,000	26,124,000
1973	2,515,000	25,872,000
1974	2,430,000	26,130,000
1975	2,907,000	25,993,000
1976	3,555,000	26,060,000

* Furnished by Hanna Mining Company

Production

The final product of the smelter is ferronickel containing 50 percent Ni. Production records of the operation are listed in Table 4.

Red Flat and Vicinity Laterite Deposits (8, Plate 1)

Location

From U.S. 101 near Gold Beach, Red Flat (Figures 5 and 6) is reached via the Hunter Creek road and the connecting prospect road in secs. 18 and 19.

History and development

Mining claims were reportedly first located in the area in 1939 by Harry Hefferley (written communication, S. J. Colebank, March 14, 1978). J. E. Morrison examined the area in 1937, reporting a few shallow trenches and a 32-ft shaft (Oregon Department of Geology and Mineral Industries, 1940). Libbey and others (1947) did reconnaissance mapping and hand-auger sampling in 1946 and 1947. U.S. Bureau of Mines personnel explored the area by preliminary hand-auger sampling in 1945 and followup star-churn drilling in 1952 and 1953. Hundhausen and others (1954) reported the results. The U.S. Bureau of Mines drilled 22 churn-drill holes 6 in. in diameter, averaging 35 ft deep but ranging from 20 to 117 ft in depth. The claims have been explored by about 5 mi of prospect roads and about 15,000 ft of bulldozer trenching. The claims are currently (1977) held by Hanna Mining Company, Red Flats Nickel Corporation, and Big Basin Nickel Corporation of Gold Beach. Appling (1955) reports sampling and mapping in the area to the north in secs. 13, 18, and 19.

A small bog near the center of SE$\frac{1}{4}$ sec. 13 contains an interesting floral assemblage typical of swampy areas in ultramafic rocks. In 1971, withdrawal from mineral entry of the entire SE$\frac{1}{4}$ sec. 13 was proposed so that it could be held as a special botanical area. Subsequent investigations delineated more completely the nickel-bearing laterites of this northern area.

Geology

The area is interpreted to be a relatively thin erosional remnant of an ultramafic thrust sheet together with a thin sheet of Colebrooke Schist overlying the Dothan-Otter Point Formation. Patches of partly serpentinized harzburgite overlie sheared serpentinite, which in turn overlies and is intermixed with thin lenses and sheets of Colebrooke Schist. This assemblage overlies relatively unaltered Dothan-Otter Point marine sediments and minor volcanic rocks. Nickel-bearing lateritic soils and saprolite have developed on the partly serpentinized harzburgite. Hotz (1964) reports that ferruginous laterites developed here from serpentinite are similar to deposits in Cuba and the Philippines. Areas of complete serpentinization and shearing, however, generally contain very little soil cover. Some areas of sheared serpentinite are reported to contain anomalous nickel (Hundhausen and others, 1954, p. 7). The ultramafic rocks have been intruded by a number of small diabase dikes, as evidenced by patches of diabase surface rubble in the soil. Slumping and landsliding are very important features in the northern, western, and southeastern extensions of lateritic soil cover.

Deposits

Hundhausen and others (1954) report the maximum depth of soil and saprolite development with or without nickel-enriched serpentinite is about 50 ft. The average depth of drilling at which the ore grade drops below 0.40 percent Ni appears to be about 27 ft, but the average thickness of the nickel-rich serpentinite deposit is 12.5 ft. A few surface patches of iron-shot accumulation occur on the untransported residual soil on the ridge top in the W$\frac{1}{2}$ sec. 30. Garnierite occurs in the nickel-enriched serpentinites a few hundred feet north of the spring near the south end of the ridge in SW$\frac{1}{4}$ sec. 30 (Hundhausen and

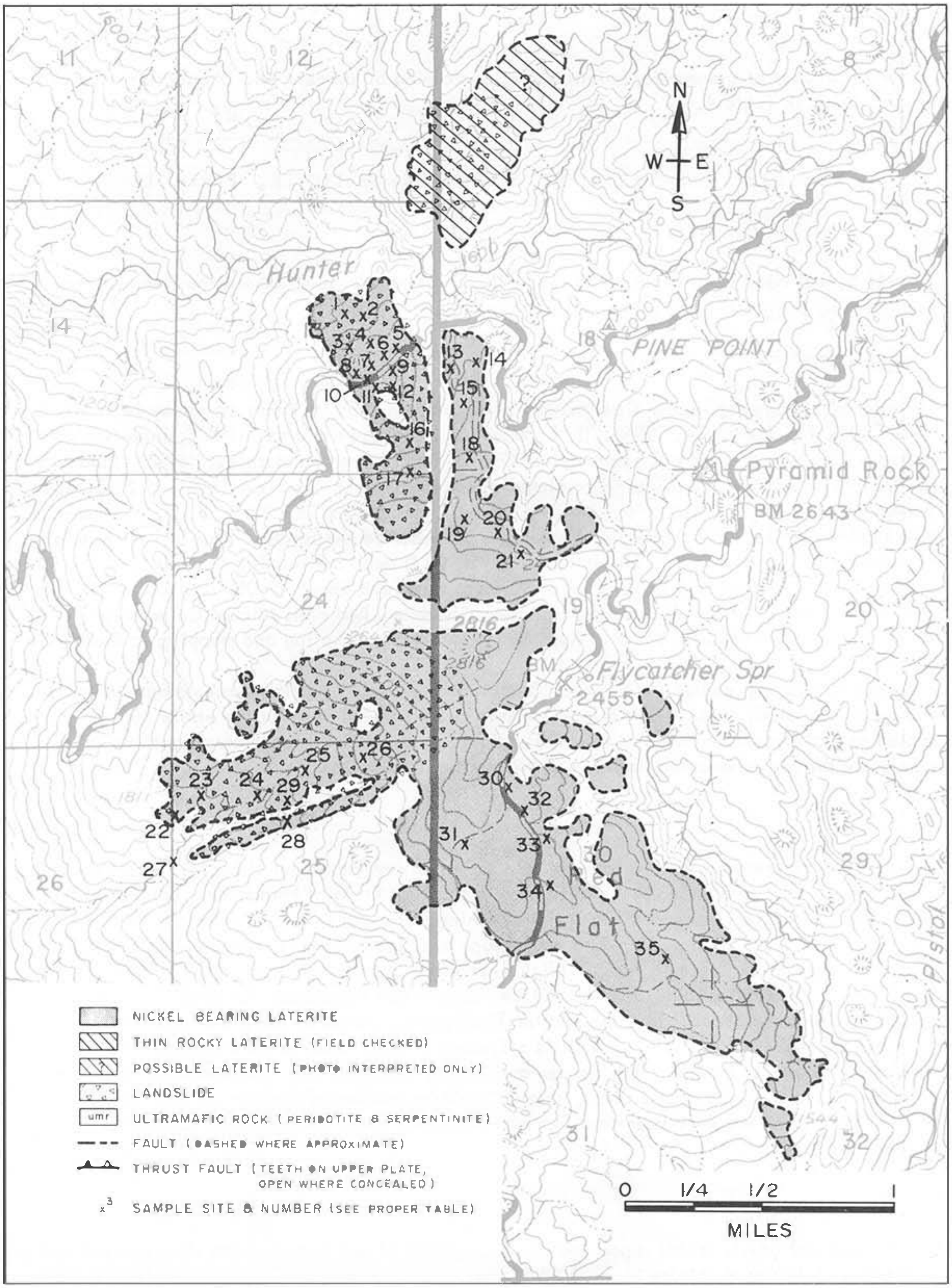

Figure 5. Geologic map of Red Flat and vicinity. Sample assay results appear in Table 5.

Figure 6. Aerial photograph of Red Flat area.

Table 5. Sample assay results, Red Flat area

Sample number ****	Assay number	Type	Depth interval (ft)	Location ¼	Sec.	Percent Ni	Co	Cr	Fe
1	AJG-69	Auger	0- 7	S/NE	13	0.69	0.10	----	----
2	AJG-68	Auger	0- 6	S/NE	13	0.50	----	----	----
3	5-AGG-80-84	Auger	0- 6	NW/SE	13	0.42	----	----	----
4	6-AAG-85	Auger	2- 3	N/SE	13	1.12	----	----	----
5	1-AGG-56-62	Auger	0- 7	NE/SE	13	0.74	----	----	----
6	2-AGG-63-66	Auger	0- 4	NE/SE	13	0.70	----	----	----
7	3-AGG-67-72	Auger	0- 6	SE	13	0.58	----	----	----
8	4-AGG-73-79	Auger	0- 7	SE	13	0.94	----	----	----
9	9-AAG-88	Auger	2- 4	E/SE	13	0.45	----	----	----
10	4-NR-2-15*	Channel	4-18	SE	13	0.83	----	----	----
11	7-AAG-86	Auger	2- 6	SE	13	0.96	----	----	----
12	8-AAG-87	Auger	2- 5.5	E/SE	13	0.90	----	----	----
13	3-NR-2-14*	Chip	0- 2	NW/SW	18	0.41	----	----	----
14	5-NR-2-16-20*	Auger	0-13.5	NW/SW	18	0.86	----	----	----
15	2-NR-2-13*	Channel	0- 2	SW	18	0.55	----	----	----
16	RF-4(5-15-75)***	Auger	0- 6.6	SE/SE	13	0.34	----	----	14.0
17	RF-7(5-76)***	Auger	0- 9	S/SE/SE	13	0.69	----	0.70	21.0
18	8-NR-3-1-2*	Auger	0- 5	SW	18	0.90	----	----	----
19	6-NR-2-21-22*	Auger	0- 5.5	NW/NW	19	0.78	----	----	----
20	7-NR-2-23-25*	Auger	0- 8.0	NW/NW	19	1.11	----	----	----
21	AJG-57	Auger	5- 9.5	NW	19	1.54	----	----	----
22	AKG-19	Channel	0- 2	W/NW/NW	25	0.13	----	1.00	----
23	AJG-11	Auger	0- 2.5	W/NW	25	0.51	----	----	----
23	RF-1(5-14-75)***	Auger	0- 4.2	NW/NW	25	0.18	----	----	----
24	AJG-12	Auger	0- 5	NW	25	0.49	0.08	0.39	12.5
24	RF-3(5-14-75)***	Grab	Creek cut	NE/NW	25	0.41	----	----	----
25	AJG-62	Auger	0- 6.5	NW/NE	25	0.72	0.06	----	----
26	AJG-63	Auger	0- 5.6	N/NE	25	1.06	----	----	----
27	AJG-14	Grab	Surface	W/SW/NW	25	0.75	----	----	----
27	RF-2(5-14-75)***	Grab	Surface	SW/NW	25	0.21	----	----	----
28	AJG-60-61	Auger	0- 9.5	E/NW	25	0.63	0.11	1.72	41.2
29	AJG-58-59	Auger	0- 9.5	E/NW	25	0.61	----	----	----
30	DH 6704**	Drill	0-10	NW	30	0.65	----	----	----
31	DH 6701**	Drill	0-25	SW/NW	30	0.78	----	----	----
32	DH 6705**	Drill	0-15	NW	30	0.57	----	----	----
33	DH 6702**	Drill	0-25	SE/NW	30	0.83	----	----	----
34	DH 6703**	Drill	0-15	NE/SW	30	0.66	----	----	----
35	DH 6706**	Drill	0-20	SE	30	0.55	----	----	----

* Appling (1955)
** Drill hole data furnished by Red Flats Nickel Corp; results averaged from 5-ft interval assays
*** Assayed by Hanna Mining Company
**** These numbers are found in Figure 5 and indicate locations from which samples were taken

others, 1954, p. 7). The presence of gornierite in the serpentinite probably best explains its anomalous nickel content.

The total area of lateritic soil cover shown in Figure 5 is about 1,100 acres. The unexamined area (mapped only from aerial photographs) north of Hunter Creek (largely in sec. 7) contains about 125 acres.

The average grade of soil and saprolite, based on a large number of samples over the entire area (south of Hunter Creek), is about 0.80 percent Ni, 0.15 percent Co, 1.14 percent Cr_2O_3, and 18 percent Fe. The average amount of unweathered rock in the soil over this area is estimated to be 40 percent by volume. The average depth of soil and saprolite is estimated to be about 8 ft. If more areas of nickel-enriched serpentinite are found, this figure will increase.

Three bulk samples submitted in 1975 by the Red Flats Nickel Corporation to the U.S. Bureau of Mines averaged 0.67 percent Ni, 0.06 percent Co, 28 percent Fe, 0.01 percent Cu, and 1.36 percent Cr.

Sample assay data obtained during this study and from other unpublished sources are given in Table 5. Considerably more Red Flat assay data are available in Hundhausen and others (1954).

Deposits in the Josephine Ultramafic Sheet

General

The accepted geologic name for the largest mass of peridotite and serpentinite exposed in Oregon is the "Josephine ultramafic sheet." It extends from the area of Eight Dollar Mountain, which is southwest of Selma, for about 22 mi south-southwest into California, and from Woodcock Mountain, west of Cave Junction, for about 16 mi west to the Vulcan Peak area. Approximately 180 sq mi lie within Oregon.

Fifteen areas of nickel laterite in the Josephine ultramafic sheet are described in alphabetical order in this report.

Boldface Ridge laterites (21, Plate 1)

Location: Thirteen small patches of lateritic soil are plotted on the Boldface Ridge area map (Figure 7) and occur in secs. 19, 20, 29, 30, and 31, T. 40 S., R. 10 W., and in secs. 24, 25, and 36, T. 40 S., R. 11 W., between Boldface and Chrome Creeks, both of which drain into the North Fork of Smith River. Access from O'Brien on U.S. 199 is by the Wimer road, Sourdough Chrome Mine road, and a trail extending out on the ridge from the Sourdough Chrome Mine.

The area has not been adequately field checked. Mapping was done with the aid of color infrared aerial photographs; outlines of soil areas are subject to corrections with more detailed field mapping.

Geology: The area is underlain by partly serpentinized harzburgite thrust over Late Jurassic marine sediments of the Dothan Formation to the west. The peridotite has been intruded by occasional dikes of dacitic to diabasic composition. Patches of bouldery, lateritic soil on the ridge are probably erosional remnants of a more extensive deposit on the upland surface. Patches on the lower slopes appear to be slumps or slide deposits.

Deposits: Very little specific information on the deposits is available. Those examined along the trail appear to be shallow and rocky. The total area of soil in 13 small patches determined mainly from aerial photographs is about 280 acres. Much of this may be too thin and rocky to be of commercial interest. A small patch of soil near the northeast edge of the map area on the small spur ridge at an elevation of about 2,400 ft has been recently claimed and explored in a preliminary fashion by Inspiration Development Company. The Department has had only two samples assayed from the area. Average grade of the northeastern patch is reported to be 0.67 percent Ni.

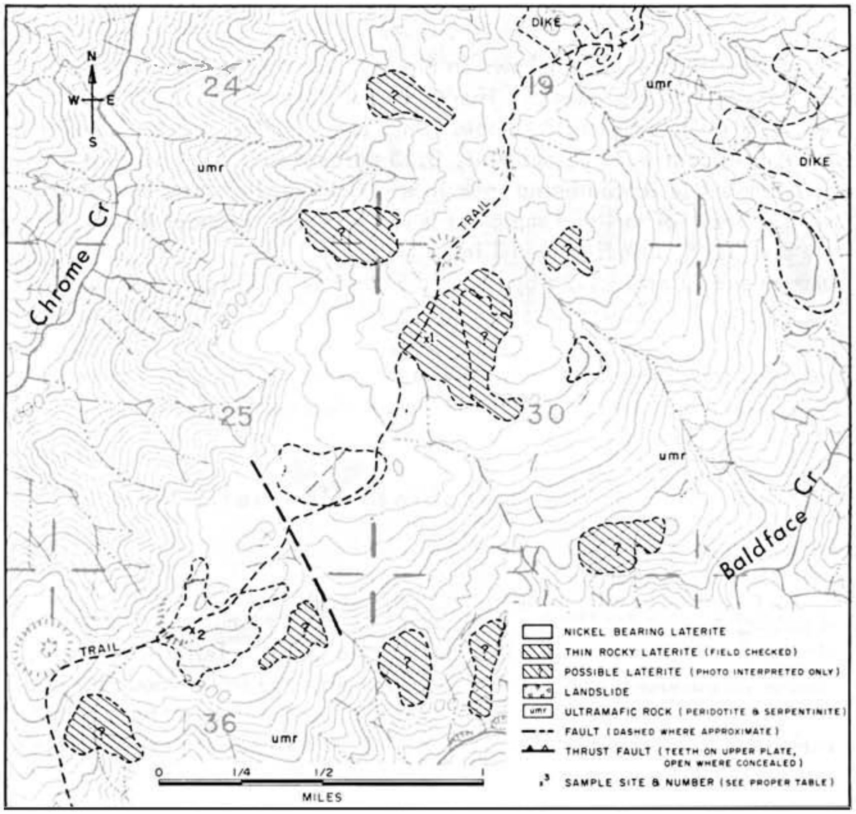

Figure 7. Geologic map of Baldface Ridge area. Sample assay results appear in Table 6.

Toble 6. Sample assay results, Boldface Ridge area

Sample number *	Assay number	Depth interval (ft)	Location ¼	Sec.	T.(S.)	R.(W.)	Percent Ni	Co	Fe	Cr
1	AFG- 58	0-1	NW	30	40	10	0.37	Trace	----	----
2	AJG-111	0-9	NE	36	40	11	0.75	0.14	45	1.78

* These numbers ore found in Figure 7 and indicate locations from which samples were token

Cedor Springs laterites (22, Plate 1)

Location: The main body of lateritic soil lies along Cook rood and across Chetco Divide trail rood in unsurveyed sec. 35, T. 40 S., R. 10 W. (Figure 8). The roods run approximately along the boundary between Josephine and Curry Counties. From O'Brien on U.S. 199, the area, o flat-topped ridge, is reached via the Wimer and Cook roods. Cedar Springs is located beside the old McGrew wagon road about 1,500 ft west of the deposit.

Geology: The area is underlain by partly serpentinized horzburgite, with some dunite and serpentinite. The main area of lateritic soil lies about 200 yd southwest of the contact with a large complex dioritic body, including granodiorite, dark hornblende diorite, and dacite porphyry, as mopped by Wells and others (1949). A few small diabase and dacite dikes also intrude the ultramafic rocks.

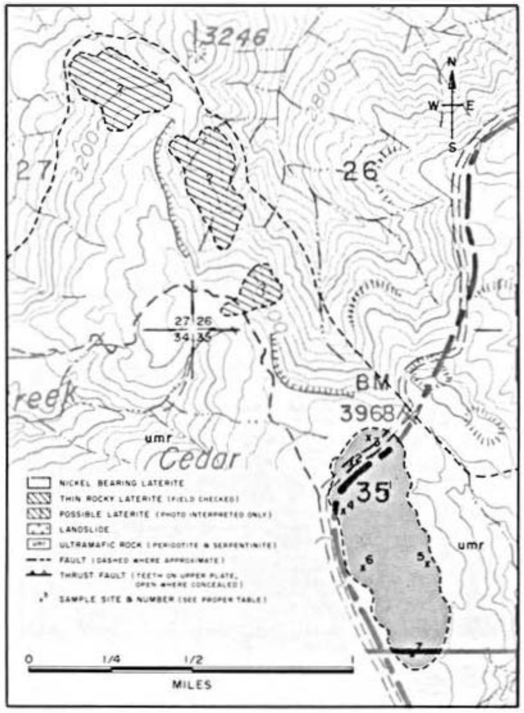

Figure 8. Geologic map of Cedar Springs area. Sample assay results appear in Table 7.

Exploration and development: Seven hand-auger samples were taken by the author in 1975. Several backhoe pits were sampled by Inspiration Development Company and the U.S. Bureau of Mines in 1977. Table 7 shows results obtained from the hand-auger and U.S. Bureau of Mines sampling.

Table 7. Sample assay results, Cedar Springs area

Sample number*	Assay number	Depth interval (ft)	Percent Ni	Co	Cr	Fe
1	AJG- 32	0- 2.5	0.62	----	----	----
2	AJG- 33	0- 7.5	0.72	0.06	0.98	22.9
3	AJG- 34	0- 7.5	0.64	----	----	----
4	AJG- 35	0- 2.7	0.62	----	----	----
5	AJG- 36	0-10	0.67	0.12	1.52	32.9
6	AJG- 37	0- 5	0.68	----	----	----
7	AJG-112	0- 5.7	0.47	0.12	1.17	34.7
8**	USBuM	0- 8	0.54	0.07	1.52	----

* Sample numbers are found in Figure 8 and indicate locations from which samples were taken

** An average of 32 U.S. Bureau of Mines pit samples taken about 500 ft apart in rows about 250 ft apart over the main area

Deposits: The main laterite area examined is about 0.75 mi long and 0.25 mi wide. The estimated amount of unweathered rock in the soil is 45 percent by volume. The maximum depth of soil is estimated to be 40 ft, with the average depth about 8 ft. The average grade of soil and saprolite, excluding rock,

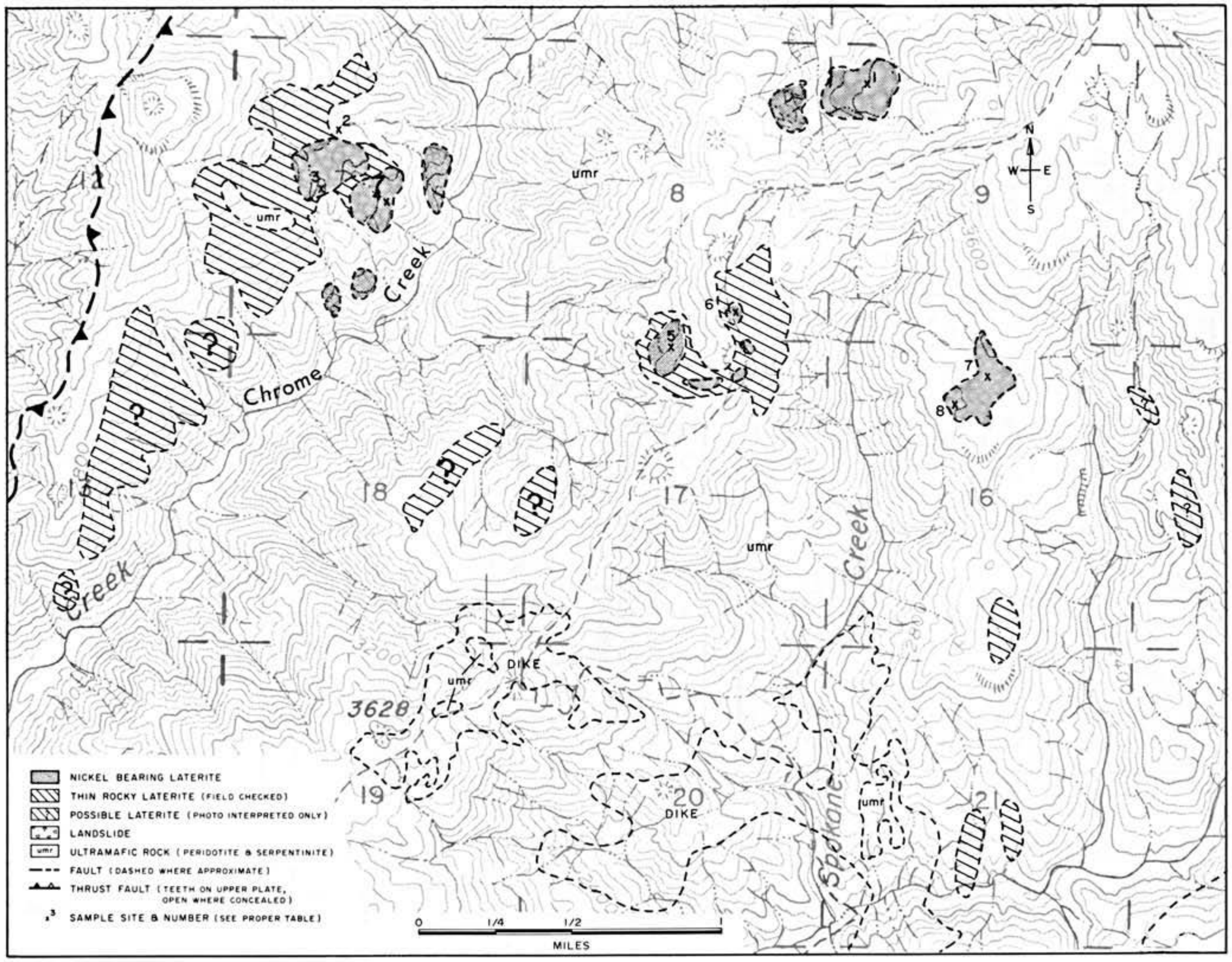

Figure 9. Geologic map of Chrome Creek and Spokane Creek areas. Sample assay results appear in Tables 8 and 17.

appears to be about 0.60 percent Ni, 0.07 percent Co, and 1.30 percent Cr.

The three small areas to the northwest along the peridotite-diorite contact were mapped from aerial photographs and have not been examined in the field. They appear to be quite rocky and may not be laterites.

Chrome Creek laterites (17)

Location: The areas designated as Chrome Creek (Figure 9) are arbitrarily separated from the Spokane Creek laterite areas by the drainage divide line between the two creeks, so the laterite area in secs. 8 and 17 is assigned, in part, to the Spokane Creek laterites. The patches of lateritic soil mapped in the Chrome Creek area are in unsurveyed secs. 7, 8, 9, 17, and 18, T. 40 S., R. 10 W.

Geology: The area is near the western edge of the Josephine ultramafic sheet about 2 mi from the thrust-fault contact with underlying Dothan Formation marine sediments. The ultramafic rocks consist of harzburgite and serpentinite that have been intruded by numerous dikes of dacitic and diabasic composition. Amphibolite of uncertain age, possibly Upper Triassic and equivalent to the Briggs Valley amphibolite, occurs as a tectonic slice in the northwestern part of the area, underlying the peridotite and overlying the Dothan Formation.

Deposits: The area has been examined only briefly in the field, and the southern patches mapped later from aerial photographs have not been inspected and sampled. The main area is on the west side of Chrome Creek in sec. 7. The more promising deposits occupy an area of about 40 acres with apparently marginal surrounding ground of about 75 or 80 acres. The two small patches in the northeastern part of the area (NE/NE sec. 8 and NW/NW sec. 9) together cover about 32 acres. They are very rocky and appear to be slump areas similar to the small 15-acre bench located about 1 mi to the southwest in secs. 8 and 17. The average amount of unweathered rock in the soil of the examined areas is estimated to be 45 percent by volume. Table 8 shows assay results of auger samples taken in the area. Additional field investigation is needed to evaluate the areas mapped from aerial photographs.

Table 8. Sample assay results, Chrome Creek area

Sample number*	Assay number	Depth interval (ft)	Location $\frac{1}{4}$	Location Sec.	Location T. (S.)	Location R. (W.)	Elevation (ft)	Percent Ni	Percent Co	Percent Cr
1	ALG-61	0-7	NW/NW	9	40	10	3,180	0.69	0.09	0.45
2	ALG-64	0-3.2	$S\frac{1}{2}/NW\frac{1}{4}$	7	40	10	2,825	0.81	----	0.63
3	ALG-63	0-5.5	SE/NW	7	40	10	2,810	0.75	0.15	1.57
4	ALG-62	0-2.7	Center	7	40	10	2,700	0.76	----	1.16
5	ALG-60	0-5.2	$\frac{1}{4}$ cor	8-17	40	10	3,260	0.39	----	----

* These numbers are found in Figure 9 and indicate locations from which samples were taken

Cleopatra - Taylor Creek laterites (24, Plate 1)

Location: Four patches of lateritic soil occur in secs. 31 and 32, T. 40 S., R. 10 W., and in secs. 5, 6, and 7, T. 41 S., R. 10 W., on the north end of Cleopatra Ridge, west of Taylor Creek. The area is about 1 mi north of the old McGrew wagon road, which at one time furnished access from the Wimer road to the Cleopatra lookout tower, now destroyed.

Geology: The area is underlain by partly serpentinized harzburgite and some dunite. These ultramafic rocks have been intruded by a few small diorite and diabase dikes; near the head of Taylor Creek, a fairly large complex diorite dike or stock cuts across the North Fork of Diamond Creek into California.

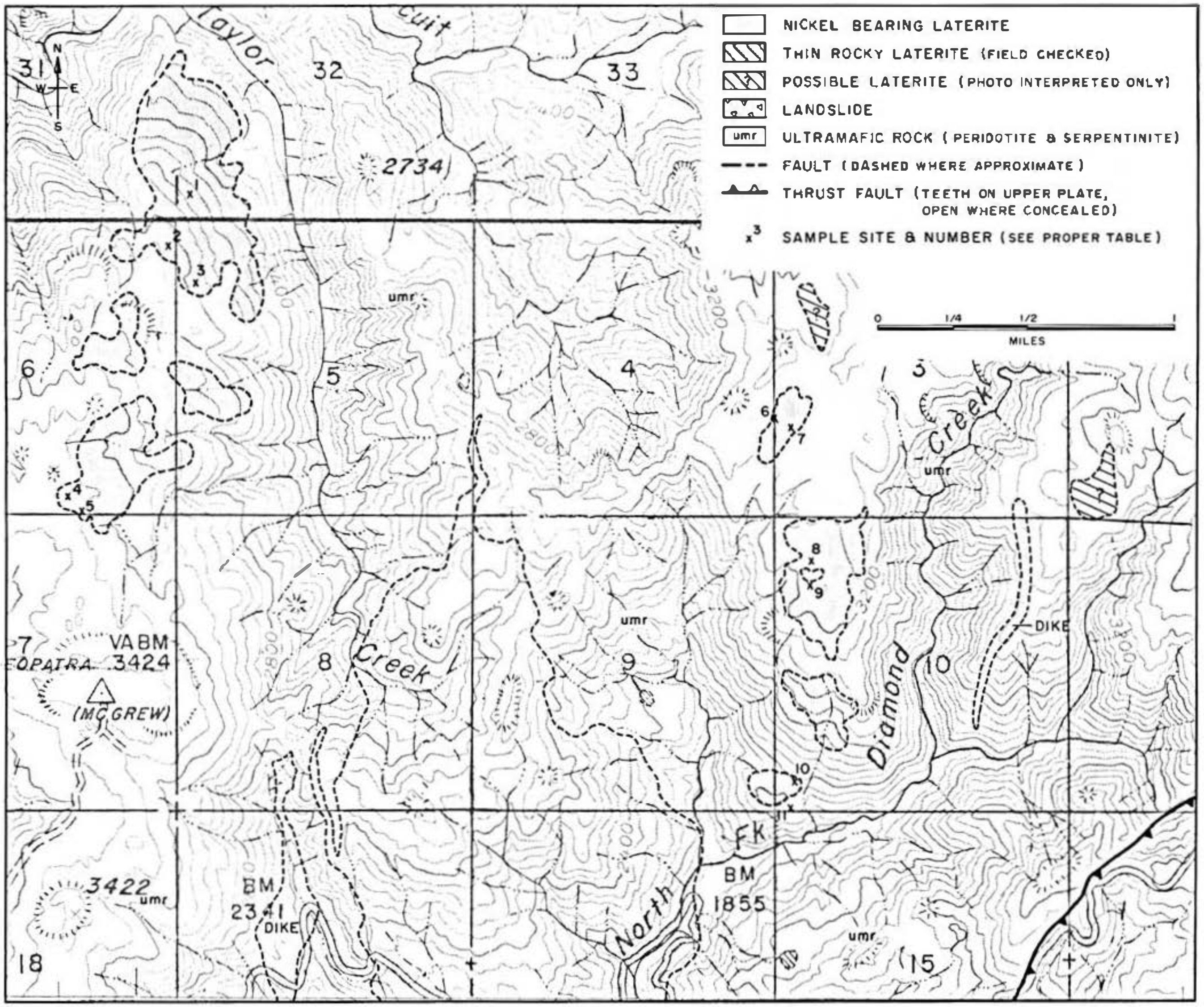

Figure 10. Geologic map of Cleopatra-Taylor Creek and Diamond areas. Sample assay results appear in Tables 9 and 11.

The mapped areas of lateritic soil total about 245 acres (Figure 10). The areas above about 2,800 ft are probably erosional remnants of a more extensive blanket of lateritic soil. Some areas below 2,800 ft probably include some slump material.

Deposits: The lower northern area is very rocky on the surface and may contain as much as 60 percent rock by volume. At least part of the lower area appears to have interesting accumulations of soil and saprolite which may reach a maximum depth of about 50 ft on slump benches. The average depth of soil and saprolite development for the mapped areas is estimated to be 10 ft. Assay results of preliminary auger samples are listed in Table 9. The average grade of soil and saprolite is about 1 percent Ni, 0.10 percent Co, and 1.80 percent Cr. Although on preliminary examination the area appears to lack value due to the abundance of unweathered rock at the surface, further investigation may be justified.

Table 9. Sample assay results, Cleopotra-Taylor Creek area

Sample number*	Assay number	Depth interval (ft)	Location ¼	Sec.	T.(S.)	R.(W.)	Elevation (ft)	Percent Ni	Co	Cr
1	AJG-16	0- 7.5	SW/SW	32	40	10	2,600	0.85	0.06	1.43
2	AJG-15	0- 7.5	NE/NE	6	41	10	1,850	1.61	0.16	1.98
3	AJG-17	0- 7.0	NW	5	41	10	2,750	1.20	0.09	2.01
4	AIG-117	0- 3	S/SE	6	41	10	3,300	0.65	----	----
5	AIG-118	0- 5	S/SE	6	41	10	3,300	0.91	0.24	----
5	AIG -119	5-10	S/SE	6	41	10	3,300	1.06	0.20	----

* These numbers are found in Figure 10 and indicate locations from which samples were taken

Cottonwood Camp laterites (13, Plate 1)

Location: This area is in unsurveyed sec. 22, T. 39 S., R. 11 W., north of Cottonwood Camp at the headwaters of the South Fork of the Chetco River on the southwest flank of Red Mountain. Aerial photographs indicate small slide or slump areas of possible nickel laterite at the head of Red Mountain Creek (Figure 11).

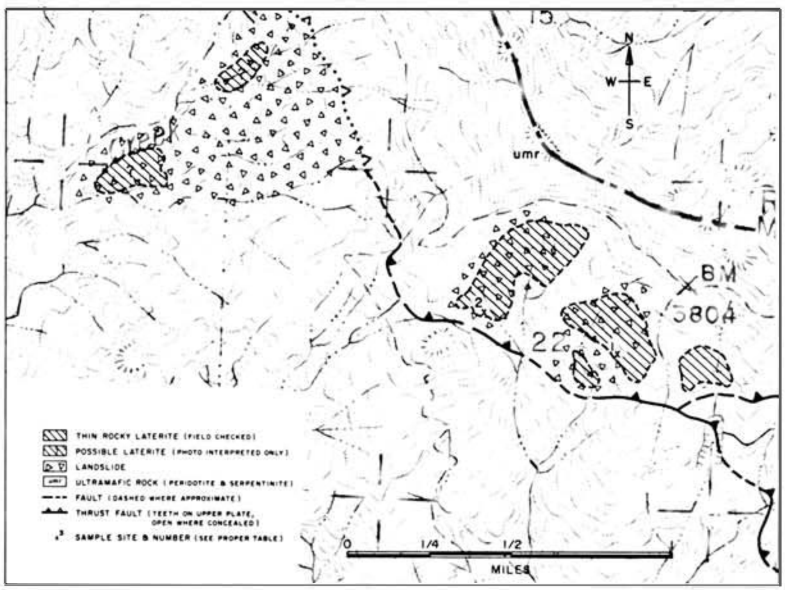

Figure 11. Geologic map of Cottonwood Camp area. Sample assay results appear in Table 10.

Geology: The area is adjacent to the thrust-fault contact where the west edge of the Josephine peridotite sheet overrides the Dothan Formation. Debris sliding from the overlying peridotite (a partly serpentinized harzburgite) down over the contact is commonplace. A tectonic slice of amphibolite exposed east of Cottonwood Camp occurs in the thrust between the peridotite and Dothan Formation. The Chetco Lake Chromite Prospect lies to the east in sec. 23.

Deposits: The area has been examined only briefly for laterites; two auger samples were taken in sec. 22. The lower portion of the slide area to the west has not been inspected or sampled. Although the area is very rocky and probably lacks interest as a source for nickel laterites, it should be investigated further. The six areas outlined on the basis of aerial photographs cover a total area of about 85 acres. The results of analyses of two samples taken in sec. 22 are given in Table 10.

Table 10. Sample assay results, Cottonwood Camp area

Sample number*	Assay number	Depth interval (ft)	Location Sec.	T.(S.)	R.(W.)	Elevation (ft)	Percent Ni	Cr
1	AKG-75	0-8.8	22	39	11	3,240	0.86	1.6
2	ALG-85	0-6	22	39	11	3,320	0.67	1.6

* These numbers are found in Figure 11 and indicate locations from which samples were taken

Diamond laterites (25, Plate 1)

Location: Several small patches of laterite occur in the headwaters of the North Fork of Diamond Creek in secs. 2, 3, 4, 9, and 10, T. 41 S., R. 10 W. (Figure 10). Access from O'Brien on U.S. 199 is via the Wimer road, a distance of about 17 mi to the North Fork of Diamond Creek, then across country north on foot; or by taking the Cook road (Chetco Divide trail) that branches off the Wimer road at about the 13-mi post, and then going southwest beyond Cedar Springs on the old McGrew wagon road. The distance from Wimer road by the latter route is about 5 mi.

Geology: This portion of the Josephine ultramafic sheet consists largely of partly serpentinized harzburgite with a few patches of dunite containing occasional chromite bands and lenses. Small diabase and dacite dikes and a large complex diorite dike with associated cinnabar mineralization have intruded the ultramafic rocks west of the laterite areas. A complex mixture of diabase, metavolcanic rocks, and gabbro is thrust over the ultramafic rocks in the vicinity of Bain Station and along Wimer road in the southeastern part of the map area (Vail, 1977).

Deposits: The laterites in this area appear to be erosional remnants of an extensive weathered surface on the peridotite. Silica boxwork rubble and outcrop are fairly abundant in the patches of laterite in the NW¼ sec. 10 and the SW¼ sec. 3. The small bench at about 2,400 ft near the section corner common to secs. 9, 10, 15, and 16 appears to be a landslide deposit and may be thicker than the other areas. The next patch to the north is probably also partly slump material but appears to be a relatively thin and rocky deposit. Total area in the six patches is about 115 acres. The maximum depth is estimated to be about 40 ft, but average depth is probably no more than 10 ft. The estimated average unweathered rock content in the soil is 50 percent by volume.

The results of analyses of six auger samples taken in the area are given in Table 11. The average grade of soil and saprolite in the area is probably about 0.75 percent Ni; the calculated grade of mixed soil and rock is about 0.50 percent Ni.

Table 11. Sample assay results, Diamond area

Sample number*	Assay number	Depth interval (ft)	Percent Ni	Co	Cr	Fe
6	AFG-56	0- 0.5	0.56	Trace	----	----
7	AFG-57	0- 1.8	0.27	Trace	----	----
8	AJG-40	0- 5	0.86	----	----	----
9	AJG-41	0- 6	0.62	0.12	1.16	23.3
10	AJG-39	0-12	0.85	----	----	----
11	AJG-38	0- 4.2	0.86	----	----	----

* These numbers are found in Figure 10 and indicate locations from which samples were taken

Doe Gap laterites (19, Plate 1)

Location: Four small patches of lateritic soil are mapped within a radius of about 1 mi of Doe Gap in unsurveyed sec. 34, T. 39 S., R. 10 W., and in secs. 3 and 4, T. 40 S., R. 10 W. (Figure 12). The Chetco Divide road and trail, which follows approximately the Curry-Josephine County line north from the Wimer road, leads into the area. Doe Gap is about 12 mi from the Wimer road and about 25 mi from O'Brien on U.S. 199. The last 6 mi of trail is narrow, unimproved, and difficult to negotiate with a standard vehicle.

Geology: The area is underlain primarily by partly to completely serpentinized harzburgite. These rocks are intruded by various dacite and diabase dikes. An 8- to 10-ft quartz vein along the trail just east of Doe Gap is probably related to these more siliceous intrusives or to the large diorite body located nearly 2 mi to the south in Boldface Creek. The lateritic soil areas appear to be erosional remnants of a more extensive soil cover derived from weathering of the peridotite.

Deposits: The four areas mapped from aerial photographs total about 95 acres. The soil appears to be quite shallow and very rocky in places. The areas have been given only a brief reconnaissance in the field. Table 12 shows the assay results from the two auger-sample sites shown on the map. Further exploration of the area is needed in order to evaluate the deposits properly. Other areas of soil may be present nearby.

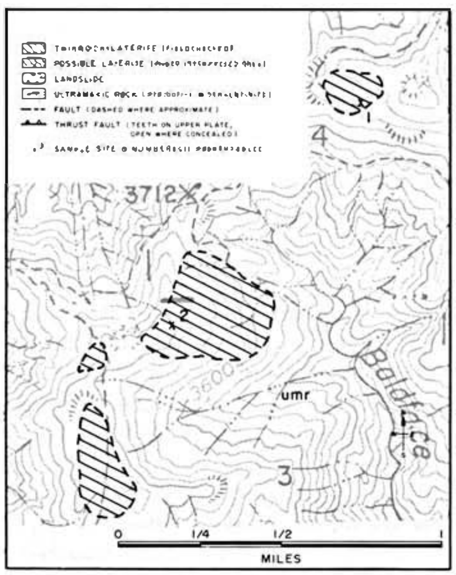

Figure 12. Geologic map of Doe Gap area. Sample assay results appear in Table 12.

Table 12. Sample assay results, Doe Gap area

Sample number*	Assay number	Depth interval (ft)	Percent Ni
1	CP-DG-2**	0 -1	0.99
1	CP-DG-3**	1 -1.5	0.50
1	CP-DG-4**	1.5-2	0.91
2	ALG-58	0 -5	0.51

* These numbers are found in Figure 12 and indicate locations from which samples were taken

**Private company assays

Eight Dollar Mountain laterites (11, Plate 1)

Location: Eight Dollar Mountain is near the northeastern extremity of the Josephine ultramafic sheet in secs. 8, 9, 10, 15, 16, 17, 19, 20, 21, 28, 29, T. 38 S., R. 8 W. Nickel-bearing lateritic soils occur on the lower flanks of the mountain from about 1,200 ft to the top at about 4,000 ft (Figure 13). The mountain lies southwest of Selma on U.S. 199 about 24 mi from Grants Pass. Access to the main deposits on the southeast face of the mountain is via a steep, winding, unimproved road leading off Eight Dollar road about 1 mi west of U.S. 199.

History and development: The first exploration activity of this area was by Freeport Sulfur Company in 1942. They located mining claims and dug discovery pits and shallow shafts. Climax Molybdenum Company explored the area in 1953 and dug more discovery cuts and sampled and mapped the area. In about 1957, New Delhi Mines, Ltd., of Canada obtained the claims and did exploration work including extensive bulldozing, contour road construction, pit enlarging, and extensive churn drilling of the main orebody in sec. 21. Subsequent assessment work by claim holders (Inter-American Nickel, Inc.) has included extending existing access roads, enlarging pits with bulldozer and backhoe, and obtaining bulk samples with a backhoe. The U.S. Bureau of Mines has done some sampling, mapping, and metallurgical testing.

The present study has involved a number of field investigations, additional reconnaissance sampling, and mapping of the area by using 1973 color infrared aerial photographs and 1976 true-color photographs.

Land status of the mountain involves public land under management of the U.S. Forest Service and Bureau of Land Management, the State of Oregon, Josephine County, and private ownership. Sec. 16 is State-owned, and the NW¼ sec. 28 is owned by Josephine County. The west half of the mountain is controlled by the U.S. Forest Service, and sec. 21 is under the management of the Bureau of Land Management. The remainder is privately owned, with scattered Bureau of Land Management parcels. Numerous mining claims are held on the public land by various individuals and groups.

Geology: Eight Dollar Mountain is a roughly cone-shaped erosional landform of peridotite (harzburgite) and serpentinite intruded by a few small basic to intermediate dikes, e.g., diabase. The ultramafic rocks have a relatively high-angle, west-dipping fault contact with steeply dipping slaty siltstone and sandstone of the Galice Formation near the east base of the mountain, and a high-angle, northeast-trending fault contact with Jurassic metavolcanic rocks of the Rogue Formation a short distance down the Illinois River from the mouth of Deer Creek.

Deposits: The main ore deposits are on the southeast flank of the mountain in sec. 21 and the NW¼ sec. 28. They appear to be remnants of old landslide or slump deposits. The main orebody in sec. 21 has an average width of about 1,500 ft and a length of about 3,900 ft. The better grade material lies between about 2,100 and 2,800 ft. While churn drilling on this deposit in the late 1950's, New Delhi Mines, Ltd., encountered bed rock at a maximum depth of about 90 ft. The average depth to bed rock in a total of 113 drill holes is about 30 ft. Bed rock is interpreted to occur at the point assays drop below 0.40 percent Ni. A few of the drill holes encountered bed rock at or near the surface.

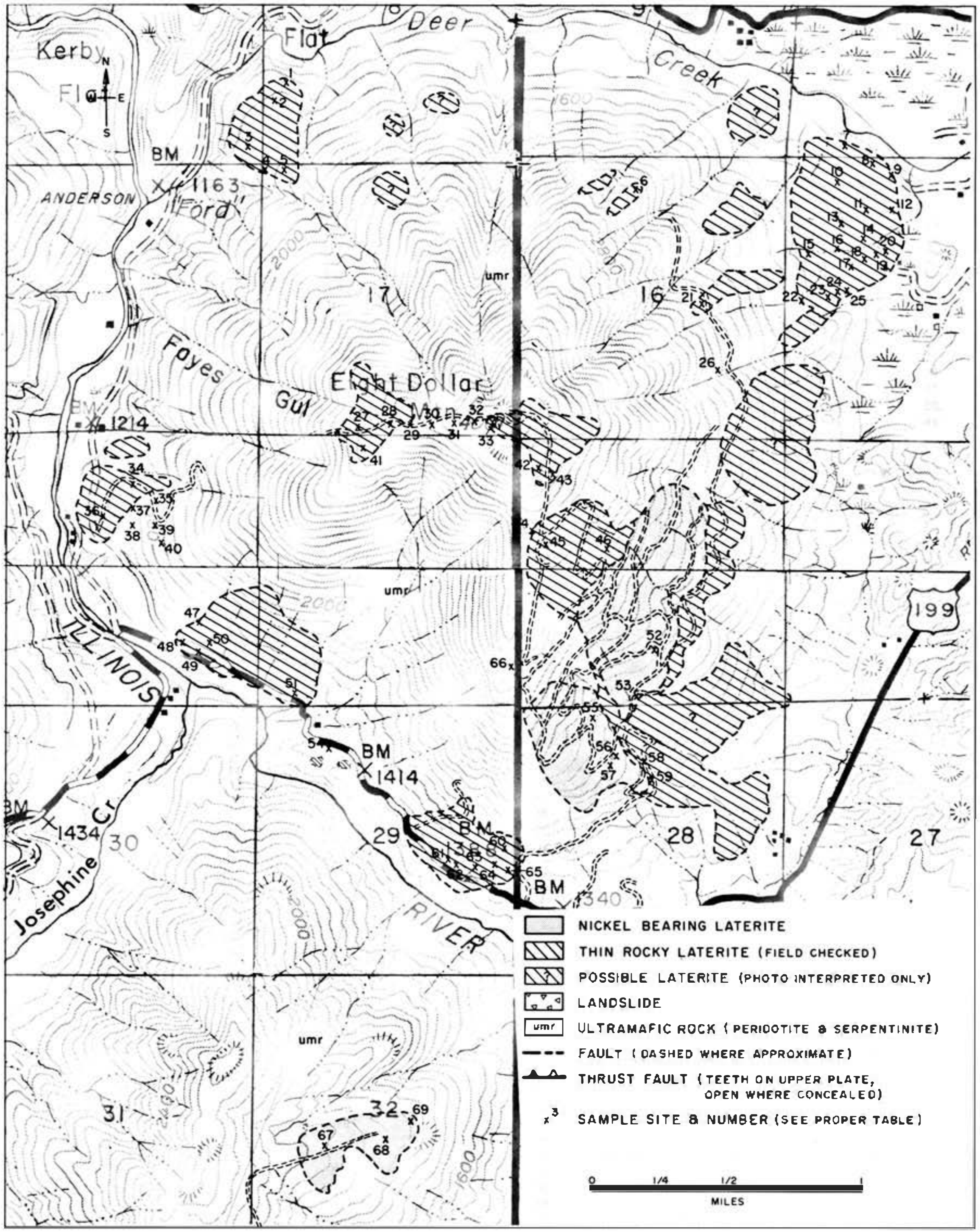

Figure 13. Geologic map of Eight Dollar Mountain and Free and Easy areas. Sample assay results appear in Table 13.

Table 13. Sample assay results, Eight Dollar Mountain and Free and Easy areas*

Sample number	Assay number	Depth interval (ft)	Type	Location ¼	Sec.	Approximate elevation (ft)	Percent Ni	Co	Cr
1	MEB- 1	0- 4.5	Auger	NW/SW	8	1,400	0.45	0.03	0.95
2	ALG-54	0- 2.5	Auger	W/SW	8	1,450	0.65	----	----
2	MEB- 2	0- 5.5	Auger	W/SW	8	1,450	0.60	0.04	1.10
3	MEB- 3	0- 5.34	Auger	SE/SE	7	1,500	0.50	0.04	1.00
4	ALG-55	0- 4.7	Auger	NW/NW	17	1,630	0.72	----	----
5	MEB- 4	0- 4.67	Auger	NW/NW	17	1,730	0.51	0.03	0.99
6	AJG-29	0- 5	Auger	NE/NW	16	2,350	0.70	0.06	1.53
7	MFW-22	0- 9	Pit	S/SW	10	1,340	0.50	0.03	0.94
7	MFW-21	9-19	Pit	S/SW	10	1,340	0.45	0.04	0.97
8 and 9	(data missing)								
10	MFW-20-23	0-12	Pit	NW/NW	15	1,410	0.45	0.03	0.78
11	MJR-53	0- 7	Pit	NE/NW	15	1,380	0.47	0.03	0.77
11	MJR-52	7-15	Pit	NE/NW	15	1,380	0.48	0.03	0.93
12	MJR-51	0-10	Pit	NE/NW	15	1,330	0.48	0.03	0.80
12	MJR-50	10-19	Pit	NE/NW	15	1,330	0.48	0.05	1.30
13	MJR-55	0- 8	Pit	NW	15	1,450	0.47	0.04	1.05
13	MJR-54	8-18	Pit	NW	15	1,450	0.39	0.03	0.83
14	MJR-57	0- 8	Pit	NW	15	1,390	0.44	0.03	0.84
14	MJR-56	8-18	Pit	NW	15	1,390	0.39	0.03	0.70
15	MFW-19	1- 7	Pit	W/NW	15	1,580	0.42	0.03	0.86
16	MFW-18	1- 3	Pit	SW/NW	15	1,470	0.36	0.03	0.80
17	MFW- 8	1- 8	Pit	SW/NW	15	1,460	0.68	0.04	0.96
18	MFW- 7	1-11.5	Pit	SE/NW	15	1,420	0.48	0.03	0.93
19	MFW- 9	1- 7.5	Pit	SE/NW	15	1,400	0.57	0.03	0.84
20	MFW- 6	1- 7.5	Pit	SE/NW	15	1,370	0.44	0.02	0.79
21	MJH-33	0- 4	Auger	E½	16	2,300	0.81	0.06	1.50
22	MFW-17	1- 7	Pit	SW/NW	15	1,670	0.53	0.04	1.20
23	(data missing)								
24	MFW-14	1-12	Pit	SW/NW	15	1,530	0.50	0.03	0.77
25	MFW-12	1-11	Pit	SW/NW	15	1,480	0.50	0.03	0.76
26	MJH-35	0- 4	Auger	SE	16	2,300	0.59	0.05	1.20
26	MJH-34	4- 9	Auger	SE	16	2,300	0.74	0.03	0.75
27	MJH-30	0- 7	Auger	SE/SW	17	3,340	1.00	0.03	0.69
28	MJH-28-29	0-11	Auger	S	17	3,520	0.87	0.03	0.61
29	MJH-26-27	0-10	Auger	SW/SE	17	3,610	0.84	0.02	0.55
30	MJH-25	0- 4	Auger	SW/SE	17	3,680	0.81	0.02	0.55
31	MJH-24	0- 7	Auger	SE/SE	17	3,790	0.32	0.01	0.41
32	MJH-22	0- 6	Auger	SE/SE	17	3,900	0.59	0.03	0.84
33	MJH-23	0- 5	Auger	SE/SE	17	3,980	0.52	0.03	0.87
34	MJH-15	0- 4	Pit	NW/NE	19	1,510	0.32	0.02	0.70
34	MJH-14	4-11	Pit	NW/NE	19	1,510	0.34	0.02	0.65
35	MJH-6-7	0- 7	Pit	NE	19	1,620	0.47	0.03	0.92
36	MJH-1-2	0-13	Pit	E/NW	19	1,400	0.35	0.02	0.57
37	MJH-4-5	0- 7	Pit	W/NE	19	1,500	0.36	0.02	0.63
37	MJH-3	7-13	Pit	W/NE	19	1,500	0.35	0.02	0.63
38	MJH-8-9-10	0-13	Pit	SW/NE	19	1,480	0.38	0.03	0.81
39	MJH-11	1-10	Pit	SW/NE	19	1,600	0.45	0.03	0.70
40	MJH-13	0- 4	Auger	SW/NE	19	1,650	0.44	0.02	0.70
41	NR-163-14	?	Auger	NE/NW	20	3,370	1.00	----	----
42	NR-163-15	?	Auger	NW/NW	21	3,700	0.85	----	----
43	MJH-31	0- 6	Auger	NW/NW	21	3,630	0.83	0.02	0.71
44	NR-3-5	2- 6	Auger	W/NW	21	3,430	0.58	----	----
45	MJH-32	0- 7	Auger	SW/NW	21	3,320	1.00	0.14	1.00
46	MFW-9	20-26	Pit	SE/NW	21	2,940	1.80	0.01	0.60
47	MJH-18-19	0-12	Pit	SE	19	1,480	0.36	0.02	0.66
48	MJH-16-17	0-13	Pit	W/SE	19	1,340	0.34	0.02	0.57
49	NR-3-8	0- 8	Roadcut	SE	19	1,300	0.35	----	----
50	MJH-20-21	0-12	Pit	E/SE	19	1,420	0.34	0.02	0.62
51	NR-3-9	0- 6	Roadcut	SW/SW	20	1,350	0.47	----	----
52	AJG-144	38-45	Pit	S½	21	2,350	1.46	----	----
53	MEB-5-6	0-10	Pit	SE/SW	21	2,180	0.64	0.03	1.00
54	NR-3-10	0- 2	Auger	NW/NW	29	1,365	0.54	----	----
55	AJG-146	0-25	Pit (grab)	N/NW	28	2,230	0.40	----	----
55	MFW-10-11	0-10	Pit	N/NW	28	2,230	0.47	0.01	0.62
56	MJH-46	0- 7	Pit	NW	28	2,000	0.51	0.03	0.90
57	AJG-145	0-25	Pit (grab)	SE/NW	28	2,020	0.78	----	----
58	MJH-44-45	0- 7	Auger	E/NW	28	1,850	1.04	0.05	0.64
59	MEB-7	0- 5	Pit	SE/NW	28	1,770	0.37	0.04	1.20
59	MEB-8	5-12	Pit	SE/NW	28	1,770	0.63	0.10	1.01
60	MJH-38-39	0-11	Pit	NE/SE	29	1,540	0.32	0.02	0.61
61	NR-3-11	0- 8	Roadcut	N/SE	29	1,430	0.56	----	----
62	ALG-28	0-10	Roadcu	N/SE	29	1,430	0.63	----	----
63	MJH-42-43	0-12	Pit	N/SE	29	1,450	0.66	0.03	0.71
64	MJH-40-41	0- 9	Pit	NE/SE	29	1,460	0.56	0.04	1.05
65	MJH-36-37	0-11	Pit	NE/SE	29	1,450	0.35	0.02	0.64
66	NR-149-10	?	Auger	SE/SE	20	3,000	0.62	----	----
67	AIG-84	0- 5	Pit	N/SW	32	2,390	0.98	----	----
67	AIG-85	5-10	Pit	N/SW	32	2,390	0.99	0.06	0.96
67	AIG-86	10-14	Auger	N/SW	32	2,390	0.86	----	----
68	AIG-88	0- 6	Pit	N½/S½	32	2,180	0.64	----	----
69	AIG-87	0- 5	Shaft	NW/SE	32	2,080	0.90	----	----

* Appling (1955); U.S. Bureau of Mines (1977); Oregon Department of Geology and Mineral Industries (1975-77)

** These numbers are found in Figure 13 and indicate locations from which samples were taken

The orebody to the south, largely in NW¼ sec. 28, is about 1,500 ft wide and 2,300 ft long. It has had little exploration and is believed to be a shallower deposit with an extimated average depth of about 15 ft.

A fair abundance of silica boxwork float at various places on Eight Dollar Mountain indicates the probability of some garnierite at fairly shallow depths. The most abundant silica boxwork float is in the lower part of the south orebody, in the draw between the two main deposits, and the outwash area down-slope.

Grade: Assays of samples from churn-drill holes have lower values than samples from open cuts and auger holes, which exclude the unweathered rock mixed in the churn-drill samples. The unweighted average of 671 assays from 105 churn-drill holes (8 of the holes failed to encounter material of greater than 0.40 percent Ni) is 0.61 percent Ni. This is believed to be close to the average grade of mixed soil, saprolite, and rock in the main northern orebody. An unweighted average of 81 pit samples taken at 5-ft intervals in 13 pits is 0.96 percent Ni. Oregon Department of Geology and Mineral Industries and U.S. Bureau of Mines analyses of soil and saprolite (excluding unweathered rock) in the main northern deposit indicate an average grade of 1.18 percent Ni, 0.08 percent Co, 24.6 percent Fe, and 1.17 percent Cr.

Fewer samples have been taken from the smaller southern area, which has an average grade of soil and saprolite of about 0.93 percent Ni and a calculated grade of about 0.58 percent Ni for mixed soil, saprolite, and rock. Estimated average unweathered rock content in the soil of the northern area is 35 percent and in the southern area 45 percent by volume.

Assay results from the few scattered samples taken in the various other satellite patches of relatively thin rocky soil and outwash areas of mixed soil and rock are summarized in Table 13.

Free and Easy laterites (12, Plate 1)

Location: The deposit, on an east-sloping ridge in S½ sec. 32, T. 38 S., R. 8 W., is about 5 mi from Kerby and may be reached by a very primitive 4-wheel road extending north from Free and Easy Pass.

Exploration: The area was located by the Freeport Sulfur Company in 1942 at about the same time as Eight Dollar Mountain. At that time, claims were located and discovery cuts were hand dug. The next work was by Climax Molybdenum Company in 1953, when a primitive road and two bulldozer cuts were made, and the area was mapped and sampled. The present investigation (1975) consisted of minor auger sampling and mapping from aerial photographs (Figure 13).

Geology: The deposit area appears to be an erosional remnant of an old landslide of mixed harzburgite, soil, saprolite, and serpentinite. The laterite area is surrounded by serpentinite and partly serpentinized harzburgite with very little or no soil cover.

Deposit: The red soil area covers about 40 acres, and the average depth is estimated at about 15 ft. The surface soil of the bulldozer trench at 2,400 ft elevation is dark reddish brown, turning to yellowish brown at about 2 ft. The estimated unweathered rock content in the soil zone is about 30 percent by volume. The maximum soil depth may be about 35 ft. An unweighted average of 10 Department and private company samples gives the grade of 0.85 percent Ni for soil and saprolite (excluding rock). Seven U.S. Bureau of Mines samples from the area average 0.867 percent Ni, 0.028 percent Co, and 1.07 percent Cr (Table 13).

Josephine Creek laterites (15, Plate 1)

Location: Several small patches of lateritic soil occur in secs. 13, 14, 22, 23, 24, 26, and 27, T. 39 S., R. 9 W., on the slopes west of Josephine Creek between about 1,700 and 3,000 ft (Figure 14). The area may be reached by going 6 mi via Tennessee Pass road west of Kerby to the ford near Bob Cutler's cabin in NW¼ sec. 24. Primitive roads lead up Josephine Creek about 1.5 mi on the east side and up the steep slope on the west side for a short distance.

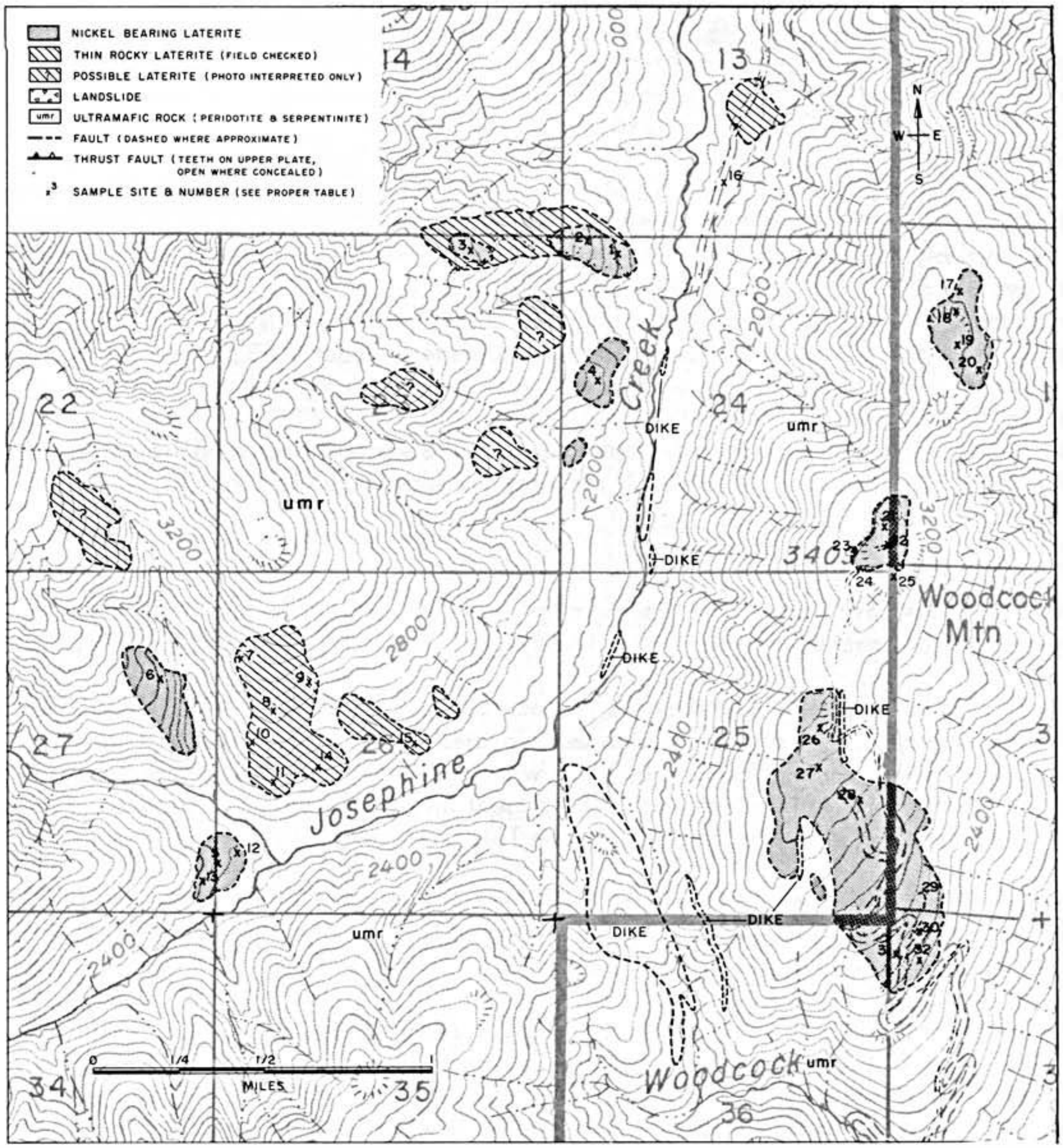

Figure 14. Geologic map of Josephine Creek and Woodcock Mountain areas. Sample assay results appear in Tables 14 and 19.

Table 14. Sample assay results, Josephine Creek area

Sample number*	Assay number	Depth interval (ft)	Location ¼	Location Sec.	Approximate elevation (ft)	Percent Ni	Percent Co	Percent Cr	Percent Fe
1	AJG-42	0-3.3	NW/NW	24	2,000	0.68	----	----	----
2	AJG-43	0-4.2	West line	13-24	2,200	0.93	----	----	----
3	AJG-44	0-5	N/NE	23	2,780	1.22	0.05	1.2	25.3
4	AJG-113	0-5.4	SW/NW	24	2,200	0.51	0.10	----	----
5	ALG-56	0-1.5	South	26-27	2,320	0.62	----	----	----
6	ALG-57	0-7	NE	27	2,800	1.19	0.11	0.6	----
7	MFW-1**	1-3.3	W/NW	26	2,950	0.76	0.05	1.5	----
8	MEB-12**	0-5.2	SW/NW	26	2,870	0.49	0.05	1.3	----
9	MEB-11**	0-3	NW	26	2,880	0.37	0.03	0.8	----
10	MEB-13**	0-2.8	SW/NW	26	2,650	0.57	0.06	2.1	----
11	MEB- 9**	0-4.7	NW/SW	26	2,460	0.52	0.06	1.8	----
12	MFW-4-5**	0-5.8	SW/SW	26	2,230	0.63	0.07	1.5	----
13	MFW-2-3**	0-4.4	SE/SE	27	2,350	0.37	0.03	1.0	----
14	MEB-14**	0-7.5	N/NW	26	2,410	0.61	0.05	1.3	----
15	MEB-15**	0-3.8	SW/NE	26	2,260	0.59	0.05	1.2	----
16	MEB-10**	0-7.8	SE/SW	13	1,700	0.45	0.04	1.2	----

* These numbers are found in Figure 14 and indicate locations from which samples were taken

** U.S. Bureau of Mines 1977 samples

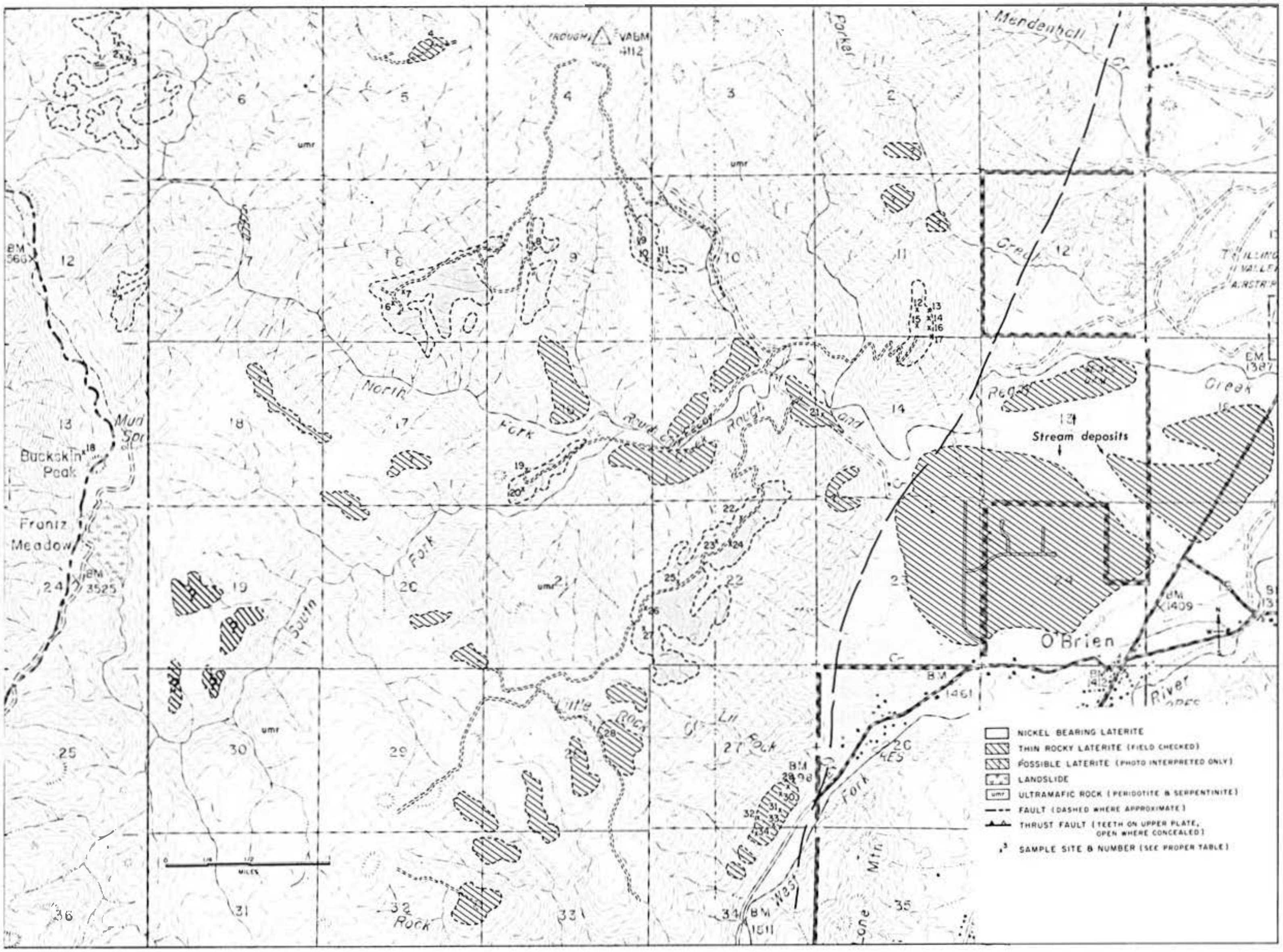

Figure 15. Geologic map of Rough and Ready Group area. Sample assay results appear in Table 15.

Exploration: The northern patches were located as the Red Baron Group of claims in 1974. A few shallow bulldozer cuts and a steep prospect road were put in by previous claimants about 15 or 20 years earlier.

Geology: The area is in the Josephine ultramafic sheet between Woodcock and Josephine Mountains. The main rock is slightly to completely serpentinized horzburgite. Serpentinization is more complete in areas of shearing and where the rocks are intruded by numerous small diabase dikes, as along Josephine Creek.

Cemented Pleistocene bench gravels occur along both sides of Josephine Creek from the water's edge to as much as 140 ft above the creek bed. Placer mining activity in these areas has produced modest amounts of gold and a fair abundance of josephinite, a nugget form of native nickel iron that is apparently derived from areas of more intense serpentinization and shearing adjacent to diabase dikes (Dick, 1975). Small blebs of josephinite have been detected in serpentinite by slabbing the rock with a diamond saw.

Deposits: The lateritic soil is the typical reddish-brown on the surface and grades rapidly into a yellow-brown at shallow depth. A few patches of iron pellets occur in places on the surface along with a minor amount of silica boxwork float. Mixed rock in the soil includes unweathered harzburgite and serpentinite boulders and occasional minor amounts of diabase-dike rubble. The estimated amount of unweathered rock in the soil varies from 20 to 85 percent and probably averages about 40 percent by volume. The total area mapped in all categories of laterites is about 190 acres; areas of known laterite and saprolite total about 60 acres. These small patches appear to be quite shallow with a maximum depth of 30 ft and an estimated average depth of about 7 ft.

Assay results of auger samples are listed in Table 14.

Rough and Ready Group laterites (20, Plate 1)

Location: This group of laterite deposits lies mainly in T. 40 S., R. 9 W., with outwash deposits extending into secs. 18 and 19, T. 40 S., R. 8 W., and Rough and Ready bench laterite patches in secs. 1 and 12 north of Mud Spring, T. 40 S., R. 10 W. (Figure 15). The group may be divided into ten areas:

1. Parker ridge (secs. 11 and 14) contains about 37 acres on the ridge southwest of Parker Creek.
2. South flank of Rough Mountain (four patches in secs. 8, 9, and 10) covers an aggregate area of about 200 acres.
3. Rough and Ready Creek deposit (SW$\frac{1}{4}$ sec. 16) covers about 30 acres.
4. Rough and Ready ridge (sec. 22, overlaps into secs. 15, 21, 27, and 28) covers about 235 acres.
5. Rough and Ready bench (west edge of sec. 6 and mainly in sec. 1, T. 40 S., R. 10 W.) is an erosionally dissected bench with residual patches of lateritic soil totaling about 115 acres.
6. Buckskin ridge (two small patches in the SE$\frac{1}{4}$ sec. 12, T. 40 S., R. 10 W.) includes about 20 acres.
7. Rough and Ready outwash (secs. 13, 14, 23, and 24, extending into secs. 18 and 19, T. 40 S., R. 8 W.) is a large alluvial outwash deposit of peridotite boulders, sand, gravel, and soil that covers more than 1,100 acres.
8. Rough and Ready Creek mixed slope-debris and bench gravel deposits (five patches in secs. 14, 15, and 16) cover about 190 acres.
9. West Fork of the Illinois River mixed slope-debris deposit (secs. 27 and 34) covers about 40 acres.
10. Various scattered, thin, rocky, upland erosional remnants and slope-debris deposits (secs. 2, 5, 11, 17, 18, 20, 28, 29, 32, and 33) have been delineated on the basis of aerial photographs and maps but have not all been examined in the field.

Exploration and development: Part of the bench gravel area along Rough and Ready Creek was worked to a small extent in the early days by gold placer miners who recovered small amounts of gold and platinum metals. Nickel exploration began in the early 1950's (Appling, 1955), and the first systematic work was done by Cominco-American, Inc., between 1968-70. The area was claimed and mapped on the basis of color aerial photographs; and some trenching, augering, and churn drilling were done. More recent

Table 15. Sample assay results, Rough and Ready Group area

Sample number ***	Assay number	Depth interval (ft)	Location ¼	Sec.	Approximate elevation (ft)	Percent Ni	Co	Cr	Fe
1	AIG-124	0- 6	NE	1	2,800	0.72	----	----	----
2	AIG-123	0- 6	NE	1	2,800	0.78	0.06	1.44	31.6
3	AIG-121-2	0- 6	NE	1	2,720	0.61	0.10	----	----
4	P-8827-28	0- 2	NE	5	3,900	0.71	----	2.16	----
5	AIG-116	0- 1	SE	12	3,520	0.99	----	----	----
6	AIG-64	1- 6	SW	8	3,000	1.45	----	2.24	40.7
7	AIG-63	1- 4	S½	8	3,080	1.23	0.14	----	----
8	AIG-48	0- 4	NW	9	3,300	0.81	----	----	----
9	AIG-80	0- 5	SE/NE	9	3,030	1.03	0.08	2.14	30.5
10	AIG-77	0- 3	NE/SE	9	2,980	0.93	----	----	----
11	AIG-78	0- 4	NW/SW	10	2,870	1.58	0.10	2.44	36.8
12	AIG-56	Pit grab	SW/SE	11	2,460	0.90	----	----	----
13	AIG-55	Pit grab	SE	11	2,400	1.10	0.08	----	----
14	AIG-54	Pit grab	SE	11	2,390	1.26	0.12	2.56	36.1
15	AIG-57	Pit grab	SW/SE	11	2,420	0.96	----	----	----
16	AIG-53	Pit grab	S/SE	11	2,380	0.84	----	----	----
17	AIG-52	Pit grab	N/NE	14	2,330	0.99	----	----	----
18	CP-MS-1*	2- 2.5	NW/SE	13	3,800	0.30	----	----	----
19	AIG-47	0- 6	SW	16	2,170	0.74	----	----	----
20	AIG-49-50	0- 8	SW/SW	16	2,090	0.85	0.07	1.06	23.0
21	P-8821-2	1- 2.5	NW/SW	14	1,650	0.36	----	1.64	----
22	AIG-70	0- 3	NW/NE	22	2,750	1.04	----	----	----
23	AIG-71	0- 7	E/NW	22	2,770	0.87	0.13	2.10	37.3
24	15615*	?	N½	22	2,770	0.57	----	----	----
25	15614*	?	NW/SW	22	2,880	0.62	----	----	----
26	C-11-19-20**	0- 6	E/SE	21	3,050	0.46	----	----	----
27	C-11-25-12-1**	0- 6	SE/SE	21	3,050	0.54	----	----	----
27	C-12-2-3**	6-12	SE/SE	21	3,050	0.87	----	----	----
28	C-12-4**	Grab	SW/NE	28	3,210	0.43	----	----	----
29	MRN-25**	0- 5	SE	27	1,680	0.36	0.03	1.2	----
30	MRN-19-20**	0- 9.5	SE/SE	27	1,680	0.51	0.03	1.02	----
31	MRN-17**	0- 5	SE/SE	27	1,590	0.51	0.04	1.6	----
31	MRN-16**	5-13	SE/SE	27	1,590	0.43	0.04	1.2	----
32	MRN- 5**	0- 3	SE/SE	27-34	1,760	0.55	0.01	1.4	----
33	MRN- 8**	0- 6	N/NE	34	1,560	0.47	0.05	1.4	----
34	MRN-12-13**	0-10	N/NE	34	1,740	0.65	0.06	1.7	----

* Private company samples
** U.S. Bureau of Mines samples
*** These numbers are found in Figure 15 and indicate locations from which samples were taken

exploration has been by Inspiration Development Company from 1973 through 1978. Their work has included some drilling, backhoe sampling, use of a 6-in. mesh screening and weighing device to determine the weight percent of unweathered rock in the laterites, extensive seismic surveys to determine the depth to unweathered bed rock, and metallurgical testing of bulk samples of soil and saprolite. During the summer of 1977, the U.S. Bureau of Mines conducted fairly extensive backhoe sampling of the outwash area.

Geology: The upland area is underlain by partly serpentinized harzburgite of the Josephine ultramafic sheet. The ultramafic rocks are in fault contact with the Upper Jurassic Galice Formation, which underlies the outwash area and lowlands to the east.

The fault strikes about N. 20° E. and appears to be nearly vertical. The peridotite has zones of nearly complete serpentinization that are somewhat sheared. A few small dikes intruding the ultramafic rocks are mainly diabasic in texture and intermediate to basic in composition. Soil areas occur as residual patches of an old upland weathered surface and in lower slumps and benches as well as in outwash deposits mixed with sand and gravel on the valley floor. Some surface accumulations of iron shot occur in the upper deposits on ridge tops and benches. Silica boxwork float also occurs in a few of the more deeply weathered areas. Deposits on the steeper slopes are generally more rocky and lower in grade. The better developed ridge-top and bench deposits generally increase in grade with depth, but transported and outwash gravel deposits do not.

Acreage, grade, and estimated depth of deposits: Department sampling has been very limited, and as confidential company data is not available for publication, grade and depth estimations for the group are preliminary and subject to correction. Sample assay results are given in Table 15.

1. Parker ridge covers an area of 37 acres with an estimated maximum depth of 16 ft and an estimated average depth of 6.5 ft; estimated quantity of unweathered rock in soil by volume is 45 percent; average arithmetic grade of soil and saprolite based on five Oregon Department of Geology and Mineral Industries samples is about 1.00 percent Ni, 0.1 percent Co, and 2.0 percent Cr.

2. South flank of Rough Mountain (three areas from west to east). Calculated average grade of soil and saprolite for all three areas combined is 1.17 percent Ni, 0.10 percent Co, and 2.27 percent Cr.
    a. Area A (largest area mainly in sec. 8) covers about 135 acres with an estimated maximum depth of 40 ft and an estimated average depth of 10 ft; estimated quantity of unweathered rock is 40 percent by volume.

    b. Area B (two small patches W½ sec. 9) covers about 40 acres with on estimated maximum depth of 16 ft and an estimated average depth of 6 ft; estimated quantity of rock is 45 percent by volume.

    c. Area C (E¼ sec. 9 and W¼ sec. 10) covers about 35 acres with an estimated maximum depth of 30 ft and on estimated average depth of 10 ft; estimated quantity of rock in soil is 35 percent.

3. Rough and Ready Creek area (SW¼ sec. 16) covers an area of 30 acres with an estimated maximum depth of 20 ft and an estimated average depth of 7 ft; estimated quantity of rock in soil is 35 percent by volume; calculated average grade of soil and saprolite is 0.80 percent Ni and 1.06 percent Cr.

4. Rough and Ready ridge (largely in sec. 22) covers an area of 235 acres with an estimated maximum depth of 25 ft and an estimated average depth of 8 ft; estimated volume of unweathered rock in soil zone is 45 percent; calculated average grade of soil and saprolite is 0.85 percent Ni, 0.13 percent Co, and 2 percent Cr; two U.S. Bureau of Mines core samples included some unweathered rock.

5. Rough and Ready bench area (mostly sec. 1) covers an area of 115 acres with an estimated maximum depth of 35 ft and estimated average depth of 10 ft; estimated volume of unweathered rock in soil zone is 40 percent; calculated average grade of soil and saprolite is 0.70 percent Ni, 1.4 percent Cr, and 0.08 percent Co.

6. Buckskin ridge area (SE¼ sec. 12) covers an area of 20 acres with an estimated maximum depth of 15 ft and an estimated average depth of 5 ft; estimated volume of unweathered rock in soil is 50 percent; calculated average grade of soil and saprolite is 0.99 percent Ni, with no other elements determined.

7. Rough and Ready outwash (secs. 13, 14, 18, 19, 23, and 24) covers an area of 1,100+ acres with an estimated maximum depth of 25 ft and an estimated average depth of 15 ft, based on U.S. Bureau of Mines data; estimated volume of unweathered rock is 90 percent; calculated grade of soil and fines based on Oregon Department of Geology and Mineral Industries data is 0.45 percent Ni, 1 percent Cr, 0.03 percent Co, and 16 percent Fe; U.S. Bureau of Mines backhoe samples in secs. 13, 14, and 18 average 0.32 percent Ni, 0.022 percent Co, and 0.60 percent Cr.

8. Rough and Ready Creek (five areas of mixed slope-debris and stream-bench deposits) (secs. 14, 15, and 16) cover 190 acres with an estimated maximum depth of 25 ft and an estimated average depth of 8 ft; estimated volume of unweathered rock is from 60 to 80 percent; approximate grade of soil and saprolite has not been determined.

9. West Fork of the Illinois River mixed slope-debris deposit (secs. 27 and 34) covers an area of about 40 acres; this area was not examined by the writer, but depth and rock-soil ratio is probably similar to the mixed slope-debris deposits on Rough and Ready Creek; the area was sampled by U.S. Bureau of Mines personnel in 1977 who inferred an average depth of about 10 ft over an area of 27 acres, with 55 percent soil and saprolite containing an average of 0.53 percent Ni, 0.04 percent Co, and 1.84 percent Cr_2O_3. The U.S. Bureau of Mines has 20 sample sites in the area, six of which are plotted in Figure 15 and listed in Table 15 (sample numbers 29 through 34).

10. Various scattered thin, rocky, upland erosional remnants and slope-debris deposits. No attempt has been made to quantify these deposits.

Smith River laterites (23, Plate 1)

Location: The area is in secs. 3, 4, 9, 10, 11, 14, and 15, T. 41 S., R. 11 W., on the west side of North Fork of the Smith River and is a northward extension of the Pine Flat laterite deposit in northern California. The area may be reached via the Wimer road either from O'Brien on U.S. 199 or Smith River, California, on U.S. 101. An alternate route is the Winchuck River road, which terminates northeast of Packsaddle Mountain near the north edge of the area and is about 20 mi from U.S. 101 near the Oregon border.

Exploration: No claims were found in the area north of Cedar Creek in 1975, when it was examined. The Pine Flat deposit in northern California has been held for several years by Hanna Mining Company. Exploration has consisted of aerial photograph reconnaissance mapping using 1973 color infrared photographs, surface reconnaissance mapping, and hand-auger sampling (Figure 16).

Geology: The area lies on the synclinal nose of a thrust sheet of ultramafic rock over Dothan Formation marine sediments. Ultramafic rocks consist of peridotite (harzburgite) that varies from fresh, unaltered rock to completely serpentinized rock. The serpentinite is more or less sheared and devoid of soil cover. The most common composition of a number of small dikes seen intruding the ultramafic rocks appears to be diabase. A few younger rhyolite or dacite porphyry dikes intrude the Dothan Formation at Fall Creek and on the North Fork of the Smith River near the south edge of sec. 2.

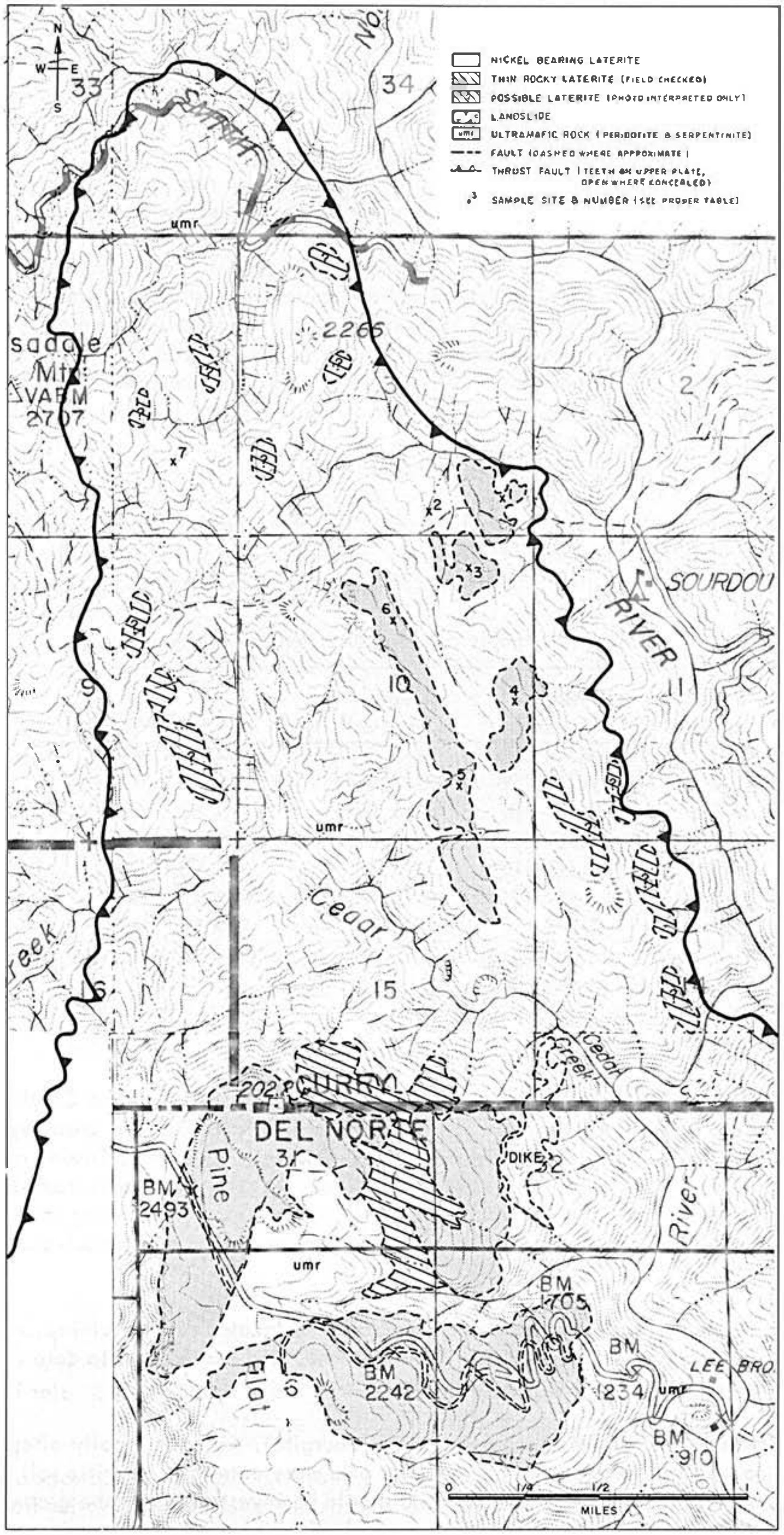

Figure 16. Geologic map of Smith River area. Sample assay results appear in Table 16.

Deposits: The patches of lateritic soil north of Cedar Creek appear to be quite thin, residual deposits overlying peridotite. Deposits on the ridge tops are probably weathered in place, while those on the flanks and benches downslope from the ridges appear to be, at least in part, transported material that has been involved in slumping and sliding. The best appearing area is the 25-acre patch in the E$\frac{1}{4}$ sec. 10, in the vicinity of sample number 4 (Figure 16), where the soil and saprolite may be 15 or more ft deep. Rock content in the soil appears to be 45 percent by volume or greater. The long narrow patch extending through sec. 10 into sec. 15 should perhaps not be mapped as a continuous body; it appears to be a series of small benches separated by steep rocky areas with very little soil on the southwest side of the ridge. The average nickel content of the soil in the area is low (Table 16), but deeper samples may have a higher nickel content. In four patches located north of Cedar Creek, the visually estimated rock content of soil is from 30 to 70 percent, and the average may be about 45 percent by volume. The northern extension of the Pine Flat deposit was not examined but is believed to be similar in composition. Benson (1963) indicates that the northern part of the Pine Flat deposit of soil and saprolite in California contains about 1 percent Ni, 0.08 percent Co, and 1.16 percent Cr_2O_3.

Maximum depth of the four patches of laterite north of Cedar Creek is probably not more than 20 ft, and the average depth over the approximately 120-acre aggregate area is estimated to be 8 to 10 ft. The 50-acre portion of the Pine Flat Mountain deposit which extends into Oregon is probably no more than 20 ft deep, with an estimated average depth of 10 ft. Further investigation of the area seems justified. The laterite patches indicated by use of aerial photographs should be checked on the ground and sampled.

Table 16. Sample assay results, Smith River area

Sample number*	Assay number	Depth interval (ft)	Percent Ni	Co	Cr_2O_3
1	AJG-105	0-3.2	0.52	----	----
2	AJG-106	0-3.5	0.62	0.03	0.67
3	AJG-107	0-6.0	0.83	0.05	1.99
4	AJG-108	0-8.0	0.66	0.12	----
5	AJG-109	0-7.1	0.90	0.05	1.53
6	AJG-110	0-5.5	0.72	0.06	2.48
7	USFS	Grab	0.53	0.07	----

* These numbers are found in Figure 16 and indicate locations from which samples were taken

Spokane Creek laterites (18, Plate 1)

Location: A few small patches of laterite occur in the drainage of Spokane Creek and another small unnamed tributary to Boldface Creek about 1 mi east of Boldface Creek in unsurveyed secs. 8, 9, 15, 16, 17, and 21, T. 40 S., R. 10 W. (Figure 9). The Wimer road, Chetco Divide road, and Cook trail lead to the McKee cabin site and Bold Eagle gold placer on Spokane Creek; from there the area may be reached by hiking up the old placer ditch and up Spokane Creek and then going cross country uphill to the main area mapped on the north edge of sec. 16. Alternate routes may be selected to reach the other mapped areas.

Exploration: In 1971, Inspiration Development Company located several claims, named the McKee Group, in the area. Only a few of these have been retained, and exploration to date (1977) has been limited to reconnaissance sampling and mapping.

Geology: The area is underlain by peridotite (harzburgite), which is locally altered to serpentinite. The small areas of soil appear to be erosional remnants of a more extensive lateritic soil cover. The larger area to the north looks like a slump or slide area and should be investigated on the ground. The ultramafic rocks have been intruded by a number of small dikes and by fairly large igneous bodies ranging in composition from quartz diorite and dacite to diabase and gabbro. These areas can be readily mapped from aerial photographs because of their relatively dense vegetative cover.

Deposit: Much of the patch of soil on the bench in the N½ sec. 16 appears to be quite rocky and shallow. In some areas, about 70 percent rock shows on the surface, as at the site of sample number 1, while other parts of the area look relatively free of rock, as near the site of sample number 2 (Figure 9). Both samples were augered to 9 ft of depth. Several rocks were encountered at sample number 1 site; none were found in the hole for sample number 2. Average depth of soil in this patch is estimated to be about 10 ft, and the average volume of rock in soil is about 45 percent. The average grade of soil and saprolite indicated by three samples is 0.54 percent Ni. The main area covers 20 acres. Further exploration of the area may be warranted.

Table 17. Sample assay results, Spokane Creek area

Sample number*	Assay number	Depth interval (ft)	Percent Ni	Co	Cr_2O_3	Fe
6	ALG- 59	0-7	0.61	0.14	0.87	----
7	AJG-120	0-9	0.54	0.04	1.33	21.7
8	AJG-119	0-9	0.41	0.03	0.98	16.6

* These numbers are found in Figure 9 and indicate locations from which samples were taken

Upper Chetco and Square Lake laterites (14, Plate 1)

Location: The area is located in secs. 8, 17, 20, 21, and 28, T. 39 S., R. 10 W., along the upper Chetco River, mainly on the crest and southwest slopes of the ridge west of Hawk's Rest and between the Little Chetco and main Chetco Rivers. The area is in the Kalmiopsis Wilderness, and access is difficult. It may be reached by hiking cross country either from the Chetco Divide trail from Doe Gap or from the Madstone cabin trail, which extends west from the end of the jeep road to Emlly cabin. The Square Lake laterite patches are along the county-line trail about 3 mi northeast of Doe Gap in sec. 24 (Figure 17).

Geology: The area is near the northern fault margin of the Josephine ultramafic sheet. The rocks are partly to completely serpentinized harzburgite intruded by various dacitic.and diabasic dikes.

Deposits: The areas of lateritic soil appear to be erosional remnants and slope soil and rock-debris slump deposits. The eight patches mapped near the upper Chetco River cover about 100 acres. Although not adequately explored, they appear to be relatively thin and rocky. The average rock content probably exceeds 40 percent by volume, and the average depth of soil and saprolite may be no greater than 10 ft. The two patches of soil near Square Lake (sec. 24) cover about 25 acres. They appear to be similar to those along the upper Chetco, but they have not been sampled.

Table 18. Sample assay results, upper Chetco and Square Lake areas

Sample number*	Assay number	Depth interval (ft)	Location ¼	Sec.	Percent Ni
1	AAG-122	0 -1.1	SW/SE	8	0.32
2	CP-MC**	2.5-3.0	SW/SE	8	0.47
3	CP-HC-1**	1.5-4.5	SE	17	0.63
4	CP-HC-2**	1.5-3.0	SE/SE	17	0.61
5	CP-HR-1**	0 -4.5	NW	21	0.62

* These numbers are found in Figure 17 and indicate locations from which samples were taken

** Private company assay

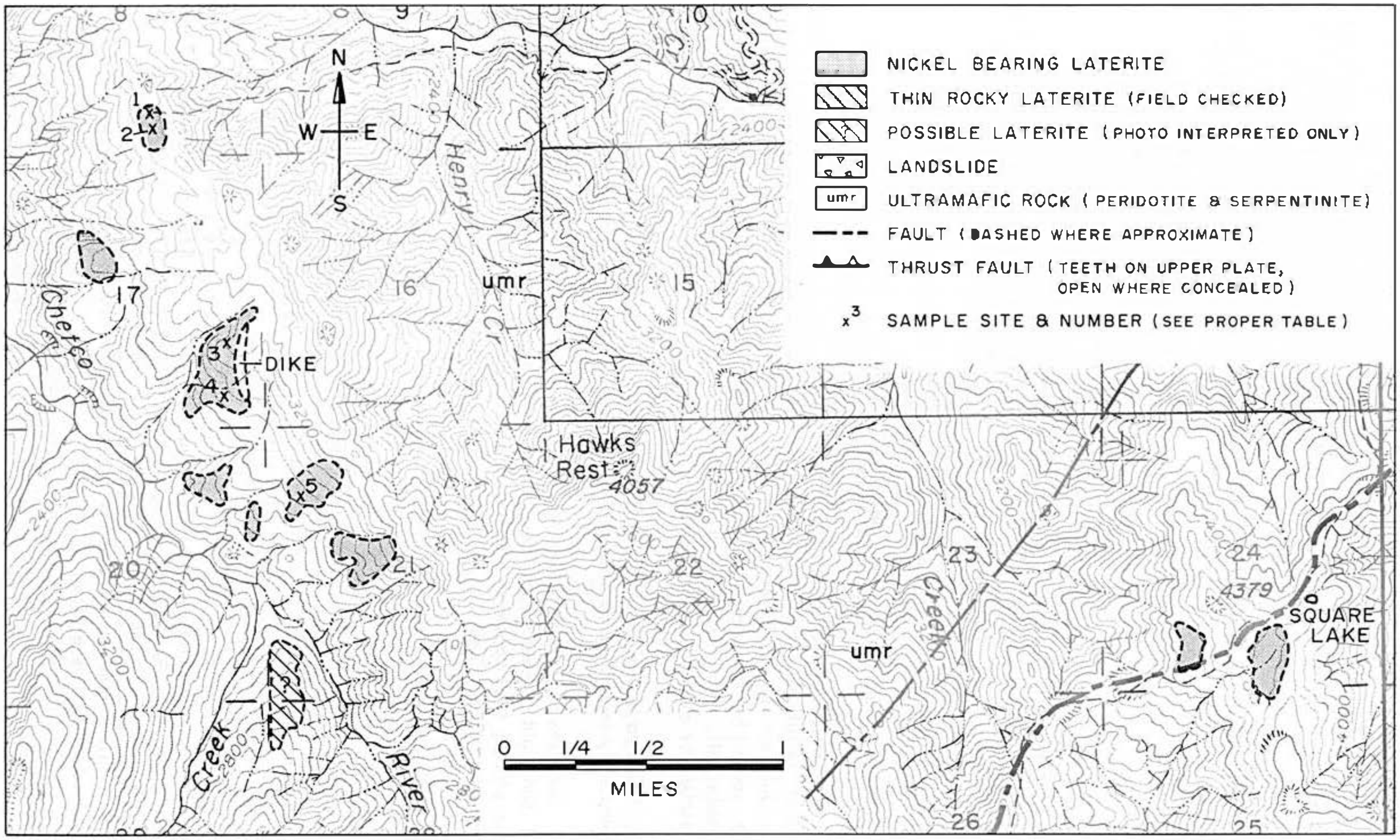

Figure 17. Geologic map of upper Chetco and Square Lake areas. Sample assay results appear in Table 18.

Woodcock Mountain laterites (16, Plate 1)

Location: Woodcock Mountain is about 3 mi west and slightly south of Cove Junction in secs. 19, 30, and 31, T. 39 S., R. 8 W., and secs. 24, 25, ond36, T. 39 S., R. 9 W. The deposits ore accessible via on unimproved dirt road which crosses private land off the south end of West Side road (Figure 14).

The bulk of the land in R. 8 W. is under control of the Bureau of Land Management; however, port of the area is owned by Josephine County and part by private interests. Land in R. 9 W. is under U.S. Forest Service and State of Oregon ownership. Deposits on public lands hove been held by mining claim locations for several years.

Exploration and development: The area was probably first explored for nickel in 1942 at about the some time as Eight Dollar Mountain. In 1947 and 1948, the Department mapped and sampled the deposit by hand ougering. Results are reported by Dole and others (1948) and Mason (1949). In 1951, the U.S. Bureau of Mines explored the deposit by bulldozer trenching and extensive soil ougering (Appling, 1955). New Delhi Mines, Ltd., Toronto, churn drilled the deposit in 1957, putting down 61 holes to on average depth of 51 ft. Work done since that time includes assessment work, reconnaissance sampling, and mopping by the writer in 1975 and by the U.S. Bureau of Mines in 1977.

Geology: The area is underlain by portly serpentinized horzburgite of the Josephine ultramafic sheet. These rocks ore in fault contact with Galice Formation marine sediments near the intersection of the east slope of the mountain and the valley floor. The western fault contact of the ultramafic rocks is with Jurassic volcanic rocks about 6 mi west of the mountain. The ultramafic rocks hove been somewhat sheared, serpentinized, and intruded by numerous small diabase and hornblende diorite dikes. Most of these dikes and the associated shearing have o northerly trend and steep dip that is parallel with the contacts and regionol tectonic fabric.

Deposits: The lateritic soil accumulations appear to be residual from an old upland weathering surface, most of which has been eroded away. Some of the moin southern area appears to be o transported slope-type deposit affected by gradual surface creep and minor slumping. Small north-trending diabase dikes form the downhill edge of deep, well-developed laterites. These dikes hove apparently retarded erosion, thus protecting part of the deposit. North-trending faults probably also affect laterite accumulation.

The main southern deposit covers an area of about 138 acres. Its overage width is about 1,300 ft and length about 4,500 ft. The central smallest and highest area covers about 15 acres and is approximately 975 ft long and 650 ft wide. The northern area covers about 22 acres and is 1,600 ft long and generally about 580 ft wide.

Depth of the deposits varies considerably. Using on arbitrary cutoff assay value of 0.40 percent Ni to indicate bed rock, the average depth calculated from 61 New Delhi Mines, Ltd., churn-drill holes in the main area is about 32 ft. The overage depth estimated from geologic mopping of all three areas is about 10 ft. Since the present map area covers on area larger than that drilled by New Delhi Mines, Ltd., on overage depth for the main southern area is estimated to be about 20 ft. The estimated average depth for the central area is about 8 ft and for the northern area about 10 ft. Estimated average content of unweathered rock intermixed with soil and saprolite in the three areas is 35 percent by volume.

The average grade of soil and saprolite for all three areas is about 1.00 percent Ni, 2.00 percent Cr_2O_3, 0.11 percent Co, and 27 percent Fe. The calculated overage grade of mixed rock, soil, and saprolite for all three areas is 0.65 percent Ni, 1.2 percent Cr_2O_3, 0.07 percent Co, and 17 percent Fe. Sample assay results are given in Table 19.

Table 19. Sample assay results, Woodcock Mountain area

Sample number*	Assay number	Depth interval (ft)	Location ¼	Sec.	Percent Ni	Cr_2O_3	Co	Fe
17	AJG-24	0- 4	NW/NW	19	0.93	----	----	----
18	AJG-25	0- 5.5	W½/NW	19	1.06	1.49	0.09	22.4
19	AJG-26	0- 5.5	W½/NW	19	1.38	2.15	0.09	27.4
20	AJG-23	0- 6.7	SW/NW	19	1.06	2.00	0.08	25.9
21	AJG-22	0- 4	SE/SE	24	1.04	----	----	----
22	AJG-27	0- 8	SE/SE	24	0.98	2.17	0.09	36.2
22	AJG-28	11-15	SE/SE	24	1.56	1.15	0.05	23.3
23	MJH-60**	1- 7	SE/SE	24	0.25	0.60	0.02	----
24	MJH-57**	0- 4	SE/SE	24	0.83	0.70	0.03	----
24	MJH-58**	4-11	SE/SE	24	0.95	0.83	0.11	----
25	MJH-52**	0- 4	SE/SE	24	0.96	1.60	0.11	----
25	MJH-53**	4-12	SE/SE	24	0.46	0.44	0.02	----
26	MFW-16-17**	0- 7	S/NE	25	1.10	2.12	0.01	----
27	MFW-18-19**	0-11.5	N/SE	25	1.10	1.33	0.01	----
28	MFW-20-21**	0- 7	NE/SE	25	0.66	1.40	0.03	----
29	AJG-54	0- 8	SW/SW	30	1.22	----	0.13	----
29	AJG-55	8-11.6	SW/SW	30	1.19	----	0.13	----
30	MJH-74-75**	0- 9	NW/NW	31	0.74	0.85	0.03	----
31	MJH-76-77**	0- 9	N	31-36	0.92	1.36	0.04	----
32	MJH-78**	0- 5	NW/NW	31	0.68	1.17	0.04	----

* These numbers are found in Figure 14 and indicate locations from which samples were taken
** U.S. Bureau of Mines samples, 1977

Other Southwest Oregon Laterite Deposits

A few other laterite deposits occur outside the main Josephine peridotite body, mainly in erosional remnants of an upper thrust plate of peridotite in Curry County. They are reported below in alphabetical order.

Collier Creek laterites (7, Plate 1)

Location: Several small patches of lateritic soil are scattered about the area north of Hurt cabin site extending into four townships (Figure 18). Patches of soil are mapped from aerial photographs in secs. 20, 29, 30, and 31, T. 36 S., R. 11 W.; the south edge of sec. 36, T. 36 S., R. 12 W.; secs. 1 and 12, T. 37 S., R. 12 W.; and minor patches in sec. 6, T. 37 S., R. 11 W. The more promising areas appear to be in sec. 1, T. 37 S., R. 12 W.

The area may be reached via Hunter Creek, Snow Camp, Game Lake, and the North Fork of Collier Creek roads (USFS Roads 368, 370, 3698, and 3795). A very steep jeep trail branches from Road 3795 and leads down to the Hurt cabin site; steep bulldozer trails extend down the south side of the ridge between Collier Creek and the North Fork of Collier Creek to about 2,200 ft, and out the ridge between the Illinois River and Horse Sign Creek in the north edge of the map area. From U.S. 101 about 2 mi south of Gold Beach, the distance to the Hurt cabin site is about 30 mi.

Exploration: There has been very little exploration of the area for nickel. Prospecting has been mainly for copper and chromite. Appling (1955) did some reconnaissance about 1954. The present investigation has consisted of studying 1973 color infrared aerial photographs and taking 10 auger samples.

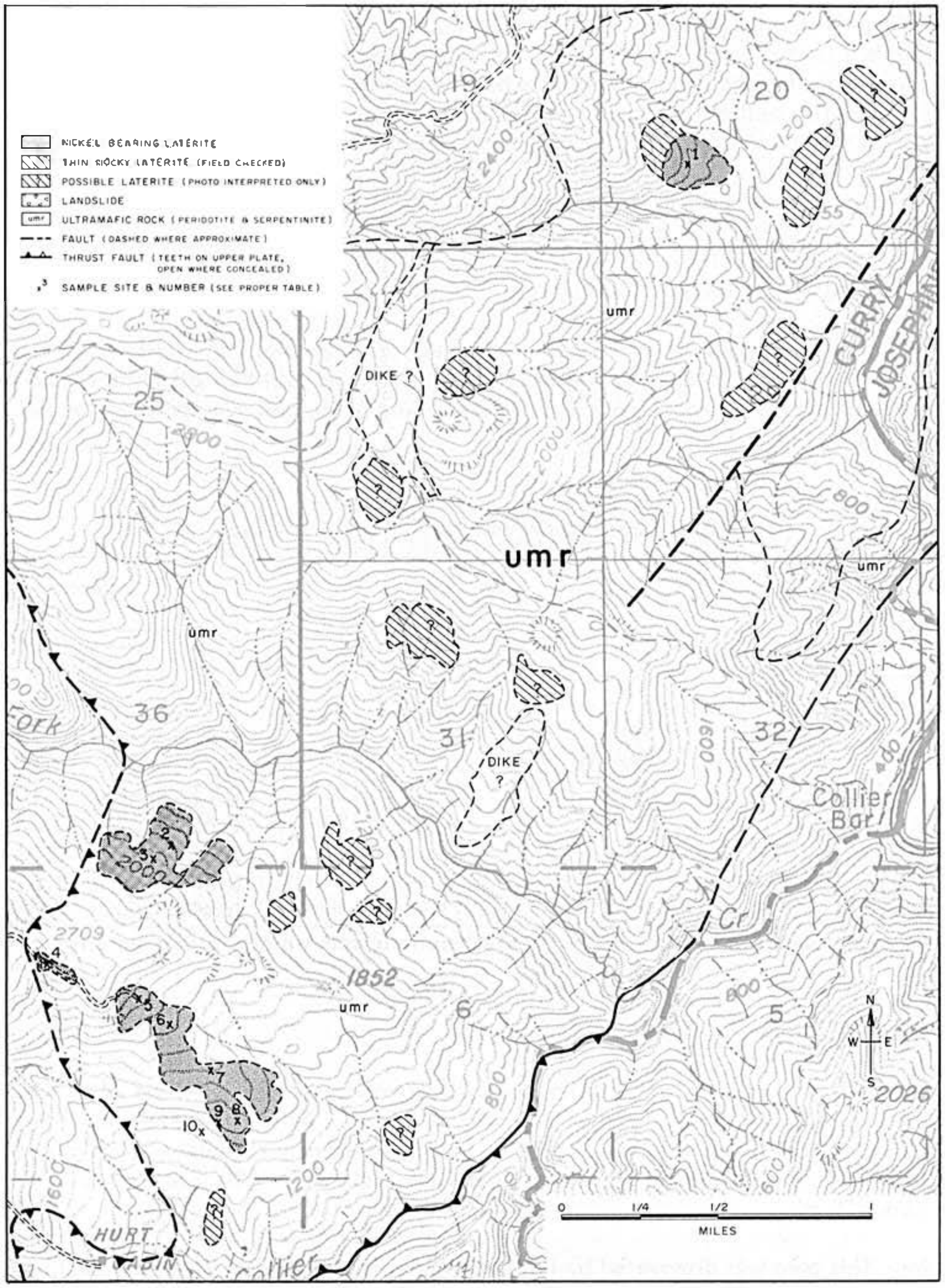

Figure 18. Geologic map of Collier Creek area. Sample assay results appear in Table 20.

Geology: The lateritic soils developed on partly serpentinized harzburgite. These ultramafic rocks are thrust over Late Jurassic marine sediments and volcanic rocks of the Dothan-Otter Point Formation and underlie an overthrust klippe of gneissic metagabbro of the Big Craggies to the east. Thrust faulting gives way to high-angle faulting to the north.

Landsliding is a common feature in the area due to oversteepened slopes and rapid downcutting of streams. Both the ultramafic and metagabbro rocks have been intruded by dikes and stocks which vary in composition and texture to include diabase, gabbro, dacite, and diorite. These intrusives vary in age from mid-Jurassic to mid-Tertiary. Lateritic soils in this area may never have been well developed.

Deposits: The deposits appear to be accumulations and residual patches of dark reddish-brown soil. Greatest soil thickness is probably in areas of slumping or sliding of near-surface debris. The soil is always mixed with varying amounts of relatively unweathered rock. Rock content varies from about 30 to 80 percent. Estimated average rock content of the areas examined is 45 percent by volume. Table 20 shows assay results.

Total area of the patches examined is about 100 acres. Possible areas of additional lateritic soil mapped from aerial photographs total about 140 acres. The maximum depth of soil in areas examined is estimated to be 35 ft, and the average depth is 8 to 10 ft. An unweighted average grade of soil and saprolite in this area is about 0.70 percent Ni.

Table 20. Sample assay results, Collier Creek area

Sample	Assay	Depth	Location				Percent			
number*	number	interval (ft)	¼	Sec.	T. (S.)	R. (W.)	Ni	Cr	Co	Fe
1	AJG- 80	0- 5.4	SW	20	36	11	0.64	----	0.05	----
2	AJG- 82	0- 6.5	SW/SE	36	36	12	0.96	1.2	0.06	23.3
3	AJG- 81	0- 3	S edge	36	36	12	0.93	----	----	----
4	AJG- 77	0-11	NW	1	37	12	0.52	----	----	----
5	AJG- 78	0- 3	SE/NW	1	37	12	0.72	----	----	----
6	AJG- 79	0- 5.6	Cent.	1	37	12	0.71	----	0.10	----
7	AJG-117	0- 4.5	SE	1	37	12	0.69	1.2	0.07	28.3
8	AJG-116	0- 3.3	SE	1	37	12	0.86	----	0.06	----
9	AJG-115	0- 5.4	SE	1	37	12	0.53	1.6	0.06	31.0
10	AJG-114	0- 2.6	SE	1	37	12	0.49	----	0.07	----

* These numbers are found in Figure 18 and indicate locations from which samples were taken

Gray Butte laterites (5, Plate 1)

Location: Small patches of lateritic soil occur in unsurveyed secs. 12, 13, and 24, T. 36 S., R. 12 W. The patch in sec. 12 lies on a slump bench northeast of Gray Butte; patches mapped in the NW¼ sec. 24 extend into the south edge of sec. 13 (Figure 19). The area may be reached by a prospect road and trail, and the northern part is about 4.5 mi north of Game Lake. The distance from U.S. 101 near Gold Beach is about 30 mi.

Exploration: This area was discovered by inspection of color infrared aerial photographs. It was visited and sampled July 3, 1975, and found to be much smaller than the original photo-plotted target. Exploration has been limited to three auger samples in the northern deposit. The southern patches were seen from Horse Sign Butte and confirmed from aerial photographs but not sampled.

Geology: Float inspected along the trail indicates that much of Gray Butte ridge may be a swarm of diabase and gabbro dikes, either in fault contact or intruding serpentinized harzburgite. Landsliding is very apparent in the area. Somewhat jumbled-appearing Dothan (?) sediments occur on the west side of the slump pond north of Gray Butte. Fossiliferous Lower Cretaceous marine sediments, including chert

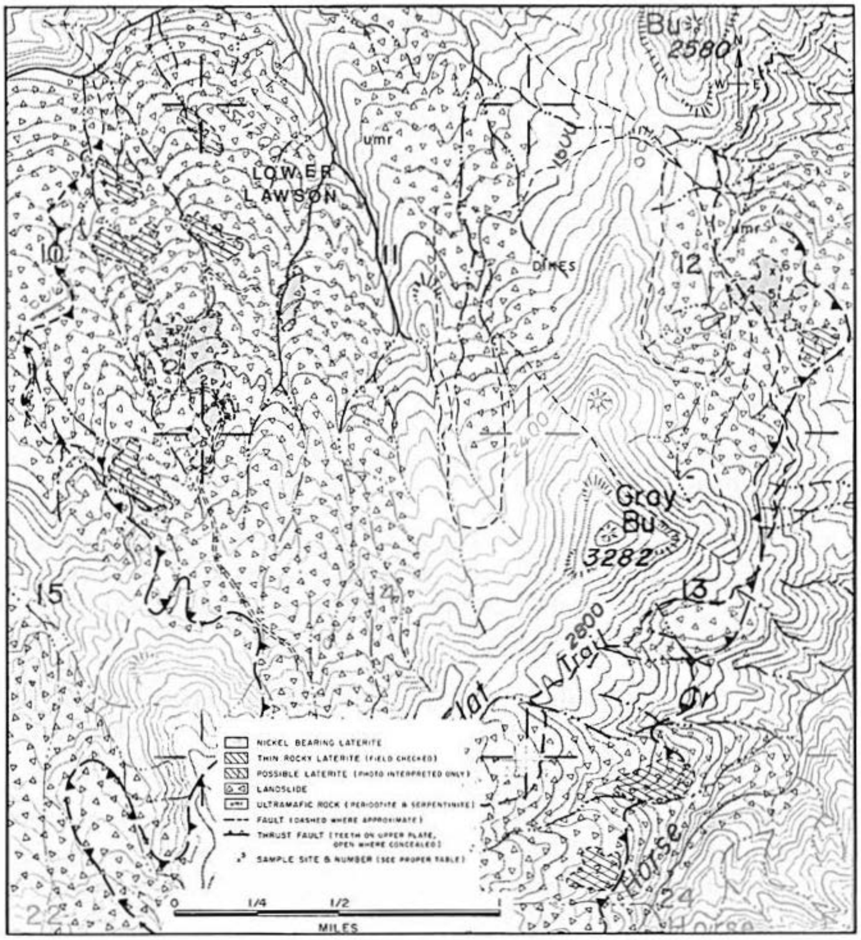

Figure 19. Geologic map of lower Lawson and Gray Butte areas. Sample assay results appear in Tables 21 and 23.

pebble conglomerate sandstone and siltstone of the Myrtle Group, underlie Horse Sign Butte, Lawson Butte, and most of Horse Sign Creek, extending north to the Agness area. At least part of the contact of the ultramafic rocks with the younger sedimentary units appears to be a thrust fault. High-angle faulting and landsliding serve to complicate and confuse geologic interpretation.

Deposits: The northern patch of lateritic soil covers about 17 acres, the two unexplored southern patches about 20 acres. Maximum depth of the northern body may be about 30 ft, and the average depth is estimated to be 9 ft. In the northern area, some pyroxenite and diabase rock fragments and residual pyroxene crystals can be seen in the soil. The first 7 ft of the 12-ft deep auger hole drilled for sample number 6 (Figure 19) is dark reddish-brown soil; the next foot is a green, highly sheared serpentinite; and the remainder is dark olive-green to brown talcose saprolite. Table 21 summarizes the assay data. The percentage of unweathered rock in the soil is estimated to be 35 percent by volume. The grade seems to be lower than normal, perhaps because of intermixing by landsliding of other rock types in the deposit area.

Table 21. Sample assay results, Gray Butte area

Sample number*	Assay number	Depth interval (ft)	Location ¼	Location Sec.	Percent Ni	Percent Co
4	AJG-73	0- 5.2	NW/SE	12	0.54	0.17
5	AJG-74	0- 3	N½/SE	12	0.25	----
6	AJG-75	0-12	N/SE	12	0.45	Trace

* These numbers are found in Figure 19 and indicate locations from which samples were taken

Iron Mountain laterites (2, Plate 1)

Location: Iron Mountain is on the Coos-Curry County border in T. 33 S., R. 12 W. The main deposit extends southwest from sec. 33 into secs. 4 and 5, T. 34 S., R. 12 W. (Figure 20) and is about 20 mi from Agness, 35 mi from U.S. 101 via Elk River, 38 mi from Gold Beach via Lobster Creek, and 30 mi from Powers via the South Fork of the Coquille River. Several timber access roads lead into the site.

Exploration: The date of discovery is not known by the writer, but the area was examined by Appling in 1954 (Appling, 1955, p. 16). Development work includes a few shallow excavations (discovery cuts) and reconnaissance auger sampling by Appling and later by this writer July 29-31, 1975, during the present investigation.

Geology: Iron Mountain is underlain by a body of partly serpentinized harzburgite a little more than a mile wide and 5 mi long, which trends about N. 20° E. These ultramafic rocks appear to have a fault-contact relationship with the surrounding Upper Jurassic Galice Formation, which is composed of dark slaty siltstone, sandstone, and lesser metavolcanic rocks (greenstone).

The high point of Iron Mountain on the line of secs. 32 and 33 is underlain by a small gabbro body which intrudes the ultramafic rocks. A slightly larger quartz diorite body is exposed on the south end of Iron Mountain in sec. 5. Other minor dikes of similar composition occur in the area. Small erosional remnants of fossil-bearing Tertiary marine sediments are exposed along the eastern fault zone near the road junction and township line between secs. 4 and 33. A small deposit of coal was once prospected in these Tertiary rocks. Among other prospects in the area are the Miss Dolly Copper Prospect in NE¼ sec. 5 and the Rock Creek chromite occurrence in SW¼ NE¼ sec. 33.

The north end of the Iron Mountain ultramafic body is cut off by a northeast-trending high-angle fault mapped by Baldwin (1973). Landsliding is common, and some lateritic soil occurs in a slide around the corner common to secs. 9, 10, 15, and 16. The origin of Mud Lake at the west edge of sec. 22 is uncertain; it may have been formed by Pleistocene alpine glaciation or slumping, or it may be a sag pond formed along a fault.

Deposits: The main deposit of lateritic soil is on the southeast slope of Iron Mountain in secs. 4, 5, and 33 in an area about 800 ft wide and a mile long. The two patches forming this main area cover about 74 acres, and the soil is relatively thin and rocky. The soil has an estimated average depth of 10 ft and an average rock content of 50 percent by volume. The five other mapped areas, apparently of minor consequence, cover a total aggregate area of about 55 acres. The northern slide area in secs. 9, 10, 15, and 16 appears to have other than ultramafic rocks intermixed in the slide, and the lateritic soil appears to be of poor grade and very rocky.

Samples taken in the area are tabulated in Table 22. Arithmetic average of the eight samples from the main deposit area is 0.70 percent Ni.

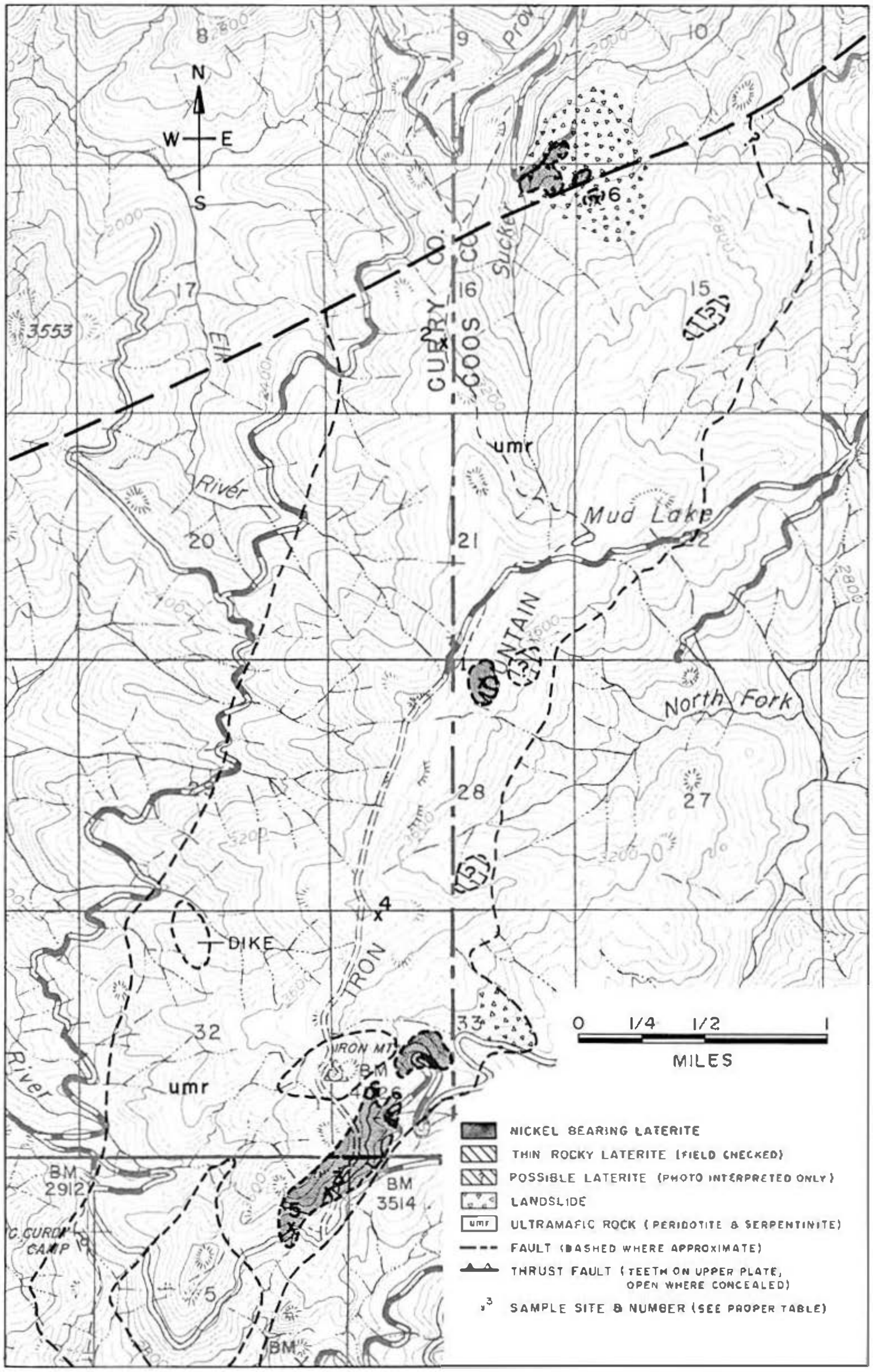

Figure 20. Geologic map of Iron Mountain area. Sample assay results appear in Table 22.

Table 22. Sample assay results, Iron Mountain area

Sample number*	Assay number	Depth interval (ft)	Location ¼	Sec.	Percent Ni	Co	Cr	Fe
1	AJG- 99	0- 3	NW/NE	28	0.85	0.06	1.20	28.2
2	AJG-100	0- 2.5	SW	16	0.22	----	----	----
3	AJG-101	0- 5	NE/NE	5	0.63	0.06	1.30	28.2
4	AJG-102	0- 2	NW/NW	33	0.26	----	----	----
5	AJG-103	0-14	NE	5	1.02	0.07	1.89	30.0
6	AJG-104	0- 5.5	NW/NW	15	0.56	0.03	0.71	13.0
Bulk sample	(Nielsen)	Surface	NE	5	0.92	0.08	2.57	37.8
U.S. Bureau Mines	NR-1- 9	0- 8	Main deposit		0.69	----	----	----
U.S. Bureau Mines	NR-1-10	0- 6	Moin deposit		0.28	----	----	----
U.S. Bureau Mines	NR-1-11	0-14	Main deposit		0.85	----	----	----
U.S. Bureau Mines	NR-1-13	0- 4	Main deposit		0.58	----	----	----
U.S. Bureau Mines	NR-1-14	0- 6	Main deposit		0.61	----	----	----

* These numbers ore found in Figure 20 and indicate locations from which samples were token

Lower Lawson laterites (4, Plate 1)

Location: Seven patches of lateritic soil hove been mopped on portly serpentinized harzburgite south of Lawson Creek in secs. 10, 11, 14, and 15, T. 36 S., R. 12 W. (Figure 19). The area is reached by timber access roods, prospect road, and trail. The prospect road leads north from Game Lake; a road on the west side of Lawson Creek ends about 3 mi from the deposits; the distance to U.S. 101 near Gold Beach is about 34 mi.

Development: The area has been explored by mining claimants in recent years, as evidenced by the prospect rood and bulldozer trenches. In July 1975, several knob-cone pine trees 4 in. in diameter were growing in the west end of o bulldozer trench at an elevation of 2,050 ft.

Geology: The prospects occur on a 1.5-mi wide, north-trending body of portly serpentinized horzburgite, bounded on the west by rocks of the Late Jurassic Dothan Formation and on the east and north by Early Cretaceous Myrtle Group sediments. Gray Butte ridge is mode up largely of diabase and gabbro dikes. Coleman (1972) mopped all of these formations with thrust-fault contacts. High-angle faulting and landsliding has further complicated the geology.

Deposits: A few areas of promising-appearing, dark red-brown lateritic soil with some accumulation of iron pellets on the surface were noted along the troil at about 2,080 ft. Hand-auger samples in this area bottomed at about 6.5 ft in sheared, green, weathered serpentinite. The soil appears to be quite shallow and may overage only about 6 ft in depth. The amount of unweathered rock in the soil varies from about 15 to 70 percent and is estimated to overage 35 percent by volume. The total area of soil patches mopped is about 70 ocres.

Sample assay data ore tabulated in Table 23.

Table 23. Sample assay results, lower Lawson area

Sample number*	Assay number	Depth interval (ft)	Location ¼	Sec.	Percent Ni	Co	Cr	Fe
1	AJG-70	0-6.5	SW/SW	11	0.51	0.08	1.89	37.5
2	AJG-71	0-3	SE/SE	10	0.65	0.07	----	----
3	AJG-72	0-7.5	SE	10	0.52	----	----	----

* These numbers are found in Figure 19 and indicate locations from which samples were token

Peavine (Red Cap Group claims) laterites (3, Plate 1)

Location: The area is located largely west of Galice on the southeast slopes of Mount Peavine. Galice Creek road and Peavine Mountain road lead into the area, which lies about 5 mi from Galice by the main road (Figure 21).

History: Seventeen lode claims were located in September 1957, and preliminary sampling was done soon thereafter by shallow augering and in shallow discovery cuts.

Geology: The lower part of the area was mapped by Wells and Walker (1953) as landslide debris downslope from a body of partly serpentinized peridotite surrounded on three sides by amphibolite and bordered on the east by metavolcanic rock of the Rogue Formation. A fairly large area appears to be covered by dark, red-brown lateritic soil and mixed rock debris that is largely peridotite. Shallow sampling indicates a poorly developed laterite with relatively little nickel enrichment. Some increase of nickel, however, may be indicated at depth (see assay results, Table 24). Further attempts to sample at greater depths may be justified.

Table 24. Sample assay results, Peavine area

Sample number*	Assay number	Type	Depth interval (ft)	Location $\frac{1}{4}$	Location Sec.	Percent Ni	Percent Co	Description
1	RG-458	Channel	0-4	SE	27	0.20	Tr	Soil
2	RG-459	Grab	Surface	SE	27	0.27	Tr	Peridotite
2	RG-460	Channel	0-2	SE	27	0.29	Tr	Soil
3	RG-461	Channel	0-3	SE	27	0.32	Tr	Soil
3	RG-462	Grab	3	SE	27	0.30	Tr	Yellow soil
4	AIG-114	Auger	0-4	SE	27	0.27	--	Soil
4	AIG-115	Auger	4-8	SE	27	0.45	--	Granular soil, saprolite, and rock fragments
5	RG-464	Grab	Roadcut	NE	34	0.24	Tr	Yellow-brown soil

* These numbers are found in Figure 21 and indicate locations from which samples were taken

Snow Camp laterites (including Windy Creek) (9, Plate 1)

Location: These laterites occur in unsurveyed secs. 19, 30, and 31, T. 37 S., R. 12 W.; secs. 24 and 25, T. 37 S., R. 12½ W.; and sec. 30, T. 37½ S., R. 12 W. The deposits extend from near Windy Creek to Snow Camp Mountain (Figure 22). The main laterite areas are on Snow Camp Meadow in secs. 24 and 25 and on the east flank of Snow Camp Mountain in sec. 30. The area, which may be reached via Hunter Creek road and Snow Camp Mountain road, is about 26 mi from U.S. 101 near Gold Beach. The southern soil patches may be reached by a new timber access road that branches south of the main road near Fairview Mountain and goes around the west side of Snow Camp Meadow and ends near Windy Creek.

Exploration: The Snow Camp Meadow area was mapped and sampled on a reconnaissance scale by the U.S. Bureau of Mines in 1955 (Appling, 1955). Several shallow bulldozer trenches have been made in the two main laterite areas. Preliminary exploration of the area, including some drilling, was reportedly done by Hanna Mining Company during the 1960's. The southern patches near Windy Creek show no evidence of exploration or claims as of July 1975. The present investigation has been limited to reconnaissance hand-auger sampling and mapping with the aid of color infrared aerial photographs.

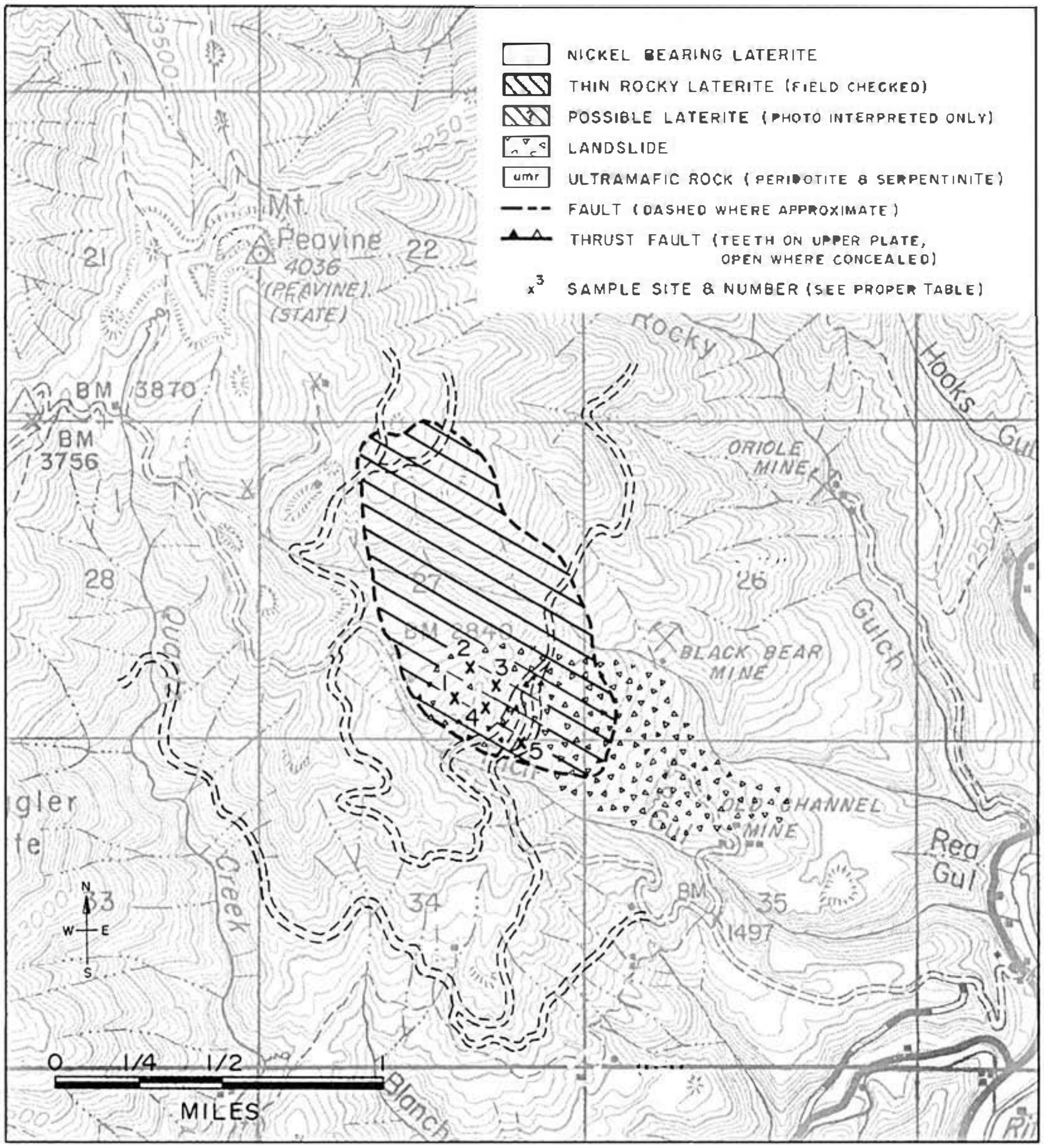

Figure 21. Approximate outline of Peavine laterite area. Sample assay results appear in Table 24.

Figure 22. Geologic map of Snow Camp Mountain, upper Lawson, and Huntley Spring areas. Sample assay results appear in Tables 25 and 27.

Geology: The reddish-brown soil patches ore developed on portly serpentinized harzburgite. These ultramafic rocks appear to be thrust over rocks of the Colebrooke Schist Formation, which are in turn thrust over rocks of the Dothan-Otter Point Formation. The Colebrooke Schist is interpreted as tectonically formed phyllitic and schistose sediments and volcanic rocks (Coleman, 1972). The Dothan and equivalent Otter Point Formations are composed of relatively unmetamorphosed latest Jurassic marine turbidites and volcanic rocks. The youngest rocks in the area, Lower Cretaceous marine sediments of the Myrtle Group, crop out south of Huntley Spring and in Windy Valley. Contacts of these rocks with ultramafic rocks are along both high-angle and thrust faults, although in some places the sediments appear to have been deposited on the ultramafic rocks. A few small diorite and gabbro intrusives penetrate the ultramafic rocks, as at Collier Butte and the area southwest of Huntley Spring. The upper peak of Snow Camp Mountain is underlain by Colebrooke metavolcanic rocks.

Deposits: Most of the lateritic soil deposits appear to be relatively shallow and rocky. The Snow Camp Meadow deposit is a large landslide area that at one time contained a small, 15-acre slide lake in the central part of the meadow. This area has a fairly thick deposit of pale, greenish-gray, fine-grained lake sediments exposed in the creek banks near the south end of the meadow. The principal area of lateritic soil appears to be in the outer ridge of the slide, but its occurrence under the lake sediments has not been determined.

The laterites and saprolite development in the meadow slide deposit may be as deep as 50 ft or more in places; average depth is estimated to be 20 ft. Estimated average depth of nickel enrichment in the Snow Camp Mountain and Windy Creek patches is about 8 ft. The average unweathered rock content of the soil and saprolite zone for all three areas is estimated to be 45 percent by volume.

The Snow Camp Meadow deposit covers about 50 acres, with an additional 15 acres covered by lake sediments. The deposits mapped on the ridge and eastern flank of Snow Camp Mountain cover about 75 acres, and the southern patches near Windy Creek include about 35 acres.

The calculated average grade of soil sampled in the area (excluding lake sediment samples) is 0.68 percent Ni, 0.08 percent Co, and 1 percent Cr. Further sampling of the area is recommended. Deeper samples may be somewhat higher in nickel content. Assay results of samples taken in the area are shown in Table 25.

Table 25. Sample assay results, Snow Camp area

Sample number*	Assay number	Type	Depth interval (ft)	Location ¼	Location Sec.	Percent Ni	Percent Co	Percent Cr	Description
5	NR-2-9**	Auger	0-2.5	SE	24(?)	0.47	----	----	
6	NR-2-8**	Auger	0-5	SE	24	0.71	0.05	----	
7	NR-2-6-7**	Auger	0-7	SW/SE	24	0.79	0.07	----	
8	NR-2-5**	Auger	0-3	¼ cor	24-25(?)	0.50	----	----	
9	NR-1-21-22**	Auger	0-7	S/SE	24	0.35	----	----	
10	NR-2-3-4**	Auger	0-7	N½	25	0.62	----	----	
11	NR-2-2**	Auger	0-3.5	NW/NE	25	0.55	----	----	
12	NR-1-23**	Auger	0-2	N/NE	25	0.33	----	----	Lake seds (?)
13	NR-2-1**	Auger	0-3	NE	25	1.08	----	----	
14	NR-1-24-25**	Auger	0-5	NE	25	0.39	----	----	Lake seds (?)
15	AJG-91	Channel	0-5	NW	30	0.77	----	----	4,170 ft el.
16	AJG-92	Auger	0-6.5	W½	30	0.94	----	----	4,065 ft el.
17	AJG-93	Auger	0-7	NE/SW	30	0.87	0.04	1.13	4,025 ft el.
18	AJG-94	Auger	0-4.2	NE/NE	30	0.54	0.14	----	3,160 ft el.

* These numbers are found on Figure 22 and indicate locations from which samples were taken

** Samples from Appling (1955)

Sourdough Flat laterites (10, Plate 1)

Location: These laterites occur in SW¼ sec. 11 and NW¼ sec. 14, T. 38 S., R. 10 W., about 1.25 mi southwest of Chetco Pass on Sourdough Flat in eastern Curry County, near the eastern boundary but inside the Kalmiopsis Wilderness (Figure 23). The deposit may be reached via the Illinois River and Chetco Pass roads and is about 20 mi from Selma on U.S. 199.

History: The area, sampled and mapped in September 1974 and reported by Ramp (1975, p. 37-39), has not previously been recognized as a nickel prospect. Small pits and trenches were dug during the early 1950's in search for chromite.

Geology: The area is part of a large landslide block made up of very coarse-grained dunite (olivine crystals up to 2 in. in diameter), harzburgite, serpentinite, occasional dike rock fragments, and red to yellow-brown lateritic soil. A short distance west of the deposit, a large diorite dike intrudes the ultramafic rocks; and a smaller dike of similar composition is exposed on the ridge to the northeast. This body of ultramafic rocks is thrust over the Chetco River gabbro-diorite complex to the west; to the south and east, it is faulted and infolded with volcanic rocks and sediments of the Rogue Formation.

Deposit: The soil is, in part, a talcose, clayey saprolite intermixed with abundant peridotite and coarse-grained dunite boulders. The amount of relatively unweathered rock in the soil is estimated to be from 30 to 80 percent, probably averaging about 50 percent by volume over the total area. Minor amounts of silica boxwork and occasional chunks of massive chromite float occur in the soil. The area of lateritic soil covers about 45 acres. The maximum depth of enrichment may be 50 ft; the estimated average depth is 10 ft. The average nickel content of the soil and saprolite is about 1 percent Ni. The unweathered coarse-grained dunite contains about 0.27 percent Ni. Sample assay results are given in Table 26.

Table 26. Sample assay results, Sourdough Flat area

Sample number*	Assay number	Depth interval (ft)	Percent Ni	Co	Cr
1	AIG- 65	0- 3	1.14	----	----
2	AIG- 91	0- 5	0.88	0.06	----
3	AIG- 92	0- 5	0.83	----	----
3	AIG- 93	5-10	1.18	0.07	1.58
4	AIG- 94	0- 3.7	1.15	0.07	----
5	AIG- 95	0- 3.3	1.27	0.08	----
6	AIG- 96	0- 2	1.30	0.08	----
7	AIG- 97	0- 1.5	0.96	0.06	----
8	AIG- 98	0- 2.7	1.16	0.07	----
9	AIG- 99	0- 3	1.14	0.07	----
10	AIG-100	0- 3	1.05	----	----
11	AIG-101	0- 1.5	1.05	----	----
12	AIG-102	0- 1.5	0.89	----	----
13	AIG-103	0- 5	0.78	----	----
13	AIG-104	5-10	0.86	0.04	1.07
14	AIG-105	0- 4	0.48	----	----

* These numbers are found in Figure 23 and indicate locations from which samples were taken

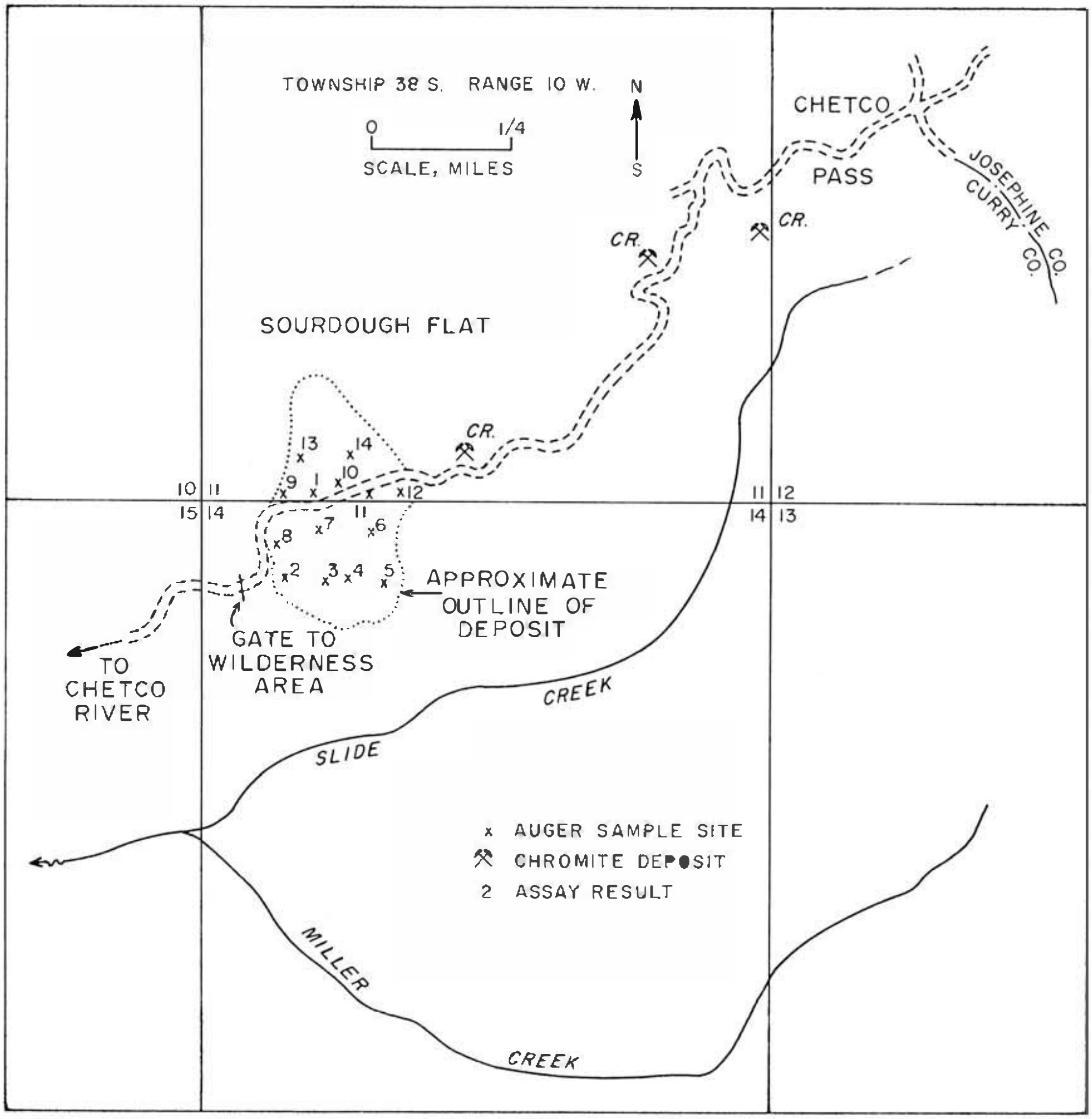

Figure 23. Map of Sourdough Flat showing distribution of laterite and location of auger samples. Sample assay results appear in Table 26.

Upper Lawson and Huntley Spring laterites (6, Plate 1)

Location: The area is located east of Fairview Mountain in secs. 7, 18, and 19, T. 37 S., R. 12 W. The main deposit is on a small ridge between forks of Lawson Creek. The area is about 27 mi from U.S. 101 near Gold Beach and may be reached via Hunter Creek road and Game Lake road. Access to the main deposit is from the road near Fairview Mountain (Figure 22).

Exploration and development: Claims were located in 1957, and some shallow bulldozer trenches and prospect roads were constructed. A minor amount of auger sampling and mapping with the aid of color infrared aerial photographs was done during the present investigation.

Geology: Some lateritic soil has developed on partly serpentinized harzburgite. These ultramafic rocks appear to occur as a thin thrust sheet over Colebrooke Schist and rocks of the Dothan-Otter Point Formation. The Colebrooke Schist and ultramafic rocks have been intruded by dikes and stocks of diorite, gabbro, and diabase. A northeast-trending near-vertical fault marks the contact of ultramafic rocks with Colebrooke Schist in the area just east of Fairview Meadow. The southeast side of the fault appears to be downthrown. Lower Cretaceous Myrtle Group rocks crop out in the area south of Huntley Spring. Slumping and sliding are common and have influenced the accumulation of soil.

Deposits: The main soil area mapped in secs. 7 and 18 covers about 90 acres. The maximum depth of soil and saprolite may be about 30 ft; the estimated average depth over the 90-acre area is 8 ft. The unweathered rock content in the soil is estimated to average 60 percent by volume. Analyses of samples taken in the area are listed in Table 27. The average content of the near-surface soil is about 0.67 percent Ni. Deeper sampling should increase the grade a little. The areas mapped from aerial photographs west of Huntley Spring in secs. 18 and 19, totaling about 40 acres, have not yet been verified by on-the-ground inspection or sampling.

Table 27. Sample assay results, upper Lawson area

Sample number*	Assay number	Type	Depth interval (ft)	Location ¼	Sec.	Elevation (ft)	Percent Ni	Co	Cr
1	AJG-64	Auger	0-3.5	SW/NE	18	3,200	0.56	----	----
2	AJG-65	Auger	0-3	E/NW	18	3,475	0.70	----	----
3	AJG-66	Auger	0-6	SE/NW	18	3,560	0.77	0.03	----
4	AJG-67	Channel	0-8	SE/NW	18	3,620	0.63	0.05	2.29

* These numbers are found in Figure 22 and indicate locations from which samples were taken

Sulfide Deposits

Shamrock Mine (26, Plate 1)*

Location: The mine is located about 20 mi northwest of Medford in E½ sec. 19, T. 34 S., R. 2 W., on the east side of Evans Creek. It may be reached by the Sams Valley and Evans Creek roads from the Medford area or from the town of Rogue River via the Evans Creek road through Wimer and is in the Trail 15-minute Quadrangle.

History and development: The area was originally prospected for quicksilver in the early 1900's, and oxidized copper-nickel outcrops were discovered about 1920. The U.S. Bureau of Mines carried on extensive exploration in 1949 and 1950 (Hundhausen, 1952). This work included constructing 4,000 ft of mine road, rehabilitating two adits, driving an additional 396 ft of drifts and crosscuts, drilling 11 diamond-drill holes totaling 3,419 ft, putting in five bulldozer trenches, and conducting extensive sampling and

* Numbers refer to deposits whose locations are shown either on Plate 1 or Plate 2, in pocket.

metallurgical testing. The underground workings in four adits total about 1,500 ft.

Geology: Sulfides that contain copper, nickel, cobalt, and platinum group metals at the Shamrock Mine are associated with basic plutonic rocks, mainly norite, which intrude rocks of the May Creek Formation, which is probably of late Paleozoic age (Page and others, 1977) and is composed mainly of quartz mica schist and phyllite with a variety of associated impure metaquartzites and amphibolites. Other intrusive rocks include peridotite, hornblende-quartz diorite, granodiorite, and pegmatite. The peridotite is largely altered to serpentinite.

The schistosity strikes northeast with highly variable dips, mainly southeast. Small, lenticular pegmatite dikes are reported to be numerous, especially along thrust faults in the mine area. They strike about N. 10° E. and dip about 50° W. Rhodonite and minor disseminated alabandite, with some associated surface residual manganese oxide, occur in quartzitic zones in the schist of the mine area.

Ore deposits: Mineralization consisting of pyrrhotite, pentlandite, and chalcopyrite is reported to occur as disseminations, blebs, veinlets, and masses in a tabular coarse-grained norite. Weak sulfide mineralization is also reported to occur as disseminations throughout most of the schist. The surface orebody is estimated from U.S. Bureau of Mines exploration to be at least 200 ft long, 200 ft deep, and from 5 to 38 ft wide. The approximate average grade reported from a 10-kg U.S. Bureau of Mines sample of representative ore contains 1.3 percent Ni, 1.1 percent Cu, 0.07 percent Co, and 0.03 oz/ton Pt.

Metallurgical test work showed the ore poses a difficult beneficiation problem, and selective flotation was not satisfactory. Further exploration of the area may be justified.

Standard Mine (northeast Oregon) (8, Plate 2)

Location: The mine is on Standard Creek, a tributary of Dixie Creek in the NE$\frac{1}{4}$ sec. 12, T. 12 S., R. 33 E. It is reached via the Dixie Creek road and is about 7 mi north of Prairie City on U.S. 26. The property includes 21 patented claims.

History: Development work at the mine began about 1880; but the most active period of development and production was between 1900 and 1907, when about 4,000 ft of underground development and considerable stoping were done (Gilluly and others, 1933, p. 101). In 1906 and 1907, shipments of 415 tons of mill concentrates netted about $18,200. Since 1907, attempts to work the mine have been short lived. In recent years, several truckloads of hand-sorted copper ore have been delivered to the Tacoma Smelter. The most recent work at the Standard Mine has been by the Standard Mining and Milling Company, Inc., who constructed a 50-ton flotation mill on the property in late 1957 and operated it during 1958.

Geology: Nickel is a minor metal occurring in sulfides contained in a quartz fissure vein in porphyritic andesite. The principal metals produced at the Standard Mine are gold, silver, copper, and cobalt. Ore minerals reported in the vein are pyrite, chalcopyrite, arsenopyrite, cobaltite, glaucodot, erythrite, bismuthinite, native bismuth, galena, and sphalerite. The cobalt minerals are reported to be mainly in the lower levels. Considerable cobalt bloom, erythrite, some nickel bloom (?), jarosite, and malachite are reported in the lowest drift. The Standard vein strikes N. 70° E. and dips steeply south. It ranges in thickness from a few inches to 4 ft. At least three other veins have been explored. The andesite country rock is intruded by granodiorite porphyry and a few diabase dikes that may be related to the mineralization.

General: Ore originating from several places in the Standard Mine, but principally from an underhand stope on the lowest level, was milled by the Standard Milling Company, Inc., during 1958. Most of the time, a bulk concentrate was made; for a period of time, however, the ore was concentrated into two fractions. The fractional products consisted of a copper concentrate and a cobalt-gold concentrate, which contain the following averages:

Copper concentrate			Cobalt - gold concentrate		
Copper	-	27%	Cobalt	-	15%
Gold	-	3.0 oz/ton	Nickel	-	7%
Cobalt	-	0.067%	Gold	-	10.0 oz/ton
			Copper	-	0.10%

Approximately 2 tons of copper concentrates were recovered to 1 ton of cobalt. The ratio of concentration was 7:1 for copper and 12-14:1 for cobalt.

Additional information on the Standard Mine can be found in Lindgren (1901), Swartley (1914), Parks and Swartley (1916), Gilluly and others (1933), Oregon Department of Geology and Mineral Industries (1941), Wagner (1956), Brooks and Ramp (1968), and Mason (1958, 1959).

Silica-Carbonate and Serpentinite Deposits of Northeastern Oregon

Work on nickel investigations in northeastern Oregon was done mainly by Howard C. Brooks, Oregon Department of Geology and Mineral Industries. Fifteen reported occurrences resulting from Department assay data were investigated. Five of these were untraceable, two were duplicate locations, five were silica-carbonate deposits, two were serpentinite, and one, the Standard, was a sulfide deposit. The general distribution of nickel-bearing rocks is shown on Plate 2 (in pocket). No larger scale maps are included in this portion of the text.

No lateritic-type deposits are found in northeastern Oregon, partly because erosion has kept pace with weathering and partly because of a relative lack of rainfall and a lack of unserpentinized peridotite. Therefore, unlike southwestern Oregon, ultramafic rocks in northeastern Oregon do not have laterites developed on their surfaces. Information on these prospects was extracted from unpublished mine-file reports prepared by Howard C. Brooks in 1977.

Brief summary reports of the investigated occurrences are given here to aid possible future investigations. Plate 2 shows general locations of these occurrences and the distribution of ultramafic rocks in northeastern Oregon.

Allen Prospect (1, Plate 2)*

Location: The Allen Prospect is located about 6 mi by road west of Sumpter on the ridge south of Grays Gulch in NE$\frac{1}{4}$ NE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 22, T. 9 S., R. 36 E.

History and development: Development of this prospect has consisted of small open cuts and a short adit.

Geology: The prospect is in a sheared lenticular serpentinite body about 1,500 ft wide and 3,000 ft long, lying between Jurassic quartz diorite and Permian Elkhorn Ridge Argillite. Some lighter green serpentine minerals may contain nickel. Five samples from the prospect range from 0.01 to 0.33 percent Ni with an average of 0.26 percent Ni.

Berry Prospect (4, Plate 2)

Location: This prospect is located on Dean Creek about 6 mi southest of John Day in the N$\frac{1}{2}$ NW$\frac{1}{4}$ sec. 2 and extends into the SE$\frac{1}{4}$ sec. 34, Tps. 13 and 14 S., R. 32 E.

History and development: A group of geological consultants mapped and sampled the property in 1956. Three diamond-drill holes were reportedly put down on the deposit in 1961. One hole was reported to have penetrated the deposit to a depth of 1,200 ft. No work has been done since 1961.

Geology: The deposit is in lenticular bodies of silica-carbonate rock altered from and surrounded by completely serpentinized olivine-rich peridotite. The silica-carbonate rock is believed to have formed by alteration of serpentinite along a major fault zone, possibly a branch of or the main portion of the high-angle, east-trending John Day Fault, which brings ultramafic rocks up into contact with Tertiary basalts of the Columbia River Basalt Group (Thayer, 1956). The area of silica-carbonate rock examined is about 1,500 ft long and 400 ft wide. Eighteen samples taken across the outcrop by Melbye and Merwin (private consultants, unpublished confidential report, 1958) range in value from 0.12 to 0.29 percent Ni with an

* Numbers refer to deposits whose locations are shown on Plate 2, in pocket.

average of 0.18 percent Ni. A random chip sample taken across the main outcrop by Brooks and Ramp assays 0.13 percent Ni and 0.10 percent Cr.

Connor Creek Prospect (3, Plate 2)

Location: The main examined prospect area is in the NW¼ sec. 35, T. 11 S., R. 45 E. near the head of Connor Creek and a tributary of Dry Creek.

History and development: The area has been prospected for native mercury, cinnabar, chromite, and gold (Brooks, 1963). The development consists of surface cuts and prospect roads. The largest cut is about 250 ft long and 60 ft wide, with a 35-ft face. All the work has been done in search of mercury and chromite, although a few samples were assayed for nickel.

Geology: The prospects are in a narrow zone of sheared, altered serpentinite along a major northeast-trending fault contact between pre-Jurassic Burnt River Schist to the north and Jurassic volcanic rocks and marine wackes to the south (Brooks and others, 1976).

The main cut exposes silica-carbonate rock composed of chalcedony, opal, and subordinate carbonate minerals. Minor cinnabar mineralization occurs in this rock. About 100 yd northeast of the main cut, small cuts and a short adit expose chromite in similar silica-carbonate altered serpentinite.

Thirteen samples taken by Brooks and Ramp in 1977 contain from 0.013 to 0.28 percent Ni and average 0.16 percent Ni. Eight of the samples contain from a trace to 0.70 lb/ton Hg and average 0.34 lb/ton Hg. Gold and silver assays of five of the samples show only trace quantities of gold and no silver.

Red Elephant Prospect (5, Plate 2)

Location: This prospect is located on Barney Creek in secs. 9 and 10, T. 14 S., R. 36 E., about 12 mi southwest of Unity via the South Fork of the Burnt River and Barney Creek roads.

History and development: About 80 tons of high-grade chromite was produced from this property in 1917 and 1918, which was then known as the Lyons Mine and later as the Hiller chrome property. Development consists of several small open cuts, an open 75-ft adit, and a caved adit connected to a short raise and glory hole. This exploration and development was for chromite (Oregon Department of Geology and Mineral Industries unpublished mine-file report, 1942).

Geology: The prospect is in serpentinite and weathered silica-carbonate rock. The serpentinite is in contact with the Jurassic Rastus Series sedimentary rocks and pre-Cenozoic Mine Ridge Schist described by Lowry (1968).

The area sampled for nickel, but not mapped, is composed of silica-carbonate rock in a zone possibly 250 ft wide and 1,200 to 1,500 ft long, which trends in a northeasterly direction. Eight samples vary from 0.10 percent to 0.41 percent Ni. The highest assay value comes from an 8.6-ft auger sample in weathered silica-carbonate rock. The arithmetic average of the eight samples is 0.235 percent Ni (Oregon Department of Geology and Mineral Industries unpublished mine-file report, 1942).

Sherwood Group Prospects (2, Plate 2)

Location: The prospects are slightly more than a mile west-northwest of Bald Mountain Lookout in the NW¼ SE¼, the SW¼ NE¼, and the SE¼ NW¼ sec. 27, T. 11 S., R. 39 E. The area is reached via Denny Creek road and is about 17 mi south of Baker.

History and development: Development of these prospects consists of several shallow cuts, trenches, test pits, a 10-ft shaft, and a short adit.

Geology: The prospects are in altered serpentinite and Burnt River Schist with associated small bodies of quartz diorite, gabbro, and serpentinite. These rocks are overlain by Miocene Dooley Mountain

Rhyolite. The Burnt River Schists of pre-Upper Triassic age include highly deformed phyllite, greenstone, greenschist, and small limestone pods (Brooks and others, 1976). The altered serpentinite is a tan to rust-brown silica-carbonate rock with streaks, patches, and disseminations of bright green minerals identified as fuchsite or mariposite (?) or both. A total of 14 samples contain from 0.05 percent to 0.50 percent Ni, with an arithmetic average of 0.23 percent Ni. Three of the samples were assayed for chromium. Values range from 0.10 to 2.36 percent Cr, with an average of 1.22 percent Cr. The samples show only trace amounts of Co, Cu, Au, and Ag.

Summers Prospect (9, Plate 2)

Location: Although this prospect is reported to be in sec. 19, T. 11 S., R. 33 E., the reported location of the assay samples showing nickel was not found by the investigators. The prospect may instead be in NE¼ sec. 23, T. 11 S., R. 33 E., adjacent to the patented Dixie Meadows Gold Mine.

History: The area was prospected by Ray Summers, who located claims in 1955. Five samples of serpentinite submitted to the Department for assay by Summers contain 0.10, 0.10, 0.67, 0.23, and 0.17 percent Ni. The sample containing 0.23 percent Ni is altered dunite with minor garnierite along the fractures similar to rocks found at Nickel Mountain (letter from Hollis Dole to Ray Summers, September 29, 1955). No further work has been done at this prospect.

Sunray (Nickel Cigar) Prospect (6, Plate 2)

Location: This prospect is located along Willow Creek southeast of the Malheur Reservoir in W½ NW¼ sec. 20, T. 14 S., R. 42 E., about 20 mi west of Huntington and about 1 mi south of Huntington junction.

History and development: Samples were submitted to the Department by Neal Isaacson, LaGrande, Oregon, in 1959, 1960, 1961, and 1967. Development consists of several bulldozer cuts.

Geology: The cuts generally expose serpentinite. Small blocks of greenstone, greenschist, phyllite, and chert are locally associated with the serpentinite. These rocks are part of a small window or fault slice of pre-Upper Triassic rocks in Jurassic sedimentary terrain (Brooks and others, 1976).

Two samples submitted by Isaacson contain 0.84 and 0.50 percent Ni and are sandy clay loam soil and altered sediments with celadonite (?). Other samples contain normal or below-normal amounts of nickel found in serpentinites. Some of the decomposed serpentinite exposed in the cuts appears soil-like and celadonite green in color, but recent samples taken by Brooks do not contain the anomalous nickel found in earlier assays. An arithmetic average of 10 samples is 0.24 percent Ni.

Table Top (Nickel Dome) Prospect (7, Plate 2)

Location: This prospect occurs near the head of Birch Creek in NW¼ sec. 34, T. 13 S., R. 43 E. The area may be reached via the Durbin Creek road either from Rye Valley from the north or Birch Creek Meadows from the south. The prospect is about 14 mi from Huntington via Birch Creek Meadows.

History and development: Claims were posted by R. A. Griffith and Lester Hice in September 1944 but were apparently never recorded. Subsequent claims have been filed on the occurrences from time to time. Development consists of several small hand-dug pits.

Geology: Prospect pits are in leached silica-carbonate rock associated with serpentinite. The ultramafic rocks occur in a window of pre-Jurassic serpentinite and Burnt River Schist which has been faulted into Jurassic wacke. These rocks are unconformably overlain by Tertiary tuffaceous sediments and thin Tertiary basalt flows (Brooks and others, 1976). The zone of leached silica-carbonate rock referred to as silica-limonite rock is about 1,000 ft long, 300 ft wide, and trends in a N. 70° E. direction. The rock resembles a siliceous gossan in which most of the limonite is believed to have been derived from

Table 28. Other miscellaneous nickel prospects not investigated at this time (reported minor occurrences and with assay data only)

Name	Location ¼	Sec.	T.	R.	Type deposit	Minerals	Percent Ni	Co	Cu	Reference
Bluff Prospect	NE	32	37 S	8 W	Serpentine shear	Magnetite, pyrrhotite, malachite	2.11	0.07	0.30	* Mine file report (1952)
							1.31	0.17	1.90	
							0.83	0.10	1.60	
Cook Prospect		27	8 S	44 E	Silica-carbonate (?)	?	0.50	----	----	Assay no. XB-47
Nickel Ridge	E½	31	40 S	9 W	Serpentine-peridotite	Garnierite and silica boxwork	1.52	----	----	** Assay no. R4-2
							1.96	----	----	Assay no. OG-125
							1.97	----	----	Assay no. OG-126
							0.65	----	----	** Assay no. R4-3
							0.75	----	----	Assay no. OG-166
										* Mine file report (1954)
Onion Mountain Prospect (Pack Trail claim)	SW	6	36 S	7 W	Serpentine shear	Magnetite, pyrrhotite, garnierite	6.71	0.32	----	Assay no. LG-605
							0.14	----	----	Assay no. MG-47
							3.81	0.25	0.50	Assay no. NG-245
							0.10	----	----	Assay no. NG-246
										* Mine file report (1953)
										Appling (1955)

* Oregon Department of Geology and Mineral Industries unpublished mine file report

** U.S. Bureau of Mines assays

leaching of iron-bearing carbonate minerals. In a few areas, the silica-limonite rock contains an attractive bright-green mineral that has been mistakenly identified as nickel bloom. Analyses, however, indicate little or no nickel. Although not positively identified at this location, a similar mineral assemblage at the Sherwood Prospect has been identified by the U.S. Bureau of Mines as fuchsite and chromian pyrophyllite. The mineral appears similar to and may be mariposite, also a chromian mica.

Samples indicate low nickel values. Of six samples, the highest value is 0.485 percent Ni; the others are between 0.10 and 0.16 percent Ni (Oregon Department of Geology and Mineral Industries unpublished mine-file report, 1948). A composite sample taken during the present investigation assays 0.10 percent Ni, no Au, and no Ag.

Table 28 contains information on miscellaneous reported nickel prospects in both southwestern and northeastern Oregon that were not investigated for this study.

Summary and Conclusions

Assuming the economics for nickel production remain favorable so that lower grade ores may be processed, reserves at the Nickel Mountain deposit are probably sufficient to last until about the year 2000 at the recent rate of production (Golder Associates, 1977).

Two other main areas of future nickel production potential lie in Oregon. One is in the Illinois Valley, in which a centrally located plant could draw from the larger, better grade, and more accessible deposits in the Josephine peridotite sheet; the other is in the Red Flat area southeast of Gold Beach. Several factors will affect this possible expansion of Oregon's nickel industry: future supply of and demand for nickel, chromium, and cobalt; national and local political policy regarding domestic production of these strategic minerals; the ability to develop efficient, inexpensive, and nonpolluting metallurgical processes; and the ability to develop satisfactory and inexpensive reclamation procedures.

Stream sediment samples derived from areas of ultramafic rocks vary quite widely in nickel content (Oregon Department of Geology and Mineral Industries, 1970). Preliminary testing has failed to explain this phenomenon satisfactorily, and more detailed geochemical study of the distribution of nickel in southwestern Oregon ultramafic rocks would be of interest.

A similar and probably related study that would be perhaps even more interesting would be to determine the origin and distribution of the native nickel-iron mineral, josephinite, in local serpentinites. Dick (1975) has confirmed the occurrence of josephinite in place in serpentinites along a shear zone with numerous small diabase dikes on Josephine, Woodcock, and Mendenhall Creeks.

This preliminary report furnished only limited data on various deposits investigated. The information gathered in each area should be sufficient for determining whether further exploration is warranted.

Preliminary tonnage calculations can be made from data presented for most of the areas described. An average specific gravity for dried soil and saprolite (excluding all unweathered rock of greater than 1 in. in diameter) is about 1.20. The material is usually quite porous. Samples obtained with a hand auger will approximate this value, but compression of the sample increases the density. A cubic foot of dried soil and saprolite in place weighs about 75 lbs, which means that it takes about 26.6 cu ft of material to produce a short ton, or just slightly more than 1 ton/cu yd. Because the density of dry saprolite is quite variable and may in some areas run as high as 1.7, an average of several measured and dried samples should probably be taken in a given deposit to establish a reliable density figure.

Estimations of depth given in most of the reports are based on limited evidence; many represent only personal judgment. Follow-up work to check depth of weathering could involve drilling and use of a backhoe, a seismograph, or both. Practice has shown that checking seismograph results with a drill or backhoe is beneficial.

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PLATE 1

DISTRIBUTION of ULTRAMAFIC ROCK & NICKEL DEPOSITS of SOUTHWESTERN OREGON

Compiled by Len Ramp

1978

LEGEND

- ULTRAMAFIC ROCK
- NICKEL LATERITE
- LARGE SCALE MAP (in text)
- (1) NICKEL DEPOSITS DISCUSSED IN TEXT

1. NICKEL MOUNTAIN MINE
2. IRON MOUNTAIN
3. PEAVINE
4. LOWER LAWSON
5. GRAY BUTTE
6. UPPER LAWSON
7. COLLIER CREEK
8. RED FLAT
9. SNOW CAMP MOUNTAIN
10. SOURDOUGH FLAT
11. EIGHT DOLLAR MOUNTAIN
12. FREE AND EASY
13. COTTONWOOD CAMP
14. UPPER CHETCO
15. JOSEPHINE CREEK
16. WOODCOCK MOUNTAIN
17. CHROME CREEK
18. SPOKANE CREEK
19. DOE GAP
20. ROUGH AND READY GROUP
21. BALDFACE RIDGE
22. CEDAR SPRING
23. SMITH RIVER
24. CLEOPATRA-TAYLOR CREEK
25. DIAMOND
26. SHAMROCK MINE (SULFIDE)

Scale 1:250,000

5 0 5 10 15 Statute Miles

5 0 5 10 15 20 Kilometers

5 0 5 10 Nautical Miles

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS
TRANSVERSE MERCATOR PROJECTION

MAGNETIC DECLINATION FOR 1970 IS 19½° (350 MILS) EASTERLY OVER THE ENTIRE AREA

GRID ZONE DESIGNATION: 10T	TO GIVE A STANDARD REFERENCE ON THIS SHEET TO NEAREST 1000 METERS	
100,000 M. SQUARE IDENTIFICATION: CD DD / 480 CC DC / 470 CB DB / 40	SAMPLE POINT: PISTOL RIVER	
	1. Read letters identifying 100,000 meter square in which the point lies:	CB
	2. Locate first VERTICAL grid line to LEFT of point and read LARGE figure labeling the line either in the top or bottom margin, or on the line itself:	8
	Estimate tenths from grid line to point:	5
	3. Locate first HORIZONTAL grid line BELOW point and read LARGE figure labeling the line either in the left or right margin, or on the line itself:	8
IGNORE the SMALLER figures of any grid number; these are for finding the full coordinates. Use ONLY the LARGER figure of the grid number; example: 4660000	Estimate tenths from grid line to point:	1
	SAMPLE REFERENCE:	CB8581
	If reporting beyond 18° in any direction, prefix Grid Zone Designation, as:	10TCB8581

Base map

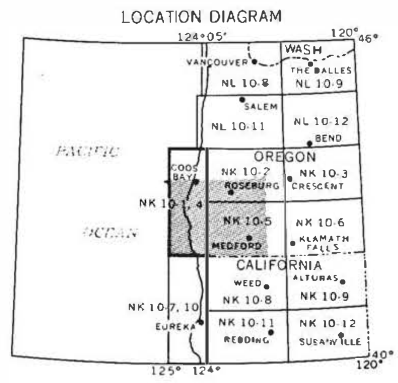
Prepared by the U.S. Army Topographic Command (KCDV), Washington, D.C. Compiled in 1958 from United States quadrangles 1:48,000, 1:50,000, and 1:62,500, 1942-55; USC&GS Charts 5802, 5702, 1947-48. Planimetry revised in part from aerial photographs taken 1957. Map field checked 1958. Revised in 1974 by the U.S. Geological Survey from aerial photographs taken 1973.

Selected hydrographic data compiled from USC&GS charts
This information is not intended for navigational purposes

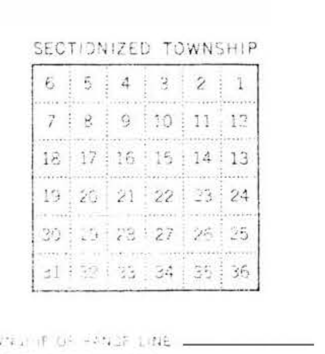
100,000-foot grids based on Oregon coordinate system, south zone

Location of geodetic control established by government agencies is shown on corresponding 1:250,000-scale Geodetic Control Diagram

LOCATION DIAGRAM



SECTIONIZED TOWNSHIP



STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
DONALD A. HULL, STATE GEOLOGIST

Prepared and Published by the Cartographic Section of the Department of Geology and Mineral Industries

MISCELLANEOUS PAPER 20 INVESTIGATIONS OF NICKEL IN OREGON 1978

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
DONALD A. HULL, STATE GEOLOGIST

PLATE 2

DISTRIBUTION of ULTRAMAFIC ROCK and NICKEL PROSPECTS of NORTHEASTERN OREGON

EXPLANATION

ULTRAMAFIC ROCK; serpentinite; includes some rock with additional alteration and a few areas of mafic rock locally.

● NICKEL PROSPECTS DISCUSSED IN TEXT

1. ALLEN
2. SHERWOOD GROUP
3. CONNOR CREEK
4. BERRY
5. RED ELEPHANT
6. SUNRAY
7. TABLE TOP
8. STANDARD
9. SUMMERS

Scale 1:250,000

20 Statute Miles

30 Kilometers

15 Nautical Miles

Prepared and Published by the Cartographic Section
of the Department of Geology and Mineral Industries

Base map from Army Map Service (Topographic)

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS

TRANSVERSE MERCATOR PROJECTION