DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1423-C

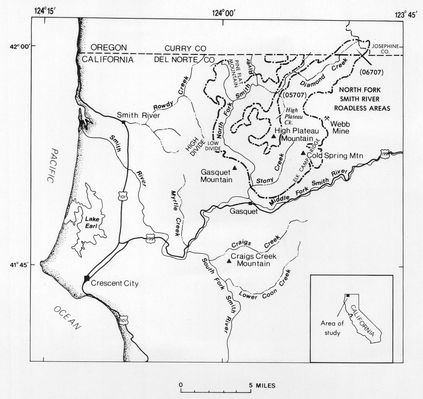


Figure 1.--Index map showing location of the North Fork Smith River Roadless Areas.

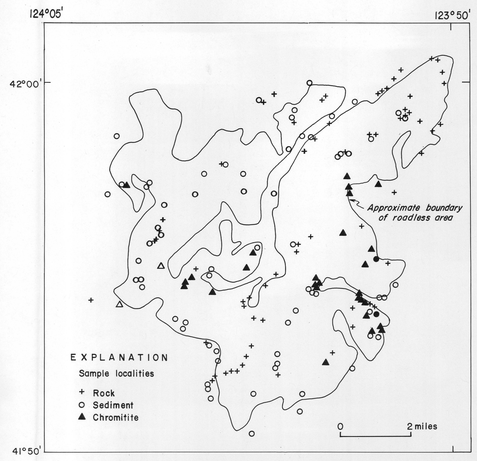


Figure 2.--Sample localities for the North Fork Smith River Roadless Areas.

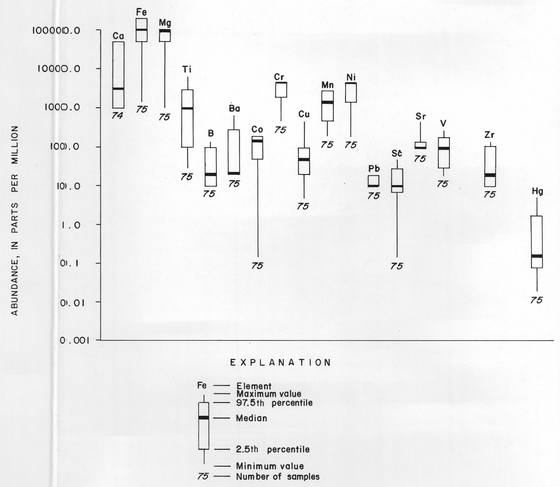


Figure 3.--Abundances of selected elements in stream-sediment samples.

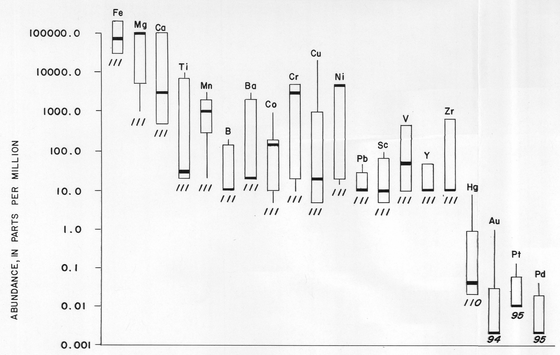


Figure 4.--Abundances of selected elements in rock samples. See figure 3 for explanation of symbols.

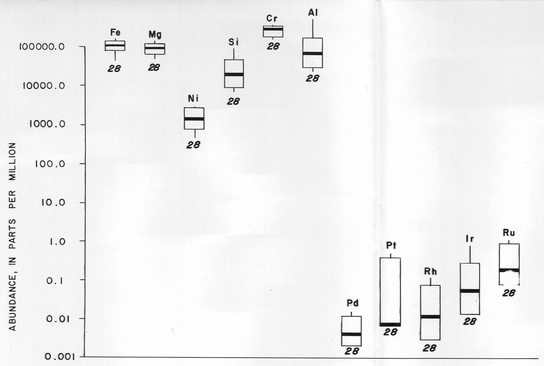
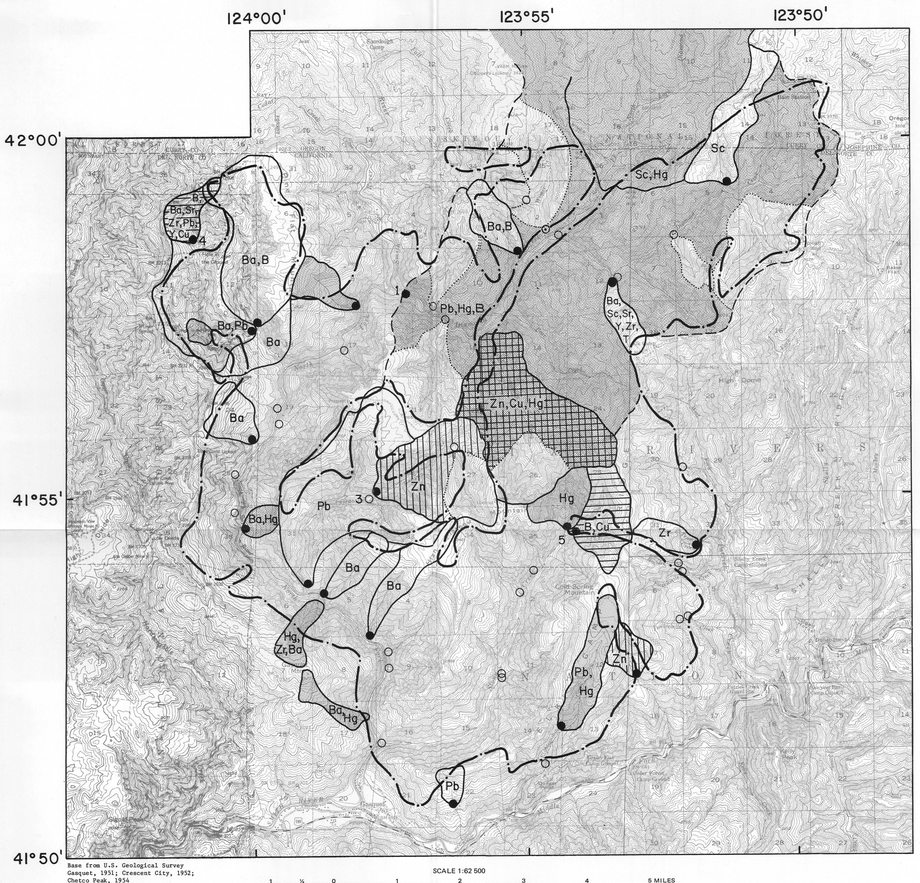


Figure 5.--Abundances of selected elements in chromitite samples. See figure 3 for explanation of symbols.

Table 1.--Anomaly levels selected for rock and stream-sediment samples
[ppm, parts per million]

Elements	Rock samples: Anomaly criteria	Rock samples: Percent anomalous	Stream-sediment samples: Anomaly criteria	Stream-sediment samples: Percent anomalous
Iron (Fe)	None	0	None	0
Magnesium (Mg)	do.	0	do.	0
Calcium (Ca)	do.	0	do.	0
Titanium (Ti)	0.5 percent	17	0.7 percent	2
Manganese (Mn)	None	0	None	0
Silver (Ag)	1.0 ppm	4	do.	0
Arsenic (As)	200 ppm	2	do.	0
Boron (B)	150 ppm	6	100 ppm	7
Barium (Ba)	300	8	do.	19
Beryllium (Be)	1.0 ppm	7	None	0
Bismuth (Bi)	10 ppm	2	do.	0
Cobalt (Co)	500 ppm	3	do.	0
Chromium (Cr)	None	0	do.	0
Copper (Cu)	150 ppm	16	100 ppm	5
Lanthanum (La)	150 ppm	5	None	0
Molybdenum (Mo)	5 ppm	5	do.	0
Niobium (Nb)	50 ppm	5	do.	0
Nickel (Ni)	None	0	do.	0
Lead (Pb)	20 ppm	7	20 ppm	9
Scandium (Sc)	None	0	30 ppm	5
Strontium (Sr)	500 ppm	6	150 ppm	4
Vanadium (V)	200 ppm	23	300 ppm	3
Yttrium (Y)	50 ppm	5	20 ppm	4
Zinc (Zn)	500 ppm	4	500 ppm	4
Zirconium (Zr)	500 ppm	5	70 ppm	8
Mercury (Hg)	1.0 ppm	5	0.5 ppm	16
Gold (Au)	.02 ppm	3	None	0
Platinum (Pt)	.1 ppm	2	do.	0
Palladium (Pd)	.02 ppm	4	do.	0
Iridium (Ir)	.1 ppm	1	do.	0



EXPLANATION

- Sample with anomalous concentrations of elements
- Sample without anomalous concentrations of elements

STREAM-SEDIMENT SAMPLE LOCALITIES--Numbers 1-5 refer to discussion in text

APPROXIMATE OUTLINES OF DRAINAGE BASINS --Anomalous element shown by chemical symbol: B, boron; Ba, barium; Cu, copper; Hg, mercury; Pb, lead; Sc, scandium; Sr, strontium; Ti, titanium; V, vanadium; Y, yttrium; Zn, zinc; Zr, zirconium

- Zn — Drainage basin with anomalous samples
- B — Drainage basin of Diamond Creek
- Drainage basin within larger basin without anomalous elements

DRAINAGE BASINS WITH ANOMALOUS:

- Mercury (Hg)
- Zinc (Zn)
- Copper (Cu)
- APPROXIMATE BOUNDARY OF ROADLESS AREAS

Figure 9.--Anomalous concentrations of elements in drainage basins in the North Fork Smith River Roadless Areas.

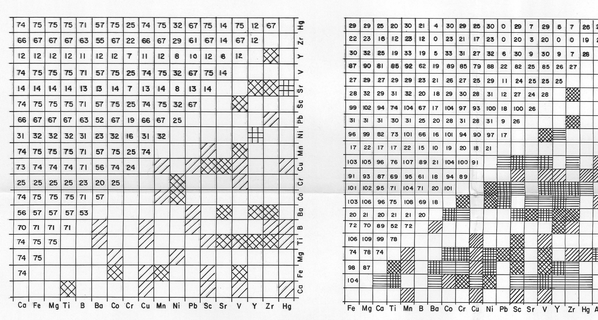


Figure 6.--Spearman rank correlations between elements in stream-sediment samples.

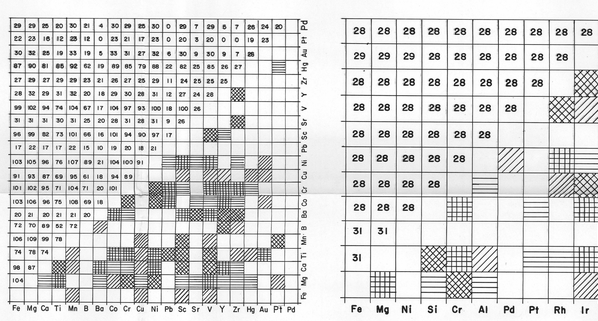


Figure 7.--Spearman rank correlations between elements in rock samples.

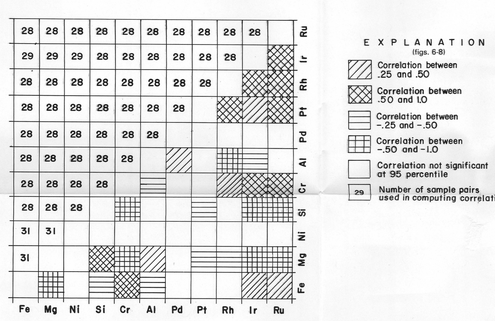


Figure 8.--Spearman rank correlations between elements in chromitite samples.

Table 2. Results of factor analyses of incompatible elements
[Model derived from Nie and others (1975)]

Factor	Eigenvalue	Percent of variance	Cumulate percent variance
1	3.45670	49.4	49.4
2	1.25565	17.9	67.3
3	.85116	12.2	79.5
4	.65698	9.4	88.9
5	.37000	5.3	94.1
6	.26478	3.8	97.9
7	.14473	2.1	100.0

Variable	Factor 1	Factor 2
B	0.15603	0.22786
Ba	.89937	-.17933
Pb	.59174	-.11249
Sr	.70876	-.08585
Y	.73106	.16780
Zr	.91804	-.12875
Hg	.26467	.93956

Variable	Estimated communality	Variance percent explained by factor 1	Variance percent explained by factor 2
B	0.16460	2	5
Ba	.76362	81	3
Pb	.40339	35	1
Sr	.52532	50	1
Y	.60441	53	3
Zr	.77080	84	2
Hg	.28728	7	88

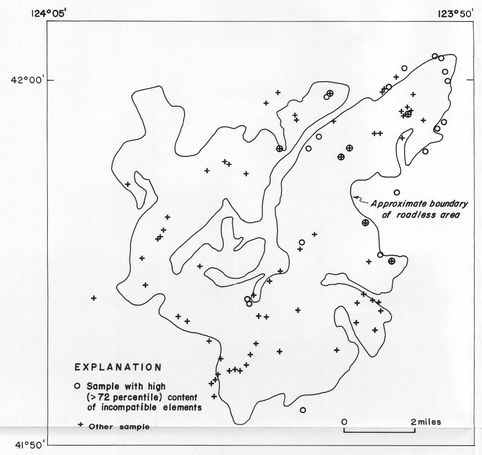


Figure 11.--Locations of samples with high values of factor 1 that represent high contents of incompatible elements.

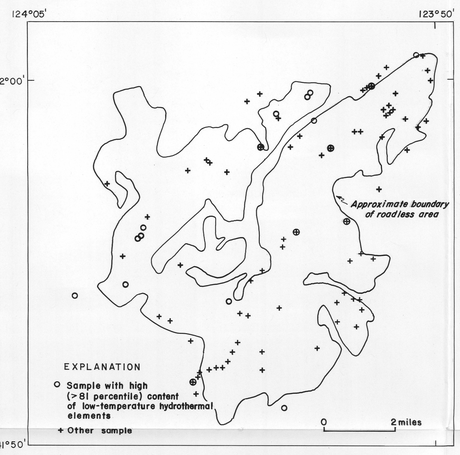


Figure 12.--Locations of samples with high values of factor 2 that represent high contents of elements associated with hydrothermal alteration.

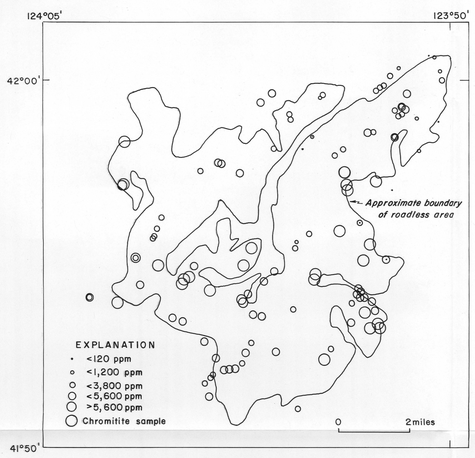


Figure 13.--Concentrations of chromium in rock and chromitite samples.

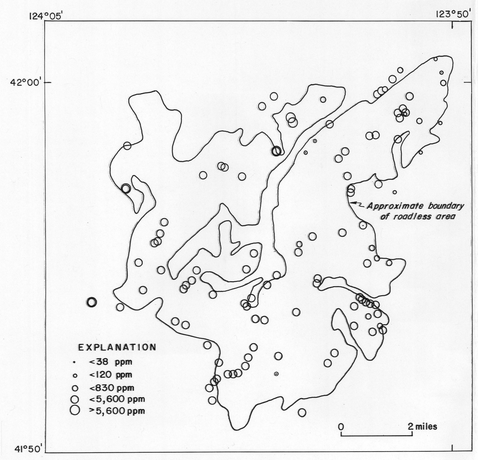


Figure 14.--Concentrations of nickel in rock and chromitite samples.

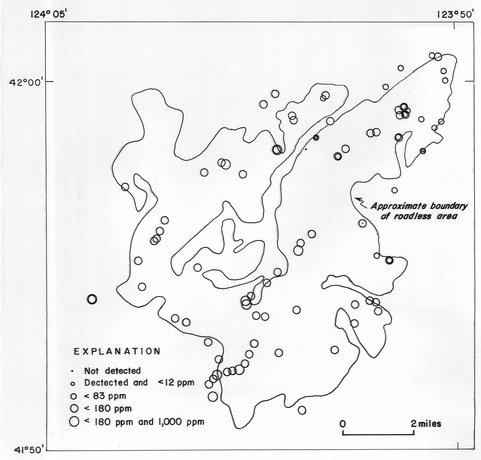


Figure 15.--Concentrations of cobalt in rock and chromitite samples.

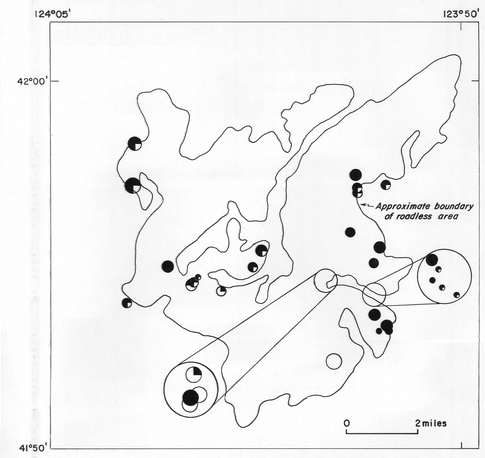
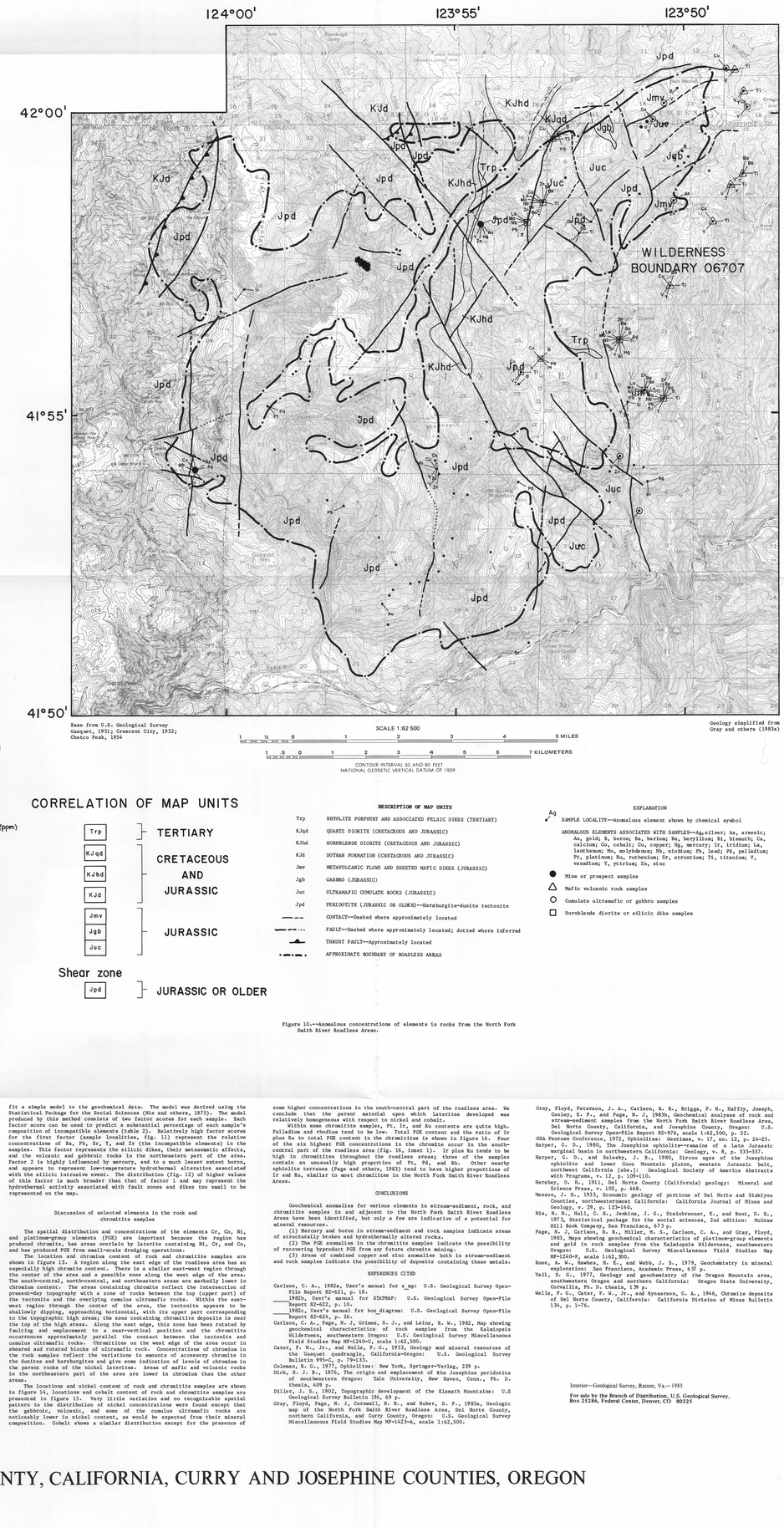


Figure 16.--Total contents of platinum group elements (PGE) and ratios of (Ir + Ru) plus ruthenium (Ru) to total PGE contents in chromitite samples.



CORRELATION OF MAP UNITS

		DESCRIPTION OF MAP UNITS
Trp	TERTIARY	RHYOLITE PORPHYRY AND ASSOCIATED FELSIC DIKES (TERTIARY)
KJqd	CRETACEOUS AND JURASSIC	QUARTZ DIORITE (CRETACEOUS AND JURASSIC)
KJhd		HORNBLENDE DIORITE (CRETACEOUS AND JURASSIC)
KJd		DOTHAN FORMATION (CRETACEOUS AND JURASSIC)
Jmv	JURASSIC	METAVOLCANIC FLOWS AND SHEETED MAFIC DIKES (JURASSIC)
Jgb		GABBRO (JURASSIC)
Juc		ULTRAMAFIC CUMULATE ROCKS (JURASSIC)
Jpd		PERIDOTITE (JURASSIC OR OLDER)--Harzburgite-dunite tectonite
Shear zone		CONTACT--Dashed where approximately located
Jpd	JURASSIC OR OLDER	FAULT--Dashed where approximately located; dotted where inferred
		THRUST FAULT--Approximately located
		APPROXIMATE BOUNDARY OF ROADLESS AREAS

EXPLANATION

- Ag — SAMPLE LOCALITY--Anomalous element shown by chemical symbol

ANOMALOUS ELEMENTS ASSOCIATED WITH SAMPLES--Ag,silver; As, arsenic; Au, gold; B, boron; Ba, barium; Be, beryllium; Bi, bismuth; Ca, calcium; Co, cobalt; Cu, copper; Hg, mercury; Ir, iridium; La, lanthanum; Mo, molybdenum; Nb, niobium; Pb, lead; Pd, palladium; Pt, platinum; Ru, ruthenium; Sr, strontium; Ti, titanium; V, vanadium; Y, yttrium; Zn, zinc

- Mine or prospect samples
- Mafic volcanic rock samples
- Cumulate ultramafic or gabbro samples
- Hornblende diorite or silicic dike samples

Figure 10.--Anomalous concentrations of elements in rocks from the North Fork Smith River Roadless Areas.

Figure 14.--Concentrations of nickel in rock and chromitite samples.

Figure 15.--Concentrations of cobalt in rock and chromitite samples.

Figure 16.--Total contents of platinum group elements (PGE) and ratios of (Ir) plus ruthenium (Ru) to total PGE contents in chromitite samples.

STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal lands to determine their mineral resource potential. Results must be made available to the public and be submitted to the President and the Congress. This report interprets the results of a geochemical sampling survey of the North Fork Smith River Roadless Areas in the Six Rivers and Siskiyou National Forests, Del Norte County, California, and Curry and Josephine Counties, Oregon. The North Fork Smith River Roadless Areas (05707 and 06707) were classified as further planning areas during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

INTRODUCTION

The North Fork Smith River Roadless Areas are located primarily in Del Norte County, northern California, include small parts of Curry and Josephine Counties, Oreg., and cover parts of the Gasquet, Crescent City, and Chetco Peak 15-minute quadrangles. The areas encompass approximately 39,400 acres of Six Rivers National Forest and 950 acres of Siskiyou National Forest and extend from just north of the California-Oregon border southward about 6 mi to the town of Gasquet, Calif. (fig. 1).

The North Fork Smith River Roadless Areas are underlain predominantly by ultramafic tectonite, layered ultramafic and gabbroic cumulate rocks, massive gabbro, and associated mafic to silicic intrusive rocks that are part of the western Jurassic belt of the Klamath Mountains province of California. The geology of the area was mapped by Gray and others (1983a) and in part builds on the early investigations and general reconnaissance studies by Diller (1902), Hershey (1911), and Maxson (1933). Also incorporated are several studies associated with the U.S. Geological Survey's World War II Strategic Minerals Investigations program which concentrated largely on mapping chromite deposits and studying the economically significant features associated with these deposits in the Josephine peridotite body (see Wells and others, 1946). Cater and Wells (1953) published a detailed account of the relation between major rock units, structure, and mineral resources of this region. This has been refined in the recent literature (Dick, 1976; Vail, 1977; Harper, 1980) and incorporated into the present study.

GEOLOGY

The major rock units of the roadless areas which are shown on the geologic map of Gray and others (1983a) and in simplified form in figure 10 of this report, have been ascribed to the Josephine ophiolite by Harper (1980). All the components of an ophiolite sequence as defined by the GSA Penrose Conference (1972) and Coleman (1977) are present; however, faulting between units precludes any estimate of thicknesses. The age of igneous parts of the Josephine ophiolite is constrained by a concordant U-Pb age of 157 m.y. (Harper and Saleeby, 1980) from a plagiogranite in the upper part of the ophiolite and by fossils identified as Buchia concentrica (Late Jurassic) that were collected from a pebble conglomerate bed overlying the ophiolite (D. L. Jones, oral commun., 1979).

A harzburgite-dunite tectonite mass (Josephine Peridotite), is the lowermost unit exposed and covers approximately 310 mi² of southwestern Oregon and northern California. The peridotite commonly displays compositional banding defined by variations in the ratio of pyroxene to olivine.

Cumulate ultramafic and gabbroic rocks are present at a number of localities near the east edge of the roadless areas. A massive serpentinite shear zone everywhere marks the contact between these cumulate rocks and the tectonite peridotite. Dunite lenses, some of which contain podiform chromite and range from several inches to tens of feet in length and thickness, may be found in both the tectonite and cumulate ultramafic unit. Most of the chromite mines in the North Fork Smith River area are located in and adjacent to the contact zone between the peridotite tectonite and cumulate rocks. The ultramafic rocks with cumulate texture are mainly wehrlite, clinopyroxenite, and dunite, all of which consist of various proportions of olivine, clinopyroxene, and spinel. Serpentine is ubiquitous as a secondary mineral replacing olivine and (or) pyroxene in the rocks. With the addition of cumulus plagioclase, the cumulate ultramafic rocks grade irregularly upward into layered clinopyroxene gabbro. This gabbro grades upward into a massive gabbro unit characterized by abrupt compositional and textural variations, intrusive gabbroic breccia, and local diabase dikes.

Minor volcanic rocks and associated diabase dike rocks occur in the northeastern part of the roadless area and are considered part of the Josephine ophiolite.

Two separate postemplacement intrusive events are indicated by small stocks and dikes that intrude the peridotite. The older intrusive rocks are of intermediate composition, mainly hornblende diorite that intruded the peridotite along predominantly north-trending shear zones occupied by serpentinite. The largest of these intruded shear zones lies in the north-central part of the roadless area from the Oregon border south across the North Fork of Diamond Creek to the area around High Plateau Creek. The second intrusive event was much more pervasive; the rocks intruded along the same shear zone and display crosscutting relations with rocks of the older event. The younger event produced mainly silicic porphyries and associated low-temperature hydrothermal metamorphism.

Nickeliferous laterites overlie relatively fresh peridotite (mainly harzburgite tectonite) occurring on flat or gently sloping erosion surfaces. The laterites probably developed during a protracted period of weathering starting in the Eocene or Oligocene and culminating in the Pliocene (see Gray and others, 1983a).

Small stream terraces formed during the Quaternary are found along the Diamond Creek drainage and along the North Fork Smith River. Landslides are abundant on steep slopes adjacent to plateau areas.

GEOCHEMISTRY

This report is a summary and interpretation of the geochemical characteristics of 111 rock samples, 75 sediment samples, and 31 chromitite samples collected in and adjacent to the North Fork Smith River Roadless Areas (fig. 2); for purposes of this discussion rock samples are exclusive of chromitite samples.

A listing of all chemical analyses performed on these samples has been published by Gray and others (1983b), which includes a discussion of the methods, accuracy, and precision of the analyses. Most of the analyses were performed using a six-step semiquantitative spectrographic method, with the following exceptions: 28 analyses of chromitites, all analyses for the platinum-group elements, and all analyses for mercury were quantitative. Six-step semiquantitative methods produce determinations that may contain substantial uncertainties in accuracy and precision. Display packages for statistical treatment of the data were developed by Carlson (1982a, b, c).

Discussion of element concentrations and associations in the samples

Selected element distributions for the stream-sediment, rock, and chromitite samples are graphically summarized in figures 3, 4, and 5, respectively. The box diagrams show typical values, typical ranges, and extreme values. The median value is considered to be typical for each element, and the range of values between the 2.5th and 97.5th percentiles is considered to be the typical range. Those elements without maximum values are present in abundances that exceed the capacity of the analytical method to quantify them; elements without minimum values are below the level of detection. Some elements such as magnesium and cobalt have very narrow ranges of variation. Both of these factors--absence of numerical values and narrow ranges--present problems in determining anomalous elements for particular samples.

Spearman rank correlation coefficients between elements are graphically summarized in figures 6, 7, and 8 and were used to define element associations for the stream-sediment, rock, and chromitite samples. These associations reflect mineral chemistry and mineral associations within the major rock units of the study area. Within the stream-sediment samples, three main groups of elements may be recognized on the basis of these interelement correlations. These associations or groups are: (1) Ni, Mg, Cr, and Co; (2) Ca, Ti, Sc, V, Fe, Mn, Cu, and Co(?); and (3) Ba, B, Pb, Sr, Y, Zr, and Co(?) (see table 1 or figures 9 and 10 for chemical symbols). Although there is some overlap between groups, each group appears to be reasonably distinct and geologically meaningful. The element associations in the rock samples tend to form similar groupings (figs. 7): (1) Mg, Ca, Cr, Au(?), and Pt(?); (2) Fe, Mn, Cu, Sc, V, Ca, Ti, and Pt(?); and (3) Ba, B, Zr, Y, Sr, Ti(?), and Hg(?). The chromitite samples (fig. 8) indicate three element associations in (1) Mg, Si, and Al; (2) Fe, Cr, Pd, Pt, Rh, Ir, and Ru; and (3) Ni. The groupings for the three types of samples reflect the variation in the relative proportions of the minerals (olivine, pyroxene, chromite, serpentine, and sulfides) that compose them.

The element associations or groups for the rock and stream-sediment samples reflect the three dominant geologic features of the roadless area. A large part of the area is underlain by the ultramafic rocks dunite and harzburgite, which are composed predominantly of olivine, pyroxene, serpentine minerals, and chromite. Typical concentrations for the element associations Ni, Mg, Cr, and Co in stream-sediment samples and Ni, Mg, Co, Cr, Au(?), and Pt(?) in rock samples. The element associations of Ca, Ti, Sc, and V in the stream-sediment samples and Fe, Mn, Cu, Sc, V, Ca, Ti, and Pt(?) in the rock samples reflect the other major group of rocks that are mafic in composition and include gabbro and basaltic to andesitic volcanic rocks. Variations in mineral proportions among pyroxene, plagioclase, ilmenite-magnetite, and chlorite account for this association. The intrusion of more silicic porphyritic rocks and the accompanying hydrothermal alteration, which form the third geologic feature, are reflected in the geochemistry of the stream-sediment samples by the association of Ba, B, Co(?), Hg, Zr, Y, Sr, and Pb and in the rock samples by Ba, B, Zr, Y, Sr, Ti(?), and Hg(?). Boron and perhaps copper represent the overprint of this later geologic event.

By using the information shown in figures 3 and 4 together with histograms and typical background levels for certain rock groups (Rose and others, 1979), threshold values for choosing anomalous samples were selected for the stream-sediment and rocks. Three factors were considered in choosing these values: the 97.5th percentile, natural breaks in the distribution near the 97.5th percentile, and typical values for sediments and ultramafic rocks. If there was a natural break in the distribution between the 90th percentile and the 97.5th percentile, the break was chosen provided it was well above the typical values published by Rose and others (1979). Lacking a natural break, the semiquantitative interval nearest to but less than the 97.5th percentile was taken provided it was well above the published typical values. When neither of these situations occurred, we judged no anomalous values to be present and did not attempt to pick anomalous samples for the element in question.

Threshold values above which samples were judged to be anomalous and the percent of samples that are anomalous for each element are listed in table 1. These data were used to generate map plots of the anomalous elements in the stream-sediment (fig. 9) and rock (fig. 10) samples.

Interpretation of element anomalies in stream-sediment and rock samples

Anomalous concentrations of elements in stream-sediment samples (fig. 9) are combined with a drainage-basin map for those basins containing anomalous amounts of any element. Each stream-sediment sample is thought to represent materials derived from its associated basin. For example, the sample labeled 1, which contained anomalous concentrations of Pb, Hg, and B, represents material from all of the Diamond Creek drainage basin outlined by the dashed lines. Smaller drainage basins within the larger one may or may not have samples with anomalous amounts of metals. The smaller basins with anomalous samples are shown with solid lines; those without are shown with dotted lines. Other larger basins with anomalous samples, labeled 2 and 3, were treated similarly.

Stream-sediment anomalies for Pb, Ba, Sr, Y, Ti, and Zr, either as single- or multiple-element anomalies, probably represent detritus from the silicic and hornblende diorite dikes that intrude the ophiolite terrane. Some of these dikes are shown on the simplified geologic map in figure 10; others are too small to display at the map scale and probably account for anomalies in drainage basins without any mapped dikes. Some of the elements, such as lead, have selected threshold values near the level of detection (table 1) and have low-level concentrations in a narrow range just above the limits of detection (fig. 3). As such, they are barely anomalous and are probably insignificant.

The scandium anomalies appear to be related to the drainage basins containing abundant gabbroic and ultramafic cumulate rocks.

Anomalous concentrations of mercury and boron in stream-sediment samples tend to correlate with drainage basins containing faults or shear zones. Within some basins, barium also seems to be related to structures. Some of the basins also contain silicic and hornblende diorite dikes. These anomalies reflect movement of hydrothermal fluids along the shear zones and faults. Some of the drainage basins with anomalous mercury and boron are located in areas with no known mercury mineralization.

The three drainage basins represented by stream-sediment samples labeled 2, 4, and 5 contain anomalous amounts of copper. The copper may represent material introduced by hydrothermal activity or it may represent minor disseminations in the rocks. There are no known mines or prospects within these drainage basins.

Anomalous concentrations of elements in rock samples are combined with a simplified geologic map modified from Gray and others (1983a) (fig. 10). Comparison of figures 9 and 10 suggests that the anomalous elements in individual samples tend to fall in groupings similar to the whole population of rock samples and, as such, reflect the geologic events and units within the roadless areas. There are, however, variations in these patterns in figure 10 and since the variations may be related to mineralization, they are discussed in more detail.

Anomalies, such as titanium and vanadium associated with mafic volcanic rocks, reflect higher concentrations of some elements in the volcanic rocks and are not indicators of mineralization. A similar interpretation is placed on the anomalous vanadium and yttrium concentrations in cumulus ultramafic and gabbroic rocks. Anomalous copper and zinc concentrations with mafic volcanic rocks and ultramafic and gabbroic rocks probably reflect minor disseminations within the samples and do not suggest broader scale mineralization, because the elements are not anomalous in the drainage basins from these areas.

The suite of elements La, Mo, Nb, Pb, Y, Sr, and Ti found to be anomalous in samples from the hornblende diorite dikes, silicic dikes, and adjacent altered rocks reflect their more alkaline character. Carlson and others (1982) identified a similar geochemical pattern in the Kalmiopsis Wilderness in Oregon immediately to the north of the North Fork Smith River Roadless Areas and thought that the silicic porphyries were related to the Tertiary Mount Emily intrusion. We suggest that the silicic rocks in the roadless areas are also related to the Mount Emily intrusion.

Two samples were taken from mines or prospects that had copper-bearing deposits (fig. 10). The elements Cu, Mo, Au, Ag, As, and Zn reflect this mineralization when found in association. Other anomalous samples contain some of these elements and could represent similar mineralization. The majority of these samples, however, are not in drainages containing stream-sediment samples with anomalous amounts of these metals, nor were concentrations of ore materials observed in the field. Therefore, there is little evidence to interpret these anomalous rock samples as being representative of extensive mineralized areas.

As in the stream sediments, the presence of anomalous amounts of boron in rock samples probably reflects the overprint of a hydrothermal event. In an attempt to understand and define the overprint of silicic igneous and hydrothermal activity, the distribution of incompatible elements, including Ba, Pb, Sr, Y, Zr, Hg, and B, was examined further. An R-mode factor analysis was used to fit a simple model to the geochemical data. The model was derived using the Statistical Package for the Social Sciences (Nie and others, 1975). The model produced by this method consists of two factor scores for each sample. Each factor score can be used to predict a substantial percentage of each sample's composition of incompatible elements (table 2). Relatively high factor scores for the first factor (sample localities, fig. 11) represent the relative concentrations of Ba, Pb, Sr, Y, and Zr (the incompatible elements) in the samples. This factor represents the silicic dikes, their metasomatic affects, and the volcanic and gabbroic rocks in the northeastern part of the area. Factor 2 is highly influenced by mercury, and to a much lesser extent boron, and appears to represent concentrations of hydrothermal alteration associated with the silicic intrusive event. The distribution (fig. 12) of higher values of this factor is much broader than that of factor 1 and may represent the hydrothermal activity associated with fault zones and dikes too small to be represented on the map.

Discussion of selected elements in the rock and chromitite samples

The spatial distribution and concentrations of the elements Cr, Co, Ni, and platinum-group elements (PGE) are important because the region has produced chromite, has areas overlain by laterite containing Ni, Cr, and Co, and has produced PGE from small-scale dredging operations.

The location and chromium content of rock and chromitite samples are shown in figure 13. A region along the east edge of the roadless area has an especially high chromite content. There is a similar east-west region through the center of the area and a possible zone along the west edge of the area. The south-central, north-central, and northeastern areas are markedly lower in chromium content. The areas containing chromite reflect the intersection of present-day topography with a zone of rocks between the top (upper part) of the tectonite and the overlying cumulus ultramafic rocks. Within the east-west region through the center of the area, the tectonite appears to be shallowly dipping, approaching horizontal, with its upper part corresponding to the topographic high areas; the zone containing chromitite deposits is near the top of the high areas. Along the east edge, this zone has been rotated by faulting and emplacement to a near-vertical position and the chromitite occurrences approximately parallel the contact between the tectonite and cumulus ultramafic rocks. Chromitites on the west edge of the area occur in sheared and rotated blocks of ultramafic rock. Concentrations of chromium in the rock samples reflect the variations in amounts of accessory chromite in the dunites and harzburgites and give some indication of levels of chromium in the parent rocks of the nickel laterites. Areas of mafic and volcanic rocks in the northeastern part of the area are lower in chromium than the other areas.

The locations and nickel content of rock and chromitite samples are shown in figure 14, locations and cobalt content of rock and chromitite samples are presented in figure 15. Very little variation and no recognizable spatial pattern to the distribution of nickel concentrations were found except that the gabbroic, volcanic, and some of the cumulus ultramafic rocks are noticeably lower in nickel content, as would be expected from their mineral composition. Cobalt shows a similar distribution except for the presence of some higher concentrations in the south-central part of the roadless area. We conclude that the parent material upon which laterites developed was relatively homogeneous with respect to nickel and cobalt.

Within some chromitite samples, Pt, Ir, and Ru contents are quite high. Palladium and rhodium tend to be low. Total PGE content and the ratio of Ir plus Ru to total PGE content in the chromitites is shown in figure 16. Four of the six highest PGE concentrations in the chromite occur in the south-central part of the roadless area (fig. 16, inset 1). Ir plus Ru tends to be high in chromitites throughout the roadless areas; three of the samples contain an unusually high proportion of Pt, Pd, and Rh. Other nearby ophiolites in Oregon (Page and others, 1983) tend to have higher proportions of Ir and Ru, similar to most chromitites in the North Fork Smith River Roadless Areas.

CONCLUSIONS

Geochemical anomalies for various elements in stream-sediment, rock, and chromitite samples in and adjacent to the North Fork Smith River Roadless Areas have been identified, but only a few are indicative of a potential for mineral resources.

(1) Mercury and boron in stream-sediment and rock samples indicate areas of structurally broken and hydrothermally altered rocks.

(2) The PGE anomalies in the chromitite samples indicate the possibility of recovering byproduct PGE from any future chromite mining.

(3) Areas of combined copper and zinc anomalies both in stream-sediment and rock samples indicate the possibility of deposits containing these metals.

REFERENCES CITED

Carlson, C. A., 1982a, User's manual for z_sp: U.S. Geological Survey Open-File Report 82-621, p. 18.

_____1982b, User's manual for STATMAP: U.S. Geological Survey Open-File Report 82-622, p. 10.

_____1982c, User's manual for box_diagram: U.S. Geological Survey Open-File Report 82-623, p. 26.

Carlson, C. A., Page, N. J., Grimes, D. J., and Leinz, R. W., 1982, Map showing geochemical characteristics of rocks and stream sediments from the Kalmiopsis Wilderness, southwestern Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1240-C, scale 1:62,500.

Cater, F. W., Jr., and Wells, F. G., 1953, Geology and mineral resources of the Gasquet quadrangle, California-Oregon: U.S. Geological Survey Bulletin 995-C, p. 79-133.

Coleman, R. G., 1977, Ophiolites: New York, Springer-Verlag, 229 p.

Dick, H. J. B., 1976, The origin and emplacement of the Josephine peridotite of southwestern Oregon: Yale University, New Haven, Conn., Ph. D. thesis, 409 p.

Diller, J. S., 1902, Topographic development of the Klamath Mountains: U.S Geological Survey Bulletin 196, 69 p.

Gray, Floyd, Page, N. J., Connell, R. R., and Huber, D. F., 1983a, Geologic map of the North Fork Smith River Roadless Area, Del Norte County, northern California, and Curry County, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1423-A, scale 1:62,500.

Gray, Floyd, Peterson, J. A., Carlson, R. R., Briggs, P. H., Haffty, Joseph, Cooley, E. F., and Page, N. J, 1983b, Geochemical analyses of rock and stream-sediment samples from the North Fork Smith River Roadless Area, Del Norte County, California, and Josephine County, Oregon: U.S. Geological Survey Open-File Report 82-976, scale 1:62,500, p. 22.

GSA Penrose Conference, 1972, Ophiolites: Geotimes, v. 17, no. 12, p. 24-25.

Harper, G. D., 1980, The Josephine ophiolite--remains of a late Jurassic marginal basin in northwestern California: Geology, v. 8, p. 333-337.

Harper, G. D., and Saleeby, J. B., 1980, Zircon ages of the Josephine ophiolite and lower Coon Mountain pluton, western Jurassic belt, northwest California [abs.]: Geological Society of America Abstracts with Programs, v. 12, p. 109-110.

Hershey, O. H., 1911, Del Norte County (California) geology: Mineral and Science Press, v. 102, p. 468.

Maxson, J. H., 1933, Economic geology of portions of Del Norte and Siskiyou Counties, northwesternost California: California Journal of Mines and Geology, v. 29, p. 123-160.

Nie, N. H., Hull, C. H., Jenkins, J. G., Steinbrenner, K., and Bent, D. H., 1975, Statistical package for the social sciences, 2nd edition: McGraw Hill Book Company, San Francisco, 675 p.

Page, N. J., Carlson, R. R., Miller, M. S., Carlson, C. A., and Gray, Floyd, 1983, Maps showing geochemical characteristics of platinum-group elements and gold in rock samples from the Kalmiopsis Wilderness, southwestern Oregon: U.S. Geological Survey Miscellaneous Field