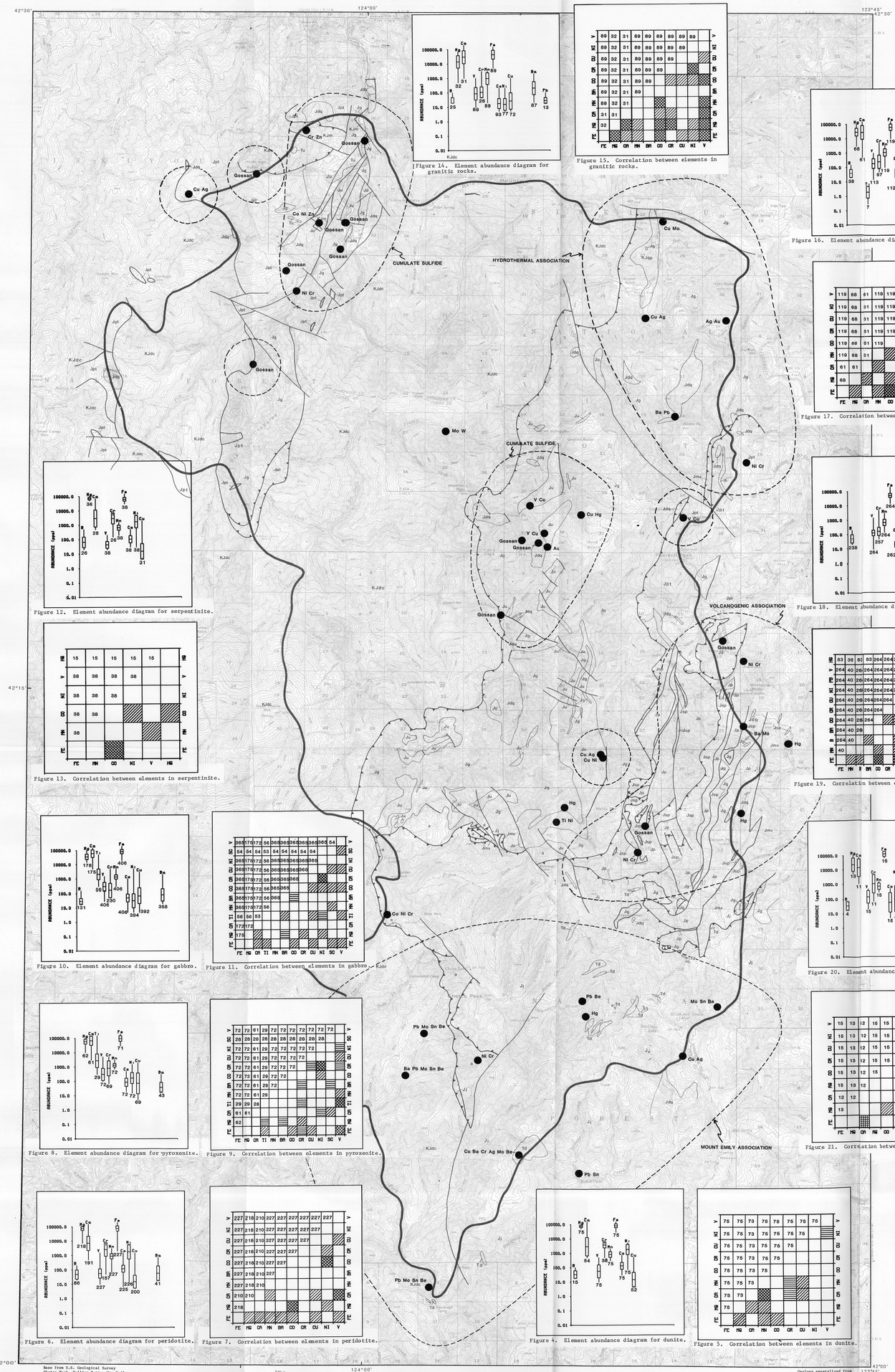

MAP SHOWING GEOCHEMICAL CHARACTERISTICS OF ROCK SAMPLES FROM THE KALMIOPSIS WILDERNESS, SOUTHWESTERN OREGON

By

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Figure 12. Element abundance diagram for serpentinite.

Figure 13. Correlation between elements in serpentinite.

Figure 14. Element abundance diagram for granitic rocks.

Figure 15. Correlation between elements in granitic rocks.

Figure 16. Element abundance diagram for volcanic rocks.

Figure 17. Correlation between elements in volcanic rocks.

Figure 18. Element abundance diagram for sedimentary rocks.

Figure 19. Correlation between elements in sedimentary rocks.

Figure 20. Element abundance diagram for gossan.

Figure 21. Correlation between elements in gossan.

Figure 10. Element abundance diagram for gabbro.

Figure 11. Correlation between elements in gabbro.

Figure 8. Element abundance diagram for pyroxenite.

Figure 9. Correlation between elements in pyroxenite.

Figure 6. Element abundance diagram for peridotite.

Figure 7. Correlation between elements in peridotite.

Figure 4. Element abundance diagram for dunite.

Figure 5. Correlation between elements in dunite.

EXPLANATION

Tu — Unpaus Formation: Sandstone and shale

Td — Dacite dikes

KJm — Myrtle Group (Lower Cretaceous and Upper Jurassic): Conglomerate, sandstone, and mudstone

KJqp — Quartz porphyry

KJdc — Dothan Formation (Cretaceous and Jurassic) and Colebrooke Schist (Upper Jurassic): Sandstone, shale, volcanic rocks, and schist

Jmv — Metavolcanic rocks

Jp — Pyroxene-bearing metavolcanic rocks

Jdq, Jd, Jg, Jm — Intrusive igneous rocks: Jdq, diorite and quartz diorite; Jd, diorite; Jg, gabbro; Jm, ultramafic rocks; predominantly metacumulate peridotite

Jpt, Jj, Jsp, Jdi — Ultramafic rocks and dikes: Jpt, peridotite; Jj, Josephine Peridotite (Jurassic or older); Jsp, serpentinite; Jdi, diabase dikes

a — Amphibolite

TERTIARY

CRETACEOUS AND JURASSIC

JURASSIC

JURASSIC AND JURASSIC OR OLDER

AGE UNKNOWN

CONTACT—Approximately located

FAULT

THRUST FAULT—Sawteeth on upper plate

BOUNDARY OF KALMIOPSIS WILDERNESS

OUTLINE OF INFORMAL ASSOCIATIONS

LOCATION OF ANOMALOUS SAMPLE—Anomalous elements or gossan indicated

STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts required the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas in Federal lands to determine their mineral resource potential. Results of these surveys were given to the public and be submitted to the President and the Congress. This report presents the results of a geochemical survey of the Kalmiopsis Wilderness in the Siskiyou National Forest, Curry and Josephine County, Oregon. Kalmiopsis Wilderness was established by Public Law 88-577, September 3, 1964.

INTRODUCTION

This report summarizes 1,307 semiquantitative chemical analyses of rocks collected to aid in the evaluation of the mineral resources of the Kalmiopsis Wilderness, Oreg. Chemical analyses and sample location maps are presented by Grimes, Leinz, and Speckman (1981). The area is located in the Klamath Mountains geomorphic province of southwestern Oregon, and the area's location and boundaries are shown on the accompanying map.

The geology of the study area is described by Page and others (1981), Gray (1980), and Ramp (1975). The rocks of the area consist of dismembered ophiolite, island-arc, and sedimentary rock sequences that lie within the Western Jurassic belt of the Klamath Mountains. All units normally found within these assemblages are present; however, thrusting and subsequent normal faulting have disrupted the geometric relations, producing a complexly faulted series of imbricate thrust slices.

METHODOLOGY

Grab samples were collected during the summers of 1976, 1977, and 1978 during the course of detailed geologic mapping. The locations of the samples are shown in figure 1. There was no formal effort statistically to randomize the samples and, consequently, some sampling bias may be caused by a tendency to select unusual rock types. Any such sampling bias is probably diluted by the large number (1,307) of samples collected for analysis. Restricting the sampled population to available outcrops may have caused additional sampling bias, as described by Miesch (1967).

Chemical analyses were prepared using the six-step semiquantitative emission spectrographic method described by Myers, Bowen, and Barnett (1961), Ward and others (1963), and Grimes and Marranzino (1968). The method is semiquantitative, that is, element concentrations are estimated to the 1, 2, 5, and 7 times the powers of 10. Data are reported in parts per million (ppm) or percent. The method allows rapid and relatively inexpensive chemical analyses for exploration purposes. Statistical properties of data generated by this method have been described by Motooka and Grimes (1976).

Retrieval and statistical reduction of the chemical analyses were performed using the RASS and STATPAC systems of computer programs described by VanTrump and Miesch (1977). Graphic displays of data sorted by rock type were prepared using unpublished computer programs created by Carlson.

Three types of graphical summaries are shown: abundance diagrams, correlation diagrams, and locations of samples with unexplained high abundances. The abundance diagrams show the geometric means, the geometric deviations, and the ranges of all elemental abundances for each major rock type. The elements are arranged in increasing atomic number from left to right. However, if the number of determinations is judged to be too small to yield useful statistics, the data for that element are not shown. Geometric statistics were computed because of the common tendency of rock analyses to show lognormal distributions. An explanation of the symbols used in the abundance diagrams is given in figure 2.

Correlations between elements within major rock types are shown in correlation diagrams using Spearman Rank Correlations (Snedecor and Cochran, 1967, p. 193). Rank correlations are more demanding than Pearson Correlations and reduce the likelihood of spurious correlations resulting from the semiquantitative nature of the reported values. All correlations shown are statistically significant at the 95 percent or better confidence level using the methods described by Snedecor and Cochran (1967, p. 193). Questionable correlations were examined graphically and subjectively rejected if the correlations appeared to be caused by shared distributions. An explanation of the patterns used on the correlation diagrams is shown in figure 3.

A review of the data showed that some reported abundances were very high and suggested that samples with unexplained high abundances in each rock type. The statistical distribution for each element was then tentatively reviewed for each major rock type. More than 200 abundances were identified as unexplained high. Of these, 84 samples contained a single unexplained abundance, and 32 samples contained unexplained abundances for more than one element. One unexplained abundance within a single sample might be the result of ordinary variance, but the chance that two or more unexplained abundances would occur in a single sample is much lower, and these abundances are considered anomalous. Many analyses for gold and mercury were made using atomic-absorption methods, and abundances above 0.1 ppm are also shown as anomalous. The location of all anomalous samples is indicated on the accompanying geologic map. Gossans, by their nature, may be guides to potential ores, and they too are shown on the map. Table 1 presents a guide to the symbols used to indicate these samples on the map.

GEOCHEMICAL DESCRIPTION OF THE MAJOR ROCK TYPES

Many of the map units presented in the accompanying simplified map contain more than one rock type. For example, the Dothan Formation and the Colebrooke Schist contain sandstone, shale, volcanic rocks, chert, and schist. Because the chemistry may vary substantially between each rock type, we believe that important distinctions would be lost if the analyses were presented by map unit. Instead, analyses for similar rock types from different map units are grouped together even when they come from units of very different ages and somewhat dissimilar environments. For example, dunite from the peridotite unit and the Josephine Peridotite is grouped with the dunite from the ultramafic rocks unit. Table 2 shows the map units and rock types included within each major rock type. The major rock groupings described below present the best practical opportunity to detect unusual samples that may indicate the presence of mineral resources. Most, if not all, the correlations discussed below are typical of the rock type discussed, and none of the correlations indicates any significant difference between these rock types in the Kalmiopsis Wilderness and similar rock types elsewhere.

Dunite

Element abundances for the dunite are presented in figure 4, and element correlations are presented in figure 5. Comparisons of figure 4 with published abundances (Coleman, 1977, or Carmichael and others, 1974) show several inconsistencies. For example, the average (arithmetic) Mg and Fe abundances we report are 26 percent and 135 percent, respectively, of those reported by Coleman for dunite from metamorphic tectonite. More Fe-rich dunite from the cumulate sequence grouped with dunite from the more voluminous tectonite could explain the Fe discrepancy, but no amount of these dunites could dilute the Mg to these levels. In addition, several analyses for samples from within the study area reported by Himmelberg and Loney (1973) agree closely with those of Coleman. These discrepancies may reflect the nature of the analytical method used. The earlier dunite are assumed to be those of grossdorite. Consequently, as the data presented by Himmelberg and Loney (1973) is grossdorite, our average values should become more realistic, with the exceptions discussed in the following text. These effects are shown in table 3 as the ratios of our abundances to those published in the literature.

Although the absolute magnitudes of the average abundances reported here may be in error, it is the relative magnitudes within a rock type that are of interest in geochemical exploration, and the analytical method retains relative positions. In figure 5, the high correlation of Ca and Mn probably reflects their presence together in clinopyroxene. The negative correlation of Cr with Co, Ni, and Mn suggests that chromite and clinopyroxene vary inversely.

Peridotite

Element abundances for peridotite are presented in figure 6, and element correlations are presented in figure 7. As with dunite, these abundances disagree somewhat with published values, as shown in table 3. Nickel, Co, and Mg are strongly correlated and are usually found within olivine. As the amount of olivine within the samples varies, as will the content of Mg, Ni and Co vary. Cr, however, is high in spinel and does not correlate with Mg, Ni, or Co but does strongly correlate with Fe and Ca. Because Ca is usually present in the clinopyroxene, the Y may be substituting for Fe in the clinopyroxene.

Pyroxenite

Element abundances for pyroxenite are presented in figure 8, and element correlations are presented in figure 9. A number of comparisons can be made between the dunite and the peridotite. Mn and Ni abundances are low whereas Co, Fe, Ti, and V are higher. The decline in the Mn and Ni (which are present in olivine) and the increase in Fe and Ti (which are present in the clinopyroxene) match the decline in the ratio of olivine to clinopyroxene. The mutual correlations of V and Ti with Fe within the pyroxenite suggest that they are present in clinopyroxene or magnetite.

Gabbro

Element abundances for gabbro are presented in figure 10, and element correlations are presented in figure 11. These samples were collected from cumulate sulfide and hydrothermal association gabbroic rocks. Many of the differences shown in table 3 may reflect the effects of comparing published gabbro analyses of gabbro from ophiolites with those from cumulate ophiolite and rocks from other environments. The effects of this mixture are reflected in figure 11 where only one element pair shows a high correlation: Ni-Cr.

Serpentinite

Element abundances for serpentinite are presented in figure 12, and element correlations are presented in figure 13. A striking resemblance between figures 12 and 4 suggests that the serpentinite samples were derived mostly from dunite. Table 3 shows that the abundances for Co and Ni, which may be of economic importance, are unchanged during serpentinization. Only Co and Fe show a strong correlation, as they do for dunite. The presence of a strong Mn and Ca correlation in dunite and the absence of a correlation in serpentinite, combined with nearly identical Mn and Ca abundances for the two rocks, may reflect greater mobility of Ca during serpentinization.

Granitic rocks

Element abundances for granitic rocks are presented in figure 14, and element correlations are shown in figure 15. Comparisons of figure 14 with abundances for leucocratic ophiolite rocks published by Coleman (1977) show substantial differences. These may reflect real chemical differences because Coleman's data are based mostly on trondhjemite and plagiogranite whereas our samples are diorite, quartz diorite, and tonalite. Alternatively, the differences may reflect the varying degree to which the granitic magmas were contaminated by more mafic inclusions and host rocks because all of the elements for which there are large significant correlations are mafic and show numerous intracorrelations.

Volcanic rocks

Element abundances for volcanic rocks are shown in figure 16, and element correlations are shown in figure 17. Comparisons with gabbroic and granitic rocks show that the volcanic rocks are intermediate between the two with respect to the mafic elements. This relative position may reflect the andesitic to dacitic compositions of the volcanic rocks. Significant large correlations in figure 14 are between Co, Cr, Ni, V, and Fe.

Sedimentary rocks

Element abundances for the sedimentary rocks are presented in figure 18, and element correlations are presented in figure 19. These rocks are mostly graywacke and shale (litirgraywacke). Because element abundances for the sedimentary rocks resemble those of the volcanic rocks, these clastic rocks are probably derived from the volcanic sequences.

Gossans

The element abundances for gossans are shown in figure 20, and the correlations are shown in figure 21. Gossans can reflect potential ores, and the wide deviations and the presence of unusual elements, for example, Ag and Au, are to be expected in such rocks. The element correlations for the gossans are typical of deposits formed by mineralizing fluids, but probably have no geologic or geochemical meaning because the gossans originated from different types of ore deposits.

UNEXPLAINED HIGH ABUNDANCES OF ELEMENTS IN ROCKS

Anomalous samples as defined earlier are shown in table 4 where they are grouped into informal associations. Each association is formed from samples that are similar in terms of (a) geologic setting, and (or) similar rock types. These associations are the Mount Emily association, the volcanogenic association, the cumulate sulfide association, and the hydrothermal association. There is also an unassigned sample category. The arrangements within each association shown in the table are designed to emphasize chemical similarities between samples. For example, the first sample in the table is a volcanic rock that contains anomalous abundances of Ba, Pb, Mo, Sn, and Be. Below it is a very similar anomalous sample that is also a volcanic rock and that contains anomalous abundances of Pb, Mo, Sn, and Be. To the right of the first sample is an anomalous sample of sedimentary rock that is somewhat similar in that it also contains anomalous abundances of Pb, Mo, and Sn, but lacks anomalous abundances of Co, Ag, and Cr. Each association is also shown schematically on the map as a heavy line enclosing locations of anomalous samples. The locations of samples with unexplained high each association are undoubtedly complex, but not enough information is presently available to define them. These associations may or may not indicate the presence of economic mineral deposits. The likelihood of economic mineral deposits may be small, and these associations should be regarded only as indications of the direction that further exploration could take.

The Mount Emily association, in the south tip of the study area, consists of samples from light-colored plagioclase-porphyry dikes that cut the Josephine Peridotite, the Dothan Formation, and the Colebrooke Schist. Many of the dikes from which these samples are taken are too small to be shown on the map. Typical dikes as much as several inches wide and as much as several tens of feet long. One exceptionally large body is shown on the map as a Tertiary dacite dike. Elements with unexplained high abundances in this association are Ba, Pb, Mo, Sn, Be, Co, Ag, and Cr. This association is typical of the late-stage magmatic setting (Levinson, 1974, p. 60), particularly involving alkalitic intrusive bodies. The Mount Emily association is also similar to the dikes of the Sixes River area of Tertiary age that lies about 8 mi southwest of the Wilderness; we believe that the dikes from which these samples came are genetically linked to the intrusion of the Mount Emily body.

Most samples in the volcanogenic association are from localities along the east boundary of the study area, at lat 42°15' N. south of the center. Three other areas are located in the northwest corner of the area. All samples are volcanic rocks or gossans. The volcanic rocks are sheared or foliated and commonly altered and may contain from stringers and visible sulfides. Many of them occupy shear zones between thrust slices. Elements with unexplained high abundances are Cu, Mo, Ni, Co, Cr, Ag, Au, Hg, Ba, and Sn. These abundances may reflect the presence of volcanogenic massive sulfide deposits, a possibility noted in the area during the course of geologic mapping (Page and others, 1981). These deposits are believed to be derived from hydrothermal deposits formed syngenetically with the volcanic rocks at a spreading center and since transported as sheared masses along thrust faults.

The cumulate sulfide association is found in four areas: the northwest corner, the central part and in two small areas east and southeast of the center of the study area. The samples consist of numerous gossans, several altered pyroxenites containing visible sulfides, a conglomerate containing a sulfide-bearing quartz vein, a sheared iron-stained amphibolite with talc, calcite, and quartz veins, and one sample each of peridotite, gabbro, granitic rock, and laterite. Elements with unexplained high abundances in this association are Cu, Ni, Zn, Co, Ag, Mg, and Au. These elements are believed to have originated as a sulfide phase that crystallized between the cumulate ultramafic and gabbroic sections of the ophiolite sequence. They may have since been mobilized by hydrothermal fluids and redeposited.

The hydrothermal association, located in the northeast corner of the map area, consists of three small areas of altered gabbro and diorite containing visible sulfides. Elements showing unexplained high abundances are Au, Ag, Cu, Mo, Bi, and Pb. These few anomalies may reflect the presence of hydrothermal sulfide veins deposited in host rocks in conjunction with the emplacement and cooling of nearby quartz diorite porphyry dikes and stocks.

The unassigned samples comprise two major rock types: sedimentary rocks and pyroxenites. Four of the five sedimentary rock samples contain unexplained high abundances of Ni and Cr. These samples probably represent rocks with higher than normal ultramafic and volcanic clasts and are probably insignificant. The Mo-W anomaly probably represents a sedimentary rock with clasts of Mo and W minerals and is also probably insignificant. Because there is no known limestone in the area, there is little likelihood that this rock is a skarn. The pyroxenite samples may be part of the cumulate sulfide association, but such a relation is not clear.

CONCLUSIONS

This study produced the following conclusions regarding the geochemical characteristics of rocks in the Kalmiopsis Wilderness. Most, if not all, the element correlations reported here are typical of the associated rock type. The element abundances reported here are in broad agreement with those published elsewhere for rocks from this area and for similar rocks from similar geologic environments. Thirty-two samples were identified as anomalous because they contained abundances for two or more elements. These anomalous samples were assigned to five informal associations on the basis of similar chemical abundances. These informal associations can be explained in terms of the geologic context of the area.

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Table 1.—Guide to the symbols used to indicate the locations of samples with unexplained high abundances

[The elements abundance needed to qualify for classification as unexplained is also given for each major rock type. n.a., not applicable]

Map symbol	Element	Major rock type[1]	Lower limit of unexplained abundance[2] (ppm)
Au[3]	Gold	Gabbro	>0.1
Hg[3]	Mercury	Peridotite	>.1
		Pyroxenite	>.1
		Gabbro	>.1
		Granitic rocks	>.1
		Volcanic rocks	>.1
Gossan[3]	n.a.	Gossan	n.a.
Ti	Titanium	Dunite	>3.0 percent
		Peridotite	>3.0 percent
		Pyroxenite	>10.0 percent
		Gabbro	>2.0 percent
V	Vanadium	Peridotite	>700.0
		Pyroxenite	>1,500.0
		Granitic rocks	>700.0
Co	Cobalt	Peridotite	>1,000.0
		Gabbro	>70.0
		Volcanic rocks	>700.0
		Sedimentary rocks	>70.0
Cu	Copper	Peridotite	>1,000.0
		Pyroxenite	>700.0
		Gabbro	>1,000.0
		Granitic rocks	>300.0
		Volcanic rocks	>1,000.0
		Serpentinite	>1,000.0
Ni	Nickel	Pyroxenite	>500.0
		Gabbro	>1,500.0
		Volcanic rocks	>1,500.0
		Sedimentary rocks	>700.0
Ba	Barium	Dunite	>100.0
		Gabbro	>1,000.0
		Granitic rocks	>1,500.0
		Volcanic rocks	>1,000.0
Cr	Chromium	Granitic rocks	>2,000.0
		Volcanic rocks	>3,000.0
		Sedimentary rocks	>700.0
Zn	Zinc	Dunite	>150.0
		Pyroxenite	>500.0
		Gabbro	>300.0
		Volcanic rocks	>150.0
		Sedimentary rocks	>300.0
B	Boron	Serpentinite	>300.0
Pb	Lead	Peridotite	>20.0
		Gabbro	>15.0
		Granitic rocks	>70.0
		Volcanic rocks	>15.0
Ag	Silver	Peridotite	>.3
		Gabbro	>.3
		Granitic rocks	>.3
		Volcanic rocks	>.3
		Sedimentary rocks	>.3
		Serpentinite	>.3
Mo	Molybdenum	Dunite	>3.0
		Peridotite	>3.0
		Gabbro	>3.0
		Granitic rocks	>3.0
		Volcanic rocks	>3.0
		Sedimentary rocks	>3.0
As	Arsenic	Peridotite	>2,000.0
Sn	Tin	Volcanic rocks	>7.0
		Sedimentary rocks	>10.0
Be	Beryllium	Granitic rocks	>3.0
		Volcanic rocks	>3.0
		Sedimentary rocks	>3.0
W	Tungsten	Sedimentary rocks	>50.0

[1]Lower limits of unexpla. [2] abundance were developed for each rock type only on the basis of the data for that rock type. In many cases, two geometric deviations above the geometric mean was chosen as the lower limit of unexplained abundance. In one cases, subjective judgments were made to modify this rule. No rock [illegible] yes or lower limits are given where unexplained abundances did not exist.

[3]All samples containing the indicated abundances of these elements were plotted on the map. Samples containing the other elements were plotted only if they contained more than one unexplained high abundance.

All samples of gossan were plotted inasmuch as gossans may represent potential ores.

Table 2.—Definitions of major rock types

[n.a., not applicable]

Major rock type	Represented map units	Represented rock types	Number of samples
Dunite	Josephine Peridotite (Jj)	Dunite	75
	Peridotite (Jpt)		
	Ultramafic rocks (Jm)		
Peridotite	Josephine Peridotite (Jj)	Peridotite	228
	Peridotite (Jpt)		
	Ultramafic rocks (Jm)		
Pyroxenite	Ultramafic rocks (Jm)	Pyroxenite	72
Gabbro	Diabase dikes (Jdi)	Gabbro	387
	Volcanic rocks (Jg)	Hornblendite	1
	Dike Complex (Jd)	Diabase	13
		Troctolite	5
		Total	406
Volcanic rocks	Pyroxene-bearing metavolcanic rocks (Jp)	Tuff	21
		Basalt	16
	Metavolcanic rocks (Jmv)	Dacite	14
	Dothan Formation and Colebrooke Schist (KJdc)	Greenstone	53
		Hyaloclastite	2
	Quartz porphyry (KJqp)	Andesite	6
	Dacite dikes (Td)	Agglomerate	2
		Porphyry	1
		Total	120
Granitic rocks	Diorite and quartz diorite (Jdq)	Aplite	5
		Granite	5
		Diorite	74
		Granodiorite	5
		Total	89
Serpentinite	Serpentinite (Jsp)	Serpentinite	38
	Ultramafic rocks (Jm)		
Gossan	n.a.	Gossan	15
Sedimentary rocks	Dothan Formation and Colebrooke Schist (KJdc)	Graywacke	171
		Sandstone	12
	Myrtle Group (KJm)	Conglomerate	13
	Umpqua Formation (Tu)	Shale	44
		Mudstone	16
		Siltstone	5
		Black shale	3
		Total	264
		TOTAL	1,307

Table 3.—Ratios of arithmetic mean abundances for rocks in the Kalmiopsis area to those reported in the literature

[—, not available; Values for pyroxenite from Bailey, Irwin, and Jones (1964); others from Coleman (1977)]

Elements	Major rock types: Dunite	Peridotite	Pyroxenite	Gabbro	Granitic rocks	Volcanic rocks
Magnesium	0.26	0.23	0.44	0.44	—	0.79
Calcium	4.33	2.38	.99	.78	—	.85
Vanadium	—	3.52	—	1.65	4.47	.45
Chromium	.97	—	.76	0.57	102.10	2.44
Manganese	.95	1.14	1.57	1.86	2.89	1.11
Iron	1.35	1.32	2.06	1.74	1.39	.88
Cobalt	—	1.30	—	.77	3.71	.81
Nickel	.95	1.15	.46	1.56	2.50	.89
Copper	—	2.64	—	4.29	74.00	2.33
Barium	—	—	—	71.00	3.20	11.10

Table 4.—Anomalous samples grouped into informal associations

MOUNT EMILY ASSOCIATION

Volcanic rocks	Sedimentary rocks	Gabbro
Ba, Pb, Mo, Sn, Be	Ba, Mo, Be, Co, Ag, Cr	Co, Ag
Pb, Mo, Sn, Be		
Pb, Mo, Sn, Be		
Mo, Sn, Be		
Mo, Sn, Be		
Pb		
Sn		
Pb		
Be		
Hg		

VOLCANOGENIC ASSOCIATION

Gossans	Volcanic rocks
Au	Ni, Cr
	Ni, Cr
	Cu, Ag
	Ba, Mo
	Hg
	Hg

CUMULATE SULFIDE ASSOCIATION

Gossans	Pyroxenite	Granitic rocks	Peridotite
S	Cu, V	Cu, V	Cu, V
	Cu Ni		
	Cu		
	Ag		

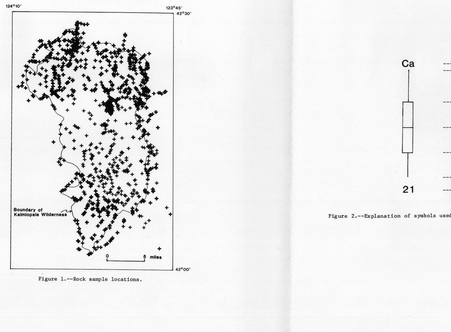
Gabbro	Sedimentary rock	Amphibolite	Laterite
Au	Cr, Zn	Cu, Hg	Cu, Ni, Zn

HYDROTHERMAL ASSOCIATION

Volcanic rocks	Gabbro
Cu, Mo	Cu, Ag
	Ag, Au
	Ba, Pb

UNASSIGNED ANOMALOUS SAMPLES

Sedimentary rocks	Pyroxenite
Ni, Cr, Cu	Ti, Ni
Ni, Cr	Hg
Ni, Cr	
Ni, Cr	
Ni, Cr	
Mo, W	



Index map showing location of Kalmiopsis Wilderness, southwestern Oregon.

Figure 1.—Rock sample locations.

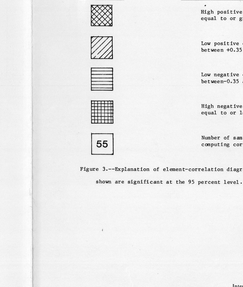


Figure 2.—Explanation of symbols used in element abundance diagrams.

Figure 3.—Explanation of element-correlation diagrams. All correlations shown are significant at the 95 percent level.

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