UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

MINERAL RESOURCE POTENTIAL OF THE TATOOSH ROADLESS AREA, LEWIS COUNTY, WASHINGTON

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STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation in the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Tatoosh Roadless Area (B6063), Gifford Pinchot and Mount Baker-Snoqualmie National Forests, Lewis County, Washington. The Tatoosh Roadless Area was classified as a further planning area during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

SUMMARY

The results of geological and geochemical surveys and investigations of mining activity in the Tatoosh Roadless Area reveal no potential for nonmetallic and energy resources in the area. The potential for metallic mineral resources is low, the only indications of possible mineralization being minor geochemical anomalies in panned-concentrate samples for vanadium, tin, arsenic, and lead in the Butter Creek subarea and for vanadium, boron, and barium in the Butter Peak subarea. None of the bedrock samples analyzed shows anomalous values of any element. No mining claims are known in the area. The nearest mining activity is a small copper deposit in a part of the Tatoosh pluton that does not extend into any of the four subareas of the roadless area.

INTRODUCTION

Tatoosh Roadless Area (B6063) is within Gifford Pinchot and Mount Baker-Snoqualmie National Forests immediately south of Mount Rainier National Park in the south-central Cascade Range of Washington (fig. 1). The study area, recommended for further planning, is composed of four separate subareas (figs. 2 and 3) that are contiguous with that part of Tatoosh Roadless Area (A6063) recommended for wilderness status. The four subareas are referred to herein as the Backbone Ridge, Butter Peak, Butter Creek, and Johnson Creek subareas; together they comprise only 5.4 mi^2. Elevations range from about 1,600 ft along Butter Creek and the Muddy Fork of the Cowlitz River to 5,096 ft at Butter Peak. Access to the Johnson Creek, Butter Creek and Butter Peak subareas is via U.S. Forest Service road network 52 from U.S. Highway 12 near Packwood. The Backbone Ridge subarea is reached via U.S. Forest Service Road 1270 from U.S. Highway 12, approximately 4 mi north of Packwood, and is crossed by Washington State Route 706.

The only published geologic mapping that encompasses the entire Tatoosh Roadless Area is a regional reconnaissance compilation by Hammond (1980). Parts of the roadless area immediately south of Mount Rainier National Park are included in the map of Fiske and others (1963). For the present study, the U.S. Geological Survey conducted geologic mapping and collected geochemical stream-sediment, pan-concentrate, and bedrock samples during July and August 1981, and July 1982.

GEOLOGIC SETTING

All four subareas of the Tatoosh Roadless Area (fig. 2) are underlain chiefly by volcanic and volcaniclastic rocks of the Eocene Ohanapecosh Formation (Fiske and others, 1963; Hammond, 1980). In the Johnson Creek and Backbone Ridge subareas, the Ohanapecosh Formation is unconformably overlain by rhyodacitic ash-flow tuff of the Eocene Stevens Ridge Formation (Fiske and others, 1963). Hypabyssal intrusive rocks of diverse composition are widespread components of the bedrock in all four subareas.

Backbone Ridge Subarea

Backbone Ridge, the largest and easternmost of the four subareas of the Tatoosh Roadless Area, consists of volcaniclastic rocks of the upper part of the Ohanapecosh Formation unconformably overlain by ash-flow tuff of the Stevens Ridge Formation (fig. 2). Both formations dip to the west at 20° to 40°, so the angular discordance at the contact is small. The unconformity is well-exposed in roadcuts along Washington State Route 706 where Stevens Ridge ash-flow tuff rests on a thick red paleosol developed on Ohanapecosh sedimentary rocks. The contact is described in detail by Fiske and others (1963, p. 24). Stevens Ridge ash-flow tuffs are characterized by abundant large and partially resorbed quartz phenocrysts and pumice lapilli whereas tuffs in the underlying Ohanapecosh are generally lithic-rich and rarely contain quartz phenocrysts. As noted by Fiske and others (1963, p. 15), however, quartz-phyric tuffs do occur locally in the uppermost part of the Ohanapecosh Formation on Backbone Ridge, suggesting that the time span represented by the unconformity in this area may not be large. The Ohanapecosh and Stevens Ridge Formations are pervasively recrystallized to zeolite-facies metamorphic assemblages of albite, quartz, zeolites, chlorite and smectitic clay minerals.

In the northern part of the Backbone Ridge subarea, a swarm of mafic dikes that trend N. 80° E. cuts the Stevens Ridge and Ohanapecosh Formations. Individual dikes are 1.5 to 6 ft thick. The dikes include aphyric to porphyritic basalt and fine- to medium-grained diabase. They display alteration similar to that of the host rocks. These mafic dikes were considered to be older than the Tatoosh pluton by Fiske and others (1963). Mafic intrusive rocks are absent in the southern half of the Backbone Ridge subarea. Instead, the Stevens Ridge Formation is intruded by several felsic sills, two of which are large enough to show on fig. 2. The sills range in composition from granodiorite to quartz monzonite, have seriate to hypidiomorphic textures, and are probably genetically related to the Tatoosh pluton to the northwest. The sills typically are extensively recrystallized to low-grade assemblages that include albite, quartz, laumontite, epidote, chlorite, smectite, sericite, and traces of pyrite.

Butter Peak Subarea

On Butter Peak, at the southern end of the Tatoosh Range, plugs and dikes of fine- to medium-grained andesite intrude a thick, rather structureless section of coarse to very coarse tuff-breccia that evidently represents the vent area of an Ohanapecosh volcano. Metamorphic recrystallization of both intrusive and host rocks to albite, quartz, chlorite, and calcite is common. Local zones of more intense hydrothermal alteration (silicification and argillization) occur but are small and contain only traces of sulfide minerals.

Butter Creek Subarea

The Butter Creek subarea is underlain entirely by volcaniclastic rocks of the Ohanapecosh Formation intruded by numerous porphyritic hypabyssal dikes and sills. The intrusive rocks range from basalt to dacite in composition. All are metamorphosed to some degree, the most common secondary minerals being albite, quartz, chlorite, prehnite, epidote, and calcite. Traces of zeolite and pyrite occur locally.

Johnson Creek Subarea

In the Johnson Creek subarea, near Johnson Lake, Ohanapecosh volcaniclastic rocks are overlain by Stevens Ridge ash-flow tuffs (fig. 2). Both units dip moderately to the south. As on Backbone Ridge, the uppermost beds of the Ohanapecosh include quartz-phenocryst-bearing tuffs that are petrographically identical to those in the Stevens Ridge Formation. The Ohanapecosh is intruded by a medium-grained quartz diorite body that extends northwestward into Mount Rainier National Park (Fiske and others, 1963). As elsewhere in the study area, all of the rocks have been subjected to low-grade metamorphism, yielding secondary mineral assemblages of albite, quartz, chlorite, smectitic clay minerals, zeolites, and calcite. Locally, sericite, epidote, siderite, and pyrite are developed near the margins of the quartz diorite intrusion.

GEOCHEMISTRY

A geochemical reconnaissance was undertaken as an integral part of the mineral resource assessment of the Tatoosh Roadless Area. Stream-sediment samples constituted the primary sampling medium and were supplemented with data from panned concentrates from stream sediments taken from the major drainages. Rock samples representing specific geologic units in the Tatoosh Roadless Area and samples taken from Eagle Peak mine northwest of the study area (fig. 1) were also analyzed. The samples were collected by W. M. Kemp, R. S. Werschky, J. G. Frisken, S. E. Church, and R. C. Evarts. Sample localities are shown in figure 3.

Stream-sediment samples were collected to give coverage of the entire Tatoosh Range, whereas rock samples were obtained mostly from within the four subareas of the roadless area that are the primary focus of this report, and from the Eagle Peak mine. Stream-sediment samples were collected from active streams draining areas as large as 3 mi^2. Sediment samples were collected from several localities within the stream, air dried, and sent to the laboratory for sieving and analysis. A total of 22 stream-sediment samples were collected.

Panned concentrates of stream sediments were taken from the larger drainages within the study area. The concentrate was panned in the field, air dried, and sent to the laboratory for separations, mineral identification, and spectrographic analysis. A total of 17 panned-concentrate samples were collected. Due to a misunderstanding in sample preparation procedures, not all samples were made available for mineral identification and the mineralogical data base is incomplete.

Sample Preparation

The stream-sediment samples were sieved through an 80-mesh (177-micron) stainless steel sieve and the minus-80-mesh fraction was ground for spectrographic analysis. A 30-mesh (590-micron) stainless steel screen was used to sieve the panned concentrate from stream-sediment samples and the minus-30-mesh fraction was retained for further separation. The most magnetic fraction was removed using an electromagnet. This fraction contained magnetite and highly magnetic rock fragments, and was discarded. The low-density fraction (specific gravity <2.8) was separated from the remaining heavy-mineral fraction by flotation in bromoform and was discarded. A final magnetic separation of the heavy-mineral fraction was made on the Frantz Isodynamic Separator at a setting of 0.6 amperes with a forward slope of 25^{o} and a side slope of 15^{o}. Under these conditions, a nonmagnetic, heavy-mineral fraction is separated from a more magnetic fraction. The magnetic fraction included many of the rock fragments and most of the mafic silicates. Mineralogically, the nonmagnetic fraction will contain sulfides, nonmagnetic oxides, sulfate and tungstate minerals, tourmaline, apatite, sphene, zircon, and other minor trace minerals that may be indicative of mineralization. Mineralogical examination of this fraction was performed using a binocular microscope. Visual identifications of the minerals present were made and the volume percent of the fraction was estimated. X-ray diffraction was used as a supplemental aid to identification. Following mineralogical examination, the samples were ground under acetone in an agate mortar prior to spectrographic analysis.

Rock samples were crushed and then ground to pass a 200-mesh (74-micron) screen prior to analysis.

Analytical methods

Analytical results reported in this study were obtained using direct-current arc emission spectrometry. Analytical values from the stream sediments and rocks are determined on a 10-milligram split of the sample. Limits of determination vary from element to element and are different in these two classes of sample material (table 1). Analytical data are obtained by visual comparison of spectra derived from the unknown sample against spectra obtained from standards made from pure oxides or carbonates (Grimes and Marranzino, 1968). The concentrations of 31 elements are routinely determined.

The concentrations of standard samples are geometrically spaced over any given order of magnitude of concentration and are prepared in such a way that the ranges of concentrations normally found in naturally occurring samples are bracketed. When comparisons are made with sample films for semiquantitative use, reported values are rounded to 100, 50, 20, 10, and so forth. Those samples whose concentrations are estimated to fall between the above values are arbitrarily given values of 70, 30, 15, 7, and so forth. The precision of the method is approximately plus or minus one reporting unit at the 83-percent confidence level and plus or minus two reporting units at the 96-percent confidence level (Motooka and Grimes, 1976). Values determined for the major elements (calcium, iron, magnesium, and titanium) are given in weight percent; all others are given in parts per million (ppm).

Results

Results of analytical work on stream sediments, panned concentrates, and rock and ore samples are given in tables 2, 3, and 4, respectively. In order to evaluate these data, information on the threshold or background values for representative rock samples of the Ohanapecosh Formation and Tatoosh plutonic rocks are summarized in table 5. These samples are from the Glacier View Roadless Area and Goat Rocks Wilderness (Evarts and others, 1983; Church and others, 1983) as well as from the Tatoosh Range (fig. 1). Threshold values are calculated to be equal to the mean plus two times the standard deviation of the data (Hawkes and Webb, 1962, p. 30). No data are available from the Stevens Ridge Formation. However, this unit is predominantly rhyodacitic ash-flow tuffs and volcaniclastic rocks, and is expected to have a chemical character similar to that of the Ohanapecosh Formation.

Values for most elements in most of the stream-sediment samples are below the threshold values given in table 5. Samples TW1003 and TW1004, from Summit and Clear Creeks, which drain an area to the east of the Tatoosh Range, show more anomalous values and have more sulfide minerals in the panned concentrates than do any of the samples from within the Tatoosh Roadless Area. Among the latter, only stream-sediment sample TW1005, from Backbone Ridge, showed values that were significantly above background for any elements, in this case nickel (100 ppm), cobalt (70 ppm) and vanadium (500 ppm). However, none of these elements were present in significant amounts in the panned concentrate (TW1005, table 3), indicating that the elevated values are not due to sulfide mineralization. Instead, they probably reflect a contribution from the swarm of basaltic dikes mapped near the crest of Backbone Ridge above sample locality TW1005 (figs. 2 and 3).

Analyses of panned concentrates do reveal minor indications of sulfide mineralization in the Tatoosh Range. Galena, pyrite, barite, and tourmaline were identified in the concentrates from drainages on both sides of the range. Collectively, these data (table 3) showed sporadic anomalous values for copper, arsenic, lead, tin, boron, barium, molybdenum, silver, and gold. Values for copper were generally low, the maximum being 150 ppm in sample TW1030, which also yielded the only detectable gold (20 ppm) and silver (3 ppm). Among panned-concentrate samples from streams that drain the four subareas of the study area, sample TW1009 (Butter Creek subarea) showed relatively high values for vanadium (500 ppm), tin (500 ppm) and arsenic (500 ppm), sample TW1010C (Butter Creek subarea) showed high lead (500 ppm), and sample TBT7 (Butter Peak subarea) contained high values of vanadium (300 ppm), boron (5,000 ppm) and barium (>10,000 ppm). However, analyses of samples of altered bedrock from these subareas (table 4) revealed no elements present at concentrations higher than threshold values.

MINING ACTIVITY

No mines or mining claims are known to exist in the Tatoosh Range or on Backbone Ridge, and no prospects were encountered during detailed geologic mapping in the four subarea of the Tatoosh Roadless Area. The closest mineral deposit is at the Eagle Peak mine, located about 3 mi northwest of the Johnson Creek subarea, along the east bank of the Nisqually River in Mount Rainier National Park (fig. 1). Huntting (1956, p. 61) provides a brief description of the deposit, which consists of a zone of mineralized joints in granodiorite of the Tatoosh pluton. Total production is reported to be less than 200 tons of ore; one 18-ton shipment assayed 8.05 percent copper, 0.09 oz per ton gold and 1.87 oz per ton silver, with 1 percent to 5 percent cobalt in some samples.

During this study, samples were collected from the Eagle Peak mine as an example of the type of mineralization that might be expected in the Tatoosh Range. Rock samples TW1040-A to TW1040-F (not shown on fig. 3), listed in table 4, were collected from the dump and adit. The dominant sulfide minerals present are pyrite, arsenopyrite, and chalcopyrite. The analyses show generally high concentrations of copper, arsenic, and cobalt. Some samples contain minor amounts of zinc, molybdenum, tungsten, silver, and tin as well. Ore from the Paradise mine, located on property adjoining the Eagle Peak mine, reportedly contained 10 percent copper (Huntting, 1956, p. 61). The adit to this mine could not be located.

MINERAL RESOURCE POTENTIAL

Geological and geochemical surveys indicate that the metallic mineral resource potential of all four subareas of the Tatoosh Roadless Area is low. The surveys show no potential for nonmetallic or energy resources in the area. Minor geochemical anomalies possibly attributable to sulfide mineralization were detected only in panned concentrates from the Butter Creek and Butter Peak subareas. Analyses of altered bedrock from these subareas failed to uncover a source for the anomalies, indicating that the sources are small and (or) are located in parts of the drainage basins outside of the subareas. No mining claims are known to exist in any of the subareas of the roadless area. The nearest mining activity is the Eagle Peak mine in Mount Rainier National Park, several miles northwest of the Johnson Creek subarea. The Eagle Peak mine, which may be representative of the type of deposit likely to be found in the Tatoosh Range, produced less than 200 tons of copper ore. This deposit, however, occurs in a coarse-grained phase of the Tatoosh pluton that is unlike any of the intrusive rocks found in the roadless area.

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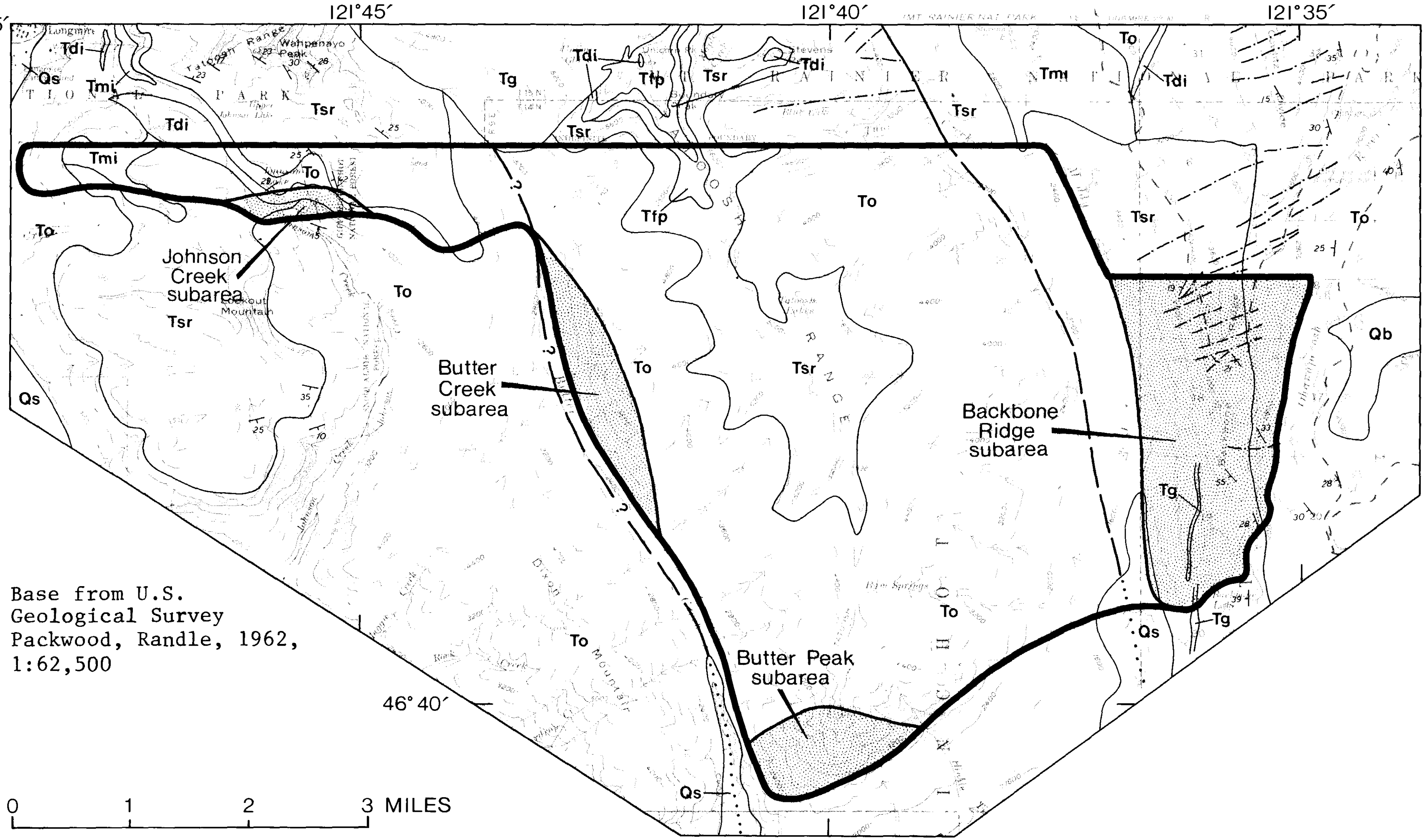
Motooka, J. M., and Grimes, D. J., 1976, Analytical precision of one-sixth order semiquantitative spectrographic analysis: U.S. Geological Survey Circular 738, 25 p.



Base from U.S. Geological Survey Packwood, Randle, 1962, 1:62,500

See following page for explanation.

Figure 2.--Geologic map of the southern Tatoosh Range and Tatoosh Roadless Area (A6063 and B6063). The four subareas (shaded) of the Tatoosh Roadless Area (B6063) are Backbone Ridge, Butter Peak, Butter Creek, and Johnson Creek. Geology modified from Fiske and others (1963) and Hammond (1980).

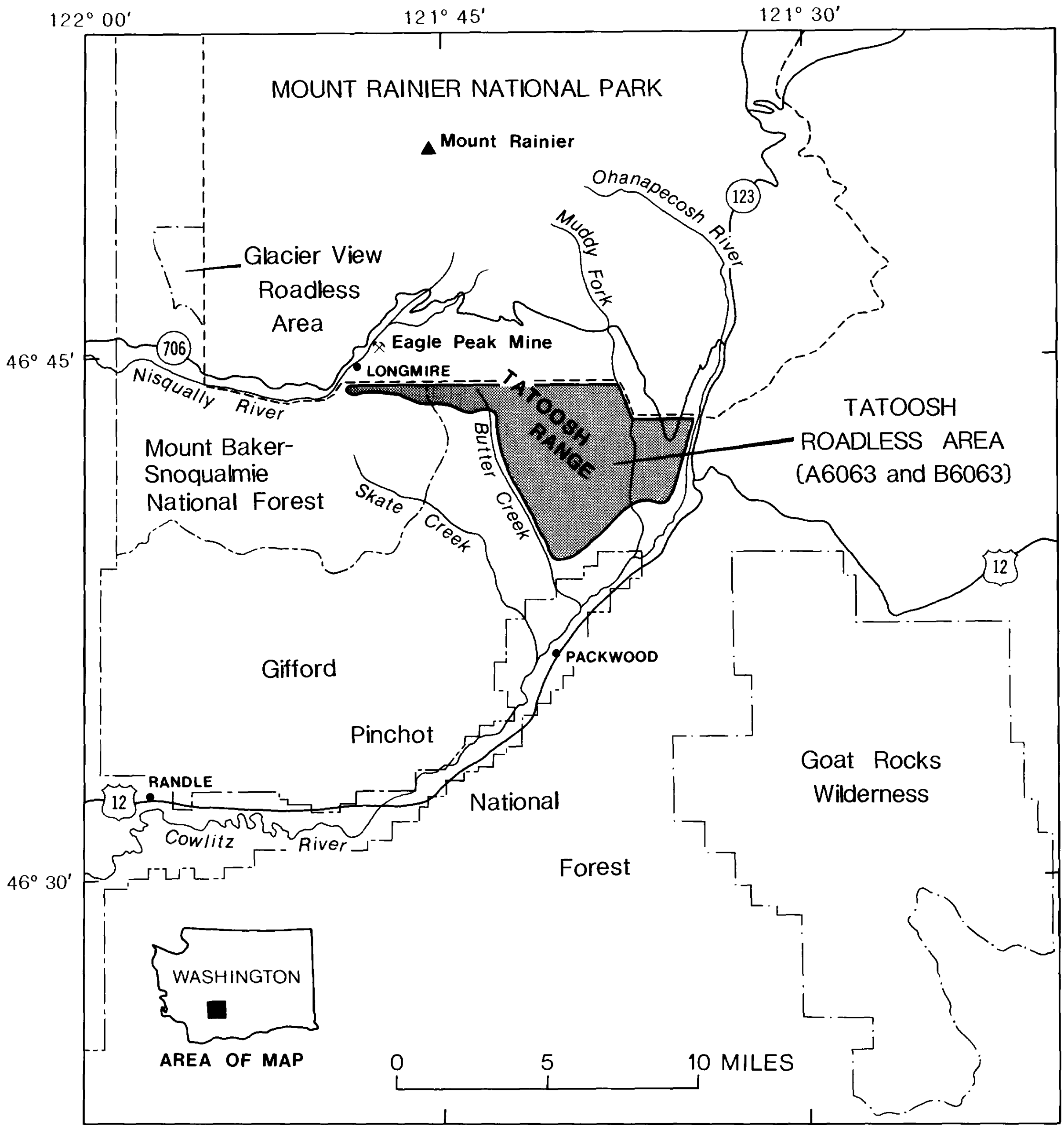
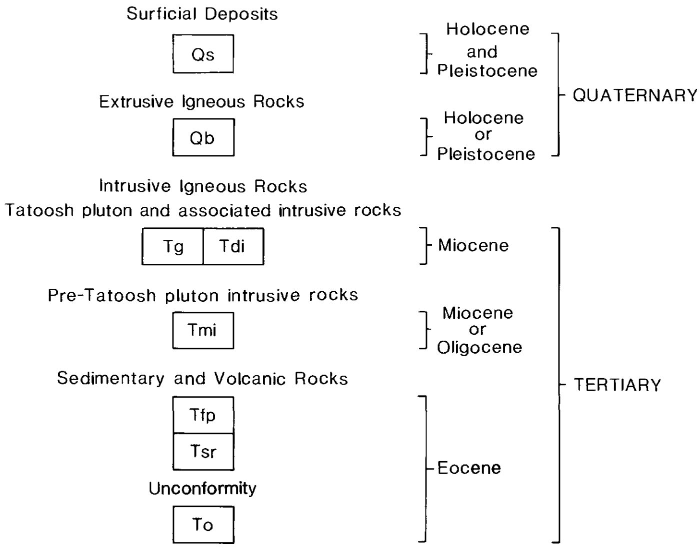


Figure 1.--Index map showing location of Tatoosh Roadless Area (A6063 and B6063) Lewis County, Washington.

EXPLANATION FOR FIGURE 2

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Surficial Deposits

Qs ALLUVIUM, GLACIAL DEPOSITS, AND MUDFLOW DEPOSITS (HOLOCENE AND PLEISTOCENE)--Unconsolidated alluvium, glacial deposits, and mudflow deposits

Extrusive Igneous Rocks

Qb BASALT (HOLOCENE OR PLEISTOCENE)--Olivine basalt lava flows east of Ohanapecosh River

Intrusive Igneous Rocks

Tatoosh pluton and associated intrusive rocks

Tg GRANODIORITE AND QUARTZ MONZONITE (MIOCENE)--Felsic phases of Tatoosh pluton between Wahpenayo and Unicorn Peaks, and sills on Backbone Ridge

Tdi DIORITE AND QUARTZ DIORITE (MIOCENE)--Sills, dikes, and small irregular intrusive bodies peripheral to southern margin of Tatoosh pluton

Pre-Tatoosh pluton intrusive rocks

Tmi MAFIC INTRUSIVE ROCKS (MIOCENE OR OLIGOCENE)--Diabase and basalt in dike swarms and larger sill complexes

Sedimentary and volcanic rocks

Tfp FIFES PEAK FORMATION (EOCENE)--Basalt, basaltic andesite, and andesite flows; minor rhyolite flows, and fine- to coarse-grained pyroclastic and epiclastic rocks

Tsr STEVENS RIDGE FORMATION (EOCENE)--Rhyodacitic ash flow tuff; subordinate fine- to coarse-grained epiclastic rocks

To OHANAPECOSH FORMATION (EOCENE)--Hetereogeneous assemblage of volcanic and volcaniclastic rocks including andesite and minor basalt and rhyolite flows and plugs, and fine- to coarse-grained pyroclastic and epiclastic rocks

CONTACT--Approximately located

?— ··· FAULT--Dashed where approximately located, queried where uncertain, dotted where concealed

25 STRIKE AND DIP OF BEDDING

MAFIC DIKE SWARM

APPROXIMATE BOUNDARY OF ROADLESS AREA

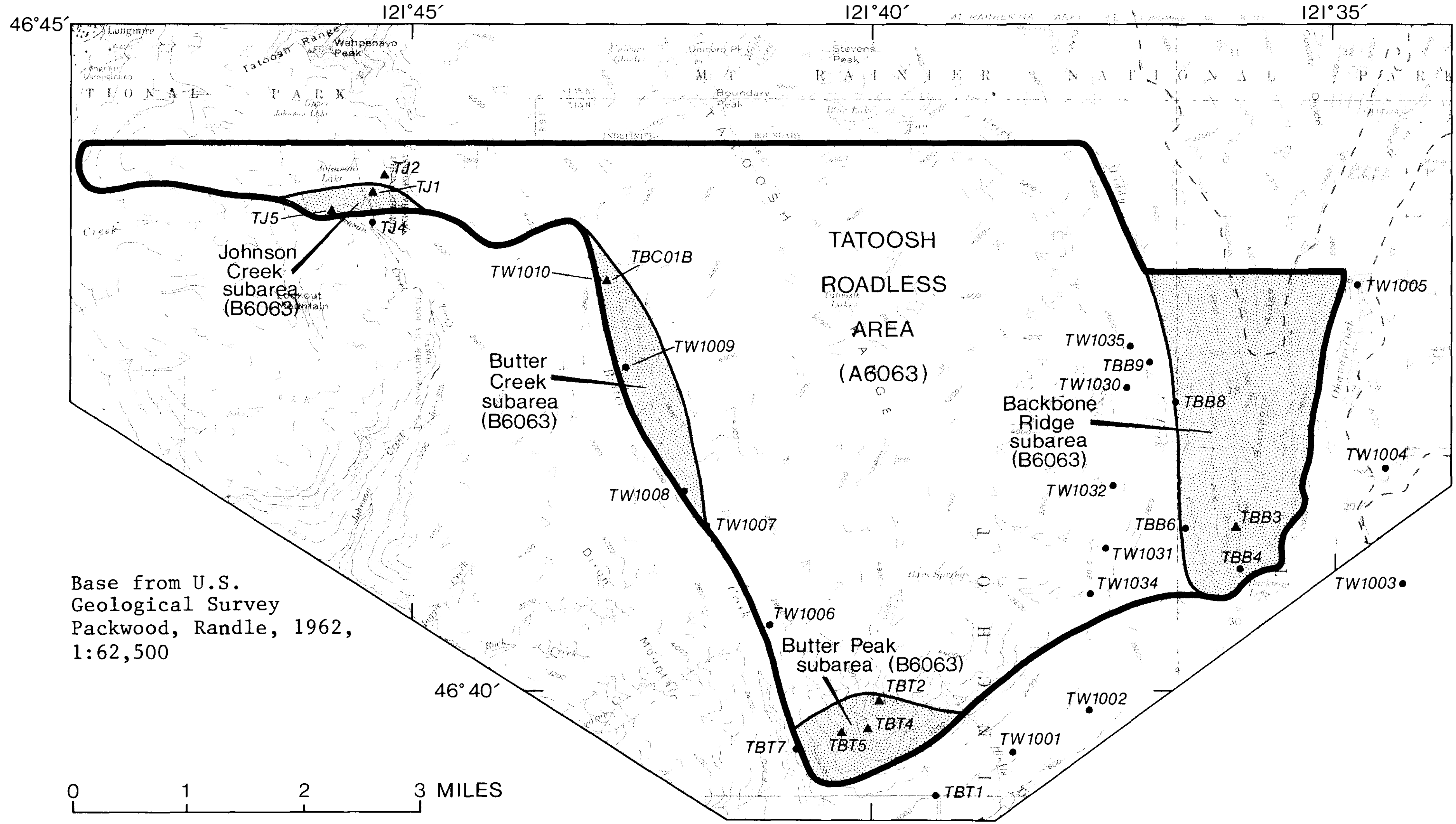


Figure 3.--Location of rock (triangles) and stream-sediment (dots) samples collected for geochemical survey of Tatoosh Roadless Area.

Table 1.--Lower limits of analytical determination for rock, stream-sediment and stream-sediment concentrate samples from Tatoosh Roadless Area
[Limits of determination of elements are in parts per million (ppm) except where noted. All analyses are by spectrographic methods; --, not analyzed]

Element	Determination limit rocks	Determination limit stream sediments	Determination limit stream sediment concentrates
Calcium (Ca)	0.05 percent	0.05 percent	0.1 percent
Iron (Fe)	.05 percent	.05 percent	.1 percent
Magnesium (Mg)	.02 percent	.02 percent	.05 percent
Titanium (Ti)	.002 percent	.002 percent	.005 percent
Silver (Ag)	.5	--	1
Arsenic (As)	200	--	500
Gold (Au)	--	--	20
Boron (B)	10	10	20
Barium (Ba)	20	20	50
Beryllium (Be)	1	1	2
Bismuth (Bi)	10	--	20
Cobalt (Co)	5	5	10
Chromium (Cr)	10	10	20
Copper (Cu)	5	5	10
Lanthanum (La)	20	--	50
Manganese (Mn)	10	10	20
Molybdenum (Mo)	5	--	10
Niobium (Nb)	20	--	50
Nickel (Ni)	5	5	10
Lead (Pb)	10	10	20
Scandium (Sc)	5	5	10
Tin (Sn)	10	--	20
Strontium (Sr)	100	100	200
Vanadium (V)	10	10	20
Tungsten (W)	50	--	100
Yttrium (Y)	10	10	20
Zinc (Zn)	200	--	--
Zirconium (Zr)	10	10	20

Table 2.--Results of spectrographic analyses of stream sediments from Tatoosh Roadless Ares
[Qualifying codes in analytical data are defined as follows: N, not detected; L, detected but below limits of analytical determination listed in table 1; G, detected, but above limits of analytical determinstion; pct, percent; ppm, parts per million; see table 1 for element names]

Sample	Latitude	Longitude	Ca-pct	Fe-pct	Mg-pct	Ti-pct	B-ppm	Ba-ppm	Be-ppm	Co-ppm	Cr-ppm
TW1001	46°39'31"	121°38'41"	2.0	10	1.5	G1.0	10	150	1.5	30	70
TW1002	46°39'52"	121°37'42"	2.0	10	1.5	1.0	10	150	1.5	30	70
TW1003	46°40'45"	121°34'22"	2.0	7	1.5	.7	20	300	1.5	30	200
TW1004	46°41'37"	121°34'30"	1.5	7	2.0	1.0	20	200	1.5	30	150
TW1005	46°43'05"	121°34'40"	2.0	10	2.0	G1.0	10	150	1.0	70	150
TW1006	46°40'30"	121°41'07"	2.0	7	1.5	.7	15	150	1.0	30	50
TW1007	46°41'15"	121°41'45"	1.5	10	1.5	1.0	10	150	1.5	30	70
TW1008	46°41'29"	121°42'06"	2.0	7	1.5	.7	10	200	1.5	30	50
TW1009	46°42'28"	121°42'40"	1.5	7	1.0	.7	10	200	1.5	20	50
TW1010	46°43'05"	121°43'00"	2.0	7	1.5	.7	10	200	1.5	20	100
TW1030	46°42'15"	121°37'15"	2.0	7	2.0	G1.0	20	300	2.0	20	70
TW1031	46°41'04"	121°37'30"	2.0	10	2.0	G1.0	10	300	2.0	30	70
TW1032	46°41'34"	121°37'25"	2.0	7	2.0	G1.0	10	200	1.5	20	50
TW1034	46°40'43"	121°37'40"	2.0	10	2.0	G1.0	10	300	2.0	30	100
TW1035	46°42'30"	121°37'08"	2.0	10	2.0	G1.0	15	300	1.5	30	70
TJ4	46°43'30"	121°45'25"	1.0	3	.7	.2	50	200	2.0	7	10
TBT1	46°39'00"	121°39'18"	1.5	7	1.5	.5	20	300	2.0	20	20
TBB4	46°40'48"	121°36'01"	1.0	3	.7	.2	15	200	1.5	7	N
TBB6	46°41'11"	121°36'34"	1.0	5	1.0	.2	15	200	2.0	10	20
TBT7	46°39'27"	121°40'56"	1.5	7	1.0	.5	70	500	2.0	20	20
TBB8	46°42'14"	121°36'55"	1.5	5	1.0	.3	10	200	2.0	20	30
TBB9	46°42'29"	121°35'58"	1.5	7	1.5	.5	10	200	1.5	30	30

Sample	Cu-ppm	Mn-ppm	Ni-ppm	Pb-ppm	Sc-ppm	Sr-ppm	V-ppm	Y-ppm	Zr-ppm
TW1001	50	1,500	50	L	20	300	300	30	150
TW1002	50	1,500	50	10	20	300	300	20	100
TW1003	50	1,000	70	10	20	300	200	20	150
TW1004	70	1,000	100	15	20	200	200	30	200
TW1005	50	1,500	100	10	20	200	500	30	150
TW1006	20	1,000	50	10	20	300	300	20	150
TW1007	30	1,000	50	10	20	200	300	20	200
TW1008	30	1,000	30	10	15	300	300	30	200
TW1009	30	1,000	30	15	20	200	200	30	200
TW1010	30	1,000	30	15	20	300	200	30	150
TW1030	100	1,500	20	10	20	300	200	20	100
TW1031	50	2,000	20	10	20	300	500	30	200
TW1032	30	1,500	15	L	15	500	200	15	100
TW1034	70	2,000	30	L	20	500	500	20	150
TW1035	50	2,000	20	10	20	500	300	20	150
TJ4	20	700	10	10	10	200	70	20	100
TBT1	50	1,000	30	15	15	500	100	20	150
TBB4	20	500	10	15	5	300	70	10	100
TBB6	30	700	20	15	10	300	100	20	100
TBT7	50	1,000	20	15	15	500	150	30	150
TBB8	20	1,000	20	10	15	300	150	20	100
TBB9	50	1,000	30	15	15	300	150	20	100

Table 3.--Results of spectrographic analyses of panned-concentrate samples from stream sediments, Tatoosh Roadless Area

[Qualifying codes in analytical data are defined as follows: N, not detected; L, detected, but below the limits of analytical determination listed in table 1; G, detected, but above the limits of analytical determination; ( ), maximum value, but more precise determination impossible due to spectral interference (Grimes and Marranzino, 1968); pct, percent; ppm, parts per million; see table 1 for element names]

Sample	Latitude	Longitude	Ca-pct	Fe-pct	Mg-pct	Ti-pct	Ag-ppm	As-ppm	Au-ppm	B-ppm	Ba-ppm	Be-ppm	Bi-ppm	Co-ppm
TW1001	46°39'31"	121°38'41"	3.0	3	.20	.7	N	N	N	50	1,000	N	N	10
TW1002	46°39'52"	121°37'42"	3.0	1	.20	.5	N	N	N	20	200	N	50	N
TW1003	46°40'45"	121°34'22"	3.0	10	3.00	2.0	N	N	N	20	10,000	N	N	100
TW1004	46°41'37"	121°34'30"	1.5	15	.20	G2.0	N	1,000	N	20	G10,000	N	N	70
TW1005	46°43'05"	121°34'40"	2.0	1	.15	.3	N	N	N	20	1,000	N	N	N
TW1006	46°40'30"	121°41'07"	3.0	2	.10	.2	N	N	N	20	700	N	N	N
TW1007	46°41'15"	121°41'45"	2.0	5	.30	G2.0	N	N	N	20	700	N	N	20
TW1008	46°41'29"	121°42'06"	2.0	7	.20	2.0	N	N	N	L	10,000	N	N	20
TW1009	46°42'28"	121°42'40"	2.0	5	.15	G2.0	N	500	N	30	700	5	N	20
TW1010	46°43'05"	121°37'03"	5.0	3	.10	G2.0	N	N	N	30	200	3	N	10
TW1030	46°42'15"	121°37'15"	5.0	3	.50	G2.0	3	N	20	100	200	2	N	N
TW1031	46°41'04"	121°37'30"	5.0	2	.50	.7	N	N	N	50	1,000		N	N
TW1032	46°41'34"	121°37'25"	5.0	3	1.50	G2.0	N	N	N	30	300	N	N	N
TW1034	46°40'43"	121°37'40"	5.0	2	.50	1.0	N	N	N	50	200	N	N	N
TW1035	46°42'30"	121°37'03"	5.0	2	.20	G2.0	N	N	N	150	500	N	N	10
TBB6	46°41'11"	121°36'34"	7.0	3	1.00	.7	N	N	N	L	300	N	N	10
TBT7	46°39'27"	121°40'56"	10.0	3	.70	G2.0	N	N	N	5,000	G10,000	3	N	N

Sample	Cr-ppm	Cu-ppm	La-ppm	Mn-ppm	Mo-ppm	Nb-ppm	Ni-ppm	Pb-ppm	Sc-ppm	Sr-ppm	Sn-ppm	V-ppm	W-ppm	Y-ppm	Zr-ppm
TW1001	30	30	N	200	N	N	N	N	N	700	N	70	N	50	G2,000
TW1002	N	10	N	150	N	N	N	N	N	700	N	50	N	20	G2,000
TW1003	1,000	200	200	1,000	100	70	200	200	(10)	300	N	200	N	200	G2,000
TW1004	50	200	100	500	N	70	70	200	(10)	700	N	100	200	200	G2,000
TW1005	N	20	N	150	N	N	N	N	N	500	N	20	N	70	G2,000
TW1006	N	50	N	100	N	N	N	N	N	700	N	N	N	100	G2,000
TW1007	30	30	N	200	N	50	10	200	(10)	500	N	150	N	70	G2,000
TW1008	20	50	N	150	N	N	15	50	(10)	700	100	100	N	70	G2,000
TW1009	50	70	N	200	N	100	N	50	(10)	300	500	500	N	200	G2,000
TW1010	70	30	50	200	N	50	N	500	(10)	300	N	200	N	100	G2,000
TW1030	N	150	50	200	N	N	N	L	20	700	N	100	N	150	G2,000
TW1031	N	50	N	200	N	N	N	N	10	700	N	50	N	150	G2,000
TW1032	30	50	50	500	N	N	N	L	30	700	N	70	N	200	G2,000
TW1034	N	100	N	150	L	N	N	N	10	700	N	50	N	70	G2,000
TW1035	N	20	N	150	N	50	N	L	15	700	N	100	N	50	G2,000
TBB6	150	15	70	500	N	N	20	N	20	700	N	100	N	200	G2,000
TBT7	70	50	500	500	N	100	15	50	(10)	1,000	N	300	N	500	G2,000

Table 4.--Results of spectrographic analyses of rock samples from Tatoosh Roadless Area and Eagle Peak mine
[Qualifying codes in analytical data are defined as follows: N, not detected; L, detected, but below the lower limits of analytical determination listed in table 1; G, detected, but above limis of analytical determination; pct, percent; ppm, parts per million; see table 1 for element names]

Sample	Latitude	Longitude	Ca-pct	Fe-pct	Mg-pct	Ti-pct	Ag-ppm	As-ppm	B-ppm	Ba-ppm	Be-ppm	Bi-ppm	Co-ppm	Cr-ppm
TBB3	46°41'12"	121°36'02"	2.0	5	1.00	.50	N	N	15	700	2.0	N	10	N
TBC01B	46°43'07"	121°42'56"	.5	2	.70	.15	N	N	20	700	2.0	N	5	N
TBT2	46°39'44"	121°39'51"	2.0	5	1.50	.50	N	N	15	500	2.0	N	20	50
TBT4	46°39'40"	121°40'04"	3.0	5	1.50	.50	N	N	10	200	1.5	N	20	N
TBT5	46°39'45"	121°40'16"	.2	2	.05	.10	N	N	50	700	2.0	N	N	N
TJ1	46°43'46"	121°45'29"	2.0	5	2.00	.50	N	N	20	500	2.0	N	30	100
TJ2	46°43'36"	121°45'49"	1.0	5	1.00	.30	N	N	100	150	2.0	N	15	N
TJ5	46°43'33"	121°45'50"	1.5	5	1.50	.20	N	N	30	200	1.5	N	10	10
TW1010-A	46°15'05"	121°43'00"	1.5	3	1.00	.30	N	N	L	700	2.0	N	10	20
TW1010-B	46°43'05"	121°43'00"	2.0	5	1.00	.50	N	N	20	1,000	2.0	N	15	15
TW1040-A*	46°15'53"	121°47'19"	3.0	10	5.00	.30	N	2,000	10	1,000	2.0	N	1,000	N
TW1040-B*	46°15'53"	121°47'19"	2.0	7	2.00	.50	N	300	15	700	2.0	10	20	N
TW1040-C*	46°15'53"	121°47'19"	.5	G20	.20	.10	10	5,000	N	1,000	N	50	700	N
TW1040-D*	46°15'53"	121°47'19"	1.0	7	1.00	1.00	L	N	20	1,500	2.0	N	30	20
TW1040-E*	46°15'53"	121°47'19"	1.5	15	1.00	.30	N	N	10	1,000	3.0	N	10	N
TW1040-F*	46°15'53"	121°47'19"	2.0	5	2.00	G1.00	N	1,000	15	2,000	N	N	30	50

Sample	Cu-ppm	La-ppm	Mn-ppm	Mo-ppm	Nb-ppm	Ni-ppm	Pb-ppm	Sc-ppm	Sn-ppm	Sr-ppm	V-ppm	W-ppm	Y-ppm	Zn-ppm	Zr-ppm
TBB3	20	30	1,000	N	N	5	L	15	N	200	100	N	30	N	150
TBC01B	7	30	500	N	N	5	10	5	N	100	50	N	30	N	200
TBT2	15	N	1,000	N	N	10	L	20	N	300	150	N	30	N	100
TBT4	50	N	700	N	N	7	L	15	N	500	100	N	30	N	100
TBT5	5	N	300	N	N	5	L	5	N	150	10	N	20	N	100
TJ1	50	N	1,000	N	N	50	10	20	N	300	150	N	30	N	150
TJ2	50	20	1,000	10	N	10	10	15	N	N	50	N	50	N	150
TJ5	7	20	1,000	N	N	5	N	7	N	150	70	N	20	N	70
TW1010-A	15	30	700	N	N	15	20	10	N	300	150	N	20	N	150
TW1010-B	L	20	1,000	N	N	10	10	20	N	300	200	N	50	N	200
TW1040-A*	7	N	1,000	5	N	10	10	20	N	200	100	N	30	N	150
TW1040-B*	1,000	20	2,000	N	N	N	10	20	N	200	100	N	50	N	300
TW1040-C*	20,000	50	500	N	N	30	15	10	N	100	20	N	15	200	70
TW1040-D*	1,500	20	700	N	N	15	20	30	N	200	200	N	30	N	150
TW1040-E*	100	20	700	N	N	N	L	10	20	200	100	50	20	N	200
TW1040-F*	100	30	1,500	N	20	20	L	30	N	100	500	N	50	N	150

*Samples from Eagle Peak mine; not on figure 3.

Table 5.--Mean, standard deviation, and threshold values for elements determined from a suite of typical rock sample of the Ohanapecosh Formation and Tatoosh pluton
[Pct, percent; ppm, parts per million; see table 1 for element names]

	Ca-pct	Fe-pct	Mg-pct	Ti-pct	B-ppm	Ba-ppm	Be-ppm	Co-ppm	Cr-ppm
Mean	1.84	5.6	1.18	0.51	24	452	1.86	21	60
Standard Deviation	±1.21	±2.24	±0.62	±0.26	±24	±340	±0.56	±12	±56
Threshold value	4.26	10.08	2.42	1.03	72	1,132	3	45	172
	Cu-ppm	**Mn-ppm**	**Ni-ppm**	**Pb-ppm**	**Sc-ppm**	**Sr-ppm**	**V-ppm**	**Y-ppm**	**Zr-ppm**
Mean	56	1,074	17	31	18	215	100	33	155
Standard Deviation	±48	±510	±15	±24	±10	±95	±60	±11	±55
Threshold value	152	2,094	47	79	38	405	220	55	265

*number of samples=15; see text for sources