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Geochemical analyses of rock samples from the Black Butte District and Holderman Mountain area, Lane County, Oregon

By

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INTRODUCTION

Rocks of the Western Cascade Range of Oregon host several types of mineral deposits including polymetallic vein, hot-spring mercury, epithermal precious-metal vein, and breccia-pipe copper deposits. Although detailed descriptive information about the mining districts and their deposits has long been published, understanding of the genesis of these deposits and their relation to Cascades arc magmatism is only beginning. A part of this understanding includes knowledge of the geochemical distribution of elements, particularly in altered rocks.

As part of a broader project on metallogenesis within the Cascades magmatic arc, I am investigating hydrothermal mineralization in the area of Black Butte and Holderman Mountain. The Black Butte district lies about 25 km south of Cottage Grove, Oreg., and Holderman Mountain is about 35 km southeast of Cottage Grove, directly west of the Bohemia Mining District (fig. 1). Polymetallic veins in the Bohemia district have been studied in much detail (see, for example, Callaghan and Buddington, 1938). Although less intensively studied, epithermal veins of the Black Butte district have also been described (Brooks, 1963, for example). Recent unpublished geological and geochemical reconnaissance studies by Weyerhaeuser Company between the Black Butte district and the western edge of the Bohemia District have revealed several hydrothermally altered areas, including the Holderman Mountain area where there are associated precious-metal concentrations. This paper presents chemical analyses and alteration mineralogy for 46 samples collected from the Black Butte District and Holderman Mountain area.

ACKNOWLDEGMENTS

Weyerhaeuser and Cone Lumber Companies kindly allowed me to collect rock samples on their respective timber lands. Without that access, this project would not have been possible. Kenneth R. Bishop of the U.S. Geological Survey in Menlo Park, Calif., performed x-ray diffraction analyses on hydrothermally altered samples to help me characterize their alteration mineralogy.

GEOLOGIC OVERVIEW

The Cascade Range in Oregon is composed primarily of Eocene to Holocene calc-alkaline volcanic and volcaniclastic rocks that formed in an arc setting related to subduction along the west margin of North America (Sherrod and Smith, 1989). The range in Oregon can be divided into two physiographic parts, the Western Cascades containing primarily deeply eroded older volcanoes and the High Cascades along the crest of the range containing young shield and stratovolcanoes for which original physiographic form is largely preserved. Known mineral deposits within the Cascade Range of Oregon are restricted to rocks of the Western Cascades, where base- and precious-metal deposits tend to cluster into well-defined districts from the Bohemia District northward and are present as isolated occurrences south of Bohemia (see Callaghan and Buddington, 1938). Rocks of the Western Cascades are characterized by thick but deeply eroded

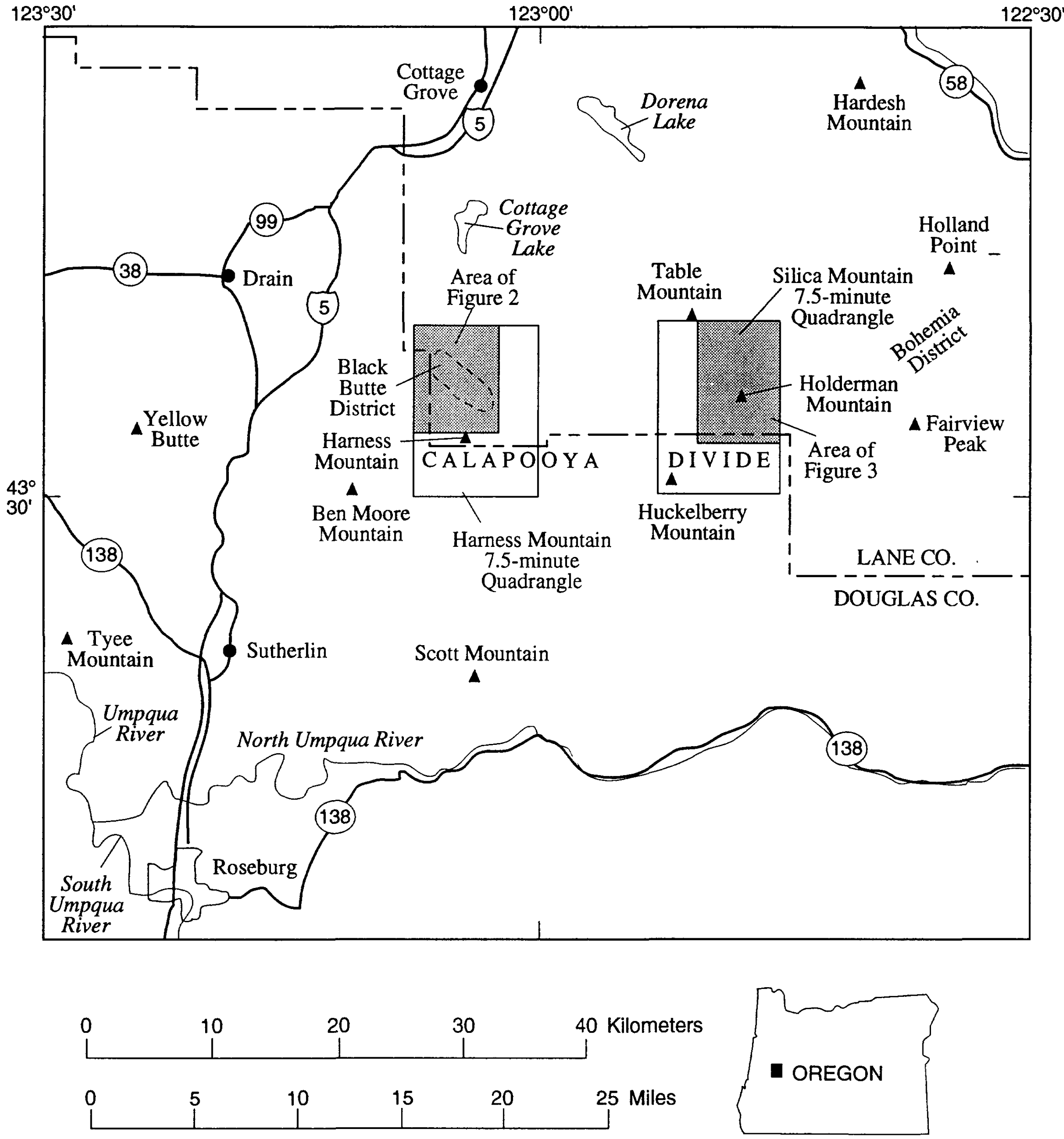

Figure 1. Index map showing location of the Black Butte district (fig. 2) and Holderman Mountain area (fig. 3), Lane County, Oregon.

sequences of subaerial volcaniclastic rocks and flows ranging in age from Eocene to Miocene and having generally andesitic compositions, although rocks of basaltic through dacitic compositions are common and rhyolites are present locally (Sherrod and Smith, 1989). Interbedded sedimentary rocks unrelated to volcanism constitute a minor component of the Western Cascades and small dioritic intrusions are widespread and commonly cluster in the larger mining districts. Because rocks of the Western Cascades formed from the eruption of numerous volcanic centers, there are literally hundreds of small overlapping and intertonguing units and very few distinctive laterally extensive marker beds (Sherrod and Smith; 1989), which makes unravelling the geology of the area very difficult; poor exposure and deep weathering in many parts of the region further obscure geologic relations. Many of the rocks have undergone regional metamorphism to zeolite-facies assemblages. More locally, contact metamorphism has altered rocks to a greenschist-facies assemblage that resembles the propylitic alteration commonly developed around mineralized areas; both are present in the study area.

Most base- and precious-metal occurrences in rocks of the Western Cascades are composed of pyrite or its oxidation products plus other sulfide minerals within quartz veins or shear zones, and typically contain gold with or without silver, lead, zinc, copper, and (or) antimony. Characteristics of many of these veins suggest that they are best classified as polymetallic vein deposits but veins in several districts may better be classified as epithermal based on the host rock, commodities present, and mineralogy (models: Mosier and others, 1986a, b; deposit descriptions: Mineral Resource Data System, 1990). Most veins in all the districts trend northwest to west and dip steeply (Callaghan and Buddington, 1938). The clustering of these deposits into discrete districts and the characteristics of many of the districts have led some researchers to propose that the major vein districts may be underlain by porphyry copper-type deposits (Power, 1984). Indeed, there is indication that a porphyry copper deposit underlies the North Santiam district (Diggles, 1991). High-grade breccia-pipe copper deposits like that recently discovered at the Bornite property in the North Santiam District (Hladky, 1993) are associated with several porphyry copper districts in the Cascade Range in both Oregon and Washington. Less common in rocks of the Western Cascades are mercury deposits. The main mercury districts are south of Cottage Grove to the California border and they generally lie west of the polymetallic/epithermal vein deposits, which may suggest a regional zonation. Characteristics of these mercury deposits indicate that they probably formed in a hot-spring setting (model: Rytuba, 1986; deposit descriptions: Mineral Resource Data System, 1990). Propylitic, argillic, and more localized silicic alteration accompany the mineral deposits within both the Holderman Mountain area and Black Butte mercury district and are present in other mineralized areas of the Cascades (R.P. Ashley and J.A. Peterson, field examinations, 1991).

Black Butte District

The Black Butte mercury district lies about 25 km south of Cottage Grove and about 32 km west of the Bohemia mining district on the north slope of the Calapooya Divide within the Harness Mountain 7.5-minute quadrangle (fig. 1). Two mines and several prospects are found in the district, most important being the Black Butte Mine (fig. 2) from which about 18,000 flasks of mercury was produced (Brooks, 1963). The Hobart Butte Mine has been exploited for high-alumina clay rather than for mercury, which is present as small quantities of cinnabar along with realgar and orpiment. Pits and trenches collectively known as the Woodward prospects can be found on Cinnabar Mountain and Little Baldy, and the Sullivan prospect is north of Dennis Creek. The host rocks of these mercury deposits are primarily andesitic pyroclastic rocks and interbedded flows of the upper part of the late Eocene to early Oligocene Fisher Formation (Derkey, 1973). Hobart Butte is underlain by pyroclastic rocks alone, whereas both flow and pyroclastic rocks are found on Black Butte and surrounding buttes. Tertiary dioritic intrusive rocks are present in the region but are not close to the deposits. Argillic alteration affected a broad area around the mercury deposits. Many of the argillically altered areas also contain dark brown replacement veinlets,

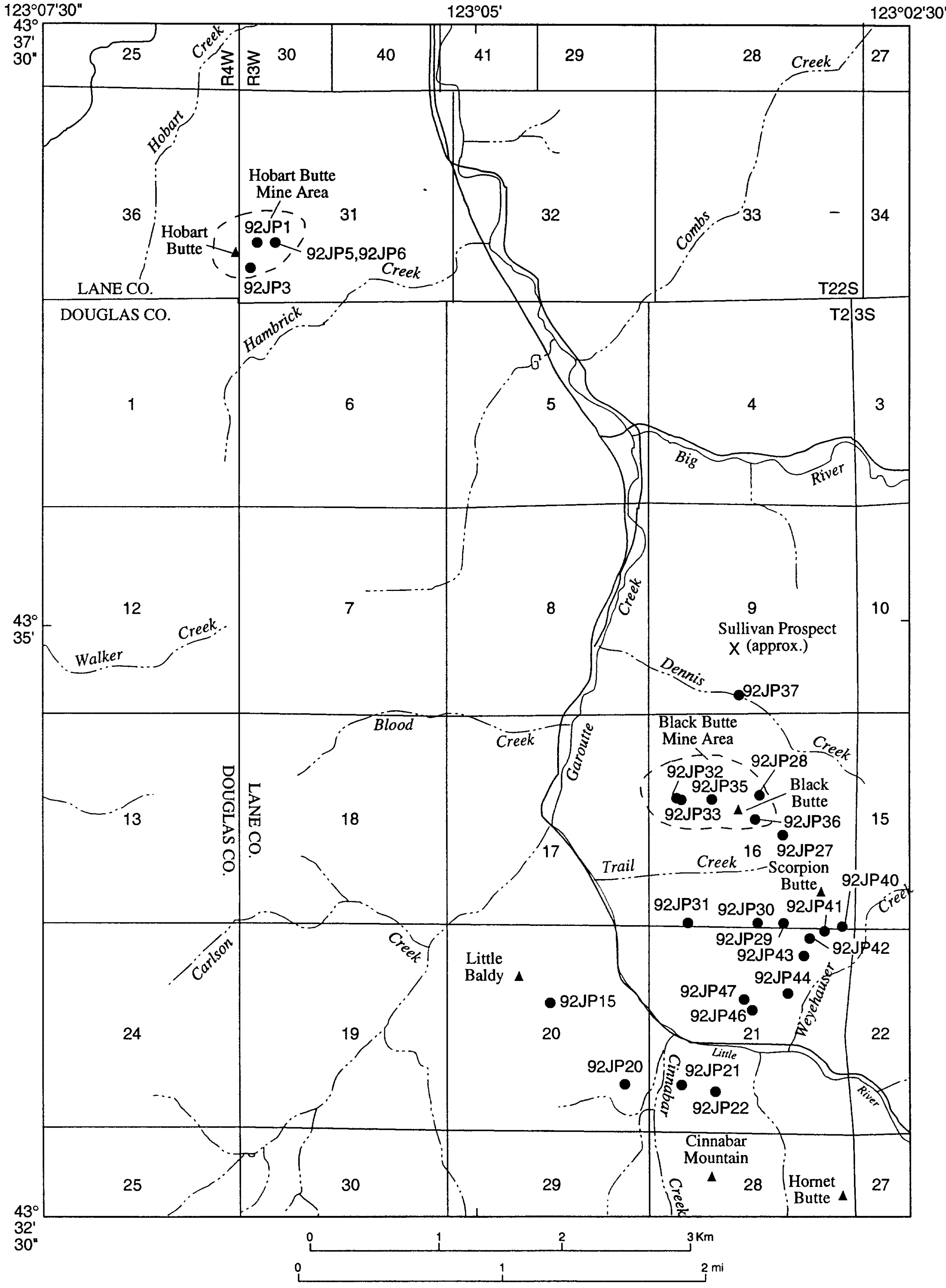

Figure 2. Map showing sample location for samples collected within the Black Butte District.

mostly less than 1 cm wide, composed of kaolinite, quartz, and iron oxide minerals. Locally, particularly south of the Black Butte Mine, silicified areas containing disseminated pyrite were found during this study. Within the mine area itself, areas altered to silica and calcite form resistant knobs referred to informally as silica ribs. In many cases alteration is so intense that it obscures the parent lithology of the altered rock. A normal fault striking approximately N. 70° W. and dipping about 58° NE. runs along the top of Black Butte, and numerous smaller subparallel faults extend away from the main fault (Brooks, 1963), but rocks of the region are not severely deformed and the complex interrelations of eruptive units often hampers the recognition of faults.

Holderman Mountain Area

The Holderman Mountain area lies directly west of the Bohemia District (fig. 1), largest and most productive of the districts in the Western Cascades of Oregon after the discovery of gold there in 1858. Both the Holderman Mountain area and the Bohemia District are underlain by rocks of the Little Butte Volcanic Series of Peck and others (1964) of Oligocene to Miocene age. These rocks are characterized by volcaniclastic and flow rocks primarily of andesitic compositions although basalts to rhyolites are also present. Holderman Mountain is underlain by several volcaniclastic rock units and by basaltic to andesitic flows, most of which have been altered to some degree. This sequence has been intruded by a basaltic plug, a rhyolitic dome and breccia, and a small dioritic stock, all within 1 km of the mineralized area. The top of Holderman Mountain was discovered to be mineralized several years ago by geologists working for Weyerhaeuser Co., and drilling and large-scale geologic mapping began there after the area was clear-cut. The surface manifestation of the mineralization includes altered pyroclastic rocks that are primarily argillized (kaolinite+quartz±illite) and locally silicified (quartz+K-feldspar±pyrite). Pyrite is present locally in a silicified and finely laminated, probably lake-bed, volcaniclastic deposit. In contrast, deposits in the Bohemia district are found within sulfide-bearing quartz veins. Tourmaline has been found within altered rocks in one locality about 1.6 km south of the mineralized area; it is too poorly exposed to adequately describe. Other silicified localities bearing disseminated pyrite have been found south of Holderman Mountain and intense propylitization characterizes some of the rocks within about 3.2 km of the mineralized area. As in the Black Butte district, many of the argillized areas contain dark-brown replacement veinlets composed of kaolinite, quartz, and iron oxides.

SAMPLE COLLECTION AND ANALYTICAL PROCEDURE

Most samples were collected from road cuts, quarries, or entrances to mines because natural outcrops are generally scarce and (or) deeply weathered. Figures 2 and 3 show the location of sample sites in the Black Butte district and Holderman Mountain area, respectively. All analyzed samples are of altered material, and an emphasis was placed on dark-brown replacement vein material. The appendix provides brief sample descriptions based on field observations and x-ray diffraction analyses. Whole-rock x-ray diffraction of samples containing replacement vein material indicates that they are composed primarily of quartz, kaolinite, and iron oxides. The argillically altered material in which the veins are generally found contains mostly kaolinite but some samples also contain minor amounts of illite, dolomite, sulfide minerals, or tourmaline. Although the replacement veins are present primarily in argillically altered rocks, some were also found in silicified rocks. Unaltered rock samples that were collected to aid in lithologic identification were not analyzed for trace elements.

All samples were crushed to less than 0.25 in. in a jaw crusher, split if necessary, and pulverized to 100 percent minus-80 mesh and 80 percent minus-100 mesh prior to analysis (Taylor, 1990). Each sample was analyzed for 40 elements by inductively coupled plasma-atomic emission spectrometry (ICP-AES) using a multiple-acid leach (Briggs, 1990); for selenium and

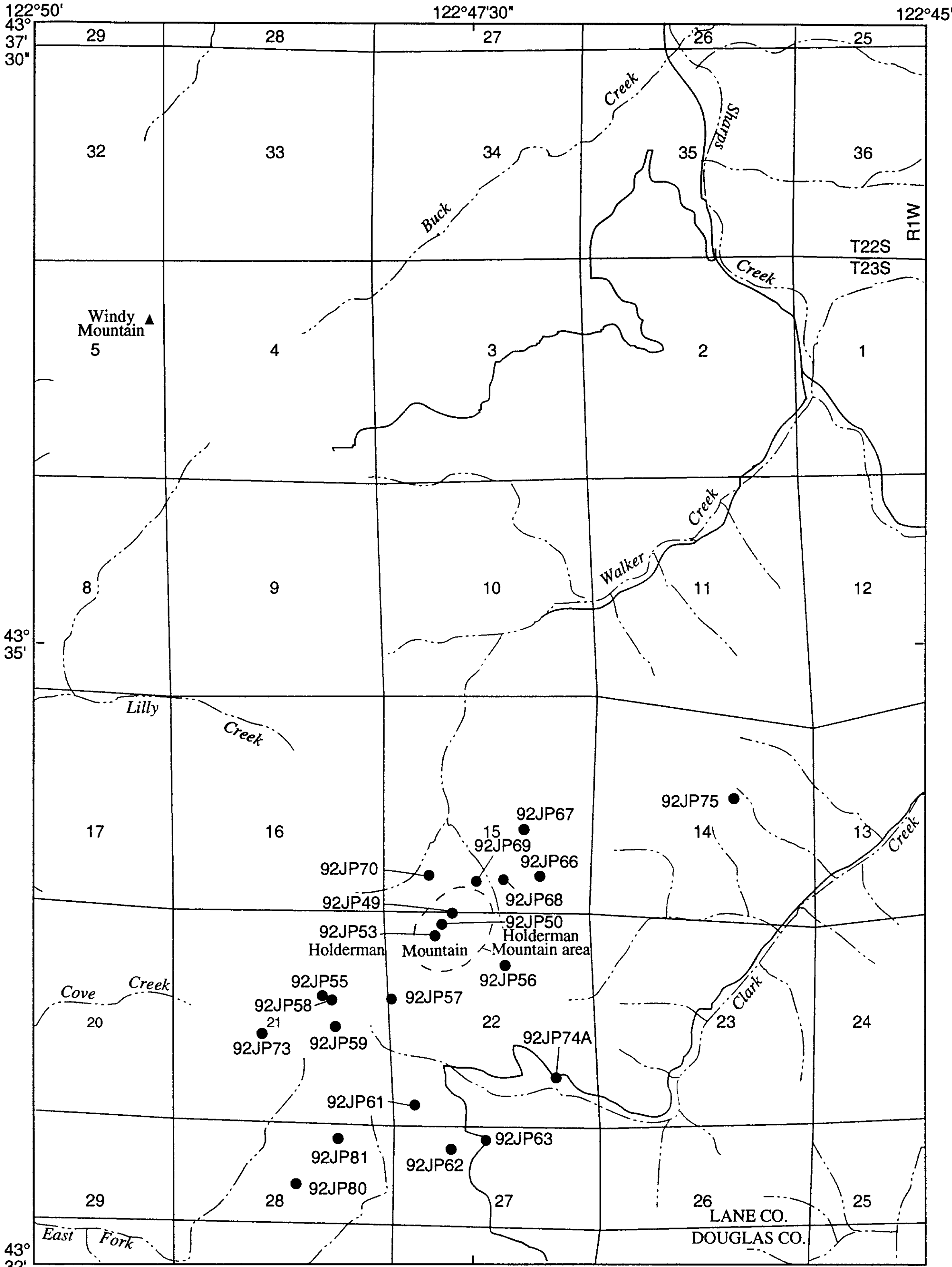

Figure 3. Map showing sample location for samples collected within the Holderman Mountain area.

arsenic by hydride generation atomic absorption spectrophotometry (Welsch and others, 1990; Crock and Lichte, 1982); for gold, tellurium, and thallium by flame atomic absorption spectrophotometry (O'Leary and Meier, 1990; O'Leary and Chao, 1990); and for mercury by continuous flow-cold vapor-atomic absorption spectrophotometry (O'Leary and others, 1990). Table 1 lists the lower limits of analytical determination for the elements analyzed. Sample analyses were performed by D.L. Fey, E.P. Welsch, D.J. Abrams, L.A. Bradley, and A.H. Love of the U.S. Geological Survey in Lakewood, Colo.

DATA

Table 2 lists the trace-element analyses of the 25 rock samples from the Black Butte District and the 21 rock samples from the Holderman Mountain area. Analyses for most of the elements are reported in parts per million, but Al, Ca, Fe, K, Mg, Na, P, and Ti are reported in percent. Au, Bi, Cd, Ho, Sn, Ta, and U, analyzed by the ICP-AES method, were not detected in any samples above their respective lower limits of analytical determination and are therefore not listed in table 2. Table 2 also lists the laboratory sample number, latitude and longitude, and the approximate percentage of the sample composed of dark-brown replacement vein material.

GENERAL OBSERVATIONS

Although the intent of this paper is not to interpret the data presented, some general observations can be made.

(1) In many cases the alteration products obscure the identity of the parent rock, but remnant textures and adjacent, less altered rocks suggest that more of the altered rocks were volcaniclastic rather than flows, probably due to a greater initial porosity of the volcaniclastic rocks.

(2) Dark-brown replacement veins are characteristically found in argillically altered rocks and may represent a more advanced alteration stage transitional to silicic alteration. Some areas around Black Butte clearly show unaltered rock grading into argillically altered rocks, which in turn grade into replacement veins, but some replacement veins are found within silicically altered rocks.

(3) Replacement veins, although present in both the Black Butte District and Holderman Mountain area, seem to be more prevalent in and around the mercury deposits.

(4) Without the benefit of rigorous statistical analysis, it appears that concentrations of As, Cr, Cu, Sr, V, Tl, and Hg are higher in the Black Butte District, whereas Ba and Au have higher concentrations around Holderman Mountain. The differences in Cr and V are attributed to higher Cr and V in the host rocks of the Black Butte area because these elements typically are not concentrated in epithermal processes.

(5) Similarly, without rigorous statistical analyses, in the Black Butte District, with the exception of the two samples collected in the pit at Hobart Butte, the samples containing a large proportion of replacement vein material ($\geq$50%) tend to have higher concentrations of As, Cu, Zn, and Tl than samples with a small proportion of vein material (<50%). Pb appears to be about the same in both kinds of samples and Ba is more abundant in samples with less vein material. It is more difficult to draw conclusions about the Holderman Mountain area because only three samples contain a large proportion of vein material. Based on this small sample size, samples with much vein material have higher concentrations of Zn and Hg, whereas samples containing less vein material have higher values for As, Ba, Pb, and Tl. Cu appears to be about the same in both types of samples.

Table 1. List of elements analyzed, analytical method used, and lower limits of alaytical determination.

[*, element not detected above lower determination limit; ICP-AES, inductively coupled plasma-atomic emission spectrometry; HG-AA, hydride generation-atomic absorption spectrophotometry; FAA, flame atomic absorption spectrophotometry; CV-AA, cold vapor-atomic absorption spectrophotometry]

Element	Analytical method	Lower limit of determination	Element	Analytical method	Lower limit of determination
Al	ICP-AES	0.005 %	La	ICP-AES	2 ppm
Ca	ICP-AES	0.005 %	Li	ICP-AES	2 ppm
Fe	ICP-AES	0.02 %	Mo	ICP-AES	2 ppm
K	ICP-AES	0.01 %	Nb	ICP-AES	4 ppm
Mg	ICP-AES	0.005 %	Nd	ICP-AES	4 ppm
Na	ICP-AES	0.006 %	Ni	ICP-AES	3 ppm
P	ICP-AES	0.005 %	Pb	ICP-AES	4 ppm
Ti	ICP-AES	0.005 %	Sc	ICP-AES	2 ppm
Mn	ICP-AES	4 ppm	Sn*	ICP-AES	5 ppm
Ag	ICP-AES	2 ppm	Sr	ICP-AES	2 ppm
As	ICP-AES	10 ppm	Ta*	ICP-AES	40 ppm
Au*	ICP-AES	8 ppm	Th	ICP-AES	6 ppm
Ba	ICP-AES	1 ppm	U*	ICP-AES	100 ppm
Be	ICP-AES	1 ppm	V	ICP-AES	1 ppm
Bi*	ICP-AES	10 ppm	Y	ICP-AES	2 ppm
Cd*	ICP-AES	2 ppm	Yb	ICP-AES	1 ppm
Ce	ICP-AES	5 ppm	Zn	ICP-AES	2 ppm
Co	ICP-AES	2 ppm	As	HG-AA	0.2 ppm
Cr	ICP-AES	1 ppm	Se	HG-AA	0.2 ppm
Cu	ICP-AES	2 ppm	Au	FAA	0.05 ppm
Eu	ICP-AES	2 ppm	Te	FAA	0.1 ppm
Ga	ICP-AES	4 ppm	Tl	FAA	0.05 ppm
Ho*	ICP-AES	4 ppm	Hg	CV-AA	0.02 ppm

Table 2. Results of geochemical analyses of rock samples collected from the Black Butte District and the Holderman Mountain area, Lane County, Oregon. All analyses by atomic emission spectrometry methods except As through Hg by various atomic absorption spectrophotometry methods

[N, not detected at limit indicated; B, not analyzed; H, interference]

Sample number	Lab number	Latitude	Longitude	Percent repl. veins	Al (%)	Ca (%)	Fe (%)	K (%)	Mg (%)	Na (%)	P (%)	Ti (%)	Mn (ppm)	Ag (ppm)	As (ppm)	Ba (ppm)	Be (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)
										Black Butte District											
92JP1A	D-528272	43°36'36"	123°06'16"	2	14.	0.02	1.6	0.02	0.01	0.01	0.12	1.5	10	<2	650	52	<1	110	<1	75	25
92JP1B	D-528273	43°36'36"	123°06'16"	90	10.	.008	18.	.01	.006	.005	.47	1.2	110	<2	1,100	18	4	59	8	51	77
92JP3	D-528274	43°36'30"	123°06'18"	1	18.	.02	.46	.02	.006	.007	.14	1.6	<4	<2	360	19	1	96	<1	60	2
92JP5	D-528275	43°36'36"	123°06'10"	0	16.	.008	1.4	<.01	<.005	.006	.03	1.3	<4	<2	53,000	110	1	130	9	58	98
92JP6	D-528276	43°36'36"	123°06'10"	0	14.	.01	.53	<.01	<.005	.006	.08	.25	<4	<2	100,000	26	1	62	<1	17	23
92JP15	D-528277	43°33'24"	123°04'34"	0	8.5	3.0	2.2	1.0	.39	2.2	.09	.49	280	<2	180	320	1	44	13	42	110
92JP20A	D-528278	43°33'04"	123°04'08"	2	10.	.04	5.0	.09	.03	.05	.07	.73	170	<2	390	36	2	31	9	220	39
92JP20B	D-528279	43°33'04"	123°04'08"	90	6.3	.02	24.	.06	.02	.03	.24	.47	700	<2	620	35	7	55	41	220	140
92JP21	D-528280	43°33'03"	123°03'48"	3	11.	.02	8.1	.09	.04	.02	.11	.75	370	<2	74	21	1	55	21	15	120
92JP22A	D-528281	43°33'01"	123°03'37"	1	11.	.02	1.7	.87	.11	.02	.07	.43	32	<2	75	77	1	35	3	84	75
92JP22B	D-528282	43°33'01"	123°03'37"	60	7.3	.009	17.	.61	.08	.01	.28	.29	780	<2	350	74	6	33	56	110	350
92JP27	D-528283	43°34'06"	123°03'13"	75	10.	.008	15.	.11	.02	.02	.12	.77	830	<2	74	47	2	96	28	25	52
92JP28	D-528284	43°34'16"	123°03'20"	80	6.6	.01	8.9	.04	.01	.02	.06	.32	280	<2	300	55	1	72	4	2	14
92JP29	D-528285	43°33'44"	123°03'12"	40	7.6	.03	11.	.04	.02	.02	.06	.44	390	<2	220	42	1	31	16	55	140
92JP30	D-528286	43°33'45"	123°03'21"	0	8.1	3.8	2.7	.10	1.5	.03	.06	.25	1,600	<2	130	19	<1	29	13	58	99
92JP31	D-528287	43°33'45"	123°03'45"	98	5.9	.04	27.	.02	.02	.01	.09	.30	570	<2	130	29	2	25	52	70	250
92JP31	D-528300	43°33'45"	123°03'45"	98	6.3	.02	24.	.03	.02	.01	.13	.44	760	<2	52	42	3	28	42	81	65
92JP32	D-528288	43°34'15"	123°03'49"	50	5.6	.02	12.	.02	<.005	.01	.04	.30	290	<2	270	28	2	21	18	75	87
92JP33	D-528289	43°34'15"	123°03'48"	0	12.	.03	3.4	.03	.02	.02	.05	.71	9	<2	43	48	<1	76	1	240	9
92JP35	D-528290	43°34'15"	123°03'37"	10	9.0	.008	11.	.03	.005	.01	.06	.62	19	<2	51	54	<1	69	3	110	110
92JP36	D-528291	43°34'10"	123°03'22"	85	6.5	.02	11.	.02	.005	.01	.23	.34	23	<2	950	30	1	37	4	56	230
92JP37	D-528292	43°34'41"	123°03'28"	30	12.	.06	5.0	.03	.01	.02	.08	.83	280	<2	180	35	1	37	23	53	190
92JP40	D-528293	43°33'43"	123°02'52"	35	6.0	.05	9.6	.03	.03	.02	.13	.49	410	<2	140	34	2	41	5	25	29
92JP41	D-528294	43°33'43"	123°02'58"	50	8.3	.07	12.	.07	.05	.02	.09	.44	1,700	<2	350	120	2	41	39	48	120
92JP42	D-528295	43°33'40"	123°03'03"	98	8.1	.05	10.	.10	.06	.02	.06	.30	2,600	<2	260	130	1	45	12	26	79
92JP43	D-528296	43°33'36"	123°03'05"	0	7.7	5.7	5.4	.32	1.90	.03	.06	.27	1,100	<2	190	61	<1	24	25	67	40
92JP44	D-528297	43°33'26"	123°03'12"	60	8.4	.10	7.0	.11	.07	.02	.05	.49	1,900	<2	82	91	1	39	60	92	120
92JP46	D-528298	43°33'22"	123°03'23"	0	8.3	6.2	4.8	.68	2.3	1.3	.07	.37	1,100	<2	37	1,100	<1	27	21	73	100
92JP47	D-528299	43°33'25"	123°03'26"	3	9.1	.04	5.1	.83	.13	.02	.05	.41	39	<2	170	120	<1	25	2	50	68

Table 2. Results of geochemical analyses of rock samples collected from the Black Butte District and the Holderman Mountain area, Lane County, Oregon—Continued

Sample number	Lab number	Latitude	Longitude	Percent repl. veins	Al (%)	Ca (%)	Fe (%)	K (%)	Mg (%)	Na (%)	P (%)	Ti (%)	Mn (ppm)	Ag (ppm)	As (ppm)	Ba (ppm)	Be (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)
Holderman Mountain area—Continued																					
92JP49	D-528301	43°33'55"	122°47'37"	0	5.4	.03	1.1	4.5	.09	.06	.02	.35	36	<2	170	300	<1	41	<1	12	6
92JP49	D-528322	43°33'55"	122°47'37"	0	4.8	.03	1.4	4.1	.07	.05	.02	.34	30	<2	160	260	<1	36	<1	10	4
92JP50	D-528302	43°33'52"	122°47'40"	0	3.4	.03	2.6	3.9	.05	.04	.01	.24	79	<2	110	260	<1	26	2	4	9
92JP53	D-528303	43°33'49"	122°47'43"	7	3.9	.03	3.1	2.2	.03	.03	.02	.07	220	<2	110	150	<1	32	3	3	6
92JP55	D-528304	43°33'35"	122°48'21"	3	7.9	.07	5.2	1.1	.09	.05	.11	.79	96	<2	220	110	1	29	3	1	19
92JP56	D-528305	43°33'42"	122°47'19"	0	3.1	.03	2.5	.63	.06	.02	.03	.19	65	4	140	51	<1	24	2	4	21
92JP57	D-528306	43°33'34"	122°47'57"	0	7.3	.03	3.9	2.8	.18	.07	.05	.31	78	<2	44	240	1	28	<1	13	16
92JP58	D-528307	43°33'34"	122°48'18"	0	6.8	.03	1.4	.28	.03	.08	.09	.13	20	<2	130	330	<1	46	<1	3	11
92JP59	D-528308	43°33'28"	122°48'15"	80	6.8	.06	14.	.09	.02	.03	.23	.60	2,600	<2	39	110	2	52	41	<1	17
92JP61	D-528309	43°33'09"	122°47'49"	2	7.4	.05	5.5	2.4	.15	.05	.06	.18	690	<2	<10	940	2	79	9	4	28
92JP62	D-528310	43°32'57"	122°47'38"	10	7.9	.21	2.7	1.4	.07	2.6	.09	.54	430	<2	<10	430	1	45	7	9	20
92JP63	D-528311	43°33'00"	122°47'25"	2	7.1	.05	3.9	1.8	.13	.06	.14	.49	200	<2	<10	480	2	55	2	<1	4
92JP66	D-528312	43°34'04"	122°47'08"	0	7.1	.48	3.4	2.0	.49	1.8	.07	.33	670	<2	120	130	1	54	6	<1	16
92JP67	D-528313	43°34'16"	122°47'13"	50	6.0	.18	12.	.04	.05	.02	.19	.58	1,100	<2	37	63	2	41	36	39	44
92JP68	D-528314	43°34'02"	122°47'20"	1	6.2	.17	2.1	1.3	.18	.05	.07	.29	310	<2	110	230	1	35	6	1	21
92JP69	D-528315	43°34'03"	122°47'30"	0	7.5	2.7	3.3	1.8	.76	2.0	.06	.25	790	<2	<10	450	1	48	10	11	23
92JP70	D-528316	43°34'04"	122°47'40"	?	8.1	.98	3.4	1.2	.40	2.9	.08	.20	720	<2	17	450	1	49	6	5	32
92JP73	D-528317	43°33'26"	122°48'41"	40	5.7	.04	17.	.68	.07	.03	.22	.53	1,900	<2	180	170	3	36	62	11	120
92JP74A	D-528318	43°33'48"	122°47'01"	0	7.4	.11	2.1	2.9	.14	2.8	.05	.16	37	<2	71	400	<1	29	2	<1	4
92JP75	D-528319	43°34'22"	122°46'01"	25	6.8	.02	12.	2.3	.17	.05	.19	.14	540	<2	100	780	4	52	19	<1	19
92JP80	D-528320	43°32'49"	122°48'30"	30	6.4	.01	11.	2.3	.14	.04	.14	.14	130	<2	99	240	3	65	3	4	76
92JP81	D-528321	43°33'00"	122°48'15"	60	5.7	.05	14.	.34	.02	.04	.22	.33	530	<2	<10	120	3	32	13	2	27

Table 2. Results of geochemical analyses of rock samples collected from the Black Butte District and the Holderman Mountain area, Lane County, Oregon—Continued

Sample number	Eu (ppm)	Ga (ppm)	La (ppm)	Li (ppm)	Mo (ppm)	Nb (ppm)	Nd (ppm)	Ni (ppm)	Pb (ppm)	Sc (ppm)	Sr (ppm)	Th (ppm)	V (ppm)	Y (ppm)	Yb (ppm)	Zn (ppm)	As (ppm)	Se (ppm)	Au (ppm)	Te (ppm)	Tl (ppm)	Hg (ppm)
Black Butte District																						
92JP1A	3	38	50	21	<2	28	57	<2	12	16	80	4	220	19	2	2	B	<0.1	N0.05	<0.05	0.10	2.1
92JP1B	2	23	24	16	<2	19	34	13	<4	34	48	6	290	31	5	300	B	.1	N.05	<.05	.70	5.7
92JP3	3	47	45	20	<2	29	50	<2	15	24	440	<4	430	19	2	<2	B	<.1	N.05	.05	.15	0.9
92JP5	3	44	56	49	<2	32	65	4	12	18	66	6	190	15	2	60	B	H	N.05	<.05	55.	180.
92JP6	2	37	29	24	<2	11	41	<2	14	26	170	<4	190	35	2	7	B	H	N.05	.05	2.8	16.
92JP15	<2	18	23	9	<2	13	21	15	5	12	340	<4	110	14	2	29	B	<.1	N.05	.05	.10	.2
92JP20A	<2	21	15	15	<2	9	13	38	4	42	87	<4	300	12	1	80	B	<.1	N.05	<.05	.30	.18
92JP20B	4	13	23	10	<2	4	40	73	<4	110	60	4	520	46	5	260	B	<.1	N.05	<.05	1.3	.35
92JP21	<2	23	29	24	<2	13	30	14	<4	22	520	<4	160	13	<1	130	B	<.1	N.05	<.05	.10	8.5
92JP22A	<2	20	17	39	<2	10	16	28	6	23	42	<4	210	13	<1	18	B	.1	N.05	<.05	.45	14.
92JP22B	<2	12	16	27	<2	6	15	29	<4	32	34	<4	230	23	4	100	B	.3	N.05	<.05	1.5	76.
92JP27	3	25	42	45	<2	21	50	34	<4	23	620	7	78	26	3	260	B	<.1	N.05	<.05	.60	.9
92JP28	2	15	37	32	<2	13	42	3	<4	26	710	4	28	31	2	87	B	<.1	N.05	<.05	.40	.9
92JP29	<2	11	23	32	<2	9	18	23	4	22	30	<4	170	18	1	130	B	.5	N:05	<.05	.20	21.
92JP30	<2	19	17	31	<2	8	13	20	5	11	220	<4	98	9	<1	160	B	1.2	N.05	<.05	.15	1.5
92JP31	<2	13	11	22	<2	4	14	84	<4	40	170	5	240	44	3	220	B	<.1	N.05	<.05	1.2	25.
92JP31	<2	12	12	23	<2	7	16	71	<4	51	280	4	250	48	4	200	B	.1	N.05	<.05	.75	8.
92JP32	<2	8	13	17	31	7	8	22	<4	15	73	<4	77	14	2	150	B	.2	N.05	<.05	.45	6.3
92JP33	<2	25	42	38	<2	14	36	12	9	10	510	<4	170	4	<1	4	B	<.1	N.05	<.05	.35	13.
92JP35	<2	17	19	22	<2	11	23	14	<4	25	660	5	170	4	<1	22	B	<.1	N.05	<.05	.20	59.
92JP36	<2	10	20	28	<2	6	17	5	5	27	260	<4	270	7	1	51	B	<.1	N.05	<.05	.25	39.
92JP37	<2	24	16	76	<2	13	19	20	6	19	280	<4	250	9	1	47	B	<.1	N.05	<.05	.15	130.
92JP40	<2	13	22	44	<2	13	27	10	<4	17	320	4	44	18	2	74	B	<.1	N.05	<.05	.20	4.
92JP41	<2	16	28	90	<2	10	26	31	10	21	38	<4	180	28	2	160	B	.1	N.05	<.05	.40	33.
92JP42	<2	17	23	36	<2	9	21	13	55	14	28	<4	98	14	1	270	B	.3	N.05	<.05	.35	5.3
92JP43	<2	17	12	28	<2	7	12	33	<4	17	300	<4	170	10	<1	39	B	.5	N.05	<.05	.25	3.1
92JP44	<2	17	10	44	<2	10	8	47	<4	22	55	<4	160	11	2	73	B	<.1	N.05	<.05	.40	3.4
92JP46	<2	17	15	24	<2	11	12	24	<4	15	560	<4	140	9	<1	63	B	<.1	N.05	<.05	.20	.35
92JP47	<2	19	16	29	<2	10	9	3	7	15	150	<4	200	5	<1	23	B	6.7	N.05	1.45	.30	4.9

Table 2. Results of geochemical analyses of rock samples collected from the Black Butte District and the Holderman Mountain area, Lane County, Oregon—Continued

Sample number	Eu (ppm)	Ga (ppm)	La (ppm)	Li (ppm)	Mo (ppm)	Nb (ppm)	Nd (ppm)	Ni (ppm)	Pb (ppm)	Sc (ppm)	Sr (ppm)	Th (ppm)	V (ppm)	Y (ppm)	Yb (ppm)	Zn (ppm)	As (ppm)	Se (ppm)	Au (ppm)	Te (ppm)	Tl (ppm)	Hg (ppm)
Holderman Mountain area																						
92JP49	<2	12	22	34	6	10	15	<2	7	11	140	<4	57	8	<1	3	B	1.2	.022	<.05	1.9	.04
92JP49	<2	11	18	38	14	9	14	<2	7	9	130	<4	47	9	<1	4	B	1.1	.016	<.05	1.7	.05
92JP50	<2	<4	12	61	<2	6	13	<2	7	7	52	<4	34	6	<1	3	B	1.1	.004	<.05	1.7	.05
92JP53	<2	4	17	55	<2	4	17	<2	5	4	27	<4	48	7	<1	67	B	<.1	N.002	<.05	.90	.04
92JP55	<2	18	16	87	<2	11	12	<2	22	20	61	<4	130	11	<1	50	B	.7	.004	<.05	.55	2.
92JP56	<2	5	12	58	<2	6	12	<2	9	8	18	<4	8	6	<1	27	B	4.5	.10	<.05	.35	.23
92JP57	<2	21	13	13	<2	12	13	<2	4	16	65	<4	59	6	<1	41	B	.9	N.002	1.1	.85	.9
92JP58	<2	12	24	110	<2	6	27	<2	9	8	1,200	<4	16	8	<1	18	B	.9	<.002	.10	.20	1.1
92JP59	2	17	21	120	<2	9	29	<2	7	28	39	<4	120	33	3	230	B	<.1	N.002	<.05	.95	2.3
92JP61	<2	18	37	29	<2	7	36	2	22	13	16	5	41	25	2	140	10	.3	N.002	<.05	.85	.4
92JP62	<2	19	15	40	2	12	17	<2	4	15	170	<4	57	13	1	19	5.6	<.1	N.002	<.05	.75	.09
92JP63	<2	15	30	100	<2	13	30	<2	11	20	27	<4	19	29	2	52	10	<.1	N.002	<.05	.90	.57
92JP66	<2	19	25	19	<2	14	26	<2	5	12	110	<4	19	16	1	76	B	.2	.008	<.05	.55	.24
92JP67	<2	10	18	140	<2	6	23	10	5	63	34	<4	280	18	1	430	B	<.1	<:002	<.05	.30	1.8
92JP68	<2	16	18	82	<2	11	19	3	9	11	14	<4	15	12	<1	54	B	.3	.002	<.05	.40	.14
92JP69	<2	17	25	54	<2	8	23	6	7	11	220	<4	60	15	<1	66	3	<.1	N.002	<.05	.50	N.02
92JP70	<2	18	29	32	<2	8	29	<2	<4	12	230	<4	50	21	1	56	B	<.1	N.002	.10	.30	.07
92JP73	<2	13	12	48	<2	6	14	10	6	21	36	<4	160	19	1	340	B	.2	N.002	<.05	.80	2.7
92JP74A	<2	16	15	7	<2	5	15	<2	12	12	140	<4	20	7	<1	43	B	.3	N.002	.10	1.3	.07
92JP75	<2	13	27	31	40	6	21	<2	62	12	71	<4	29	12	1	140	B	.2	N.002	<.05	1.6	.38
92JP80	<2	13	32	30	<2	8	37	<2	33	15	34	4	21	23	2	300	B	.6	N.002	<.05	.85	.63
92JP81	<2	10	16	67	<2	6	17	<2	<4	12	68	4	33	24	2	290	9.3	<.1	N.002	<.05	.40	.86

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Sample number	Tentatively identified rock type	Alteration	Minerals identified by x-ray diffraction
		Black Butte district	
92JP1	Tuffaceous rocks	Argillic, repl. veins	Quartz, kaolinite
92JP3	Lithic (pumiceous?) tuff	Argillic, repl. veins?	Quartz, kaolinite
92JP5	Lapilli tuff with carbonized wood	Argillic lapilli, realgar	Not x-rayed
92JP6	Lapilli tuff	Argillic, realgar, orpiment	Quartz, kaolinite, realgar
92JP15	Dacite	Chloritized, epidotized? pyrite	Quartz, calcite, plagioclase (phenocrysts), kaolinite, K-feldspar?, pyrite
92JP20	Volcaniclastic rock	Argillic, repl. veins	Quartz, kaolinite, hematite, goethite
92JP21	Flow (based on surrounding rocks)	Argillic, repl. veins	Quartz, kaolinite, goethite, minor hematite
92JP22	Flow	Argillic, repl. veins	Quartz, kaolinite
92JP27	Partially welded? tuff	Weak argillic	Quartz, kaolinite, minor hematite
92JP28	Flow	Argillic, repl. veins	Quartz, kaolinite, goethite, hematite
92JP29	Volcaniclastic rock	Argillic, repl. veins	Quartz, kaolinite, goethite, hematite
92JP30	Dacite	Argillized feldspar, silicic groundmass, pyrite	Quartz, kaolinite, dolomite, pyrite, siderite?
82JP31	Flow (based on field notes)	Argillic, repl. veins	Quartz, kaolinite, goethite
92JP32	Volcaniclastic rock	Argillic, repl. veins	Quartz, kaolinite, goethite, hematite
92JP33	Volcanic breccia	Weak argillic, very minor quartz veins	Quartz, kaolinite
92JP35	Volcaniclastic rock	Argillic, white veins	Quartz, kaolinite, goethite, hematite
92JP36	Flow	Argillic, repl. veins	Quartz, kaolinite, goethite, hematite
92JP37	Volcaniclastic rock	Argillic, repl. veins	Quartz, kaolinite, hematite, goethite?
92JP40	Volcaniclastic rock	Argillic, repl. veins	Quartz, kaolinite, goethite, hematite
92JP41	Flow	Argillic, silicic, repl. veins	Quartz, kaolinite
92JP42	Volcaniclastic rock	Argillic, silicic, repl. veins	Quartz, kaolinite
92JP43	Volcaniclastic rock	Argillic, silicic, pyrite	Quartz, dolomite, kaolinite, pyrite
92JP44	Volcaniclastic rock	Argillic, repl. veins	Quartz, kaolinite, goethite, hematite
92JP46	Volcaniclastic rock	Silicic, pyrite	Quartz, dolomite, plagioclase, kaolinite, pyrite, siderite?
92JP47	Volcaniclastic rock	Argillic, repl. veins	Quartz, kaolinite, goethite, hematite
		Holderman Mountain area	
92JP49	Lapilli? tuff	Argillic	Quartz, K-feldspar, minor kaolinite?, minor muscovite/illite?
92JP50	Thin-bedded water-laid tuff	Silicic, pyrite	Quartz, K-feldspar, pyrite
92JP53	Totally altered, original rock obscure	Argillic, silicic, repl. veins, thin quartz veins	Quartz, kaolinite, K-feldspar
92JP55	Volcaniclastic rock	Argillic, silicic, repl. veins	Quartz, kaolinite, goethite, hematite
92JP56	Volcaniclastic rock	Argillic, silicic, repl. veins, pyrite	Quartz, kaolinite, pyrite
92JP57	Lithic-lapilli tuff	Argillic, very narrow repl. veins	Quartz, illite/muscovite, goethite
92JP58	Lapilli tuff	Argillic lapilli	Quartz, kaolinite
92JP59	Undetermined	Repl. veins	Quartz, kaolinite
92JP61	Lapilli tuff	Argillic, repl. veins	Quartz, kaolinite, muscovite/illite
92JP62	Volcaniclastic rock	Argillic, silicic, repl. veins, tourmaline?	Quartz, kaolinite, plagioclase, muscovite, tourmaline?
92JP63	Flow	Silicic, repl. veins	Quartz, kaolinite, hematite/pyrite
92JP66	Flow	Silicic, pyrite, calcite	Quartz, plagioclase, siderite?, pyrite?, illite
92JP67	Lapilli? tuff	Argillic lapilli, repl. veins	Quartz, kaolinite, hematite
92JP68	Undetermined	Silicic, repl. veins. pyrite	Quartz, kaolinite, pyrite?/hematite?, muscovite?
92JP69	Lithic tuff	Propylitic, pyrite	Quartz, plagioclase, calcite, kaolinite, muscovite, siderite
92JP70	Volcaniclastic rock	Silicic, pyrite	Quartz, clacite, plagioclase, kaolinite, muscovite/illite, pyrite?, minor chlorite? (probably), siderite??
92JP73	Volcaniclastic rock	Argillic, repl. veins	Quartz, kaolinite
92JP74A	Volcaniclastic rock	Silicic, amethyst. pyrite	Quartz, kaolinite, muscovite
92JP75	Volcaniclastic rock	Argillic, repl. veins	Quartz, muscovite/illite, kaolinite, hematite?
92JP80	Volcaniclastic rock	Silicic, argillic, repl. veins	Quartz, plagioclase, pyrite, muscovite/illite, prehnite? (not likely)
92JP81	Volcaniclastic rock	Silicic, argillic, repl. veins	Quartz, kaolinite, hematite?, clay?, illite?