Chemical Composition of the Cougar Point Tuff and Rhyolite Lava Flows From the Bruneau-Jarbidge Eruptive Center, Owyhee County, Idaho

Bill Bonnichsen

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Idaho Geological Survey
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CHEMICAL COMPOSITION OF THE COUGAR POINT TUFF AND RHYOLITE LAVA FLOWS FROM THE BRUNEAU-JARBIDGE ERUPTIVE CENTER, OWYHEE COUNTY, IDAHO

by

Bill Bonnichsen[1]

ABSTRACT

Thirty-two rock analyses for major oxides and seventeen analyses for minor elements of samples from the Cougar Point tuff and rhyolite lava flows in the Bruneau-Jarbidge eruptive center show that the rock units, taken together, fall within a continuous compositional range with no significant gaps. This implies that all units were derived from a similar source. Each unit is characterized by a small quantity of a mafic component (Fe, Mg, Ca, Ti, P, Sr, Zr, and probably Al and Zn) that varies in abundance from unit to unit. Overall the rhyolite units become increasingly mafic from the oldest to the youngest, suggesting that as volcanism progressed in the developing eruptive center the temperature of successive batches of magma increased.

INTRODUCTION

The Bruneau-Jarbidge eruptive center in southeastern Owyhee County (Figure 1) was the site of numerous eruptions of rhyolitic magma during Miocene time. The first group of eruptions formed the Cougar Point tuff (Coats, 1964; Bushnell, 1967; Citron, 1976; and Bonnichsen, 1981). The extrusion of several major rhyolite lava flows, accompanied by the deposition of stream and lake sediments, followed the eruption of the Cougar Point tuff and filled in the eruptive center. The principal geographic features and geologic units in the area are shown in Figures

[1] Idaho Bureau of Mines and Geology, Moscow, Idaho 83843.

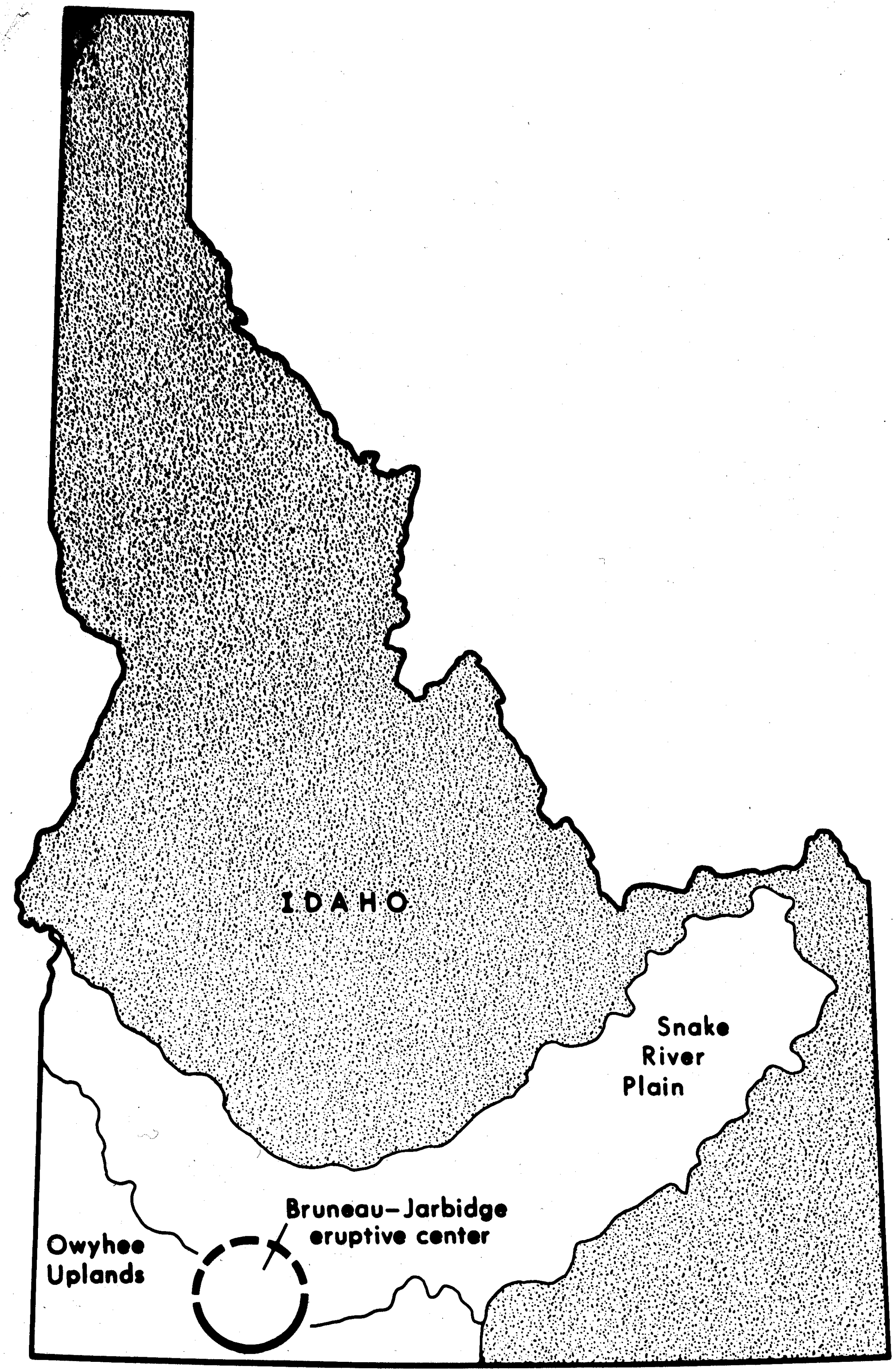

Figure 1. Index map showing the location of the Bruneau-Jarbidge eruptive center, Idaho.

2 and 3. The stratigraphic succession of units in the Cougar Point tuff and the overlying group of lava flows is portrayed in Figure 4.

The Cougar Point tuff consists of at least nine separate welded ash-flow tuff units separated by beds of sediment and unconsolidated tuff. Most are compound cooling units. The Cougar Point tuff is overlain by several large rhyolite lava flows that fill the interior of the Bruneau-Jarbidge eruptive center (Figures 3 and 4). Chemical analyses for some of these units (Triguero Homestead rhyolite, Indian Batt rhyolite, Bruneau Jasper rhyolite, Dorsey Creek rhyolite, and the unnamed flows in and adjacent to the eastern portion of the eruptive center) are also presented. Samples from the other rhyolite flows noted in Figure 4, the Sheep Creek rhyolite, Long Draw rhyolite, and lower rhyolite flows at Louse Creek and Poison Creek, have yet to be analyzed. In the past, the Cougar Point tuff and overlying rhyolite lava flows have been considered part of the heretofore undivided Idavada Volcanics (Malde and Powers, 1962; Malde and others, 1963; and Rember and Bennett, 1979). The geology of each of the units is discussed in more detail by Bonnichsen (1981).

CHEMISTRY

Major element analyses of twenty Cougar Point tuff and nine rhyolite lava flow samples were performed by X-ray fluorescence at the Department of Geology, Washington State University. Duplicate major element analyses of three samples, determined at the University of Manitoba, are included. In addition, analyses for Rb, Sr, Zr, Pb, Zn, Th, and Mo, determined by Conoco, Inc. with X-ray fluorescence, are included for eight of the Cougar Point tuff units and four of the rhyolite lava flows. Details concerning the location, geologic unit, and nature of the twenty-nine analyzed samples are in Table 1, and the analyses are presented in Tables 2, 3, 4, and 5. Nearly all samples are from the basal vitrophyre layers of their unit.

The major element contents, expressed as weight percentages of oxides, for the Cougar Point tuff samples are reported in Table 2. The major element analyses for the rhyolite lava flow samples are reported

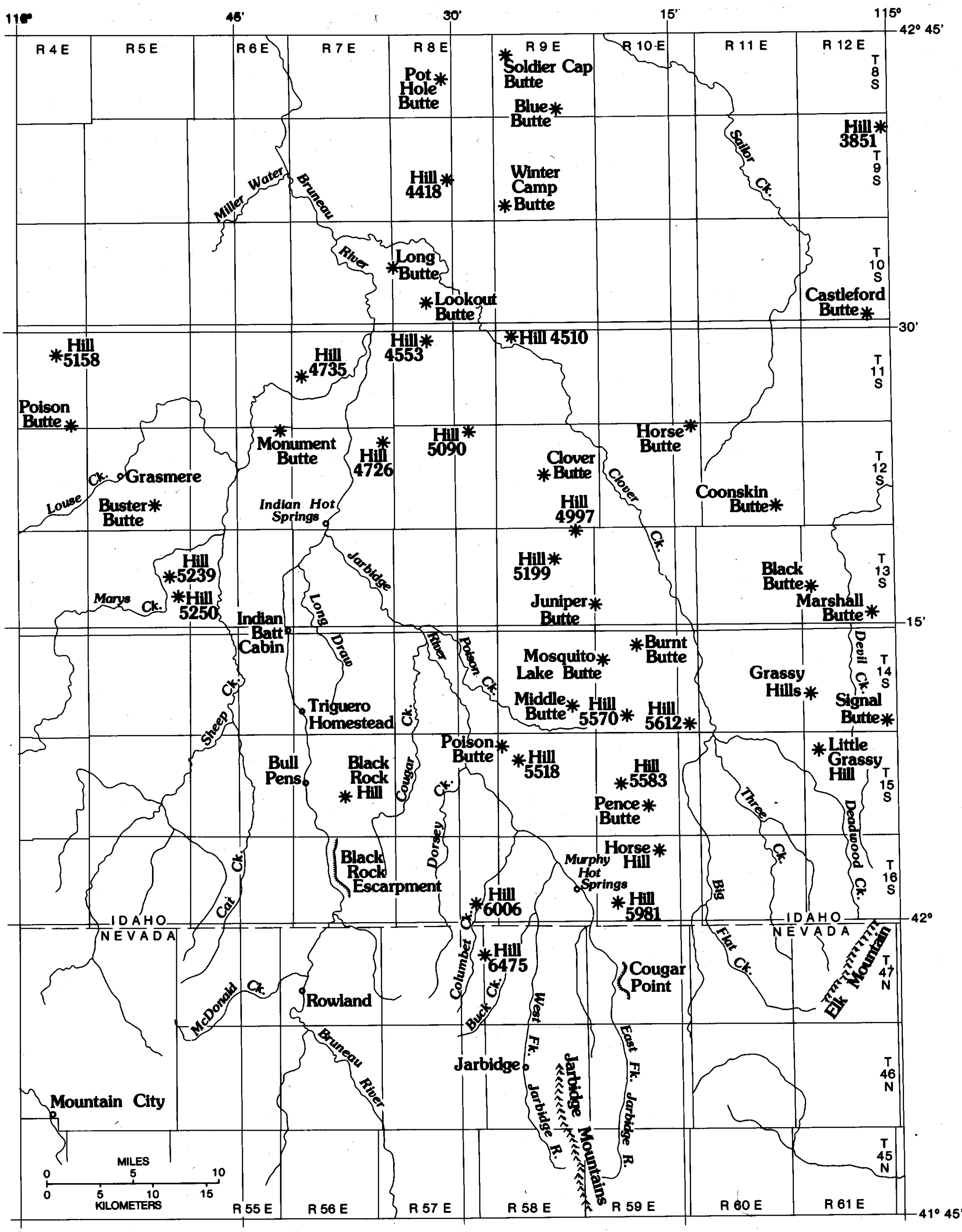

Figure 2. Geographic reference map of eastern Owyhee County, Idaho, and vicinity.

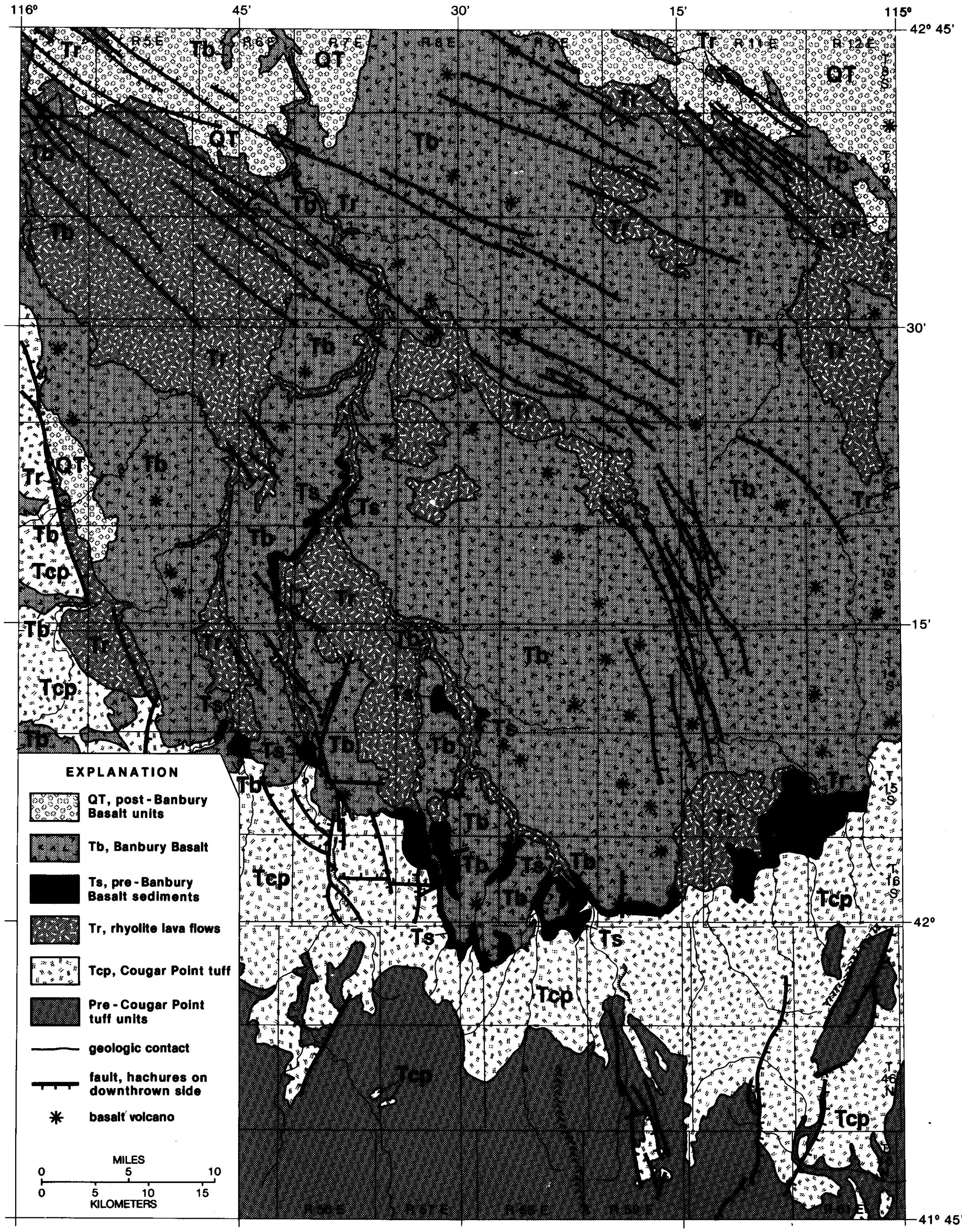

Figure 3. Generalized geologic map of eastern Owyhee County, Idaho, and vicinity.

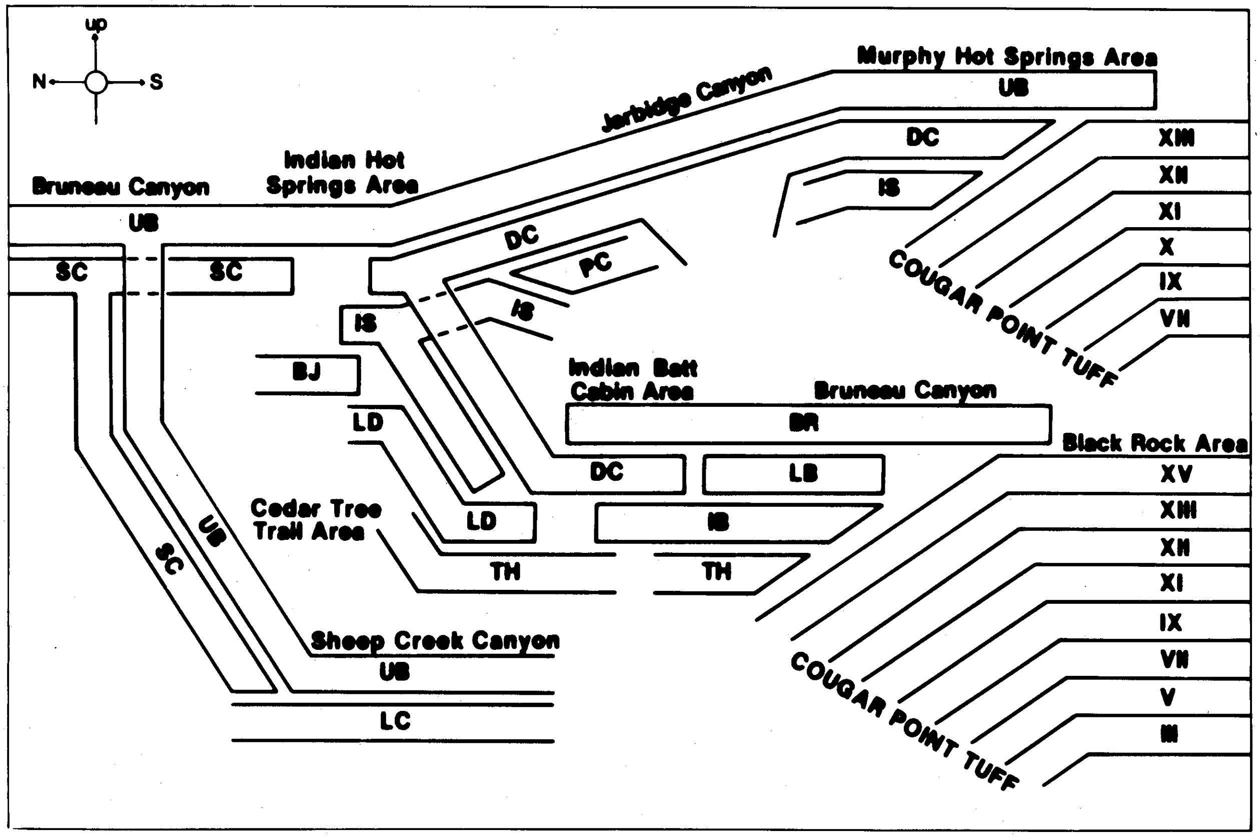

Figure 4. Schematic fence diagram showing the stratigraphic succession and lateral distribution of volcanic units exposed in canyon walls in the Bruneau-Jarbidge eruptive center (BJ--Bruneau Jasper rhyolite, BR--Black Rock basalt, DC--Dorsey Creek rhyolite, IB--Indian Batt rhyolite, IS--Indian Springs basalt, LB--lower basalt at Triguero Homestead, LC--lower rhyolite at Louse Creek, LD--Long Draw rhyolite, PC--lower rhyolite at Poison Creek, SC--Sheep Creek rhyolite, TH--Triguero Homestead rhyolite, UB--undivided flows of the Banbury Basalt, roman numerals--cooling units of the Cougar Point tuff).

in Table 3. Table 4 contains the duplicate major element analyses, and Table 5 contains the minor element data.

For major oxides in the Cougar Point tuff, at least two analyses per unit are presented, except for unit X. For each unit, samples were selected from localities many miles apart to test the compositional uniformity within individual units. The results, displayed in Figure 5 for major elements and in Figure 6 for minor elements, show that the abundance variation for most elements in most units is much less than the overall compositional variation in the Cougar Point tuff. These results reveal that even though each Cougar Point tuff unit has a lateral extent of many miles and is volumetrically large, each unit has a narrow compositional range. Some units have compositions different enough from those of adjacent ones (for example, compare XI with XII) so that they can be easily distinguished by their major or minor element abundances. However, other pairs (for example, compare VII with XII or XI with XIII) are indistinguishable by their major element compositions or the available minor element data.

Inspection of the unit-to-unit variation among the Cougar Point tuff analyses in Figures 5 and 6 reveals that some elements vary in a similar or coherent fashion with stratigraphic position, whereas others show opposing trends. This also has been determined by plotting one element versus another; however, these plots are not included. Silica, K_2O, Rb, Th, and probably Pb vary in a similar fashion, and their unit-to-unit abundance variation is opposite that of the coherent group of Fe_2O_3, MgO, CaO, TiO_2, MnO, P_2O_5, Sr, and Zr. In the Cougar Point tuff, the variation exhibited by Al_2O_3, Na_2O, Zn, and Mo is not distinctive enough to assign them conclusively to one or the other group. The Al_2O_3 and Zn are more like the iron and related elements group than the silica group, however.

The assignment of the elements into these two groups reflects the fact that each batch of rhyolitic magma contained a small amount of a dissolved mafic component (the Fe, Mg, Ti, etc. group) which varies in abundance from unit to unit. Thus, the principal compositional variation among the Cougar Point tuff units is that some are more mafic than others.

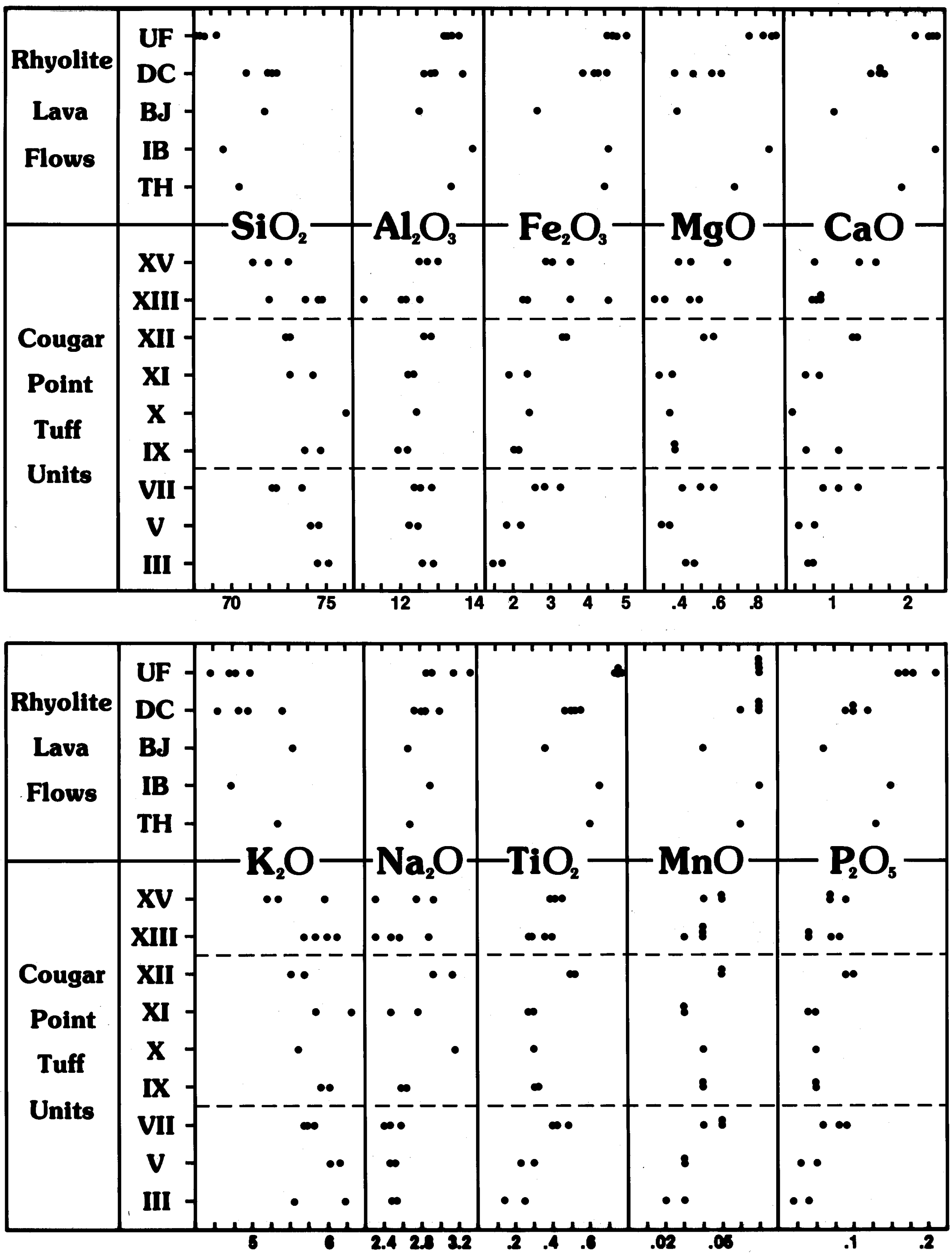

Figure 5. Weight percent of major oxides versus stratigraphic position of the Cougar Point tuff units and rhyolite lava flows. All analyses in Tables 2, 3, and 4 are plotted. (BJ--Bruneau Jasper rhyolite, DC--Dorsey Creek rhyolite, IB--Indian Batt rhyolite, TH--Triguero Homestead rhyolite, UF--unnamed flows from eastern part of area).

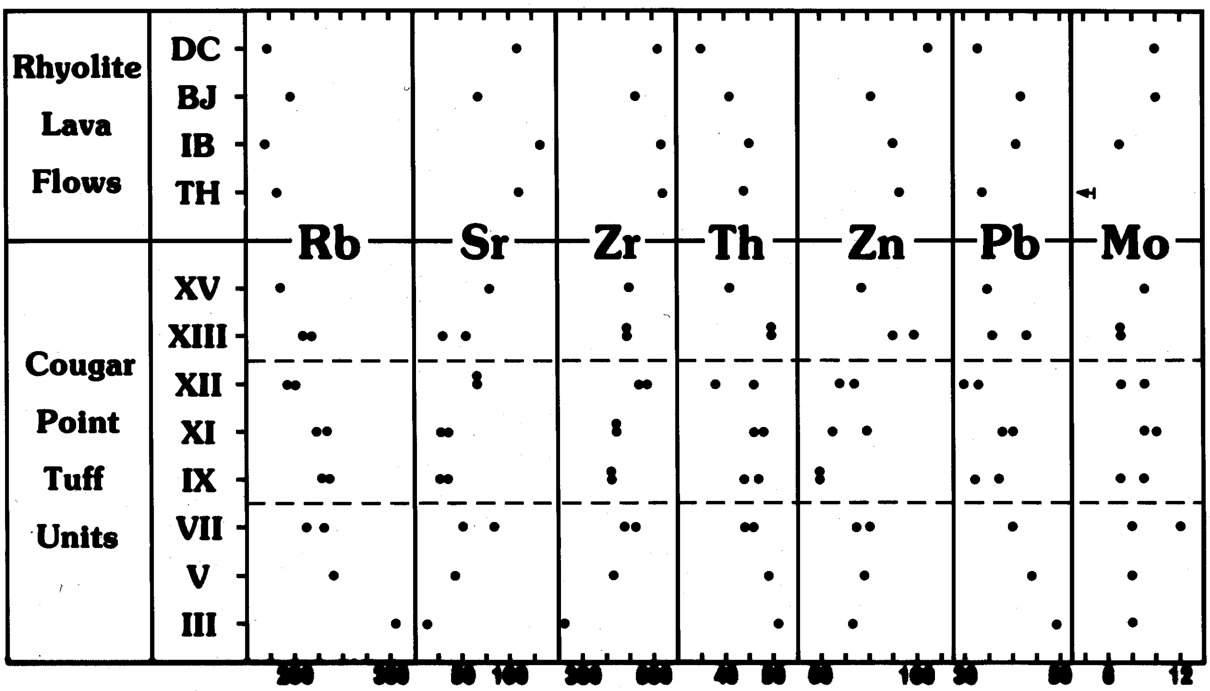

Figure 6. Abundance of minor elements (parts per million) versus stratigraphic position of the Cougar Point tuff units and rhyolite lava flows. Abbreviations used for the rhyolite lava flows are identified in the caption for Figure 5.

Inspection of Figures 5 and 6 shows that units VII, XII, and XV are the three most mafic and that the Cougar Point tuff becomes increasingly mafic from bottom to top, or oldest to youngest, although local reversals of the trend do occur. The two conspicuous reversals in this overall trend are between units VII and IX and between units XII and XIII. They suggest that the Cougar Point tuff consists of three cycles (separated by the horizontal dashed lines in Figures 5 and 6) and that in each cycle the magma became increasingly mafic as successive batches were erupted. The lower cycle consists of units III, V, and VII; the middle cycle consists of units IX, X, XI, and XII; and the upper cycle consists of units XIII and XV.

The subdivision of the Cougar Point tuff into these three compositional cycles should be considered as strictly descriptive; it is not meant to imply any particular type of genetic relationship among the successive batches of magma that erupted. Each cooling unit was a distinct major volcanic event, separated from the others by sufficient time for complete cooling, by the deposition of sediment layers between the units, and in many cases by sufficient time for the Earth's magnetic field to reverse its polarity (Bonnichsen, 1981). Whether some of the Cougar Point tuff units were successive magma batches from the same source volume or magma chamber cannot be assessed with the currently available data. The overall chemical similarity among all the units does support the idea that all are from a similar source and were formed under similar conditions, however.

The rhyolite lava flows have compositions that generally are more mafic than those of the older Cougar Point tuff units (Figures 5 and 6). There is a little overlap, however, between the least mafic lava flows and the most mafic Cougar Point tuff units; for example, compare Cougar Point tuff unit XV with the Bruneau Jasper rhyolite lava flow. Since all of the rhyolite lava flows are younger than the Cougar Point tuff units, the general trend of the rhyolite magmas becoming increasingly mafic with decreasing age was continued.

The mutual proportions of several chemical constituents in the units are illustrated in triangular variation diagrams in Figures 7 and 8. In both figures the rhyolite lava flows are portrayed by the small triangles; the more mafic Cougar Point tuff units (VII, XII, and XV) are open circles; and the other, less mafic welded tuff units, are filled circles.

Some of the principal mutual variations among the major oxides are illustrated in Figure 7. Three of these plots (all except the CaO-P_2O_5-TiO_2 plot in the lower right portion of the figure) illustrate the point made previously that the Cougar Point tuff ash-flow units are less mafic and richer in alkalis than the younger rhyolite lava flows which fill the interior of the Bruneau-Jarbidge eruptive center. Secondly, these three plots illustrate that a continuous range of compositions exists among the units; there are no apparent compositional gaps. Furthermore, each rock group--the rhyolite lava flows, the more mafic ash-flow units at the cycle tops, and the other, less mafic ash-flow units--has a discreet, fairly restricted compositional range, so that only a limited amount of compositional overlap exists between the groups.

The (FeO+MgO)-Na_2O-K_2O plot (upper left, Figure 7) illustrates that the K/Na ratio generally increases when progressing from the rhyolite lava flows to the more mafic ash-flow units and that the ratio achieves its highest values in the least mafic ash-flow units. The K_2O-MgO-FeO plot (upper right, Figure 7) shows no significant variation in the Fe to Mg ratio over the entire range of compositions or flow types. The CaO-(FeO+MgO)-(Na_2O+K_2O) plot (lower left, Figure 7) indicates a slight increase in the Ca/(Mg+Fe) ratio in progressing from the least to the most mafic compositions. This very likely is related to the greater abundance of plagioclase crystals in the rhyolite lava flows than in most of the Cougar Point tuff units.

The CaO-P_2O_5-TiO_2 plot (lower right, Figure 7) reveals that no significant variation exists in mutual proportions of Ti and P over the entire range of compositions or flow types. This is similar to the observation regarding the Fe to Mg ratio in the K_2O-MgO-FeO triangle. Similar plots examining the mutual proportions of Fe and Mg to Ti and to P, and all of these to Mn, also show little variation among any of this group of elements. The CaO-P_2O_5-TiO_2 plot also shows the rhyolite lava flows to have a much more restricted range of CaO relative to P_2O_5 and TiO_2 and in general to be more enriched in CaO relative to P_2O_5 and

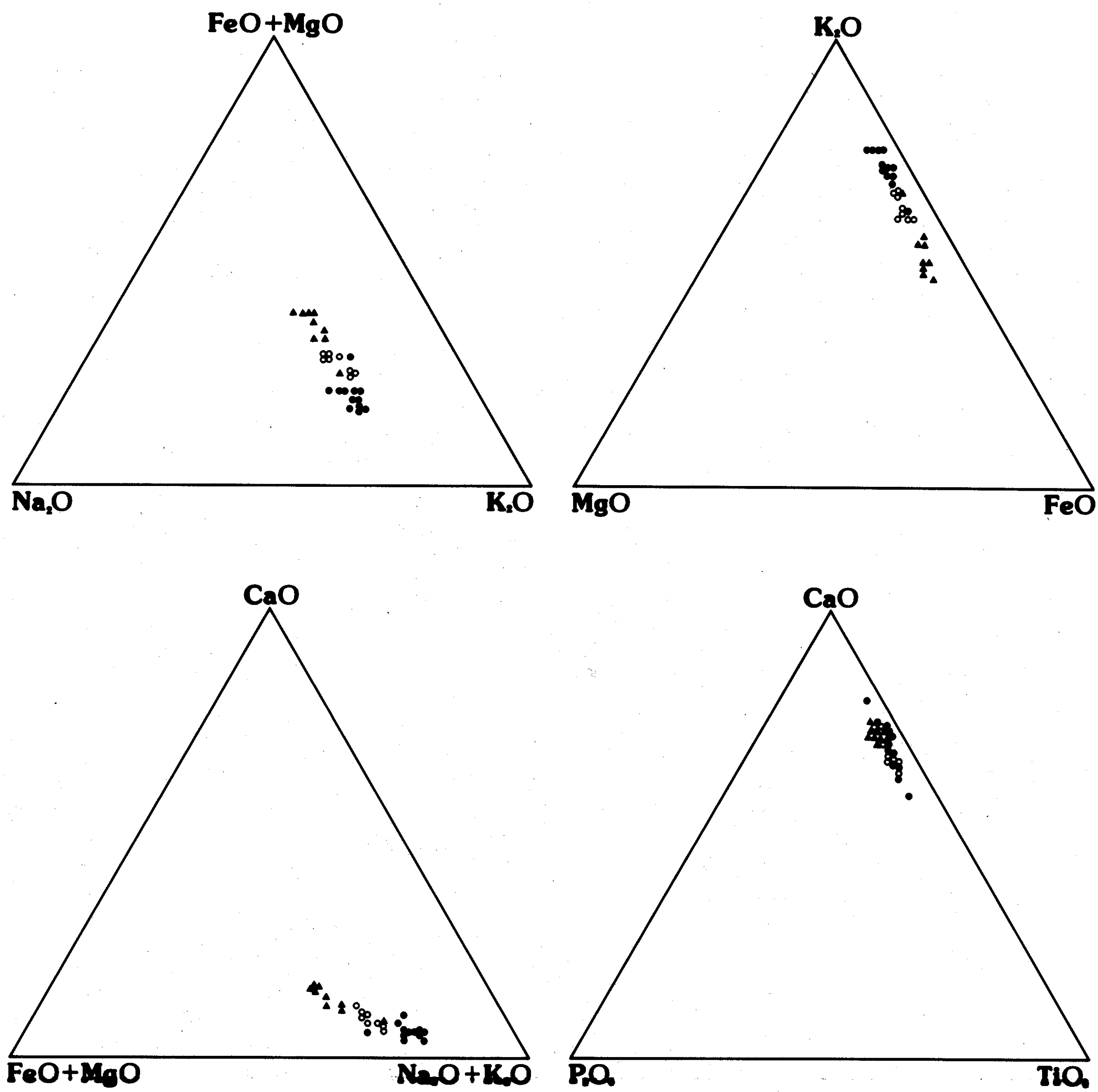

Figure 7. Variation diagrams showing mutual proportions in the weight percentages of various major oxides in the Cougar Point tuff and rhyolite lava flows. All analyses in Tables 2 and 3 are plotted. The total iron content is expressed as FeO, rather than Fe_2O_3 as in the tables and Figure 5. Triangles are rhyolite lava flows; open circles are the more mafic Cougar Point tuff units (VII, XII, and XV); and the filled circles are the other Cougar Point tuff units.

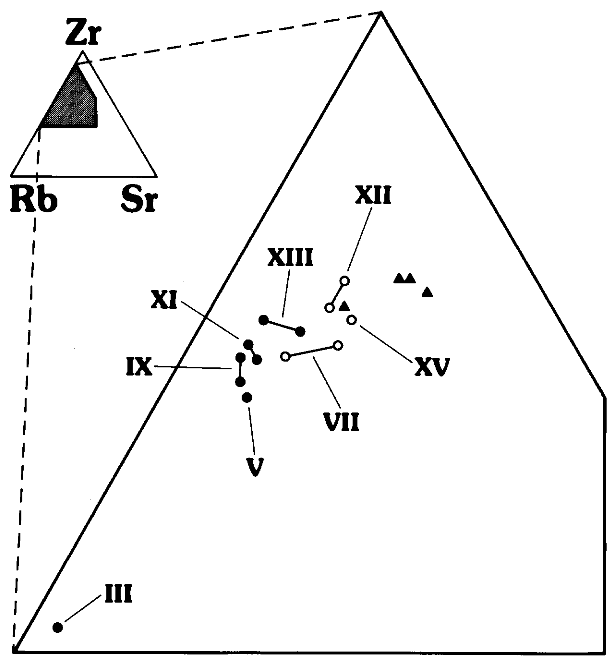

Figure 8. Mutual proportions of Zr, Rb, and Sr in the Cougar Point tuff units and rhyolite lava flows. Triangles are rhyolite lava flows; open circles are the more mafic Cougar Point tuff units (VII, XII, and XV); and the filled circles are the other Cougar Point tuff units.

TiO_2 than many of the ash-flow units. This also probably reflects the greater abundance of plagioclase crystals in the rhyolite lava flows than in the Cougar Point tuff units.

The plot of mutual proportions of Zr, Rb, and Sr in Figure 8 illustrates relationships very similar to those noted among the major oxides. Each unit is characterized by its own fairly narrow range of mutual proportions of these elements, and except for the one Sr and Zr impoverished sample (I-569, Table 5) from unit III, the group forms a continuous compositional field with no apparent gaps. The rhyolite lava flows and more mafic ash-flow units have the greatest enrichment of Sr and Zr relative to Rb.

SUMMARY AND DISCUSSION

Abundances of the major and minor elements in samples from the Cougar Point tuff and from the younger rhyolite lava flows within the Bruneau-Jarbidge eruptive center have led to several important conclusions regarding the chemical characteristics of these rhyolite units, and their origin. Each rhyolite unit, regardless if an ash-flow or a lava flow, shows a compositional range considerably less than for the total group of units, even though the samples were collected from locations many miles apart.

The combination of elements that appear to be especially useful for discriminating one unit from another includes Si, Fe, Ca, K, Ti, P, Rb, Sr, and Zr. The combination of major oxide content, minor element chemistry, magnetic polarity and stratigraphic position (Bonnichsen, 1981), and petrographic features seems to characterize each unit.

The rhyolite units contain small amounts of a mafic group of elements (Fe, Mg, Ca, Ti, Mn, P, Sr, Zr, and probably Al and Zn) that vary in abundance from unit to unit. On the basis of these abundance variations the Cougar Point tuff has been divided into a lower cycle (units III, V, and VII), a middle cycle (units IX, X, XI, and XII), and an upper cycle (units XIII and XV). Each cycle becomes more mafic stratigraphically upwards so that the units most enriched in the mafic elements are the cycle tops (VII, XII, and XV). The existence of these cycles may be related to some specific set of progressive variations in the magma source area, or it may be only a fortuitous variation with no real significance.

The rhyolite lava flows that erupted later than the Cougar Point tuff units and filled in much of the Bruneau-Jarbidge eruptive center are generally more mafic than the ash-flow units, but they do show compositional overlap with the most mafic ash-flow units. An overall trend from less mafic to more mafic is apparent throughout the entire stratigraphic succession of Cougar Point tuff and rhyolite lava flow units, although it is somewhat disrupted by the Cougar Point tuff cycles.

Taken together, the rock analyses form a continuous compositional range with no significant gaps. This is taken to imply that considerable similarity existed in the source areas from which the magmas were derived and in the combination of physical conditions and processes that existed during their evolution. The temperature at which the magmas were formed and erupted probably was the principal variable responsible for the compositional variation among the rhyolite units. It is probable that the more mafic a unit is, the higher its temperature was during formation and eruption.

ACKNOWLEDGMENTS

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Table 1. Locations and descriptive notes for analyzed samples from the Cougar Point tuff and from rhyolite lava flows in the Bruneau-Jarbidge eruptive center, Idaho.

Sample Number	Geologic Unit	Nature of Sample	Quadrangle	Location Section	Location Township	Location Range
I-15	unnamed rhyolite flow	basal vitrophyre	Buhl	NE 20	10S	13E
I-76	Cougar Point tuff, XIII	upper vitrophyre	Murphy Hot Springs	SE NW 24	16S	9E
I-84	Dorsey Creek rhyolite	lithic rock from base	Dishpan	NE SE 10	16S	9E
I-411	Bruneau Jasper rhyolite	upper vitrophyre	Stiff Tree Draw	NE SW 15	12S	7E
I-445	Indian Batt rhyolite	basal vitrophyre	Triguero Lake	SE NW 30	14S	7E
I-448	Triguero Homestead rhyolite	vitrophyre	Triguero Lake	SE NW 30	14S	7E
I-454	Cougar Point tuff, V	basal vitrophyre	Triplet Butte	NW SW 9	16S	7E
I-457	Cougar Point tuff, VII	basal vitrophyre	Triplet Butte	NW SW 9	16S	7E
I-459	Cougar Point tuff, XV	basal vitrophyre	Triplet Butte	SE SW 9	16S	7E
I-461	Cougar Point tuff, XIII	basal vitrophyre	Triplet Butte	SE SW 9	16S	7E
I-463	Cougar Point tuff, XI	basal vitrophyre	Triplet Butte	NW SW 9	16S	7E
I-466	Cougar Point tuff, IX	basal vitrophyre	Triplet Butte	NW SW 9	16S	7E
I-496	Dorsey Creek rhyolite	upper vitrophyre	Dishpan	NE NW 24	15S	8E
I-529	Dorsey Creek rhyolite	basal vitrophyre	Dishpan	NE SW 3	16S	9E
I-556	Cougar Point tuff, V	basal vitrophyre	Jarbidge	NE SE 21	47N	58E

Table 1. Continued.

Sample Number	Geologic Unit	Nature of Sample	Quadrangle	Location Section		Township	Range
I-568	Cougar Point tuff, III	fused ash at base	Triplet Butte	NW NE	28	16S	7E
I-569	Cougar Point tuff, III	basal vitrophyre	Triplet Butte	NW NE	28	16S	7E
I-693	unnamed rhyolite flow	upper(?) vitrophyre	Horse Butte	SW NW	11	11S	11E
I-719	unnamed rhyolite flow	upper vitrophyre	Big Bend Crossing	SE SW	23	12S	12E
I-783	Cougar Point tuff, XV	basal vitrophyre	Triplet Butte	SE SW	13	15S	6E
I-799	Cougar Point tuff, XII	basal vitrophyre	Triplet Butte	SE NE	28	16S	7E
I-841	Cougar Point tuff, VII	basal vitrophyre	Jarbidge	SW NE	28	47N	58E
X-20	Cougar Point tuff, XII	basal vitrophyre	Jarbidge	NW	20	47N	59E
X-37	Cougar Point tuff, XIII	basal vitrophyre	Jarbidge	NW	20	47N	59E
X-72	Cougar Point tuff, X	lithic rock	Jarbidge	NW	20	47N	59E
X-116	Cougar Point tuff, IX	basal vitrophyre	Jarbidge	NW	20	47N	59E
X-174	Cougar Point tuff, XI	basal vitrophyre	Dishpan	NW NE	33	16S	9E
X-214	Cougar Point tuff, VII	basal vitrophyre	Jarbidge	NW	20	47N	59E
S-193	Cougar Point tuff, XV	vitrophyre	Dishpan	SE SW	21	16S	9E

Table 2. Chemical composition (weight percent) of Cougar Point tuff samples. Analyzed by X-ray fluorescence at Department of Geology, Washington State University, June 1980.

Sample Number	SiO_2	Al_2O_3	TiO_2	Fe as Fe_2O_3	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	Sum
I-76	74.68	12.15	0.40	3.52	0.04	0.77	0.49	6.13	2.48	0.07	100.72
I-454	74.23	12.47	0.30	2.21	0.03	0.76	0.33	6.17	2.47	0.05	99.04
I-457	73.73	12.51	0.40	2.58	0.04	0.89	0.50	5.72	2.40	0.06	98.84
I-459	73.03	13.02	0.41	3.07	0.05	1.38	0.65	5.20	2.93	0.07	99.80
I-461	74.75	12.52	0.29	2.29	0.03	0.86	0.45	5.68	2.89	0.04	99.81
I-463	73.18	12.21	0.30	2.38	0.03	0.83	0.28	5.85	2.77	0.04	97.88
I-466	74.77	12.20	0.32	2.15	0.04	1.09	0.36	6.03	2.63	0.05	99.64
I-556	74.61	12.21	0.23	1.83	0.03	0.55	0.29	6.03	2.51	0.03	98.32
I-568	74.57	12.87	0.25	1.73	0.02	0.74	0.42	6.23	2.49	0.04	99.36
I-569	75.12	12.58	0.14	1.47	0.03	0.65	0.46	5.54	2.53	0.02	98.53
I-783	71.19	12.72	0.45	3.54	0.05	1.59	0.45	5.35	2.75	0.09	98.19
I-799	72.97	12.64	0.52	3.36	0.05	1.23	0.52	5.52	3.12	0.10	100.02
I-841	72.24	12.83	0.48	3.27	0.05	1.34	0.57	5.70	2.58	0.09	99.15
X-20	73.11	12.81	0.50	3.40	0.05	1.19	0.57	5.69	2.92	0.09	100.32
X-37	73.98	12.09	0.28	2.36	0.04	0.80	0.31	6.00	2.57	0.04	98.45
X-72	76.14	12.46	0.30	2.45	0.04	0.48	0.34	5.61	3.16	0.05	101.03
X-116	73.94	11.96	0.31	2.03	0.04	0.66	0.36	5.91	2.59	0.05	97.84
X-174	74.44	12.36	0.28	1.88	0.03	0.66	0.35	6.31	2.48	0.05	98.83
X-214	72.36	12.38	0.42	2.86	0.05	1.09	0.40	5.82	2.46	0.08	97.92
S-193*	72.04	12.53	0.39	2.92	0.04	0.78	0.39	5.96	2.32	0.07	97.44

*S-193 values for SiO_2 and Al_2O_3 were determined April 1981.

Table 3. Chemical composition (weight percent) of samples from rhyolite lava flows in southwestern Idaho. Analyzed by X-ray fluorescence at Department of Geology, Washington State University, June 1980.

Sample Number	SiO_2	Al_2O_3	TiO_2	Fe as Fe_2O_3	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	Sum
I-15	69.25	13.61	0.77	4.77	0.07	2.31	0.89	4.99	2.87	0.17	99.70
I-84	72.47	13.72	0.55	4.52	0.07	1.70	0.62	4.84	2.83	0.10	101.42
I-411*	71.87	12.51	0.36	2.69	0.04	1.03	0.38	5.55	2.67	0.06	97.16
I-445	69.59	13.97	0.65	4.55	0.07	2.39	0.87	4.72	2.90	0.15	99.86
I-448	70.48	13.38	0.60	4.47	0.06	1.93	0.68	5.34	2.68	0.13	99.74
I-496	72.13	12.89	0.47	3.90	0.07	1.54	0.57	4.95	3.00	0.09	99.61
I-529	72.04	12.92	0.52	4.28	0.07	1.65	0.47	5.41	2.81	0.10	100.27
I-693	68.16	13.23	0.75	5.08	0.07	2.36	0.77	4.47	3.34	0.18	98.40
I-719	68.59	13.43	0.75	4.71	0.07	2.41	0.90	4.79	3.16	0.21	99.04

* I-411 values for SiO_2 and Al_2O_3 were determined April 1981.

Table 4. Chemical composition (weight percent) of three rhyolite samples from southwestern Idaho. Analyzed at Department of Earth Sciences, University of Manitoba, by K. Ramlal, August 1972, by methods described in Wilson and others, 1969.

Sample Number	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	H_2O	CO_2	S	Sum
I-15	68.45	13.26	2.01	2.32	0.84	2.12	2.92	4.71	0.74	0.16	0.07	2.42	0.00	0.00	100.02
I-76	72.05	11.04	3.18	1.22	0.26	0.86	2.31	5.84	0.36	0.08	0.04	2.98	0.04	0.01	100.27
I-84	70.90	12.66	1.84	2.16	0.37	1.67	2.74	4.53	0.51	0.12	0.06	1.96	0.08	0.01	99.61

(For plotting in Figure 5 all Fe is calculated as Fe_2O_3 so that I-15 is 4.59, I-76 is 4.54, and I-84 is 4.24.)

Table 5. Concentrations of selected trace elements (in parts per million) in samples of rhyolite lava flows and Cougar Point tuff. X-ray fluorescence analyses provided by Conoco, Inc. Research and Development Department, Ponca City, Oklahoma, December 1979.

Sample Number	Rb	Sr	Zr	Pb	Zn	Th	Mo
			rhyolite lava flow samples				
I-411	195	68	530	42	81	41	10
I-445	170	133	642	41	90	45	7
I-448	182	110	642	34	93	44	<5
I-529	173	109	623	33	105	35	10
			Cougar Point tuff samples				
I-454	241	42	434	44	78	49	8
I-457	231	51	483	76	75	46	8
I-459	185	79	500	35	77	41	9
I-461	209	55	497	43	99	50	7
I-463	233	35	455	38	79	48	10
I-466	237	34	418	37	59	44	7
I-569	307	13	229	49	73	51	8
I-799	194	65	571	33	74	38	7
I-841	213	83	528	40	80	44	12
X-20	201	64	549	30	68	46	9
X-37	218	30	488	36	90	49	7
X-116	229	28	434	32	60	47	9
X-174	224	29	442	40	65	46	9

REFERENCES CITED

Bonnichsen, Bill, 1981, Stratigraphy and measurements of magnetic polarity for volcanic units in the Bruneau-Jarbidge eruptive center, Owyhee County, Idaho: Idaho Bureau of Mines and Geology Open-File Report 81-5, 75 p.

Bushnell, Kent, 1967, Geology of the Rowland quadrangle, Elko County, Nevada: Nevada Bureau of Mines Bulletin 67, 38 p.

Citron, G. P., 1976, Idavada ash flows in the Three Creek area, southwestern Idaho, and their regional significance: Cornell University M.S. thesis, 83 p.

Coats, R. R., 1964, Geology of the Jarbidge quadrangle, Nevada-Idaho: U. S. Geological Survey Bulletin 1141-M, 24 p.

Malde, H. E. and H. A. Powers, 1962, Upper Cenozoic stratigraphy of western Snake River Plain, Idaho: Geological Society of America Bulletin, v. 73, p. 1197-1220.

Malde, H. E., H. A. Powers, and C. H. Marshall, 1963, Reconnaissance geologic map of west-central Snake River Plain, Idaho: U. S. Geological Survey Miscellaneous Geologic Investigations Map I-373.

Rember, W. C. and E. H. Bennett, 1979, Geologic map of the Twin Falls quadrangle, Idaho: Idaho Bureau of Mines and Geology Geologic Map Series, Twin Falls 2° quadrangle.

Wilson, H. D. B., L. C. Kilburn, A. M. Graham, and Ken Ramlal, 1969, Geochemistry of some Canadian nickeliferous ultrabasic intrusions, *in* H. D. B. Wilson, editor, Magmatic Ore Deposits--A Symposium: Economic Geology Monograph 4, p. 294-309.