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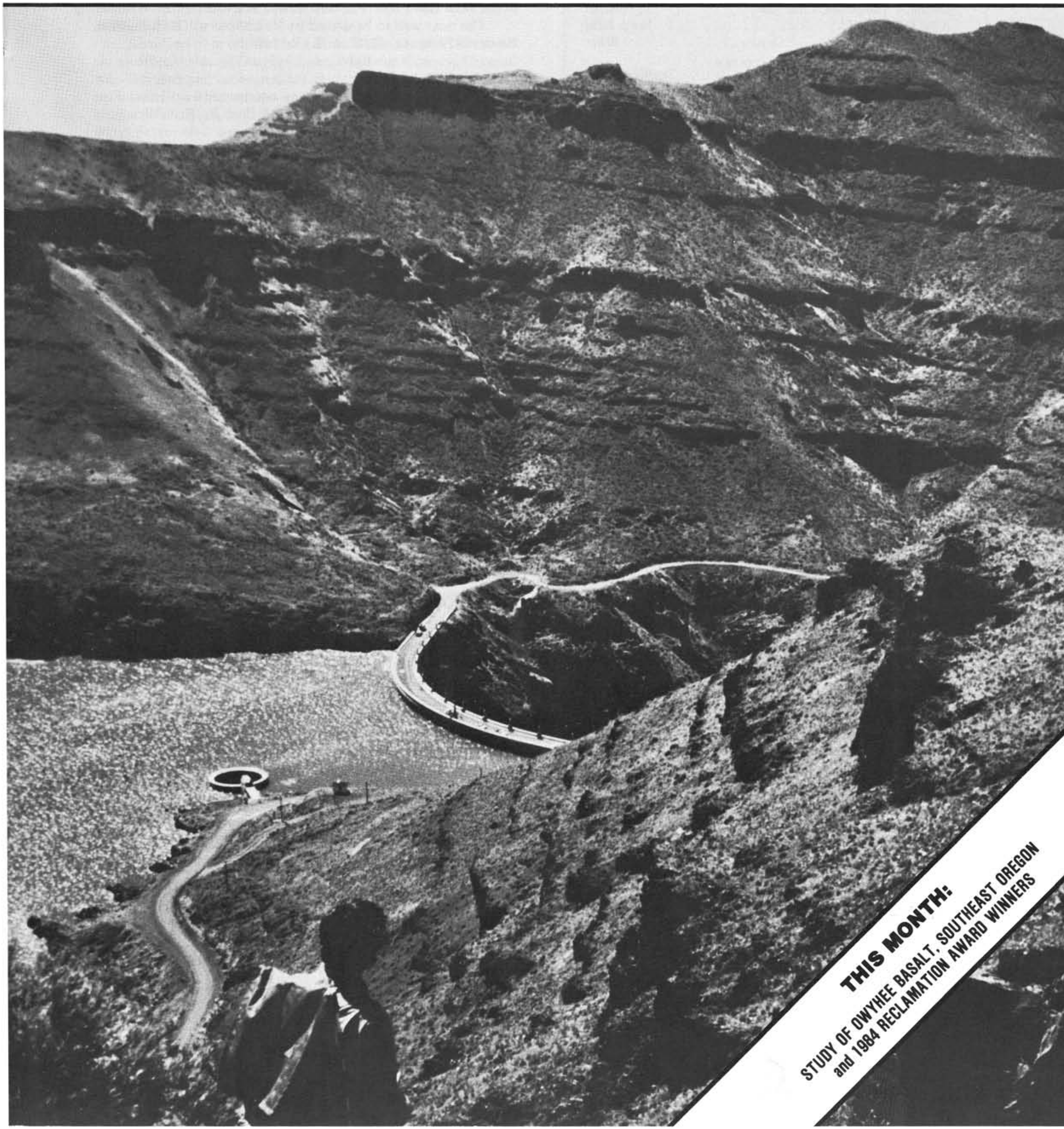

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The style to be followed is generally that of U.S. Geological Survey publications (see the USGS manual *Suggestions to Authors*, 6th ed., 1978). The bibliography should be limited to "References Cited." Authors are responsible for the accuracy of their bibliographic references. Names of reviewers should be included in the "Acknowledgments."

Authors will receive 20 complimentary copies of the issue containing their contribution. Manuscripts, news, notices, and meeting announcements should be sent to Beverly F. Vogt, Publications Manager, at the Portland office of DOGAMI.

COVER PHOTO

View overlooking Owyhee Lake and Dam. Rocks in foreground and across lake are Owyhee Basalt, which is the unit discussed in paper beginning on next page. Area in foreground includes section measured and sampled for this study. Type section for Owyhee Basalt is on opposite side of Lake Owyhee.

OIL AND GAS NEWS

Columbia County — Mist Gas Field

Difficulty with cementing the production casing in Columbia County 23-36 in sec. 36, T. 6 N., R. 5 W., delayed completion of the Reichhold Energy Corporation well until January 8. The well was drilled in December 1984 to a total depth of 1,879 ft. The well becomes the southernmost extension of the Mist Gas Field. The well flowed at a rate of 2.27 MMcfd.

The next well to be drilled by Reichhold will be Longview Fibre 42-22 in sec. 22, T. 6 N., R. 5 W.

Douglas County

Amoco Production Company continues to drill ahead on Weyerhaeuser B No. 1 well in sec. 13, T. 5 S., R. 9 W.

Wheeler County

Steele Energy Corporation's Keys 1 in sec. 28, T. 9 S., R. 23 E., is still drilling ahead to a proposed total depth of 8,000 ft.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
285	Ty R. Settles Cindy 1 039-00008	NW¼ sec. 23 T. 16 S., R. 5 W. Lane County	Application; 2,500.
286	Ty R. Settles Cindy 2 039-00009	SW¼ sec. 23 T. 16 S., R. 5 W. Lane County	Application; 2,500.

□

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For more information or to order documents, contact Julie Jackson at the American Geological Institute, 4220 King Street, Alexandria, VA 22302 (phone 800/336-4764). □

Geochemistry, geochronology, and magnetostratigraphy of a measured section of the Owyhee Basalt, Malheur County, Oregon

by D.E. Brown and J.R. Petros, Pinnacle Geotechnical Services, Ltd., 310 SW 4th Ave., Portland, OR 97204

ABSTRACT

A section of seventeen lava flows of the Owyhee Basalt on the northeast side of Owyhee Lake, Malheur County, Oregon, was sampled and measured for thickness and field paleomagnetic polarity. Thin-section analyses, major- and trace-element chemical analyses, and potassium-argon age determinations were performed on selected samples. Also measured and sampled were an underlying unit of rhyodacite and five feeder dikes in the Owyhee Lake area. The total thickness of the measured section was 254 m, including ten interflow sedimentary and pyroclastic units. Paleomagnetic polarity was reversed in the underlying rhyodacite, transitional in the first flow, normal in the second through sixteenth flows, and reversed in the seventeenth flow. The section was composed chiefly of high-alumina, calc-alkaline basalt and basaltic andesite lava flows. Silica content was found to generally increase from 50.33 percent in the first flow to 57.09 percent in the seventeenth flow. Potassium-argon age of the uppermost flow was 15.3±0.6 million years (m.y.); the age of the underlying rhyodacite was 22.8±2.6 m.y. This study was supported by U.S. Department of Energy (DOE) Cooperative Agreement No. DE-FC07-79ET27220 and was part of an Oregon Department of Geology and Mineral Industries (DOGAMI) study of the geology and geothermal resources of the Western Snake River Plain.

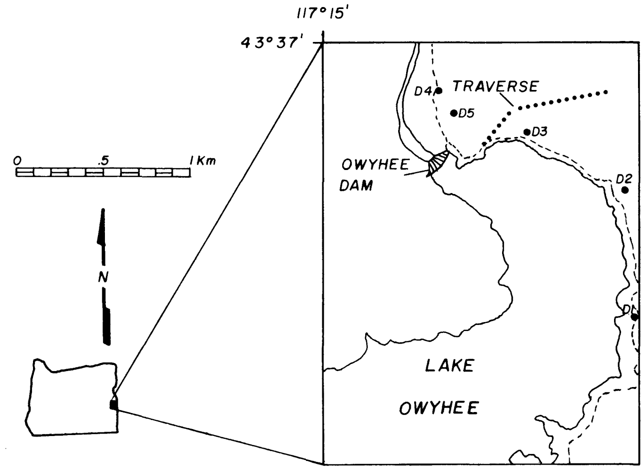


Figure 1. Map showing location of study area and route of traverse (dotted line) along which samples F-1 to -17 were collected in sequence, with F-1 taken from the lowest flow of the Owyhee Basalt. Dike sample locations are indicated by the letter "D." Dashed line indicates road. Rocks of the Sucker Creek Formation crop out locally along the eastern shore of Lake Owyhee. The rhyodacite first described by Bryan (1929) is exposed along the north shore of Lake Owyhee. All of the rest of the rock exposed in the map area is Owyhee Basalt.

INTRODUCTION

The measured section of Owyhee Basalt is located on Owyhee Ridge on the northeastern side of Owyhee Lake, Malheur County, Oregon (Figures 1 and 2). It is directly across Owyhee Dam from the type section of Kittleman and others (1965) and was chosen because outcrop exposure and access to the section were better and more flows were present in the section (Figure 3).

Seventeen flows, five feeder dikes, and an underlying rhyodacite unit were examined for this study. The paleomagnetic polarity of each flow was measured in the field using a hand-held fluxgate magnetometer.

Chemical analysis for major-oxide and trace-element composition of the flows and dikes was carried out using the atomic absorption method (Christine McBirney, University of Oregon, analyst). Potassium-argon age determinations were made by Stanley Evans of the University of Utah Research Institute.

PREVIOUS WORK

The Owyhee Basalt was first defined by Bryan (1929) from exposures along the lower Owyhee River. Renick (1930) surveyed the geology of Malheur County. A type section was defined by Kittleman and others (1965) at exposures near the west abutment of Owyhee Dam. Kittleman (1962) and Kittleman and others (1967) produced geologic maps that show the distribution of the Owyhee Basalt. Corcoran and others (1962) compiled a geologic map of the Mitchell Butte quadrangle using data from Corcoran (1953) and Porter (1953). The 1962 map shows the distribution of the unit in outcrop and, on the basis of petroleum-exploration well logs, its distribution beneath surficial units. Newton and Corcoran (1963) showed the unit in cross-sections. Watkins and Baksi (1974) studied the paleomagnetics and geochronology of the formation, and Benson and Kittleman (1968) analysed the structure of the flow layering in the rhyodacite at the dam.

Bryan (1929) first mapped and described the underlying porphyritic rhyodacite unit. Kittleman (1962) included the unit in his Barstovian Jump Creek Rhyolite based on stratigraphic and petrologic similarities. Kittleman and others (1965, 1967), however, mapped the rhyodacite separately from the Jump Creek Rhyolite. Corcoran and others (1962) included the unit in the Barstovian Sucker Creek Formation. Field relationships observed during this study indicate that the rhyodacite intrudes the Sucker Creek Formation at the dam site.

DESCRIPTION OF MEASURED SECTION

Rhyodacite

The base of the measured section is dark-purple to gray rhyodacite that underlies the Owyhee Basalt and intrudes and nonconformably overlies the Sucker Creek Formation. The unit is intrusive at the dam site and forms thick flows that extend several miles south of the dam on the west bank of the reservoir. Associated and interfingering with the rhyodacite are ash-fall tuffs and lapilli-fall tuffs.

The rhyodacite is hypocrystalline and porphyritic, with

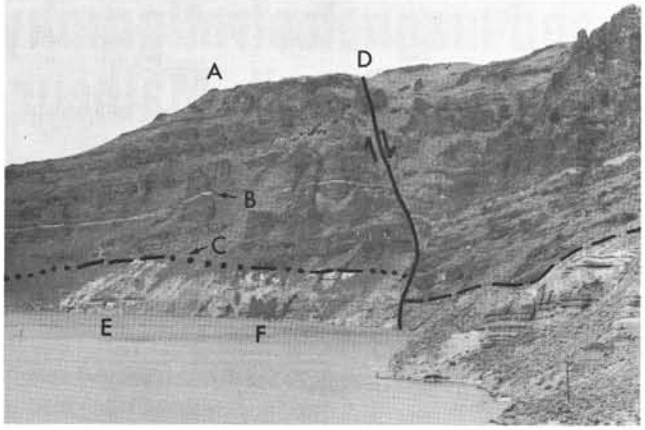


Figure 2. View of measured section. A = location of measured section; B = distinctive marker bed between flows 6 and 7; C = contact with underlying Sucker Creek Formation; D = normal fault with about 30 m of offset; E = intake structure for the Owyhee Irrigation Project; F = feeder dikes. Photo taken facing north from the east side of the reservoir.

large crystals of plagioclase and a little orthoclase. Some of the feldspars are embayed and others resorbed. The groundmass is glassy with small crystals of plagioclase and sanidine.

Owyhee Basalt

A thick sequence of conformable lava flows of the Owyhee Basalt nonconformably overlies the rhyodacite. Seventeen flows and ten interbeds with a total thickness of 254 m were measured. Further investigation is likely to show that there are more than seventeen flows contained in the formation. Kittleman (1962) described the Owyhee Basalt as being about 400 m thick at the dam, with as many as twelve flows present. Kittleman and others (1965), however, defined the type section on the west abutment, where they measured 357 m of section with twelve basalt flows. Watkins and Baksi (1974) reported sixteen flows but did not measure the thickness (Figure 4).

The Owyhee Basalt is generally light- to medium-gray aphyric basalt. The few phenocrysts are clinopyroxene surrounded by plagioclase laths. Sparse iddingstitized olivine crystals occur in the bottom few flows and are completely absent in the top of the sequence. The lavas are holocrystalline and ophitic. The texture is diabasic to felty, grading to pilotaxitic in the upper flows. Intergranular olivine is common in the groundmass in the lower flows but nearly absent in upper flows.

Figure 3. Typical jointing of Owyhee Basalt. Photo taken facing north from below Owyhee Dam.

This description agrees closely with Corcoran (1953), Kittleman (1962), and Kittleman and others (1965, 1967), all of whom described the unit as an aphanitic, generally olivine-free basalt. Porter (1953), however, described the unit in the Owyhee Ridge area as a diabasic basalt that contains as much as 18 percent olivine. Porter (1953) may have been describing only the lowest flows in the stack or may have confused the Owyhee Basalt with flows of younger olivine basalts mapped by Kittleman (1962) and by Kittleman and others (1967) on the south end of the Owyhee Ridge.

The Owyhee Basalt lava flows are scoriaceous to vesicular, with flow breccias common at the base. Columns are rare, and the outcrops are usually platy to rubbly (Figure 3). A few of the flows are massive to blocky, and some formed pillows where they flowed into water.

There are ten interbeds that are commonly dark-red to purple basaltic scoria and agglomerate. Several thicker interbeds may actually be mudflows. Kittleman and others (1965) also measured several interbeds that they described as mainly scoria or volcaniclastic rocks. These volcaniclastic units perhaps correlate with the mudflows described in this report (Figure 4).

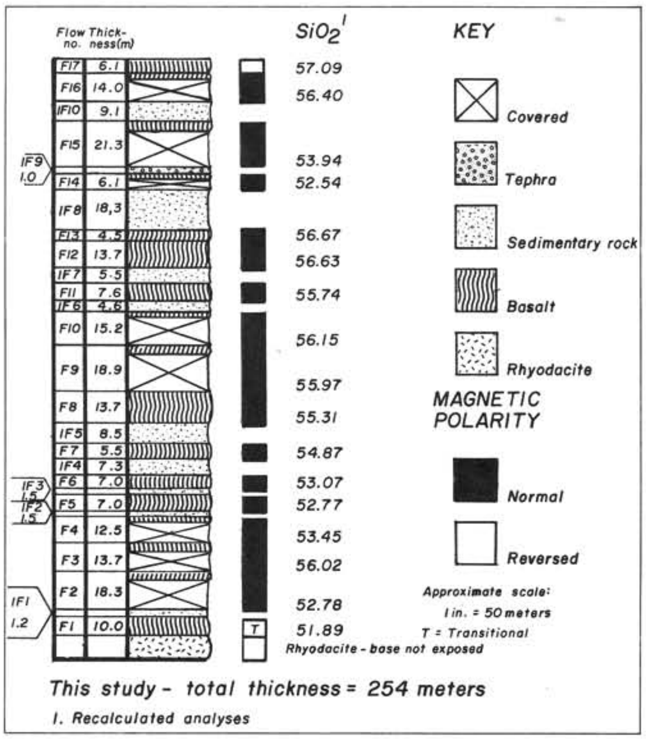


Figure 4. Stratigraphic column showing thickness of Owyhee Basalt flows and interbeds and SiO_2 content and magnetic polarity of basalt flows.

Dikes

The dikes that were sampled crop out near the measured section (Figure 1). None were traced upward into a particular flow, though they disappear within the overlying Owyhee Basalt sequence. The contacts are baked and glassy, and the form of the dikes is very sinuous, following the jointing habit of the Sucker Creek mudflows and other sediments. Only the unaltered cores of thick dikes were sampled. In many places, the dikes pass into sills that extend only a few meters from the dikes. The thicknesses of the dikes range from several centimeters to several meters.

The dikes are massive or vesicular, with jointing both parallel and at right angles to the contact. All of the dikes stand out in positive relief against the softer, more easily eroded Sucker Creek Formation. In some cases (Figure 3), the dikes have been left as free-standing basaltic "walls" several tens of meters high.

The dikes are aphyric, holocrystalline to hypocrystalline, and ophitic, with felty to diktytaxitic texture. Four dikes have intergranular olivine in the groundmass and may be related to the lower flows of the Owyhee Basalt. The fifth dike is free of olivine and may be related to the upper flows.

GEOCHEMISTRY

Each of the seventeen lava flows and five of the dikes were sampled and analyzed for major oxides and trace elements. The results of these analyses are presented in Table 1. Also plotted on Figure 5 are results of analyses by Kittleman and others (in preparation).

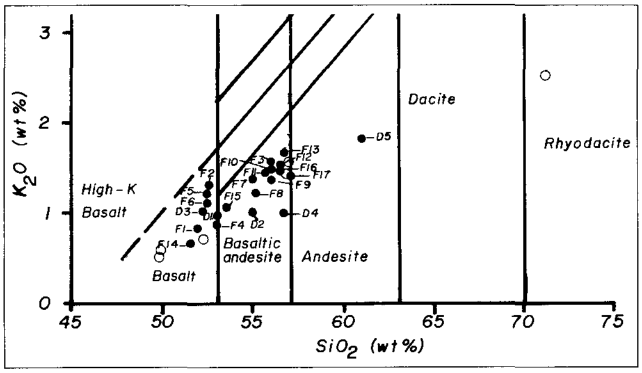


Figure 5. K_2O vs. SiO_2 volcanic rock classification chart. Fields from Priest (1980). Solid circles indicate analyses of samples from this study; open circles are analyses from Kittleman and others (in preparation).

MAJOR ELEMENTS

All of the flows and dikes plot on the K_2O vs. SiO_2 diagram (Figure 5) as basalt or basaltic andesite, except for dike sample D-5, which plots in the andesite field. The SiO_2 content tends to increase over time (F-1 comes from the bottom flow and F-17 the uppermost flow), a tendency that was recognized by Kittleman (1962) and Kittleman and others (1965). Three exceptions are flow samples F-5, F-14, and F-15, which are less silicic than the underlying flows.

A plot of FeO/MgO vs. SiO_2 (Figure 6) indicates that the samples, with the exception of dike sample D-5 and flow sample F-15, plot in two fields. Generally, samples from flows 6 and older form one cluster, while samples from flow 7 and the younger flows form another. Younger flows, with the exception of flows 14 and 15, are within the calc-alkaline field, and lower flows are within the tholeiitic field. A plot of FeO vs. SiO_2 (Figure 7) also shows the two groups, as well as decreasing FeO in the uppermost flows. As in Figures 5 and 6, samples D-5, F-14, and F-15 are the only exceptions. A plot of Al_2O_3 vs. normative plagioclase (Figure 8) also shows that all of the samples within the calc-alkaline field clustered loosely into two groups.

Figure 9 (total alkalies [$Na_2O + K_2O$] vs. SiO_2) places all of the flows and most of the dikes within the high-alumina basalt field. It also shows the loose grouping of upper flows and the lower flows, except for dike samples D-1 and D-4.

An AFM diagram (Figure 10) shows all of the dikes and flows within the calc-alkaline field. Again, there is the suggestion of a two-cluster arrangement, with D-5, F-14, and F-15 being aberrant.

Fields for other eastern Oregon basalts are presented on Figures 6 through 9. The field for Basin and Range basalts (which includes the Steens Basalt from Gunn and Watkins, 1970) was taken from Hart (1982) and includes basalts ranging in age from 0.25 to 15.04 m.y. The field for the Columbia River

Table 1
Major Oxide, Trace Element Analysis and
Normative Composition of the Owyhee Basalts[1]

SAMPLE NUMBER	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	D1	D2	D3	D4	D5
Major Oxides (wt%)																						
SiO_2	50.33	51.48	55.50	51.92	51.54	51.54	53.85	54.39	55.50	55.34	54.60	55.93	55.44	50.00	52.50	55.27	56.69	49.92	52.88	50.77	54.62	60.55
TiO_2	1.47	1.70	1.24	1.54	1.63	1.21	1.24	1.13	1.09	1.20	1.19	0.96	1.27	1.30	.96	1.04	1.08	1.04	1.11	1.52	1.01	0.76
Al_2O_3	16.54	15.97	16.14	15.56	16.03	16.19	16.69	16.80	16.81	16.53	16.77	16.77	16.69	16.45	17.29	16.72	17.40	16.41	16.65	16.24	16.39	16.54
Fe_2O_3	6.82	7.39	4.07	7.90	5.98	7.21	5.57	5.49	3.37	4.52	4.35	3.27	5.68	8.00	8.97	4.78	4.02	5.81	4.17	7.89	4.91	2.58
FeO	3.08	2.58	3.95	2.35	3.82	2.78	3.00	2.94	4.77	3.66	3.77	4.49	2.37	1.10	0.36	3.03	3.02	2.51	3.70	2.20	2.35	2.94
MnO	0.14	0.15	0.15	0.16	0.16	0.17	0.15	0.13	0.15	0.15	0.15	0.15	0.13	0.24	0.20	0.13	0.14	0.15	0.16	0.15	0.11	0.12
MgO	5.64	5.08	4.63	5.07	5.15	4.91	4.58	4.68	4.72	4.30	4.46	4.46	3.79	5.36	3.65	4.23	4.35	5.42	4.51	5.31	4.23	3.01
CaO	8.19	8.64	8.17	8.55	8.75	8.61	8.21	8.24	7.71	7.76	7.60	7.52	7.25	8.99	9.06	7.62	7.52	8.65	8.48	8.84	8.49	5.77
Na_2O	3.61	3.25	3.58	3.16	3.20	3.30	3.37	3.37	3.50	3.56	3.57	3.59	3.57	3.20	3.57	3.60	3.72	2.54	3.36	3.29	3.00	3.81
K_2O	0.78	1.23	1.48	0.89	1.18	1.10	1.34	1.17	1.35	1.41	1.42	1.44	1.63	0.65	1.00	1.44	1.33	0.87	0.97	1.00	0.96	1.80
H_2O+	0.81	0.65	0.53	0.82	0.72	0.67	0.72	0.65	0.38	0.31	0.61	0.40	0.66	1.39	0.61	0.51	1.14	2.84	1.37	0.64	2.69	0.61
H_2O-	1.92	1.44	1.02	2.07	1.40	1.35	1.39	1.13	0.66	0.52	0.77	0.57	1.20	2.68	1.21	1.22	0.78	4.12	2.00	1.67	2.69	0.61
P_2O_5	0.59	0.59	0.39	0.60	0.61	0.60	0.51	0.36	0.33	0.39	0.33	0.33	0.39	0.48	0.47	0.43	0.27	0.39	0.40	0.59	0.36	0.22
Total	100.64	100.15	100.85	100.59	100.17	99.64	100.62	100.48	100.34	99.65	99.59	99.88	100.07	99.84	99.85	100.02	101.46	100.67	99.76	100.11	100.88	99.84
Tot.Fe[2]	9.65	9.62	7.83	9.90	9.58	9.72	8.32	8.14	8.02	7.99	7.99	7.67	7.78	8.97	8.87	7.61	6.83	8.45	7.92	9.72	7.16	5.49
Trace Elements (ppm)																						
Ba	538	571	673	586	602	639	693	630	679	702	709	731	691	634	631	699	743	589	653	560	537	1037
Co	41	38	35	35	46	45	40	36	42	37	36	41	33	35	60	38	40	37	43	46	35	46
Cr	107	112	86	106	97	95	79	96	96	75	80	79	74	102	121	88	85	120	71	121	73	42
Cu	53	57	100	55	55	59	51	55	49	41	44	44	51	58	52	55	36	64	52	52	48	48
Li	19	21	12	15	10	15	16	15	11	14	11	9.9	15	18	14	12	12	10	11	13	8.5	9.6
Ni	77	78	46	74	70	71	59	41	48	45	48	45	48	68	65	61	49	92	46	79	42	35
Rb	13	22	21	11	20	15	25	17	18	17	24	23	29	11	8.7	25	19	11	19	9.4	24	0.43
Sr	518	502	501	510	562	538	551	528	496	538	510	528	518	55	544	576	576	494	496	518	532	443
Zn	101	101	96	107	112	99	96	89	86	92	87	90	85	90	89	88	85	90	37	107	83	66
Catanorms																						
Ap	1.27	1.27	0.82	1.30	1.31	1.29	1.09	0.76	0.69	0.830	0.705	0.69	0.83	1.05	1.01	0.91	0.56	0.87	0.87	1.27	0.78	0.47
Il	2.11	2.44	1.74	2.22	2.34	1.74	1.76	1.60	1.53	1.702	1.695	1.35	1.81	1.90	1.38	1.48	1.51	1.55	1.61	2.18	1.47	1.08
Mt	2.42	2.42	1.95	2.49	2.41	2.43	2.08	2.04	2.00	1.999	1.996	1.91	1.95	2.22	2.21	1.90	1.69	2.11	1.97	2.44	1.80	1.36
Or	4.76	7.49	8.84	5.46	7.18	6.78	8.09	7.04	8.05	8.479	8.575	8.62	9.88	4.04	6.10	8.69	7.90	5.53	5.97	6.10	5.93	10.86
Ab	29.36	30.11	32.50	29.47	29.61	30.69	30.94	30.85	31.75	32.538	32.769	32.66	32.90	30.24	33.09	33.03	33.59	24.53	31.44	30.52	28.18	34.95
An	29.64	26.16	23.86	26.63	26.68	27.04	27.05	27.80	26.44	25.410	26.113	25.75	25.36	30.11	29.12	25.76	27.00	33.14	28.64	27.47	29.73	23.21
Qz	1.40	2.25	5.00	4.26	2.43	2.26	4.55	5.13	5.42	5.757	4.744	5.85	6.53	1.84	3.01	5.74	6.49	4.65	4.78	1.24	9.04	13.01
En	16.11	14.47	12.92	14.54	15.65	14.03	12.93	13.17	13.16	12.085	12.588	12.47	10.74	15.57	10.40	11.93	12.07	16.10	12.97	15.14	12.21	8.49
Fs	8.03	7.71	6.50	8.25	7.78	8.51	7.00	6.96	6.90	6.752	6.722	6.72	6.38	7.58	8.00	6.52	5.65	7.36	6.73	8.05	6.07	4.70
Fo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Di	9.69	11.27	11.64	10.68	11.15	10.50	8.95	9.16	8.02	8.951	8.186	7.91	7.16	10.83	11.30	8.00	6.99	8.22	9.98	11.08	9.49	3.65
Hy	19.80	16.55	13.61	17.45	16.86	17.30	15.45	15.54	16.06	14.334	15.218	15.24	13.54	17.74	12.76	14.46	14.23	19.34	14.71	17.66	13.54	11.37
Ol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D.I.[3]	35.53	39.87	46.35	39.19	39.22	39.66	43.59	43.04	45.23	46.774	46.083	47.13	49.32	36.12	42.21	47.46	47.98	34.72	42.19	37.87	43.15	58.83

1. Christine McBirney, University of Oregon; Analyst
2. Total Fe as Fe^{+2}
3. Thornton-Tuttle differentiation index

Basalt Group was taken from McDougall (1976). These fields are for comparison only to show that these lavas are not genetically related to the Owyhee Basalt.

Comparison of the fields indicates that the Owyhee Basalt differs from the Basin and Range and Columbia River basalts in that the Owyhee Basalt is more silicic and less iron rich than the other lavas. The only case of an overlap in compared fields is on the total alkali vs. SiO_2 diagram (Figure 8), where the most silicic flows of the Columbia River Basalt Group overlap the lower flow group of the Owyhee Basalt.

A trend in chemistry of the flows is apparent from our diagrams: There is a smooth increase in SiO_2 from flows 1 to 6. Then there is an increase of about 2.3 percent SiO_2 between flows 6 and 7, and a general increase of SiO_2 up to flow 14. At that point the SiO_2 drops back to 50.0 percent and begins to increase to 56.7 percent in flow 17. A well-recognized marker bed of light-brown sediments (Figures 2 and 4) was found between flows 6 and 7, and a mudflow and sediments occur between flows 13 and 14. Each of the changes in the SiO_2 content is associated with a probable hiatus in the eruptive sequence, evidenced by the volcaniclastic interbeds throughout the measured section.

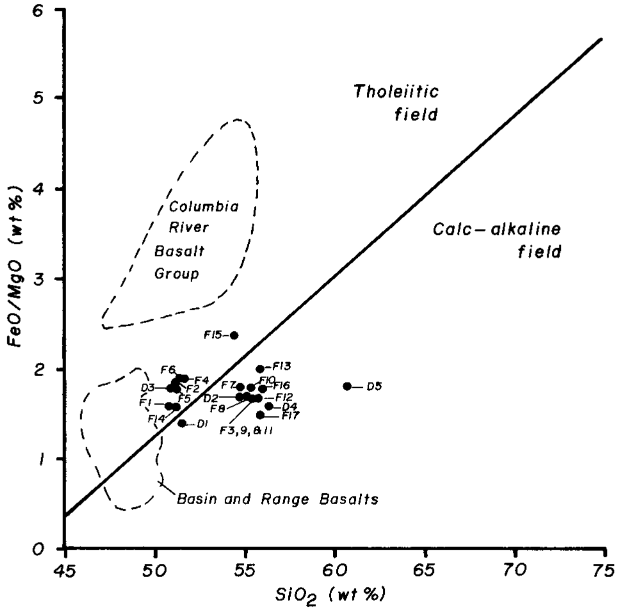


Figure 6. FeO/MgO vs. SiO_2. Fields from Miyashiro (1974). Columbia River Basalt Group data from McDougall (1976). Basin and Range basalt data from Hart (1982) include basalts ranging in age from 15 to 0.25 million years (m.y.).

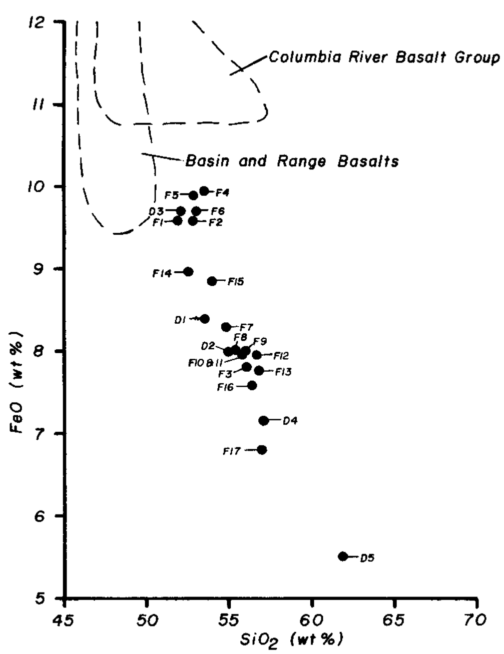


Figure 7. FeO vs. SiO_2. Total iron recalculated as FeO. Columbia River Basalt Group and Basin and Range basalt data from sources indicated in Figure 6.

TRACE ELEMENTS

Trace-element analyses are plotted and presented in Harker diagrams (Figure 11). The data plot within a narrow range, except for Cu in sample F-3, Co in sample F-15, and Cr in sample D-4.

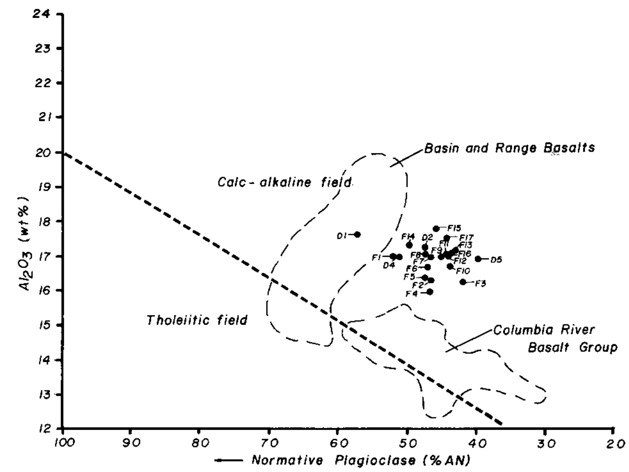


Figure 8. Al_2O_3 vs. normative plagioclase. Slope of boundary line from Irvine and Barager (1971). Columbia River Basalt Group and Basin and Range basalt data from sources indicated in Figure 6.

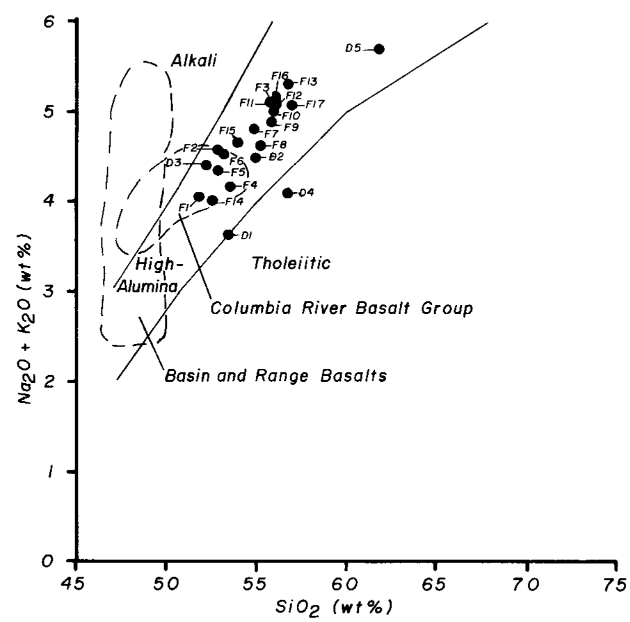


Figure 9. $Na_2O + K_2O$ vs. SiO_2. Alkali basalt and tholeiitic basalt fields of Macdonald and Katsura (1964) for Hawaiian rocks. Columbia River Basalt Group and Basin and Range basalt data from sources indicated in Figure 6.

Sample D-5 appears from inspection of the major-element data to be anomalous. The trace-element data indicate that sample D-5 is probably from a different parent magma than the rest of the samples. The Ba and Co values are much higher than those from the other analyses, and the Sr, Rb, and Cr are much lower. Rb is less than 1 part per million, which is extremely low.

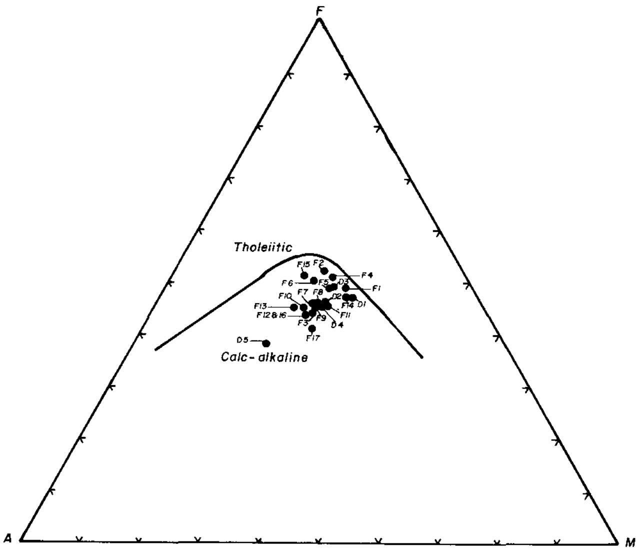


Figure 10. AFM ternary diagram. A = alkalies (Na_2O-K_2O); F = FeO; M = MgO. Tholeiitic — calc-alkaline boundary from Irvine and Barager (1971).

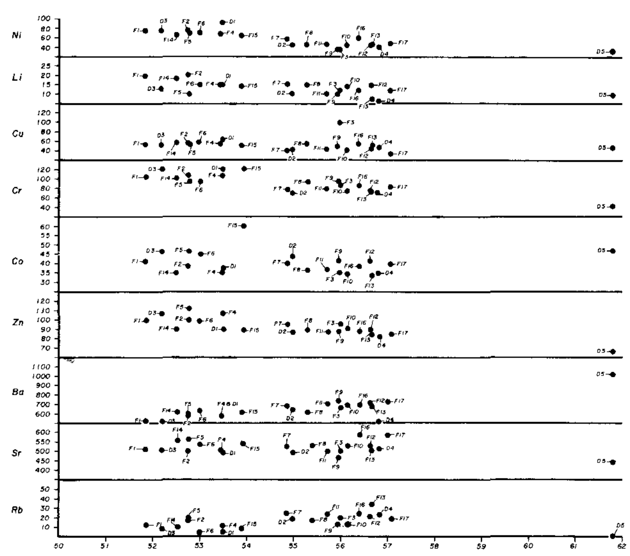


Figure 11. Trace-element diagram.

GEOCHRONOLOGY

Potassium-argon analyses from our study are given in Table 2 together with relevant K-Ar dates reported by Watkins and Baksi (1974). Stratigraphic relationships suggest that the K-Ar date on the rhyodacite at Owyhee Dam (Table 2, OBR-1) is too old. The Sucker Creek Formation intruded by the rhyodacite contains fossils that are of Barstovian age (about 16.5 to 12 m.y. old) (Chaney and Axelrod, 1959; Kittleman and others, 1965). Potassium-argon dates for the Sucker Creek Formation are near 15.5 m.y. B.P. (before the present) (Kittleman and others, in preparation). The high atmospheric ^{40}Ar in the rock sampled for this study may have resulted in an inaccurate date.

The uppermost flow of Owyhee Basalt that was measured yielded a K-Ar date of 15.3 m.y. (Table 2, OBF-17), somewhat older than dates reported by Watkins and Baksi (1974) (Table 2; Figure 12). Ranges of precision at one standard deviation do not overlap; however, the mean is near 14.5 m.y., which is close to the age for the Owyhee Basalt suggested by Kittleman and others (in preparation). This is in accord with paleontologic ages of underlying and overlying rocks which contain Barstovian fossils (Kittleman and others, 1965; Kittleman and others, in preparation).

Table 2. K-Ar ages

Sample no.	$\%K_2O$	$\%Atm^{40}Ar$	$Moles^{40}Ar^*$	Age (m.y.)[a]
Flow 5[b]	1.25	30.4	-	13.4±0.3
	1.25	34.5	-	13.3±0.3
Flow 16[b]	1.167	34.6	-	13.1±0.3
	1.167	87.1	-	16.4±0.3
	1.078	39.3	-	13.6±0.3
OBR-1[c]	0.44	88.0	-	22.8±2.6
OBF-17[c]	0.91	57.0	2.804×10^{11}	15.3±0.6

[a]K-Ar constants: $\lambda_\beta = 4.962 \times 10^{-10}/yr$; $\lambda_\varepsilon = 0.581 \times 10^{-10}/yr$; $K^{40}/K_t = 1.167 \times 10^{-4}/atm$.

[b]From Watkins and Baksi (1974), recalculated with new constants (Dalrymple, 1979).

[c]Obtained for this study. Analyses by Stanley Evans, University of Utah Research Institute.

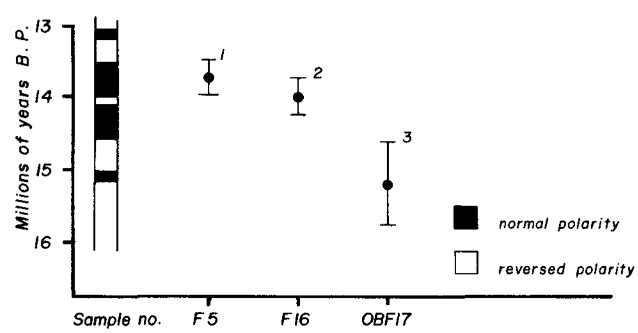


Figure 12. Age-correlation plot with magnetic polarity time scale of Ness and others (1980). 1. Watkins and Baksi (1974), normal polarity, 13.8±0.3 m.y. B.P. 2. Watkins and Baksi (1974), reversed polarity, 14.0±0.3 m.y. B.P. 3. This study, reversed polarity, 15.3±0.6 m.y. B.P.

MAGNETOSTRATIGRAPHY

Magnetic polarity of each flow was determined using a hand-held fluxgate magnetometer. At least three oriented samples were taken from the middle of each lava flow. Where weak or spurious readings were recorded, up to twelve oriented samples were measured at each outcrop.

The paleomagnetic polarity of the underlying rhyodacite is reversed. The polarity of the bottom flow (flow 1) of the Owyhee Basalt is transitional, with an equal number of readings of normal, reversed, and no meter deflection at all (Figure 4). Flows 2 through 16 have normal magnetic polarity, and flow 17 is reversed.

Watkins and Baksi (1974) report the same pattern. Their bottom two flows are transitional, the middle flows are normal, and the top flow is reversed. Their readings, however, were taken in the laboratory from oriented core samples. In addition, they measured sixteen flows, compared to seventeen flows measured in this study. This may be due to flow pinch-out, common in volcanic stratigraphy.

SUMMARY AND CONCLUSIONS

Samples were taken from seventeen lava flows and five dikes. Paleomagnetism of the flows and dikes was determined with a fluxgate magnetometer. Two K-Ar age determinations were made, and 22 samples were analyzed geochemically. Thin sections from the samples were also examined with a petrographic microscope. The underlying rhyodacite was also sampled and tested.

The Owyhee Basalts are fine-grained, holocrystalline, ophitic basalts to basaltic andesite. Olivine is sparse in the lower flows and absent in the upper ones. The groundmass is diabasic to felty, with the upper flows becoming pilotaxitic.

The Owyhee Basalt is high-alumina calc-alkaline basalt and basaltic andesite with major-oxide and trace-element chemistry dissimilar to the other regional basalt units of the area. The dikes sampled are chemically and microscopically similar to the Owyhee Basalt. Thus, with the exception of sample D-5, the dikes appear to be feeders for the Owyhee Basalt. Sample D-5 is an andesite and may be a feeder dike either for a younger unit that no longer exists on the ridges around the reservoir or for a siliceous flow of the Owyhee Basalt that was not sampled during this study. Changes in the chemistry coincide with thick interbeds. This may indicate the lavas were erupted in at least three or more episodes separated by significant amounts of time.

Age of the basalts is probably about 14.5 m.y. The eruption of the lavas appears to span a paleomagnetic epoch, with the bottom of the sequence being transitional, the middle flows normal, and the top flow reversed. Uncertainties in the K-Ar data make it difficult to assign the sequence to a specific magnetic epoch.

ACKNOWLEDGEMENTS

The study was undertaken as a task within a program of regional geothermal assessment supported by USDOE Cooperative Agreement No. DE-FC07-79ET27220. We thank Shannon and Wilson, Inc., of Portland for providing the fluxgate magnetometer and Laurence R. Kittleman and Albert F. Waibel for their critical review of this study. Further thanks must be extended to George R. Priest and Beverly F. Vogt of the Oregon Department of Geology and Mineral Industries for their patience and encouragement.

REFERENCES CITED

Benson, G.T., and Kittleman, L.R., 1968, Geometry of flow layering in silicic lavas: American Journal of Science, v. 266, no. 4, p. 265-276.

Bryan, K., 1929, Geology of reservoir and dam sites, with a report on the Owyhee Irrigation Project, Oregon: U.S. Geological Survey Water-Supply Paper 597-A, 72 p.

Buwalda, J.P., 1924, The age of the Payette Formation and the old erosion surface in Idaho: Science, v. 60, p. 572-573.

Chaney, R.W., and Axelrod, D.I., 1959, Miocene floras of the Columbia Plateau: Carnegie Institution of Washington Publication 617, 237 p.

Corcoran, R.E., 1953, The geology of the east-central portion of the Mitchell Butte quadrangle: Eugene, Oreg., University of Oregon master's thesis, 80 p.

Corcoran, R.E., Doak, R.A., Porter, P.W., Pritchett, F.I., and Privrasky, N.C., 1962, Geology of the Mitchell Butte quadrangle, Oregon: Oregon Department of Geology and Mineral Industries Geological Map Series GMS-2, scale 1:125,000.

Dalrymple, G.B., 1979, Research note: Critical tables for conversion of K-Ar ages from old to new constants: Geology, v. 7, no. 11, p. 558-560.

Gunn, B.M., and Watkins, N.D., 1970, Geochemistry of the Steens Mountain Basalts, Oregon: Geological Society of America Bulletin, v. 81, no. 5, p. 1497-1515.

Hart, W.K., 1982, Chemical, geochronologic, and isotopic significance of low-K, high-alumina olivine tholeiite in the northwestern Great Basin, U.S.A.: Cleveland, Ohio, Case Western Reserve University doctoral dissertation, 410 p.

Irvine, T.N., and Baragar, W.R.A., 1971, A guide to the chemical classification of the common volcanic rocks: Canadian Journal of Earth Sciences, v. 8, no. 5, p. 523-548.

Kittleman, L.R., Jr., 1962, Geology of the Owyhee Reservoir area, Oregon: Eugene, Oreg., University of Oregon doctoral dissertation, 174 p.

Kittleman, L.R., Green, A.R., Haddock, G.H., Hagood, A.R., Johnson, A.M., McMurray, J.M., Russell, R.G., and Weeden, D.A., 1967, Geologic map of the Owyhee region, Malheur County, Oregon: Eugene, Oreg., University of Oregon Museum of Natural History Bulletin 8, scale 1:125,000.

Kittleman, L.R., Green, A.R., Hagood, A.R., Johnson, A.M., McMurray, J.M., Russell, R.G., and Weeden, D.A., 1965, Cenozoic stratigraphy of the Owyhee region, southeastern Oregon: Eugene, Oreg., University of Oregon Museum of Natural History Bulletin 1, 45 p.

Kittleman, L.R., Milhollen, G.L., Leeman, W.T., and Davis, D.A., in preparation, Neogene volcanism and chronology of the Owyhee Upland, northwestern Great Basin, Oregon.

Macdonald, G.A., and Katsura, T., 1964, Chemical composition of Hawaiian lavas: Journal of Petrology, v. 5, pt. 1, p. 82-133.

McDougall, I., 1976, Geochemistry and origin of basalt of the Columbia River Group, Oregon and Washington: Geological Society of America Bulletin, v. 87, no. 5, p. 777-792.

Miyashiro, A., 1974, Volcanic rock series in island arcs and active continental margins: American Journal of Science, v. 274, no. 4, p. 321-355.

Ness, G., Levi, S., and Couch, R., 1980, Marine magnetic anomaly timescales for the Cenozoic and Late Cretaceous: A precis, critique, and synthesis: Reviews of Geophysics and Space Physics, v. 18, no. 4, p. 753-770.

Newton, V.C., Jr., and Corcoran, R.E., 1963, Petroleum geology of the western Snake River basin, Oregon-Idaho: Oregon Department of Geology and Mineral Industries Oil and Gas Investigation 1, 67 p.

Porter, P.W., 1953, Geology of the lower Sucker Creek area, Mitchell Butte quadrangle, Oregon: Eugene, Oreg., University of Oregon master's thesis, 81 p.

Priest, G.R., 1980 [compl. 1979], Geology and geochemistry of the Little Walker volcanic center, Mono County, California: Corvallis, Oreg., Oregon State University doctoral dissertation, 253 p.

Renick, B.C., 1930, The petrology and geology of a portion of Malheur County, Oregon: Journal of Geology, v. 38, no. 6, p. 481-520.

Smith, H., 1932, The fossil flora of Rockville, Oregon: Eugene, Oreg., University of Oregon master's thesis, 41 p.

Watkins, N.D., and Baksi, A.K., 1974, Magnetostratigraphy and oroclinal folding of the Columbia River, Steens, and Owyhee basalts in Oregon, Washington, and Idaho: American Journal of Science, v. 274, no. 2, p. 148-189. □

Pacific Northwest Metals and Minerals Conference to be held in April

Ray Lasmanis, Washington State Geologist and chairman of the 1985 Pacific Northwest Metals and Minerals Conference, has announced that the conference will be held April 25-27 at the historic Davenport Hotel in Spokane, Washington. The theme for the conference is Recovery '85. More information regarding the program and registration can be obtained from registration chairman Jim Spear, U.S. Bureau of Mines, East 360 3rd Street, Spokane, WA 99202. □

Papers invited for Mount St. Helens symposium

Eastern Washington University announces a symposium, "Mount St. Helens, Five Years Later," to be held May 16-18, 1985, in Cheney, Washington. Interested persons are invited to submit papers on physical science related to current and previous eruptions of Mount St. Helens; the social, psychological, and economics of the eruptions; and volcanology. Papers must be submitted by March 15, 1985. For additional information on the symposium, contact: Eastern Washington University, Five Years Later, University Conference Center, Louise Anderson Hall, Cheney, WA 99004. □

OSHD, PGE are co-winners of 1984 Reclamation Award

by Paul F. Lawson, Supervisor, Mined Land Reclamation Program, Albany Field Office, Oregon Department of Geology and Mineral Industries

The 1984 Award for the Outstanding Mined Land Reclamation Project went to two nominees, the Oregon State Highway Division (OSHD) and Portland General Electric Company (PGE). In what is expected to remain a rare situation, the selection committee determined that both operators deserved the award for their accomplishments in 1984.

On December 3, 1984, in St. Helens, Oregon, the author, acting on behalf of and before the Governing Board of the Oregon Department of Geology and Mineral Industries (DOGAMI), presented awards to Charles Goodwin, Jr., Vice President, Thermal Operations, PGE, and Douglas Green, Engineer and Project Manager in the Eugene office of OSHD.

PGE was honored for the reclamation of its proposed Pebble Springs nuclear site in Gilliam County. The initial excavation was for exploratory purposes. The site was found to be satisfactory and would have become the construction site for PGE's Pebble Springs nuclear power generation plant upon approval of the project. However, the site was not used and was returned to productive grazing land.

PGE's reclamation plan provided that if the site was not used for construction, it would be restored by partial backfilling and blending into the adjacent terrain. Approximately 12 acres were affected by the exploratory activities; 6 acres required intensive reclamation efforts, since they contained the main excavation consisting of two large trenches. The first cut was nearly ½ mi long, up to 400 ft wide, and approximately 40 ft deep. A second trench over 600 yd long crossed the first. Both cuts were benched.

In the reclamation, topsoil was shoved back from the edges of the cuts for some distance; then the cuts were filled by blading, pushing, and compacting, so that slopes shallower than 3 ft horizontal to 1 ft vertical were created. The topsoil, then, was respread, and a good, moderate drainage was established. Fertilizer and seed were applied as recommended by a representative of the Soil Conservation Service. In each case, the amounts used were greater than suggested. Seed was applied professionally by drill.

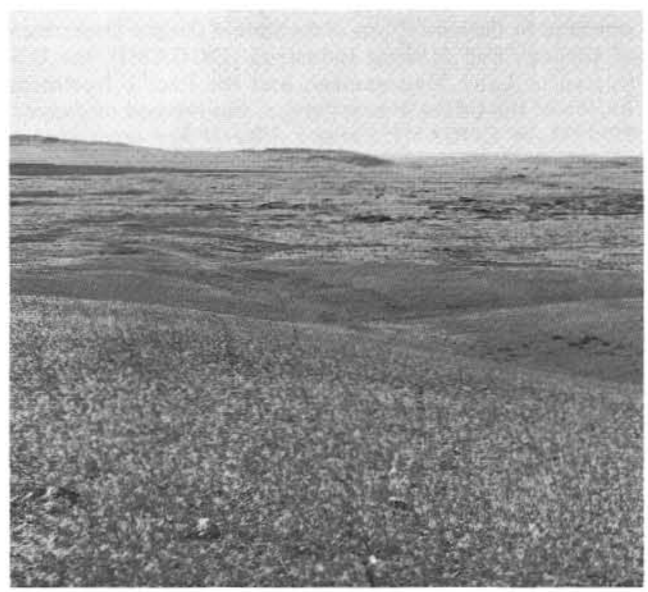
In addition, a number of scattered small test pits were filled and reseeded. Now the site is more productive as grazing land than the adjacent areas and shows no sign of erosion. Total cost of the reclamation project is reported to be near $75,000, with much of that sum spent on the above-mentioned 6 acres.

OSHD reclaimed approximately 16 acres of a basalt quarry on Rattlesnake Butte, south of Cottage Grove, Lane County. About 10 of these acres were exempt from reclamation, since they had been mined before the reclamation law existed. However, the Highway Division voluntarily included them in the reclamation project.

As readers familiar with hard-rock quarries know, such sites are difficult and present a real challenge to reclamation. It is to OSHD's credit that, through careful site development and the saving of much, if not all, of the available material for resoiling, it was able to reclaim the site with gentle slopes, excellent stands of grasses on much of the site, and a minimum of bare or sparsely covered rock. Even some incipient landsliding stemming from an earlier period appears to have been stabilized, and no drainage or erosion problems are apparent. Since this site is surrounded by forest, we can anticipate a natural succession of recovery, with brushy plants, trees, and accompanying wildlife. The cost of reclamation, calculated from the reported deployment of equipment alone, must have exceeded $5,000 per acre.

While OSHD was the permittee and accountable party in this reclamation project, its contracting firm, Peter Kiewit and Sons, deserves commendation for the manner in which it fulfilled the conditions of the contract. Finally, it is well worth noting that the same Eugene office of OSHD was a runner-up for this award in 1983 with another of its reclamation sites.

Exploratory excavation at PGE Pebble Springs nuclear reactor site. Two trenches with maximum dimensions of approximately ½ mi long, 400 ft wide, and 40 ft deep, before reclamation was begun. (Aerial photo courtesy PGE)



PGE's former proposed nuclear reactor site at Pebble Springs after reclamation. Approximately 275,000 cu yd of material was moved in an affected area of 6 acres. View is to southwest. (MLR photo)

The runner-up among the 1984 nominees was the Washington County Department of Public Works. The agency may not have won, but it made big winners of the citizens of Washington County by the efficient management of approximately 15 acres of the county's Durham quarry, which is still being mined. This site in the southwest portion of the Portland metropolitan area and just west of Interstate Highway I-5 is located in a region of intensive development. The 15 acres, which were all mined before the reclamation law existed, were exempt from mandatory reclamation and so were reclaimed voluntarily. Yet, this example shows how the rewards can justify voluntary reclamation.

After at least half a million and perhaps more than one million cubic yards of rock had been mined from this part of the Durham quarry for county use, the area was backfilled with dry demolition waste, left to settle, and eventually sold for over $1.2 million to development interests. Citizens of the county have profited and will continue to profit from this operation in numerous ways: from the rock used in road and street building and maintenance and in various other ways; from the availability of an essential landfill site; from the sale of the land; from the tax revenue generated by acreage that is now very valuable and by the improvements and businesses on the land; and, in many cases, from the economic stimulus and the services available through the presence of the offices and businesses now resident on this land.

These selections were made by a committee composed of one representative each from the mining industry, environmental interest groups, and Oregon's Mined Land Reclamation Program. The purposes of the award program are to (1) recognize and commend the outstanding example of mined land reclamation and the operator performing it, (2) acknowledge and praise other operators and their projects which were nominated and considered for the annual award, and (3) encourage and further the goal of sensible mined land reclamation, both mandatory and voluntary. In making its decision, the selection committee considered these criteria: (1) Compliance with the approved reclamation plan (when reclamation is mandatory), (2) imagination and/or innovativeness in accomplishing the planned reclamation, (3) future value of the site, (4) appropriateness to the local environment, (5) safety, and (6) aesthetics.

Oregon State Highway Division reclamation site on Rattlesnake Butte, a basalt quarry that yielded approximately 500,000 cu yd of rock. An area of 16 acres was reclaimed successfully. View is toward west. (MLR photo)

Oregon's Mined Land Reclamation Act was established in 1972 to insure that mined land is left reasonably safe and nonpolluting and particularly that it is prepared for a future beneficial use. Beyond the limits of the law's applicability, the State of Oregon encourages and assists any operator considering to undertake voluntary reclamation. To date, over 1,400 acres in Oregon have been reclaimed to agriculture, forestry, housing, industrial, recreation, wildlife habitat, and other uses.

Nominations for the Outstanding Mined Land Reclamation Project Award are invited at any time from anyone with knowledge of a deserving project. Such nominations should be sent to Mined Land Reclamation Program, 1129 SE Santiam Road, Albany, Oregon 97321, or communicated by phone to (503) 967-2039. □

New mineral resource map of Oregon available

A comprehensive map of Oregon's mineral resources, produced by the joint efforts of the State of Oregon Department of Geology and Mineral Industries (DOGAMI), the U.S. Bureau of Land Management, and the Pacific Northwest Region of the USDA Forest Service, was released on January 17, 1985, by DOGAMI. Entitled *Mineral Resources Map of Oregon*, it was published as map GMS-36 in DOGAMI's Geological Map Series.

Present on the occasion of the joint release of the new Mineral Resources Map of Oregon *were (from left) Paul M. Vetterick, Associate State Director, U.S. Bureau of Land Management, Oregon-Washington; Donald A. Hull, Oregon State Geologist; and Carlin B. Jackson, Director of Lands and Minerals, USDA Forest Service, Pacific Northwest Region. (Photo courtesy U.S. Bureau of Land Management)*

The new six-color map was produced at a scale of 1:500,000 and is approximately 42 by 59 inches large. Principally a nontechnical publication intended for use by the general public, it graphically depicts Oregon's known mineral resources as of the end of 1983. It is also intended to aid federal, state, and local authorities in assessing the impact of land use planning on mineral exploration and development and to serve as a guide to private industry in identifying areas favorable for discovery of new mineral deposits.

The map was compiled by DOGAMI geologist M.L. Ferns and U.S. Geological Survey (USGS) staff member D.F. Huber using the computerized resource data systems of the USGS and the U.S. Bureau of Mines, various published and unpublished reports, and information provided by private industry. Funded in part by the U.S. Bureau of Land Management and the USDA Forest Service, the map shows mineral producers and known localities of gold, silver, nickel, copper, chromite, mercury, tungsten, antimony, cobalt, molybdenum, manganese, iron, bentonite, silica, limestone, diatomite, clay, perlite, asbestos, zeolite, coal, natural gas, and uranium. Also printed on the map are short discussions of Oregon's mineral resources, a list of 110 metallic-mineral producers with significant past production, and a compilation of historical mineral-production data.

The new map, GMS-36, is now available at the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, 1400 SW 5th Ave., Portland, OR 97201. The purchase price is $8. Orders under $50 require prepayment. □

AVAILABLE DEPARTMENT PUBLICATIONS

GEOLOGICAL MAP SERIES

		Price	No. copies	Amount
GMS-4:	Oregon gravity maps, onshore and offshore. 1967	$ 3.00		
GMS-5:	Geologic map, Powers 15-minute quadrangle, Coos and Curry Counties. 1971	3.00		
GMS-6:	Preliminary report on geology of part of Snake River canyon. 1974	6.50		
GMS-8:	Complete Bouguer gravity anomaly map, central Cascade Mountain Range, Oregon. 1978	3.00		
GMS-9:	Total-field aeromagnetic anomaly map, central Cascade Mountain Range, Oregon. 1978	3.00		
GMS-10:	Low- to intermediate-temperature thermal springs and wells in Oregon. 1978	3.00		
GMS-12:	Geologic map of the Oregon part of the Mineral 15-minute quadrangle, Baker County. 1978	3.00		
GMS-13:	Geologic map, Huntington and part of Olds Ferry 15-min. quadrangles, Baker and Malheur Counties. 1979	3.00		
GMS-14:	Index to published geologic mapping in Oregon, 1898-1979. 1981	7.00		
GMS-15:	Free-air gravity anomaly map and complete Bouguer gravity anomaly map, north Cascades, Oregon. 1981	3.00		
GMS-16:	Free-air gravity anomaly map and complete Bouguer gravity anomaly map, south Cascades, Oregon. 1981	3.00		
GMS-17:	Total-field aeromagnetic anomaly map, south Cascades, Oregon. 1981	3.00		
GMS-18:	Geology of Rickreall, Salem West, Monmouth, and Sidney 7½-min. quads., Marion/Polk Counties. 1981	5.00		
GMS-19:	Geology and gold deposits map, Bourne 7½-minute quadrangle, Baker County. 1982	5.00		
GMS-20:	Map showing geology and geothermal resources, southern half, Burns 15-min. quad., Harney County. 1982	5.00		
GMS-21:	Geology and geothermal resources map, Vale East 7½-minute quadrangle, Malheur County. 1982	5.00		
GMS-22:	Geology and mineral resources map. Mount Ireland 7½-minute quadrangle, Baker/Grant Counties. 1982	5.00		
GMS-23:	Geologic map, Sheridan 7½-minute quadrangle, Polk/Yamhill Counties. 1982	5.00		
GMS-24:	Geologic map, Grand Ronde 7½-minute quadrangle, Polk/Yamhill Counties. 1982	5.00		
GMS-25:	Geology and gold deposits map, Granite 7½-minute quadrangle, Grant County. 1982	5.00		
GMS-26:	Residual gravity maps, northern, central, and southern Oregon Cascades. 1982	5.00		
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