

GEOLOGIC ANALYSIS OF THE PORTLAND HILLS- CLACKAMAS RIVER ALIGNMENT, OREGON

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Introduction

The striking linear east face of the Portland Hills (Tualatin Mountains) passes southeastward into co-linear segments of the Clackamas River. An analysis of the fault-like lower Clackamas portion of this alignment was completed in 1971 as part of a master's thesis (Schmela, 1971).

Because the nature of the linearity in the lower Clackamas River area is obscured by overlying lava flows, alluvium, and vegetation, indirect morphologic and geophysical methods were required to study it. As discussed below, the analysis of morphologic and structural alignments, geological relationships, and gravity magnetic data strongly suggest the presence of a northwest-trending fault in this area.

Previous Work

The origin of the linear eastern front of the Portland Hills has long been a subject of debate. Diller (1915) and Treasher (1942) both noted the Portland Hills linearity and believed it to be a possible fault. Trimble (1963) studied the Portland area and concluded that there was no evidence of a major fault fronting the Portland Hills or along the Clackamas River. Schlicker and Deacon (1967), however, show a segment of a major regional fault fronting the Portland Hills.

Balsillie and Benson (1971) support the concept of a fault along the northeast face of the Portland Hills on the basis of a structural interpretation of the columnar jointing in the Columbia River Basalt. Briefly, they infer the orientation of the flow surfaces from the orientation of the columnar jointing. The flow surfaces, in turn, indicate vertical offsets along the eastern front of the ridge, a relationship which Balsillie and Benson attribute to faulting.

First-motion studies of Portland earthquakes have been conducted by Dehlinger and Berg (1962), Westphal (1962), Dehlinger and others (1963),

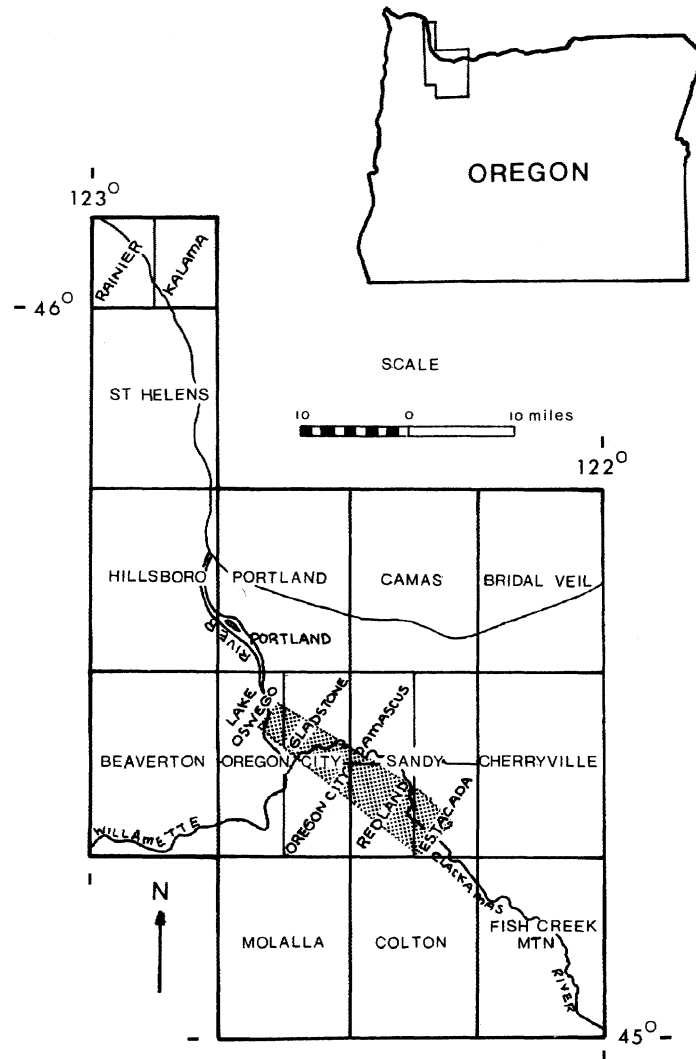


Figure 1. Location map showing quadrangles included in morphologic alignment study. Area of geophysical investigation indicated by shading.

Schlicker and others (1964), and Heinrichs and Pietrafesa (1968). These studies present evidence in support of one or more northwesterly trending faults in the Portland area.

Morphologic and Structural Alignments

Method

Analysis of linear landforms was performed to evaluate morphological alignments for structural significance. Twelve 15-minute and two 7½-minute quadrangle maps (Figure 1) were analyzed for quantitative distribution of length and orientation of alignments. Geologic maps were similarly evaluated for orientation of faults and fold axes. Structural alignments were compared to the morphological orientations.

Faults, joints, and bedding commonly form morphological alignments by the process of differential erosion. Linear landforms including straight stream segments, ridge crests, and linear breaks in slope angle, are easily recognized and are not subject to significant interpreter bias.

Following standard procedures rose diagrams were assembled for the purpose of interpreting the linear geomorphic features. As shown in Figure 2 linear landforms exceeding a preselected length were plotted for each of the quadrangles in the study area. The length and orientation of the lineations were then tabulated and graphically assembled on rose diagrams (Figure 3). Figure 4 is a composite of the rose diagrams for each of the quadrangles, and emphasizes the prominent northwesterly trend of the linear geomorphic features in the study area.

Analysis

Anomalies from a random distribution are believed to reflect underlying structural alignments. In the region studied, the morphologic rose diagrams, Figures 3 and 4, show that 50 percent of all the alignments trend northwest; nearly 25 percent trend N. 20° W. and N. 40° W.; 21 percent form other secondary trends oriented N-S, E-W, and N. 50-60° E. The prominent northwesterly trend is present even in the quadrangles nearest the west flank of Mt. Hood, where a dominant east-west trend from consequent drainage would be expected to mask regional trends. A strong structural framework underlying the Portland area is indicated by the consistency and prominence of the northwesterly morphologic trend in all quadrangles.

The northwest trend is further supported by the orientation of known faults (Figure 5) and fold axes in the area and by seismic first-motion studies. Approximately 60 percent of the known mapped faults and fold axes concur with the dominant northwest morphologic trend of N. 40° W.; 22 percent trend N. 40-50° E.; and 17 percent trend in the N-S orientation. The structural alignments coincide very closely to the morphological

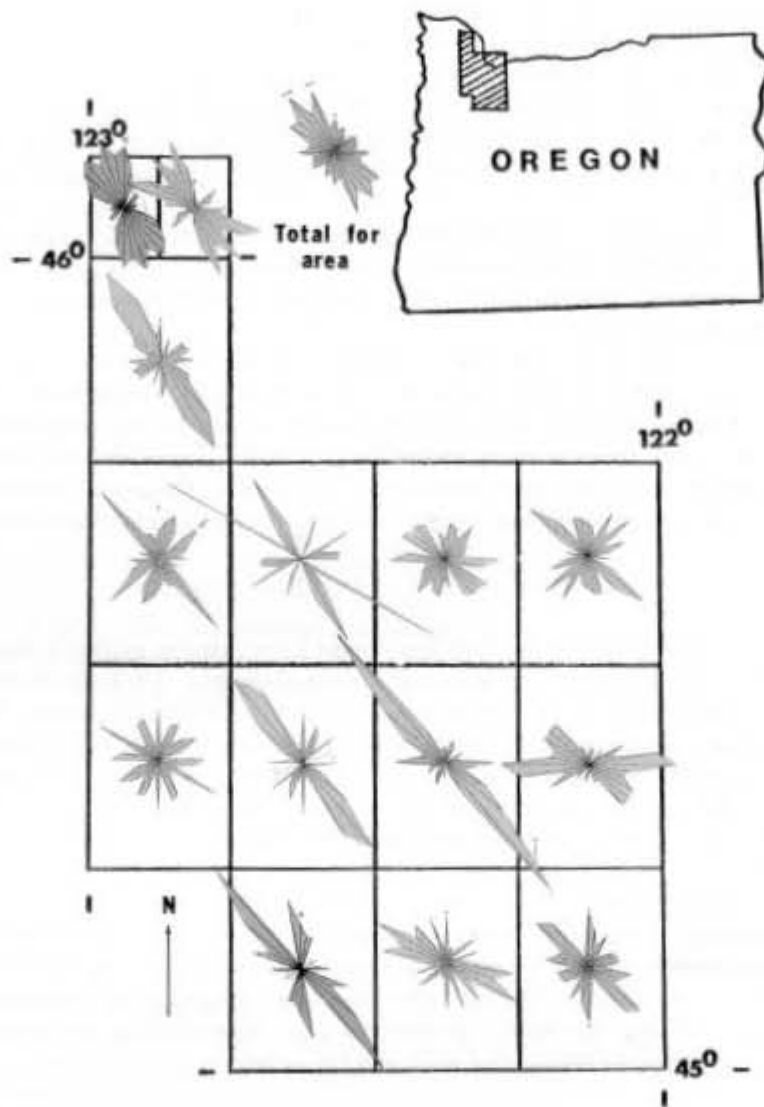


Figure 3. Orientation-length distribution of morphologic alignments measured in individual quadrangle sheets. Quadrangle names are listed on the location map, Figure 1.

alignments. Seismic first-motion analyses of the November 5, 1962 Portland earthquake suggest a motion source of a northwest-trending, right-lateral strike-slip fault. The motion data, however, also fit a northeast-trending, left-lateral strike-slip fault (Dehlinger and others, 1963). Westphal (1962) suggested that the seismic activity was related to the Portland Hills fault. Gallagher (1969) indicates that the motion occurred along a normal fault striking N. 54°E. or along a right-lateral strike-slip fault striking N. 12°W. Gallagher believed the data were most consistent with the N. 54° E. trending fault.

In summary, the dominant morphologic and geologic trends are consistent, sympathetic and parallel as determined by morphology, structure, and seismicity. The Portland Hills-Clackamas River alignment parallels the most prominent trend.

The preferred northwest orientation of the morphologic alignments is not in itself conclusive evidence for interpretation of the geologic structure. This statistical analysis method is intended as a preliminary indicator of probable structural features to guide geologic studies. However, the consistency and parallelism of geologic and seismic alignments strengthen the interpretation that it represents a geologic structural trend of major significance.

Geologic Investigations

Geologic cross sections developed from existing geologic maps and from all available well log data were made (Schmela, 1971) in an attempt to test the possibility of offsets along the Portland Hills-Clackamas River alignment. Cross sections show 120 to 195 feet of possible east-side-down faulting or folding of units across the Portland Hills-Clackamas River alignment. Generally, the map and well data are not sufficient in themselves to determine conclusively the nature of the subsurface structure along the alignment.

Entrenchment of the Clackamas River into Quaternary terrace deposits provides evidence for recent rejuvenation of the Clackamas River. The entrenchment is probably caused by tectonic uplift which may still be in progress. The downcutting may also have been caused or accentuated by a change in stream regimen by non-tectonic processes such as an increase in stream competency associated with glacial retreat.

Structure

Broad northwest-trending synclines and anticlines typify the Portland-lower Clackamas River area. Surface evidence for offset of geologic units to verify faulting is obscured by more recent volcanic units and alluvium and by the presence of a thick soil cover.

A broad synclinal downwarp in the Columbia River Basalt underlies the lower Clackamas River area. The basalt is downfolded to a depth of

Figure 4. Summary of all orientation-length distribution of morphologic alignments. Area within circle represents the area of random alignment orientation. Scale: 1"=4%

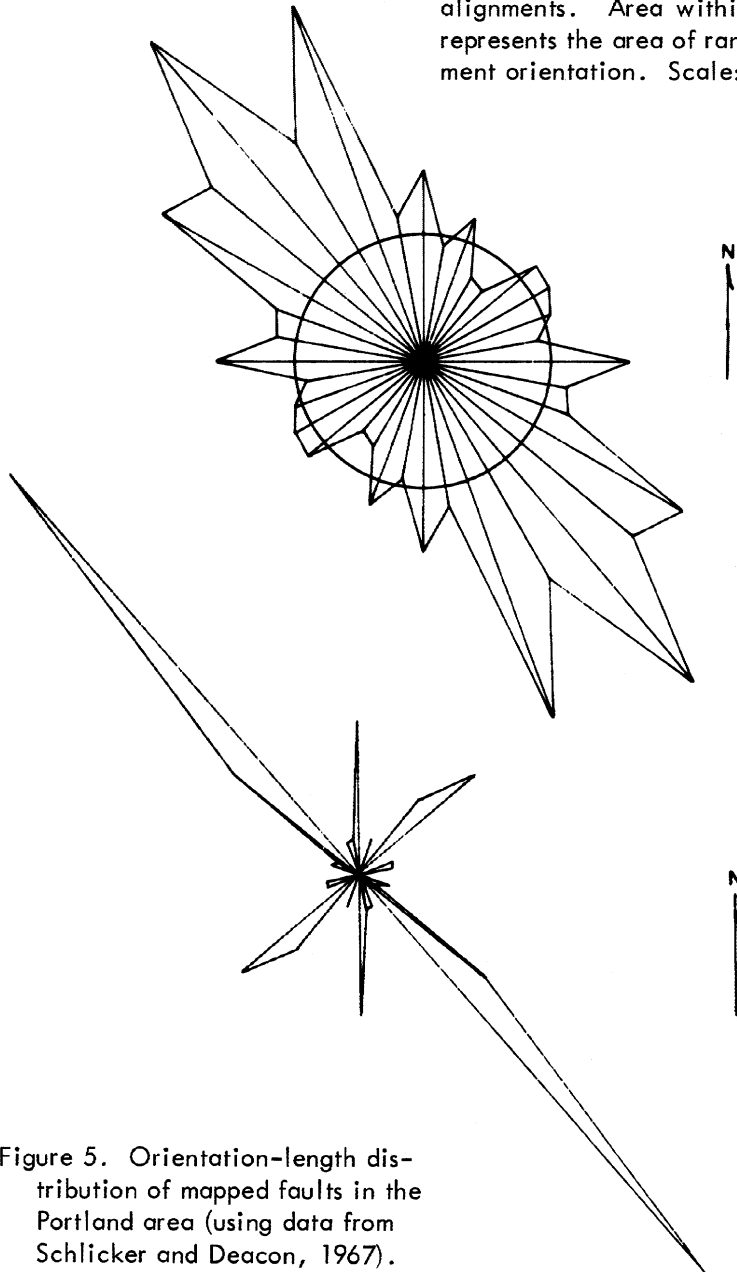


Figure 5. Orientation-length distribution of mapped faults in the Portland area (using data from Schlicker and Deacon, 1967).

about 60 feet below sea level in the area a few miles east of Oregon City (Wells and Peck, 1961). Farther north in the Portland area, the Ladd well (39th and Glisan Streets) encountered basalt downfolded to a depth of at least 1070 feet below sea level. The inferred top of the Columbia River Basalt horizon is upwarped to elevations of 1000 to 1200 feet along the Portland Hills anticline.

Schlicker and Deacon (1964) indicate that a major normal fault separates the eastern side of the Portland Hills from the syncline under Portland. Balsillie and Benson (1971) present evidence for more than 700 feet of offset north of downtown Portland.

Geophysical Evidence

Gravity data

Gravimetric information was obtained from six gravity traverses, averaging three miles in length, with a total of 166 gravity stations. It was believed that an anomaly might exist in this locality due to either a fault or a steep fold in the Columbia River Basalt.

Gravitational anomalies result from lateral variations in the gravitational pull of the earth caused by contrasting near-surface densities. The negative Bouguer anomalies in all traverses show the regional influence of low density Cascade Range volcanic rocks in causing a 2.5 milligal/mile decrease in gravity to the southeast (Berg and Thiruvathukal, 1967). The Bouguer values obtained in this study are in close agreement with the Oregon gravity map and show the steadily westward decreasing negative anomaly that suggests a westward rising of the Columbia River Basalt. Well log data support this conclusion.

In addition, the detailed gravity traverses of this study show an average 2.18 milligals/0.2 mile gravity downdrop to the east, coincident with the morphologic alignment. The gravity change is consistent in direction and amplitude and defines a zone of possible faulting or steep folding aligned with the southeasterly extension of the Portland Hills fault.

Magnetic data

Magnetic data were obtained from three traverses, averaging two miles in length, with a total of 50 magnetic stations. The magnetic traverses revealed a consistent abrupt change in the magnetic gradient across the morphologic alignment suggesting a structural feature, possibly a fault.

The methods used in conducting the geophysical traverses along with the data from the gravity, magnetic, and well logs are described by Schmela (1971, p. 69-113). The gravity and magnetic stations are plotted as cross profiles, correlated to surface geology, and are contained in the map pocket of that thesis.

State-wide alignment

Alignments on a state-wide scale support local interpretation. Preliminary trends recognized from studies in progress (by the authors) on morphological alignments of the state of Oregon and by studies conducted by Dr. John E. Allen on alignments of volcanic eruption centers in the Portland area (Allen, personal communication, 1971) are compatible with the dominant trends recognized in this study.

A series of co-aligned linear morphologic features trending N. 40-50° W. extends over 300 miles southeasterly across the state of Oregon. The regional features line up with the Portland Hills-Clackamas River trend and include segments of the Metolius River, Crooked River, and the southern edge of Hampton Buttes. The alignment is readily seen on the state 1:250,000 plastic relief map series.

The geologic map of Oregon (Walker and King, 1969) shows numerous faults with a general trend of N. 40-50° W. occurring along the above mentioned trend. The Brothers fault zone is one segment of the co-linear features (Higgins and Waters, 1967) and is believed to be a reflection of a deeply buried fault with lateral displacement (Walker, 1969). Furthermore, several volcanic vents are concentrated along this segment of the state-wide alignment (Walker and King, 1969).

We believe these features indicate that a major fault system which includes the Portland Hills-Clackamas River structural alignment extends for considerable distances across much of Oregon.

Origin of alignments

The mechanism and time of origin of the structural alignments is not well known. A major northwest-southeast structural alignment in the state of Washington has been shown by Mackin and Cary (1965) to be a result of the folding of the Eocene Weaver Plain. They indicate that these recent alignments are trends controlled by the ancestral Calkins Range, a range dominant during Oligocene time in the Pacific Northwest.

It is possible that the trends we see today in the Portland-Clackamas River area were first developed in older underlying rock units and that they have been regenerated in the overlying younger rock units by more recent sympathetic deformation.

Conclusions

It is concluded that the Portland Hills-Clackamas River alignment is part of a major structural fault system which extends across the state of Oregon to the southeast as far as Steens Mountain. A series of regionally co-aligned morphologic and structural features striking N. 40-50° W. are aligned with the Portland Hills-Clackamas River alignment. Surface and

subsurface geology and gravity and magnetic data in the Portland region all support this interpretation.

The morphologic and structural alignments in the Portland region are significant indicators of underlying geologic structure. The consistency of the dominant northwesterly morphologic trends, N. 20° W. and N. 40° W., is considered to be a reliable structural indicator because the known faults and fold axes present a matching dominant northwest orientation when statistically plotted. The dominant local northwest trends are suggestive of underlying geologic control, possibly remnants of the Oligocene Calkins Range. The alignments, including the secondary northeast trends, may reflect continued or renewed deformation along these pre-established structures.

In the Portland area, the geologic information derived from map and well data generally lack any definitive evidence concerning the specific nature of subsurface structural feature which controls the morphologic alignment. The gravity traverses present a consistent Bouguer anomaly across the alignment which suggests possible fault or fold displacements in the Columbia River Basalt. Magnetic anomalies coincident with the Portland Hills-Clackamas River alignment further support the presence of an underlying geologic structure.

Acknowledgments

Dr. Richard Blank aided greatly in the interpretation of the geophysical data. Appreciation is expressed to Robert J. Deacon, Dr. John E. Allen, and members of the Oregon Department of Geology and Mineral Industries for their criticism of this manuscript.

Geophysical instruments used in this study were loaned by Dr. Richard Couch, Oregon State University, and by Dr. Richard Blank, University of Oregon.

References Cited

- Balsillie, J. H., and Benson, G. T., 1971, Evidence for the Portland Hills Fault: Ore Bin, v. 33, no. 6, p. 109-118.
- Berg, J. W., Jr., and Thiruvathukal, J. V., 1967, Complete Bouguer gravity anomaly map of Oregon: Oregon Dept. Geology and Mineral Industries Map GMS-4b.
- Dehlinger, P., and Berg, J. W., Jr., 1962, The Portland earthquake of November 5, 1962: Ore Bin, v. 24, no. 11, p. 185-188.
- Dehlinger, P., Bowen, R. G., Chiburis, E. F., and Westphal, W. H., 1963, Investigations of the earthquake of November 5, 1962, north of Portland: Ore Bin, v. 25, no. 4, p. 53-68.

- Diller, J. S., and others, 1915, Guidebook of the western United States, pt. D, The Shasta route and coast line: U.S. Geol. Survey Bull. 614, 146 p.
- Gallagher, J. N., 1969, A method for determining the source mechanism in small earthquakes, with application to the Pacific Northwest region: Oregon State Univ. doctoral dissert., 187 p., unpub.
- Heinrichs, D. F., and Pietrafesa, L. J., 1968, The Portland earthquake of January 27, 1968: Ore Bin, v. 30, no. 2, p. 37-40.
- Higgins, M. W., and Waters, A. C., 1967, Newberry caldera, Oregon: a preliminary report: Ore Bin, v. 29, no. 3, p. 37-60.
- Mackin, J. H., and Cary, A. S., 1965, Origin of Cascade landscapes: Washington Div. Mines and Geology Inf. Circ. no. 41, 35 p.
- Schlicker, H. G., Deacon, R. J., and Twelker, N. H., 1964, Earthquake geology of the Portland area, Oregon: Ore Bin, v. 26, no. 12, p. 209-230.
- Schlicker, H. G., and Deacon, R. J., 1967, Engineering geology of the Tualatin Valley region, Oregon: Oregon Dept. Geology and Mineral Industries Bull. 60, 103 p.
- Schmela, R. J., 1971, Geophysical and geological analysis of a fault-like linearity in the Lower Clackamas River area, Clackamas County, Oregon: Portland State Univ., master's thesis, 113 p., unpub.
- Treasher, R. C., 1942, Geologic history of the Portland area: Oregon Dept. Geology and Mineral Industries short paper 7, 17 p.
- Trimble, D. E., 1963, Geology of Portland, Oregon and adjacent areas: U.S. Geol. Survey Bull. 1119, 119 p.
- Walker, G. W., 1969, Geology of the High Lava Plains province, in Mineral and water resources of Oregon: Oregon Dept. of Geology and Mineral Industries Bull. 64, p. 77-79.
- Walker, G. W., and King, P. B., 1969, Geologic map of Oregon: U.S. Geol. Survey, Map I-595. (Scale 1:2,000,000)
- Westphal, W. H., 1962, Seismic aftershock investigations--Project Vela, Portland, Oregon, earthquake of November 6, 1962: Stanford Research Institute, Tech. Rpt. 1, 11 p.

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GEOCHRONOLOGY OF THE CLARNO IGNEOUS ACTIVITY IN THE MITCHELL QUADRANGLE, WHEELER COUNTY, OREGON

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Introduction

Detailed mapping of the geology of the Mitchell quadrangle by Oles and Enlows (1971) led to the discovery that those rocks lying above the Cretaceous and below the John Day Formation which Merriam (1901) had referred to his Clarno Formation might best be termed a "group." Two sequences of rock, each ascribed to the Clarno in the Mitchell quadrangle, are separated by an angular unconformity. The authors, therefore, referred to the two sequences informally as Lower Clarno and Upper Clarno.

The Lower Clarno consists of about 4000 feet of andesite flows and intrusions, basaltic intrusions, volcanic breccia and tuffaceous sediments. The Upper Clarno consists of 2000 feet of similar andesite flows, mudflows, tuffaceous sediments, and dikes of both basaltic and andesitic composition chiefly associated with Keyes Mountain, an exhumed Oligocene volcano.

Although separated by an angular unconformity, the lithology, petrography and chemistry of all Clarno flows are so similar that they are considered comagmatic.

Procedure and Analytical Techniques

In order to determine the time span of Clarno volcanic activity in the Mitchell quadrangle, a sequence of samples was collected, including specimens from the oldest and the youngest flows, dike rocks, and two of the older plug intrusions. To these can be added two Clarno samples collected by R. L. Hay and reported in Evernden, et al. (1964).

Sample KA 818 collected by Hay near the center of the SW $\frac{1}{4}$ sec. 8, T. 11 S., R. 21 E. is described as, "Pyroxene andesite from 100 foot lava flow about 100 feet above base of a 400 foot series of flows forming the uppermost part of the Clarno Formation (approximately 5000 feet of Clarno here)." Although collected near the top of the Clarno sequence in this location, it is actually near the top of the lower Clarno as defined by Oles and Enlows (1971). Sample KA 824A was collected by Hay from a bentonite claystone 20 feet thick which underlies KA 818.

Three samples of the John Day Formation collected in the Mitchell area by Hay and reported by Evernden et al. (1964) have been used in an attempt to define the top of the Clarno.

K-Ar dates for all the rock specimens mentioned above, both Clarno and John Day, are listed in Tables 1 and 2.

Clarno specimens were processed at the Kline Geology Laboratory of Yale University of Donald Parker. Mineral separates were recovered from the 40- to 100-mesh sieve fraction of crushed rock using a vibrating shape sorter, magnetic separators, and heavy liquids. Whole rock samples were prepared by crushing the rock and recovering the 5-mesh material for the Ar analysis. The material was then further ground for the K analysis.

The K analyses were done with a model 303 Perkin-Elmer atomic absorption spectrophotometer using a Na-Li alkali buffer. The Ar analysis was done by typical isotope dilution analysis procedures in the static mode on a modified Nier type 60° sector mass spectrometer (Armstrong, 1970). The total analytical error is given with the dates in Table 2.

Table 1 illustrates the time span of Clarno igneous activity in the Mitchell quadrangle. Lowermost Clarno rests on Cretaceous strata of Cenomanian age. Clarno igneous activity lasted for about 16 million years, from about 46 million years before present to 30 million years before present. Apparently deposition of the John Day Formation began very soon after extrusion of the last Upper Clarno flow. In the northwestern part of the Mitchell quadrangle the John Day Formation rests with angular discordance on a regolith-mantled terrane of Lower Clarno flows. Unfortunately in the southeastern part of the quadrangle where John Day rests upon Upper Clarno the contact is poorly exposed and the relationships of the units are obscure. Both formations are gently inclined. John Day, however, does rest upon an irregular Upper Clarno topography, and occasional inliers of Upper Clarno interrupt the John Day cover.

Summary

In the Mitchell quadrangle for a period of 16 million years, from approximately 46 to 30 million years before present, a series of hornblende and/or hypersthene andesite flows of markedly similar texture and composition with associated dikes and volcanic-derived sediments built up a rock mass some 6000 feet thick. A basal sequence, informally termed Lower Clarno, is apparently of upper Eocene (Uintan and Duchesnean) age. Sometime in the period between 37.5 and 32.7 million years ago in lowermost Oligocene (Chadronian) time, these rocks were subjected to orogenic activity and major folds were produced. Following or during the period of orogeny, weathering and dissection formed a topography of considerable relief upon which was deposited a younger sequence of similar flows and volcanic-derived sediments (informally termed Upper Clarno) approximately 2000 feet thick. This second period of volcanic and sedimentary activity lasted until about 30 million years before present and was immediately succeeded by the deposition of the extensive volcanoclastic sediments of the John Day Formation.

Table 1. Geochronology of the Clarno Rocks of the Mitchell Quadrangle

Epoch	Time in millions of years before present	Clarno rocks	John Day rocks near Mitchell	Age	North American land mammal stages
MIOCENE (lower)	-20-				
	-25-		Upper tuff Mid. ignimbrite	24.9my* 25.3my*	Arikareean -- 25.6 --
OLIGOCENE	-30-	Nelson Creek dikes		29.4my	Whitneyan -- 29 ? --
	-35-	Keyes Mtn. flows Airport dikes	Lower John Day tuff	31.1my* 32.7my 33.3my	Orellan -- 31.6 --
		Lower Clarno bentonite**		36.5my*	Chadronian -- ? --
		Uppermost Lower Clarno flow		37.5my*	
	-40-	White Butte (whole rock)		40.5my	Duchesnean -- 40 --
EOCENE	-45-	Lowermost Lower Clarno flow Marshall Butte		43.3my 44.8my	Uintan -- 45.4 --
	-50-	White Butte (hornblende)		46.1my	
	-55-				

Time scale after Harland, W. B., et al., 1964

* From Evernden, et al., 1964

** Stratigraphically below uppermost Lower Clarno flow

*** Orogeny occurred sometime between 37.5 and 32.7 million years ago

=== Precise boundaries between Epochs unknown

Acknowledgments

The authors thank Richard L. Armstrong of Yale University for the use of his equipment and for his technical assistance.

Table 2. K-Ar dates on Clarno and John Day rocks
of the Mitchell quadrangle

EMT-11

Material: Diabase dike, whole rock analysis
 Locality: Nelson Creek, sec. 2, T. 12 S., R. 21 E.
 Stratigraphy: Cuts Cretaceous sedimentary rocks and upper Clarno flows
 Data first analysis:
 K = 0.8810, 0.8750, 0.8660 Avg. = 0.8740%
 Ar 40/38 = 0.52722
 Age = 29.3317 \pm 0.5866 m.y.
 Data second analysis:
 K = 0.8810, 0.8750, 0.8660 Avg. = 0.8740%
 Ar 40/38 = 0.60354
 Age = 29.4461 \pm 0.5889 m.y.

M-859

Material: Diabase dike, whole rock analysis
 Locality: West of landing strip, sec. 26, T. 11 S., R. 21 E.
 Stratigraphy: Cuts Cretaceous sedimentary rocks
 Data first analysis:
 K = 0.8360, 0.8280, 0.8250 Avg. = 0.8297%
 Ar 40/38 = 1.5636
 Age = 33.4757 \pm 1.2738 m.y.
 Data second analysis:
 K = 0.8360, 0.8280, 0.8250 Avg. = 0.8297%
 Ar 40/38 = 1.48080
 Age = 33.2966 \pm 1.2327 m.y.

KFO-901

Material: Andesite flow, whole rock
 Locality: Keyes Creek, SW $\frac{1}{4}$ sec. 32, T. 11 S., R. 22 E.
 Stratigraphy: Upper Clarno flow off Keyes Mountain
 Data first analysis:
 K = 0.1290, 0.1310 Avg. = 0.1300%
 Ar 40/38 = 0.17265
 Age = 35.5886 \pm 3.4077 m.y.
 Data second analysis:
 K = 0.1290, 0.1310 Avg. = 0.1300%
 Ar 40/38 = 0.22100
 Age = 30.0923 \pm 4.7059 m.y.

Table 2. Continued

W-3-58

Locality: White Butte SE $\frac{1}{4}$ sec. 17, N $\frac{1}{2}$ sec. 20, T. 12 S., R. 21 E.

Stratigraphy: Intrudes Cretaceous sedimentary rocks and Lower Clarno volcanic breccia

- A. Material Hornblende from hornblende andesite
 Data K = 0.4710, 0.4880 Avg. = 0.4795%
 Ar 40/38 = 0.21901
 Age = 46.1110 \pm 3.9601 m.y.
- B. Material Hornblende andesite, whole rock
 Data K = 1.5100, 1.4900 Avg. = 1.5000%
 Ar 40/38 = 1.96280
 Age = 40.5524 \pm 0.9020 m.y.

KFO - 1112

Material: Andesite, whole rock

Locality: Bridge Creek, sec. 21, T. 11 S., R. 21 E.

Stratigraphy: Lower Clarno flow, initial Clarno deposition in this region

Data first analysis:

K = 0.9250, 0.9500 Avg. = 0.9375%
 Ar 40/38 = 0.89660
 Age = 42.3114 \pm 0.8462 m.y.

Data second analysis:

K = 0.9250, 0.9500 Avg. = 0.9375%
 Ar 40/38 = 0.99160
 Age = 43.3548 \pm 0.8671 m.y.

KFO - 1702B

Material: Melabasalt, whole rock

Locality: Marshall Butte, sec. 29, T. 11 S., R. 22 E.

Stratigraphy: Intrudes Cretaceous sedimentary rocks, is overlain by Upper Clarno mudflows

Data first analysis:

K = 1.2000, 1.2000, 1.1900 Avg. = 1.967%
 Ar 40/38 = 1.07110
 Age = 45.0299 \pm 0.9006 m.y.

Data second analysis

K = 1.2000, 1.2000, 1.1900 Avg. = 1.967%
 Ar 40/38 = 1.10430
 Age = 44.8056 \pm 0.8961 m.y.

Table 2. Continued

*KA 818

Material: Pyroxene andesite, whole rock
Locality: Near center SW $\frac{1}{4}$ sec. 8, T. 11 S., R. 21 E.
Stratigraphy: Pyroxene andesite from 100-foot lava flow about 100 feet above base of 400-foot series of flows forming the uppermost part of the Clarno Formation

Data:

$$K = 0.972\%$$

$$A_{40}^{at} = 54\%$$

$$\text{Age} = 37.5 \text{ m.y.}$$

*KA 824A

Material: Sanidine
Locality: Near SE corner sec. 2, T. 11 S., R. 20 E.
Stratigraphy: Sanidine from a crystal-rich bentonite claystone 20-foot thick bed which underlies the pyroxene andesite of KA 818

Data:

$$K = (4.59 \pm 0.15)\%$$

$$A_{40}^{at} = 14\%$$

$$\text{Age} = 36.5 \pm 0.9 \text{ m.y.}$$

*KA 489

Material: Sanidine
Locality: NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, T. 11 S., R. 20 E.
Stratigraphy: From 8-foot sequence of tuffs interbedded 165 feet above base of John Day Formation, which is at least 2000 feet thick in this area. Bridge Creek flora well developed in beds both above and below tuff.

Data:

$$K = 5.71\%$$

$$A_{40}^{at} = 54\%$$

$$\text{Age} = 31.1 \text{ m.y.}$$

* Taken from Evernden, J. F., et al., 1964, Potassium-argon dates and the Cenozoic mammalian chronology of North America: Amer. Jour. Sci., v. 262, p. 145-198.

Table 2. Continued

*KA 648

Material: Obsidian
 Locality: SW $\frac{1}{4}$ sec. 31, T. 10S., R. 21 E.
 Stratigraphy: 1100 to 1135 feet above base of John Day Formation 1-inch lapilli (only interior fragments used for run) from widespread ignimbrite unit which has been commonly used to separate middle and upper members of John Day Formation, Early Arikarean fossils abundant below, Late Arikarean fossils above.
 Data:
 K = 4.51%
 A₄₀^{at} = 58%
 Age = 25.3 m.y.

*KA 649A

Material: K-albite
 Locality: SW corner sec. 29, T. 10 S., R. 21 E.
 Stratigraphy: Approximately 1550 feet above base of John Day Formation
 Data:
 K = 1.43%
 A₄₀^{at} = 70%
 Age = 24.9 m.y.

* Taken from Evernden, J. F., et al., 1964, Potassium-argon dates and the Cenozoic mammalian chronology of North America: Amer. Jour. Sci., v. 262, p. 145-198.

References

- Armstrong, R. L., 1970, Geochronology of Tertiary igneous rocks, eastern Basin and Range Province, western Utah, eastern Nevada, and vicinity, U.S.A.: *Geochimica et Cosmochimica Acta*, v. 34, p. 203-232.
 Evernden, J. F., Savage, D. E., Curtis, G. H., and James, G. T., 1964, Potassium-argon dates and the Cenozoic mammalian chronology of North America: *Amer. Jour. Sci.*, v. 262, p. 145-198.
 Harland, W. B., Smith, A. Gilbert, and Wilcock, Bruce (eds.), 1964, The Phanerozoic time-scale. A symposium dedicated to Professor Arthur Holmes: *Geol. Soc. London Quart. Jour.*, supp. v. 120S, 458 p.
 Oles, Keith F. and Enlows, Harold E., 1971, The bedrock geology of the Mitchell quadrangle, Wheeler County, Oregon: *Bull. 72, Oregon Department of Geology and Mineral Industries*, 62 p.

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"ENGINEER OF THE YEAR" HONORED

Harry Czyzewski, President of Metallurgical Engineers, Inc., has been selected as the 1972 "Engineer of the Year" by the Professional Engineers of Oregon. He was honored at the annual PEO meeting and awards banquet held at the Sheraton Hotel on May 12, 1972. The topic of the PEO meeting was "Involvement," which fits Harry Czyzewski to an "I."

Czyzewski organized MEI as a Metallurgical Consulting Engineer in 1946. He joined PEO in 1949. He served as president and is now chairman of the PEO Goals for Engineering Education Committee.

He is also active in the Consulting Engineers Council of Oregon and CEC-USA, American Foundrymen's Society, American Institute of Mining, Metallurgical & Petroleum Engineers, and American Society for Metals. He is a member and past president of the State Board of Engineering Examiners of Oregon, and a Fellow in the American Institute of Chemists.

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THREE GROUND WATER STUDIES IN OREGON PUBLISHED

Harney Valley

"Ground-water Resources in Harney Valley, Harney County, Oregon," by A. R. Leonard, has been published as Ground Water Report No. 16 by the Oregon State Engineer, in cooperation with the U.S. Geological Survey and Harney County Court. The 85-page bulletin discusses the geology, ground-water availability, quality of the water, uses, and other pertinent data including information on hot-water wells and springs. Accompanying the report are a generalized geologic map, an aquifer map, and a map showing variations in chemical quality of ground water. A limited number of copies of the report are available from the Oregon State Engineer in Salem.

Molalla-Salem slope area

"Geology and Ground Water of the Molalla-Salem Slope Area, Northern Willamette Valley, Oregon," by E. R. Hampton has been published by the U.S. Geological Survey as Water Supply Paper 1997. The 83-page report includes a summary of the geologic history of the area, descriptions of the geologic units, discussions of the distribution, quality, and quantity of ground water in the area, and basic well data. A geologic map and a map showing the thickness of the principal water-yielding units accompany the report. Water Supply Paper 1997 is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price is \$5.25.

Ashland area

"Availability and Quality of Ground Water in the Ashland Quadrangle, Jackson County, Oregon," by J. H. Robison, has been issued by the U.S. Geological Survey, in cooperation with the State Engineer and Jackson County, as Hydrologic Investigations Atlas HA-421. The Atlas is on one sheet 30 by 40 inches and includes a geohydrologic map, information on distribution of ground water in the various geologic units, data on chemical character of the water, and its chief uses. Atlas HA-421 is for sale by the U.S. Geological Survey for \$1.00.

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GEOLOGIC MAP OF BURNS AREA PRINTED

A preliminary, uncolored geologic map of the Burns and West Myrtle Butte 15-minute quadrangles, by R. C. Green, has been printed by the U. S. Geological Survey as Miscellaneous Field Studies Map MF-320. The map is to be incorporated into the AMS Burns sheet, which will be published in color at a later date. The area mapped lies mainly north and west of Burns in Harney County, and is occupied by Triassic(?), Jurassic, Tertiary, and Quaternary rocks. A copy of the map may be consulted at the Portland office of the Oregon Department of Geology and Mineral Industries.

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MINED LAND RECLAMATION LAW

On July 1, 1972 the Mined Land Reclamation Law goes into effect. All surface operations which remove more than 10,000 cubic yards of material or disturb more than two acres of land annually come under the law. The Department of Geology and Mineral Industries will administer the law in cooperation with various other state agencies and local governments. All operators subject to the law must obtain a permit. Forms will be available from the Department shortly before the first of July. Requests for permit application blanks or information concerning the law should be addressed to the Department at 1069 State Office Building, Portland 97201.

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