

# OREGON GEOLOGY

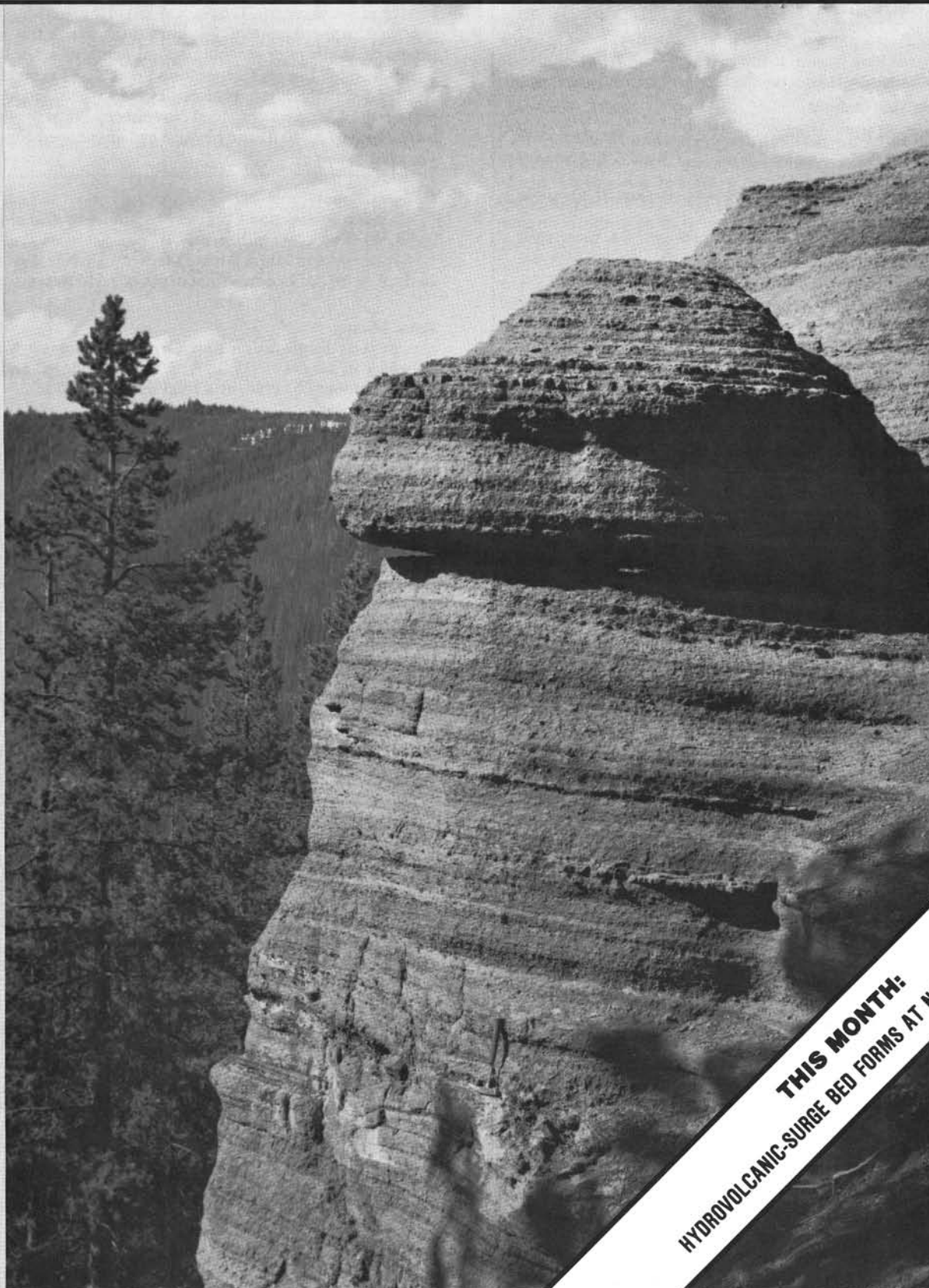
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**THIS MONTH:**  
HYDROVOLCANIC-SURGE BED FORMS AT NEWBERRY VOLCANO

# OREGON GEOLOGY

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## Information for contributors

*Oregon Geology* is designed to reach a wide spectrum of readers interested in the geology and mineral industry of Oregon. Manuscript contributions are invited on both technical and general-interest subjects relating to Oregon geology. Two copies of the manuscript should be submitted, typed double-spaced throughout (including references) and on one side of the paper only. Graphic illustrations should be camera-ready; photographs should be black-and-white glossies. All figures should be clearly marked, and all figure captions should be typed together on a separate sheet of paper.

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

Thinly bedded mafic tuff outcrop in the East Wall of Newberry caldera. Rock hammer gives scale. Article beginning on next page discusses some hydrovolcanic-surge bed forms found in this location.

# OIL AND GAS NEWS

## Columbia County — Mist Gas Field

Reichhold Energy Corporation Columbia County 23-4 in SW¼ sec. 4, T. 6 N., R. 5 W. was spudded November 17, 1984. The well was drilled to a total depth of 3,034 ft and was plugged and abandoned November 29, 1984.

Reichhold Energy Corporation Columbia County 23-36, located in SW¼ sec. 36, T. 6 N., R. 5 W., in the southeast part of the field, approximately 1¼ mi southeast of the nearest producer, is idle after reaching a total depth of 1,879 ft.

Reichhold Energy Corporation Polak 31-12 in sec. 12, T. 6 N., R. 5 W., in the east part of the field and approximately 2 mi due north of Mist was spudded November 1, 1984, drilled to a total depth of 2,750 ft, and plugged and abandoned November 12, 1984.

## Douglas County

Amoco Production Company continues to drill ahead on its 13,500-ft well, Weyerhaeuser "B" No. 1.

Hutchins and Marrs Great Discovery 2 in NW¼ sec. 20, T. 30 S., R. 9 W., drilled to a total depth of 3,510 ft, remains idle.

## Lane County

Leavitt Exploration and Drilling Company Maurice Brooks 1 in sec. 34, T. 19 S., R. 3 W., was plugged and abandoned October 25, 1984, at a total depth of 925 ft.

## Lincoln County

Damon Petroleum Company Longview Fibre 1, a reentry and deepening of Ehrens Petroleum Company Longview Fibre 1 in sec. 20, T. 9 S., R. 11 W., was plugged and abandoned November 29, 1984.

## Marion County

Oregon Natural Gas Development Corporation Werner 34-21 in sec. 21, T. 5 S., R. 2 W., was drilled to a total depth of 2,808 ft and suspended November 26, 1984. The drilling permit for this well was originally issued to Reichhold Energy Corporation.

## Wheeler County

Steele Energy Corporation Keys 1 in sec. 28, T. 9 S., R. 23 E., approximately 25 mi southeast of Fossil, is drilling ahead to a projected total depth of 8,000 ft.

## Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
281	Leavitt's Exploration Jackson 1 36-039-00006	NW¼ sec. 14 T. 19 S., R. 4 W. Lane County	Application; 3,000.
282	Leavitt's Exploration Jackson 2 36-039-00007	SE¼ sec. 11 T. 19 S., R. 4 W. Lane County	Application; 3,000.
283	ARCO Banzer 34-16 36-009-00136	SE¼ sec. 16 T. 6 N., R. 5 W. Columbia County	Location; 3,500.
284	ARCO Columbia County 44-21 36-009-00137	SE¼ sec. 21 T. 6 N., R. 5 W. Columbia County	Location; 3,500.

(Continued on page 9, *Oil and Gas News*)

# Hydrovolcanic-surge bed forms in the East Wall tuff deposit of Newberry Volcano, central Oregon

by Erick A. Bestland, Department of Geology, University of Oregon, Eugene, Oregon 97403

## ABSTRACT

Low-angle cross-stratification and dunelike structures believed to represent deposition by hydrovolcanic pyroclastic surges are present in the bedded basaltic tephra in the East Wall of Newberry Volcano, central Oregon. The hydrovolcanic surges were accompanied by eruption clouds that deposited associated air-fall tephra beds. Hydrovolcanic (phreatomagmatic) deposits indicate the presence of considerable amounts of water in the subsiding caldera at the time of eruption. One dune bed

form in the Newberry caldera wall is particularly well developed and is interpreted as an antidune with upcurrent dune-crest migration representing a single surge event. The bedding attitudes of the tuff deposit and the current direction indicated by the dune bed form suggest that the source vent for this tuff deposit was located in the northeast corner of the caldera.

## INTRODUCTION

Newberry Volcano (Figure 1), located in central Oregon on the east flank of the Cascade Mountains, is a large Quaternary shield volcano. A 6- to 8-km-wide caldera at the shield's summit contains Paulina and East Lakes along with a great variety of volcanic features on its floor and in its walls. The volcanic accumulations in the caldera include obsidian flows, rhyolite flows and tuffs, basaltic cinder cones, basalt and andesite flows, and mafic tephra beds (Higgins and Waters, 1968; Higgins, 1973; MacLeod and Sammel, 1982).

A well-bedded basaltic tephra unit exposed in the northern half of the East Wall of Newberry caldera (Figure 2) contains in some parts distinct low-angle cross-stratification and dunelike structures. This tuff unit crops out for 3/4 km along the East Wall, attaining a maximum thickness of about 40 m. The tuff

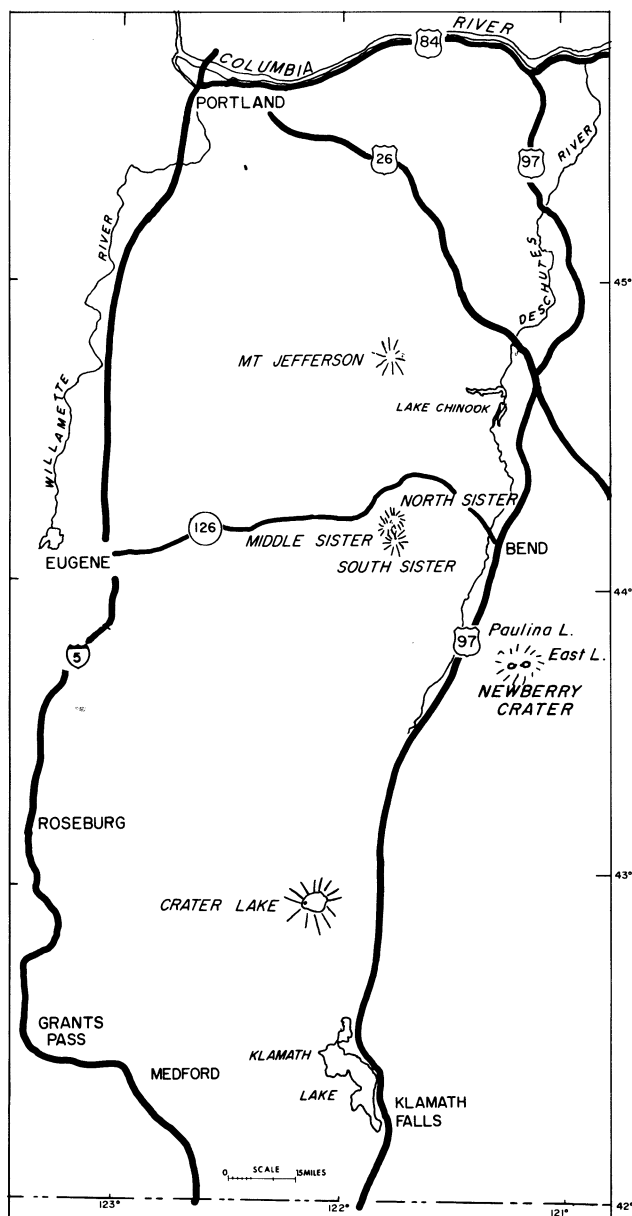


Figure 1. Location of Newberry Volcano and other major Quaternary volcanoes in the central Oregon Cascades.

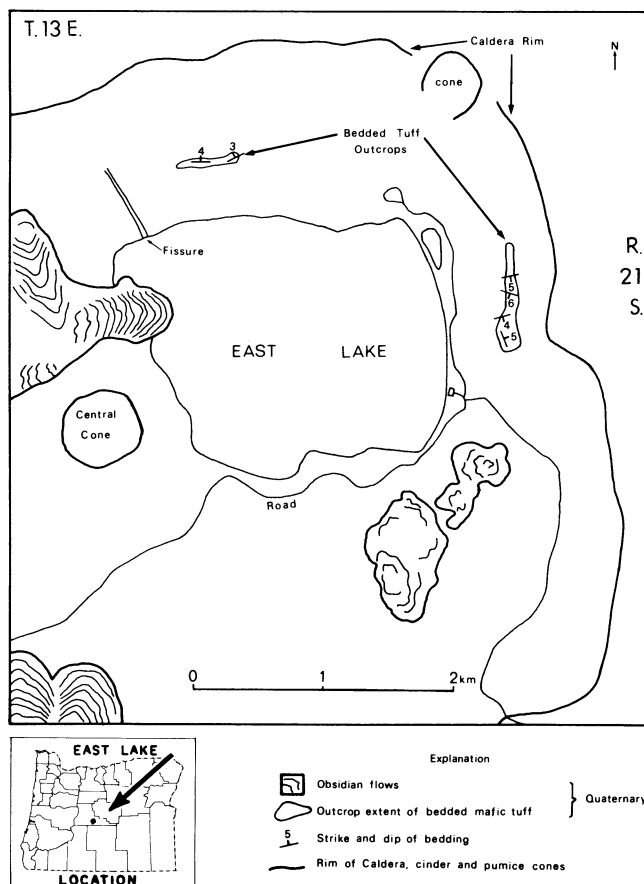


Figure 2. Geologic sketch map of the east half of Newberry caldera.

unit rests stratigraphically between a platy andesite flow and a welded ignimbrite.

Bedded basaltic tuff deposits in the caldera walls were described by Williams (1935). Deposits in the north, east, and south walls and in Paulina Gorge were later mapped by Higgins (1968, 1973) and Higgins and Waters (1968). Both Williams and Higgins attributed the origin of the tuff to interaction of magma with water, creating explosive eruptions and wet ash clouds from which ash and lapilli were deposited by air fall.

### HYDROVOLCANIC SURGES

Hydrovolcanic surges, or "base surges," are commonly produced by hydrovolcanic (phreatic) eruptions (Wohletz and Sheridan, 1983). The term "hydrovolcanic surge" is used here to differentiate surges produced by hydrovolcanic eruptions from pyroclastic surges associated with ignimbrites (ground surges and ash-cloud surges such as those summarized by Wright and others, 1980); however, the transport and depositional mechanisms operating in these two types of surges are probably much the same.

The key differences between the two types of surges are the mode of formation and the temperature of the surge. Hydrovolcanic surges are produced by the low-temperature (100°-300° C) conversion of water to steam by magma-water interaction. Ignimbrite-related pyroclastic surges are thought to form immediately in front of large ignimbrite flows (Sparks and Walker, 1973) and from the overriding associated ash-cloud (Fisher, 1979). Pyroclastic surges associated with ignimbrites are not well understood but are probably a much higher temperature phenomenon and are generally dryer (less steam) than hydrovolcanic surges.

Hydrovolcanic surges have only recently been recognized (Moore, 1967). They are believed to be low-concentration, turbulent density flows that develop from the combined effects of the baseward expansion of a hydrovolcanic explosion followed by column collapse of the resulting eruption cloud (Waters and Fisher, 1971; Wohletz and Sheridan, 1983). Surges of all kinds are distinct from pyroclastic flows (ignimbrites) in that they are highly fluidized, low-concentration flows that deposit sorted, medium-grained, cross-bedded tephra.

As summarized by Wohletz and Sheridan (1979), the deposits of hydrovolcanic surges are typified by thin, continuous beds of coarse- to fine-grained tephra showing low-angle cross-stratification. Massive tuff beds with distinctive pebble stringers and thinly bedded tuff beds lacking cross-stratification have been identified as surge beds by tracing more obvious cross-bedded surge beds laterally into these bed types. Before surge flows were observed depositing dunelike, cross-stratified tephra, deposits containing dunelike structures were thought to be air-fall deposits reworked by eolian or aqueous processes.

Numerous papers have been published dealing with the many facets of pyroclastic surges since the recognition of surges as a distinct depositional process. The interest in this phenomenon stems from the similarity of appearance between sedimentary structures found in surge deposits and structures from known sedimentary environments. This similarity leads to an obvious question: Do physical processes that govern known sedimentary systems apply to base surges? This paper argues for the application of concepts from physical sedimentology, such as the flow-regime concept, to surge flows. By analyzing surge bed forms and comparing them to known sedimentary structures, good estimations of the nature of surges are possible.

### TUFF RINGS AND TUFF CONES

Tuff rings and tuff cones are produced by successions of hydrovolcanic eruptions and are abundant features in many

volcanic terranes (Green and Short, 1971). They are particularly common where surface waters or aquifers are present, for example, along shorelines of oceanic volcanoes, lakes, and caldera lakes.

Wohletz and Sheridan (1983) conclude from their studies of tuff rings, tuff cones, and the deposits therein that, in general, there are several distinct differences between the hydrovolcanic tuff deposits occurring in tuff rings and those occurring in tuff cones. Tuff rings have low-angle (<5°), thinly bedded tuff beds containing abundant cross-stratified surge bed forms. Tuff cones have much steeper, more massively bedded tuffs that rarely contain cross-stratification but do contain abundant pebble stringers. Along with the outward-dipping beds that make up the major part of such deposits, tuff rings and tuff cones commonly have beds proximal to the vent that dip inward toward the vent. Both of these deposit types contain varying amounts of graded air-fall beds.

The differences between these two hydrovolcanic deposit types are attributed to varying water/magma ratios that change the character of the resulting hydromagmatic eruption (Wohletz and Sheridan, 1983). Generally, surge deposits in tuff rings result from eruptions of low water/magma ratios producing "dry" (superheated steam) high-energy surges that travel far from the vent. Massively bedded tuff-cone deposits result from higher water/magma ratios producing "wet" (little or no superheated steam), low-energy surges that tend to deposit most of the entrained debris close to the vent, thereby producing the steep slopes.

### EAST WALL TUFF RING

The bedded tuff in the East Wall (cover photo) was originally part of a larger tuff ring. A tuff-ring interpretation is indicated by the low-angle bedding attitudes, the lateral consistency of the bedding dips, and the thinly bedded and cross-stratified tuff beds. Since the bedding attitudes are consistent over 1 km, the vent direction is updip from the beds in a northerly direction. The surge direction indicated by the antidune (Figures 3 and 4) agrees with this vent direction. The vent location was probably in the northeast corner of the present caldera at or near the elevation of these beds.

Although the tuff beds in the North Wall of the caldera (Figure 5) are similar in lithology and stratigraphic position to the East Wall bedded tuffs, the attitudes of the North Wall tuff beds, when combined with the attitudes of the East Wall tuff beds, do not provide an encircling geometry; therefore, the vent locations for these tuff units can only be estimated.

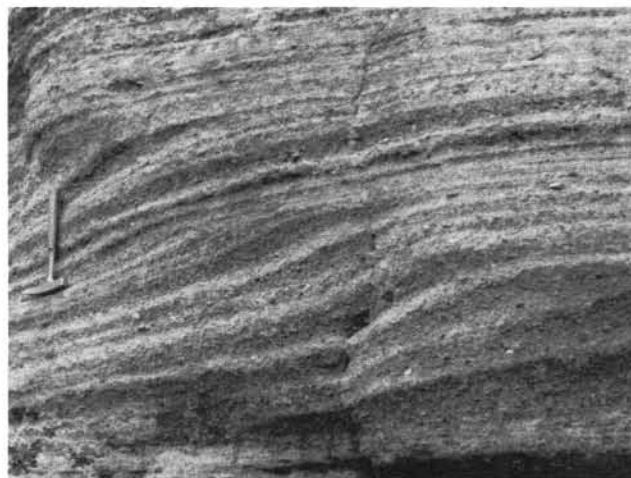


Figure 3. Antidune structure in the East Wall bedded tuff deposit. Surge flow was from left to right.



Figure 4. Close-up of antidune shown in Figure 3. The inclined bedding in the antidune consists of light-colored, finer grained layers alternating with dark-colored, coarser grained layers.

#### SURGE BED FORMS IN THE EAST WALL TUFF DEPOSIT

The tuff deposits in the walls of Newberry caldera were examined in this investigation to determine bedding attitudes and the possible presence of surge bed forms. One surge bed form in the East Wall tuff unit is particularly well developed (Figure 3) and is interpreted as a climbing antidune that was deposited from a surge flowing roughly north to south.

An alternative interpretation for this dune form is that it was deposited from a surge traveling south to north and is therefore a "regular" dune. However, the characteristic antidune features of the dune form, the bedding attitudes, and the lack of hydroclastic tuff to the south along the caldera wall all indicate the vent was to the north.

Characteristic antidune features in this structure are the upcurrent dune-crest migration, the absence of high-angle cross-stratification, and the uniform thickening of the deposit on the downstream side of the dune crest. Upcurrent dune crest migration is caused by greater stoss-side deposition than lee-side deposition and is distinctive of antidune structures (Simmons and others, 1965; Middleton, 1965). The absence of high-angle cross-stratification indicates that slip-face and/or erosional surfaces failed to develop during deposition of this structure. In aqueous systems, climbing ripple and dune structures develop where the fallout of suspended sediment is great enough to overcome the erosion caused by the tractional current flowing over the obstructing bed form (Jopling and Walker, 1968). When suspended sediment concentration is this high, aggradation over the entire bed form occurs with only a minimum of sediment movement by traction.

Thickening of individual layers on the downstream side of the antidune crest suggests the preservation of a change in flow regime. Downstream thickening from antidune crests, at least in aqueous systems, is caused by a change from the high-flow, or shooting-flow, regime, where sediment is mainly transported, to the lower flow regime, where sediment is deposited. A flow-regime change such as this is termed a hydraulic jump and has been described from turbidity currents (Komar, 1971) as well as from flume studies. Presumably, a similar process operated in the surge that deposited the antidune in the East Wall tuff deposit.

#### DISCUSSION

The 1965 phreatomagmatic eruptions of Taal Volcano, Philippines, produced superb "base surges" which were ob-

served to radiate outward from the eruption center and travel along the ground or water surface at up to 50 m/sec (Moore, 1967). These surges formed dunelike structures consisting of wet ash and lapilli and having wavelengths up to 20 m. The dune-crest orientations were perpendicular to the direction of surge flow. The crests of some of these dunes showed migration toward the eruption center, into the surge flow, analogous to antidunes in aqueous systems (Waters and Fisher, 1971). These antidune structures developed from one surge event. Crowe and Fisher (1973) conclude that the presence of upcurrent dune-crest migration, low-angle dune stratification, and the absence of angle of repose cross-stratification indicate that these structures are antidunes. Well-developed antidunes have also been described from ancient tuff deposits (Crowe and Fisher, 1973; Schmincke and others, 1973).

Antidunes are commonly formed in the upper flow regimes of aqueous systems such as fluvial channels, turbidity currents, and the backwash of waves. They are, however, rarely preserved in naturally occurring sediments and therefore the majority of what is known about them comes from flume studies. The flow-regime interpretation for hydrovolcanic-surge antidunes made by Crowe and Fisher (1973) and Schmincke and others (1973) is tenuous. The interpretation of antidune structures in the East Wall of Newberry caldera is also tenuous and is made with reservations. These reservations stem from the lack of knowledge about the exact physical parameters of surges and, specifically, the role that particle cohesiveness plays in deposition. The antidune interpretation for surge bed forms is based

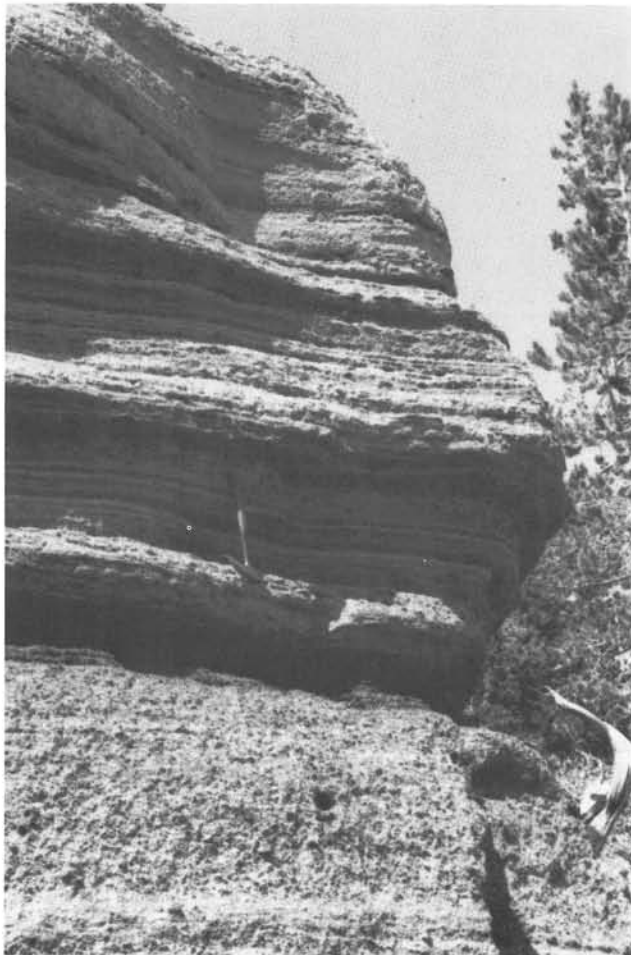


Figure 5. Massive and thinly bedded mafic lapilli tuff outcrop in the North Wall of Newberry caldera.

on the similar appearance of these structures to antidunes in aqueous systems and the determination that hydrovolcanic surges are density flows.

## CONCLUSIONS

(1) The East Wall bedded tuff was deposited, at least in part, by hydrovolcanic surges. This tuff deposit has the appearance and bed forms typical of hydrovolcanic surge deposits observed at Taal Volcano and studied in ancient tuffs by other workers. (2) The vent location for the tuff ring, of which this deposit is only a part, was located at or near the elevation of these beds in the northeast corner of the caldera. (3) These tuff beds record a period of abundant water at or near the ground surface during the period of these eruptions but do not record the first occurrence of water in the slowly forming caldera. (4) The antidune bed form in the East Wall is comparable to other such structures in hydrovolcanic surge deposits. This antidune apparently records deposition from a hydrovolcanic surge in the antidune phase of the upper flow regime.

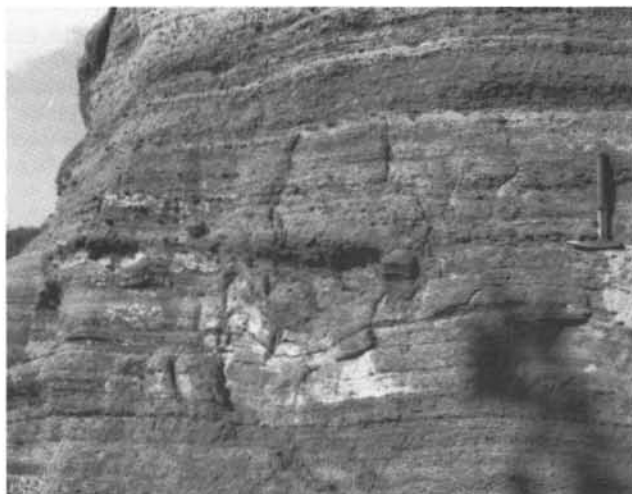


Figure 6. Bomb sags in East Wall bedded tuff (center and right). Plastic deformation during impact indicates wet sediments.

## BLM and BIA reach agreement on mineral procedures

The Bureau of Land Management (BLM) and Bureau of Indian Affairs (BIA) have agreed to mutually acceptable practices for solid and fluid mineral exploration, leasing, and development on Indian lands where there is a federal mineral trust management responsibility.

A memorandum of understanding covering this agreement was recently signed by Stanley Speakes, BIA Portland area director; William G. Leavell, Oregon-Washington BLM state director; and BLM state directors in Alaska, Montana, and Idaho.

Leavell said the agreement applies to general administrative policies and practices for prospecting permits, leases, and exploration and mining plans.

For additional information on mineral exploration and development on Indian lands, contact Eric Hoffman, geologist, BLM, Oregon State Office, phone (503) 231-6974, or Jim Labret, area geologist, BIA, Spokane Agency, phone (509) 258-4561.

— BLM News, Oregon and Washington

## ACKNOWLEDGEMENTS

S. Boggs, Jr., and B.H. Baker read the manuscript and provided valuable suggestions and criticisms. Special thanks go to A.G. Dochnahl for reviewing the manuscript and for field consultations.

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## State Capitol mineral display demonstrates gemstone faceting

In the State Capitol display case of the Oregon Council of Rock and Mineral Clubs, the Columbia-Willamette Faceters' Guild of Portland currently shows gemstones and the process by which rough stones are turned into faceted gems.

Guild president Sid Word and vice president Louise Schwiier, assisted by Guild members Jerry Schwiier, Grover Sparkman, and Elton McCawley, arranged the display which features a jamb-peg-type facet cutter and 25 dopped quartz specimens in various stages of the faceting process. In addition, the display contains a collection of Oregon heliolite, commonly known as sunstone, from the Rabbit Hills and Steens Mountain areas of southern Oregon and opals and other stones from Opal Butte in Morrow County. Diagrams, charts, and photos provide additional information.

The display will remain until the end of February 1985. It will be followed by an exhibit provided by the Portland Earth Science Organization. □

## GRC calls for papers for geothermal symposium in Hawaii

The Geothermal Resources Council is calling for papers for the 1985 International Symposium on Geothermal Energy to be held August 26-30, 1985, at the Kona Surf Hotel in Kailua-Kona, Hawaii. The symposium is intended to provide a forum for exchange of new and significant information on all aspects of the exploration, development, and use of geothermal resources.

Papers are solicited in the following areas: (1) Exploration and development, including geology, geophysics, geochemistry and hydrology. (2) Drilling technology and materials. (3) Well logging and completion. (4) Reservoir, including testing, stimulation, engineering, modeling, and reinjection. (5) High- and low-temperature power generation. (6) Direct use. (7) Multipurpose and byproduct. (8) Societal and institutional aspects. (9) Economics, financing, and marketing. (10) International cooperation and education. (11) Environmental concerns and waste disposal.

For information on the symposium, contact the Geothermal Resources Council, P.O. Box 1350, Davis, CA 95617-1350, phone (916) 758-2360. □

## New USGS publication focuses on new ideas in hydrology

Short topical papers that touch on critical issues and innovative techniques in hydrology — from determining concentrations of toxic metals to more reliable methods for estimating streamflow — are presented in a publication recently released as Water-Supply Paper 2262 by the U.S. Geological Survey (USGS). The new publication is aimed at meeting widespread public and professional interest in timely results of hydrologic studies derived from the federal research program, the federal-state cooperative program, and work done on behalf of federal agencies.

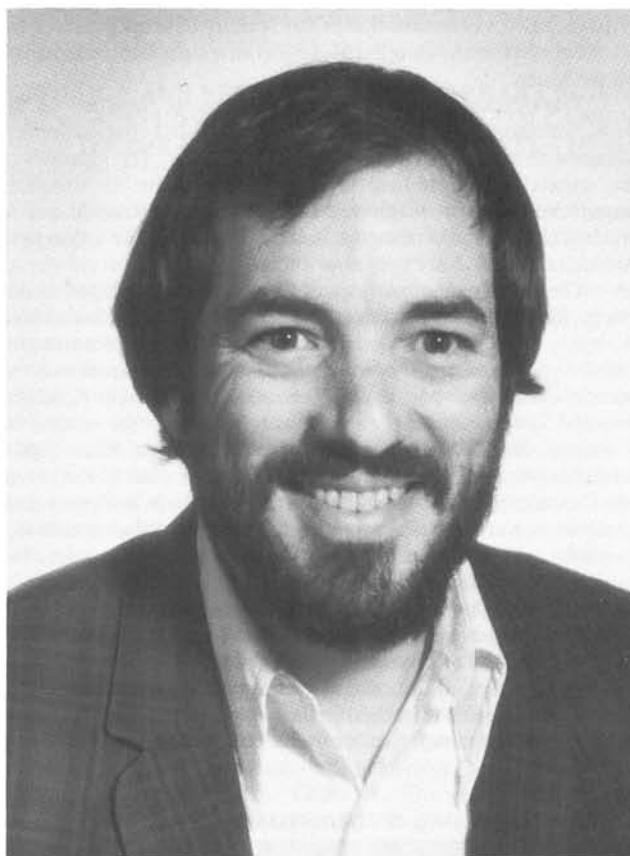
The eight articles in the new, 66-page Water-Supply Paper 2262 address a broad array of topics on sediment chemistry, pesticides in biota, and streamflow characteristics. Their subjects are:

- (1) A quick, accurate technique for measuring oxygen in the root zone of saturated and unsaturated soils.
- (2) A method for measuring surface runoff and collecting sediment samples from small drainage areas.
- (3) The significance of organic carbon in volcanic ash from the 1980 eruption of Mount St. Helens.
- (4) Pesticide residues in aquatic plants and animals, including organochlorine pesticide and polychlorinated biphenyls.
- (5) A computer model of the interference of cadmium-carbonate precipitation in the determination of cation-exchange separation factors.
- (6) Establishing confidence limits for determining concentrations of tracer particles in sediment samples.
- (7) Determination of aquatic humic substances in natural waters.
- (8) The use of channel cross-section properties for estimating streamflow characteristics.

Published under the title *Selected Papers in the Hydrologic Sciences, 1984*, the new release is the first of a series of special topical papers that will be published each year. The series is intended to be a forum for new ideas in hydrology, and a discussion section for readers' comments and authors' replies will be included in each issue after this initial one.

## U of O geology professor receives Lindgren Award

Mark H. Reed, Assistant Professor of Geology at the University of Oregon since 1979, was given the Lindgren Award at the annual meeting of the Geological Society of America held in November 1984 at Reno, Nevada. The award, which is given each year to a geologist in early or mid career who specializes in the geology of ore deposits, was given to Reed for his outstanding research accomplishments. The following three papers that he wrote were specifically cited in the award: (1)



Mark H. Reed

Calculation of multicomponent chemical equilibria and reaction processes in systems involving minerals, gases, and an aqueous phase (published in *Geochimica et Cosmochimica Acta*, 1982); (2) Seawater-basalt reaction and the origin of greenstones and related ore deposits (published in *Economic Geology*, 1983); and (3) Geology, wall-rock alteration, and massive sulfide mineralization in the West Shasta district, California (published in *Economic Geology*, 1984).

The award, which was first given in 1964, carries with it a lifetime membership in the Society of Economic Geologists. □

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Copies of USGS Water-Supply Paper 2262 may be purchased for \$3 per copy from the Branch of Distribution, Text Products Section, U.S. Geological Survey, 604 S. Pickett St., Alexandria, VA 22304. Orders must include check or money order payable to Department of the Interior-USGS and must specify the report number (WSP 2262). □

## ABSTRACTS

*The Department maintains a collection of theses and dissertations on Oregon geology. From time to time, we print abstracts of new acquisitions that we feel are of general interest to our readers.*

### INVESTIGATION OF $P_n$ WAVE PROPAGATION IN OREGON, by Steven J. Ganoe (M.S., Oregon State University, 1983)

An investigation into the nature of  $P_n$  wave propagation was conducted for the portion of Oregon west of 120° W. longitude. This included a determination of the velocity of propagation of the  $P_n$  wave as it travels along the Moho and an insight into the structure of the Moho.

Traveltimes from selected regional events recorded on the U.S. Geological Survey's Oregon network of short-period vertical seismometers made up the data set for this study. The locations of the events were examined in order to determine the distances associated with the traveltimes as accurately as possible and to determine the effects of errors in the distances on the subsequent analysis.

Three methods of analysis of the data were employed in this study. The first method was a traveltime analysis that included both a single and two simultaneously determined least-squares straight-line fits, performed on the whole region as well as on areas east and west of the Cascade Mountains. This analysis resulted in  $P_n$  velocities of 7.756 km/sec for the whole array, 7.975 km/sec west of the Cascades, and 7.751 km/sec east of the Cascades and Moho depths of 32 km average for the whole array, 22 km west, and 37 km east of the Cascades. The second method was a time-term analysis which resulted in a crustal thickness map for the region that indicated a possible isostatic crustal root associated with the Cascades, but which does not fully compensate them. The possibility of partially molten or high temperature material in the areas of Mount Hood and Newberry crater was also indicated. The third method was a velocity vs. azimuth analysis which found anisotropy in the  $P_n$  velocity with the fast direction oriented generally southwest-northeast. The results of the method further supported the hypothesis that partially molten material exists in the Mount Hood and Newberry crater areas.

### PETROCHEMICAL EVOLUTION OF HIGH CASCADE VOLCANIC ROCKS IN THE THREE SISTERS REGION, OREGON, by Scott Stevens Hughes (Ph.D., Oregon State University, 1983)

Multi-element abundances and petrographic data are compiled for a suite of 50 volcanic rocks and selected mineral separates located within the Three Sisters area. Major element oxides, obtained by X-ray fluorescence and atomic absorption spectrophotometry, and trace element concentrations, obtained by sequential instrumental neutron activation analyses, enable classifications of normal basalts, divergent basalts, Mount Washington (MW) and North Sister (NS) type basaltic andesites, dacites and rhyodacites. Petrochemical types and geochemical models are evaluated in light of field studies (E.M. Taylor, Oregon State University), regional geologic environment and comparisons with similar systems.

High-alumina olivine tholeiites exhibit low Fe' values and fractionated abundances of K, Ba, Sr, REE, and Sc which produce nonchondritic monotonic patterns relative to ionic radii. Primary basalts are modeled as 14 percent melts, with minor olivine crystallization, from a LIL element-enriched spinel lherzolite source. Divergent basalts represent contaminated magmas or different sources. Basaltic andesites having up to approximately 62 wt. percent SiO<sub>2</sub> also exhibit low Fe' and fractionated monotonic

trace element patterns and are modeled as 10 percent primary melts from similar source regions. Basalts and basaltic andesites contain source-equilibrated olivine and plagioclase phenocrysts attesting to their primary origin. One andesite sample (SiO<sub>2</sub>=58.6 wt. percent) is derived by significant fractionation of a basalt parent and represents a low-SiO<sub>2</sub> and high-TiO<sub>2</sub> member of an early Pleistocene silicic system. Dacites and rhyodacites (SiO<sub>2</sub>=62.2-75.8 wt. percent) have strongly fractionated non-monotonic trace element patterns and are derived by extensive (greater than 60 percent) fractionation from primary NS basaltic andesite magmas. A petrochemical hiatus is recognized between mafic and silicic compositions.

A comprehensive model of High Cascade volcanic evolution is presented which incorporates a series of events in a subduction zone-mantle-crust system: Hydrous fluids, expelled from a dehydrating subducted slab, become enriched in incompatible elements through processes of liquid extraction and small amounts of partial melting. These fluids ascend through the overlying mantle wedge, contaminating and catalyzing mafic melts which accumulate and fractionate in upper mantle and lower crust regions. Mafic magmas erupt as near-primary liquids or are intruded into upper crust regions where extensive fractionation produces siliceous dacites and rhyodacites. The magmatic events are conceptualized as vertical sequences of basalt-basaltic andesite-dacite-rhyodacite magmas produced in response to the advancing front of hydrous fluids and erupted during tensional readjustments of a thermally weakened crust.

### PALEOMAGNETISM OF JURASSIC PLUTONS IN THE CENTRAL KLAMATH MOUNTAINS, SOUTHERN OREGON AND NORTHERN CALIFORNIA, by Karin L. Schultz (M.S., Oregon State University, 1983)

An understanding of the tectonic history of the Klamath Mountains is crucial for a valid paleogeographic reconstruction of the Pacific Northwest. However, prior to this study there were very few paleomagnetic (PM) data from the Klamath Mountains (KM), which resulted in conflicting interpretations about the role of the KM province in the tectonic evolution of western North America. Twenty-eight sites from five unmetamorphosed Middle Jurassic KM plutons with K-Ar ages ranging from 161 to 139 m.y. B.P. yielded stable PM results showing (1) a direction for the 160-m.y. B.P. Ashland pluton ( $D=324^\circ$ ,  $I=63^\circ$ ,  $\alpha_{95}=8^\circ$ ,  $n=6$ ) nearly concordant with the coeval expected direction ( $D=337^\circ$ ,  $I=54^\circ$ ) and (2) clockwise rotated directions for the plutons of Grants Pass ( $D=045^\circ$ ,  $I=67^\circ$ ,  $\alpha_{95}=12^\circ$ ,  $n=4$ ), Greyback ( $D=083^\circ$ ,  $I=63^\circ$ ,  $\alpha_{95}=9^\circ$ ,  $n=9$ ), and the Wooley Creek batholith and Slinkard pluton combined ( $D=037^\circ$ ,  $I=60^\circ$ ,  $\alpha_{95}=11^\circ$ ,  $n=9$ ).

Tectonic interpretations of these PM data are difficult; two interpretations are offered to explain the observed directions. In the first, the mean PM direction of the four plutons with discordant directions ( $D=057^\circ$ ,  $I=65^\circ$ ,  $\alpha_{95}=7^\circ$ ,  $n=22$ ) is restored to the expected 150 m.y. B.P. (the average K-Ar age for these four plutons) direction by rotation of a rigid block  $\sim 87^\circ$  in a counterclockwise sense about a vertical axis (the possibility of tilt of these four plutons is disregarded in this interpretation). The Ashland pluton which shows no rotation is problematic. Either there was (is) a tectonic boundary west of the Ashland pluton, separating it from the rotation of the others, or the Ashland pluton was influenced both by clockwise rotation and tilt, the combined effect producing an essentially concordant PM direction. In the second interpretation we distinguish between the northern KM, intruded by the Grants Pass and Greyback Mountain plutons, and the southern region intruded by the Wooley Creek batholith and the Ashland and Slinkard plutons. The bases for this distinction are recent geologic and gravity studies which suggest that post-Middle Jurassic uplift of the domal Condrey Mountain Schist may have caused radially outward tilt of its adjacent terranes and plutons

intruded therein, causing some of the observed discordances in their PM directions. Thus, in the second interpretation it is envisioned that (a) the northerly portion of the KM, intruded by the Grants Pass and Greyback plutons, was affected primarily by clockwise rotation about a vertical axis, and (b) discordant directions for the remaining plutons intruded farther south are due primarily to tilt in response to Condrey Mountain uplift. Based on the observed inclinations, there is no evidence of transport of the Klamath Mountain province along lines of longitude since Middle Jurassic time.

Tectonic interpretations of the PM results of this study are consistent with significant post-Middle Jurassic clockwise rotation of the Klamath Mountains. The first interpretation above yields ~87° of clockwise rotation of the terrane examined. According to the second interpretation, a clockwise rotation of ~100° is inferred from the average of the PM results of the northern Grants Pass and Greyback plutons. Therefore, 10° to 25° of clockwise rotation of the KM may have occurred prior to the formation of the Oregon Coast Range (~55 m.y. B.P.), and the two provinces may have rotated together since post-lower Eocene time.

#### **STRATIGRAPHIC RELATIONSHIPS OF THE TILLAMOOK VOLCANICS AND THE COWLITZ FORMATION IN THE UPPER NEHALEM RIVER-WOLF CREEK AREA, NORTHWESTERN OREGON**, by Michael K. Jackson (M.S., Portland State University, 1983)

The upper Nehalem River-Wolf Creek area is located on the northeastern flank of the Tillamook Highlands in the northern Oregon Coast Range. Three rock-stratigraphic units underlie the thesis area, and these units range from late Eocene to Oligocene in age.

The oldest exposed unit is the late Eocene Tillamook Volcanics. It consists of mostly subaerial basalt flows, minor pyroclastic rocks, and basaltic sandstones and conglomerates. Most of the flow rocks are microphyric with micropheocrysts of plagioclase and, less commonly, pyroxene. Plagioclase and pyroxene phenocrysts occur in some rocks. The basaltic sandstones and conglomerates, which are interbedded with the volcanic flow rocks, contain clasts that were locally derived from the Eocene volcanic center(s) in the Coast Range. These volcanic sedimentary interbeds were probably deposited in subaerial paleochannels, and some units are debris-flow deposits. Around the periphery of the mapped volcanic terrane is a fossiliferous conglomerate, which is overlain by marine mudrocks of the Cowlitz Formation.

Samples from the Tillamook Volcanics in the thesis area are varied in major-, minor-, and trace-element geochemical composition. The volcanic flows range from 49.9 to 59.8 percent SiO<sub>2</sub>, and a typical flow rock contains 52.6 percent SiO<sub>2</sub>. The analyzed samples are characterized by high total alkalis, total iron, titania, and phosphate contents. The samples classify predominantly as alkalic basalt. The wide range in geochemical composition, which is characteristic of the rocks in the thesis area, is also typical of volcanic rocks from other late Eocene volcanic centers in the Coast Range. In major-element composition, REE patterns, Th-Hf-Ta ratios, and petrographic characteristics, the Tillamook Volcanics in the thesis area are comparable to volcanic rocks in an oceanic-island tectonic setting.

Sedimentary rocks of the late Eocene Cowlitz Formation depositionally overlie and flank the Tillamook Volcanics in the thesis area. The Cowlitz Formation is characterized by arkosic, micaceous, and carbonaceous sandstones, siltstones, and mudstones. Quartz, plagioclase, K-feldspar, and mica are the major detrital components of the sandstones of the Cowlitz Formation, and the detrital composition indicates a continental, metamorphic and/or plutonic provenance. Lithofacies, sedimentary structure, stratification sequences, and fossil paleoecology are interpreted to

indicate a storm-influenced or storm-dominated, paleodepositional environment in a nearshore, shallow-marine, shelf basin. This basin was located on the Eocene continental margin. The Tillamook Volcanics formed a paleotopographic, volcanic high on the westward side of this basin.

The Cowlitz Formation is unconformably overlain by the Keasey Formation, which is Oligocene in age. The Keasey Formation consists of tuffaceous, fossiliferous siltstones and mudstones that were deposited in a deep, cool-water environment.

The upper Nehalem River-Wolf Creek area is structurally deformed by northwest- and northeast-trending faults. The dominant fault trend is N. 50°-70° W., and a less prominent trend is N. 20°-40° E. The northwest-trending Gales Creek fault is transverse to the southwest part of the thesis area. The style of faulting indicates a pattern of northwest-trending, en echelon faults.

#### **GEOLOGY AND PETROLOGY OF GEARHART MOUNTAIN: A STUDY OF CALC-ALKALINE VOLCANISM EAST OF THE CASCADES IN OREGON**, by Tom H. Brinkowski (M.S., University of Oregon, 1983)

Gearhart Mountain is one of several calc-alkaline volcanoes east of the Cascades in Oregon. It erupted 8.7 m.y. ago, and was partly buried by high-Al basalts soon afterward. Stratigraphic evidence indicates that Gearhart Mountain formed before the development of Basin and Range structure in the area, and apparently because of this did not erupt a compositionally bimodal suite.

Volcanism at Gearhart began with the formation of a basaltic shield, and continued with the eruption of voluminous andesites that make up the bulk of the exposed units. Late-stage units are more silicic and include dacite and rhyolite. The final volcanic activity was the intrusion of many large dacitic dikes. Petrographic and chemical evidence indicates that the Gearhart units are the products of a continuous fractional crystallization sequence. Fractionation of magnetite is responsible for the calc-alkaline affinity of Gearhart rocks.

Chemical comparisons demonstrate that the Gearhart units are not related to the surrounding flood basalts. Comparison with the Cascades and other calc-alkaline centers east of them reveals a progressive eastward increase in Na, Sr, Ba, K, Al, and Fe-number. This increase is best explained by decreased early plagioclase fractionation eastward in the magmas of these centers, resulting from increasing crustal thicknesses. Similar variations have been observed in the Cascades. The mechanism causing eastward variation in Fe-number remains obscure. □

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## **AIPG officers elected**

The American Institute of Professional Geologists (AIPG), Oregon Section, has re-elected its 1984 officers for the 1985 term. They are: President—Allen F. Agnew, Vice President—Durga N. Rimal, and Secretary-Treasurer—Jerry J. Gray.

President Agnew has just been honored with the AIPG Public Service Award. It was presented to him at the organization's national annual meeting in October in Orlando, Florida, for his service to the public in over 45 years of professional activity. □

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### ***(Oil and Gas News, continued from page 2)***

#### **Preliminary statistics for 1984**

The following statistics for the year 1984 are based on current and projected data and are subject to revision:

Total wells drilled:	21	
Total feet drilled:	70,000	
Total drilling permits issued:	29	
Total wells completed to production:	4	
Total production (billion cubic feet):	2.9	□

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## NEW DOGAMI PUBLICATIONS

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Two new reports were released by the Oregon Department of Geology and Mineral Industries (DOGAMI). They are available now for purchase or inspection at the DOGAMI offices in Portland, Baker, and Grants Pass, whose addresses are listed in the box on page 2. Prepayment is required for all orders totaling less than \$50.

Released November 29, 1984:

**GEOCHEMICAL DATA FOR THE BOURNE, MT. IRELAND, GRANITE, GREENHORN, AND THE NORTHEAST, NORTHWEST, AND SOUTHWEST QUARTERS OF THE BATES QUADRANGLES, BAKER AND GRANT COUNTIES, OREGON, by M.L. Ferns, H.C. Brooks, G.L. Baxter, and D.G. Avery. DOGAMI Open-File Report 0-84-3, \$5.00.**

The 20-page report contains locations and analytical data for 273 samples of mineralized rock collected during geologic mapping projects in the quadrangles listed in its title. Concentrating on traditional eastern Oregon gold-mining country, these mapping projects were conducted during the field seasons of the years 1980 through 1983 and were funded in part by the U.S. Forest Service.

The data for each sample are presented in tabular form and include location, sample type, geologic unit, and concentrations of eight metals: Gold, silver, copper, lead, zinc, molybdenum, cobalt, and nickel. Maps of the seven quadrangles showing the sample locations are included in microfiche form.

Although the geologic maps produced in the mapping project are not included in the new open-file report, they are an integral part of it. Reference to them is required for interpretation of some of the data presented in the tables. These maps have been published and are available as DOGAMI maps GMS-19, -22, -25, -28, -29, -31, and -35 (see list of publications at end of this issue).

Released December 28, 1984:

**SURVEY OF DIGITAL MAP REQUIREMENTS OF STATE AGENCIES AND SELECT ORGANIZATIONS, by Glenn W. Ireland, State Resident Cartographer. DOGAMI Open-File Report 0-84-6, \$5.00**

The 56-page report is the product of a survey of state agencies, all of which coordinate their mapping through the State Map Advisory Committee. The survey will be used by local, state, and federal agencies, as they jointly plan future computerizing of maps. The survey was a joint effort of the Oregon Department of Geology and Mineral Industries and the U.S. Geological Survey. □

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### BLM releases results of southeast Oregon mineral survey

A 334-page report on minerals in Bureau of Land Management (BLM) wilderness study areas in southeast Oregon was made public by the BLM on January 9. The study, which was conducted for BLM by Barringer Resources, Inc., consisted of geochemical and mineralogical evaluation of heavy mineral concentrates collected from 1,250 sites over 1.1 million acres of the study areas in BLM's Burns, Prineville, and Vale districts. Most of the mineral concentrates had been collected as part of an earlier, BLM-funded study conducted by the Oregon Department of Geology and Mineral Industries (DOGAMI) during

1981-1982. (Results of the DOGAMI study were released as Open-File Report 0-83-2 and may be purchased from the Portland DOGAMI office for \$15).

In the current Barringer study, up to 14 metals were analyzed, and 42 areas were identified with varying degrees of base- and precious-metal potential. Microfiche copies of the Barringer report may be purchased for \$12 at the Portland office, Bureau of Land Management, 825 NE Multnomah Street, Portland, OR 97208. □

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### Correlation section of northwest Oregon now available

The Portland office of the Oregon Department of Geology and Mineral Industries (DOGAMI) has available for sale a number of copies of *Correlation Section 24, Northwest Oregon*, by Wesley G. Bruer, Michael P. Alger, Robert J. Deacon, H. Jack Meyer, Barbara B. Portwood, and Alan F. Seeling. This correlation section was prepared by the Pacific Section of the American Association of Petroleum Geologists to show subsurface correlations in oil and gas exploratory wells extending from Astoria to Eugene. In most cases, the correlations, names, benthic foraminifera stages, and stratigraphic relationships follow those indicated in a DOGAMI publication, Oil and Gas Investigation 7, *Correlation of Cenozoic Stratigraphic Units of Western Oregon and Washington*.

Published at a horizontal scale of 1 in. = 4 mi and vertical scale of 1 in. = 800 ft in one color on a 25- by 52-in. sheet, Section 24 closely matches four of the areas included in Oil and Gas Investigation 7 (above). In addition, it serves to tie together two recent biostratigraphic studies published also by DOGAMI, Oil and Gas Investigation 9, *Subsurface Biostratigraphy, East Nehalem River Basin*, and Oil and Gas Investigation 12, *Biostratigraphy of Exploratory Wells, Northern Willamette Basin*.

All of the above-mentioned publications are available over the counter and by mail from the Oregon Department of Geology and Mineral Industries, State Office Building, Portland, OR 97201. Cost of *Correlation Section 24* is \$5. Prices of the other publications are indicated in the publication list on the back page of *Oregon Geology*. Orders under \$50 require prepayment. □

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### BLM publishes book on Oregon archaeology

The Bureau of Land Management (BLM) announces the publication of *Archaeology of Oregon*, a 142-page synthesis of information assembled in the cultural resources management program in Oregon.

C. Melvin Aikens, University of Oregon, wrote the book for BLM, tracing prehistoric civilization, their life styles, habitations, weapons, food gathering, migrations, and unique traits.

Archaeological specimens from the Oregon State Museum of Anthropology on the University of Oregon campus were photographed for the book. Also included are maps showing archaeological sites and areas roamed by prehistoric peoples.

Detailed chapters include the Great Basin, Columbia Plateau, Lower Columbia and Coast, Willamette Valley, Southwestern Mountains, and Ancient Oregon Cultures in Perspective.

Copies of the book are available for \$7 in BLM's state and district offices, university book stores, and historical museums.

— BLM News, Oregon and Washington

## AVAILABLE DEPARTMENT PUBLICATIONS

GEOLOGICAL MAP SERIES		Price	No. copies	Amount
GMS-4:	Oregon gravity maps, onshore and offshore. 1967 . . . . .	\$ 3.00	_____	_____
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