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

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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.

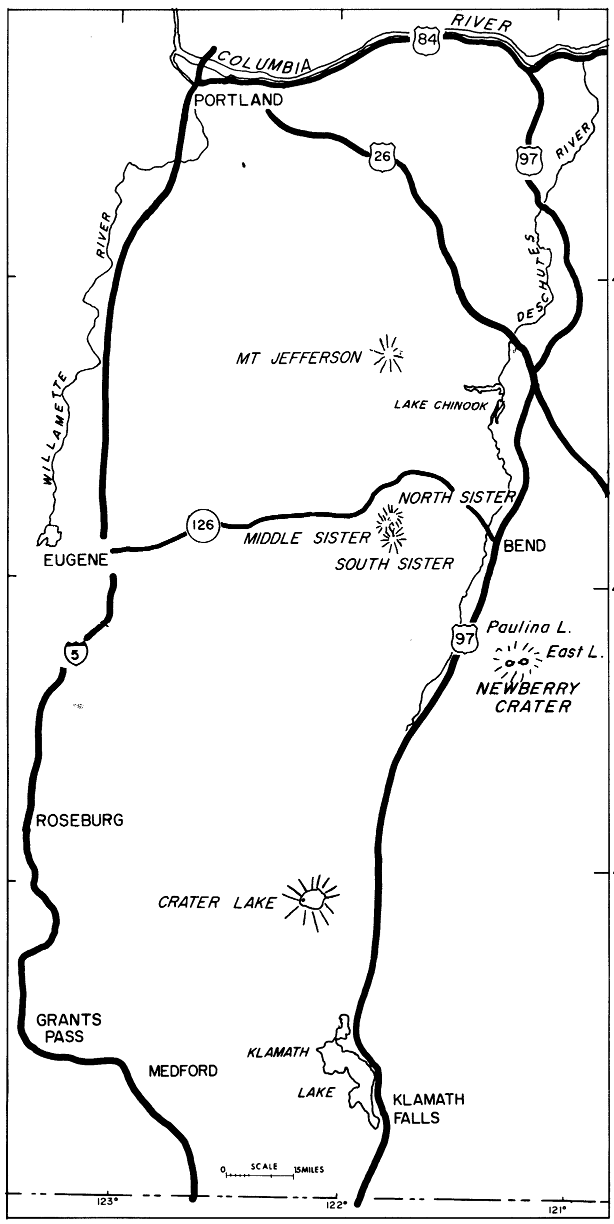

Figure 1. Location of Newberry Volcano and other major Quaternary volcanoes in the central Oregon Cascades.

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

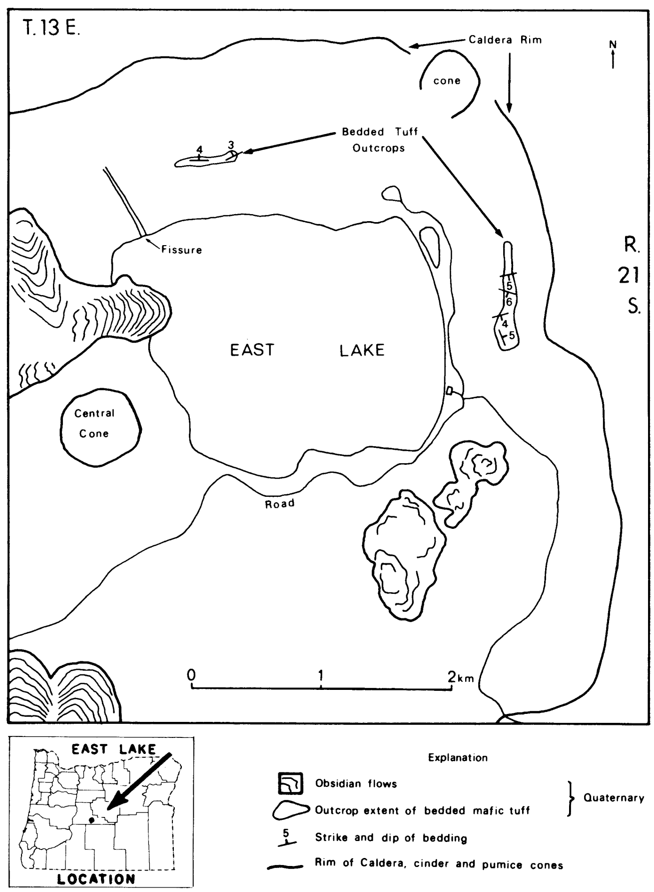

Figure 2. Geologic sketch map of the east half of Newberry caldera.

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.

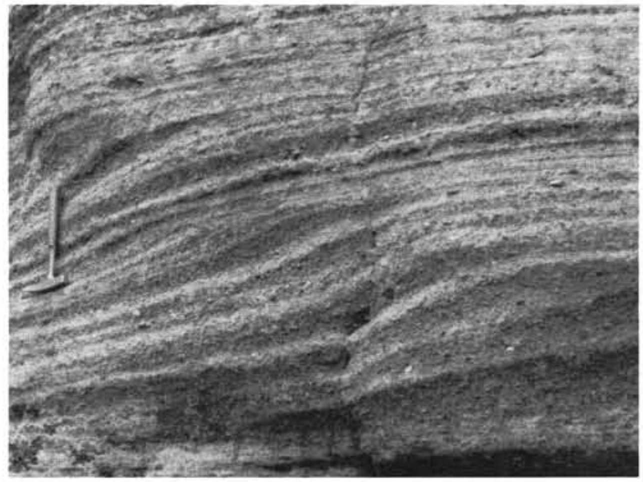

Figure 3. Antidune structure in the East Wall bedded tuff deposit. Surge flow was from left to right.

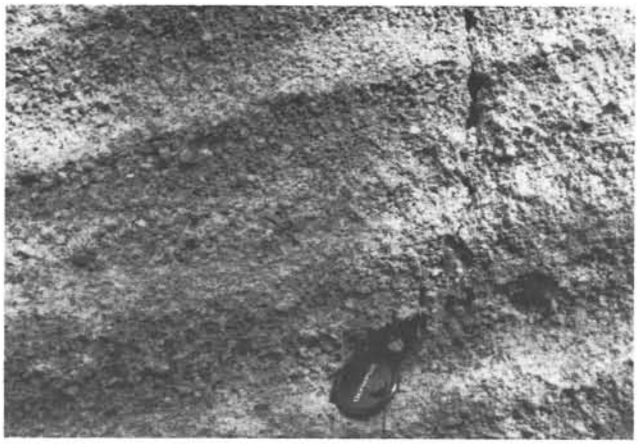

Figure 4. Close-up of antidune shown in Figure 3. The inclined bedding in the antidune consists of light-colored, finer grained layers alternating with dark-colored, coarser grained layers.

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 observed 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

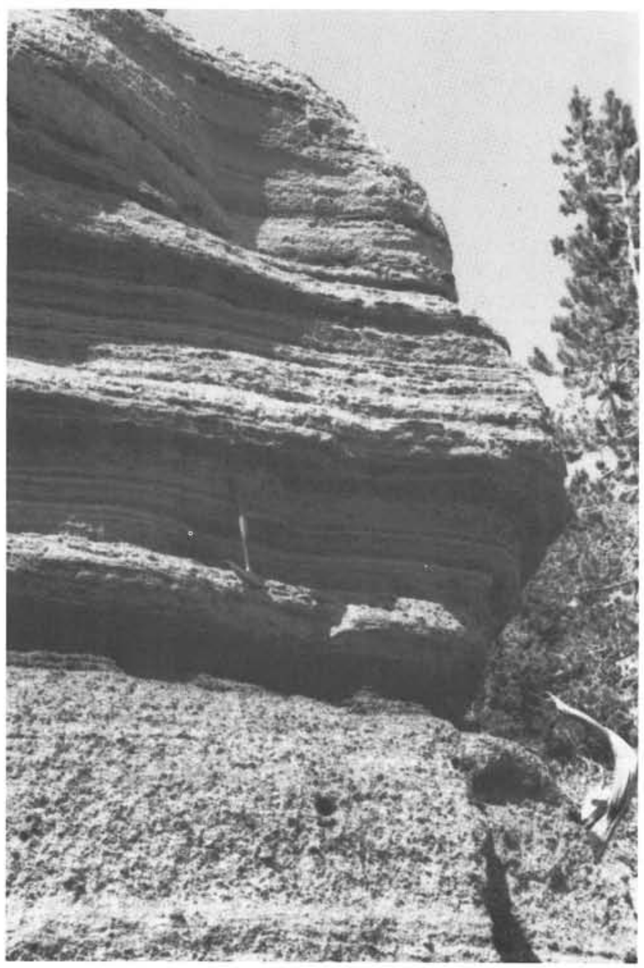

Figure 5. Massive and thinly bedded mafic lapilli tuff outcrop in the North Wall of Newberry caldera.

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.

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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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*

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 Schwier, assisted by Guild members Jerry Schwier, 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.

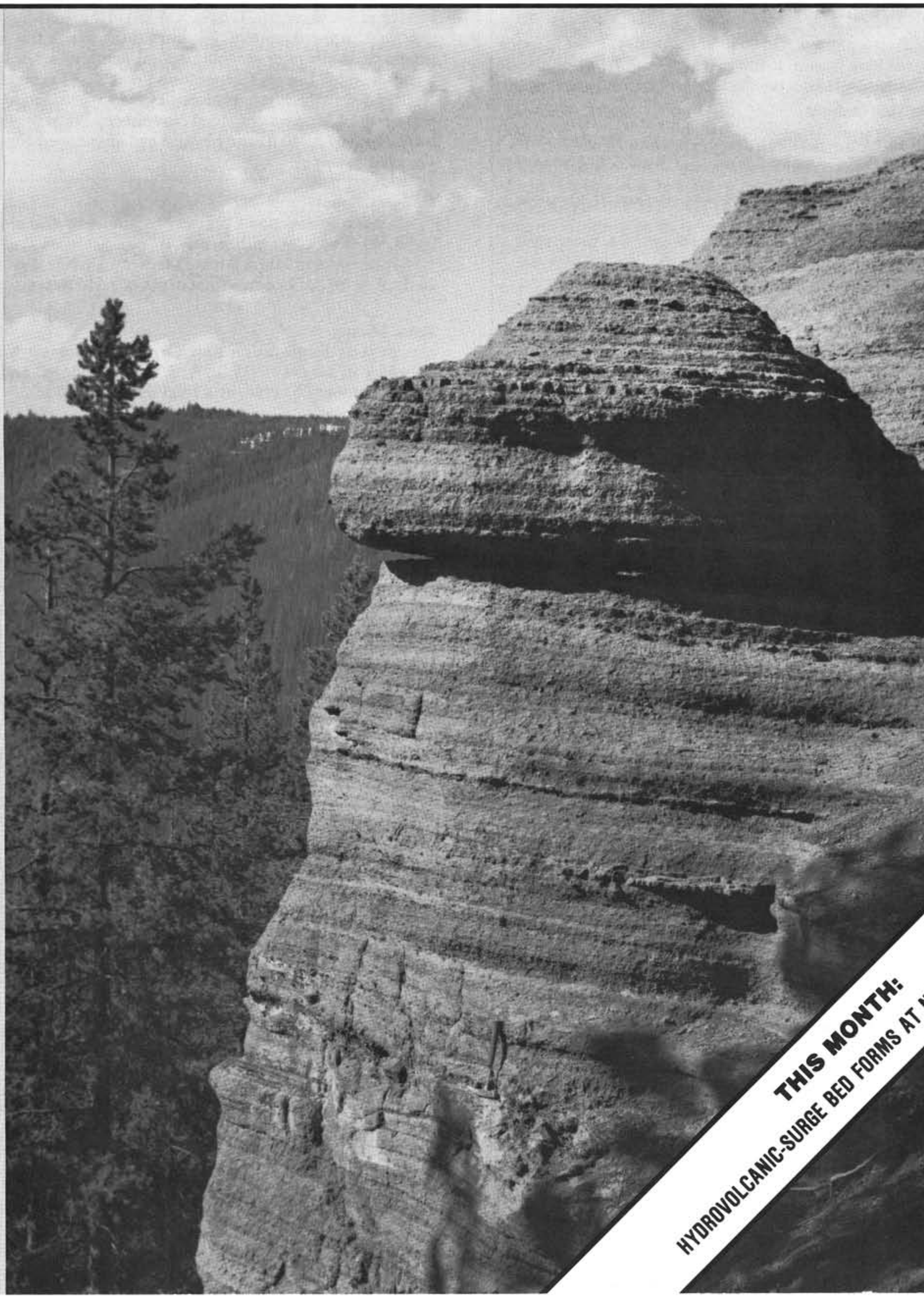
The display will remain until the end of February 1985. It will be followed by an exhibit provided by the Portland Earth Science Organization. □

OREGON GEOLOGY

published by the

Oregon Department of Geology and Mineral Industries

VOLUME 47, NUMBER 1 JANUARY 1985



THIS MONTH:
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OREGON GEOLOGY
(ISSN 0164-3304)

VOLUME 47, NUMBER 1 JANUARY 1985

Published monthly by the Oregon Department of Geology and Mineral Industries (Volumes 1 through 40 were entitled *The Ore Bin*).

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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

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 1¾ 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****)*