OREGON GEOLOGY

published by the
Oregon Department of Geology and Mineral Industries

VOLUME 46, NUMBER 1 JANUARY 1984

OREGON GEOLOGY
(ISSN 0164-3304)

VOLUME 46, NUMBER 1 JANUARY 1984

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

Main Office: 1005 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133.
Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496.
Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039.
Paul F. Lawson, Supervisor

Subscription rates: 1 year, $6.00; 3 years, $15.00. Single issues, $.75 at counter, $1.00 mailed.
Available back issues of *The Ore Bin*: $.50 at counter, $1.00 mailed.

Address subscription orders, renewals, and changes of address to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

Send news, notices, meeting announcements, articles for publication, and editorial correspondence to the editor, Portland office. The Department encourages author-initiated peer review for technical articles prior to submission. Any review should be noted in the acknowledgments.

Second class postage paid at Portland, Oregon.
Postmaster: Send address changes to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

COVER PHOTO

Phantom Ship, a small island in Crater Lake, the attraction of Crater Lake National Park in Klamath County. The andesitic dikes that hold up the "sails" of the "ship" are related to the oldest rocks exposed in the caldera wall – about 400,000 years old. Under certain viewing conditions, the island seems to become invisible – which gave rise to the name. See stories related to Crater Lake National Park on pages 3 and 10.

OIL AND GAS NEWS

Mist Gas Field boundaries

Oregon Administrative Rules governing the Mist Gas Field allow drilling as close as 250 ft from a spacing-unit boundary without the need for a public hearing. This compares with 500 ft for statewide setback requirements. Due to the complex geology and the small size of pools discovered so far at Mist, the Governing Board of the Oregon Department of Geology and Mineral Industries (DOGAMI), at its November 28, 1983, meeting, enlarged the size of the Mist Field to reduce the size of the setback over a wider area. The field was enlarged from its former size of 42 mi² to a new size of 141 mi² – an increase of 335 percent. A new map reflecting these changes will be available from DOGAMI later this year as Open-File Report O-84-2. The change became effective December 8, 1983.

Mist Gas Field activity

Reichhold Energy spudded Columbia County 23-22 on December 10, 1983. The well is located in sec. 22, T. 6 N., R. 5 W. and has a proposed depth of 5,000 ft.

Douglas County

Glory Hole 1, drilled by Hutchins and Marrs in sec. 10, T. 27 S., R. 7 W., has been suspended. Abandonment of this well is planned, as well as further drilling of other wells in the area.

Morrow County

Oregon Natural Gas Development Company, operator for a group of several companies, has proposed Morrow County's first deep exploration well (see table below). The well, with a proposed depth of 10,000 ft, will be located 10 mi northeast of Heppner and will be drilled this winter. The nearest deep test was the 1957 well drilled by Standard Oil some 35 mi to the southwest, to a depth of 8,726 ft.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
254	Oregon Nat. Gas Development Dougherty 1-21 049-00001	NE¼ sec. 21 T. 1 S., R. 27 E. Morrow County	Location; 10,000

□

Mining-claim information available from BLM

The U.S. Bureau of Land Management (BLM) has information available on regulations and procedures for staking a mining claim on federal lands. For a free packet of information write to Pat Pickens, BLM, P.O. Box 2965, Portland, OR 97208, or call (503) 231-6281. This packet of regulations and information is also available over the counter at the BLM office on the 14th floor of 825 NE Multnomah, Portland. □

CONTENTS

The caves of Crater Lake National Park

by John Eliot Allen, Geo artment, Portland State University, P. O. Box 751, Portland, OR 97207

ABSTRACT

At least five notable caves occur within Crater Lake National Park outside the rim, and over 30 within the rim of the caldera, most of them near the lake level which has varied as much as 30 feet within the last 100 years. The caves originated, in order of abundance, from wave erosion on strongly jointed platy lavas (25), erosion of layers of mudflow (in a few cases possibly morainal) material interbedded between the flows (11), beneath jumbles of great blocks of lava on the surfaces of the rhyodacite flows (2), sublimated gas cavity (1), and meandering of a stream, deeply incised in thick ash-flow material (1).

PREFACE

During the summer of 1935, as my very first professional job out of school, I was Ranger Naturalist at Crater Lake. Although my work took up all my time during the week, we did have one day a week off, and we used this for scientific research. I wrote one article on the "Waterfalls of Crater Lake" which was published in the park "Nature Notes," but my main project was caves. It turned out to be too long to publish in the "Notes," and the manuscript has languished in the files at the park for nearly 50 years!

Recently I had occasion to correspond with Ann Cordero, Seasonal Park Naturalist at the lake, and asked her if the manuscript was still in the files. She sent me a copy, which is reproduced here for the first time, with slight additions.

INTRODUCTION

From prehistoric times, caves have occupied a vital place in the affairs of the human race. One of the early fossil men, Synanthropus, lived deep in a limestone cavern in the hills near what is now Beijin (Peking). Cro-Magnon man used the caves of Altamira, Spain, and southern France for ceremonial purposes, and left evidence of his superlative artistry on their walls. The oracles of ancient Greece and Rome frequently chose caves as the dwelling places for their mysteries, and several of the Old Testament prophets spoke from the mouths of caves.

Caves have had a strong effect upon more recent history and literature, from Beowulf to Ali Baba, from King Alfred and Robert Bruce to Captain Jack of the Modoc wars, from the Count of Monte Cristo to Tom Sawyer.

From a place of shelter and protection to which prehistoric man owed his safety, caves in historic times have sometimes taken on an ominous or dreaded aspect, and this spell may well be the result of generations of supernatural and superstitious beliefs.

Before any discussion of caves, the scientist should try to define the term "cave." It must be large enough to enter, or else a rabbit burrow would qualify. It must be enclosed above, or else any deep quarry, crater, or gorge would be a cave. Man-made excavations such as tunnels, adits, and shafts must be excluded. Perhaps "Any natural opening beneath the surface of the earth, large enough to enter and enclosed above" will do, although the definition in the American Geological Institute *Glossary of Geology* runs to five lines!

The area of Crater Lake National Park is underlain entirely by igneous materials (Williams, 1942), predominantly volcanic in origin, consisting, in approximate order of abundance, of andesitic lava flows, glowing avalanche and ash flow and fall deposits, rhyodacite domes and short thick flows, basaltic cinder cones, and glacial moraines. Most of the latter rocks are covered with air-fall deposits formed *circa* 7,000 years ago when Crater Lake was formed but are found within the rim of the caldera beneath the air-fall deposits and interbedded between the lava flows.

All but a few of the caves have been formed during the last 7,000 years, which enables one to calculate the rate of formation of such caves under the conditions prevailing during that very short geologic time.

The most prevalent origin of world caves, of course, is by solution in limestone, which is not found within the park. The andesitic and rhyodacitic lavas are too viscous to form lava tube caves, common elsewhere in the basaltic flows of other parts of Oregon.

The 40 or more caves in Crater Lake National Park (Figure 1) fall into five genetic categories:

1. Twenty-five caves, produced mostly by wave erosion in strongly jointed platy andesitic lava flows. All but six occur within the rim.

2. Eleven caves, produced by erosion of less resistant mudflow or glacial debris lying between lava flows. Six of this type

---

SPECIAL NOTICE

We are publishing this paper because of its unique contribution to the knowledge about Crater Lake National Park—not as an encouragement to "cavers" for casual exploration.

We must warn our readers that the caves in the Park are considered to be unsafe and are, therefore, off limits to Park visitors.

For special research purposes, a written permit to enter the caves must be obtained. It may be requested from (and **may** be granted by) the Park authorities by writing to Crater Lake National Park, Box 7, Crater Lake, OR 97604. (ed.)

John Eliot Allen

The author of this paper, John Eliot Allen, Professor Emeritus of Portland State University, is one of the "grand old men" of Oregon geology, well known as a geologist, teacher, and author.

Allen began his professional connection with Crater Lake National Park—and indeed his professional career—as a park ranger-naturalist in 1935. He was part of the beginnings of the Oregon Department of Geology and Mineral Industries and served on its staff for nearly a decade. He also guided the early steps of the Portland State University Geology Department, serving as its head for 18 years.

The most recent book in Allen's long list of publications, The Magnificent Gateway *(1979), brought him back to the object of his earliest research, the Columbia River Gorge, about which he wrote his master's thesis in 1932. At present, he is most widely known through his regular contributions to the science section in the Thursday edition of* The Oregonian. *(ed.)*

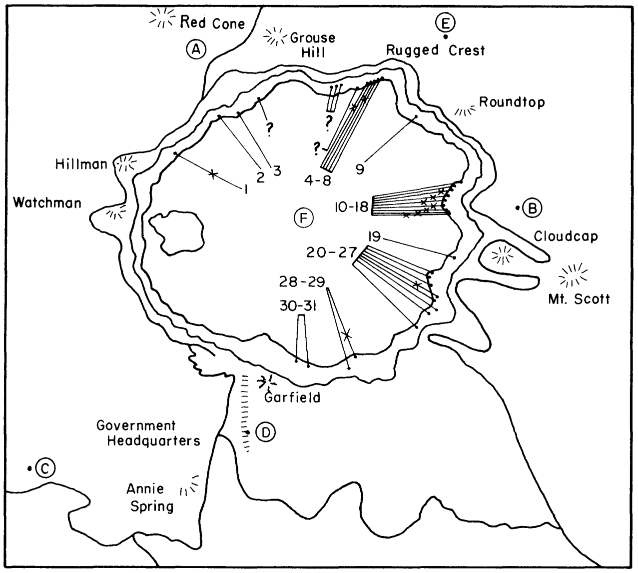


Figure 1. Caves in Crater Lake National Park. A=North Entrance, B=Bear Creek, C=Music Shell, D=Castle Crest, E=Rugged Crest, F (1-31)=caves within the rim, X=caves of special interest within the rim.

occur within the rim (9, 21, 22, 25, 26 and 29) and 5 outside the rim (B and D, nos. 1 to 4).

3. Two caves, one beneath the jumble of large blocks, one on the surface of the Rugged Crest dacite flow (E), and one on Castle Crest (D, no. 5).

4. One cave, the Music Shell (C), was formed by the deep incision of Castle Creek in ash fall and flow deposits, and the meandering of the stream as it cut down to produce a 75-ft overhang.

5. One cave, the North Entrance Cave (A), lies near the surface of the Llao Rock rhyodacite flow, and consists of an elongated complex network of channelways with sublimated minerals on the walls.

NORTH ENTRANCE CAVE (A)

This cave is located on the backslope of the Llao Rock rhyodacite flow on the Diamond Lake Road. The entrance is completely hidden, and it can only be explored with special permission of the Superintendent of the Park. It well merits further study!

In 1935, I slid down a narrow opening in the roof, and the cave quickly opened out into a cavern 40 ft long and over 10 ft wide and high, with numerous small channels, all but a few of them too small to enter, extending downward in all directions (Figure 2).

The general trend of the passages is N. 15° E., and most of the lower passages correspond to this direction. Those that could be explored are shown in the cross section, although they do not all lie exactly in this plane.

A cold draft sufficiently strong to extinguish a match comes out through the entrance, and as far as could be tested, is derived from the northern rather than the southern channels.

The walls when fresh are of highly scoriaceous lava, often spiny or fibrous, rough and cindery, and extremely hard on the hands! This forms a crust from 1 to 2 in. thick over the wall rock of well-banded glassy rhyodacite, whose flow structure is in places alternated with pumiceous or included fragments.

A considerable amount of thin crystalline flakes of specular hematite was found on the rough surfaces in several places, especially in the northern channels, indicating that sublimation had been at work at temperatures above 500° C.

The cave is in no way a lava tube; the evidence seems to point toward an origin as a steam vent, opened by fracturing of the extremely viscous rhyodacite while still hot.

BEAR CREEK CAVE (B)

Bear Creek heads in a dry ravine just east of Skell Head on the Rim Road. The south side of the ravine forms a line of cliffs 200-300 ft high which extend out to a point about ¾ mi east of the rim. If one follows eastward along the base of the cliffs to just around the point, one comes, at an elevation of about 6,950 ft, upon the largest cave now known in the park.

This cave, whose mouth is 40 ft wide and about 10 ft high, extends back and up to the west into a dacite cliff for over 150 ft, rising about 80 ft within this distance (Figure 3). It averages 20 ft in diameter and is nearly circular, but its origin is not that of a lava tube. The material of the floor, beyond a few feet of sandy accumulation near the mouth, is a mudflow or moraine.

Many of the cave surfaces are covered with minute (½ to 1 in.) siliceous stalactites, resulting from the weathering and redeposition of the silica from the feldspars abundant in the dacite above. A few of them may be calcareous, since they could be scratched with a knife blade, but no acid for testing was available.

The cave is a result of the erosion by stoping of the less resistant material of a ridge buried beneath the dacite flow.

This cave was discovered by white men on June 11, 1932, by a party composed of Ed Johns, Al Swan, P.H. Rushmore, and others, engaged in pine beetle control work in the park. Indians are said to have mentioned it, saying that on rare occasions their hunters had used it for shelter.

THE MUSIC SHELL-LLAO'S HALLWAY (C)

At the lower end of that weird, vertical-walled gorge in the ash flows called Llao's Hallway, just above the junction of Castle Creek and Little Castle Creek, the west-flowing stream, which is dry most of the time during late summer months, makes a sudden meander to the south.

This meander grew in radius as the stream cut down through the 200 ft of tough pumice and ash flow until at the present time the gorge wall has been undercut to form an overhang of over 75 ft, resulting in a remarkably perfect natural acoustic arch at least 50 ft high, which is most effective in concentrating the sounds of Castle Creek at its focus.

CASTLE CREEK CAVES (D)

Several caves are visible from Government Headquarters in the face of the steep cliffs that rise on the east side of Munson Valley and are known as Castle Crest. Some of these are only accessible with rock-climbing gear, others may be reached by a steep climb up the talus and through chimneys, or by climbing down from above.

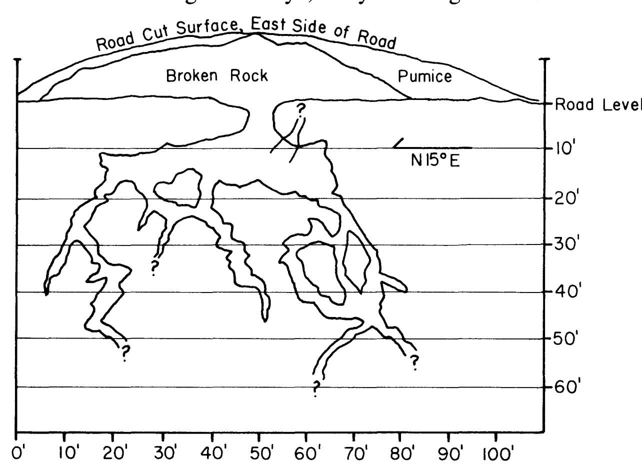


Figure 2. North Entrance cave, longitudinal section.

Those that were visited in 1935 are numbered on Figure 4 and described below. Others, several of them larger and more imposing, at least from the vantage point of the opposite wall of the valley, could not be reached.

1. The mouth of this cave measures 10 by 30 ft and is nearly 25 ft deep. Another cave just north of it could not be reached. The caves are cut in a layer of mudflow or moraine over which the lava poured. The cliffs were later formed by the erosion of the glacier that cut Munson Valley.

2. With a mouth from 5 to 10 ft wide and 4 to 6 ft high, this cave has an overhang of at least 30 ft. Its origin is the same as for cave 1. A 10-ft pinnacle in the mud flow rises opposite the mouth of the cave.

3. This cave is one of the most spectacular of the group, lying just above the steep wall at the top of the cliff. The cave is really a natural tunnel, since it goes through and opens out to the rear as well as below the main cliff face. The front entrance, about 10 ft in diameter, lies below the back entrance, which is an open pit on the level of the ridge top. The roof is only 5 to 10 ft thick and about 15 ft wide from front to back. The cave was caused when a pile of mudflow or morainal rubble, overwhelmed and buried by a lava flow, was later eroded out to form the cave.

4. Two other small caves have the same character as the last, except that they both lie entirely within the mudflow. The southern cave has an 8- by 10-ft opening, is 15 ft long, with a 3- by 8-ft back door. The second, only 40 ft farther north, is still shorter, with an entrance only 5 ft in diameter and a roof of about that thickness.

5. This cave resulted when a giant block of lava leaned against the base of the cliff to produce a cavity 10 ft deep and wide, with a height of about 5 ft.

As far as can be told from a distance, the other unexplored caves in Castle Crest originated by erosion of the more easily eroded mudflow or morainal material, most often opening just below the base of a massive flow of overlying andesite.

RUGGED CREST CAVES (E)

In a reconnaissance of the peculiar castellated rocks on the surface of the Cleetwood Cove rhyodacite flow (including Mazama Rock and many others), two caves of sufficient size to merit attention were discovered.

They lie about ¾ mi northeast of Cleetwood Cove at an elevation of about 6,675 ft, on the edge of a steep break in the slope to the north, several hundred yards west of the valley wall which drops off to the east.

Here two giant blocks of dacite, the western one 300 ft long by 75 ft wide and 30 ft high, and the eastern 200 by 50 by 40 ft, each have within them a cave. The western cave is a tortuous passage extending downwards for over 30 ft at an angle of more than 45° along a cleft which has split the rock apart about 4 ft.

The other cave, 300 ft to the east, is a horizontal north-south-trending passage completely through the rock about 10 ft above its base. It averages 4 ft in height and 7 ft in width. This cave, rather than being caused by displacement, is the result of the erosion of a mudflow layer enclosed within the rock.

CAVES WITHIN THE RIM (F)

A total of over forty caves with dimensions varying from 3 or 4 to 50 ft may be seen from the surface of the lake, and several of these are of sufficient interest or beauty to merit pointing out on the special boat trip. These caves are marked with x's on Figure 1 and asterisks in the text.

Many caves above the water's edge were not visited due to inaccessibility or lack of time. Some of these are described, others are only noted on the map with a question mark. All but six of these caves (1, 9, 21, 22, 25, and 26) have resulted from the erosion of the lava flows along joints; the six are due to erosion in mudflow or morainal material between the lava flows.

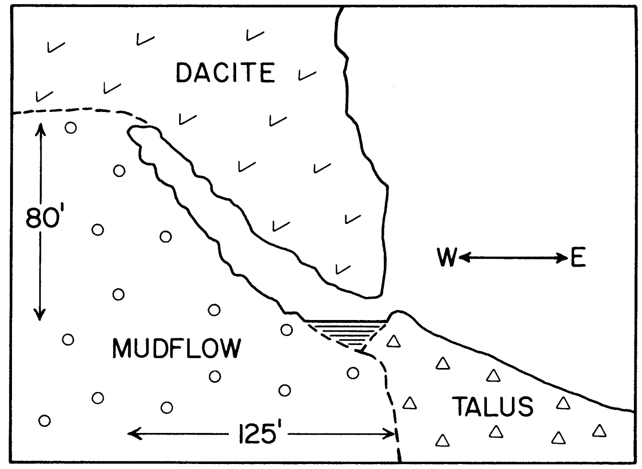


Figure 3. Bear Creek cave, cross section.

Since the time this article was written, conditions have changed a bit. The elevation of the water in the lake changes with time. When J.S. Diller was there in 1896, he placed a brass plug in a cliff face at the water's edge below the present Sinnott Memorial. When I was there in 1935, after considerable search, we found this plug, then 25 ft above the water level. Since that time, the water level has fluctuated about 3 ft (M. Briggs, personal communication, 1983). The current status of the lake level should be determined and the necessary mental adjustments should be made before one tries to repeat the following clockwise boat trip around the lake.

1. On the south side of the base of the Devil's Backbone, over 200 ft above the water level, is a cave of considerable dimensions, which was not visited but which seems to be due to the erosion of a mudflow partially surrounded by the lava dike.

2. A small cave with a bottom 4 ft below water level lies ¼ mi west of Llao Rock. Its dimensions are 10 ft wide, 5 ft deep, with a 7-ft roof. It resulted from the breaking-out of jointed rock.

3. This cave is a low crevice at the water's edge, perhaps 5 ft deep.

The caves on the west side of Cleetwood Cove (numbered 4 to 8) are carved in a thick (40-50 ft) flow of gray andesite, which is characterized by a fine (½ to 1 in.) horizontal platy cleavage. When these plates break out, governed by the major vertical joints (which trend east-west), they leave rounded columns with more or less perfect gothic arches between them over the caves. For this reason, the name "Cathedral Columns" is suggested for these cliffs on the west side of the Cove.

*4. "House Cave," the largest and westernmost cave of the area, differs from the others in being nearly square, with dimensions averaging 20 ft in all directions; more accurately, 25 ft deep, 15-20 ft wide, with a roof 10-15 ft high.

5. "Fireplace Cave" has a mouth only 4 ft wide and 2½ ft high, but inside, 10 ft back from the mouth, the roof rises to over 10 ft, and it is possible to stand erect.

6. "Arch Cave" is the most perfect and the deepest of the gothic recesses between the columns. It is 12 ft high, 6 ft wide at the base, and extends inward for 20 ft. Since, like the other caves, it extends east-west, it can be seen only from well within Cleetwood Cove.

7. This is a broader cave, without special characteristics. It is 25 ft high, 15 ft deep, and 10 ft wide.

8. This is a small cave with an entrance only 5 ft high, but it extends back for 15 ft, narrowing and forking toward the end.

9. This group of caves is located at the base of a 75-ft cliff, just west of the West Palisade, about 300 ft above the water. One cave is as much as 15 ft deep; others are 20-30 ft wide and 10 ft deep, but with very low entrances. They are the result of the erosion of a layer of mudflow which lies beneath the massive lava flow. At one place,

where the cliff overhangs at least 35 ft, the jointed lava has broken out in a chimney 15 ft square, the top of which extends upwards for 20 ft, entirely enclosed except at the base.

10. This is a small cave between Skell Head and the point to the north, that faces to the north and lies about 15 ft above the water. It is only 5 ft wide and quickly narrows to a crevice.

11. Several shallow caves in platy andesite lie above a rock beach about ¼ mi north of Pinnacle Rock ("Captain Applegate").

Around the base of Skell Head there is a large number of caves and crevices at the water's edge which have for many years been called "The Grottos." Most of them are the result of the breaking-out of blocks in the vertically cleaved andesite, whose wavy patterns give a unique loveliness to the cliffs there. Seven of these caves are sufficiently noteworthy for description and naming.

12. "Square Grotto," the first to be seen on the boat trip, lies just south of Pinnacle Rock, at the water's edge, and is about 5 ft square.

*13. "Lens Grotto" is a peculiar lens-shaped cavern 20 ft high, 6 ft wide, and 10 ft deep, which lies about 3 ft above the water. It is caused by the erosion of a lens-shaped body of mudflow within the lava.

*14. "Grotto Crevice" lies 300 ft south of Lens Grotto. This is a cave that is not easy to find, since it is only 5 ft wide at its entrance and about 6 ft high, with a floor at least 20 ft below the water's surface. If one places the nose of the boat in the opening, there is a narrow ledge along which one can climb into the crevice, which extends for 20 ft into the andesite.

15. "Llao's Jaws" is not a water-level grotto, since it is at the head of a rock slope 30 ft above the water. It has an entrance 10 ft square, the top of which is jagged and toothed. The floor rises another 15 ft, and the greatest length of the cave, about 40 ft, is nearly at right angles to the entrance. The entrance faces almost north.

*16. "The Grotto" is located 100 ft south of Llao's Jaws and is the largest and loveliest of the grottos. The opening, which faces northwest, is about 6 ft wide, and the roof is only 6 ft above the lake level (1935) and is studded with the same jagged toothlike spires as Llao's Jaws. The cave is 20 ft deep, and when the boat is run into it, the water below the boat has a deep brilliant blue color that is indescribable. Although the entrance is only 6 ft wide, the cave below the water surface is twice that deep. An overhang that almost reaches the water cuts off half the opening.

17. A small south-facing grotto lies 300 ft south of The Grotto; it is 10 ft wide and 7 ft high and narrows to a crack within 25 ft.

18. "Hidden Grotto" faces almost due south, so that it can be seen only from a boat skirting the shore very closely. It is 5 ft wide, 15-20 ft high and 20 ft deep, of just such proportions that, the floor being below water level, a rowboat will fit in and be completely hidden. This is the last of the Grotto group.

19. Below one of the cliffs that lie under and to the south of Castle Rock is a cave at least 25 ft wide, with an opening 5-8 ft high. Since it lies 150 ft above the water at the base of a 150-ft thick andesite flow, it was not explored.

20. This cave lies above a rock slope 10 ft above water level. It is 8 ft wide, 5-6 ft high, and 10 ft deep with several short side openings.

21. At the tip of Sentinel Point there is a cave with a water floor in a mudflow. The cave is 15 ft wide, 20 ft high, and 10-15 ft deep.

22. A small cave 300 ft southeast of Sentinel Point lies 10 ft above the water in a mudflow. It is 8 ft deep, 5 ft high, and 4 ft wide.

*23. "Blue Crevice" is a deep, mossy crevice in the vertically cleaved rock that, although only 2½ ft wide at the entrance, averages twice that width in the 25 ft of its depth. The crevice is 20 ft high, and the floor slopes so steeply below the water level that at the mouth the water is at least 75 ft deep, and a resulting deep blue light comes from below. If the nose of the boat is placed in the opening, there is a narrow ledge along which one can climb into the crevice

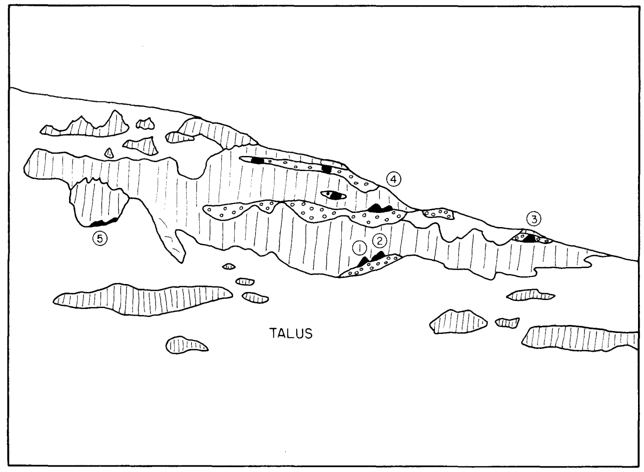


Figure 4. Caves in Castle Crest, east of Government Headquarters.

and get the full effect of the color. A third of the way from the end, there is a side opening 2½ ft wide and 4 ft deep. The crevice bears N. 75° W.

24. There are several vertical openings in the jointed andesite at the water's edge here, none of them very deep. They average 5-10 ft wide and 15-30 ft high.

25 and 26. These are two inaccessible openings 200 and 400 ft above the water in the face of the cliffs. They are of interest in that they are eroded into layers of mudflow and stand out quite clearly in the morning light. Neither can be very deep.

27. A small cave 5 ft above water level, on the first point northeast of Kerr Notch, is 4 to 5 ft wide and 10 ft deep.

*28. "Phantom Cave" lies just east of the Phantom Ship and derives its name from the fact that from within the cave the Ship is framed in its triangular opening. The top of the opening is 13 ft above the water, and its base is 10 ft wide. The cave slopes back and upwards for 30 ft from the mouth, the roof being 12-18 ft high. The cave has resulted from the breaking-out of the rock along rhomboidal cleavages.

29. Another unvisited cave lies almost 900 ft above the water at the base of Dutton Cliff, at the head of the great talus slope. It appears to be about 30 ft wide and 15 ft high at the entrance. It is due to the erosion in a fragmental layer of mudflow or moraine underlying the massive cliff.

30. This tiny cave lies 8 ft above the water, with an entrance 5 ft square. It is only 4 ft deep.

31. Another similar cave 10 ft above the water is 10 ft deep, with an entrance 3 ft high and 4-6 ft wide. Both these last two caves are the result of the breaking-out of cleaved rock fragments.

ACKNOWLEDGMENTS

Ann Cordero, Seasonal Park Naturalist in 1983, kindly copied and sent me a copy of the 1935 manuscript. William Robert McCulloch redrafted the figures.

REFERENCES

Bacon, Charles R., 1983, Eruptive history of Mount Mazama and Crater Lake caldera, Cascade Range, U.S.A., *in* Aramaki, S., and Kushiro, I., eds., Arc volcanism: Journal of Volcanology and Geothermal Research, v. 18, p. 57-115.

Cranston, K.R., 1980, Crater Lake, gem of the Cascades: Lansing, Mich., KRC Press, 111 p.

Harris, S.L., 1976, Fire and ice—the Cascade volcanoes: Seattle, Wash., Pacific Search Press, 320 p.

Williams, Howel, 1942, The geology of Crater Lake National Park, Oregon: Carnegie Institute of Washington Publication 540, 162 p. □

Temperature data and drilling history of the Sandia National Laboratories well at Newberry caldera

by Gerald L. Black, George R. Priest, and Neil M. Woller, Oregon Department of Geology and Mineral Industries

ABSTRACT

A new geothermal well drilled by Sandia National Laboratories in Newberry caldera reached temperatures in excess of 158° C at depths of 350 to 424 m. Artesian fluids entered the well between about 379 and 397 m at a rate of about 340 liters per minute (lpm). The temperature of the main fluid entry is probably in excess of 170° C. The temperature-depth profile of the Sandia well is similar in shape to the nearby Newberry 2 drill hole but reaches higher temperatures at equivalent depths. It is possible that the Sandia well, which is closer to the caldera ring-fault system than Newberry 2, intercepted some of the same hot-water aquifers that Newberry 2 encountered, but the Sandia well is closer to the source of the fluids.

INTRODUCTION

Sandia National Laboratories, Albuquerque, New Mexico, drilled well RDO-1 in Newberry caldera in September and October of 1983. The drilling began on September 16, 1983, and the hole was abandoned on October 20, 1983, as a result of casing problems. The well, which reached a depth of 424 m, was drilled about 457 m southeast of the U.S. Geological Survey (USGS) Newberry 2 drill hole (Figure 1).

The Oregon Department of Geology and Mineral Industries (DOGAMI) and Columbia Geoscience of Hillsboro, Oregon, assisted Sandia scientists with planning and logging the well. Edward A. Sammel of the USGS was also involved in the planning stages.

This report focuses on the temperature data obtained from the well. Lithologic data will be presented in later papers by Marshall Gannett of Columbia Geoscience, John Eichelberger of Sandia National Laboratories, and Terry E.C. Keith of the USGS, and the drilling history will be discussed by Sandia.

TEMPERATURE LOG ANALYSIS

General observations

The final temperature log of RDO-1 was taken on October 6, 1983, two days after mud circulation ceased (Figure 2, Table 1). The log is characterized by very low gradients in the upper part of the well and a very high gradient in the lower part. In the interval from 38 m to approximately 274 m, the hole is essentially isothermal, with a temperature of about 40° ±5° C. From 274 m to the last measurement at 350.5 m, the hole has a linear (conductive) gradient of 1,665° C/km. The temperature probe failed at a depth of 350.5 m, so the final log did not reach total depth.

Earlier temperature logs utilizing Sandia's thermocouple

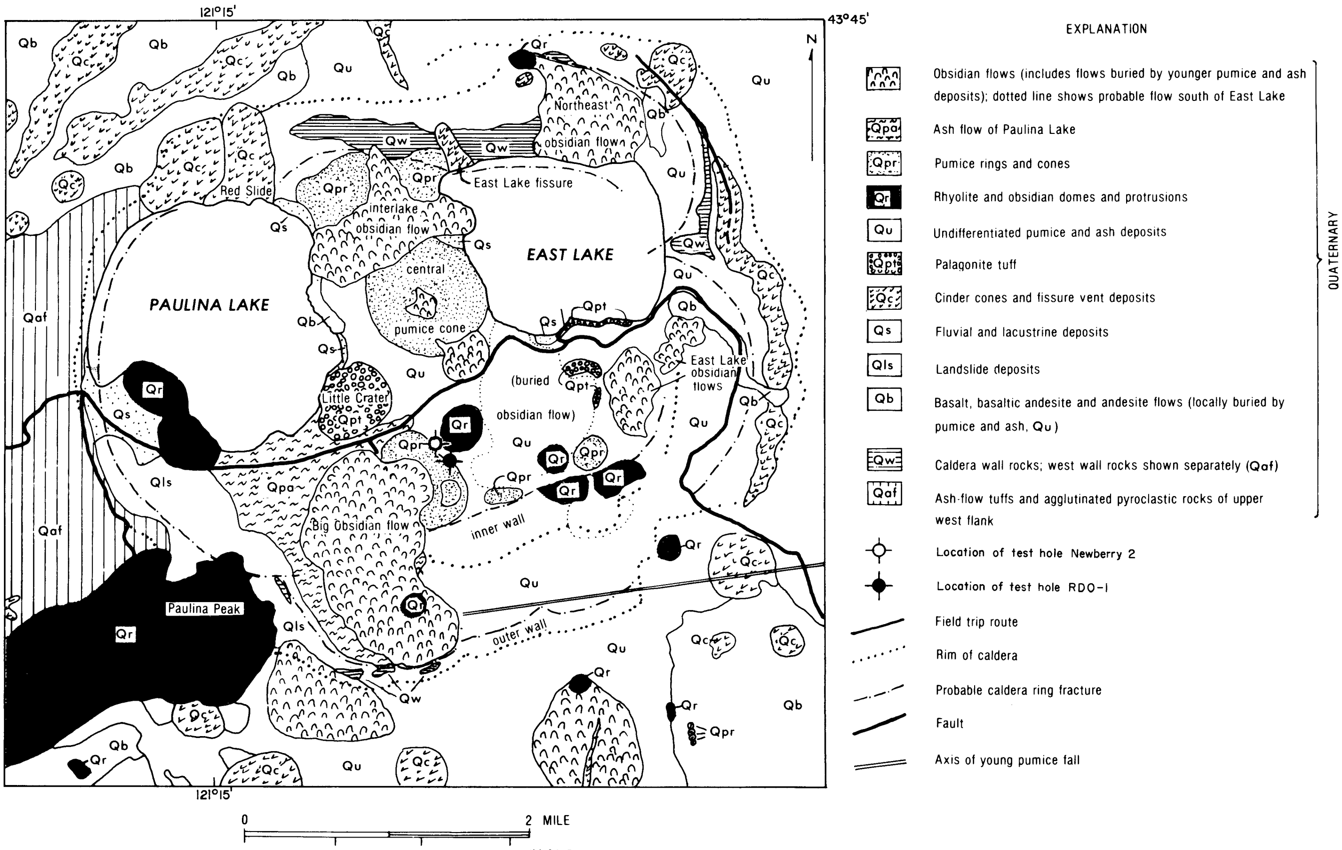


Figure 1. Locations of USGS well Newberry 2 and Sandia National Laboratories well RDO-1. Geologic map is from MacLeod and Sammel (1982).

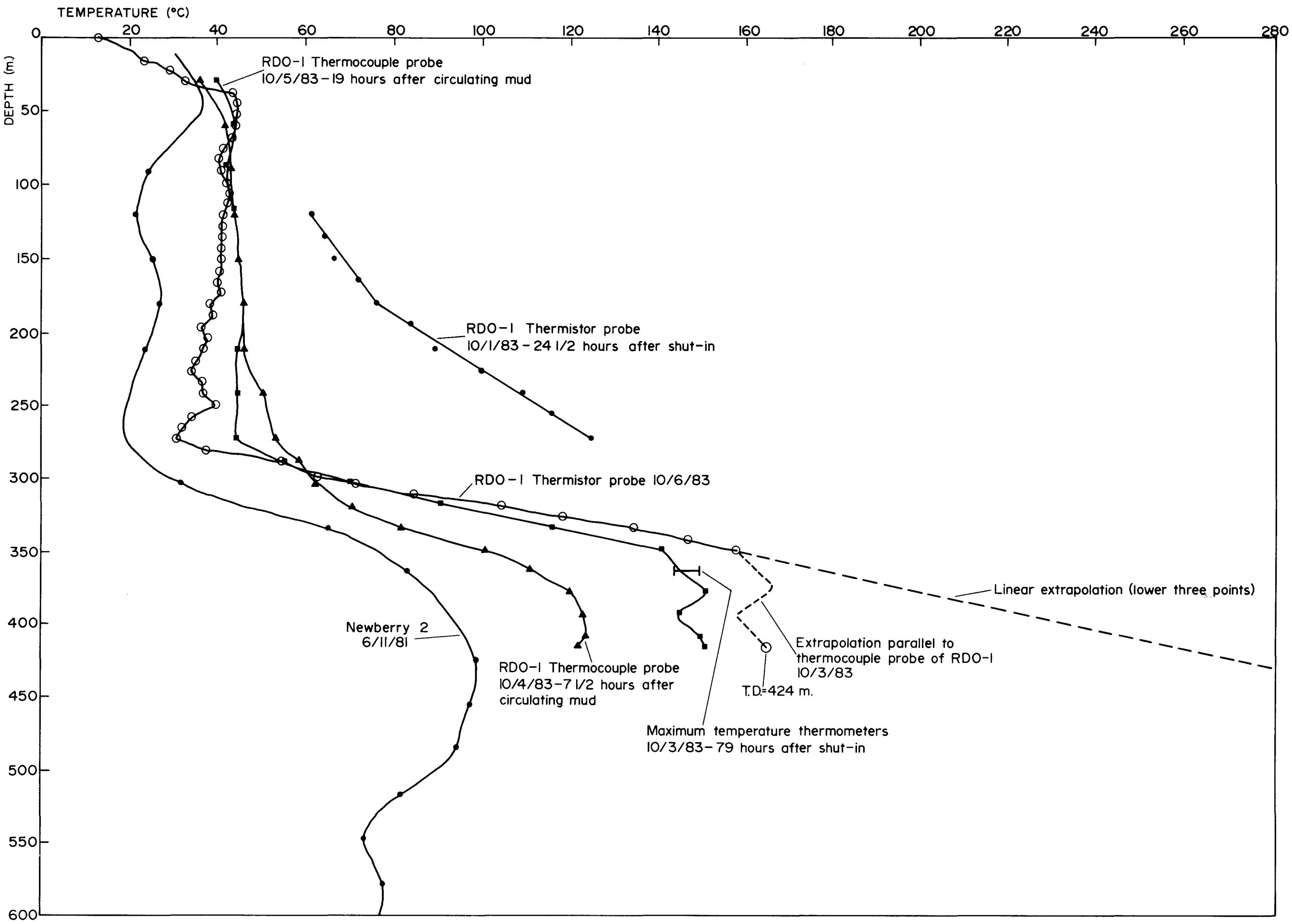


Figure 2. Temperature-depth profiles run at various times during and after drilling the RDO-1 drill hole compared to the profile of the Newberry 2 drill hole at equivalent depths. Thermocouple logs were run by Sandia National Laboratories. The thermistor probe was provided by David D. Blackwell, Southern Methodist University. The first thermistor log was run by Marshall Gannett of Columbia Geoscience; the final log was run by Gerald L. Black of the Oregon Department of Geology and Mineral Industries.

probe indicate that the temperature profile below about 351 m has a very low, irregular gradient, which probably reverses near the bottom of the hole. The earlier logs also show considerable cooling in the lower part of the well as a result of mud circulation. It is probable that the hole was not in complete thermal equilibrium when the final log was completed.

Detailed log analysis

0-38 m: In this interval, the gradient is 770° C/km. It represents conductive heat flow between the surface and a warm aquifer at 38 m. Nearby water wells indicate that the volcaniclastic rocks from 12 to 38 m are saturated. The conductive gradient indicates that there is probably neither rapid lateral nor vertical ground-water flow in this interval.

38-67 m: A warm aquifer (44.5° C) causes this isothermal section of the profile.

Negative inflection at 84, 183, 198, 239, and 274 m: All of these negative inflections (Figure 2) occur in the portion of the hole which has been cased off (casing was set to 305.7 m), so it is unlikely that they are the result of disturbances caused by the injection of drilling fluid into permeable zones in the formation. Mud was circulated in the hole shortly before the temperature log of 10/4/83 was run. As can be seen in Figure 2, the upper portion of the hole was roughly isothermal at a temperature just over 40° C, 19 hours after mud circulation ceased, although the wide separation of data points could allow short wave length temperature inflections to go unnoticed. On the final log of 10/6/83 (Figure 2), the upper portion of the hole had apparently cooled (the DOGAMI thermistor probe and the Sandia thermocouple were not calibrated against one another), and several negative temperature inflections are present. The inflection at 84 m correlates with a pumiceous layer and probably represents a relatively cool aquifer. The inflections at 183, 198, 239, and 274 m do not correlate with lithologic changes. All occur in a portion of the hole composed of uniform basaltic lapilli tuff (Marshall Gannett, personal communication, 1983). The inflections at 183 and 198 m are minor and may be of no significance, or they may represent very small, slightly cool aquifers. The inflections at 239 and 274 m are of higher amplitude than those of 183 and 198 m. They flank what is probably a small, warm aquifer at 250 m. The minimum at 274 m correlates precisely with a cool aquifer in the nearby Newberry 2 drill hole (MacLeod and Sammel, 1982). The convex shape of the temperature-depth curve above and below the temperature minimum indicates that the hole is not yet in equilibrium at that point. Projection of the linear segments just above and below the convex segments indicates that the temperature should eventually stabilize at about the same temperature as observed in Newberry 2.

111-274 m: The overall gradient, except for one interval from 121 to 175 m which is essentially isothermal at a temperature of 41.5° C, is −69.8° C/km. This overall negative gradient, which reaches a minimum temperature of 31.4° C at 274 m, indicates the influence of a cold aquifer at 274 m.

274-350.5 m: The smooth linear gradient of 1,665° C/km in this interval is representative of conductive heat flow through relatively impermeable rocks. These rocks consist predominantly of the fine clay-rich volcanic sediments and devitrified tuffs which are incompetent and incapable of sustaining open fractures for fluid movement (Marshall Gannett, personal communication, 1983).

350.5-424 m (total depth): The last temperature probe did not cover this interval because of failure of the cable and loss of the probe at 350.5 m.

The log of 10/4/83 turns isothermal at approximately 375 m. The hot aquifer occurs between 379 and 397 m (Marshall Gannett, personal communication, 1983). The log of 10/5/83 turns isothermal at approximately 350 m. The difference between the two logs results from intraborehole upflow caused by the overpressured hot aquifer. The negative inflection at approximately 380 m may result from the injection of drilling mud into the hot aquifer. Approximately 80 barrels of fluid were pumped back into the thermal aquifer about two days before this log was run (Marshall Gannett, personal communication, 1983).

By projecting the gradient from the thermocouple log of 10/5/79 onto the bottom of the thermistor profile of 10/6/83, a highly speculative bottom-hole temperature of 158°-166° C is predicted. However, in view of the amount of fluid pumped back into the formation, it is likely that the bottom-hole temperature is in excess of 170° C.

POSSIBLE RELATIONSHIP OF RDO-1 TO NEWBERRY 2

The absolute temperatures in the RDO-1 hole are higher than the nearby Newberry 2 well, but the thermal profiles of the two wells are very similar (Figure 2). This similarity implies that components of common aquifers were encountered in both holes. The fluids in Newberry 2 may be cooler than those in RDO-1 as a result of conductive cooling and mixing with cool meteoric water. RDO-1 may therefore be closer to the source of the upwelling thermal waters which have migrated laterally to the Newberry 2 well. RDO-1 is also closer to the caldera ring fault system than Newberry 2. While it is only speculation, a possible interpretation is that thermal water is convecting up the nearby ring faults and spreading out laterally along permeable layers within the caldera. If this is the case, then similar lateral circulation may be occurring from the ring faults into permeable layers outside of the caldera as well.

CONCLUSIONS

Drill hole RDO-1, drilled to 424 m by Sandia National Laboratories, intercepted a moderate-temperature hydrothermal system at shallow depth in Newberry caldera. Between about 379 and about 397 m, fluids in excess of 158° C produced artesian flow at 340 lpm. Although not reliably measured, the temperature at the fluid entry was probably in excess of 170° C.

Temperatures, although not fully recovered from drilling effects, clearly show that the temperature-depth profile of RDO-1 is very similar to, but much hotter than, that of the nearby Newberry 2 hole drilled by the USGS. The RDO-1 hole may be closer to the source of the shallow thermal water encountered in Newberry 2. Closer proximity of RDO-1 to thermal fluids possibly upwelling in a caldera ring-fracture system may be the cause of the differences in temperature between the two wells.

Table 1. *Temperature-depth log of the Sandia well in Newberry caldera, taken 10-6-83, approximately two days after circulating mud. Total depth of well=1,390 ft; depth logged=1,150 ft*

Depth (ft)	Temp. ° C	Depth (ft)	Temp. ° C
0	14.43	600	39.15
25	20.08	625	39.60
50	23.68	650	36.93
75	29.47	675	38.19
100	33.10	700	37.15
125	43.78	725	35.84
150	44.67	750	34.38
175	44.58	775	36.82
200	44.36	800	37.51
225	43.87	825	40.13
250	41.64	850	35.08
275	40.38	875	32.20
300	41.23	900	31.40
325	42.26	925	38.06
350	42.79	950	55.39
375	42.47	975	63.22
400	41.74	1000	71.78
425	41.64	1025	85.04
450	41.35	1050	104.92
475	41.17	1075	118.78
500	41.38	1100	134.70
525	40.98	1125	147.58
550	40.53	1150	158.27
575	41.28		

REFERENCES CITED

MacLeod, N.S., and Sammel, E.A., 1982, Newberry volcano, Oregon: A Cascade Range geothermal prospect: Oregon Department of Geology and Mineral Industries, Oregon Geology, v. 44, no. 11, p. 123-131.

——— 1981, Results of test drilling at Newberry volcano, Oregon: Geothermal Resources Council Bulletin, v. 10, no. 11, p. 3-8 □

Unique state map produced by OSU

Oregon State University researchers at the Environmental Remote Sensing Applications Laboratory (ERSAL) have produced this map of Oregon called the Oregon Landsat Mosaic. It combines satellite pictures of Oregon in a conventional map format with standard map information such as roads, towns, and county boundaries, and Oregon is the first state for which a map of these pictures has been prepared.

The Oregon Landsat Mosaic is a composite of 74 different satellite photographs, the most detailed satellite imagery of Oregon available through 1982—that of Landsat-3 RBV (Landsat is the name of the satellite, and this one is the third in a series launched by NASA in 1978; RBV designates the camera system as "Return Beam Vidicon").

Landsat-3 has been taking pictures from a circular orbit at an altitude of 920 km (570 mi). The orbit is synchronized with the rotation of the earth and also sun-synchronous, so that the satellite covers areas repeatedly, on a regular schedule, and at approximately the same time of day (in this case, 10:05 a.m. PST). Since clouds often cover the state and block the satellite's view, the pictures chosen for the mosaic are mostly summertime photos taken in 1978, 1979, and 1980.

Portions of the RBV pictures were composed for the mosaic by matching them to the 1:500,000 base map of Oregon produced by the U.S. Geological Survey. The resolution quality of the pictures is better than 40 m (43 yds).

The resulting Oregon Landsat Mosaic measures 42 by 53 in. and is available in a black-and-white and a three-color version. A 1,000-word text of technical information about the satellite system and the mosaic is included in the side margin. The three-color version is sold by the Oregon Department of Geology and Mineral Industries in Portland. See the listing under "Miscellaneous Publications" on the last page of this issue. □

Howel Williams honored in new geographic name

The U.S. Board on Geographic Names approved, at its October 1983 meeting, the name "Williams Crater" for a previously nameless but quite conspicuous and geologically fascinating feature in Crater Lake National Park. Thanks to the efforts of U.S. Geological Survey geologist Charles R. Bacon, who has been studying Crater Lake for several years now, the new name will be published in the Board's Decision List 8304 reading, in part, as follows:

Williams Crater: cinder cone, in Crater Lake National Park, on the slope of Mount Mazama, 0.97 km (0.6 mi) WNW of Hillman Peak; named for Dr. Howel Williams (1898-1980), Professor of Geology at the University of California at Berkeley, and author of "The Geology of Crater Lake National Park". . . .

To quote Bacon, "Williams wrote the definitive account of the geology of the park and many landmark papers in volcanology. At the time of his death in 1980, he was perhaps the world's preeminent volcanologist. . . . Crater Lake was dear to his heart, and his work there has had an impact on countless park visitors."

Informally, the small cinder cone just outside the Crater Lake caldera had been known as "Forgotten Crater"—a name Williams made known in his 1942 study (Williams, 1942), where he referred to a 1932 note by D. LeC. Evans in the *Nature Notes* published by the park's staff. Williams recognized that this cone was not much older than the caldera itself, that it might be related to the eruptive center at Hillman Peak, one of the few still remaining eruptive peaks that once made up the volcanic complex of Mount Mazama, and that it had erupted a puzzling variety of lavas.

Bacon's research now shows that Williams crater is probably 22,000 to 30,000 years old. The three gray lava flows emanating from the rusty-red cinder cone are composed of spectacularly banded, "commingled" andesite and dacite lava, which itself contains inclusions of basalt. What happened here "may have been initiated by an eruption of typical High Cascade basaltic magma. . . . Because of its proximity to the Mazama magmatic system, this disturbance came under the influence of the local stress field and allowed the basaltic magma access to the margins of a compositionally zoned system by opening of radial fractures. Eruption of highly complex, varyingly mixed and commingled magmas followed" (Bacon, 1983).

Bacon says that he chose this feature around the Crater Lake caldera to commemorate Williams because it was first described by Williams "and because virtually every topographic pimple [there] already has a name."

REFERENCES CITED

Bacon, C.R., 1983, Eruptive history of Mount Mazama and Crater Lake caldera, Cascade Range, U.S.A., *in* Aramaki, S., and Kushiro, I., eds., Arc volcanism: Journal of Volcanology and Geothermal Research, v. 18, p. 57-115.

Williams, H., 1942, The geology of Crater Lake National Park, Oregon: Carnegie Institution of Washington Publication 540, 162 p. □

Oregon land use symposium planned

A symposium on Oregon's land use planning process will be held February 17-18, 1984, on the campus of Lewis and Clark Law School in Portland. The program is sponsored by *Environmental Law*, the school's law journal.

The symposium is entitled "Oregon Land Use: Promoting Growth and Preservation in the Next Decade" and will take a retrospective and prospective look at Oregon's statewide land use planning process which has been criticized as an obstacle to economic growth and applauded as a model of environmental prudence.

Speakers will include local, state, and national experts in land use law, planning, and practice, chosen to provide a cross section of viewpoints.

The agenda will focus both on current policy issues and the practical aspects of participating in the Oregon land use planning process. Continuing legal education credit is available for Washington attorneys and may be available for other states.

For more information, contact Renee Fitzgerald, Editor-in-Chief, (503) 244-1181, x701; or Laurie Bennett, Program Chairperson, (503) 244-1181, x702. □

AIME annual meeting announced

The American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) will hold its 113th annual meeting in Los Angeles, California, from February 26 to March 1, 1984. Concurrently, there will be annual meetings of SME-AIME, TMS-AIME, and WAAIME.

There will be all-Institute meetings and social events, as well as extensive technical programs by several of the subgroups of the Institute. Featured speaker at the all-Institute luncheon on February 27 will be Harry M. Conger, Chairman of the Board and Chief Executive Officer of Homestake Mining Company.

For advance registration (deadline February 10, 1984) and further information, write to Society of Mining Engineers of AIME, Meetings Dept., Caller No. D, Littleton, CO 80127. □

Grant money available from Mazamas

Each year the Mazamas provide grants to aid scholarly studies related primarily to living features of the outdoors and the interaction between people and their environment. The Mazamas have recently supported research on such subjects as the vegetation of Baldy Mountain, the geology of the Slesse Peak area, the ecology of Bighorn Sheep, and the perception of climbers of their impact on Grand Teton National Park. Preference is given to subjects of interest to Mazamas.

Applications for such grants must be postmarked or received by the Research Committee before March 1, 1984. Grants will be awarded by the Research Committee on May 1, 1984. Detailed information on conditions of awards, deadlines, and application procedure may be obtained from the Mazamas, 909 NW 19th Ave., Portland, OR 97209. Letters requesting information should be marked "Mazama Research Grant Information" on the envelope. □

New mineral display at State Capitol features Salem meteorite

The Willamette Agate and Mineral Society of Salem is providing the collection for December 1983 through February 1984 in the State Capitol display case of the Oregon Council of Rock and Mineral Clubs.

More than 50 specimens are being shown, all of them from Oregon and representing 12 Oregon counties. The varied display includes thundereggs (the "Oregon state rock"), various kinds of petrified wood, jade, obsidian, rough and faceted sunstones, and fossils.

Featured in the display are the fragments of the Salem meteorite of 1981, the first Oregon meteorite whose fall was witnessed and which was then recovered. The meteorite specimens were loaned by finder and owner Deputy Sheriff Jim Price of Salem.

The Rogue Gem and Geology Club of Grants Pass will provide the subsequent display scheduled to open March 1, 1984. □

Available publications

BULLETINS	Price	No. Copies	Amount
33. Bibliography (1st supplement) geology and mineral resources of Oregon, 1947: Allen	$ 3.00		
35. Geology of the Dallas and Valsetz quadrangles, rev. 1964: Baldwin (map only)	3.00		
36. Papers on Tertiary foraminifera: Cushman, Stewart, and Stewart, 1949: v. 2	3.00		
44. Bibliography (2nd supplement) geology and mineral resources of Oregon, 1953: Steere	3.00		
46. Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey	3.00		
49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch	3.00		
53. Bibliography (3rd supplement) geology and mineral resources of Oregon, 1962: Steere and Owen	3.00		
61. Gold and silver in Oregon, 1968: Brooks and Ramp	17.50		
62. Andesite Conference guidebook, 1968: Dole	3.50		
65. Proceedings of the Andesite Conference, 1969: (copies)	10.00		
67. Bibliography (4th supplement) geology and mineral resources of Oregon, 1970: Roberts	3.00		
71. Geology of selected lava tubes in Bend area, Oregon, 1971: Greeley (copies)	5.00		
78. Bibliography (5th supplement) geology and mineral resources of Oregon, 1973: Roberts	3.00		
81. Environmental geology of Lincoln County, 1973: Schlicker and others	9.00		
82. Geologic hazards of Bull Run Watershed, Multnomah, Clackamas Counties, 1974: Beaulieu	6.50		
83. Eocene stratigraphy of southwestern Oregon, 1974: Baldwin	4.00		
84. Environmental geology of western Linn County, 1974: Beaulieu and others	9.00		
85. Environmental geology of coastal Lane County, 1974: Schlicker and others	9.00		
87. Environmental geology of western Coos and Douglas Counties, 1975	9.00		
88. Geology and mineral resources of upper Chetco River drainage, 1975: Ramp	4.00		
89. Geology and mineral resources of Deschutes County, 1976: Peterson and others	6.50		
90. Land use geology of western Curry County, 1976: Beaulieu	9.00		
91. Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties, Oregon, 1977: Beaulieu	8.00		
92. Fossils in Oregon (reprinted from *The Ore Bin*), 1977	4.00		
93. Geology, mineral resources, and rock material of Curry County, Oregon, 1977	7.00		
94. Land use geology of central Jackson County, Oregon, 1977: Beaulieu	9.00		
95. North American ophiolites, 1977	7.00		
96. Magma genesis: AGU Chapman Conference on Partial Melting, 1977	12.50		
97. Bibliography (6th supplement) geology and mineral resources of Oregon, 1971-75, 1978	3.00		
98. Geologic hazards of eastern Benton County, Oregon, 1979: Bela	9.00		
99. Geologic hazards of northwestern Clackamas County, Oregon, 1979: Schlicker and Finlayson	10.00		
100. Geology and mineral resources of Josephine County, Oregon, 1979: Ramp and Peterson	9.00		
101. Geologic field trips in western Oregon and southwestern Washington, 1980	9.00		
102. Bibliography (7th supplement) geology and mineral resources of Oregon, 1976-1979, 1981	4.00		
GEOLOGIC MAPS			
Reconnaissance geologic map of Lebanon quadrangle, 1956	3.00		
Geologic map of Bend quadrangle and portion of High Cascade Mountains, 1957	3.00		
Geologic map of Oregon west of 121st meridian (USGS I-325), 1961	5.50		
Geologic map of Oregon east of 121st meridian (USGS I-902), 1977	5.50		
GMS-4: Oregon gravity maps, onshore and offshore, 1967 (folded)	3.00		
GMS-5: Geologic map of Powers quadrangle, Oregon, 1971	3.00		
GMS-6: Preliminary report on geology of part of Snake River Canyon, 1974	6.50		
GMS-8: Complete Bouguer gravity anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00		
GMS-9: Total field aeromagnetic anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00		
GMS-10: Low- to intermediate-temperature thermal springs and wells in Oregon, 1978	3.00		
GMS-12: Geologic map of the Oregon part of the Mineral quadrangle, 1978	3.00		
GMS-13: Geologic map of the Huntington and part of the Olds Ferry quadrangles, Oregon, 1979	3.00		
GMS-14: Index to published geologic mapping in Oregon, 1898-1979, 1981	7.00		
GMS-15: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, northern Oregon, 1981	3.00		
GMS-16: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, southern Oregon, 1981	3.00		
GMS-17: Total-field aeromagnetic anomaly map, Cascade Mountain Range, southern Oregon, 1981	3.00		
GMS-18: Geology of the Rickreall, Salem West, Monmouth, and Sidney 7½-minute quadrangles, Marion, Polk, and Linn Counties, Oregon, 1981	5.00		
GMS-19: Geology and gold deposits map of the Bourne quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-20: Map showing geology and geothermal resources of the southern half of the Burns 15-minute quadrangle, Oregon, 1982	5.00		
GMS-21: Geology and geothermal resources map of the Vale East 7½-minute quadrangle, Oregon, 1982	5.00		
GMS-22: Geology and mineral resources map of the Mt. Ireland quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-23: Geologic map of the Sheridan quadrangle, Polk and Yamhill Counties, Oregon, 1982	5.00		
GMS-24: Geologic map of the Grand Ronde quadrangle, Polk and Yamhill Counties, Oregon, 1982	5.00		
GMS-25: Geology and gold deposits map of the Granite quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-26: Residual gravity maps of the northern, central, and southern Cascade Range, Oregon, 1982	5.00		
GMS-27: Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1° by 2° quadrangle, 1982	6.00		
GMS-28: Geology and gold deposits map of the Greenhorn quadrangle, Baker and Grant Counties, Oregon, 1983	5.00		
GMS-29: Geology and gold deposits map, NE¼ Bates quadrangle, Baker and Grant Counties, Oregon, 1983	5.00		
OIL AND GAS INVESTIGATIONS			
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well	3.00		
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well, 1973	3.00		
5. Prospects for natural gas production or underground storage of pipeline gas, upper Nehalem River Basin, Columbia-Clatsop Counties, Oregon, 1976	5.00		
6. Prospects for oil and gas in the Coos Basin, western Coos, Douglas, and Lane Counties, Oregon, 1980: Newton and others	9.00		
7. Correlation of Cenozoic stratigraphic units of western Oregon and Washington, 1983	8.00		

← ORDER FORM — CUT ON DASHED LINE →

Available publications (continued)

SPECIAL PAPERS	Price	No. Copies	Amount
1. Mission, goals, and programs of Oregon Department of Geology and Mineral Industries, 1978	3.00	_____	_____
2. Field geology of SW Broken Top quadrangle, Oregon, 1978: Taylor	3.50	_____	_____
3. Rock material resources of Clackamas, Columbia, Multnomah, and Washington Counties, Oregon, 1978: Gray and others	7.00	_____	_____
4. Heat flow of Oregon, 1978: Blackwell, Hull, Bowen, and Steele	3.00	_____	_____
5. Analysis and forecasts of the demand for rock materials in Oregon, 1979: Friedman and others	3.00	_____	_____
6. Geology of the La Grande area, Oregon, 1980: Barrash and others	5.00	_____	_____
7. Pluvial Fort Rock Lake, Lake County, Oregon, 1979: Allison	4.00	_____	_____
8. Geology and geochemistry of the Mt. Hood volcano, 1980: White	3.00	_____	_____
9. Geology of the Breitenbush Hot Springs quadrangle, Oregon, 1980: White	4.00	_____	_____
10. Tectonic rotation of the Oregon Western Cascades, 1980: Magill and Cox	3.00	_____	_____
11. Theses and dissertations on the geology of Oregon: Bibliography and index, 1899-1982, 1982: Neuendorf and others	6.00	_____	_____
12. Geologic linears of the northern part of the Cascade Range, Oregon, 1980: Venkatakrishnan, Bond, and Kauffman	3.00	_____	_____
13. Faults and lineaments of the southern Cascades, Oregon, 1981: Kienle, Nelson, and Lawrence	4.00	_____	_____
14. Geology and geothermal resources of the Mount Hood area, Oregon, 1982: Priest and Vogt	7.00	_____	_____
NEW! 15. Geology and geothermal resources of the central Oregon Cascade Range, 1983: Priest and Vogt	11.00	_____	_____ ←
16. Index to the *Ore Bin* (1939-1978) and *Oregon Geology* (1979-1982), 1983: Mahoney and Steere	4.00	_____	_____
SHORT PAPERS			
21. Lightweight aggregate industry in Oregon, 1951: Mason	1.00	_____	_____
24. The Almeda Mine, Josephine County, Oregon, 1967: Libbey	3.00	_____	_____
25. Petrography, type Rattlesnake Formation, central Oregon, 1976: Enlows	3.00	_____	_____
27. Rock material resources of Benton County, 1978: Schlicker and others	4.00	_____	_____
MISCELLANEOUS PAPERS			
1. A description of some Oregon rocks and minerals, 1950: Dole	1.00	_____	_____
5. Oregon's gold placers (reprints), 1954	1.00	_____	_____
8. Available well records of oil and gas exploration in Oregon, rev. 1982: King, Olmstead, and Newton	4.00	_____	_____
11. Collection of articles on meteorites, 1968 (reprints from *The Ore Bin*)	3.00	_____	_____
15. Quicksilver deposits in Oregon, 1971: Brooks	3.00	_____	_____
17. Geologic hazards inventory of the Oregon coastal zone, 1974: Beaulieu, Hughes, and Mathiot	5.00	_____	_____
18. Proceedings of Citizens' Forum on potential future sources of energy, 1975	3.00	_____	_____
19. Geothermal exploration studies in Oregon—1976, 1977	3.00	_____	_____
20. Investigations of nickel in Oregon, 1978: Ramp	5.00	_____	_____
MISCELLANEOUS PUBLICATIONS			
Landforms of Oregon (17 × 12 inches)	1.00	_____	_____
Mining claims (State laws governing quartz and placer claims)	1.00	_____	_____
Geological highway map, Pacific NW region, Oregon-Washington (published by AAPG)	5.00	_____	_____
Geothermal resources of Oregon map, 1982 (published by NOAA)	3.00	_____	_____
Fifth Gold and Money Session and Gold Technical Session Proceedings, 1975	5.00	_____	_____
Sixth Gold and Money Session and Gold Technical Session Proceedings, 1978	6.50	_____	_____
Back issues of *The Ore Bin*	50¢ over the counter; $1.00 mailed	_____	_____
Back issues of *Oregon Geology*	75¢ over the counter; $1.00 mailed	_____	_____
Colored postcard, *Geology of Oregon*	10¢ each; 3 for 25¢; 7 for 50¢; 15 for $1.00	_____	_____
Oregon Landsat mosaic map, 1983 (published by ERSAL, OSU)	$8.00 over the counter; $11.00 mailed	_____	_____

Separate price lists for open-file reports, geothermal energy studies, tour guides, recreational gold mining information, and non-Departmental maps and reports will be mailed upon request.

OREGON GEOLOGY

1005 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

PUBLICATIONS ORDER

Minimum mail order $1.00. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $50.00. Foreign orders: please remit in U.S. dollars.

Fill in appropriate blanks and send sheet to Department.

YOUR NAME ______________________________

ADDRESS ______________________________

______________________________ Zip __________

Amount enclosed $__________

OREGON GEOLOGY

____ Renewal ____ New Subscription ____ Gift

____ 1 Year ($6.00) ____ 3 Years ($15.00)

NAME ______________________________

ADDRESS ______________________________

______________________________ ZIP __________

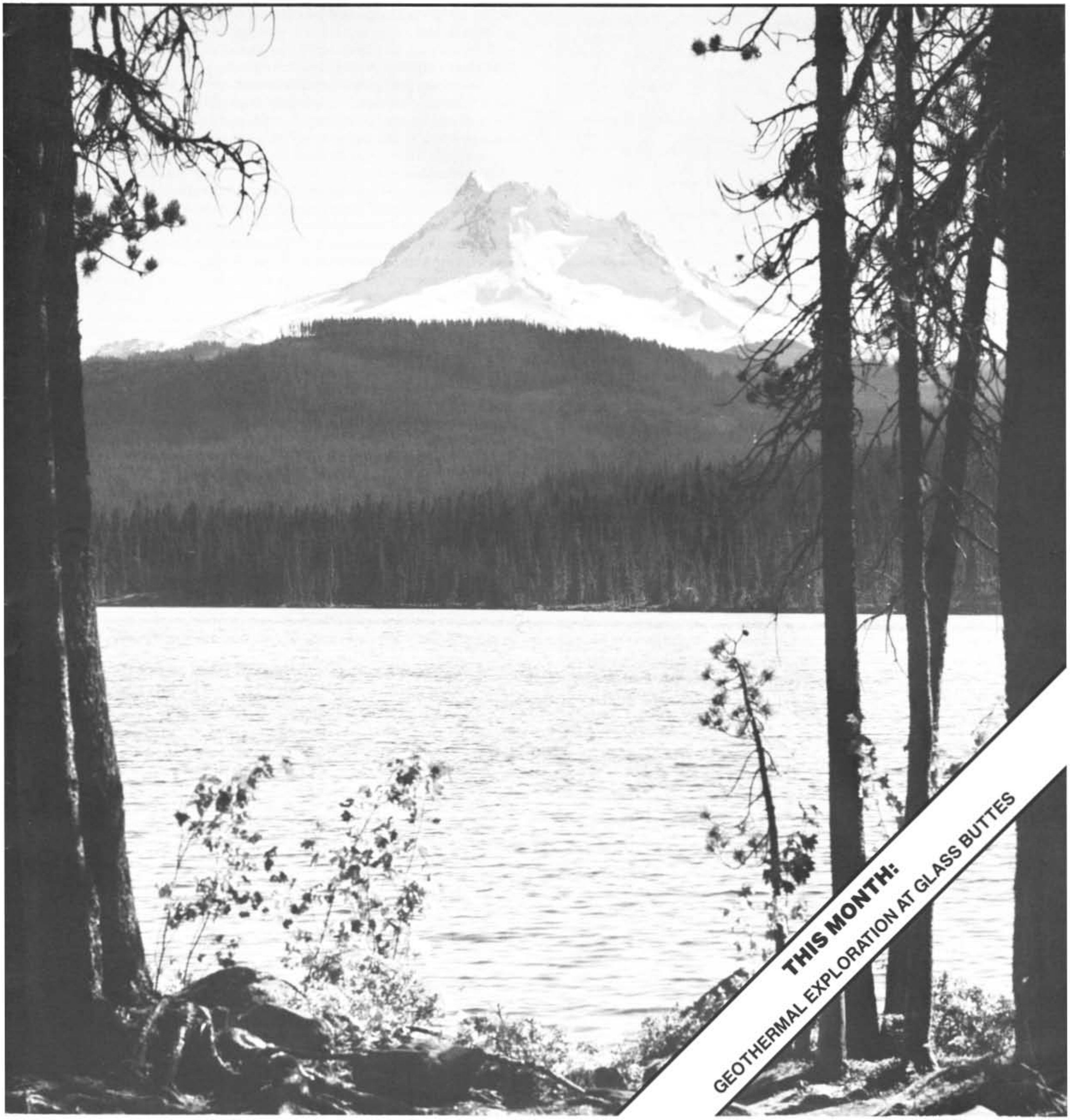
(If Gift, From: ______________________________)

OREGON GEOLOGY

published by the

Oregon Department of Geology and Mineral Industries

VOLUME 46, NUMBER 2 FEBRUARY 1984



THIS MONTH:
GEOTHERMAL EXPLORATION AT GLASS BUTTES

OREGON GEOLOGY
(ISSN 0164-3304)

VOLUME 46, NUMBER 2 FEBRUARY 1984

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

Main Office: 1005 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133.
Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496.
Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039.
Paul F. Lawson, Supervisor

Subscription rates: 1 year, $6.00; 3 years, $15.00. Single issues, $.75 at counter, $1.00 mailed.
Available back issues of *The Ore Bin*: $.50 at counter, $1.00 mailed.

Address subscription orders, renewals, and changes of address to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

Send news, notices, meeting announcements, articles for publication, and editorial correspondence to the editor, Portland office. The Department encourages author-initiated peer review for technical articles prior to submission. Any review should be noted in the acknowledgments.

Second class postage paid at Portland, Oregon.
Postmaster: Send address changes to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

COVER PHOTO

North flank of Mount Jefferson, central Oregon Cascade Range, viewed across Olallie Lake. Geology and geothermal resources of the central Cascades are the subject of a new DOGAMI publication announced on page 22. (State Highway Division photograph)

OIL AND GAS NEWS

Mist Gas Field: New producer

The last well to be drilled in 1983, Reichhold Energy's Columbia County 23-22, was completed to production. The well, 1.5 mi south of the nearest production to date in the field, is located in sec. 22, T. 6 N., R. 5 W., and was completed on December 20, 1983. The total depth of the well was 2,028 ft, and the tested rate was 3 million cfd. The well is significant as the only new gas producer of the year as well as being a new pool discovery. Offset wells have not yet been located.

Mist Gas Field: New well

Reichhold Energy has spudded a new well in the Mist Gas Field: Crown Zellerbach 23-26, located in sec. 26, T. 6 N., R. 4 W. The well was spudded on January 5, 1984, and has a proposed total depth of 4,000 ft. The well will be 7 mi southeast of production.

1983 production total

Preliminary gas production figures indicate that during the year, 3,871,019 Mcf of gas was produced from the Mist Gas Field. Reichhold Energy Corporation is the operator of all the producing wells. A complete summary of 1983 drilling and production will appear in the March 1984 issue of *Oregon Geology*.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
255	Reichhold Energy Corp. Columbia County 13-34A 009-00123	SW¼ sec. 34 T. 7 N., R. 5 W. Columbia County	Application; 2,800.

□

Wilderness studies announced

The U.S. Bureau of Mines has announced its plans for mineral-assessment studies in proposed wilderness areas on federal (BLM) lands in Oregon during 1984. Anybody who has mineral interests or mining claims in any of the areas listed below is invited to contact the appropriate project leader at the Western Field Operations Center, U.S. Bureau of Mines, 360 East 3rd, Spokane, WA 99202, phone (509) 456-5350.

Wilderness Study Area	Project Leader	Estimated time in field
Pueblo Mountains	Steven R. Munts	05/29/84-08/30/84
High Steens	Leon E. Esparza	06/12/84-08/30/84
Little Blitzen Gorge	Thomas J. Peters	09/04/84-09/13/84
Owyhee Canyon	Mitch J. Linne	05/29/84-07/19/84
Honeycomb	Douglas R. Scott	07/24/84-09/23/84

All the areas involved were included in a recent mineral-assessment study by the Oregon Department of Geology and Mineral Industries (Open-File Report O-83-2), which identified some areas with anomalous metal values. □

CONTENTS

Geothermal exploration at Glass Buttes, Oregon*

by Keith E. Johnson and Eugene V. Ciancanelli, Cascadia Exploration Corporation, 3358 Apostol Road, Escondido, CA 92025

ABSTRACT

Glass Buttes is a Pliocene-Pleistocene bimodal volcanic center located in central Oregon along the Brothers fault zone. The silicic volcanic rocks were erupted within a northwest-trending graben. Hydrothermally altered rocks prove the former presence of a high-temperature geothermal system. Data from temperature-gradient wells define a thermal anomaly of about 8 sq mi located adjacent to the alteration within an area which has undergone subsidence. The temperatures and gradients measured are sufficient to suggest the possible presence of commercial geothermal temperatures at a depth of less than 10,000 ft.

INTRODUCTION

This paper is based largely upon the exploration efforts of the Vulcan Geothermal Group which holds federal geothermal leases at Glass Buttes. Various reports completed by Cascadia Exploration and other consultants to the Vulcan Group form the basis for this paper.

Phillips Petroleum and the Vulcan Geothermal Group separately filed lease applications at Glass Buttes in 1974. At that time, geologic information on the area was scant, but several factors contributed to the attractiveness of Glass Buttes. These included the presence of a volcanic center, the abundance of silicic volcanic rocks, the presence of hydrothermal alteration and mercury mineralization, the existence of numerous Cenozoic faults, and a reported warm well in the area.

The earliest geothermal exploration at Glass Buttes was sponsored by the Oregon Department of Geology and Mineral Industries (DOGAMI). This preliminary work involved an electrical resistivity survey and temperature-gradient measurements (Hull, 1976; Bowen and others, 1977; Hull and others, 1977). Phillips Petroleum conducted geothermal research from 1977 to 1980, including geologic mapping, geophysical surveys, and temperature-gradient wells. The Vulcan Group began its exploration in 1978 with geologic mapping (Ciancanelli and Emmet, 1979). Gradient drilling in 1979 was followed by additional drilling and a soil-mercury survey in 1981 (Geothermal Services, Inc., 1979, 1981; Ciancanelli and Johnson, 1981). This paper outlines the major conclusions of these investigations.

GEOLOGY

Glass Buttes is located in the High Lava Plains province of Oregon (Figure 1). This province marks the northern border of the Basin and Range province and is dominated by late Miocene to Pleistocene volcanic rocks. These rocks probably overlie older Paleozoic to Tertiary rocks which crop out within the Basin and Range to the south and within isolated areas to the north. Late Tertiary and Quaternary silicic volcanic rocks of the High Lava Plains were shown by Walker (1974) to display a systematic progression in age, becoming younger to the west. The most recent rhyolitic volcanism in this trend occurs at Newberry volcano.

The most striking structural feature of the High Lava Plains is the west-northwest-trending Brothers fault zone (Walker, 1969). This zone of en echelon faults contains most of the silicic volcanic centers within the High Lava Plains. The faults of the Brothers fault

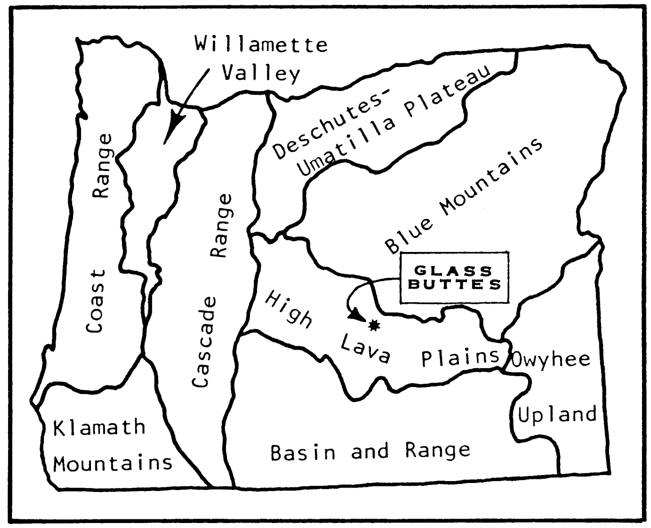


Figure 1. Index map showing the location of Glass Buttes and the physiographic provinces of Oregon.

zone display normal offsets, although some authors have suggested right-lateral motion along the zone (e.g., Lawrence, 1976). The presence of such a distinct tectonic feature spatially coincident with numerous volcanic centers strongly suggests the Brothers fault zone is a deep-seated structure.

Rock units of the Glass Buttes area can be divided into four major groups (Ciancanelli and Emmet, 1979) that differentiate three periods of volcanism. Although three periods are suggested, temporal overlap of the periods is probable. Within each group, several different units were mapped, but for clarity, only the four major groups are shown in Figure 2. The four rock groups are as follows:

1. **Pre-Glass Buttes volcanic rocks.** These are the oldest rocks exposed in the area and are probably early Pliocene or older. The rocks of this group are nearly all olivine-bearing basalt flows that comprise the flat-lying area surrounding Glass Buttes. Also included within this group are two interbedded welded-tuff units located in the eastern portion of the area. The welded-tuff units are tentatively correlated with the Devine Canyon and the Wagontire Mountain welded tuffs (Greene, 1973; Walker and Swanson, 1968).

2. **Glass Buttes silicic volcanic rocks.** Most of the rocks comprising the Glass Buttes area are silicic rocks including rhyolite and rhyodacite flows and tuffs. A series of silicic domes form the elongate west-northwest-trending pattern of silicic volcanism at Glass Buttes. Post-volcanic erosion leading to poor exposures and the great petrographic diversity within individual rock units and flows deter accurate mapping of all individual units within this group. Most of Glass Buttes consists of a mappable unit composed of rhyolite flows that appear in outcrop as flow-banded or pumiceous rhyolite. Below the surface, however, is reddish-brown obsidian. The bulk of silicic volcanism is probably Pliocene, based upon an age of 4.9±0.3 m.y. (Walker, 1974) for the main silicic unit of the area. A few mappable individual rhyolite and dacite units overlie this main unit, suggesting some silicic volcanism after 4.9 m.y. B.P.

* Reprinted with permission from *Geothermal Resources Council Transactions*, v. 7 (1983), p. 169-174. This volume, which contains the transactions of the 1983 annual meeting in Portland, Oregon, is available from Geothermal Resources Council, P.O. Box 1350, Davis, CA 95617. Price is $33 (10 percent discount for GRC members), plus $3.50 shipping and handling.

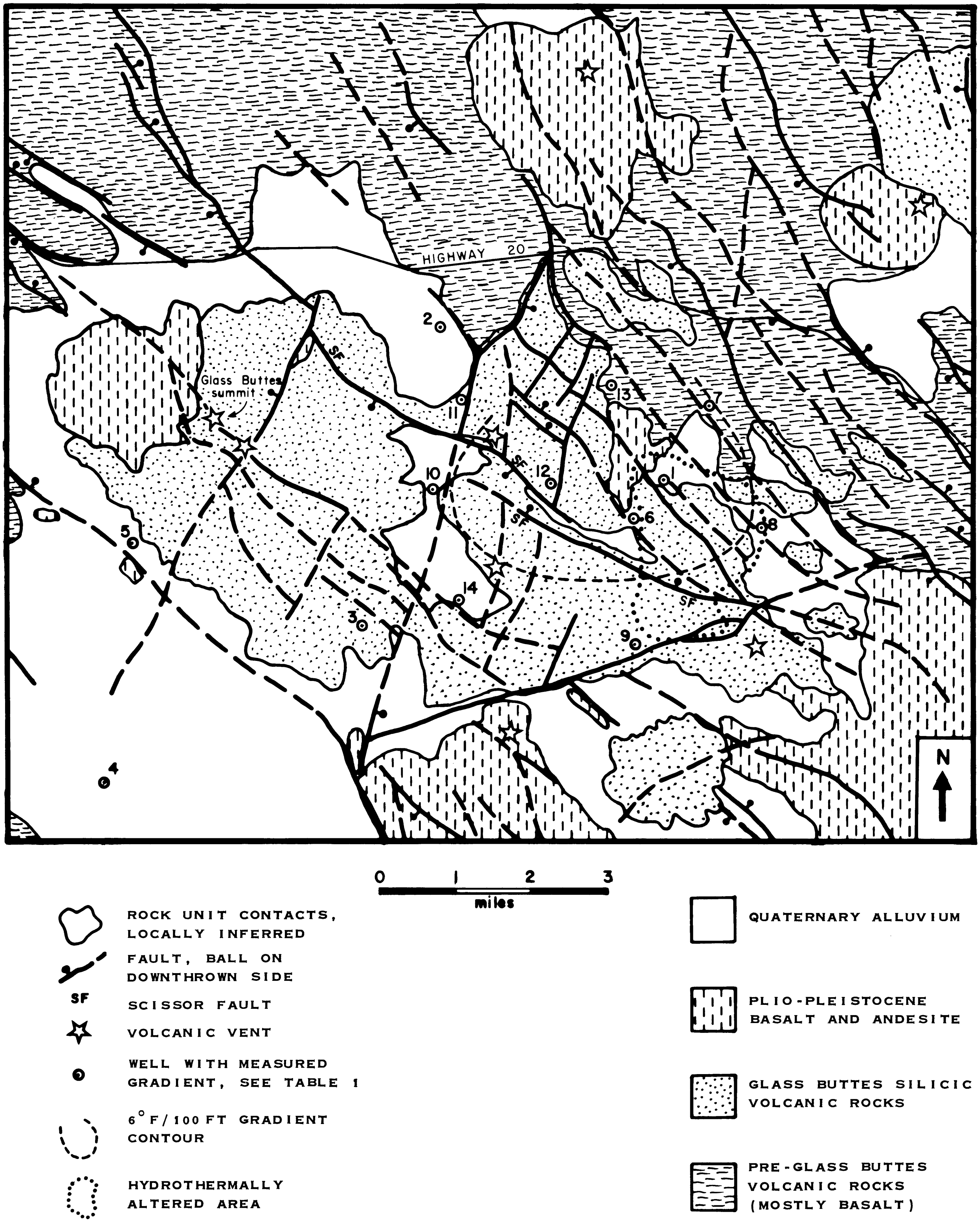


Figure 2. Generalized geologic map of the Glass Buttes area. A high-altitude photograph was used as a base map. Some distortion is present. Simplified from Ciancanelli and Johnson (1981).

3. **Plio-Pleistocene basalt and andesite.** This group of rocks forms a crude ring around the central silicic volcanic rocks, partially separating them from the older Tertiary olivine basalt flows. Although the Plio-Pleistocene basalt flows are very similar in outcrop to the older basalt flows, they do differ petrographically, and the younger basalt is more porphyritic. A large andesite flow present on the northwest flank of Glass Buttes is part of this rock group and was apparently erupted during the waning stages of silicic volcanism. Also included within this group are several basalt cinder cones within or near the younger porphyritic basalt flows. These cones probably represent vents for the younger basalt and suggest a ring-fracture system around the Glass Buttes silicic domes.

4. **Tertiary-Quaternary sediments.** Extensive areas of alluvium surround the buttes. The alluvium consists of boulder- to clay-size volcanic material shed from the complex. Local playa deposits are also located on the flat-lying basalt flows which surround the buttes.

A large area of intense hydrothermal alteration is exposed in the eastern portion of Glass Buttes (Figure 2), primarily within the silicic volcanic rocks. The alteration is characterized by silicification, development of hydrothermal clay minerals, and deposition of pyrite and metacinnabar along fractured and brecciated zones (Ciancanelli and Emmet, 1979; Berri and others, 1983). The alteration apparently occurs extensively in the subsurface below the exposed area, as suggested by drill-hole cuttings (Berri and others, 1983). Mining operations at this site have recovered mercury, but the operations are inactive at the present time. The area is a potential target for epithermal gold mineralization.

Structurally, the majority of mappable faults trend in a northwest-southeast direction, parallel or subparallel to the Brothers fault zone (Figure 2) and display normal offsets. The overall structural pattern suggests emplacement of the Glass Buttes domes within a northwest-trending graben (Ciancanelli and Emmet, 1979; Berri and others, 1983). Seemingly, the northwest structural trend represents an "open" fracture set along which magma could rise. Berri and others (1983) note the importance of northwest-trending normal faults as sites of permeable zones within the altered area.

A northwest-trending fault, a scissor fault (Figure 2), may be an important structure related to the thermal anomaly and the distribution of hydrothermal alteration (Ciancanelli and Johnson, 1981). The scissor fault consists of two strands that cut along the northeast side of Glass Buttes and through the southern half of the hydrothermal alteration (Figure 2). The majority of hydrothermal alteration and the central portion of the thermal anomaly lie north of the scissor fault. In the hinge area of the fault where the two fault strands overlap, numerous northeast-trending faults intensely fracture the rhyolite. This area lies in the center of the thermal anomaly.

SOIL-MERCURY SURVEY

With hydrothermal alteration and mercury mineralization in the eastern half of the area, a soil-mercury survey was conducted to determine the surficial distribution of mercury (Ciancanelli and Johnson, 1981). It was hoped that the survey would aid in defining permeable structures and subsurface alteration. After the collection and analysis of over 100 soil samples, however, all samples except a very few contained very low mercury concentrations. The few samples which contained elevated mercury were collected within and immediately adjacent to the exposed hydrothermal alteration.

From the soil-mercury survey, it was concluded that no near-surface alteration is present west of the known area of hydrothermal alteration. During field mapping, it was noted that the contact between intensely altered and unaltered rocks is extremely sharp, rarely more than a few inches or feet across. The mercury geochemistry also established this sharp transition, indicating that the hydrothermal reservoir was a tightly confined system. Volcanic rocks adjacent to or even above the active hydrothermal system may have remained unaltered if permeability was insufficient to allow thermal-water passage into the rock. The soil-mercury sur-

TABLE 1

GRADIENT WELL DATA[a]

FIGURE 2 NUMBER	NAME	LOCATION	DATE MEASURED	MEASURED DEPTH (FT)	MAXIMUM TEMP °F	APPROX. GRADIENT (°F/100 FT)	OPERATOR
1	23/23/27C[b]	27-23S-23E	8/07/73	721	118.1	11.0	DOGAMI
2	BR-75-21	18-23S-23E	9/30/75	205	65.7	7.3	DOGAMI
3	BR-75-22	2-24S-22E	10/02/75	197	64.3	6.7	DOGAMI
4	BR-75-23	20-24S-22E	10/02/75	197	58.0	3.9	DOGAMI
5	Musser Well[b]	32-23S-22E	9/10/79	580	86.9	10.9	Vulcan Group
6	Strat #1	33-23S-23E	2/03/78	1984	200.7	7.4	Phillips Pet.
7	Strat #2	22-23S-23E	11/15/80	1180	104.1	5.7	Phillips Pet.
8	Strat #3	35-23S-23E	?	840	75.9	3.4	Phillips Pet.
9	Strat #4	9-24S-23E	11/15/80	1945	121.7	3.4	Phillips Pet.
10	GB-1	31-23S-23E	9/03/81	1160	96.8	4.8	Vulcan Group
11	GB-16	19-23S-23E	10/19/79	2000	136.4	4.2	Vulcan Group
12	GB-18	29-23S-23E	9/03/81	1290	165.8	10.5	Vulcan Group
13	GB-22	21-23S-23E	1980	400	99.1	12.3	Phillips Pet.
14	GB-31	6-24S-23E	9/03/81	1165	98.4	3.9	Vulcan Group

[a]. See text for references.

[b]. Previously existing water well. Gradient measured by operator.

vey also demonstrated that, if alteration is present at depth, no mercury is reaching the surface. Soil-mercury appears to be an inappropriate method of geothermal exploration at Glass Buttes.

TEMPERATURE GRADIENTS

Data from two existing water wells and twelve temperature-gradient holes are available for the area (Table 1). The earliest gradient drilling was completed by DOGAMI (Bowen and others, 1977; Hull and others, 1977). Phillips Petroleum drilled numerous shallow wells and four deeper wells. Data for some of these wells were obtained by Cascadia Exploration from Phillips Petroleum in 1980. The Vulcan Geothermal Group also drilled four gradient wells (Geothermal Services, Inc., 1979, 1981). The locations of the wells for which data were available to the authors are shown in Figure 2.

Loss of circulation was common and dramatically impaired the recovery of drill cuttings below about 500 ft. Those cuttings which were recovered from Phillips and Vulcan Group wells were dominated by rhyolite flows, obsidian, perlite, and pumice (Ciancanelli and Johnson, 1981). Gradient well Strat #4 contained abundant basalt and volcaniclastic sediments and was therefore presumed to lie on the southern flank of silicic volcanism. The presence of local subsidence was suggested by examination of the cuttings of the wells north of Strat #4. Thicker alluvial deposits in GB-22 and Strat #2 indicate subsidence in this area relative to areas farther south. This small basin is probably a local feature within the larger northwest-trending graben which encloses Glass Buttes. The thickening Quaternary alluvial deposits indicate relatively recent subsidence and therefore relatively recent fault movement in this small area.

Approximate temperature gradients for each well are shown in Table 1, and temperature profiles are shown in Figure 3. The gradients shown were obtained from assessment of each individual well profile (Ciancanelli and Johnson, 1981). During these assessments, poor correlation was found between the overall gradient of an intermediate to deep well and the gradient determined for the same well in the upper 600 ft. On the basis of this poor correlation, it was determined that gradients from wells less than 1,000 ft deep may not correctly reflect the gradient for that location.

Based upon gradients for the wells, a distinct gradient anomaly was outlined (Ciancanelli and Johnson, 1981) (Figure 2). The anomaly overlaps and lies adjacent to the altered area but cannot be defined to the north due to the lack of wells in that area. The southern edge of the anomaly is defined by lower gradients of 3.4° to 4.8° F/100 ft in Strat #3, Strat #4, GB-31, and GB-1. The central portion of the anomaly contains much higher gradients of 10.5° to 12.3° F/100 ft, as displayed in 23/23/27C, GB-18, and possibly GB-22. The 6° F/100-ft contour shown in Figure 2 encloses approximately 8 sq mi.

Isotherm contour maps constructed for various depths show an anomaly similar to that of the gradient data, although the shape is more elongate in the northwest direction. This northwest trend suggests an affinity to the scissor fault, which lies along the southwest edge of the anomaly. The isotherm maps also offer a weak suggestion of a northwest shift in the anomaly with depth. Regardless of the exact shape, a thermal anomaly is present and is located in the hinge area of the scissor fault where numerous northeast faults cross the predominant northwest trends. Local subsidence in the area of the anomaly is suggested by drill-hole cuttings.

Blackwell (1982) assessed the gradient-well data. From the temperature profiles (Figure 3), he suggested the presence of porous material at shallow and intermediate depths which are intervals of lost circulation. Certainly, loss of circulation was a serious problem, as previously noted. Only perched water tables were intercepted, and the true water table has not yet been reached even in the deepest holes (about 2,000 ft deep). In portions of the gradient wells (below 1,200 ft), the temperature profiles appear to represent conductive gradients.

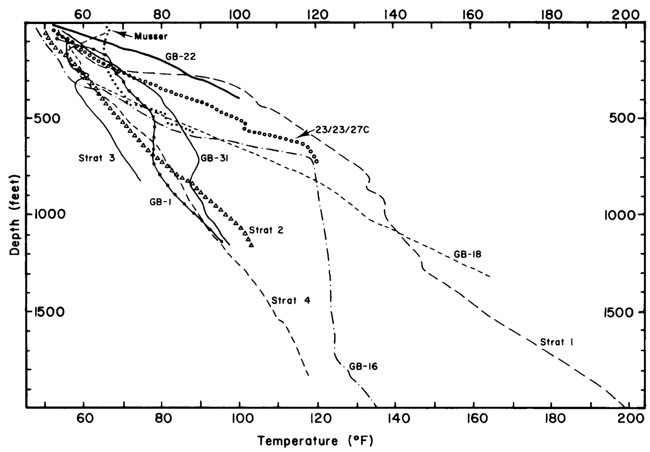


Figure 3. Temperature profiles for various wells of the Glass Buttes area. The final temperature log for each well is shown.

CONCLUSIONS

1. Glass Buttes lies within the northwest-trending Brothers fault zone. This highly fractured zone is probably a deep-seated tectonic feature along which magma has risen in numerous localities.

2. Pliocene to Pleistocene(?) volcanism centered at Glass Buttes was bimodal in character. A central core of silicic volcanism is surrounded by mafic volcanic rocks. Some silicic and probably basaltic volcanism has occurred since 4.9±0.3 m.y. B.P.

3. A large area of hydrothermal alteration and mineralization proves the presence of a high-temperature hydrothermal system at Glass Buttes in the past. A soil-mercury survey indicates no near-surface alteration is present west of the surficially exposed alteration.

4. A thermal-gradient map and isotherm maps (at various depths) define an anomaly of about 8 sq mi. The anomaly is open to the north since data are lacking in that area.

5. The thermal anomaly partially overlaps the surficial hydrothermal alteration and coincides with a local subsiding basin. An identified scissor fault lies along the southwest edge of the anomaly and may represent a controlling structure for the anomaly and a possible underlying geothermal reservoir.

6. The highest temperature encountered in the gradient wells is 210° F at about the 2,000-ft depth. Gradients of over 10° F/100 ft were measured in three wells. If the temperature profiles exhibited in the gradient wells approximate deeper conditions, commercial temperatures for electrical generation would be expected at between 5,000 and 10,000 ft in depth.

ACKNOWLEDGMENTS

The authors wish to thank the Vulcan Geothermal Group for permission to publish the data collected from the exploration program at Glass Buttes. In particular, appreciation is extended to Norman Knowles and Jim Kirker who managed the exploration program.

REFERENCES CITED

Berri, D.A., Cummings, M.L., and Johnson, M.J., 1983, Geology and alteration of a Pliocene silicic volcanic center, Glass Buttes, Oregon [abs.]: Geological Society of America Abstracts with Programs, v. 15, no. 5, p. 326.

Blackwell, D.D., 1982, Discussion of exploration results for the Glass Buttes geothermal project, central Oregon: A report prepared for Francana Resources, Inc., 9 p.

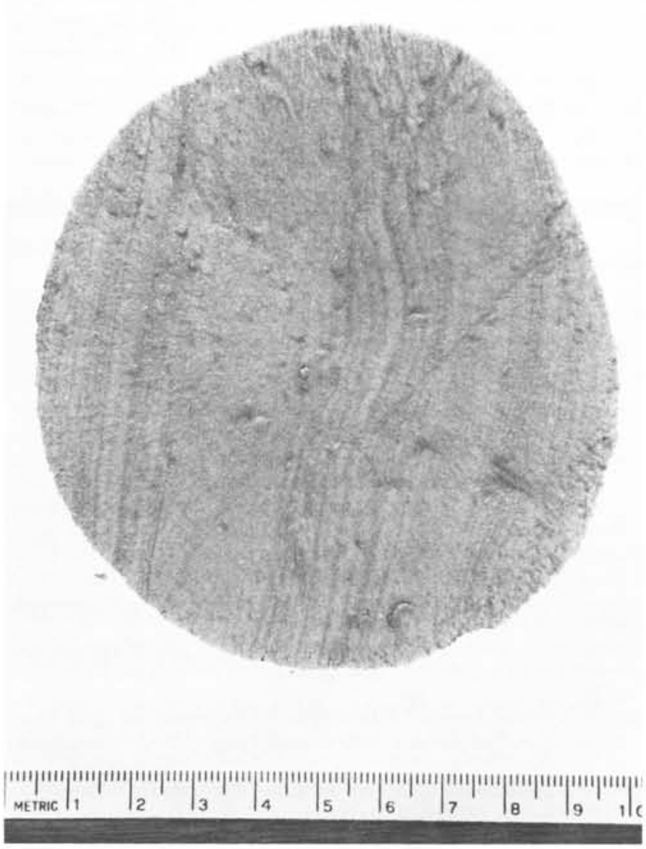
(Continued on page 20, **Glass Buttes***)*

A note on some remarkable concretions from the Yamhill Formation, Oregon

Four highly unusual, almost two-dimensional concretions were collected by Carl J. Williams in August 1983 from near the type locality of the Yamhill Formation (Baldwin and others, 1955) on Mill Creek in Yamhill County, southwest of Sheridan, Oregon.

The disk-shaped concretions occur near a zone of ordinary, light yellowish-gray (5*Y* 8/1*), ellipsoidal calcareous concretions, from 5 to 8 cm in diameter and from 1 to 2 cm thick, in a highly foraminiferal, obscurely color-laminated, olive-gray (5*Y* 4/1) mudstone.

The newly found specimens are light olive-gray, nearly circular, and almost perfectly flat disks with a maximum thickness of little more than 1 mm and diameters of 40, 43, 60, and 100 mm. They are calcareous, and, in reflected light, the partly radiating structure of the calcite crystals which impregnated the mudstone is easily visible.



Unusual, ultrathin concretion from the Yamhill Formation

These concretions were formed along planar fractures inclined about 25° to the color bedding in the mudstone, so that the laminations show across the diameter of the concretions. Therefore, they were emplaced at a later stage of ground-water deposition than the ordinary concretions, which are parallel to the bedding.

* Terminology describing color taken from Rock-Color Chart prepared by Rock-Color Chart Committee and sold by Geological Society of America, Boulder, CO 80301.

REFERENCE CITED

Baldwin, E.M., Brown, R.D., Jr., Gair, J.E., and Pease, M.H., Jr., 1955, Geology of the Sheridan and McMinnville quadrangles, Oregon: U.S. Geological Survey Oil and Gas Investigations Map OM-155.

John Eliot Allen, Emeritus Professor of Geology, Portland State University

Marine geology in U.S. faces challenge of new frontier

March 10, 1984, will be the first anniversary of the presidential proclamation that extended the national domain for seabed resources to 200 nautical miles off the coasts of the continental United States and U.S.-related islands. This newly created U.S. Exclusive Economic Zone (EEZ) is approximately one and two-thirds larger than the corresponding onshore area. The proclamation means that the nation now claims jurisdiction over the mineral and energy resources believed to be contained within the nearly four billion acres of largely unexplored ocean bottom.

Assessment and development of minerals in the EEZ have been made a key part of the program of the U.S. Department of the Interior, and three of its agencies, the U.S. Geological Survey (USGS), the U.S. Bureau of Mines (USBM), and the Minerals Management Service, jointly sponsored a symposium in November 1983. A proceedings volume describing the conclusions and recommendations of the symposium will be published and made available to the public. The USGS recently published a description of its exploratory marine geology program ("The Marine Geology Program of the U.S. Geological Survey," USGS Circular 906) and an information booklet entitled "The Exclusive Economic Zone: An Exciting New Frontier."

The resource potential of the EEZ is expected to include petroleum and heavy minerals such as titanium, platinum, gold, and cobalt. Most of the zone, however, is still unexplored; intensified exploration efforts may produce many new discoveries. Such exploration will also benefit the progress of onshore geologic studies by increasing understanding of geologic features that are common to both offshore and onshore geology.

Off the coast of Oregon, the most promising mineral-resource area known so far is the southern end of the Juan de Fuca Ridge, an active sea-floor spreading center that is known to include at least six hot-water vents. These vents deposit polymetallic sulfides that are judged to contain high quantities of zinc and iron and lesser quantities of silver and cadmium. The USBM has analyzed some early samples provided by the USGS and has developed a leaching process to recover silver and zinc from those deposits. One of the analyzed samples contained a zinc concentration high enough for direct processing in a conventional zinc smelter. Details of the sample analyses and leaching tests are described in USBM Technical Progress Report 122, "Cl_2-O_2 Leaching of Massive Sulfide Samples from the Southern Juan de Fuca Ridge, North Pacific Ocean."

If further study shows these deposits are large enough, they may be considered for future mining. Such mining will have to be highly inventive, since sea-floor mining technology is not yet fully developed, and the deposits on the ridge crest are under nearly 8,000 ft of water.

The USBM and USGS reports mentioned above are available free, in single copies, from the following addresses: Publications Distribution Section, Bureau of Mines, 4800 Forbes Ave., Pittsburgh, PA 15213 (phone 412-621-4500, ext. 342); and Branch of Distribution, U.S. Geological Survey, 604 South Pickett St., Alexandria, VA 22304 (phone 703-756-6141).

—Compiled from USBM and USGS news releases

PSU students win awards at Northwest Mining Convention

Two Portland State University students won awards for poster session presentations at the Northwest Mining Association Convention held in Spokane, Washington, last December.

Christine Budai won first prize for her presentation, "Depositional Model of the Antelope Coal Field, Wyoming," and was awarded a Hewlett-Packard programmable calculator.

Christine Budai

Michael Johnson won third prize for his presentation, "Geology, Alteration, and Mineralization of a Silicic Volcanic Center, Glass Buttes, Oregon," and received an award of fifty dollars.

Michael Johnson

Prizes were awarded to the top five of twenty-six poster sessions. The presentations were judged mainly on expertise in the area of study, clarity of presentation, and diagrammatic representation. The winning PSU students are both master's candidates working under Professor M.L. Cummings, Ph.D., Economic Geologist in PSU's Department of Geology. □

Walter Sullivan receives award from earth-science editors

Walter Sullivan, science editor of *The New York Times*, was named recipient of the Association of Earth Science Editors' (AESE) Award for Outstanding Editorial or Publishing Contributions. The award was presented at the association's annual meeting, which was held October 9-12, 1983, in Houston, Texas.

Sullivan, who has served as science editor for the *Times* since 1964, was recognized for his singular achievements in communicating scientific information to the public principally through the newspaper medium.

In addition to his regular contributions to the pages of *The New York Times*, Sullivan has written several books that have served effectively to communicate new scientific concepts to the informed reader. His book *Continents in Motion – The New Earth Debate* (McGraw Hill, 1974) outlines the impact of the concept of global plate tectonics on scientific thought and investigation.

Past award recipients include Philip H. Abelson of the American Institute of Physics, Brian J. Skinner of Yale University, Robert L. Bates of Ohio State University, and Wendell Cochran of the American Geological Institute.

The Association of Earth Science Editors is a member society of the American Geological Institute. It was founded in 1967 to foster education and to promote the interchange of ideas on general and specific problems of selection, editing, and publishing in the earth sciences. The association numbers about 350 members, most of whom work in the United States and Canada. Its next annual meeting will be held October 8-10, 1984, in Portland, Oregon. □

(**Glass Buttes**, *continued from page 18)*

Bowen, R.G., Blackwell, D.D., and Hull, D.A., 1977, Geothermal exploration studies in Oregon – 1976: Oregon Department of Geology and Mineral Industries Miscellaneous Paper 19, 50 p.

Ciancanelli, E.V., and Emmet, P.A., 1979, Geology of the Glass Butte geothermal prospect, Lake County, Oregon: A report prepared for the Vulcan Group, 56 p.

Ciancanelli, E.V., and Johnson, K.E., 1981, Analysis of data from the 1981 temperature-gradient wells and the soil-mercury geochemical survey, Glass Buttes, Oregon: A report prepared for the Vulcan Group Venture, 43 p.

Geothermal Services, Inc., 1979, Glass Butte prospect – Oregon: GTS Job No. 4-79, a report prepared for Francana Resources, Inc., 19 p.

– – – 1981, Glass Butte II prospect, Oregon: GTS Job No. 22-81, a report prepared for Francana Resources, Inc., 14 p.

Greene, R.C., 1973, Petrology of the welded tuff of Devine Canyon, southeastern Oregon: U.S. Geological Survey Professional Paper 797, 26 p.

Hull, D.A., 1976, Electrical resistivity survey and evaluation of the Glass Buttes geothermal anomaly, Lake County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report 0-76-1, 29 p.

Hull, D.A., Blackwell, D.D., Bowen, R.G., and Peterson, N.V., 1977, Heat flow study of the Brothers fault zone, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report 0-77-3, 99 p.

Lawrence, R.D., 1976, Strike-slip faulting terminates the Basin and Range province in Oregon: Geological Survey of America Bulletin, v. 87, no. 6, p. 846-850.

Walker, G.W., 1969, Geology of the High Lava Plains province, *in* Mineral and Water Resources of Oregon: Oregon Department of Geology and Mineral Industries Bulletin 64, p. 77-79.

– – – 1974, Some implications of late Cenozoic volcanism to geothermal potential in the High Lava Plains of south-central Oregon: Oregon Department of Geology and Mineral Industries, Ore Bin, v. 36, no. 7, p. 109-119.

Walker, G.W., and Swanson, D.A., 1968, Laminar flowage in a Pliocene soda rhyolite ash-flow tuff, Lake and Harney Counties, Oregon: U.S. Geological Survey Professional Paper 600-B, p. B37-B47. □

NWMA elects new leaders

The Northwest Mining Association (NWMA), an organization that represents the interests of the minerals industry in Alaska, Idaho, Montana, Oregon, Washington, and western Canada, elected new officers for 1984 at its 89th annual convention in Spokane, Washington, in December 1983.

The 1984 president is George D. Tikkanen, Vice President for Mining and Exploration, Cominco American Inc. Lees J. Burrows, Blue Bore Inc.; Eberhard Schmidt, Amoco Minerals Co.; and Karl W. Mote were elected First, Second, and Third Vice Presidents, respectively.

New trustees are Earl H. Bennett, Idaho Bureau of Mines and Geology; Bonnie Butler Bunning, Washington State Department of Natural Resources; Eugene Callahan, Coeur d'Alene Mines Corp.; Martin W. Dippold, Cominco American Inc.; Gene K. Ealy, Hecla Mining Co.; Ray W. Hammitt, Amoco Minerals Co.; Buster LaMoure, U.S. Forest Service; Fred. H. Lightner, Pegasus Gold Corp; Joseph F. McAleer, Molycorp Inc.; Gregory E. McKelvey, Cominco American Inc.; Walter C. Meyers, Amselco Exploration Inc.; and Philip J. Rush, American Copper and Nickel Co., Inc. □

Northwest Petroleum Association expands scope of activities

The Northwest Petroleum Association (formerly the Northwest Association of Petroleum Landmen) has expanded its membership to include all those engaged in energy resource exploration, development, and management. The Association's goal is to promote communication and education among its members, government, and the Northwest community. The Association will also promote exploration in the Northwest.

Officers for 1983-84 are Garth T. Tallman, Tallman & Associates, President; Vern C. Newton, Consulting Geologist, Vice-President; Barbara B. Portwood, Oregon Natural Gas Development Corporation, Secretary; and Ron L. Hordichok, Northwest Natural Gas Company, Treasurer. Directors are Wesley G. Bruer, Consulting Geologist, Bert B. Mueller, Reichhold Energy Corporation, and S. Kyle Huber, Huber & Associates.

Those persons interested in membership should call (503) 226-4211, extension 4308, or write to Barbara B. Portwood, Secretary, Northwest Petroleum Association, 220 N.W. Second Avenue, Portland, OR 97209. □

Isochron/West features index to K-Ar age determinations in Oregon

The August 1983 issue of *Isochron/West* features a paper entitled "Index to K-Ar Determinations for the State of Oregon," by Robin B. Fiebelkorn, George W. Walker, Norman S. MacLeod, Edwin H. McKee, and James G. Smith, all of the U.S. Geological Survey (USGS). The report includes a 38-page table of all the available potassium-argon age determinations on rocks and minerals in the State of Oregon by county. The age determinations came from published reports and unpublished USGS and non-USGS investigations through December of 1982. Index maps showing sample locations from various parts of the state are included in the back of the paper.

Isochron/West is sponsored jointly by the New Mexico Bureau of Mines and Mineral Resources and the Nevada Bureau of Mines and Geology. Single issues of the magazine are available for $2 and may be purchased from *Isochron/West*, c/o New Mexico Bureau of Mines and Mineral Resources, Campus Station, Socorro, New Mexico 87801. □

USGS offers publications on national parks

A detailed list of the reports and maps of the U.S. Geological Survey (USGS) that describe the geologic processes that shaped the varied landscapes and scenic beauty of the national parks is available to the public.

As visitors travel through the scenic park areas, they are treated to spectacular vistas such as Old Faithful Geyser in Yellowstone National Park, Yosemite's El Capitan, or the deep gorge of the Grand Canyon that tell a long and exciting history in their exposed rocks. The USGS has published a variety of maps and reports on these and other scenic wonders to help people understand the processes that have created them.

The detailed list describes 64 selected publications on 40 national parks and includes information on the availability of each publication and ordering instructions. Publications range from special topographic maps to geologic maps and professional papers that focus on a specific aspect of the geology in an area and include materials suitable for both technical and nontechnical audiences.

Copies of the list are available free upon request from the Geologic Inquiries Group, U.S. Geological Survey, 907 National Center, Reston, VA 22092. The list is also available over the counter at the 10 USGS Public Inquiries Offices; the one for the Orgon region is at 678 U.S. Courthouse, West 920 Riverside Ave., Spokane, WA 99201, phone (509) 456-2524. □

AGI tabulates numbers of geology students

In its monthly newsletter *Geospectrum*, the American Geological Institute (AGI) published results of an annual study of student enrollment in geoscience departments. Conducted by AGI's Nick Claudy, editor of the *Directory of Geoscience Departments*, the study produced the following information:

Of the 560 degree-granting departments in the United States and Canada, 478 returned his questionnaires. . . . For 1982-83, the total number of geoscience students at all levels in the U.S. was 47,301, or 6.4 percent more than the year before. Male enrollment rose 6.7 percent, female, 5.5 percent. . . . The U.S. had 36,893 undergraduate majors (up 7.4 percent), 7,511 master's candidates (up 2.2 percent), and 2,897 Ph.D. candidates (up 5 percent). . . . Of the total geoscience enrollment, geology accounted for 34,884 (74 percent). . . . In earth-science teaching, enrollment rose for the first time in nine years, by 3.5 percent. . . . Degrees totaled 9,586 (1.8 percent more men, 3.5 percent more women). . . . Bachelor candidates were up by 5.4 percent; masters down by 7.2 percent; doctors down by 3.9 percent. . . . The total for minority students rose from 1,224 to 1,240, up 1.3 percent. American Indians and native Alaskans rose 113.5 percent, and Asians and Pacific Islanders 18.6 percent. But Hispanic numbers fell 3.4 percent and American Blacks 17.1 percent. . . . Only 202 degrees were awarded to members of minority groups, meaning even more trouble ahead for companies and schools concerned with equal-opportunity quotas. □

Lecture on Thomas Condon available in print

The life of Oregon's pioneer paleontologist and early state geologist Thomas Condon was the subject of the Sixth Annual Helen Oliver Memorial Lecture at the First Congregational Church in Portland on October 29, 1983. The lecture was given by Egbert S. Oliver, Emeritus Professor of English at Portland State University.

The printed lecture, "Thomas Condon of Oregon," is now available for $2 as an illustrated booklet at the bookstore of the Oregon Historical Society, 1230 SW Park Ave., Portland, OR 97205. □

NEW DOGAMI PUBLICATIONS

Four new reports were released by the Oregon Department of Geology and Mineral Industries (DOGAMI) during January. They are described below and are available for purchase or inspection at the DOGAMI offices in Portland, Baker, and Grants Pass, whose addresses are listed in the box on page 14. Prepayment is required for all orders under $50.

Released January 1, 1984:

FIFTH ANNUAL REPORT OF THE STATE MAP ADVISORY COMMITTEE FOR OREGON, 1983, by J.D. Beaulieu, Committee Chairman. DOGAMI Open-File Report O-84-1, $2.00.

The State Map Advisory Committee is composed of representatives from federal and state agencies and universities and is charged by Executive Order to identify the state's needs in the area of mapping and to coordinate all mapping efforts for maximum efficiency. The committee gives direction to mapping projects in Oregon and has as its major long-term objectives the completion of the 7½-minute topographic map series and the coordinated development of a digital map data base for the state.

This 39-page report contains summaries of the committee's activities, meetings, and workshops and of the progress of digital mapping by state agencies in 1983; statistical summaries of the year's mapping accomplishments; and the report of the Resident Cartographer to the State of Oregon. It also includes a membership and selected mailing list and the Governor's Executive Order on the reorganization of the committee.

A key factor of the committee's success is the work of the Resident Cartographer to the State of Oregon. This position was created by a cooperative agreement between the U.S. Geological Survey and the State of Oregon. One of the past year's accomplishments for the committee and the Resident Cartographer was the recent completion of a two-volume set of Oregon geographic names – a computerized compilation of all the geographic names which appear on topographic maps of Oregon.

Released January 3, 1984:

MINERAL POTENTIAL OF THE FALL CREEK MINING DISTRICT: A GEOLOGICAL-GEOCHEMICAL SURVEY, by J.J. Gray and D.A. Berri. DOGAMI Open-File Report O-83-5, $6.00.

More widespread mineralization than had been known before in the area and a likely economic potential for gold and silver were found in the study of the Fall Creek district north of Oakridge in Lane County, an old mining area that produced gold for some time in the past between 1901 and 1931. The report was prepared for the U.S. Forest Service (USFS) and was intended to assist the USFS in the planning and management of that part of the Willamette National Forest which is located in the Sardine Butte 15-minute quadrangle.

In the survey, information on known mineral deposits was reviewed and updated, a geologic map of the Sardine Butte quadrangle was prepared (scale 1:62,500), zones of alteration were mapped, and 124 stream-sediment and rock-chip samples were analyzed geochemically for gold, silver, arsenic, copper, mercury, molybdenum, lead, and zinc. The 32-page report is accompanied by one map and two microfiche, the latter containing raw analytical data and computer-generated statistical analyses of the data.

Released January 6, 1984:

SURVEY OF POTENTIAL GEOTHERMAL EXPLORATION SITES AT NEWBERRY VOLCANO, DESCHUTES COUNTY, OREGON, edited by G.R. Priest, B.F. Vogt, and G.L. Black. DOGAMI Open-File Report O-83-3, $20.00.

View of Newberry caldera, looking south.

Newberry volcano, located south of Bend in central Oregon and best known for the two lakes, Paulina and East Lakes, in its caldera, may possess significant geothermal resources under both the caldera itself and large areas of the volcano's flanks. That is the main conclusion of a variety of studies undertaken by DOGAMI for the Bonneville Power Administration.

The report consists of 174 pages of text, illustrations, and appendices and is accompanied by eight blackline maps. It compiles and interprets the available geologic, hydrologic, geochemical, and geophysical data on the volcano and concludes with detailed recommendations for further geothermal exploration. For the study, new aeromagnetic and gravity maps were interpreted by A. Griscom and C.W. Roberts of the U.S. Geological Survey; D.D. Blackwell and J.L. Steele of Southern Methodist University developed numerous theoretical conductive and convective heat-flow models for a wide range of possible magmatic heat sources; and in a new soil-mercury survey 1,641 samples were analyzed and plotted on a soil-mercury contour map that covers most of the 500 sq mi of Newberry volcano.

Released January 13, 1984:

GEOLOGY AND GEOTHERMAL RESOURCES OF THE CENTRAL OREGON CASCADE RANGE, edited by G.R. Priest and B.F. Vogt. DOGAMI Special Paper 15, $11.00.

The results of six years of geologic and geothermal research on the central Oregon Cascade Range have been compiled and analyzed in this study. It contains contributions by many researchers, both from DOGAMI and universities in Utah and Texas, and was funded primarily by the U.S. Department of Energy.

The 124-page publication includes four new one-color and two-color maps (two in the text, two as separate plates) of central Cascade areas that are of particular interest for geothermal exploration. It provides numerous new K-Ar dates and chemical analyses of volcanic rocks and tabulates and interprets all of the publicly available heat-flow data for the entire Oregon Cascade Range. A final chapter discusses geothermal exploration targets and techniques for the central Cascades.

From all current geologic, geochemical, and geophysical data, the report develops a volcano-tectonic model for the study area, concluding that Basin and Range spreading processes have strongly affected the central Cascades during the last 8 to 10 million years and possibly earlier. □

ORDER FORM — CUT ON DASHED LINE

Available publications

BULLETINS	Price	No. Copies	Amount
33. Bibliography (1st supplement) geology and mineral resources of Oregon, 1947: Allen	$ 3.00		
35. Geology of the Dallas and Valsetz quadrangles, rev. 1964: Baldwin (map only)	3.00		
36. Papers on Tertiary foraminifera: Cushman, Stewart, and Stewart, 1949: v. 2	3.00		
44. Bibliography (2nd supplement) geology and mineral resources of Oregon, 1953: Steere	3.00		
46. Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey	3.00		
49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch	3.00		
53. Bibliography (3rd supplement) geology and mineral resources of Oregon, 1962: Steere and Owen	3.00		
61. Gold and silver in Oregon, 1968: Brooks and Ramp	17.50		
62. Andesite Conference guidebook, 1968: Dole	3.50		
65. Proceedings of the Andesite Conference, 1969: (copies)	10.00		
67. Bibliography (4th supplement) geology and mineral resources of Oregon, 1970: Roberts	3.00		
71. Geology of selected lava tubes in Bend area, Oregon, 1971: Greeley (copies)	5.00		
78. Bibliography (5th supplement) geology and mineral resources of Oregon, 1973: Roberts	3.00		
81. Environmental geology of Lincoln County, 1973: Schlicker and others	9.00		
82. Geologic hazards of Bull Run Watershed, Multnomah, Clackamas Counties, 1974: Beaulieu	6.50		
83. Eocene stratigraphy of southwestern Oregon, 1974: Baldwin	4.00		
84. Environmental geology of western Linn County, 1974: Beaulieu and others	9.00		
85. Environmental geology of coastal Lane County, 1974: Schlicker and others	9.00		
87. Environmental geology of western Coos and Douglas Counties, 1975	9.00		
88. Geology and mineral resources of upper Chetco River drainage, 1975: Ramp	4.00		
89. Geology and mineral resources of Deschutes County, 1976: Peterson and others	6.50		
90. Land use geology of western Curry County, 1976: Beaulieu	9.00		
91. Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties, Oregon, 1977: Beaulieu	8.00		
92. Fossils in Oregon (reprinted from *The Ore Bin*), 1977	4.00		
93. Geology, mineral resources, and rock material of Curry County, Oregon, 1977	7.00		
94. Land use geology of central Jackson County, Oregon, 1977: Beaulieu	9.00		
95. North American ophiolites, 1977	7.00		
96. Magma genesis: AGU Chapman Conference on Partial Melting, 1977	12.50		
97. Bibliography (6th supplement) geology and mineral resources of Oregon, 1971-75, 1978	3.00		
98. Geologic hazards of eastern Benton County, Oregon, 1979: Bela	9.00		
99. Geologic hazards of northwestern Clackamas County, Oregon, 1979: Schlicker and Finlayson	10.00		
100. Geology and mineral resources of Josephine County, Oregon, 1979: Ramp and Peterson	9.00		
101. Geologic field trips in western Oregon and southwestern Washington, 1980	9.00		
102. Bibliography (7th supplement) geology and mineral resources of Oregon, 1976-1979, 1981	4.00		
GEOLOGIC MAPS			
Reconnaissance geologic map of Lebanon quadrangle, 1956	3.00		
Geologic map of Bend quadrangle and portion of High Cascade Mountains, 1957	3.00		
Geologic map of Oregon west of 121st meridian (USGS I-325), 1961	5.50		
Geologic map of Oregon east of 121st meridian (USGS I-902), 1977	5.50		
GMS-4: Oregon gravity maps, onshore and offshore, 1967 (folded)	3.00		
GMS-5: Geologic map of Powers quadrangle, Oregon, 1971	3.00		
GMS-6: Preliminary report on geology of part of Snake River Canyon, 1974	6.50		
GMS-8: Complete Bouguer gravity anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00		
GMS-9: Total field aeromagnetic anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00		
GMS-10: Low- to intermediate-temperature thermal springs and wells in Oregon, 1978	3.00		
GMS-12: Geologic map of the Oregon part of the Mineral quadrangle, 1978	3.00		
GMS-13: Geologic map of the Huntington and part of the Olds Ferry quadrangles, Oregon, 1979	3.00		
GMS-14: Index to published geologic mapping in Oregon, 1898-1979, 1981	7.00		
GMS-15: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, northern Oregon, 1981	3.00		
GMS-16: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, southern Oregon, 1981	3.00		
GMS-17: Total-field aeromagnetic anomaly map, Cascade Mountain Range, southern Oregon, 1981	3.00		
GMS-18: Geology of the Rickreall, Salem West, Monmouth, and Sidney 7½-minute quadrangles, Marion, Polk, and Linn Counties, Oregon, 1981	5.00		
GMS-19: Geology and gold deposits map of the Bourne quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-20: Map showing geology and geothermal resources of the southern half of the Burns 15-minute quadrangle, Oregon, 1982	5.00		
GMS-21: Geology and geothermal resources map of the Vale East 7½-minute quadrangle, Oregon, 1982	5.00		
GMS-22: Geology and mineral resources map of the Mt. Ireland quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-23: Geologic map of the Sheridan quadrangle, Polk and Yamhill Counties, Oregon, 1982	5.00		
GMS-24: Geologic map of the Grand Ronde quadrangle, Polk and Yamhill Counties, Oregon, 1982	5.00		
GMS-25: Geology and gold deposits map of the Granite quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-26: Residual gravity maps of the northern, central, and southern Cascade Range, Oregon, 1982	5.00		
GMS-27: Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1° by 2° quadrangle, 1982	6.00		
GMS-28: Geology and gold deposits map of the Greenhorn quadrangle, Baker and Grant Counties, Oregon, 1983	5.00		
GMS-29: Geology and gold deposits map, NE¼ Bates quadrangle, Baker and Grant Counties, Oregon, 1983	5.00		
OIL AND GAS INVESTIGATIONS			
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well	3.00		
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well, 1973	3.00		
5. Prospects for natural gas production or underground storage of pipeline gas, upper Nehalem River Basin, Columbia-Clatsop Counties, Oregon, 1976	5.00		
6. Prospects for oil and gas in the Coos Basin, western Coos, Douglas, and Lane Counties, Oregon, 1980: Newton and others	9.00		
7. Correlation of Cenozoic stratigraphic units of western Oregon and Washington, 1983	8.00		

Available publications (continued)

SPECIAL PAPERS	Price	No. Copies	Amount
1. Mission, goals, and programs of Oregon Department of Geology and Mineral Industries, 1978	3.00	____	____
2. Field geology of SW Broken Top quadrangle, Oregon, 1978: Taylor	3.50	____	____
3. Rock material resources of Clackamas, Columbia, Multnomah, and Washington Counties, Oregon, 1978: Gray and others	7.00	____	____
4. Heat flow of Oregon, 1978: Blackwell, Hull, Bowen, and Steele	3.00	____	____
5. Analysis and forecasts of the demand for rock materials in Oregon, 1979: Friedman and others	3.00	____	____
6. Geology of the La Grande area, Oregon, 1980: Barrash and others	5.00	____	____
7. Pluvial Fort Rock Lake, Lake County, Oregon, 1979: Allison	4.00	____	____
8. Geology and geochemistry of the Mt. Hood volcano, 1980: White	3.00	____	____
9. Geology of the Breitenbush Hot Springs quadrangle, Oregon, 1980: White	4.00	____	____
10. Tectonic rotation of the Oregon Western Cascades, 1980: Magill and Cox	3.00	____	____
11. Theses and dissertations on the geology of Oregon: Bibliography and index, 1899-1982, 1982: Neuendorf and others	6.00	____	____
12. Geologic linears of the northern part of the Cascade Range, Oregon, 1980: Venkatakrishnan, Bond, and Kauffman	3.00	____	____
13. Faults and lineaments of the southern Cascades, Oregon, 1981: Kienle, Nelson, and Lawrence	4.00	____	____
14. Geology and geothermal resources of the Mount Hood area, Oregon, 1982: Priest and Vogt	7.00	____	____
NEW! 15. Geology and geothermal resources of the central Oregon Cascade Range, 1983: Priest and Vogt	11.00	____	____
16. Index to the *Ore Bin* (1939-1978) and *Oregon Geology* (1979-1982), 1983: Mahoney and Steere	4.00	____	____
SHORT PAPERS			
21. Lightweight aggregate industry in Oregon, 1951: Mason	1.00	____	____
24. The Almeda Mine, Josephine County, Oregon, 1967: Libbey	3.00	____	____
25. Petrography, type Rattlesnake Formation, central Oregon, 1976: Enlows	3.00	____	____
27. Rock material resources of Benton County, 1978: Schlicker and others	4.00	____	____
MISCELLANEOUS PAPERS			
1. A description of some Oregon rocks and minerals, 1950: Dole	1.00	____	____
5. Oregon's gold placers (reprints), 1954	1.00	____	____
8. Available well records of oil and gas exploration in Oregon, rev. 1982: King, Olmstead, and Newton	4.00	____	____
11. Collection of articles on meteorites, 1968 (reprints from *The Ore Bin*)	3.00	____	____
15. Quicksilver deposits in Oregon, 1971: Brooks	3.00	____	____
17. Geologic hazards inventory of the Oregon coastal zone, 1974: Beaulieu, Hughes, and Mathiot	5.00	____	____
18. Proceedings of Citizens' Forum on potential future sources of energy, 1975	3.00	____	____
19. Geothermal exploration studies in Oregon—1976, 1977	3.00	____	____
20. Investigations of nickel in Oregon, 1978: Ramp	5.00	____	____
MISCELLANEOUS PUBLICATIONS			
Landforms of Oregon (17 × 12 inches)	1.00	____	____
Mining claims (State laws governing quartz and placer claims)	1.00	____	____
Geological highway map, Pacific NW region, Oregon-Washington (published by AAPG)	5.00	____	____
Geothermal resources of Oregon map, 1982 (published by NOAA)	3.00	____	____
Fifth Gold and Money Session and Gold Technical Session Proceedings, 1975	5.00	____	____
Sixth Gold and Money Session and Gold Technical Session Proceedings, 1978	6.50	____	____
Back issues of *The Ore Bin*	50¢ over the counter; $1.00 mailed	____	____
Back issues of *Oregon Geology*	75¢ over the counter; $1.00 mailed	____	____
Colored postcard, *Geology of Oregon*	10¢ each; 3 for 25¢; 7 for 50¢; 15 for $1.00	____	____
Oregon Landsat mosaic map, 1983 (published by ERSAL, OSU)	$8.00 over the counter; $11.00 mailed	____	____

Separate price lists for open-file reports, geothermal energy studies, tour guides, recreational gold mining information, and non-Departmental maps and reports will be mailed upon request.

OREGON GEOLOGY
1005 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

PUBLICATIONS ORDER

Minimum mail order $1.00. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $50.00. Foreign orders: please remit in U.S. dollars.

Fill in appropriate blanks and send sheet to Department.

YOUR NAME ____________________

ADDRESS ____________________

____________________ Zip________

Amount enclosed $________

OREGON GEOLOGY

____ Renewal ____ New Subscription ____ Gift

____ 1 Year ($6.00) ____ 3 Years ($15.00)

NAME ____________________

ADDRESS ____________________

____________________ ZIP ________

(If Gift, From: ____________________)

OREGON GEOLOGY

published by the

Oregon Department of Geology and Mineral Industries

VOLUME 46, NUMBER 3 MARCH 1984

THIS MONTH:

ANNUAL SUMMARIES: MINERAL INDUSTRY AND MINED LAND RECLAMATION IN OREGON, 1983

OREGON GEOLOGY
(ISSN 0164-3304)

VOLUME 46, NUMBER 3 — MARCH 1984

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

Main Office: 1005 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133.
Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496.
Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039.
Paul F. Lawson, Supervisor

Subscription rates: 1 year, $6.00; 3 years, $15.00. Single issues, $.75 at counter, $1.00 mailed.
Available back issues of *The Ore Bin*: $.50 at counter, $1.00 mailed.

Address subscription orders, renewals, and changes of address to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

Send news, notices, meeting announcements, articles for publication, and editorial correspondence to the editor, Portland office. The Department encourages author-initiated peer review for technical articles prior to submission. Any review should be noted in the acknowledgments.

Second class postage paid at Portland, Oregon.
Postmaster: Send address changes to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

COVER PHOTO

Winner of the annual Outstanding Mined Land Reclamation Project award for 1983, the operations and maintenance headquarters of Multnomah County in Portland. Foreground and background of the photo show evidence of (respectively) past and ongoing mining activity. See annual report on mined land reclamation in Oregon in 1983 on page 33. (State Highway Division photo)

OIL AND GAS NEWS

Mist Gas Field

Reichhold Energy Corporation has drilled and abandoned Crown Zellerbach 23-26, located in sec. 26, T. 6 N., R. 4 W. The well was drilled to a total depth of 4,382 ft and was plugged on January 18, 1984.

Preparation is under way to build locations for and spud two offset wells to the most recent pool discovery, Columbia County 23-22. The two new locations (table below) will be located one-half mile east and one-half mile south of the new producer. Meanwhile, construction has begun on the pipeline to well 23-22.

Public hearing

On January 17, 1984, a public hearing was held in St. Helens to discuss the application for permit 255, Reichhold Energy Corporation, Columbia County 13-34A. This is a proposed well for a spacing unit in the Mist Gas Field for which there is already a producing well. An exception to the spacing rule would need to be granted by the Governing Board of DOGAMI to allow a second well in the spacing unit. The unit is the SW¼ sec. 34, T. 7 N., R. 5 W. The testimony has been given to the Board for a decision.

DOGAMI Board meets

The Governing Board of DOGAMI met February 27, 1984, in Roseburg, Oregon. The only oil and gas agenda item was the decision on an exception to the spacing unit rule (see item above). We will print the results in the next issue of *Oregon Geology*.

Other agenda items included discussion of the policy on offshore mineral development, water planning, non-metallic minerals assessment, and legislative proposals for the 1985 legislature.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
256	Reichhold Energy Corp. Columbia County 43-22 009-00124	SE¼ sec. 22 T. 6 N., R. 5 W. Columbia County	Application; 4,000.
257	Reichhold Energy Corp. Columbia County 21-27 009-00125	NW¼ sec. 27 T. 6 N., R. 5 W. Columbia County	Application; 4,000.

□

Information for contributors to *Oregon Geology*

Readers are invited to submit manuscripts on Oregon geology and other related subjects. 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 or any related questions should be addressed to Beverly F. Vogt, Publications Manager, at the Portland office of DOGAMI. □

CONTENTS

Mineral industry in Oregon, 1983

by Mark L. Ferns, Len Ramp, Howard C. Brooks, and Jerry J. Gray, Oregon Department of Geology and Mineral Industries

INTRODUCTION

Oregon's mineral industry saw a slow recovery in industrial minerals (primarily cement, stone, and sand and gravel) production in 1983. No formal canvass of precious-metal producers was made, but field observations indicate that gold and silver production remained low. The reopening of the Hanna Mining Company's nickel mine and smelter at Riddle on a part-time basis in November indicated a strengthening minerals industry at year's end.

METALS

The Hanna Mining Company nickel plant (14*) at Riddle was reopened on November 7 after an 18-month closure due to high power costs and low nickel prices. An off-peak power rate agreement with the Bonneville Power Administration has allowed for continued part-time operation of the plant.

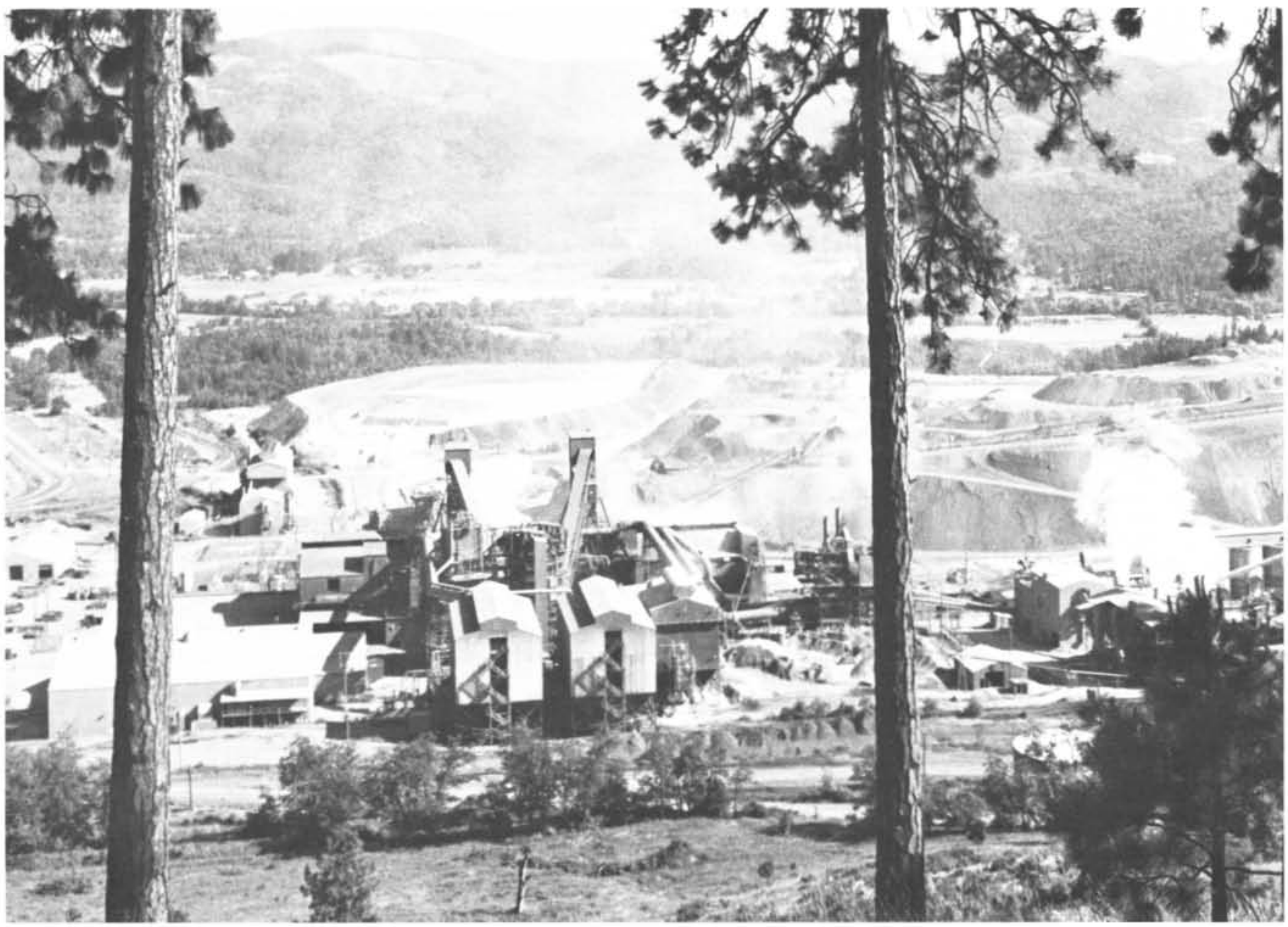
Smaller placer mines continued to supply most of the gold produced in the state. Small operations on Sucker Creek (19), Josephine Creek (18), Coffee Creek (13), and in the Galice Creek area (15) in southwestern Oregon and on Burnt River (3), Pine Creek (6), Elk Creek (4), and Clarks Creek (7) in northeastern Oregon were among the most productive.

Several small lode gold and silver mines were intermittently worked during the spring and summer of 1983. The Pyx Mine (2) in Grant County and the Thomason Mine (5) in Baker County continued small-scale operations from 1982. The Sunny Valley Mining and Development Company shipped a small amount of ore from the Greenback Mine (16) to the smelter at Tacoma, Washington. The property is now being evaluated by Mega Gold Resources, Inc. The Lyons Brothers of John Day produced a small amount of silver ore from the old Tempest Mine (1) in Grant County. The mine has been operating on a small scale since 1980. Cash Industries produced an undisclosed amount of silver ore from the old Bay Horse Mine (9) on the Snake River early in the summer of 1983. This property is a noted past producer of silver (over 150,000 oz) and is now being drilled by Silver King Mines, Inc.

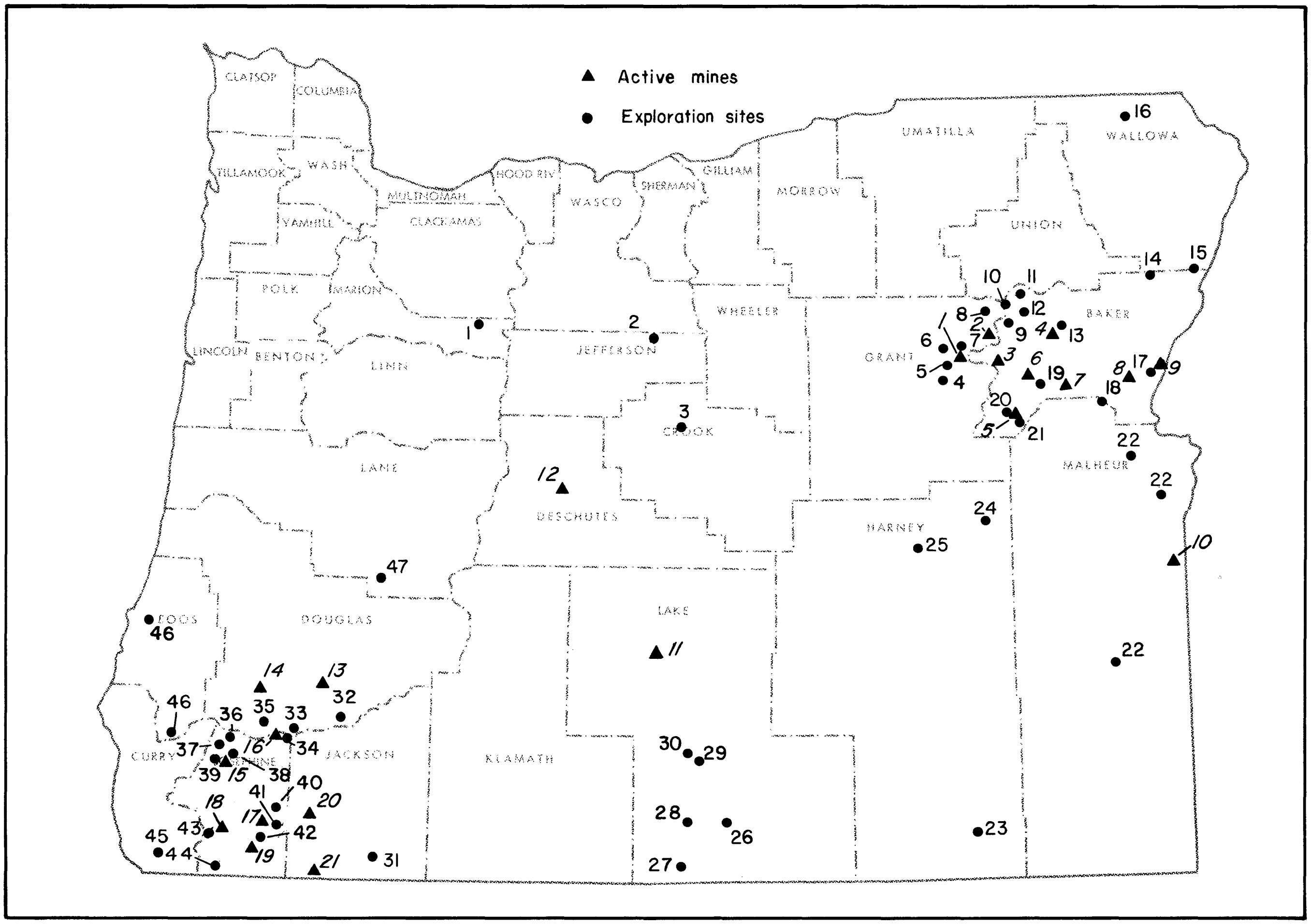
NONMETALS

Block soapstone production at Steatite of Southern Oregon (21) continued at a steady pace. This operation supplies markets as far away as New York and Alaska with carving-grade soapstone. The Oregon Portland Cement plant (8) at Durkee operated at an

* All mine numbers in this section refer to "Active Mines" on location map and in Table 1.



Hanna Mining Company nickel smelter plant at Riddle in Douglas County, Oregon. Slag piles in background. Ore is mined at Nickel Mountain, a few miles from the plant. This operation is the nation's only domestic mine source of nickel.



EXPLANATION

ACTIVE MINES

1. Tempest Mine (Ag)
2. Pyx Mine (Au)
3. North Fork Burnt River placers (Au)
4. Elk Creek placers (Au)
5. Thomason Mine (Au)
6. Pine Creek placers (Au)
7. Clarks Creek placers (Au)
8. Oregon Portland Cement (limestone)
9. Bay Horse Mine (Ag)
10. Adrian (bentonite-zeolite)
11. Christmas Valley Diatomite
12. Bend area pumice mines
13. Coffee Creek placers (Au)
14. Nickel Mountain Mine (Ni)
15. Galice Creek area placers (Au)
16. Greenback Mine (Au)
17. Red Rose Mine (Au)
18. Josephine Creek placers (Au)
19. Sucker Creek placers (Au)
20. Bristol Silica (dolomite)
21. Steatite of S. Oregon (soapstone)

EXPLORATION SITES AND AREAS

1. North Santiam area (Au, Ag, Cu, Zn)
2. Oregon King, Axehandle Mines area (Au, Ag)
3. Gold Hill area (Au, Hg)
4. Cougar Ridge area (Au)
5. Dixie Meadows Mine (Au)
6. Susanville area (Au, Hg)
7. Vinegar Hill-Sunrise Butte area (Au, Ag, Mo)
8. Buffalo Mine (Au, Ag)
9. Bald Mountain, Ibex Mines (Au, Ag)
10. Cable Cove area (Au, Ag)
11. Meadow Lakes area (Cu, Mo, Ag)
12. North Pole-Columbia lode (Au, Ag)
13. Gray Eagle Mine (Au)
14. Cornucopia Mine (Au, Ag)
15. Iron Dyke Mine (Au, Cu, Ag)
16. Flora coal deposits
17. Bay Horse Mine (Ag)
18. Sunday Hill Mine (Au)
19. Hereford area (Au)
20. Record Mine (Au)
21. Grouse Springs area (Cu, Mo)
22. Vale-Weiser area (Au)
23. Fields area (Au)
24. Eagle Picher claims (diatomite)
25. Idol City area (Au)
26. Quartz Mountain area (Au)
27. Dry Creek-Fitzwater Point area (Au, Hg)
28. Salt Creek area (Au)
29. Tucker Hills area (metallic and nonmetallic)
30. Paisley area (Au, Cu)
31. Barron Mine (Au, Ag)
32. Rowley Mine (Cu, Ag, Zn)
33. Martha Mine (Au)
34. Greenback Mine (Au)
35. McCullough Creek area (Au, Ag, Cu, Zn)
36. North Fork Silver Creek area (Au)
37. Yankee Silver Mine (Au, Ag)
38. Almeda Mine (Au, Ag, barite)
39. Brass Ledge Mine (Cu, Ag, Au)
40. Iron Hat prospect (Au)
41. Ida Mine (Au, Cu)
42. Babcock Mine (Au, Ag, Cu, Co)
43. Lightning Gulch area (Au, Ag)
44. Turner-Albright Mine (Au, Ag, Cu, Co)
45. Mount Emily area (Au)
46. Coos County coal deposits
47. Bohemia district (Au, Ag, Cu, Zn)

Mining and mineral exploration in Oregon, 1983 (excluding sand and gravel and stone). Active mines are keyed to Table 1; exploration sites are keyed to Table 2.

increased rate in 1983 following a merger with the Ash Grove Cement Company of Overland Park, Kansas. Bentonite and zeolite continued to be produced at the Teague Minerals Products plant (10) near Adrian.

OREGON'S MINERAL PRODUCTION
MILLIONS OF DOLLARS

	ROCK MATERIALS SAND, GRAVEL, STONE	OTHER MINERALS & METALS CEMENT, NICKEL, PUMICE, ETC.	NATURAL GAS	TOTAL
1983	82	41	10	133
1982	73	37	10	120
1981	85	65	13	163
1980	95	65	12	172
1979	111	54	+	165
1978	84	44	0	128
1977	74	35	0	109
1976	77	35	0	112
1975	73	33	0	106
1974	75	29	0	104
1973	55	26	0	81
1972	54	22	0	76
1971	56	22	0	78
1970	48	20	0	68

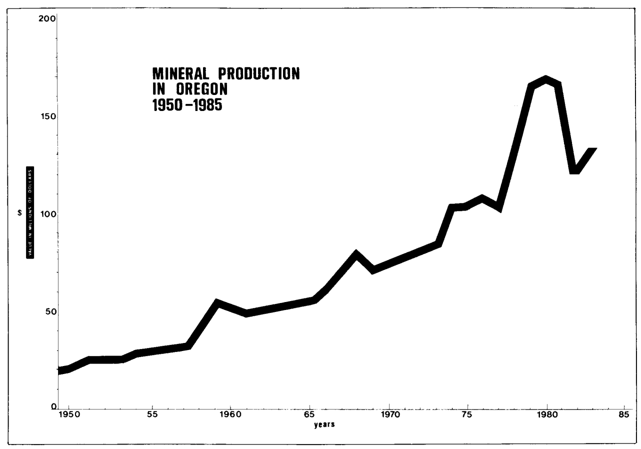
Summary of mineral production in Oregon for the last 14 years. Data for 1983 derived from U.S. Bureau of Mines annual preliminary Mineral Industry Survey *and Oregon Department of Geology and Mineral Industries natural gas production statistics.*

Table 1. *Active mines in Oregon, 1983*

Map no.	Name	Location	Comments
1.	Tempest Mine	Sec. 10 T. 9 S., R. 34 E. Grant County	Lyons Brothers continued small production of silver ore.
2.	Pyx Mine	Sec. 1 T. 10 S., R. 35 E. Grant County	Continued small production by Myron Woodley and partners.
3.	North Fork Burnt River placers	T. 10 S., Rs. 35, 35½ E. Baker County	Several small seasonal operators. Max Buckner operation.
4.	Elk Creek placers	T. 10 S., R. 39 E. Baker County	Several small seasonal operators.
5.	Thomason Mine	Sec. 6 T. 14 S., R. 37 E. Baker County	Small seasonal operation by Art Cheatham and partners.
6.	Pine Creek placers	T. 12 S., R. 39 E. Baker County	Several small seasonal operators.
7.	Clarks Creek placers	Tps. 12, 13 S., R. 41 E. Baker County	Several small seasonal operators.
8.	Oregon Portland Cement	Sec. 11 T. 12 S., R. 43 E. Baker County	Continued production.
9.	Bay Horse Mine	Sec. 9 T. 13 S., R. 45 E. Baker County	Small production of silver ore by Case Minerals (see text).
10.	Adrian (bentonite-zeolite)	Sec. 29 T. 23 S., R. 46 E. Malheur County	Continued production.
11.	Christmas Valley Diatomite	T. 27 S., R. 17 E. Lake County	Continued production for pet litter and floor sweep.
12.	Bend area pumice	Bend area Deschutes County	Continued production.
13.	Coffee Creek placers	Sec. 7 T. 30 S., R. 2 W. Douglas County	Seasonal operation by Bill Smith.
14.	Nickel Mountain Mine	Sec. 17 T. 30 S., R. 6 W. Douglas County	Mine and smelter reopened on a limited basis in November.

Table 1. *Active mines in Oregon, 1983—Continued*

Map no.	Name	Location	Comments
15.	Galice Creek area placers	T. 34 S., R. 8 W. Josephine County	Small seasonal operations on Galice Creek and on the old channel.
16.	Greenback Mine	Secs. 32, 33, 5 Tps. 33, 34 S., R. 5 W. Josephine County	Small smelter shipment to Tacoma (see text).
17.	Red Rose Mine	Secs. 19, 20 T. 38 S., R. 5 W. Josephine County	Some ore milled from dump by owner Dave Vallandigham.
18.	Josephine Creek placers	Secs. 30, 36 T. 38 S., Rs. 8, 9 W. Josephine County	Doodlebug dredge operation and other small operators.
19.	Sucker Creek placers	T. 40 S., Rs. 6, 7 W. Josephine County	Small seasonal operations.
20.	Bristol Silica	Sec. 30 T. 36 S., R. 3 W. Jackson County	Reportedly shipped about 1,000 tons of silica rock.
21.	Steatite of Southern Oregon	Secs. 10, 11 T. 41 S., R. 3 W. Jackson County	Continued production of carving-grade soapstone.



Mineral production in Oregon between 1950 and 1983.

EXPLORATION AND DEVELOPMENT

Coal: Coal exploration continued at 1982's pace. Utah International continued to evaluate the lignite deposit (16**) in the Flora-Promise area with a shallow drilling program. The drilling program was set up to determine both the extent of the coal field and the hydrologic characters of the adjoining aquifers. Some 44,000 acres of Boise Cascade lands in this area are currently under a lease option to Utah International.

The Coos County coal fields (46) also continue to be the subject of exploration activity. Shell Oil conducted a small drilling program on lands whose mineral rights are held by the American Coal Company.

Nonmetals: Zeolite, clay, perlite, and diatomite were the principal nonmetallic exploration targets in 1983. Eagle Picher continued evaluation of diatomite deposits (24) near Harper and

** All site numbers in this section refer to "Exploration sites and areas" on location map and in Table 2.

Table 2. *Exploration sites and areas in Oregon, 1983*

Map no.	Site or area name	Location	Commodity	Comments
1.	North Santiam area	Sec. 27 T. 8 S., R. 5 E. Marion County	Au, Ag, Cu, Zn	Continued work in the vicinity of the Ruth Mine.
2.	Oregon King and Axehandle Mines area	T. 9 S., R. 17 E. Jefferson County	Au, Ag	Exploration program by Ocelot Mining Corporation.
3.	Gold Hill area	Tps. 13, 14 S., R. 19 E. Crook County	Au, Hg	Exploration program by Utah International.
4.	Cougar Ridge area	Sec. 12 T. 12 S., R. 33 E. Grant County	Au	Surface trenching and sampling of old workings by a local group (Cougar Ridge Mining Co., Inc.).
5.	Dixie Meadows Mine	Sec. 23 T. 11 S., R. 33 E. Grant County	Au	Property dropped by Western Nuclear and later acquired by Big Turtle Mines.
6.	Susanville area	T. 10 S., R. 33 E. Grant County	Au, Ag	Intensive surface drilling and sampling program by American Copper and Nickel.
7.	Vinegar Hill-Sunrise Butte area	T. 10 S., R. 34 E. Grant County	Au, Ag, Mo	Sampling and drilling program by American Copper and Nickel.
8.	Buffalo Mine	Sec. 14 T. 8 S., R. 35½ E. Grant County	Au, Ag	Property acquired by Great American Gold Corporation.
9.	Bald Mountain-Ibex Mines	Sec. 4 T. 9 S., R. 36 E. Baker and Grant Counties	Au, Ag	NERCO completed first phase of evaluating the Bald Mountain-Ibex vein with 54,000 ft of underground diamond drilling.
10.	Cable Cove area	T. 8 S., R. 36 E. Baker and Grant Counties	Au, Ag	Small-scale sampling program by local group.
11.	Meadow Lakes area	T. 8 S., R. 37 E. Baker and Grant Counties	Cu, Mo, Ag	Small drilling program by Manville.
12.	North Pole-Columbia lode	Sec. 32 T. 8 S., R. 37 E. Baker County	Au, Ag	Property held by Brooks Minerals, Inc.
13.	Gray Eagle Mine	Sec. 7 T. 9 S., R. 41 E. Baker County	Au	Small exploration program by Big Turtle Mines.
14.	Cornucopia Mine	Secs. 27, 28 T. 6 S., R. 45 E. Baker County	Au, Ag	Full ownership acquired by UNC Resources, Inc.
15.	Iron Dyke Mine	Sec. 21 T. 6 S., R. 48 E. Baker County	Au, Cu, Ag	Full ownership acquired by Silver King. Tentative plan to reopen in 1984.
16.	Flora coal deposits	Northern Wallowa County	Coal	Utah International conducted drilling and hydrologic study programs.
17.	Bay Horse Mine	Sec. 9 T. 13 S., R. 45 E. Baker County	Ag	Exploration program of drilling and sampling by Silver King Mines, Inc.
18.	Sunday Hill Mine	Sec. 17 T. 13 S., R. 42 E. Malheur County	Au	Sampling program by Capri Resources, Vancouver.
19.	Hereford area	T. 12 S., R. 38 E. Baker County	Au	Continued exploration programs by Amselco and AMAX.
20.	Record Mine	Sec. 1 T. 14 S., R. 36 E. Baker County	Au	Exploration program by Manville.
21.	Grouse Springs area	Secs. 24, 25 T. 14 S., R. 36 E. Baker County	Cu, Mo	Small drilling program by Manville.
22.	Vale-Weiser area	Northern and central Malheur County	Au	Sampling and drilling programs on epithermal gold prospects held by Manville and others.
23.	Fields area	Harney County	Au	Exploration programs by FMC and Inspiration Development.

Table 2. *Exploration sites and areas in Oregon, 1983 – continued*

Map no.	*Site or area name*	*Location*	*Commodity*	*Comments*
24.	Eagle Picher claims	Malheur and Harney Counties	Diatomite	Exploration and development program.
25.	Idol City area	T. 21 S., R. 32 E. Harney County	Au	Sampling and drilling program by Noranda.
26.	Quartz Mountain area	T. 37 S., R. 16 E. Lake County	Au	Sampling and drilling program by Anaconda.
27.	Dry Creek-Fitzwater Point area	T. 41 S., R. 18 E. Lake County	Au, Hg	Continued exploration by U.S. Steel.
28.	Salt Creek area	T. 38 S., R. 21 E. Lake County	Au	Continued exploration by Freeport Minerals.
29.	Tucker Hills area	T. 34 S., R. 19 E. Lake County	Metallic and nonmetallic	Continued exploration by Houston International.
30.	Paisley area	T. 34 S., Rs. 18, 19 E. Lake County	Au, Cu	Continued exploration by Chevron.
31.	Barron Mine	Sec. 23 T. 39 S., R. 2 E. Jackson County	Au, Ag	Sampling and mapping program by Genex Resources, Vancouver.
32.	Rowley Mine	Sec. 4 T. 32 S., R. 2 W. Douglas County	Cu, Ag, Zn	Mapping and drilling program by Standard Metals.
33.	Martha Mine	Sec. 28 T. 33 S., R. 5 W. Josephine County	Au	Small exploration program by Jacksonville Mining Co.
34.	Greenback Mine	Secs. 32, 33, 5 Tps. 33, 34 S., R. 5 W. Josephine County	Au	Small production by Sunny Valley Mining and Development Co. early in 1983. Property now being evaluated by Mega Gold Resources Ltd.
35.	McCullough Creek area	Secs. 30, 31 T. 32 S., R. 6 W. Douglas County	Au, Ag, Cu, Zn	Continued exploration programs by Exxon and Boise Cascade.
36.	North Fork Silver Creek area	T. 35 S., R. 9 W. Josephine County	Au	Large number of claims held by Goldwin Resources.
37.	Yankee Silver Mine	Secs. 25, 26 T. 34 S., R. 8 W. Josephine County	Au, Ag	Property purchased by Condaka Metals, Inc., who are conducting a drilling and sampling program.
38.	Almeda Mine	Sec. 13 T. 34 S., R. 8 W. Josephine County	Au, Ag, barite	Geochemical sampling program by Blue Diamond Energy Resources and Comanche Petroleum.
39.	Brass Ledge Mine	Sec. 28 T. 34 S., R. 8 W. Josephine County	Cu, Ag, Au	Airborne E.M. program by Condaka Metals.
40.	Iron Hat prospect	Sec. 17 T. 37 S., R. 5 W. Josephine County	Au	Geochemical sampling, airborne E.M., and mapping programs by Condaka Metals.
41.	Ida Mine	Sec. 26 T. 35 S., R. 5 W. Josephine County	Au, Cu	Old workings reopened and sampled by SCORE Resources.
42.	Babcock Mine	Sec. 5 T. 39 S., R. 6 W. Josephine County	Au, Ag, Cu, Co	Airborne E.M. program by Condaka Metals.
43.	Lightning Gulch area	Tps. 38, 39 S., R. 9 W. Josephine County	Au, Ag	Airborne E.M. program by Condaka Metals.
44.	Turner-Albright Mine	Secs. 15, 16 T. 41 S., R. 9 W. Josephine County	Au, Ag, Cu, Co	Gray Rock attempting to extend ore reserves by drilling program.
45.	Mount Emily area	T. 40 S., R. 12 W. Curry County	Au	Small exploration program by Mount Emily Mining and Exploration Co. (Joe Montgomery and Associates) of Vancouver, B.C.
46.	Coos County coal deposits	Coos Bay and Eden Ridge coal fields	Coal	Small drilling program by Shell Oil.
47.	Bohemia district	T. 23 S., Rs. 1, 2 E. Lane County	Au, Ag, Cu, Zn	Underground work by Galactic Resources in early 1983 on the Champion.

announced plans in January 1984 to build a $13 million processing plant west of Vale. The plant is expected to provide full-time employment to 30 or 40 people in the production of filter-grade diatomite.

Metals: Acquisition, exploration, and evaluation of precious-metal deposits around the state continued at a strong pace in 1983. Development activity, however, has declined, in part due to falling metal prices. The principal exploration areas continue to be the newly recognized zones of Tertiary epithermal gold mineralization in Harney, Lake, and Malheur Counties and the old gold districts in Baker and Grant Counties, northeast Oregon, and in Douglas, Jackson, and Josephine Counties, southwest Oregon.

American Copper and Nickel continued its strong exploration program in Grant and Baker Counties, having just completed an extensive diamond drilling program on the Badger, Bull of the Woods, and Gem veins in the old Susanville district (6). NERCO, Inc., completed the initial phase of a Bald Mountain-Ibex evaluation program which saw over 50,000 ft of underground diamond drilling on the Bald Mountain-Ibex vein (9). NERCO announced a joint venture exploration program of the property with American Copper and Nickel in 1984. Current plans call for an above-ground diamond drilling program to be started on the Grand Trunk and Belle of Baker claims to the east of the main Bald Mountain workings.

UNC Resources, Inc., has acquired full ownership of the Cornucopia Mine (14) in eastern Baker County. Exploration and development of the property was at a low level in 1983.

Silver King Mines, Inc., acquired the two-thirds interest of Texasgulf, Inc., in the Iron Dyke Mine (15) on the Snake River, along with a 100 percent interest in the Red Ledge property in Idaho. Silver King had been in a joint venture partnership with Texasgulf on the Iron Dyke since 1978. The property had produced 36,000 tons of high-grade gold copper ore when last operated in 1980 and 1981. Silver King has also begun an exploration and evaluation program at the Bay Horse Mine (17), which is about 70 mi south of the Iron Dyke on the Snake River. Current plans call for the stockpiling of ore from both properties for shipment to the company's mill at Copper Cliffs, Idaho.

Volcanogenic sulfide deposits continued to be the focus of exploration activity in southwestern Oregon. Boise Cascade and Exxon are continuing to explore in the McCullough Creek area (35). Gray Rock is attempting to extend the ore reserves previously established by Noranda at the Turner-Albright Mine (44). Noranda had announced that their exploration program outlined over 3 million tons of gold copper ore at the Turner-Albright.

Active exploration of epithermal gold deposits in central and southeastern Oregon continued at a strong pace throughout 1983. Diamond-drill programs were under way at Idol City (25), Quartz Mountain (26), and in the Vale-Weiser area (22). Many of the prospects undergoing evaluation are new gold prospects discovered since 1978.

Low-level exploration of base-metal deposits continued despite depressed metal prices. Manville continued shallow diamond-drilling programs at Meadow Lakes (11) and Grouse Springs (21).

The Oregon Department of Geology and Mineral Industries released the results of several geochemical surveys during 1983. These included studies of 18 BLM wilderness areas in southeast Oregon (Open-File Report O-83-2) and of the western part of the Ochoco National Forest in central Oregon (Open-File Report O-83-4). The results of a similar survey in the Fall Creek district in western Oregon (Open-File Report O-83-5) were released in January 1984. Geologic maps of mineralized areas in Baker and Grant Counties released by the Department in 1983 included the Granite (GMS-25), Greenhorn (GMS-28), and Bates NE (GMS-29) quadrangles. Similar maps of the Bates NW and Bates SW quadrangles in Grant County and the Pearsoll Peak SE quadrangle in Josephine and Curry Counties are in progress. □

Scientists report on Mount St. Helens monitoring efforts

Monitoring efforts of Mount St. Helens by scientists of the U.S. Geological Survey (USGS) and the University of Washington geophysics program at the Cascades Volcano Observatory, Vancouver, Washington, were described in a series of eight articles in the September 30, 1983, issue of *Science Magazine*. Subjects ranged from earthquakes occurring beneath the volcano, ground measurements on the crater floor and lava dome, to daily gas emissions from the crater. Some highlights:

Fifteen eruptions have taken place in the horse-shoe-shaped crater of Mount St. Helens since the catastrophic events of May 18, 1980. Since late October 1980, the eruptions have been predominantly non-explosive dome-building events. Since early February 1983, the 750-ft-high lava dome in the middle of the crater has been growing continuously, extruding lava high on its northeast flank. This marks the longest dome-building eruption to date.

Information from six seismometers on the cone and 10 others in the surrounding area is radioed to the University of Washington in Seattle and analyzed and interpreted by seismologists. Seismic data provide information about the location, depth and frequency of earthquakes, times of degassing events for the dome, and rockfalls associated with dome growth. Each of the eruptions in 1981-82 was preceded by an increase in earthquake activity which was used to anticipate the time of the eruptions, particularly 1-2 days before an expected event.

Measurements inside the crater by USGS scientists using precise surveying equipment and simple tape measures show that the crater floor becomes deformed prior to an eruption, as magma rises upward from a deeper source. In late 1980, cracks often appeared on the crater floor before eruptions and extended outward from the dome like spokes of a wheel. Measurements show that the cracks widen with time, especially just before an eruption. Other parts of the crater floor often become slightly wrinkled several weeks before an eruption. A few of these wrinkles develop into features called thrust faults, sometimes growing from less than 1 ft high, to as high as 10-15 ft. The movement of the crater floor along these faults increases before eruptions, and by measuring the rate of movement scientists have been able to predict eruptions one to three weeks in advance.

Electronic tiltmeters specifically designed for use at Mount St. Helens are used to measure small changes in slope of the crater floor, much like a carpenter's level. These tiltmeters, installed within several hundred feet of the dome, show rapid changes hours to days before an eruption and send information by radio to the USGS Cascades Volcano Observatory in Vancouver.

Monitoring the shape of the dome is also used to anticipate eruptions one to three weeks in advance. Measurements between points on the dome and crater floor show that the dome grows or swells as magma moves upward into the dome before it is eventually erupted on the surface of the dome to form a new lobe. Repeated surveys to targets placed on the dome reveal movements that speed up as the eruption nears. Before the May 14, 1982, eruption, for example, a target placed on the west side of the dome was moving roughly 1 in. per day two weeks before the eruption; this movement increased to about 7 ft per day two days before the eruption. This increase in the rate of movement before the eruption is the key for predictions.

The lava-dome eruptions have each added a new flow of sticky viscous dacite magma to the composite lava dome. The major-element chemical composition of the dome has remained essentially constant at 62-63 percent SiO_2, suggesting that no new material has been added to the shallow magma system since the summer of 1980. An increase in the crystallinity of the dacite suggests that a deeper, gas-poor, crystal-rich layer is now being tapped rather than a gas-rich magma as during the explosive eruptions of 1980.

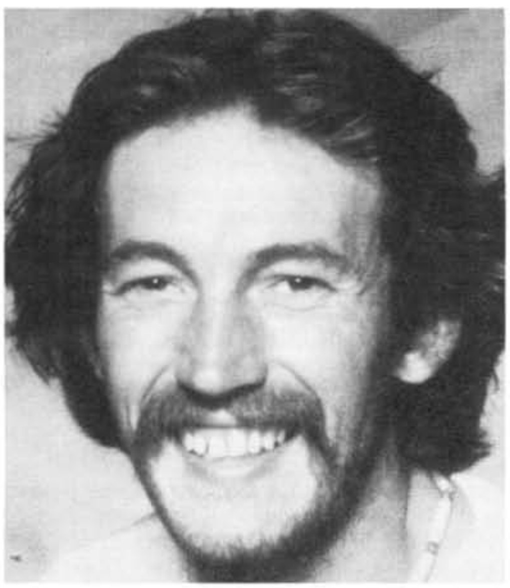
– USGS News Release

Surface mined land reclamation in Oregon, 1983

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

In 1983, Oregon's Mined Land Reclamation Program (MLR) made progress in several areas. The most important single item is the reclamation of over 380 acres during the year. Other developments are detailed later in this report. In 1983, 785 field inspections were conducted, compared to 682 in 1982, 912 in 1981, and 681 in 1980. Also in 1983, 19 Surface Mining Permit sites (SMP's), 18 Limited Exempt sites (LE's), and 45 Total Exempt sites (TE's) were transferred from state to county jurisdiction under provisions of ORS 517.780.

After a five-month nationwide recruiting program, Frank Schnitzer was hired and began work in February. Frank is a soils scientist with an advanced degree. He has two years of comparable mining regulatory work in Wyoming in addition to other experience. He has had surface mined land reclamation experience with coal, uranium, bentonite, trona, and limestone operations as well as the more common minerals.



E. Frank Schnitzer

The unanimous choice of the selection committee for the 1983 Mined Land Reclamation Award was Multnomah County. After mining approximately 870,000 cubic yards of sand and gravel for local needs, the county used the site for a county landfill. After the landfill stabilized and was no longer chemically active, a portion was re-excavated to a stable base, and an exceptionally well planned and efficient building was completed for the county's Division of Operations and Maintenance (county shops). Other finalists in 1983 included Harold Knapp of Knapp Ranches, Port Orford, for pasture and recreation (organized rifle range); the Oregon State Highway Division, Department of Transportation, for water impoundment (public fishing and other public recreation, including flying of model seaplanes) and pasture; and Vernon Egge of Egge Sand and Gravel, Eugene, for areas reclaimed to wildlife management, agriculture, and a (permitted) solid-waste disposal site. More details and some photographs of these projects were published in the December 1983 issue of *Oregon Geology*.

The award program exists to provide recognition for outstanding performance and results in mined land reclamation and to encourage further sensible mined land reclamation, both mandatory and voluntary. While they cannot all be named, we do appreciate the efforts of the many additional operators who comply with the law and reclaim mined lands. Most reclaimed lands are worth at least as much as they were before mining. Some are substantially more valuable.

Regrettably, noncompliance also is a fact of life. The Department reclaimed one site, after it was legally declared abandoned, and the operator forfeited his security. It appears likely that the Department will reclaim at least three or four sites in 1984.

Several changes in law governing reclamation (ORS 517.750-517.955 and 990[4], [5], and [6]) were made by the 1983 Legislative Assembly. Authority was granted to increase new permit fees from $390 per year to a maximum of $415 and renewal fees from $290 per year to a maximum of $315. So far, the Department has not found it necessary to initiate a request to increase fees.

The Legislative Assembly, recognizing the added cost to the Department if it has to contract reclamation work, authorized a "per-site" bond of up to $2,000 on "aggregate" sites, in addition to the existing maximum bond of $500 per acre. This amount will meet the cost of moving equipment to and from the site, a cost that usually does not arise when the operator completes reclamation before leaving the site. The maximum bond of $500 per acre was unchanged. Other changes relative to "aggregate" sites were an increase in the authorized lien from $500 per acre to $2,000 per site plus $1,500 per acre (ORS 517.865). A provision was adopted authorizing the Department to accept a single bond covering two or more sites operated by a single company or owned by a single landowner.

The Legislature also directed the Department to conduct a study of the alternatives for recovering the costs of mined land reclamation. Authorization was given to appoint an advisory committee from mining industries, governmental agencies, and other interested persons. The results of the study, and any recommendations are to be reported by the Department to the Sixty-Third Legislative Assembly. The committee has been appointed and the study is under way.

Another series of amendments concerns ORS 517.750. Definitions were added for "processing," "surface impacts of underground mining," and "underground mining." The previously existing definition of surface mining was rewritten into two parts in an attempt to define more clearly what is and is not surface mining under this law. The Department will henceforth regulate the reclamation aspects of surface impacts of underground mining. Rules to implement these new provisions are being drafted for review, public hearings, and adoption.

Finally, amendments to ORS 517.780 were made. A terminal date was established for Subsection (2) which provides for a city or county to administer the mined land reclamation law. This amendment terminates such an option unless a city or county has a reclamation ordinance approved by the Department prior to July 1, 1984. An added provision directs the Department to review the implementation of county ordinances adopted pursuant to ORS 517.780(2). The Department may withdraw approval of such ordinances upon finding that implementation does not meet standards prescribed by the law and state rules.

An automatic data processing system of the personal computer class with word processing and database management software was procured in the summer of 1983. The word processing capability is now very valuable in editing the large number of inspection reports, as well as many letters and other communications which must be produced. The data base is still being established with the insertion of data from approximately 2,300 site files. As the system develops it is expected that the administrative efficiency of the MLR program will be significantly enhanced, particularly the ability to identify monthly renewals and current delinquencies and to act on them promptly and efficiently.

Status of the Mined Land Reclamation Program

Total acreage reclaimed

1972 through Dec. 1980:	443
1972 through Dec. 1981:	805.75
1972 through Dec. 1982:	961.65
1972 through Dec. 1983:	1,344.15
(1983:	382.5)

Total acreage under security to guarantee reclamation

December 31, 1980:	2,173
December 31, 1981:	2,606
December 31, 1982:	3,105
December 31, 1983:	3,189

Uses to which acreage was reclaimed

	Agriculture	Forestry	Housing	Other*
1972 through 1980	251	6.5	37	148
During 1981	168	7	21	167.5
During 1982	105	14.5	0	36
During 1983	52.65	264	0	66
Total	576.65	292	58	417.5

* "Other" includes a wide variety of uses but contains a high percentage of various kinds of water impoundments, sites for wildlife management, industrial-commercial construction, and permanent stockpile sites.

Changes: New and closed sites, 1980-1983
(Permits issued for new sites, records closed, sites reclaimed, or activity legally terminated)

	Surface mining permit[1]		Limited exemption[2]		Total exemption[3]	
Year	New	Closed	New	Closed	New	Closed
1980	46	19	34	4	46	3
1981	84	32	50	7	51	26
1982	35	34	24	14	106	28
1983[4]	56	37	21	9	54	34

[1] Sites requiring a fee, reclamation, and security.

[2] Sites requiring a fee, but legally exempt from reclamation and security until horizontal expansion occurs—after July 1, 1972, or January 1, 1981 (different provisions). Expansion requires conversion to surface mining permit; expansion area **only** is then subject to reclamation and bonding.

[3] Sites legally exempt from fee, reclamation, and bonding—for various specific reasons, most commonly "access roads," size, and inactivity. (Surface mining permit category sites **cannot** go to total exemption status if the surface mining permit has been utilized.)

[4] During 1983 there were 49 other changes in status from one category to another.

Total number of sites under permit

As of	Surface mining permit	Limited exemption	Total exemption
December 31, 1980	348	333	571
December 31, 1981	399	338	587
December 31, 1982	400	287	648
December 31, 1983	405	254	602 □

Task force to study alternatives to MLR Program bonding system

The Governing Board of the Oregon Department of Geology and Mineral Industries (DOGAMI) has appointed a task force to conduct a study of all possible alternatives for guaranteeing recovery of costs of mined land reclamation in the state of Oregon. The study will deal specifically with bonding or other security systems assuring the availability of funds in the event DOGAMI must reclaim mined lands.

The task force, known as the Mined Land Reclamation Advisory Committee, was created in response to a charge established in amendments to Mined Land Reclamation legislation which the 62nd Oregon Legislative Assembly enacted. Included in the task force are representatives from the mining industry, government agencies, environmental groups, and bonding companies.

The eight committee members are Stan Biles, Assistant to the Director, Oregon Department of Environmental Quality; Kathleen Brophy, Surety Manager, Industrial Indemnity Company, Portland; Bruce Henderson, Oregon Environmental Council; Randall Hledick, Director of Land Use and Environmental Affairs, Wildish Sand and Gravel Company, Eugene; Howard Long, Manager, Fidelity and Surety Bond Department, North Pacific Insurance Company, Portland; William Lyons, Vice President for Planning and External Affairs, Northwest Energy Resources Company (NERCO), Portland; and John Beaulieu, Deputy State Geologist, and Donald Haagensen, Governing Board member, of DOGAMI.

The task force met for the first time on February 8, 1984. Activities of the anticipated four- to six-month study by the committee will include, but are not necessarily limited to, presentations by selected speakers and investigations of related mined land reclamation practices in other states. DOGAMI will report the results of the study and any recommendations to the 63rd Oregon Legislative Assembly. □

AEG to hold symposium on ore exploration

The Association of Exploration Geochemists (AEG) will hold a symposium on *Exploration for Ore Deposits of the North American Cordillera* on March 25-28, 1984, at the MGM Grand Hotel in Reno, Nevada.

The program will include technical sessions, a poster session and trade exhibit, and field trips both before and after the symposium. A full-day short course on the design of geochemical exploration programs will be offered on March 23 and 24. Keynote speaker will be R.W. Boyle of the Geological Survey of Canada.

For further information on registration, reservations, special travel services, and program details contact the Reno Symposium Executive Committee, P.O. Box 9777, University Station, Reno, Nevada 89507. Technical Program Chairman is J.W. Motter, phone (702) 323-3050. □

GSOC luncheon meetings announced

The **Geological Society of the Oregon Country** (GSOC) holds noon meetings in the Standard Plaza Building, 1100 SW Sixth Ave., Portland, OR, in Room A adjacent to the third-floor cafeteria. Upcoming meetings, topics, and speakers:

March 16—*Indian Ruins of the Southwest*, by Lloyd A. Wilcox, past president of GSOC, active member of the Archaeologic Society, participant in dig at the Calico Man site.

April 6—*Spring in the Mojave Desert*, by Donald Barr, naturalist.

April 20—*Statues of the Easter Islands*, by Esther Schwartz.

For additional information, contact Viola L. Oberson, Luncheon Program Chairwoman, phone (503) 282-3685. □

Available publications

ORDER FORM — CUT ON DASHED LINE

BULLETINS	Price	No. Copies	Amount
33. Bibliography (1st supplement) geology and mineral resources of Oregon, 1947: Allen	$ 3.00		
35. Geology of the Dallas and Valsetz quadrangles, rev. 1964: Baldwin (map only)	3.00		
36. Papers on Tertiary foraminifera: Cushman, Stewart, and Stewart, 1949: v. 2	3.00		
44. Bibliography (2nd supplement) geology and mineral resources of Oregon, 1953: Steere	3.00		
46. Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey	3.00		
49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch	3.00		
53. Bibliography (3rd supplement) geology and mineral resources of Oregon, 1962: Steere and Owen	3.00		
61. Gold and silver in Oregon, 1968: Brooks and Ramp	17.50		
62. Andesite Conference guidebook, 1968: Dole	3.50		
65. Proceedings of the Andesite Conference, 1969: (copies)	10.00		
67. Bibliography (4th supplement) geology and mineral resources of Oregon, 1970: Roberts	3.00		
71. Geology of selected lava tubes in Bend area, Oregon, 1971: Greeley (copies)	5.00		
78. Bibliography (5th supplement) geology and mineral resources of Oregon, 1973: Roberts	3.00		
81. Environmental geology of Lincoln County, 1973: Schlicker and others	9.00		
82. Geologic hazards of Bull Run Watershed, Multnomah, Clackamas Counties, 1974: Beaulieu	6.50		
83. Eocene stratigraphy of southwestern Oregon, 1974: Baldwin	4.00		
84. Environmental geology of western Linn County, 1974: Beaulieu and others	9.00		
85. Environmental geology of coastal Lane County, 1974: Schlicker and others	9.00		
87. Environmental geology of western Coos and Douglas Counties, 1975	9.00		
88. Geology and mineral resources of upper Chetco River drainage, 1975: Ramp	4.00		
89. Geology and mineral resources of Deschutes County, 1976: Peterson and others	6.50		
90. Land use geology of western Curry County, 1976: Beaulieu	9.00		
91. Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties, Oregon, 1977: Beaulieu	8.00		
92. Fossils in Oregon (reprinted from *The Ore Bin*), 1977	4.00		
93. Geology, mineral resources, and rock material of Curry County, Oregon, 1977	7.00		
94. Land use geology of central Jackson County, Oregon, 1977: Beaulieu	9.00		
95. North American ophiolites, 1977	7.00		
96. Magma genesis: AGU Chapman Conference on Partial Melting, 1977	12.50		
97. Bibliography (6th supplement) geology and mineral resources of Oregon, 1971-75, 1978	3.00		
98. Geologic hazards of eastern Benton County, Oregon, 1979: Bela	9.00		
99. Geologic hazards of northwestern Clackamas County, Oregon, 1979: Schlicker and Finlayson	10.00		
100. Geology and mineral resources of Josephine County, Oregon, 1979: Ramp and Peterson	9.00		
101. Geologic field trips in western Oregon and southwestern Washington, 1980	9.00		
102. Bibliography (7th supplement) geology and mineral resources of Oregon, 1976-1979, 1981	4.00		
GEOLOGIC MAPS			
Reconnaissance geologic map of Lebanon quadrangle, 1956	3.00		
Geologic map of Bend quadrangle and portion of High Cascade Mountains, 1957	3.00		
Geologic map of Oregon west of 121st meridian (USGS I-325), 1961	5.50		
Geologic map of Oregon east of 121st meridian (USGS I-902), 1977	5.50		
GMS-4: Oregon gravity maps, onshore and offshore, 1967 (folded)	3.00		
GMS-5: Geologic map of Powers quadrangle, Oregon, 1971	3.00		
GMS-6: Preliminary report on geology of part of Snake River Canyon, 1974	6.50		
GMS-8: Complete Bouguer gravity anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00		
GMS-9: Total field aeromagnetic anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00		
GMS-10: Low- to intermediate-temperature thermal springs and wells in Oregon, 1978	3.00		
GMS-12: Geologic map of the Oregon part of the Mineral quadrangle, 1978	3.00		
GMS-13: Geologic map of the Huntington and part of the Olds Ferry quadrangles, Oregon, 1979	3.00		
GMS-14: Index to published geologic mapping in Oregon, 1898-1979, 1981	7.00		
GMS-15: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, northern Oregon, 1981	3.00		
GMS-16: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, southern Oregon, 1981	3.00		
GMS-17: Total-field aeromagnetic anomaly map, Cascade Mountain Range, southern Oregon, 1981	3.00		
GMS-18: Geology of the Rickreall, Salem West, Monmouth, and Sidney 7½-minute quadrangles, Marion, Polk, and Linn Counties, Oregon, 1981	5.00		
GMS-19: Geology and gold deposits map of the Bourne quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-20: Map showing geology and geothermal resources of the southern half of the Burns 15-minute quadrangle, Oregon, 1982	5.00		
GMS-21: Geology and geothermal resources map of the Vale East 7½-minute quadrangle, Oregon, 1982	5.00		
GMS-22: Geology and mineral resources map of the Mt. Ireland quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-23: Geologic map of the Sheridan quadrangle, Polk and Yamhill Counties, Oregon, 1982	5.00		
GMS-24: Geologic map of the Grand Ronde quadrangle, Polk and Yamhill Counties, Oregon, 1982	5.00		
GMS-25: Geology and gold deposits map of the Granite quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-26: Residual gravity maps of the northern, central, and southern Cascade Range, Oregon, 1982	5.00		
GMS-27: Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1° by 2° quadrangle, 1982	6.00		
GMS-28: Geology and gold deposits map of the Greenhorn quadrangle, Baker and Grant Counties, Oregon, 1983	5.00		
GMS-29: Geology and gold deposits map, NE¼ Bates quadrangle, Baker and Grant Counties, Oregon, 1983	5.00		
OIL AND GAS INVESTIGATIONS			
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well	3.00		
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well, 1973	3.00		
5. Prospects for natural gas production or underground storage of pipeline gas, upper Nehalem River Basin, Columbia-Clatsop Counties, Oregon, 1976	5.00		
6. Prospects for oil and gas in the Coos Basin, western Coos, Douglas, and Lane Counties, Oregon, 1980: Newton and others	9.00		
7. Correlation of Cenozoic stratigraphic units of western Oregon and Washington, 1983	8.00		

Available publications (continued)

SPECIAL PAPERS	Price	No. Copies	Amount
1. Mission, goals, and programs of Oregon Department of Geology and Mineral Industries, 1978	3.00		
2. Field geology of SW Broken Top quadrangle, Oregon, 1978: Taylor	3.50		
3. Rock material resources of Clackamas, Columbia, Multnomah, and Washington Counties, Oregon, 1978: Gray and others	7.00		
4. Heat flow of Oregon, 1978: Blackwell, Hull, Bowen, and Steele	3.00		
5. Analysis and forecasts of the demand for rock materials in Oregon, 1979: Friedman and others	3.00		
6. Geology of the La Grande area, Oregon, 1980: Barrash and others	5.00		
7. Pluvial Fort Rock Lake, Lake County, Oregon, 1979: Allison	4.00		
8. Geology and geochemistry of the Mt. Hood volcano, 1980: White	3.00		
9. Geology of the Breitenbush Hot Springs quadrangle, Oregon, 1980: White	4.00		
10. Tectonic rotation of the Oregon Western Cascades, 1980: Magill and Cox	3.00		
11. Theses and dissertations on the geology of Oregon: Bibliography and index, 1899-1982, 1982: Neuendorf and others	6.00		
12. Geologic linears of the northern part of the Cascade Range, Oregon, 1980: Venkatakrishnan, Bond, and Kauffman	3.00		
13. Faults and lineaments of the southern Cascades, Oregon, 1981: Kienle, Nelson, and Lawrence	4.00		
14. Geology and geothermal resources of the Mount Hood area, Oregon, 1982: Priest and Vogt	7.00		
NEW! 15. Geology and geothermal resources of the central Oregon Cascade Range, 1983: Priest and Vogt	11.00		
16. Index to the *Ore Bin* (1939-1978) and *Oregon Geology* (1979-1982), 1983: Mahoney and Steere	4.00		
SHORT PAPERS			
21. Lightweight aggregate industry in Oregon, 1951: Mason	1.00		
24. The Almeda Mine, Josephine County, Oregon, 1967: Libbey	3.00		
25. Petrography, type Rattlesnake Formation, central Oregon, 1976: Enlows	3.00		
27. Rock material resources of Benton County, 1978: Schlicker and others	4.00		
MISCELLANEOUS PAPERS			
1. A description of some Oregon rocks and minerals, 1950: Dole	1.00		
5. Oregon's gold placers (reprints), 1954	1.00		
8. Available well records of oil and gas exploration in Oregon, rev. 1982: King, Olmstead, and Newton	4.00		
11. Collection of articles on meteorites, 1968 (reprints from *The Ore Bin*)	3.00		
15. Quicksilver deposits in Oregon, 1971: Brooks	3.00		
17. Geologic hazards inventory of the Oregon coastal zone, 1974: Beaulieu, Hughes, and Mathiot	5.00		
18. Proceedings of Citizens' Forum on potential future sources of energy, 1975	3.00		
19. Geothermal exploration studies in Oregon—1976, 1977	3.00		
20. Investigations of nickel in Oregon, 1978: Ramp	5.00		
MISCELLANEOUS PUBLICATIONS			
Landforms of Oregon (17 × 12 inches)	1.00		
Mining claims (State laws governing quartz and placer claims)	1.00		
Geological highway map, Pacific NW region, Oregon-Washington (published by AAPG)	5.00		
Geothermal resources of Oregon map, 1982 (published by NOAA)	3.00		
Back issues of *The Ore Bin*	50¢ over the counter; $1.00 mailed		
Back issues of *Oregon Geology*	75¢ over the counter; $1.00 mailed		
Colored postcard, *Geology of Oregon*	10¢ each; 3 for 25¢; 7 for 50¢; 15 for $1.00		
Oregon Landsat mosaic map, 1983 (published by ERSAL, OSU)	$8.00 over the counter; $11.00 mailed		

Separate price lists for open-file reports, geothermal energy studies, tour guides, recreational gold mining information, and non-Departmental maps and reports will be mailed upon request.

OREGON GEOLOGY

1005 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

PUBLICATIONS ORDER

Minimum mail order $1.00. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $50.00. Foreign orders: please remit in U.S. dollars.

Fill in appropriate blanks and send sheet to Department.

YOUR NAME ______________________

ADDRESS ______________________

______________________ Zip______

Amount enclosed $______

OREGON GEOLOGY

____ Renewal ____ New Subscription ____ Gift

____ 1 Year ($6.00) ____ 3 Years ($15.00)

NAME ______________________

ADDRESS ______________________

______________________ ZIP ______

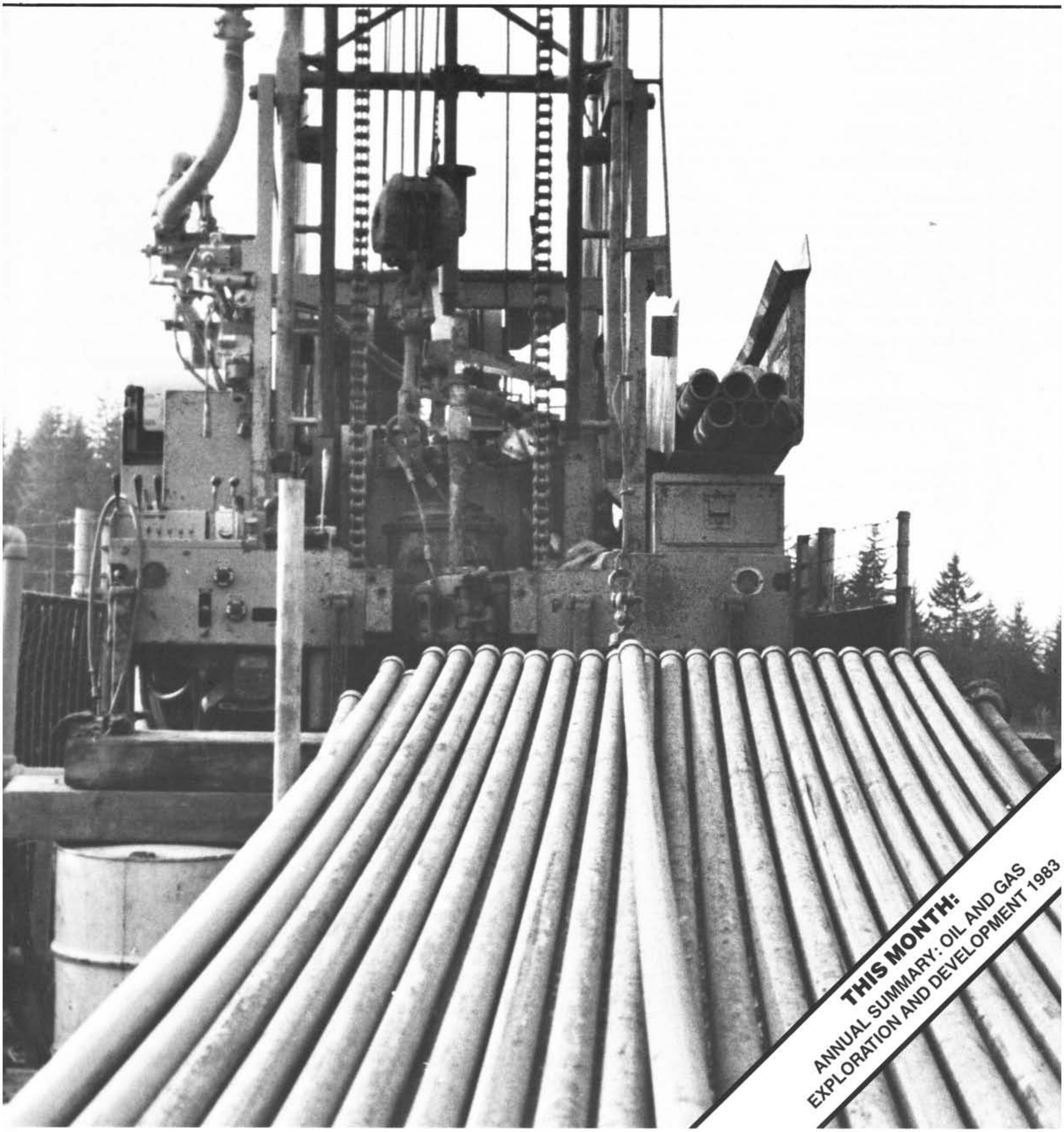
(If Gift, From: ______________________)

OREGON GEOLOGY

published by the

Oregon Department of Geology and Mineral Industries

VOLUME 46, NUMBER 4 **APRIL 1984**



OREGON GEOLOGY
(ISSN 0164-3304)

VOLUME 46, NUMBER 4 — APRIL 1984

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

Main Office: 1005 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133.
Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496.
Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039.
Paul F. Lawson, Supervisor

Subscription rates: 1 year, $6.00; 3 years, $15.00. Single issues, $.75 at counter, $1.00 mailed.
Available back issues of *The Ore Bin*: $.50 at counter, $1.00 mailed.

Address subscription orders, renewals, and changes of address to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

Send news, notices, meeting announcements, articles for publication, and editorial correspondence to the editor, Portland office. The Department encourages author-initiated peer review for technical articles prior to submission. Any review should be noted in the acknowledgments.

Second class postage paid at Portland, Oregon.
Postmaster: Send address changes to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

COVER PHOTO

Jannsen Drilling Company workover rig at Reichhold Longview Fibre 12-33 in Mist Gas Field. Article beginning on next page summarizes oil and gas activity in Oregon during 1983.

OIL AND GAS NEWS

New producers at Mist Gas Field

On February 20, 1984, Reichhold Energy spudded Columbia County 43-22 in sec. 22, T. 6 N., R. 5 W. The well, an offset to the recently completed Columbia County 23-22, was drilled and completed to production on February 29. The total depth is 2,252 ft, and the initial production was 1.3 million cubic feet per day.

DOGAMI Board Meeting

At the February 27, 1984, meeting of the Governing Board, one agenda item concerned the proposal by Reichhold Energy to drill Columbia County 13-34A in the Mist Gas Field. The proposed well would be in a spacing unit where a producer already exists. Testimony from a January 17, 1984, hearing was discussed, and the Board voted to permit the drilling of the new well.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
258	Reichhold Energy Corp. Crown Zellerbach 34-28 009-00126	SE¼ sec. 28 T. 6 N., R. 4 W. Columbia County	Application; 2,500.
259	Hutchins & Marrs Great Discovery 2 019-00023	NW¼ sec. 20 T. 30 S., R. 9 W. Douglas County	Application; 3,500.

□

Former Governing Board Chairman dies

Fayette Ingalls Bristol, former member and chairman of the Governing Board of the Oregon Department of Geology and Mineral Industries (DOGAMI) between 1961 and 1972 died in Lincoln City on Sunday, February 26, 1984.

Born in Hillsdale, Michigan, Bristol attended Michigan State University, where he studied mining engineering. After moving to Oregon, he began his own company, Oregon Lime Products, in Williams. He later started Bristol Silica Company in Rogue River. From 1967 to 1978, he owned and operated the Bristol Chemical Company in Portland.

During his lifetime, Bristol was also deeply involved in politics and civic affairs. He served as state representative from Josephine County from 1956 to 1959. He was appointed by then Governor Mark Hatfield to the DOGAMI Governing Board on April 1, 1961, and was reappointed by Hatfield to a second term. He was reappointed to a third term by then Governor Tom McCall and served as chairman during that term. He was also president of the Oregon Mining Association and a member of the Society of Mining Engineers.

Bristol is survived by two daughters, two sons, a sister, and four grandchildren. □

CONTENTS

Oil and gas exploration and development in Oregon, 1983

by William L. King, Oregon Department of Geology and Mineral Industries

ABSTRACT

Leasing decreased and terminations increased during 1983. Drilling decreased 44 percent compared to last year. Two new operators were active in the state, drilling in the Willamette Valley and in the southern Coast Range. Mist Gas Field production continued at a strong rate. A new pool was discovered 1½ mi from the nearest Mist producing well. Injection began into Oregon's first salt-water disposal well. The Mist Gas Field boundaries were enlarged. The Governing Board considered various issues. Three oil and gas hearings were held. The Northwest Association of Petroleum Landmen changed its name. Seismic permitting was active.

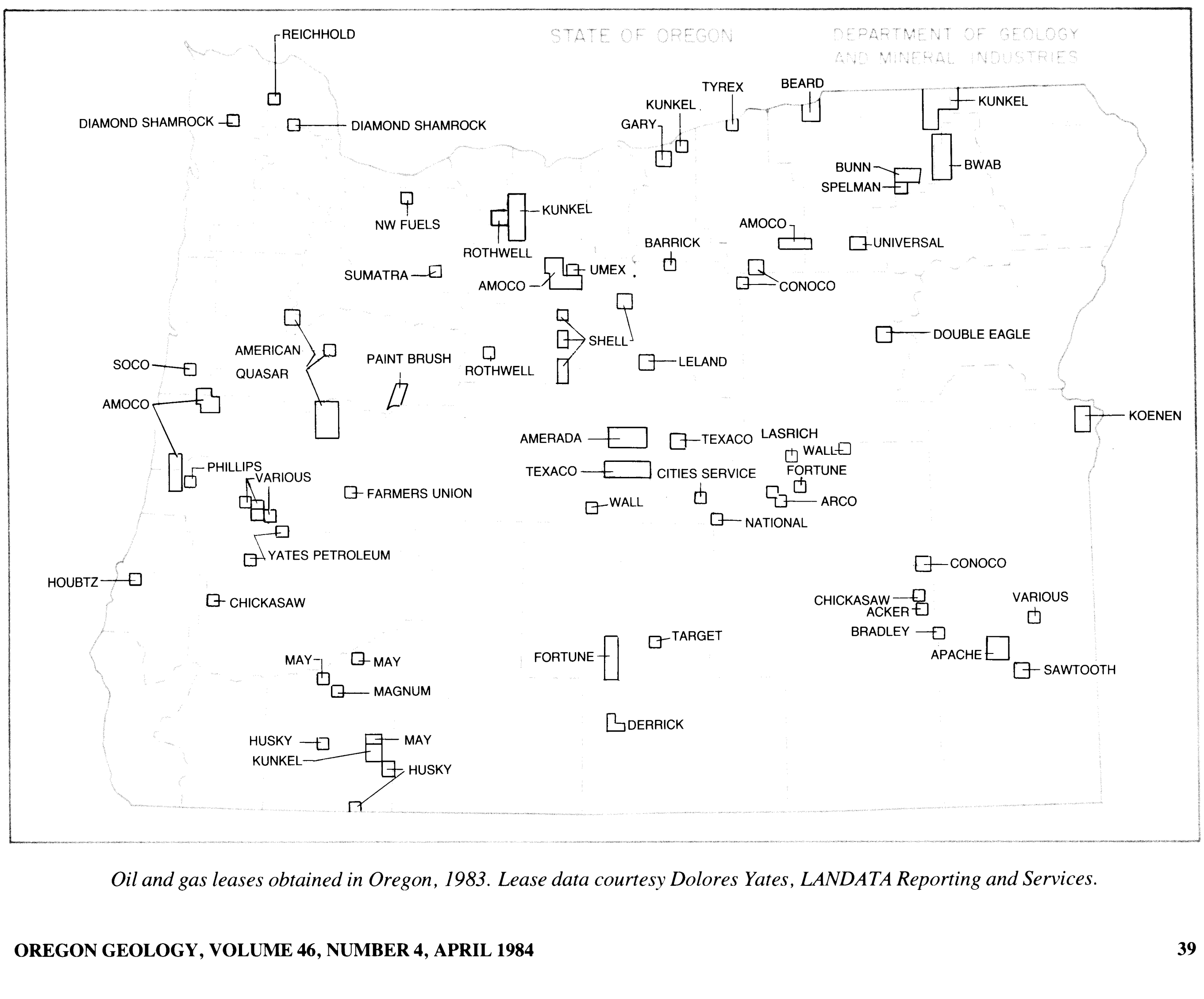
LEASING ACTIVITY

Leasing of federal land in Oregon for oil and gas exploration decreased in 1983. There were fewer applications than in 1982. The number of leases issued also decreased, with a total 310 comprising 675,050 acres as compared to 2,249 comprising 6.9 million acres for the previous year.

Bureau of Land Management (BLM) leases issued on land where there are no known producing geological structures are subdivided into over-the-counter (OTC) leases and simultaneous oil and gas (SOG) leases. OTC leases are granted on new applications. SOG leases are granted on property previously leased but then expired, canceled, relinquished, or terminated. Every OTC expiration must be reprocessed through the SOG program. In October, however, the SOG program was closed for an undetermined period, which accounts for the lull in OTC leasing.

Terminations increased during 1983. Historically, terminations average 10 to 20 leases per month. During July and August, however, this increased to an average of 300 per month, due probably to the inability of speculators to find buyers before the rental payments were due. The first year's rental, which is submitted when the application is filed, is credited when the lease is issued. If buyers are not found before the second year's due date, many leases are dropped. At year's end, 2,373 leases totaling 5,987,386 acres of federal land were under lease in Oregon.

No oil and gas lease sales were held during 1983 by the Oregon Division of State Lands. At the end of the year, 780 leases were in effect on state lands, comprising a total of 320,000 acres, a decrease of 24,000 acres from the previous year. This is a very small rate of surrender, considering the general industry trend. Counties with the most remaining leased acres are Clatsop, 78,000 acres; Coos, 58,000 acres; Malheur, 54,000 acres; Douglas, 30,000 acres; and Harney, 26,000 acres. Total lease rental income for the year

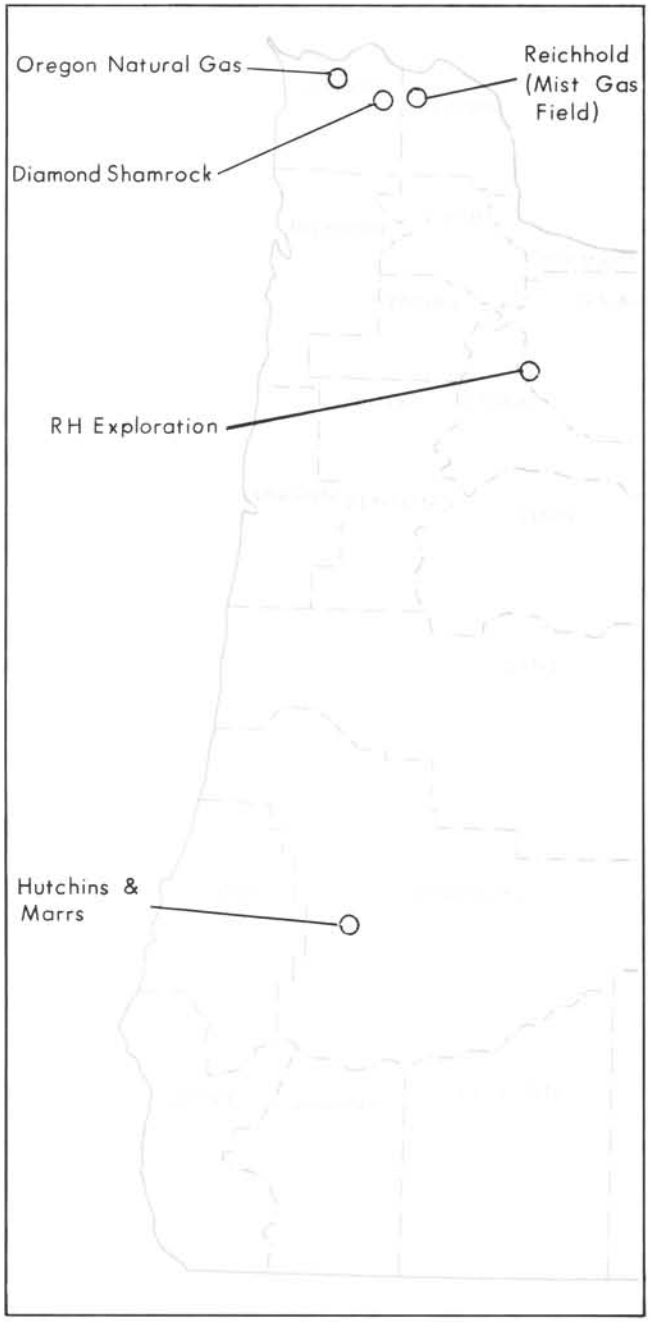


Oil and gas leases obtained in Oregon, 1983. Lease data courtesy Dolores Yates, LANDATA Reporting and Services.

Table 1. *Oil and gas permits and drilling activity in Oregon, 1983*

Permit no.	Operator, well API number	Location	Status, depth (ft) TD=total depth PTD=proposed TD; RD=redrill
199	Oregon Natural Gas Dev. Patton 32-9 007-00011-01	NE¼ sec. 9 T. 7 N., R. 8 W. Clatsop County	Abandoned, dry hole; RD: 3,917.
208	Reichhold Energy Wilson 11-5 009-00099	NW¼ sec. 5 T. 6 N., R. 5 W. Columbia County	Suspended; TD: 2,827.
226	Diamond Shamrock Watzek 22-19 007-00012	NW¼ sec. 14 T. 6 N., R. 6 W. Clatsop County	Abandoned, dry hole; TD: 5,190.
227	Diamond Shamrock State of Oregon 23-33 007-00013	NE¼ sec. 33 T. 6 N., R. 7 W. Clatsop County	Permit issued; PTD: 7,000.
228	Reichhold Energy Columbia County 23-28 009-00111	SW¼ sec. 28 T. 7 N., R. 5 W. Columbia County	Permit issued; PTD: 2,600.
229	Reichhold Energy Columbia County 23-35 009-00112	SW¼ sec. 35 T. 7 N., R. 5 W. Columbia County	Permit issued; PTD: 2,800.
230	Reichhold Energy Columbia County 14-33 009-00113	SW¼ sec. 33 T. 7 N., R. 5 W. Columbia County	Abandoned, dry hole; TD: 3,105.
231	Reichhold Energy Longview Fibre 23-12 009-00114	SW¼ sec. 12 T. 6 N., R. 5 W. Columbia County	Permit issued; PTD: 3,000.
232	Reichhold Energy Polak 31-12 009-00115	NE¼ sec. 12 T. 6 N., R. 5 W. Columbia County	Permit issued; PTD: 3,000.
233	Diamond Shamrock Clatsop County 33-11 007-00014	SE¼ sec. 11 T. 6 N., R. 6 W. Clatsop County	Abandoned, dry hole; TD: 4,223.
234	Reichhold Energy Werner 34-21 047-00014	SE¼ sec. 21 T. 5 S., R. 2 W. Marion County	Permit issued; PTD: 3,500.
235	Diamond Shamrock Watzek Trust 23-4 007-00015	SW¼ sec. 4 T. 6 N., R. 6 W. Clatsop County	Permit issued; PTD: 6,000.
236	Diamond Shamrock Watzek Trust 31-4 007-00016	NE¼ sec. 4 T. 6 N., R. 6 W. Clatsop County	Permit issued; PTD: 6,000.
237	Reichhold Energy Columbia County 23-22 009-00116	SW¼ sec. 22 T. 6 N., R. 5 W. Columbia County	Completed, gas; TD: 2,028.
238	Leavitt Exploration Maurice Brooks 1 039-00005	NE¼ sec. 34 T. 19 S., R. 3 W. Lane County	Permit issued; PTD: 3,000.
239	Petrol. & Min. Analysis Keech 1 047-00015	NE¼ sec. 15 T. 9 S., R. 2 W. Marion County	Permit issued; PTD: 3,600.
240	RH Exploration Rose 1 005-00002	NE¼ sec. 20 T. 5 S., R. 1 E. Clackamas Co.	Suspended; PTD: 3,500.
241	RH Exploration Anderson 1 005-00003	SW¼ sec. 29 T. 5 S., R. 1 E. Clackamas Co.	Suspended; PTD: 3,500.
242	RH Exploration Rose 2 005-00004	SW¼ sec. 20 T. 5 S., R. 1 E. Clackamas Co.	Application; PTD: 4,000.
243	Reichhold Energy Investment Management 21-20 009-00117	NW¼ sec. 20 T. 6 N., R. 4 W. Columbia County	Abandoned, dry hole; TD: 2,505.
244	Hutchins & Marrs Lord's Will 1 019-00018	SW¼ sec. 3 T. 27 S., R. 7 W. Douglas County	Permit issued; PTD: 4,000.
245	Hutchins & Marrs Lord's Will 2 019-00019	SE¼ sec. 34 T. 26 S., R. 7 W. Douglas County	Permit issued; PTD: 4,000.
246	Hutchins & Marrs Lord's Will 3 019-00020	NE¼ sec. 3 T. 27 S., R. 7 W. Douglas County	Permit issued; PTD: 4,000.
247	Hutchins & Marrs Glory Hole 1 019-00021	NW¼ sec. 10 T. 27 S., R. 7 W. Douglas County	Suspended; TD: 2,987.
248	Reichhold Energy Crown Zellerbach 33-26 009-00118	SE¼ sec. 26 T. 6 N., R. 4 W. Columbia County	Permit issued; PTD: 4,000.
249	Reichhold Energy Busch 14-15 009-00119	SW¼ sec. 15 T. 6 N., R. 5 W. Columbia County	Permit issued; PTD: 2,800.
250	Reichhold Energy Longview Fibre 33-36 009-00120	SE¼ sec. 36 T. 6 N., R. 5 W. Columbia County	Permit issued; PTD: 4,000.
251	Reichhold Energy Grimsbo 11-16 009-00121	NW¼ sec. 16 T. 6 N., R. 5 W. Columbia County	Permit issued; PTD: 2,600.
252	Hutchins & Marrs Great Discovery 1 019-00022	SE¼ sec. 3 T. 27 S., R. 7 W. Douglas County	Permit issued; PTD: 4,500.
253	Reichhold Energy Adams 32-34 009-00122	NE¼ sec. 34 T. 7 N., R. 5 W. Columbia County	Permit issued; PTD: 2,800.
254	Oregon Nat. Gas Dev. Dougherty 1-21 049-00001	NE¼ sec. 21 T. 1 S., R. 27 E. Morrow County	Permit issued; PTD: 10,000.
255	Reichhold Energy Columbia County 13-34A 009-00123	SW¼ sec. 34 T. 7 N., R. 5 W. Columbia County	Application; PTD: 2,800.

Christmas tree and cellar, Reichhold Columbia County 23-22, Oregon's latest discovery in the Mist Gas Field.



Oil and gas drilling sites in Oregon, 1983. All drilling was in western Oregon.

amounted to $356,000, which includes rentals from 31,202 acres under lease option to Mobil Oil.

State law authorizes a county court to execute an oil and gas lease involving county-owned mineral rights through a process of advertising with subsequent competitive bidding. Leases are granted to the highest bidder. Douglas County held a lease auction in December. One block of 9,921 acres west and southwest of Roseburg was offered. A bid of $1.25 per acre for a lease term of five years was offered and accepted, there being no opposing bids. Selmar H. Hutchins was the successful bidder. Prior to this auction, the county had held no oil and gas lease auctions since 1978, when Mobil Oil leased acreage there.

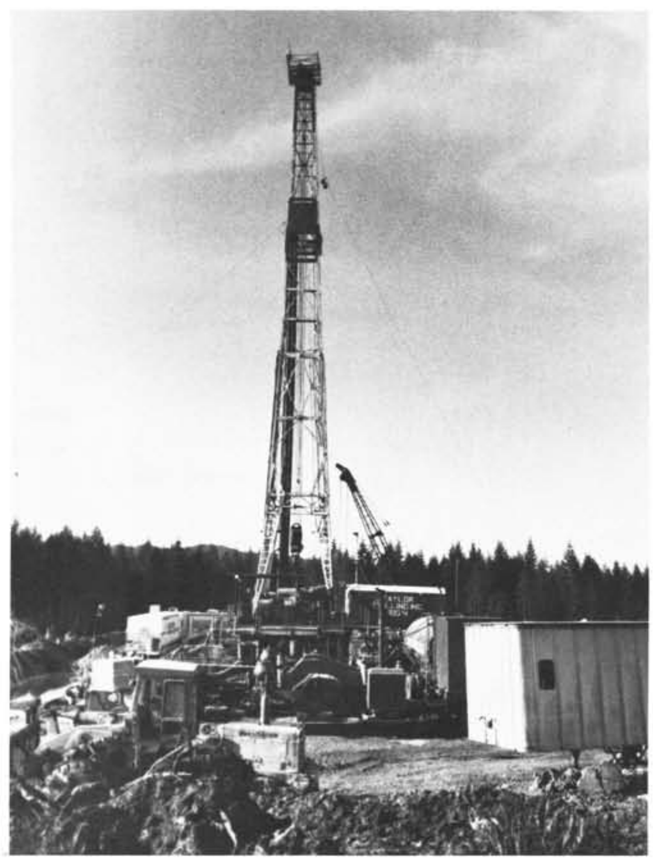
DRILLING ACTIVITY

During 1983, 10 oil and gas test wells were drilled in Oregon. This was a decrease of eight wells, or 44 percent, compared to the preceding year, 1982. Twenty-nine oil and gas drilling permits were issued in 1983, however, an increase of 81 percent over the preceding year, indicating industry's continued interest in Oregon's hydrocarbon potential.

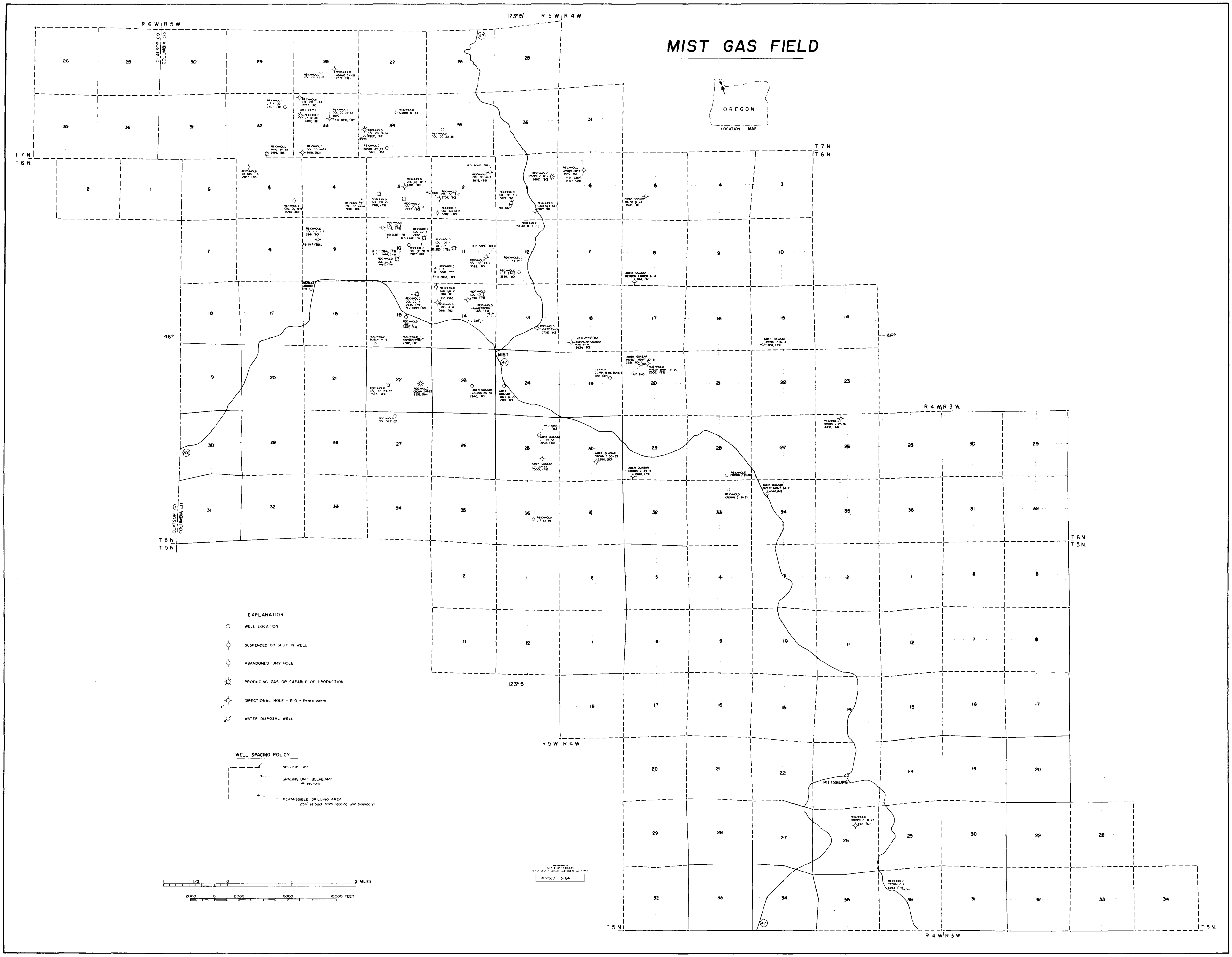
Most of the drilling was in Columbia and Clatsop Counties, in the northwest part of the state, by established operators. Reichhold Energy Corporation led the activity with four wells drilled in the Mist Gas Field area. Three of these wells were dry holes, but one, Columbia County 23-22, was completed as a gas well. Diamond Shamrock Corporation, which was recently renamed Diamond Chemicals Company, continued its exploration effort in Clatsop County by drilling two wells with a combined total footage of 9,413 ft. This brings the total number of Diamond Shamrock wells drilled in Clatsop County since 1981 to five, with a combined total footage of 29,072 ft. Oregon Natural Gas Development Corporation Patton 32-9, located east of Olney in Clatsop County, was redrilled to 3,917 ft in an unsuccessful attempt to establish production. This redrill footage, combined with Oregon Natural Gas Development Corporation's previous Clatsop County drilling, brings its total footage in the county to 22,050 ft since 1981.

Two new operators were active in other areas in Oregon in 1983. RH Exploration drilled two wells in the Willamette Valley, east of Monitor in Clackamas County, and Hutchins and Marrs drilled one well west of Melrose in Douglas County.

The deepest hole drilled in Oregon in 1983 was by Diamond Shamrock to a total depth of 5,190 ft. The average well depth for the year was 3,164 ft. Total footage drilled was 31,635 ft, a decrease of 53 percent from 1982's total. Sixty percent of the wells drilled were wildcats. The remainder were in the Mist Gas Field area.



Taylor Drilling Company rig at Diamond Shamrock Clatsop County 33-11 location.



Mist Gas Field, as revised by DOGAMI Governing Board in November 1983. This map is available at a much larger scale (1:24,000) on a 40×50-in. sheet as DOGAMI Open-File Report 0-84-2 (cost $5).

April 2, 1984

Dear Oregon Geology reader,

We are trying to evaluate the usefulness and effectiveness of Oregon Geology. We would also like to know more about our readers. We would appreciate it if you would complete this questionnaire and return it to us within a month. This is your opportunity to tell us what you want--or need--from Oregon Geology, so please be candid.

1. Where do you live? ____
2. How long have you subscribed to Oregon Geology? ________________________
3. What is your occupation? ____
4. Check categories below that describe you.
   - ____ Oregon resident
   - ____ Professional geologist
   - ____ Teacher or professor
   - ____ State of Oregon employee (which agency?)__________
   - ____ Legislator
   - ____ Recreational miner (rockhounding, weekend placering, mineral collecting)
   - ____ Gemstone miner, dealer, or cutter
   - ____ Oil and gas industry employee
   - ____ Natural resource agency employee
   - ____ Student
   - ____ Member of environmental group
   - ____ Federal employee (which agency?)__________
   - ____ News media representative
   - ____ Amateur geologist or paleontologist
   - ____ Prospector or explorationist
   - ____ Mine developer, owner, or operator
   - ____ Other mineral industry employee
   - ____ Geothermal industry employee
5. How much of an issue of Oregon Geology do you usually read?
   ____ Very little ____ Some, mostly by skimming
   ____ Only read papers of interest to me ____ Read most ____ Read all
6. Some of the material in Oregon Geology is very technical; some is not. How would you rate the content and style of writing in papers and articles that interest you?
   ____ Too technical ____ Just right ____ Not technical enough
7. Check the topics you enjoy--or would enjoy--in Oregon Geology.
   - ____ Annual summaries of oil and gas, mineral, mined-land reclamation, and geothermal activity
   - ____ Monthly oil and gas news
   - ____ Field trip guides
   - ____ Announcements of new publications
   - ____ Meeting announcements
   - ____ Geology
   - ____ Book reviews
   - ____ Industry news
   - ____ Mineral and gemstone localities
   - ____ Mining history
   - ____ Summaries of geology and mineral resources of various counties
   - ____ Plate tectonics
   - ____ Mineral exploration and development
   - ____ Geothermal exploration and development
   - ____ Oil and gas exploration and development
   - ____ Meteorites
   - ____ News of people
   - ____ Thesis abstracts
   - ____ Geology of specific areas; e.g., Blue Mountains, Cascades, state parks, urban areas
   - ____ Legislative news and Governing Board actions
   - ____ Other (specify)
8. How could Oregon Geology be improved to meet your needs and interests more fully?
   ____
   ____
9. Is the type too small for you to read? ________________________
10. Would Oregon Geology be as useful to you if it came out less frequently but with more pages?
    ____
11. Would you accept an increase in cost so that each issue could have more pages, longer articles, and more variety?________________________

12. Other comments ____

____

____

Remove this sheet from your magazine, fold as indicated, tape or staple, stamp with a 20¢ stamp, and send to us. Results will be announced in an upcoming issue of Oregon Geology.

Thank you for your help.

Beverly F. Vogt
Publications Manager

Rather than leave the rest of the questionnaire sheet blank, we are printing our current open-file report list on the rest of the sheet. This list, which is available free of charge from the Portland office of the Oregon Department of Geology and Mineral Industries, is frequently updated as new open-file reports are released. If the reports are still in print and available for sale, the prices are listed.

April 1, 1984

OPEN-FILE REPORTS

		Price, if for sale
O-69-1	Analyses of stream-sediment samples from southwestern Oregon. Bowen, 1969, 439 p.	-----
O-70-1	Sand and gravel, Bear Creek and Rogue River Valleys, Jackson County. Schlicker & Deacon, 1970, 49 p.	-----
O-70-2	Gravel resources of the Applegate River area in Jackson County. Schlicker & Deacon, 1970, 17 p.	-----
O-71-1	Folsom Basin disposal site, Klamath County. Newton, 1971, 10 p.	-----
O-71-2	Geologic evaluation of Alkali Lake disposal site. Newton & Baggs, 1971, 90 p.	-----
O-71-3	Engineering geology of La Grande and vicinity. Schlicker & Deacon, 1971, 16 p., 1 map	-----
O-72-1	Mineral resource status of state-owned lands in Malheur County. Wagner, 1972, 27 p., 41 maps.	-----
O-73-1	Geologic criteria for siting nuclear power plants in Oregon. Newton & Peterson, 1973, 65 p., 7 maps	-----
O-74-1	A preliminary geological investigation of the ground effects of earthquakes in the Portland metropolitan area, OR. Hammond & others, 1974, 40 p.	-----
O-75-1	A review of geological conditions at the Pebble Springs nuclear plant site. Newton & Peterson, 1975, 15 p.	-----
O-75-2	Central Western and High Cascades geological reconnaissance and heat flow hole location recommendations. Peterson & Youngquist, 1975, 41 p.	5.00
O-75-3	Geothermal gradient data for Oregon. Bowen, 1975, 134 p., 1 map	10.00
O-75-4	Geothermal gradient data, Vale area, Malheur County, OR. Hull, 1975, 18 p.	5.00
O-75-5	A preliminary annotated bibliography of the geology of Mount Hood. McCarthy, 1975, 9 p.	5.00
O-75-6	Economic factors affecting the mining, processing, gasification, and marketing of Coos Bay coals. Mason & Hughes, 1975, 61 p., 4 maps	13.00
O-75-7	Geothermal studies and exploration in Oregon. Bowen & others, 1975, 65 p., 2 Ore Bins	5.00
O-75-8	An estimate of southeast Oregon's geothermal potential. Fisher, 1975, 9 p.	-----
O-75-9	Aggregate resources of Josephine County. Schlicker & others, 1975, 47 p., 28 maps	-----
O-76-1	Electrical resistivity survey and evaluation of the Glass Buttes geothermal anomaly, Lake County. (Appendix: Reconnaissance dipole-dipole resistivity survey in the Glass Buttes area). Phoenix Geophysics, Inc., 1976, 26 p., 5 plates	8.00
O-76-2	Geothermal gradient data, Brothers fault zone, Oregon. Hull & others, 1975, 24 p.	5.00
O-76-3	Ferruginous bauxites of the Pacific Northwest, Hook, 1976, 26 p.	5.00
O-76-4	Stream-sediment geochemistry, northeastern Oregon. DOGAMI, 1976, 47 p., 33 maps	25.00
O-76-5	Preliminary report on the reconnaissance geology of the upper Clackamas and North Santiam Rivers area, Cascade Range. Hammond, 1976, 115 p.	-----
O-76-6	Engineering geology of the John Day area, Grant County. Schlicker & Brooks, 1976, 31 p., 1 map	5.00
O-77-1a	Preliminary geologic map of the Sawtooth Ridge quadrangle. Brooks & others, 1977	5.00
O-77-1b	Preliminary geologic map of the Keating NW quadrangle. Brooks & others, 1977.	5.00
O-77-2	Geothermal gradient data for Oregon. Hull & others, 1977, 134 p.	5.00
O-77-3	Heat flow study of the Brothers fault zone, OR. Hull & others, 1977, 110 p.	5.00
O-77-4	Geologic restraints to development in selected areas of Marion County. Schlicker, 1977, 59 p.	5.00
O-77-5	Reconnaissance geologic map of the Virtue Flat quadrangle. Brooks & McIntyre, 1977	5.00
O-77-6	Preliminary geologic map of the Baker quadrangle. Brooks, 1977.	5.00
O-78-1	Geologic hazards review, Trojan nuclear plant site, Columbia County, OR. DOGAMI, 1978, 35 p..	5.00
O-78-2	Supplement to the Feb. 11, 1974, Pebble Springs review. Newton & Peterson, 1978, 25 p.	5.00
O-78-3	Preliminary geologic map of the Bowen Valley quadrangle. Brooks & McIntyre, 1978.	5.00
O-78-4	Geothermal gradient data for Oregon. Hull & others, 1978, 187 p., 1 map	5.00
O-78-5	Reconnaissance study of Oregon's stone quarries and asbestiform minerals occurrences within 10 mi of serpentinite. Gray, 1978, 40 p.	5.00
O-78-6	Geophysical logs, Old Maid Flat 1, Clackamas County. DOGAMI, 1978, 7 borehole logs, 2 p.	-----
O-79-1	Annotated bibliography of the geology of the Columbia Plateau (Columbia River basalt) and adjacent areas of Oregon. Bela, 1979, 744 p.	20.00

O-79-2	Geochemical studies of rocks, water, and gases at Mount Hood. Wollenberg & others, 1979, 57 p.	5.00
O-79-3	Chemical analyses of thermal springs and wells in Oregon. USGS & DOGAMI, 1979, 169 p. . . .	5.00
O-79-4	Mineral resources maps and indexes of geologic mapping (pre-1960 and 1960-1979) of AMS sheets. Hollis (Rockwell Hanford Operations), 1979, 10 maps	-----
O-79-5	Micropaleontological study of four deep wells in Coos County, OR. McKeel, 1979, 26 p. . . .	5.00
O-79-6	Geologic map of the Bullrun Rock quadrangle. Brooks & Fern, 1979	5.00
O-79-7	Geologic map of the Rastus Mountain quadrangle. Brooks & Fern, 1979	5.00
O-79-8	Geothermal resource assessment of Mount Hood. Riccio, ed., 1979, 273 p., 5 maps	-----
O-79-9	Annual report of the State Map Advisory Committee for Oregon. Beaulieu, 1979, unpag.	-----
O-80-1	Micropaleontological study of five wells, western Willamette Valley. McKeel, 1980, 21 p.. .	5.00
O-80-2	*Preliminary geology and geothermal resource potential of the* Belknap-Foley area, OR. Brown & others, 1980, 58 p., 1 map	5.00
O-80-3	-----Willamette Pass area, OR. Brown & others, 1980, 65 p., 1 map	5.00
O-80-4	-----Craig Mountain-Cove area, OR. Brown & others, 1980, 68 p., 1 map	5.00
O-80-5	-----Western Snake River plain, OR. Brown & others, 1980, 114 p., 4 maps.	10.00
O-80-6	-----northern Harney Basin, OR. Brown & others, 1980, 52 p., 4 maps	7.00
O-80-7	-----southern Harney Basin, OR. Brown & others, 1980, 90 p., 8 maps	10.00
O-80-8	-----Powell Buttes area, OR. Brown & others, 1980, 117 p., 1 map	5.00
O-80-9	-----Lakeview area, OR. Peterson & others, 1980, 108 p., 2 maps	7.00
O-80-10	-----Alvord Desert area, OR. Peterson & Brown, 1980, 57 p., 2 maps	7.00
O-80-11	Engineering and air and mud drilling data, DOGAMI well Old Maid Flat 7A, DOGAMI, 1980, 1 sheet, folded into 16 p.	-----
O-80-12	Geothermal gradient drilling, north-central Cascades of Oregon, 1979. Youngquist, 1980, 47 p., 2 gamma-ray logs.	5.00
O-80-13	Lithologic logs of 11 wells and foraminiferal species lists of 4 wells in southwestern Oregon (accompanies *Oil and Gas Investigation 6*). DOGAMI & McKeel, 1980, 81 p.	5.00
O-80-14	Progress report on activities of the low-temperature resource-assessment program 1979-80. DOGAMI, 1980, 79 p.	5.00
O-81-1	Annual report of the State Map Advisory Committee for Oregon, 1980. Beaulieu, 1981, 28 p. .	-----
O-81-2	Geophysical logs, Old Maid Flat 7A well, Clackamas County. DOGAMI, 1981, 2 parts folded log copies: O-81-2A, 4 logs, shallow (96-1,190 ft); O-81-2B. 2 logs, deep (96-5,952 ft). Set.	100.00
O-81-3	Geothermal gradient data for Oregon. Blackwell & others, 1981, 3 parts:	
	O-81-3A, for 1978, 63 p.	5.00
	O-81-3B, for 1979, 98 p.	6.00
	O-81-3C, for 1980, 374 p.	12.00
O-81-5	Preliminary geologic map, Amity, Mission Bottom quadrangles. Brownfield & Schlicker, 1981. .	5.00
O-81-6	Preliminary geologic map, McMinnville, Dayton quadrangles. Brownfield & Schlicker, 1981 . .	5.00
O-81-7	Rock material resources, Marion, Polk, Yamhill, Linn Counties. Gray & Throop, 1981, 47 p., 3 maps.	7.00
O-81-8	Reconnaissance geochemical study, Quartzville mining district. Munts, 1981, 14 p., 1 map. .	5.00
O-81-9	Seismic and volcanic hazard evaluation of the Mount St. Helens area, Wash., relative to the Trojan nuclear site, Oreg. Beaulieu & Peterson, 1981, 80 p.	5.00
O-81-10	Post-Columbia River Basalt Group stratigraphy and map compilation of the Columbia River Plateau, Oreg. Shannon/Wilson & DOGAMI, 1981, 79 p., 6 maps	10.00
O-82-1	Annual report of the State Map Advisory Committee for Oregon, 1981. Beaulieu, 1981, 24 p. .	-----
O-82-2	Preliminary geologic map, Ballston quadrangle. Brownfield, 1982	5.00
O-82-3	Geologic map, Langlois quadrangle. Brownfield, 1982	5.00
O-82-4	Geothermal gradient data for Oregon (1981). Blackwell & others, 1982, 430 p.	15.00
O-82-5	Final technical report, Oregon low-temperature resource-assessment program. Priest & others, 1982, 54 p.	5.00
O-82-6	Bibliography of landslide deposits for the state of Oregon. Bela, 1982, 40 p.	6.00
O-82-7	Geology and geothermal resources of the Cascades. Priest & Vogt, 1982, 206 p., 5 maps. . . .	-----
O-82-8	Gravity and aeromagnetic maps, Powell Buttes area. OSU Geophysics Group, 1982, 4 maps . . .	8.00
O-82-9	Gravity anomalies in the Cascade Range in Oregon: Structural and thermal implications. OSU Geophysics Group, 1982, 66 p.	5.00
O-83-1	Annual report of the State Map Advisory Committee for Oregon, 1982. Beaulieu, 1983, 29 p. .	-----
O-83-2	Geology and mineral resources of 18 BLM Wilderness Study Areas, Harney and Malheur Counties. Gray & others, 1983, 106 p., 24 microfiche	15.00
O-83-3	Survey of potential geothermal exploration sites at Newberry volcano, Deschutes County. Priest & others, 1983, 174 p., 8 maps.	20.00
O-83-4	Geochemical survey of the western part of the Ochoco National Forest, Crook and Wheeler Counties. Ferns & Brooks, 1983, 38 p., 1 map, 3 microfiche.	6.00
O-83-5	Mineral potential of the Fall Creek mining district: A geological-geochemical survey. Gray & Berri, 1983, 32 p., 1 map, 2 microfiche	6.00
O-83-6	Preliminary geologic map, W. half, Vancouver 1°x 2° quadrangle, Oreg. Wells & others, 1983. .	6.00
O-84-1	Annual report of the State Map Advisory Committee for Oregon, 1983. Beaulieu, 1984, 39 p. .	2.00
O-84-2	Mist Gas Field map. DOGAMI, 1984, 1 map	5.00
O-84-3		
O-84-4	Heat-flow map of the Cascade Range of Oregon, and index map of mapping in the Oregon Cascades. DOGAMI, 1984, 2 maps.	5.00

GAS PRODUCTION

One well was completed to production during 1983 at the Mist Gas Field. To date, 12 wells have been completed. Of this total, eight are currently producing, one is awaiting pipeline connection, two are shut in, and one has been converted to a salt-water disposal well. During 1983, the number of producing wells varied from six to eight. Production rates during the year ranged from 7.1 to 10.8 million cubic feet per day (cfd). Eight different pools have been designated. One additional pool will be designated for Reichhold Columbia County 23-22, which was completed December 21, 1983. The price of Mist Gas Field gas from the Federal Energy Regulatory Commission price schedule ranged from $3.299 per million British thermal units (MMBtu) to $3.564 per MMBtu, or from $3.09 per thousand cubic feet (Mcf) to $3.34 per Mcf. Beginning in May, however, Mist gas was no longer sold at the federally controlled ceiling price but rather at a monthly negotiated contract price which was lower than the federal price. This contract price ranged from $2.945 per MMBtu to $3.219 MMBtu, or from $2.76 per Mcf to $3.02 per Mcf. Total gas produced in 1983 was 3.16 billion cubic feet. Using federal prices from January through April and contract prices from May through December, the value of this gas was $9.5 million.

NEW POOL DISCOVERY

Reichhold Energy Corporation Columbia County 23-22, located in sec. 22, T. 6 N., R. 5 W., in the Mist Gas Field, was drilled to a total depth of 2,028 ft and completed as a gas well December 21, 1983, flowing 3 MMcfd. This well is 1½ mi south of the nearest producing well and approximately 1 mi south of and 1 mi west of, respectively, the nearest dry holes. No wells have been drilled south or west of Columbia County 23-22. A new pool, the twelfth to date, will be designated for this discovery.

Flaring gas during initial potential test at Reichhold Columbia County 23-22, December 1983.

Reichhold Columbia County 13-1, Oregon's first salt-water disposal well. Vacuum truck in background is transferring salt water to holding tank for injection into the well.

SALT WATER DISPOSAL

A water pollution control facilities permit that was issued in August by the Oregon Department of Environmental Quality (DEQ) to Reichhold Energy Corporation authorized injection of salt water into their Columbia County 13-1 RD located in sec. 1, T. 6 N., R. 5 W., in the Mist Gas Field. This permit, issued in conjunction with the Oregon Department of Geology and Mineral Industries (DOGAMI), authorizes injection of salt water extracted with natural gas into the depleted Clark and Wilson sand from which the well formerly produced. DOGAMI also issued an injection permit. This is the first waste disposal well of this type in Oregon.

Three Reichhold wells, Columbia County 4 RD, Longview Fibre 12-33, and Paul 34-32, are currently producing salt water which is being injected into Columbia County 13-1 RD. A maximum of 1,000 barrels per week is permitted. During 1983, a total of 20,486 barrels was injected.

Welex personnel preparing to run a bridge plug to stop water production at Reichhold Columbia County 4 at Mist Gas Field.

The DEQ permit also authorizes the spreading of salt water on unpaved roads and along road rights-of-way during summer months under dry conditions. Restrictions are included in this phase of the disposal process to prevent stream pollution or damage to vegetation. During 1983, a total of 10,666 barrels was disposed of by surface spreading.

MIST GAS FIELD BOUNDARIES

The boundaries of the Mist Gas Field were changed in November by DOGAMI's Governing Board. Prior to this action, the official boundaries had never been designated. After the previously accepted boundaries were revised at a public hearing, the new boundaries were approved by the Governing Board. The effect will be to increase the field area from 42 to 141 sq mi, thereby enlarging the area within which special setback distances apply. The statewide setback distance is 500 ft from a quarter section boundary. The Mist Gas Field distance is 250 ft. A reduced version of the revised Mist Gas Field map is printed with this article. The new map is also available at a scale of 1:24,000 as DOGAMI Open-File Report O-84-2, *Mist Gas Field Well Location Map* (cost $5), at the Department's Portland office. This map replaces the old map in Open-File Report O-81-4, which is no longer available.

OTHER

DOGAMI's Governing Board met five times during 1983. Various issues considered were an appeal on the compulsory integration rule, unlawful well abandonment, request for suspended well status, bond releases, a memorandum of understanding with DEQ regarding underground injection, field boundaries designation, amending orders, petitions to distribute revenues, and adoption of administrative rules.

Three oil and gas hearings were held. Two of these were contested case hearings to amend orders and terminate escrows. The third was an administrative rules hearing to establish a rule to designate boundaries for the Mist Gas Field.

The Northwest Association of Petroleum Landmen, founded last year, has changed its name to the Northwest Petroleum Association. Membership has grown to 165 members. Four quarterly meetings were held during 1983, three in Portland and one in Olympia.

Seismic permits were issued by the Oregon Department of Transportation for various parts of the state. Most of the applications were for permits in western Oregon in the Mist-Clatskanie area of Columbia County, in the eastern Willamette Valley east of Salem, and in the western Willamette Valley from Eugene to Forest Grove, indicating continued interest in this part of the state as a possible oil and gas province. Seismic permits issued for western Wheeler County, which is in eastern Oregon, indicate a possible extension of interest in the exploration activities occurring to the north in central Washington. □

Rogue Gem and Mineral Club display featured in Capitol Building

On March 1, 1984, members of the Rogue Gem and Mineral Club of Grants Pass installed a new exhibit in the Oregon Council of Rocks and Mineral Club display case on the first floor of the Capitol Building in Salem. Included in the display are more than fifty separate items from eight Oregon counties, Mexico, and Brazil.

Featured in the display are such items as two functioning clocks, one of pink and black rhodonite and one of green Cedar Mountain jade, soapstone sculptures, rhodonite bookends, agate book ends, jade and rhodonite bowls, a marble vase, an obsidian goblet, and a rodingite shot glass.

The variety of materials in the exhibit includes a large calcite crystal, rhodonite, Cedar Mountain jade, soapstone, rodingite, marble, obsidian, Oregon picture rock, Graveyard Point plume agate, petrified wood, carnelian, Blue Mountain jasper, serpentine/tremolite, and thundereggs.

This exhibit, which replaced that of the Willamette Agate and Mineral Society, will remain in place until June 1, 1984. □

GSOC meetings announced

The Geological Society of the Oregon Country (GSOC) holds noon meetings in the Standard Plaza Building, 1100 SW Sixth Ave., Portland, Oregon, in Room A adjacent to the third-floor cafeteria, and 8-p.m. evening lectures at Portland State University, Room 371, Cramer Hall. Upcoming meetings, topics, and speakers are:

April 20 (luncheon) – *Statues of the Easter Islands*, by Esther Schwartz.

May 4 (luncheon) – *A Message From the Stone Age*, by John Nance, author and photographer.

May 11 (lecture) – Michael Cummings, PSU Geology Department, will introduce *GSOC Scholarship Award students*.

May 18 (luncheon) – *Archaeological Specimens – Fake or Genuine?* by Harvey Steele, past president of the Archaeological Society.

May 25 (lecture, "Invite a Guest Night") – *Oregon from the Air*, by Ewart Baldwin, author of *Geology of Oregon*.

June 1 (luncheon) – *An Elder Hostel Experience*, by Wally McClung, naturalist-photographer, GSOC president in 1969.

June 8 (lecture) – *Geology of Death Valley*, by Donald D. Barr, naturalist-biologist, GSOC president in 1968.

For additional information about the lectures or luncheons, contact Viola L. Oberson, GSOC president, phone (503) 282-3685.

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.

THE GEOLOGY AND STRATIGRAPHY OF THE TERTIARY VOLCANIC AND VOLCANICLASTIC ROCKS, WITH SPECIAL EMPHASIS ON THE DESCHUTES FORMATION, FROM LAKE SIMTUSTUS TO MADRAS IN CENTRAL OREGON, by Jeremy Barth Jay (M.S., Oregon State University, 1982)

A sequence of volcanic, volcaniclastic, and epiclastic deposits from Oligocene to Recent age are exposed in the region from Lake Simtustus to Madras in central Oregon. The epiclastic sediments of the Oligocene John Day Formation are unconformably overlain by two flows of the middle Miocene Columbia River Basalt Group. The upper Miocene and lower Pliocene Deschutes Formation generally overlies the Columbia River basalt. The Deschutes Formation includes ash flows, pumice and ash falls, lava flows, and epiclastic deposits. An ash-flow tuff with a composition similar to other Deschutes ash flows occurs between flows of Columbia River basalt suggesting that the formations interfinger.

The two flows of Columbia River basalt have compositions typical of the Prineville chemical type. The flows contain an average of 1.24 weight-percent P_2O_5, and K_2O is high compared to other types of Columbia River basalt.

The Columbia River basalt and underlying rocks have been moderately deformed, producing broad anticlines and synclines and normal faults with small displacement. Northwest of Madras, the Columbia River basalt dips three or four degrees to the southeast. The Deschutes Formation and overlying rocks are generally flat lying and undeformed. No faults were found extending into the Deschutes deposits.

The Pelton Basalt Member is an 80- to 150-ft-thick unit of tholeiitic basalt that occurs near the base of the Deschutes Formation. It contains numerous discontinuous flow units which represent separate lobes of a compound lava flow. No interbeds or paleosols between flow units were found. The basalt is probably the result of a single prolonged eruption. Six intraformational lava flows occur interstratified with volcaniclastic and epiclastic deposits. Five of these flows are basalt; one flow is basaltic andesite.

The Deschutes volcaniclastic rocks generally occur in a 400-ft-thick interval above the Pelton Member and below rim-forming basalt lavas. The best exposures of these deposits are at the Vanora Cliff and at the cliff on the north side of the mouth of Willow Creek. Rocks in both of these areas are exposed as the result of large landslides. The ash-flow tuffs range in composition from dacite to rhyolite and in thickness from three to 60 ft. The deposits generally have restricted areas of exposure. The strikes of paleochannels filled by ash flows and the orientation of the long axes of clasts in underlying fluvial conglomerates indicate a west or southwest provenance for these deposits.

Seven lithic-rich laharic-breccia deposits occur interstratified with the ash flows and epiclastic deposits. The laharic breccias are the most resistant and extensive volcaniclastic rocks in the mapped area. In certain outcrops, the breccias consist of as much as 70 percent angular to subrounded lithic clasts suspended in a fine-grained matrix of glass shards. The deposits are more numerous, thicker, and more poorly sorted to the north and northwest, indicating a provenance to the northwest. Many features of the deposits are similar to volcanic lahars but other characteristics indicate that the materials were subjected to temperatures above the Curie point of the clasts. Some of these units might have been produced by a combination of fluvial materials and a hot pyroclastic flow.

A widespread sheet of tholeiitic basalt caps the Deschutes Formation. Similarity between eight chemical analyses, constant phenocryst mineralogy, and uniform normal paleomagnetic polarity of samples from Binder's Canyon to Round Butte Dam suggest that the rim-forming flow is a single sheet of lava that originally covered the mapped area.

Round Butte cinder cone and lava flow are the youngest Deschutes Formation deposits in the mapped area. The Round Butte deposits have a composition similar to other intraformational lavas and therefore represent a continuation of the volcanism that has occurred throughout the late Miocene and early Pliocene in the Deschutes Basin.

STRUCTURE AND INFLUENCE OF THE TILLAMOOK UPLIFT AND THE STRATIGRAPHY OF THE MIST AREA, OREGON, by Moinoddin Murtuzamiya Kadri (M.S., Portland State University, 1982)

Around the hamlet of Mist in Columbia County, northwestern Oregon, four formations ranging in age from late Eocene to middle Miocene are exposed. The late Eocene Keasey Formation consists of gray, tuffaceous, concretionary mudstone, siltstone, and minor sandstone. The unstable and complex environment of deposition is indicated by lutokinesis and wide, shallow submarine channels.

Deltaic deposits of the Pittsburg Bluff Formation unconformably overlie the Keasey Formation. The lower laminated member (informal) of the Pittsburg Bluff Formation consists of finely laminated mudstone and interlayered arkosic sandstone. The upper siltstone member (informal) consists of bioturbated, carbonaceous siltstone and sandstone. It crops out in an arcuate belt generally paralleling the Nehalem River and thins rapidly towards the west.

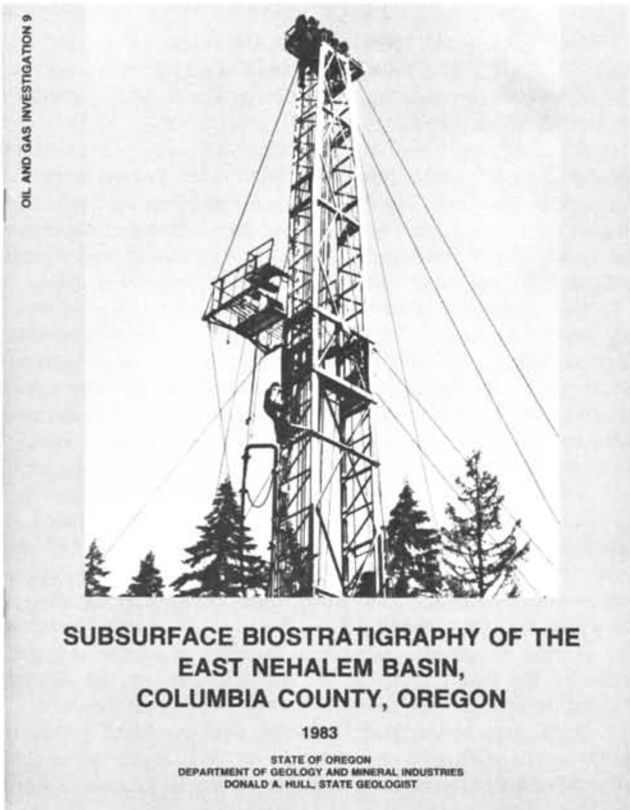
The middle Miocene Astoria Formation unconformably overlies the Pittsburg Bluff and Keasey Formations and consists of poorly consolidated, lithic arkosic to quartzose sandstone and siltstone. Primary structure is well developed in the Astoria Formation; micro cross-bedding and trough cross-bedding are common in the sandstone. The Columbia River Basalt Group is represented by the Grande Ronde and Frenchman Springs geochemical types. Some of the basalt clasts in the conglomerates in the Astoria Formation were derived from Columbia River basalt flows.

Fifty-three sedimentary samples were analyzed for their minor and trace element concentrations utilizing instrumental neutron activation analysis. Concentrations of Na, K, La, Sm, and Sc, and their ratios appear to establish significant trends. The data suggest a major break from a granitic-metamorphic provenance and a volcanic-component-dominated provenance between the Cowlitz and Keasey Formations respectively. The provenance of the Astoria Formation indicates the presence of flood basalts.

Complex faulting along northeast-southwest and younger northwest-southeast trends primarily involves vertical movements. Exposed faults have steep dips, narrow shear zones, very little drag and form horsts and grabens. Pi-S_0 diagrams of the Keasey, Pittsburg Bluff, and Scappoose Formations indicate near-horizontal to northerly or northeasterly dips. Northeast-trending, horizontal Beta axes in the Pittsburg Bluff (siltstone member) and Scappoose Formations parallel the axis of the Tillamook arch. The northwest-trending Beta axis of the Scappoose Formation probably reflects the latest structural grain of the area. Near-horizontal dips of the strata, especially those of the post-Cowlitz age, the high-angle faults, and the horizontal Beta axes probably preclude uplift involving extensive compression and thrusting. The post-Keasey uplift produced an unconformity and restricted the deposition of coarser lithofacies of the Pittsburg Bluff Formation to the east and around the nose of the plunging axis of the Tillamook arch. Post-Keasey but pre-Astoria uplift along the axis of the Tillamook arch and Willapa Hills upwarp produced the east-west trending Columbia River synclinal trough. The Astoria Formation and the Columbia River basalt flows are depositionally confined to this structural downwarp. Continuity in the outcrop pattern of the middle Tertiary units perhaps precludes any large-scale strike-slip offset. □

New biostratigraphic study analyzes subsurface of Mist Gas Field area

Fifteen wells drilled in the area of Columbia County's Mist Gas Field, Oregon's only producing natural gas field, are the subject of a biostratigraphic study published by the Oregon Department of Geology and Mineral Industries (DOGAMI).



Oil and Gas Investigation 9.

The newly published report, entitled *Subsurface Biostratigraphy of the East Nehalem Basin, Columbia County, Oregon*, was prepared by paleontologist Daniel R. McKeel and has been released as DOGAMI's Oil and Gas Investigation 9. It includes individual fossil reports based on 1,478 samples taken from 15 wells, with sample-by-sample descriptions of rock types and marine fossils. These identifications are used to determine the age, water depth, and paleoenvironment for each distinctive well interval. Included with this 34-page report is a separate subsurface illustration that contains a surface location map and key correlations for all the wells in the form of three separate north-south cross sections.

Using technical data and actual well cutting samples, this study precisely interrelates the ages and kinds of rocks in the wells of the Mist Gas Field area. The result is a better understanding of detailed geology of the area, which, in turn, will aid future exploration, promote positive regulation of the resource, and provide a useful basis for resource conservation and environmental protection, according to Deputy State Geologist John D. Beaulieu.

Oil and Gas Investigation 9 is now available at the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, OR 97201. The purchase price is $6. Orders under $50 require prepayment. □

Fireball sighted

A fireball sighting on February 16, 1984, at 6:07 p.m. PST, was reported by two separate observing parties, Philip Brodahl of Portland and Gary Messer and John Borden of Albany.

Bordahl made his observation at lat. 45°26'N., long. 122°39'W. and was facing east. He first saw the fireball 6° south of east at an altitude of 45° and saw it last due east at an altitude of 20°. The angle of descent of the fireball was approximately 60°, and the duration of its flight was two seconds. The fireball was three times the size of Venus and white. It had a white, 25°-long tail. There was no sound or breakup. At the time of the observation, the sun was below the horizon, but it was not totally dark yet.

Messer and Borden sighted the same fireball at lat. 44°40'N., long. 123°9'W. and were facing north. The fireball was first seen in the east at an altitude of 70° and was last seen 3° north of east at an altitude of 20°, when it disappeared behind a band of clouds. The fireball's angle of descent was 30°, and the duration of its flight was three seconds. Its size was one-tenth of the full moon, and its color was light blue-green. No tail, sound, or breakup was observed. Messer and Borden also reported that the sun had set but that it was not totally dark yet. □

AIME announces 1984 spring field trip

The Oregon section of the American Institute of Mining and Metallurgical Engineers (AIME) announces that the annual spring field trip will be on the geology and hydrothermal alteration of Glass Buttes in south-central Oregon. Glass Buttes is a Pliocene silicic volcanic center in the High Lava Plains province of Oregon. The buttes are underlain by rhyolitic glass domes, flows, and sparse pyroclastic deposits that are interlayered with, and overlain by, basalt. Mercury was mined from hydrothermally altered rocks in the eastern end of the complex during the 1950's. The hydrothermal alteration is dominated by opal replacement of glass, with minor alunite, opal, and hyalite veins. Precious-metal mineralization occurs locally at the surface and in the subsurface.

The field trip is scheduled for June 9 and 10, 1984. On June 9, the trip will focus on the hydrothermal alteration zones, and on June 10, the emphasis will be on the volcanic stratigraphy of the Glass Buttes complex. Trip leaders will be Michael L. Cummings and Michael J. Johnson of Portland State University. Further information may be obtained from the Department of Geology, Portland State University, P.O. Box 751, Portland, Oregon 97207, phone (503) 229-3022. □

Historic candlestick discovered at Oregon Historical Society

Norman Wagner's excellent article on miner's candlesticks (*Oregon Geology*, v. 44, no. 12) captured my interest and has led to an important discovery concerning Oregon's heritage of inventors. As Curator of Technology, one of my responsibilities is to care for our regional collection of mining artifacts, so naturally after reading the article I dashed to our storage room and double-checked our dozen or so candlesticks for errors in our catalog descriptions. After several letters to and from Mr. Wagner, and instructions on how to scrutinize a candlestick for patent dates, we discovered that one of the Society's candlesticks, 73-89.13, with previously unnoted date or manufacturer, was faintly stamped "JAN 9 1883." Further checking, especially in Ramsdell's and Wagner's book on miner's candlesticks, indicates the candlestick was made and patented by John Jones of Oregon City, patent no. 270,316. This is an important discovery because as of this writing it is the only known surviving example of the earliest Oregon patent for a miner's candlestick. Also, it is only the third example extant of five miner's candlesticks patented by Oregonians between 1883 and 1908.

—Ron Brentano, Oregon Historical Society

ORDER FORM — CUT ON DASHED LINE

Available publications

BULLETINS	Price	No. Copies	Amount
33. Bibliography (1st supplement) geology and mineral resources of Oregon, 1947: Allen	$ 3.00		
35. Geology of the Dallas and Valsetz quadrangles, rev. 1964: Baldwin (map only)	3.00		
36. Papers on Tertiary foraminifera: Cushman, Stewart, and Stewart, 1949: v. 2	3.00		
44. Bibliography (2nd supplement) geology and mineral resources of Oregon, 1953: Steere	3.00		
46. Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey	3.00		
49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch	3.00		
53. Bibliography (3rd supplement) geology and mineral resources of Oregon, 1962: Steere and Owen	3.00		
61. Gold and silver in Oregon, 1968: Brooks and Ramp	17.50		
62. Andesite Conference guidebook, 1968: Dole	3.50		
65. Proceedings of the Andesite Conference, 1969: (copies)	10.00		
67. Bibliography (4th supplement) geology and mineral resources of Oregon, 1970: Roberts	3.00		
71. Geology of selected lava tubes in Bend area, Oregon, 1971: Greeley (copies)	5.00		
78. Bibliography (5th supplement) geology and mineral resources of Oregon, 1973: Roberts	3.00		
81. Environmental geology of Lincoln County, 1973: Schlicker and others	9.00		
82. Geologic hazards of Bull Run Watershed, Multnomah, Clackamas Counties, 1974: Beaulieu	6.50		
83. Eocene stratigraphy of southwestern Oregon, 1974: Baldwin	4.00		
84. Environmental geology of western Linn County, 1974: Beaulieu and others	9.00		
85. Environmental geology of coastal Lane County, 1974: Schlicker and others	9.00		
87. Environmental geology of western Coos and Douglas Counties, 1975	9.00		
88. Geology and mineral resources of upper Chetco River drainage, 1975: Ramp	4.00		
89. Geology and mineral resources of Deschutes County, 1976: Peterson and others	6.50		
90. Land use geology of western Curry County, 1976: Beaulieu	9.00		
91. Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties, Oregon, 1977: Beaulieu	8.00		
92. Fossils in Oregon (reprinted from *The Ore Bin*), 1977	4.00		
93. Geology, mineral resources, and rock material of Curry County, Oregon, 1977	7.00		
94. Land use geology of central Jackson County, Oregon, 1977: Beaulieu	9.00		
95. North American ophiolites, 1977	7.00		
96. Magma genesis: AGU Chapman Conference on Partial Melting, 1977	12.50		
97. Bibliography (6th supplement) geology and mineral resources of Oregon, 1971-75, 1978	3.00		
98. Geologic hazards of eastern Benton County, Oregon, 1979: Bela	9.00		
99. Geologic hazards of northwestern Clackamas County, Oregon, 1979: Schlicker and Finlayson	10.00		
100. Geology and mineral resources of Josephine County, Oregon, 1979: Ramp and Peterson	9.00		
101. Geologic field trips in western Oregon and southwestern Washington, 1980	9.00		
102. Bibliography (7th supplement) geology and mineral resources of Oregon, 1976-1979, 1981	4.00		
GEOLOGIC MAPS			
Reconnaissance geologic map of Lebanon quadrangle, 1956	3.00		
Geologic map of Bend quadrangle and portion of High Cascade Mountains, 1957	3.00		
Geologic map of Oregon west of 121st meridian (USGS I-325), 1961	5.50		
Geologic map of Oregon east of 121st meridian (USGS I-902), 1977	5.50		
GMS-4: Oregon gravity maps, onshore and offshore, 1967 (folded)	3.00		
GMS-5: Geologic map of Powers quadrangle, Oregon, 1971	3.00		
GMS-6: Preliminary report on geology of part of Snake River Canyon, 1974	6.50		
GMS-8: Complete Bouguer gravity anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00		
GMS-9: Total field aeromagnetic anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00		
GMS-10: Low- to intermediate-temperature thermal springs and wells in Oregon, 1978	3.00		
GMS-12: Geologic map of the Oregon part of the Mineral quadrangle, 1978	3.00		
GMS-13: Geologic map of the Huntington and part of the Olds Ferry quadrangles, Oregon, 1979	3.00		
GMS-14: Index to published geologic mapping in Oregon, 1898-1979, 1981	7.00		
GMS-15: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, northern Oregon, 1981	3.00		
GMS-16: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, southern Oregon, 1981	3.00		
GMS-17: Total-field aeromagnetic anomaly map, Cascade Mountain Range, southern Oregon, 1981	3.00		
GMS-18: Geology of the Rickreall, Salem West, Monmouth, and Sidney 7½-minute quadrangles, Marion, Polk, and Linn Counties, Oregon, 1981	5.00		
GMS-19: Geology and gold deposits map of the Bourne quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-20: Map showing geology and geothermal resources of the southern half of the Burns 15-minute quadrangle, Oregon, 1982	5.00		
GMS-21: Geology and geothermal resources map of the Vale East 7½-minute quadrangle, Oregon, 1982	5.00		
GMS-22: Geology and mineral resources map of the Mt. Ireland quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-23: Geologic map of the Sheridan quadrangle, Polk and Yamhill Counties, Oregon, 1982	5.00		
GMS-24: Geologic map of the Grand Ronde quadrangle, Polk and Yamhill Counties, Oregon, 1982	5.00		
GMS-25: Geology and gold deposits map of the Granite quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-26: Residual gravity maps of the northern, central, and southern Cascade Range, Oregon, 1982	5.00		
GMS-27: Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1° by 2° quadrangle, 1982	6.00		
GMS-28: Geology and gold deposits map of the Greenhorn quadrangle, Baker and Grant Counties, Oregon, 1983	5.00		
GMS-29: Geology and gold deposits map, NE¼ Bates quadrangle, Baker and Grant Counties, Oregon, 1983	5.00		
OIL AND GAS INVESTIGATIONS			
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well	3.00		
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well, 1973	3.00		
5. Prospects for natural gas production or underground storage of pipeline gas, upper Nehalem River Basin, Columbia-Clatsop Counties, Oregon, 1976	5.00		
6. Prospects for oil and gas in the Coos Basin, western Coos, Douglas, and Lane Counties, Oregon, 1980: Newton and others	9.00		
7. Correlation of Cenozoic stratigraphic units of western Oregon and Washington, 1983	8.00		
NEW! 9. Subsurface biostratigraphy of the east Nehalem Basin, 1983: McKeel	6.00		

Available publications (continued)

SPECIAL PAPERS	Price	No. Copies	Amount
1. Mission, goals, and programs of Oregon Department of Geology and Mineral Industries, 1978	3.00	_____	_____
2. Field geology of SW Broken Top quadrangle, Oregon, 1978: Taylor	3.50	_____	_____
3. Rock material resources of Clackamas, Columbia, Multnomah, and Washington Counties, Oregon, 1978: Gray and others	7.00	_____	_____
4. Heat flow of Oregon, 1978: Blackwell, Hull, Bowen, and Steele	3.00	_____	_____
5. Analysis and forecasts of the demand for rock materials in Oregon, 1979: Friedman and others	3.00	_____	_____
6. Geology of the La Grande area, Oregon, 1980: Barrash and others	5.00	_____	_____
7. Pluvial Fort Rock Lake, Lake County, Oregon, 1979: Allison	4.00	_____	_____
8. Geology and geochemistry of the Mt. Hood volcano, 1980: White	3.00	_____	_____
9. Geology of the Breitenbush Hot Springs quadrangle, Oregon, 1980: White	4.00	_____	_____
10. Tectonic rotation of the Oregon Western Cascades, 1980: Magill and Cox	3.00	_____	_____
11. Theses and dissertations on the geology of Oregon: Bibliography and index, 1899-1982, 1982: Neuendorf and others	6.00	_____	_____
12. Geologic linears of the northern part of the Cascade Range, Oregon, 1980: Venkatakrishnan, Bond, and Kauffman	3.00	_____	_____
13. Faults and lineaments of the southern Cascades, Oregon, 1981: Kienle, Nelson, and Lawrence	4.00	_____	_____
14. Geology and geothermal resources of the Mount Hood area, Oregon, 1982: Priest and Vogt	7.00	_____	_____
15. Geology and geothermal resources of the central Oregon Cascade Range, 1983: Priest and Vogt	11.00	_____	_____
16. Index to the *Ore Bin* (1939-1978) and *Oregon Geology* (1979-1982), 1983: Mahoney and Steere	4.00	_____	_____
SHORT PAPERS			
21. Lightweight aggregate industry in Oregon, 1951: Mason	1.00	_____	_____
24. The Almeda Mine, Josephine County, Oregon, 1967: Libbey	3.00	_____	_____
25. Petrography, type Rattlesnake Formation, central Oregon, 1976: Enlows	3.00	_____	_____
27. Rock material resources of Benton County, 1978: Schlicker and others	4.00	_____	_____
MISCELLANEOUS PAPERS			
1. A description of some Oregon rocks and minerals, 1950: Dole	1.00	_____	_____
5. Oregon's gold placers (reprints), 1954	1.00	_____	_____
8. Available well records of oil and gas exploration in Oregon, rev. 1982: King, Olmstead, and Newton	4.00	_____	_____
11. Collection of articles on meteorites, 1968 (reprints from *The Ore Bin*)	3.00	_____	_____
15. Quicksilver deposits in Oregon, 1971: Brooks	3.00	_____	_____
17. Geologic hazards inventory of the Oregon coastal zone, 1974: Beaulieu, Hughes, and Mathiot	5.00	_____	_____
18. Proceedings of Citizens' Forum on potential future sources of energy, 1975	3.00	_____	_____
19. Geothermal exploration studies in Oregon—1976, 1977	3.00	_____	_____
20. Investigations of nickel in Oregon, 1978: Ramp	5.00	_____	_____
MISCELLANEOUS PUBLICATIONS			
Landforms of Oregon (17 × 12 inches)	1.00	_____	_____
Mining claims (State laws governing quartz and placer claims)	1.00	_____	_____
Geological highway map, Pacific NW region, Oregon-Washington (published by AAPG)	5.00	_____	_____
Geothermal resources of Oregon map, 1982 (published by NOAA)	3.00	_____	_____
Back issues of *The Ore Bin*	50¢ over the counter; $1.00 mailed	_____	_____
Back issues of *Oregon Geology*	75¢ over the counter; $1.00 mailed	_____	_____
Colored postcard, *Geology of Oregon*	10¢ each; 3 for 25¢; 7 for 50¢; 15 for $1.00	_____	_____
Oregon Landsat mosaic map, 1983 (published by ERSAL, OSU)	$8.00 over the counter; $11.00 mailed	_____	_____

Separate price lists for open-file reports, geothermal energy studies, tour guides, recreational gold mining information, and non-Departmental maps and reports will be mailed upon request.

OREGON GEOLOGY

1005 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

PUBLICATIONS ORDER

Minimum mail order $1.00. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $50.00. Foreign orders: please remit in U.S. dollars.

Fill in appropriate blanks and send sheet to Department.

YOUR NAME ______________________________

ADDRESS ______________________________

______________________________ Zip________

Amount enclosed $__________

OREGON GEOLOGY

____ Renewal ____ New Subscription ____ Gift

____ 1 Year ($6.00) ____ 3 Years ($15.00)

NAME ______________________________

ADDRESS ______________________________

______________________________ ZIP ________

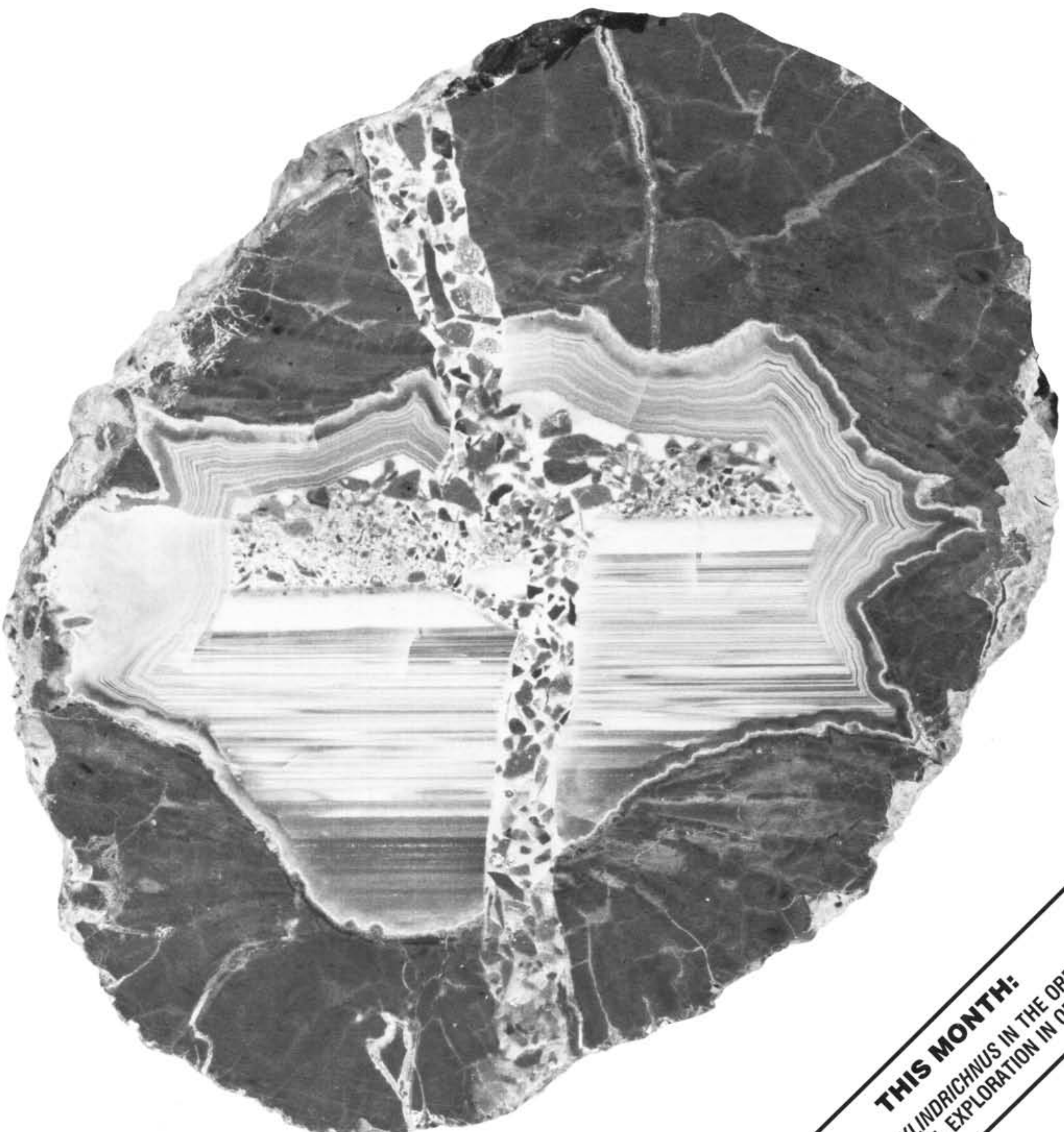
(If Gift, From: ______________________________)

OREGON GEOLOGY

published by the

Oregon Department of Geology and Mineral Industries

VOLUME 46, NUMBER 5 MAY 1984



THIS MONTH:

THE TRACE FOSSIL *CYLINDRICHNUS* IN THE OREGON OLIGOCENE
and GEOTHERMAL EXPLORATION IN OREGON, 1983

OREGON GEOLOGY

(ISSN 0164-3304)

VOLUME 46, NUMBER 5 MAY 1984

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

Main Office: 1005 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133.
Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496.
Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039.
Paul F. Lawson, Supervisor

Subscription rates: 1 year, $6.00; 3 years, $15.00. Single issues, $.75 at counter, $1.00 mailed.
Available back issues of *The Ore Bin*: $.50 at counter, $1.00 mailed.

Address subscription orders, renewals, and changes of address to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

Send news, notices, meeting announcements, articles for publication, and editorial correspondence to the editor, Portland office. The Department encourages author-initiated peer review for technical articles prior to submission. Any review should be noted in the acknowledgments.

Second class postage paid at Portland, Oregon.
Postmaster: Send address changes to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

COVER PHOTO

Unusual "thunder egg" (rock structure formed in welded tuffs and rhyolites, of spherical or ellipsoidal shape, containing cores of chalcedony and sometimes quartz) from central Oregon. This cut specimen, which was recently donated to the Portland State University Department of Geology, records a late-stage fracturing event during which jaspery breccia entered the thunder egg from below (note triangular fragment of white agate in center of photo). Photo and description courtesy John E. Allen, Emeritus Professor, Department of Geology, Portland State University.

OIL AND GAS NEWS

Mist Gas Field

As mentioned in the annual summary report published in the April issue of this magazine, the Mist Gas Field has begun to produce water in three of the wells. Reichhold Energy Corporation has performed remedial work on one of the wells, Paul 34-32, in an attempt to prevent the water from entering the perforations. No results are known at this time. The contractor was A.M. Jannsen Well Drilling Company.

Water from the well Paul 34-32 is hauled to the well Columbia County 13-1 for disposal. □

PSU lectures announced

The spring term lecture series of the Portland State University Department of Geology is scheduled to conclude with seminar speakers from the Seattle area. The final three lectures, presented in cooperation with PSU's Environmental Sciences and Hydrology Programs, are listed below and will be held at 3:00 p.m. in Room 250, Cramer Hall, on the PSU campus in Portland.

May 23 – *Gravity changes and surface deformation on stratovolcanoes*, by Al Eggers, University of Puget Sound.

May 29 – *Estimates of flood and sedimentation hazards around active volcanoes*, by Thomas Dunne, University of Washington.

May 30 – *Hillslope runoff processes and their significance*, by Thomas Dunne, University of Washington. □

USGS revises hazard warning system

New criteria and terms have been adopted by the U.S. Geological Survey (USGS) for issuing formal statements to government officials and the public about geologic hazards such as earthquakes, volcanic eruptions, and landslides.

In the future, any formal statement issued by the director of the USGS concerning a geologic hazard will be called a hazard warning and will address a condition "that poses a significant threat to public health and safety and for which near-term public response would be expected," according to USGS Director Dallas L. Peck.

The previous system had three categories of hazard statements – notice of potential hazard, hazard watch, and hazard warning. Peck explained that "if a potential hazard is not apt to occur in the near future or doesn't suggest that the public should do something different than [continue] normal activity, then we don't want to generate excessive concern from the public, news media, and public officials over the hazard with a formal hazard warning."

"Understandably, a hazard warning tends to create some anxiety within a community," Peck said. The new system, in his words, "will help eliminate situations in which USGS statements might cause unwarranted public concern over potential hazards that present low risk to the public."

The new system will continue earlier provisions for forwarding information to local and state officials about lesser geologic or hydrologic hazards or hazards that may require longer-range actions. □

CONTENTS

The trace fossil *Cylindrichnus* in the Oregon Oligocene

by William N. Orr and Paul R. Miller, Geology Department, University of Oregon, Eugene, Oregon 97403

INTRODUCTION

A trace fossil is the track, trail, or burrow of a prehistoric organism. Because an animal could potentially leave an infinite number of tracks, the reader might think trace fossils would greatly outnumber ordinary fossils in the geologic record. However, the probability of preserving a track in soft sediment, as opposed to the hard shell of a mollusc, for example, precludes an overabundance of trace fossils in the record. To the geologist, trace fossils are more useful as indices of particular paleoenvironments than as biostratigraphic markers. Unlike most other fossils, trace fossils are rarely reworked from older sediments into younger.

Marine shallow water intervals of the Oligocene informally designated "Butte Creek Beds" in Marion County, Oregon, have yielded trace fossil specimens assignable to the genus *Cylindrichnus*.

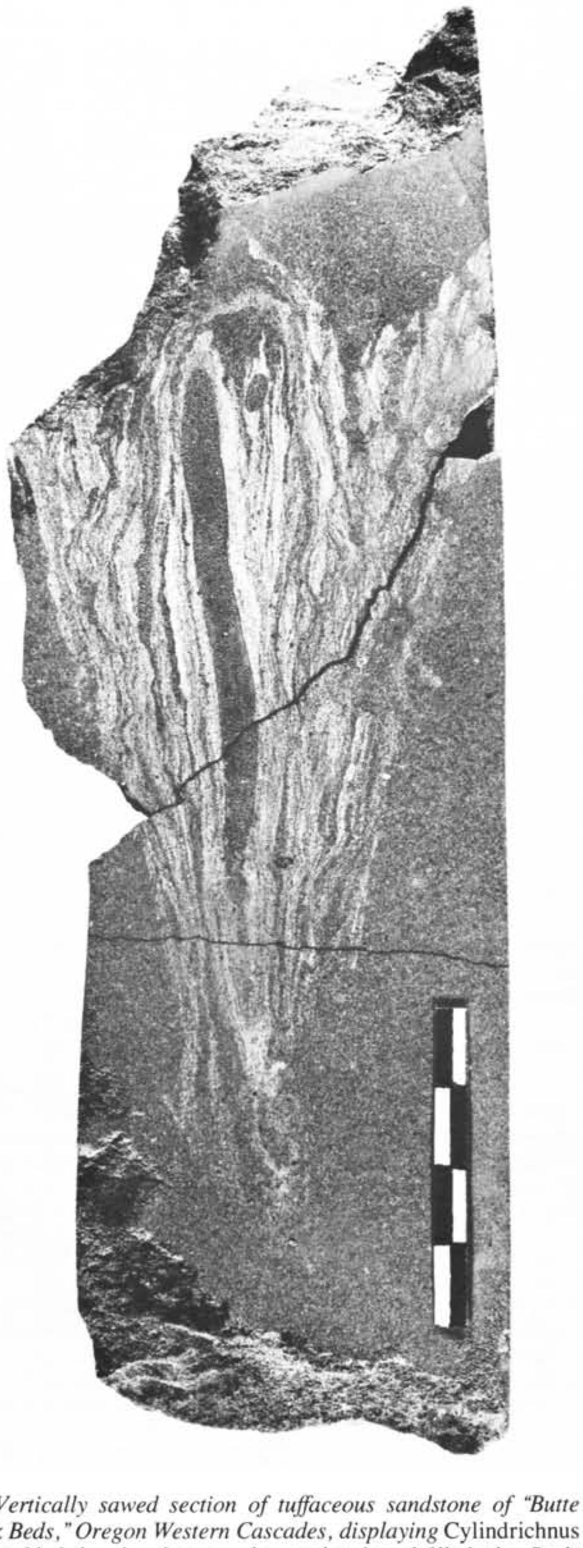
To date there are less than a half-dozen published reports of trace fossils in Oregon, and this is the first record of *Cylindrichnus*.

DESCRIPTION

Preserved in an upright, concave upward position, these cone-shaped specimens are a series of tall, tapering, cone-in-cone, sand and clay sheaths surrounding a central sand-filled tube. Subconical clay sheaths fade into the sand at both the proximal and distal ends, with a maximum height of 120 mm. Maximum cone diameter on the dorsal margin (at the distal lip) is 60 mm. The central sand-filled tube averages 4 mm in diameter. As many as 20 to 30 light-colored separate clay sheaths make up and are responsible for the high visibility of this trace fossil. These clay sheaths are not part of the stratigraphic laminae of the entombing sandstones. Unlike many previously described cone-shaped trace fossils, Oregon specimens flare out at the open end and show no constriction of the cone or truncation by the overlying sedimentary sequence. The clay sheaths are commonly rippled or rugose as a by-product of preconsolidation settling of the sediments. Fossils are preserved in a near-shore infra-littoral tuffaceous sand/silt (Orr and Faulhaber, 1975; Orr and Miller, 1983). Upper Oligocene mollusc-dominated invertebrate faunas at the same interval bear all the characteristics of an undisturbed biococenosis paleoenvironment (Orr and Miller, 1981, 1982).

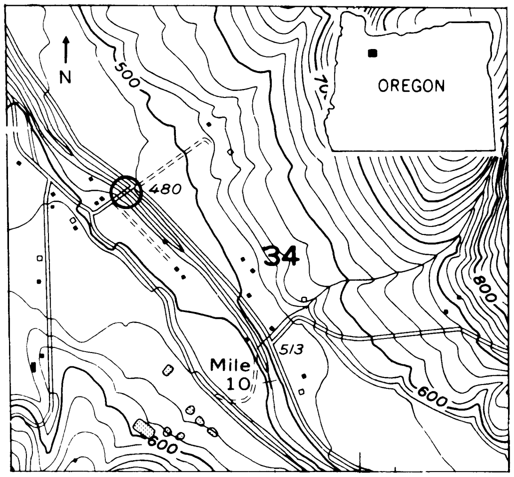
DISCUSSION

Examination of the trace fossil literature reveals considerable diversity with respect to the taxonomic status of cone-shaped trace fossils. Oregon specimens conform well in shape to the genus *Cylindrichnus* first described by Toots (1962), but Toots' specimens were only half as large as ours. Chamberlain (1978) distinguishes *Cylindrichnus* from a similar form *Rosselia* by the size disparity and thinner, tapering shape of the former. Oregon specimens are not truncate at the distal end, as Chamberlain notes is often the case for *Cylindrichnus*. Frey and Howard (1970) use the genus *Asterosoma* as part of a gradational sequence for *Cylindrichnus*. A similar form, *Anemonichnus* (Chamberlain and Clark, 1973) is reported by those authors from the late Paleozoic rocks in Utah. Those authors note that the latter form is similar to extant anemone burrows reported by Shinn (1968). Howard's (1966) report of *Cylindrichnus* from the Cretaceous of Utah compares well with our specimens. A similar but, with respect to symmetry, quite distinct form, *Conostichnus* (Lesquereux, 1876), from upper Paleozoic rocks in southern Oklahoma, was demonstrated by Chamberlain (1971) to represent the probable trace fossil of a burrowing coelenterate. The same author has shown that a succession of



Vertically sawed section of tuffaceous sandstone of "Butte Creek Beds," Oregon Western Cascades, displaying Cylindrichnus *sp. wrinkled clay sheaths around central and sand-filled tube. Scale is in centimeters.*

spiraling motions by a burrowing organism could produce the cone-in-cone structure of the similar trace fossil *Rosselia*. Chamberlain considered *Conostichnus* to be the trace fossil of a permanent shelter, whereas *Rosselia* may represent the by-product of a sediment processor such as a worm. Several authors have also suggested that a cone-in-cone structure may represent the vertical track of an organism keeping pace with sedimentation.



Map (scale 1:24,000) showing sec. 34 (see "LOCALITY" in text), where the trace fossil Cylindrichnus *was found. Circle indicates exact location of Abiqua Road (north of creek), approximately 3.5 mi southeast from intersection with State Highway 213 and, via 213, approximately 6.5 mi east of Silverton.*

LOCALITY

The trace fossil *Cylindrichnus* was found in the northwest corner of sec. 34, T. 6 S., R. 1 E., in Marion County. The fossils were taken from exposures of siltstone and sandstone in the bed of Abiqua Creek beneath the bridge where the Abiqua Creek road crosses the creek. This locality is stratigraphically within the designated "Unit II" of Orr and Miller (1983). The stratigraphy of the "Butte Creek Beds" has been described by Orr and Miller (1983).

REFERENCES

Chamberlain, C.K., 1971, Morphology and ethology of trace fossils from the Ouachita Mountains, southeast Oklahoma: Journal of Paleontology, v. 45, p. 212-245, pl. 29-32.

——— 1978, Recognition of trace fossils in cores, *in* Trace fossil concepts: SEPM Short Course 5, p. 119-166.

Chamberlain, C.K., and Clark, D.L., 1973, Trace fossils and conodonts as evidence for deep-water deposits in the Oquirrh Basin of central Utah: Journal of Paleontology, v. 47, p. 663-683, pl. 1-3.

Frey, R.W., and Howard, J.D., 1970, Comparison of Upper Cretaceous ichnofaunas from siliceous sandstones and chalk, western interior region, U.S.A., *in* Crimes, T.P., and Harper, J.C., eds., Trace fossils: Geological Journal Special Issue 3, p. 141-166.

Howard, J.D., 1966, Characteristic trace fossils in Upper Cretaceous sandstones of the Book Cliffs and Wasatch Plateau: Utah Geological and Mineralogical Survey Bulletin 80, p. 35-53.

Lesquereux, L., 1876, Species of fossil marine plants from the Carboniferous measures: Indiana Geological Survey Annual Report 7, p. 134-145.

Orr, W.N., and Faulhaber, J., 1975, A middle Tertiary cetacean from Oregon: Northwest Science, v. 49, no. 3, p. 174-181, figs. 1-6.

Orr, W.N., and Miller, P.R., 1981, Mid-Tertiary cetacea (whales) of the Oregon Western Cascades [abs.]: Proceedings of the Oregon Academy of Science.

——— 1982, Mid-Tertiary stratigraphy of the Western Cascades [abs.]: Geological Society of America, Cordilleran Section, Abstracts with Programs, v. 14, no. 4, p. 222.

——— 1983, Fossil cetacea (whales) in the Oregon Western Cascades: Oregon Geology, v. 45, no. 9, p. 95-98.

Shinn, E.A., 1968, Burrowing in Recent lime deposits of Florida and the Bahamas: Journal of Paleontology, v. 42, p. 879-894, pl. 109-112.

Toots, H., 1962, Paleoecological studies on the Mesaverde Formation in the Laramie Basin: Laramie, Wyo., University of Wyoming master's thesis. □

Publications received

From time to time, we print information about new books that we have received in the Department's Portland library. These books are available from the publisher or may be ordered from local bookstores.

Mount St. Helens, An Annotated Bibliography, by Caroline D. Harnly and David A. Tyckoson (1984; hardbound; 261 pages, 5½ × 8½; Scarecrow Press, Inc., P.O. Box 656, Metuchen, NJ 08840; $17.50): The authors, who are reference librarians, have compiled a collection of 1,700 annotated citations from journals, technical reports, conference proceedings, trade newspapers, dissertations, maps, and books covering both the technical and popular literature on the eruption of Mount St. Helens from March 1980 through December 1982. The references are divided into ten broad categories: general Mount St. Helens information; geological studies; atmospheric and climatic studies; chemical and physical studies; effects on agriculture; biological and environmental effects; medical and health effects; business, commercial, and economic implications; industrial and engineering aspects; and social and cultural aspects. An author index and chapters listing special maps, dissertations, books, and material on Mount St. Helens before the 1980 eruption are also included.

Contributions to the Tectonics and Geophysics of Mountain Chains (Geological Society of America Memoir 158), edited by Robert D. Hatcher, Jr., Harold Williams, and Isidore Zietz (1983; hardbound; 8½ × 11; 228 pages plus 9 oversize plates in a rear pocket; Geological Society of America, Inc., Publications Sales, Department 58, P.O. Box 9140, Boulder, CO 80301; $42.50): This volume grew out of a GSA Penrose Conference held in Helen, Georgia, in May 1980, where geologists and geophysicists from academic institutions, government, and industry addressed some of the complex problems of orogenic terranes. The papers presented in this volume develop ideas either generated by the conference or presented there. Topics covered by the 15 papers in the book include regional geology and tectonics of the Appalachian orogen; comparisons with the Caledonides, Mauritanides, Alps, and the North American Cordillera; the application of mechanical principles to structural problems; and the utilization of reflection seismology to interpret tectonics of mountain chains. The text is illustrated with numerous maps and figures; one of the plates is a two-color map, and the rest are one color.

The Role of Heat in the Development of Energy and Mineral Resources in the Northern Basin and Range Province (Geothermal Resources Council Special Report No. 13) (1983; hardbound; 8½ × 11; 384 pages; Geothermal Resources Council, P.O. Box 1350, Davis, CA 95617; $30 plus $3.50 handling and mailing): This publication contains 27 papers, including five papers on the northern Basin and Range province, six papers on active hydrothermal systems, four on thermogenics and hydrocarbon resources, six on fossil hydrothermal systems, and six on regional geophysics of the northern Great Basin. The publication is a product of a symposium co-sponsored by the Geothermal Resources Council and the American Association of Petroleum Geologists and convened in Reno, Nevada, in May 1983. □

Geothermal exploration in Oregon, 1983

by George R. Priest, Oregon Department of Geology and Mineral Industries

ABSTRACT

Drilling continued at a very low level in 1983 and was chiefly centered on Newberry volcano and the central High Cascades. The total acreage of leased geothermal lands in Oregon increased by 45 percent in 1983, primarily because of the release of large tracts of pending leases in Deschutes National Forest and new leases to California Energy in Winema National Forest. For the first time in the history of geothermal leasing in Oregon, the acreage leased by the U.S. Forest Service (USFS) exceeded the acreage leased by the U.S. Bureau of Land Management (BLM). This was caused primarily by the release of part of the large backlog of pending USFS leases but also reflected continued investor confidence in Newberry volcano and the Cascades. The nearly 50-percent decrease in BLM leased acreage may in part reflect the fact that developers are trading off former holdings at Basin and Range sites for Cascade sites in order to stay under the current acreage ceiling of 20,480 acres.

The geothermal group of the Oregon Department of Geology and Mineral Industries (DOGAMI) published Special Paper 15, a comprehensive summary of the geology and geothermal resources of the Central Cascades. A similar report on Newberry volcano was released as an open-file report. In addition, DOGAMI assisted Sandia National Laboratories in drilling a well at Newberry caldera.

New life will be pumped into the Oregon Institute of Technology (OIT) and the DOGAMI geothermal programs in 1984 by a planned $530,000 grant from the U.S. Department of Energy (USDOE). Most of the money will go to OIT to revive recently canceled services such as the institute's newsletter and free technical transfer program. The money will not be enough, however, for new research drilling by DOGAMI.

LEVEL OF GEOTHERMAL EXPLORATION

The level of geothermal exploration in 1983 was similar to the low level which characterized 1982. The continuing power surplus and the low cost of competing energy sources such as coal, oil, and hydropower have all combined to depress the market for geothermal energy. With no current market incentive, developers are reluctant to sink large amounts of capital into drilling and other expensive exploration techniques. Only the largest companies, such as Union Oil of California, can afford to invest in capital-intensive near-term exploration for long-term payoffs expected when the current energy surplus disappears.

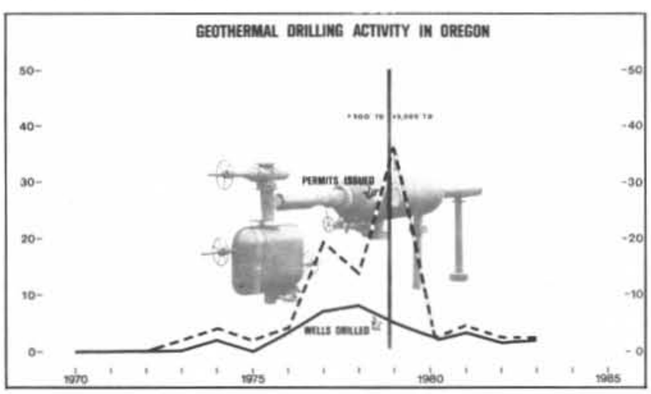


Figure 1. Geothermal well drilling in Oregon. Vertical line indicates time when definition of geothermal well was changed to a depth greater than 2,000 ft.

DRILLING ACTIVITY

Drilling activity continued to be low, although more permits for deep test wells were processed in 1983 than in 1982 (Tables 1 and 2, Figures 1 and 2). Only three groups were involved in significant geothermal drilling in Oregon during 1983. Union Oil of California (Table 2) drilled three 2,000-ft prospect wells in the Newberry-High Cascades area. Occidental Geothermal, Inc. (Table 1) drilled on the west flank of Newberry volcano, just outside the caldera. After the 1983 field season, the company revised the target depth of its drilling permit from 3,000 ft to 4,500 ft. Finally, Sandia National Laboratories (Table 1, Orvail Buckner Drilling) drilled a rotary-drill hole to 1,390 ft in Newberry caldera, near the U.S. Geological Survey (USGS) Newberry 2 site (see Black and others, 1984, for location of the Newberry 2 well).

Table 1. Permits for geothermal wells (greater than 2,000 ft in depth)

Permit number	Operator, well, API number	Location	Status, proposed total depth (ft)
94	John W. Hook and Assoc., Inc. USA-Site A 017-90003	SE¼ sec. 34 T. 20 S., R. 8 E. Deschutes County	Application; 4,000.
95	John W. Hook and Assoc., Inc. USA-Site B 017-90004	SW¼ sec. 17 T. 20 S., R. 8 E. Deschutes County	Application; 4,000.
96	Orvail Buckner Drilling RDO-1 017-90005	SW¼ sec. 31 T. 21 S., R. 12 E. Deschutes County	Abandoned at 1,390 ft; 5,000.
97	Occidental Geothermal, Inc. Well No. 72-03 017-90006	NE¼ sec. 3 T. 22 S., R. 12 E. Deschutes County	Suspended; orig. 3,000, now 4,500.

The emphasis on the Cascades and on Newberry volcano, which began in 1981, continued in the drilling activity of 1983. All of the holes drilled were in these two areas. Newberry volcano remained the most popular target, but the High Cascade Range, particularly the area just south of the silicic South Sister volcano and the area between Mount Jefferson and Green Ridge, were also attracting drilling interest.

A major increase in drilling activity around the flanks of the Mount Mazama volcano (Crater Lake) is expected for 1984. California Energy Company, Inc., has a very large block of unitized

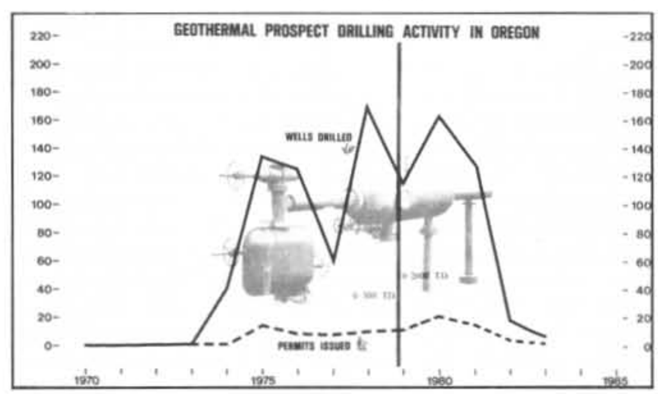


Figure 2. Geothermal prospect-well drilling in Oregon. Vertical line indicates time when definition of prospect well was changed to a depth less than 2,000 ft.

Table 2. *Permits for geothermal prospect wells (less than 2,000 ft in depth)*

Permit number	Operator	Location	Issue date, status
94	Union Oil of California	Eight locations in the Western Cascades, Deschutes, Lane, and Linn Counties	March 1983; drilled three holes to 2,000 ft.

leases covering most areas adjacent to the Crater Lake National Park. Unitized lease blocks must, by law, have a substantial amount of development every year. A large capital investment by California Energy, probably including extensive drilling, can thus be expected this summer.

LEASING

For the first time in the history of geothermal leasing in Oregon, USFS active-leased acreage now exceeds BLM acreage (Figure 3, Table 3). In 1983, the USFS granted large numbers of leases in the Winema and Deschutes National Forests, causing a 235-percent increase in the acreage of active noncompetitive geothermal leases on USFS lands (Figure 3, Table 3). The 45-percent increase in the total acreage of federal lands leased for geothermal resources in Oregon was caused in large part by this release of USFS noncompetitive leases which had been pending for years. If 284 USFS leases still pending are also released, then another sharp increase in the numbers of active leases may be expected. The logjam of pending leases on USFS lands has been a major impediment to geothermal development in the Cascades for years. It now looks as though it is finally beginning to break.

According to current statutes, the BLM can increase the acreage limitation of 20,480 acres to as much as 51,400 acres as of December 20, 1985. If BLM increases the limit to the maximum that it is allowed, leasing could be dramatically affected in future years.

At the present time, holders of prime leases in such areas as Newberry volcano, for example, are being forced to give up other lease blocks in order to stay below the 20,480-acre limit. This limitation may, in part, explain the nearly 50-percent decrease in active leases on BLM lands (Figure 3, Table 3), as holders of southeast Oregon Basin and Range leases (chiefly BLM lands) traded off those leases for the newly available Newberry and Cascade areas (chiefly USFS lands).

Some companies such as California Energy are avoiding the acreage limitation by unitizing hundreds of thousands of acres. As mentioned above, however, the accelerated development mandated on unitized lands requires substantial capital outlay in the first few years. This can prove to be an unacceptable risk for smaller companies.

The shift from BLM to USFS leases reflects a fundamental change in the emphasis of the geothermal industry in Oregon. Prior to 1980 and 1981, Basin and Range targets were predominant, but the discovery of high-temperature resources at Meager Creek in the British Columbia Cascades and a similar discovery at Newberry volcano demonstrated to explorationists the tremendous potential of the Cascades. It became apparent from the results at Newberry that high-temperature reservoirs could exist in youthful volcanic areas without significant hot-spring activity. This conclusion implied that, even though most of the High Cascade Range lacks significant hot springs, large, undetected reservoirs could still exist almost anywhere. This caused a rush to lease Cascade lands, especially lands next to silicic volcanic centers such as Crater Lake and the South Sister.

Thus there is hope that Oregonians may some day see electricity produced from geothermal plants harnessing Cascade heat sources. If so, geothermal energy may prove in the future to be a very important alternative to electrical generation by coal and nuclear energy.

KGRA LEASE SALES

On September 23, 1983, the BLM opened and read bids on 3,658.6 acres of land in the McCredie Hot Springs Known Geothermal Resource Area (KGRA). Gaslight Corporation was the only bidder and acquired 360 acres for $720. The company reportedly intends to develop a resort at McCredie Hot Springs.

Table 3. *Geothermal leases in Oregon, 1983*

Types of leases	Numbers	Acres
Federal active leases:		
Total, 1/1/1983	259	449,316
Changes during 1983:		
Noncompetitive, BLM	−70	−112,147 (−46%)
Noncompetitive, USFS	+172	+320,735 (+235%)
KGRA, BLM	−4	−8,645 (−14%)
KGRA, USFS	+2	+2,933 (+43%)
Subtotal	+100	+202,876 (+45%)
Total, 12/31/1983	359	652,192
Federal leases relinquished:		
Noncompetitive, BLM	68	112,137
Noncompetitive, USFS	9	16,459
KGRA, BLM	4	8,645
KGRA, USFS	1	2,133
Federal leases pending (total since 1974):		
Noncompetitive, BLM	5	No data
Noncompetitive, USFS	284	No data
State leases (total since 1974):		
Total active in 1983	11	22,404
Total applications pending in 1983	0	0
Private leases (total since 1974):		
Total active in 1983	No data	200,000 (est.)

DOGAMI RESEARCH

The DOGAMI geothermal research group was reduced to one staff member during most of the 1983 field season because of continually dwindling government support for the program. However, during the fall of 1983, DOGAMI employed two additional geologists: one to serve in an 18-month regional geothermal resource study sponsored by the Bonneville Power Administration (BPA), and one to assist with the drilling done by Sandia National Laboratories in Newberry caldera.

The BPA study is a cooperative effort involving state agencies in Oregon, Washington, Idaho, and Montana and will result in a summary of the resource base and development possibilities of all potential geothermal resources in the BPA service area. The emphasis of the BPA study is on potential electrical-load offsets that could be realized from geothermal energy. The study will be used by planners at BPA to evaluate the contribution of geothermal energy to the region's future electrical-power needs.

The Sandia project was intended to investigate the deep parts of the Newberry geothermal system, and the drill hole was originally aimed at reaching about 5,000 ft. However, serious problems with the cement job in the upper casing string, coupled with artesian fluids at moderately high (170° C) temperature, caused the hole to be abandoned at 1,390 ft. For information on the temperatures in the well, see Black and others (1984). Sandia National Laboratories is also preparing a report on the drilling history and data from the well (Jim Dunn, personal communication, 1983).

The DOGAMI geothermal staff also initiated a long-term research project aimed at assessing the geothermal potential of the central Oregon Cascade Range. This program will investigate structure, heat flow, and hydrothermal resources in the area from Mount Jefferson to Crater Lake. Much work has already been done in previous programs, but there are still large gaps in the geologic mapping and, particularly, in the heat-flow data base. As a first step, mapping of the North Santiam area in the vicinity of Mount Jefferson was begun by the writer during the summer of 1983. In addition, a task force of researchers interested in the Cascades was organized by DOGAMI at the 1983 fall meeting of the American Geophysical Union in San Francisco. The task force, which consists of USGS, university, and DOGAMI personnel, is preparing a scientific plan for surface surveys and deep drilling in the central Oregon Cascade Range. Researchers interested in becoming involved in preparation or review of the scientific plan are encouraged to contact the following people who are coordinating various aspects of the proposed investigation:

- Hydrothermal and hydrologic studies—Terry E.C. Keith, Edward A. Sammel, and Robert H. Mariner, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025, phone (415) 323-8111.
- Geophysical studies—Richard W. Couch and G. Steven Pitts, Department of Geophysics, School of Oceanography, Oregon State University, Corvallis, Oregon 97331, phone (503) 754-4430; and David D. Blackwell, Geothermal Laboratory, 253 Heroy Building, Southern Methodist University, Dallas, Texas 75275, phone (214) 692-2745.
- Geologic studies—George R. Priest, Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, Oregon 97201, phone (503) 229-5580; and Edward M. Taylor and Gary Smith, Department of Geology, Oregon State University, Corvallis, Oregon 97331, phone (503) 754-2484.

In 1984, the geothermal research group will finish the previously mentioned geologic map of the North Santiam area and begin mapping a similar-sized area to the south. The goal of this mapping program is to eventually complete detailed mapping of the structural boundary between the High Cascade and Western Cascade Range from the North Santiam River to the Rogue River.

DOGAMI GEOTHERMAL PUBLICATIONS

Two new geothermal publications and an *Oregon Geology* paper were completed in 1983 and released by DOGAMI in January 1984:

1. Priest, G.R., and Vogt, B.F., eds., 1983, *Geology and Geothermal Resources of the Central Oregon Cascade Range*: DOGAMI Special Paper 15, 123 p., 3 plates (price $11).
2. Priest, G.R., Vogt, B.F., and Black, G.L., eds., 1983, *Survey of Potential Geothermal Exploration Sites at Newberry Volcano, Deschutes County, Oregon*: DOGAMI Open-File Report O-83-3, 174 p., 8 maps (price $20).
3. Black, G.L., Priest, G.R., and Woller, N.M., 1984, *Temperature Data and Drilling History of the Sandia National Laboratories Well at Newberry Caldera*: DOGAMI, *Oregon Geology*, v. 46, no. 1, p. 7-9 (price $.75 over the counter, $1 mailed).

Special Paper 15 summarizes the results of six years of geologic and geothermal research funded by the USDOE. It includes new geologic maps, radiometric dates, geochemical analyses, and a complete summary of heat-flow data for the central Cascades.

In 1982, a preliminary version of Special Paper 15 was released for review as Open-File Report O-82-7 (Priest and Vogt, 1982). Special Paper 15 is not, however, identical with the earlier report. It has been extensively revised and contains geologic data collected during an additional field season in the Waldo Lake-Willamette Pass area. A new geologic map of the entire Waldo Lake 15-minute quadrangle is the result of this additional field season of work.

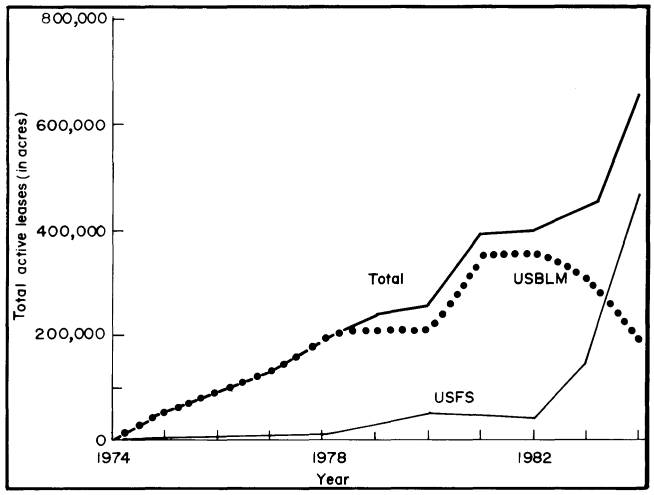


Figure 3. Change of pattern of active geothermal leases on federal lands in Oregon from the inception of leasing in 1974 through December of 1983.

Owing to budgetary constraints, two maps included in Open-File Report O-82-7 were omitted from Special Paper 15. The maps, an index map to geologic mapping in the Cascades and a 1:250,000-scale map showing the heat-flow data base for the entire Cascade Range, are, however, available as Open-File Report O-84-4 (Priest and others, 1984). Most of the data given on the geologic index map can also be obtained from an index to theses and dissertations in Oregon, DOGAMI Special Paper 11 (Neuendorf and others, 1982), and the index to published geologic mapping in Oregon, DOGAMI map set GMS-14 (Schumacher, 1981). However, only Open-File Reports O-82-7 and O-84-4 show the actual boundaries of unpublished Cascade thesis maps.

Open-File Report O-83-3 (item 2, above) is the final report for a BPA-funded study aimed at evaluating and updating the current data base on geothermal resources at Newberry volcano. A soil-mercury survey of the entire volcano was conducted by DOGAMI as part of this study (Priest and others, 1983a). In this survey, 1,641 samples were collected from an area covering 500 sq mi of the volcano. The survey showed large mercury anomalies associated with both the caldera and the south and east flanks of the volcano (Figure 4). Also included in the report were new interpretations and models for available geophysical data. The series of gravity and aeromagnetic maps included in the report should prove valuable to explorationists. All of the available geographic, geologic, geophysical, and geochemical data were utilized to develop a drilling program which could put constraints on the geothermal potential of the flanks of the volcano.

The *Oregon Geology* article on the Sandia National Laboratories well (item 3, above) summarizes the results of several temperature logs of the 1,390-ft well. When compared at equivalent depths to the USGS Newberry 2 well, the Sandia well has much higher temperatures. This is remarkable when one considers that the two wells are only 1,500 ft apart. Black and others (1984) concluded that the Sandia well may have encountered the same flow of hot water that occurred in Newberry 2 at a depth of 1,300-1,400 ft but that the Sandia well is closer to the source of the fluids, which probably emanate from the caldera ring-fault system.

NEW USDOE FUNDING ANNOUNCED

In a Washington, D.C., news release of December 14, 1983, Senator Mark Hatfield announced that $530,000 will be given to Oregon from a total of $2 million allocated by the USDOE to assist the western states in geothermal research. Of that amount, about $342,000 is expected to go to OIT for continuation of the services the institute provides (Paul Lienau, personal communication,

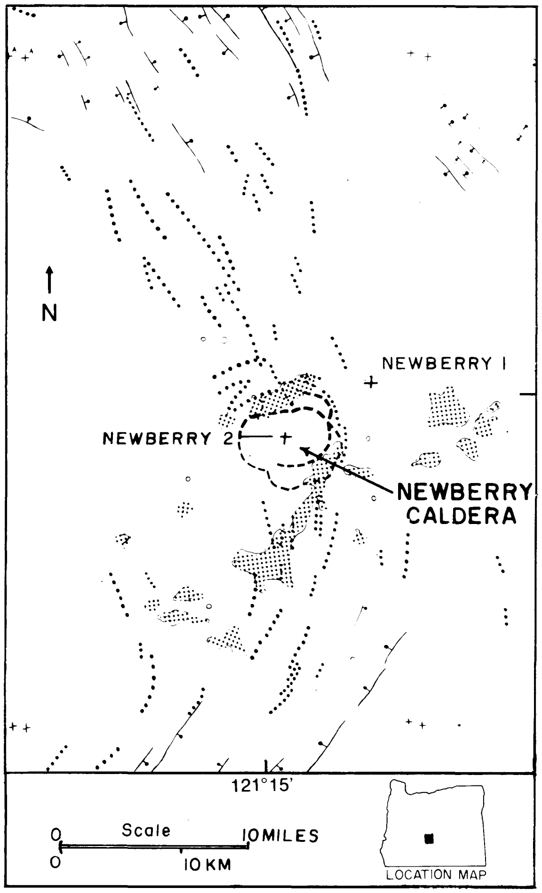


Figure 4. Geologic structures and soil-mercury anomalies in the Newberry volcano area. Shaded areas = soil-mercury anomalies; thin solid lines = faults; dashed lines = caldera ring fractures; dotted lines = fissures and associated volcanic vent alignments; + = USGS drill holes. The area is covered by the geologic map of MacLeod and others (1982). Figure taken from Priest (1983).

1984), about $150,000 will be made available to DOGAMI, and the balance is being held in reserve. OIT had previously received $70,800 of federal support in 1983 for technology transfer.

These new USDOE funds will help to restore some Oregon geothermal research programs, which had all but disappeared in recent years. The funds will also substantially revitalize the OIT program. OIT offers technological assistance to developers of low-temperature geothermal resources. The funding to DOGAMI will be inadequate for the aggressive drilling and mapping programs which have characterized its research in the past, but the support will allow a modest amount of temperature logging of water wells as well as some geologic mapping.

It is to be hoped that this new support for state programs from USDOE signals an important change in funding priorities. The level of funding for all state-coupled geothermal research has steadily declined over the last three years.

OIT GEO-HEAT UTILIZATION CENTER

During 1983, the OIT Geo-Heat Utilization Center offered a limited program of technical assistance to developers interested in utilization of low- to moderate-temperature geothermal resources. The Center completed a feasibility analysis for a district heating system for the City of Vale and has continued to monitor the Lakeview low-temperature electrical generation project operated by Wood and Associates. Computer programs simulating electrical generation from Freon-based binary wellhead generators are being developed as part of the Lakeview project. The Geo-Heat Center also completed a district heating analysis guide. The guide and the Lakeview and Vale work were funded under subcontracts from the Oregon Department of Energy (ODOE).

The Center cooperated with the USGS, the Lawrence Berkeley Laboratory, and Stanford University during hydrologic testing of the Klamath Falls geothermal system. The pump test was supervised by Edward A. Sammel of the USGS and is discussed below in the USGS section of this report.

The previously mentioned USDOE support will allow OIT to expand its services. There will be free feasibility analysis and consulting for developers, amounting to as much as 64 hours per site, if the initial proposal to USDOE is approved (Paul Lienau, personal communication, 1984). A referral service identifying organizations that can be contacted for particular information and services will also be offered. A quarterly bulletin, monthly newsletter, library, and tour program will be available to the public. A speaker's bureau for geothermal conferences will also be part of the services. The new USDOE program will be operated for 18 months under the upcoming contract.

OREGON DEPARTMENT OF ENERGY (ODOE)

In 1983, ODOE supported some OIT activities, subcontracted a number of studies to OIT (mentioned above), provided direct technical assistance to the City of Vale, provided public information, and responded to inquiries on geothermal energy and development from the public. ODOE also participated in the above-mentioned regional geothermal assessment project funded by BPA, working closely with DOGAMI on compilation of the Oregon data.

ODOE reviewed applications for state tax credits for geothermal heating development, processing eight applications for direct use and forty-five applications for ground-water heat pumps in 1983. A 25-percent tax credit, up to a maximum of $1,000, is offered for individual residences for the year of the installation. A 35-percent tax credit apportioned over as much as five years is offered to businesses.

ODOE now has a new geothermal program manager. David Brown, who left the position on December 15, 1983, to join a private consulting firm, has been replaced by Alex Sifford, formerly of Eliot Allen and Associates, Salem. Sifford has extensive experience in geothermal energy work from his association with Eliot Allen and from a previous position as geothermal program manager for the State of Idaho.

U.S. GEOLOGICAL SURVEY (USGS)

Geothermal research in Oregon by the USGS was sharply curtailed because of budget cuts. A few projects, however, were completed in 1983 or are still continuing.

According to Walter D. Mooney (personal communication, 1984), a 60-km east-west seismic refraction line was completed across Newberry volcano in the fall of 1983. Five shots along the line and two shots offset to the east were recorded at stations spaced 500 m apart. Although the data have not yet been reduced, magma bodies as small as 2 to 3 km in diameter down to depths of 10 km beneath the volcano should be detectable at this station spacing. The offset shots were done to explore the crust-mantle boundary.

Edward A. Sammel (USGS), in cooperation with Lawrence Berkeley Laboratory, conducted a pump test of the Klamath Falls hydrothermal system between July 5 and August 26, 1983. The test was preceded in June by tracer tests conducted by Stanford University. Important conclusions from the testing were presented at a public meeting in Klamath Falls on January 25, 1984. It was found that (1) temperatures did not change during the test; (2) the cone of depression encountered no major hydrologic barriers; (3) drawdown was very significantly decreased in all wells when reinjection was employed; (4) the thermal waters are tens of thousands of years old and receive essentially no local recharge. Mixing calculations by A.H. Truesdell (USGS) indicated that (5) the deep thermal water has equilibrated with an extensive volume of rock and has an estimated minimum reservoir temperature of 180° C. Finally, (6) the entire shallow hydrothermal system responds as one relatively simple system with two distinct types of permeability, a fracture-controlled system with rapid flow and a system controlled by intergranular permeability with slower flow (E.A. Sammel, personal communication, 1984).

Extensive reconnaissance-level geologic mapping by G.W. Walker, N.S. MacLeod, and D.R. Sherrod continued in the Cascades. This project is aimed at completing the Roseburg and Salem 1°×2° quadrangle maps, which will eventually be combined into a new compilation map covering the western half of Oregon.

Information from previous USGS field work at Newberry volcano and the Cascades was published chiefly in USGS open-file reports and as short papers in conferences. The following are some of the more important papers which were published in 1983 or are in press for 1984:

1. Summary papers were published on the geology (Bacon, 1983a,b) and the heat flow and limnology (Williams and von Herzen, 1983) of Crater Lake.

2. Keith and others (1984) interpreted the hydrothermal alteration mineralogy of the Newberry 2 drill hole. Bargar and Keith (1984) presented the full data set from the hole in an open-file report.

3. Data from time-domain electromagnetic soundings (Fitterman, 1983a,b) and Schlumberger soundings (Bisdorf, 1983) of Newberry volcano were released as open-file reports.

4. The hydrology of Newberry volcano was summarized in two papers (Sammel, 1983; Sammel and Craig, 1983).

5. A major paper summarizing results of a seismic refraction line from Mount Hood to Crater Lake will soon be published in the Journal of Geophysical Research (Leaver and others, 1984).

ACKNOWLEDGMENTS

Edward A. Sammel (USGS), Walter D. Mooney (USGS), Paul Lienau (OIT Geo-Heat Utilization Center), and Alex Sifford (ODOE) provided the information about the geothermal programs of their organizations. Special thanks must go to Jacki Clark who every year is kind enough to provide complete statistics on BLM and USFS leases.

REFERENCES CITED

Bacon, C.R., 1983a, Eruptive history of Mount Mazama and Crater Lake caldera, Cascade Range, U.S.A.: Journal of Volcanology and Geothermal Research, v. 18, p. 57-115.

——— 1983b, The precursory and climactic eruptions of Mount Mazama and collapse of Crater Lake caldera, Oregon [abs.]: Geological Society of America Abstracts with Programs, v. 15, no. 5, p. 330.

Bargar, K.E., and Keith, T.E.C., 1984. Hydrothermal alteration mineralogy in Newberry 2 drill core, Newberry volcano, Oregon: U.S. Geological Survey Open-File Report 84-92, 62 p.

Bisdorf, R.J., 1983, Schlumberger soundings near Newberry caldera, Oregon: U.S. Geological Survey Open-File Report 83-825, 52 p.

Black, G.L., Priest, G.R., and Woller, N.M., 1984, Temperature data and drilling history of the Sandia National Laboratories well at Newberry caldera: Oregon Department of Geology and Mineral Industries, Oregon Geology, v. 46, no. 1, p. 7-9.

Fitterman, D.V., 1983a, Results of time-domain electromagnetic soundings at Newberry volcano, Oregon [abs.]: EOS (American Geophysical Union Transactions), v. 64, p. 899.

——— 1983b, Time-domain electromagnetic soundings of Newberry volcano, Deschutes County, Oregon: U.S. Geological Survey Open-File Report 83-832, 64 p.

Keith, T.E.C., Mariner, R.H., Bargar, K.E., Evans, W.C., and Presser, T.S., 1984, Hydrothermal alteration in drill hole Newberry 2, Oregon: Fluid chemistry and secondary mineral distribution: Geothermal Resources Council Bulletin, in press.

Leaver, D.S., Mooney, W.D., and Kohler, W.M., 1984, A refraction study of the Oregon Cascades: Journal of Geophysical Research, in press.

MacLeod, N.S., Sherrod, D.R., and Chitwood, L.A., 1982, Geologic map of Newberry volcano, Deschutes, Klamath, and Lake Counties, Oregon: U.S. Geological Survey Open-File Report 82-847, 27 p., scale 1:62,500.

Neuendorf, K.K.E., Mahoney, K.E., and Staub, P.E., 1982, Theses and dissertations on the geology of Oregon. Bibliography and index, 1899-1982: Oregon Department of Geology and Mineral Industries Special Paper 11, 16 p.

Oregon Department of Geology and Mineral Industries, 1984, Heat-flow map of the Cascade Range of Oregon and index map of mapping in the Oregon Cascades: Oregon Department of Geology and Mineral Industries Open-File Report O-84-4, 2 maps.

Priest, G.R., 1983, Geology of the Newberry volcano area, Deschutes County, Oregon, *in* Priest, G.R., Vogt, B.F., and Black, G.L., eds., Survey of potential geothermal exploration sites at Newberry volcano, Deschutes County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-83-3, p. 5-20.

Priest, G.R., Hadden, R.M., Woller, N.M., and Brand, C.B., 1983a, Preliminary soil-mercury survey of Newberry volcano, Deschutes County, Oregon, *in* Priest, G.R., Vogt, B.F., and Black, G.L., eds., Survey of potential geothermal exploration sites at Newberry volcano, Deschutes County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-83-3, p. 45-67.

Priest, G.R., and Vogt, B.F., eds., 1982, Geology and geothermal resources of the Cascades, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-82-7, 206 p.

——— 1983, Geology and geothermal resources of the central Oregon Cascade Range: Oregon Department of Geology and Mineral Industries Special Paper 15, 123 p.

Priest, G.R., Vogt, B.F., and Black, G.L., eds., 1983b, Survey of potential geothermal exploration sites at Newberry volcano, Deschutes County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-83-3, 174 p.

Sammel, E.A., 1983, The shallow hydrothermal system at Newberry volcano, Oregon: A conceptual model: Geothermal Resources Council Transactions, v. 7, p. 325-330.

Sammel, E.A., and Craig, R.W., 1983, Hydrology of the Newberry volcano, Oregon: U.S. Geological Survey Water-Resources Investigations Report 83-4091, 52 p.

Schumacher, C.A., 1981, Index to published geologic mapping in Oregon, 1898-1979: Oregon Department of Geology and Mineral Industries Geologic Map Series GMS-14, 6 sheets, scale 1:1,000,000.

Williams, D.L., and von Herzen, R.P., 1983, On the terrestrial heat flow and physical limnology of Crater Lake, Oregon: Journal of Geophysical Research, v. 88, no. B2, p. 1094-1104. □

GRC annual meeting announced

The 1984 annual meeting of the Geothermal Resources Council will be held August 26-29 at the MGM Grand Hotel in Reno, Nevada.

The three-day meeting will include a technical program consisting of oral and poster presentations, special sessions, commercial and educational events, luncheons, special events, a guest program, and both pre- and post-meeting field trips.

There will also be a display of the winning entries in the fifth annual photograph contest. Winning photos automatically become candidates for use as a cover on the GRC Bulletin. Entries for this contest must be submitted by July 6, 1984, to the Geothermal Resources Council, 111 G Street, Suite 29, or P.O. Box 1350, Davis, CA 95617-1350. Use this address, or phone (916) 758-2360, also to obtain further information about the contest or the annual meeting. □

Did you know...

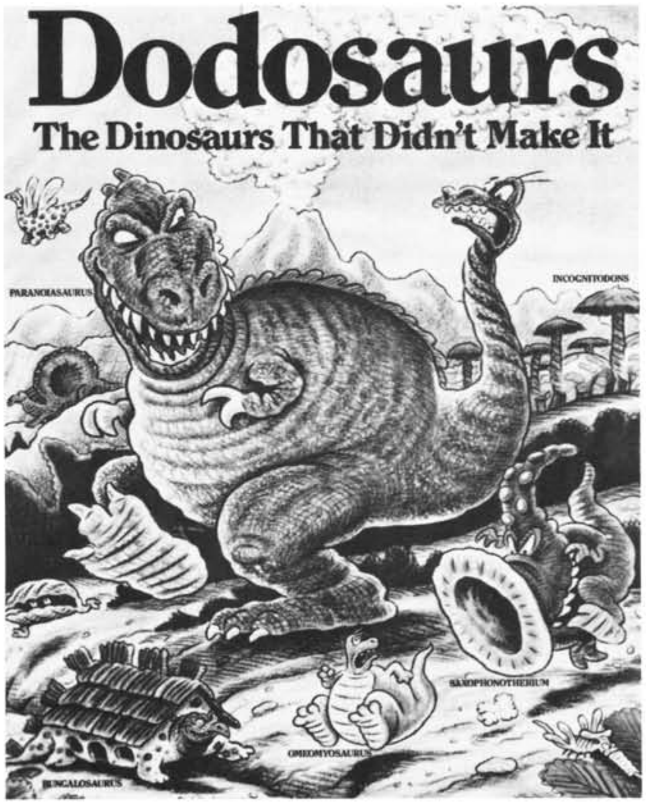
...that you can receive monthly information about the new publications of the U.S. Geological Survey—just for the asking? Just send your request to be placed on the list of subscribers for *New Publications of the Geological Survey* to National Mapping Division, National Center, Mail Stop 582, Reston, VA 22092. □

BOOK REVIEW

by Ralph S. Mason, former State Geologist

Dodosaurs. The Dinosaurs That Didn't Make It, by Rick Meyerowitz and Henry Beard, New York, Harmony Books, 1983, 63 p. $7.95.

Deadly serious, truly scientific publications are easy to review, even though they may be deadly dull. Science is usually quantifiable and dependable, and scientific writers rarely stray very far from home base. *Dodosaurs*, on the other hand, is none of these. The author, who is a cofounder of the Harvard *Lampoon*, and the illustrator, who has also done artwork for the *Lampoon*, *Time*, and *Newsweek*, have apparently thrown their bonnets over the windmill, as the saying goes, kicked over the traces, and taken off into the wild blue yonder in a flying machine constructed of pure whimsy and powered by 180-spoof fuel. And there you have it.



Part of jacket design for Dodosaurs, *featuring the giant Paranoiasaurus, whose carnivorous front end posed a constant threat to his herbivorous rear end and who is surrounded here by, in the foreground, such smaller creatures as a Clamphibian, a Bungalosaurus, the ever-fearful Omeomyosaurus, a Saxophonotherium, and, in the background, a herd of Incognitodons (no, that's not a forest!), a Kaleidoscophus, and a Polychromodon.*

The naturalist-author Gerald Durrell once claimed he had a zoo in his suitcase. These guys not only have a zoo in a book but have invented a whole new geologic time chart and geographic area to accommodate their wildly imaginative prehistoric denizens. Unlikely animals glare at one in full color from every page, while the rather sparse text tries to explain how, when, and where they lived, but skillfully avoids why. The Dodosaurs, according to the author, lived on a land mass called Extragaea during the Moronic, Idiotic, and Preposterous geologic periods. The Dodosaurs belonged to a separate class of animals, the Ineptiles, some of whom had tired blood, assured their own oblivion by sporting self-defeating physical conformations such as having two tails and no head, two heads and no tail, and everything, or nothing, in between. For instance the Chopstichthyosaur was outfitted with, you guessed it, chopsticks for eating, while the Triunclogosincus looked suspiciously like that necessary household appliance, the "plumber's helper."

How do you treat a book such as this? Take it seriously, finding deeply hidden truisms visible only to the select few, or play it for laughs, chuckle at the witticisms and funny drawings, and then put it down and get back to perusing the *Wall Street Journal*? Maybe a bit of both. Believe it or not, there is quite a bit of sound historical geology tucked away in the text, but it is overshadowed by the absurdities created and flaunted everywhere in this large-format book. At first blush, *Dodosaurs* looks like a fanciful picture book

The authors of Dodosaurs, *pondering a model of the majestic Blunderdon ("almost ninety feet from the tip of its tail to the tip of its tail"): "Considering its monumental defects, if it were alive today, it would almost certainly be dead." (Illustration by Rick Meyerowitz, © 1983)*

for primary kids, and doubtless they would laugh all the way through the merry menagerie. Adults will smile at the nutty nomenclature, but the loudest guffaws will undoubtedly arise from the professional geology community, since the memory of not-so-funny-at-the-time boners by other professionals (remember the Piltdown Hoax?) may be revived here. And lastly, some of those same experts will ask themselves reproachfully "Why didn't I think of this before they did?" This brings us to the close of the Preposterous. □

Workshop on geothermal economics announced

The Geothermal Resources Council and the U.S. Department of Energy are sponsoring a workshop on geothermal economics and related institutional factors, May 21-23, 1984, in Palm Springs, California. The workshop fee is $100.

The workshop is intended primarily for those actively involved in the development of geothermal energy and, in particular, those developing funding programs for power plants. It is recommended also for geologists, reservoir and design engineers, attorneys, accountants, economists, and employees of financial houses.

For information and registration, call (800) 525-3587 (in Colorado 337-4809) on weekdays between 9:00 a.m. and 8:00 p.m. (Mountain Time), or write to GRC-Convention Center, 2323 S. Troy, Suite 105B, Aurora, CO 80014. □

ORDER FORM — CUT ON DASHED LINE

Available publications

BULLETINS	Price	No. Copies	Amount
33. Bibliography (1st supplement) geology and mineral resources of Oregon, 1947: Allen	$ 3.00		
35. Geology of the Dallas and Valsetz quadrangles, rev. 1964: Baldwin (map only)	3.00		
36. Papers on Tertiary foraminifera: Cushman, Stewart, and Stewart, 1949: v. 2	3.00		
44. Bibliography (2nd supplement) geology and mineral resources of Oregon, 1953: Steere	3.00		
46. Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey	3.00		
49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch	3.00		
53. Bibliography (3rd supplement) geology and mineral resources of Oregon, 1962: Steere and Owen	3.00		
61. Gold and silver in Oregon, 1968: Brooks and Ramp	17.50		
62. Andesite Conference guidebook, 1968: Dole	3.50		
65. Proceedings of the Andesite Conference, 1969: (copies)	10.00		
67. Bibliography (4th supplement) geology and mineral resources of Oregon, 1970: Roberts	3.00		
71. Geology of selected lava tubes in Bend area, Oregon, 1971: Greeley (copies)	5.00		
78. Bibliography (5th supplement) geology and mineral resources of Oregon, 1973: Roberts	3.00		
81. Environmental geology of Lincoln County, 1973: Schlicker and others	9.00		
82. Geologic hazards of Bull Run Watershed, Multnomah, Clackamas Counties, 1974: Beaulieu	6.50		
83. Eocene stratigraphy of southwestern Oregon, 1974: Baldwin	4.00		
84. Environmental geology of western Linn County, 1974: Beaulieu and others	9.00		
85. Environmental geology of coastal Lane County, 1974: Schlicker and others	9.00		
87. Environmental geology of western Coos and Douglas Counties, 1975	9.00		
88. Geology and mineral resources of upper Chetco River drainage, 1975: Ramp	4.00		
89. Geology and mineral resources of Deschutes County, 1976: Peterson and others	6.50		
90. Land use geology of western Curry County, 1976: Beaulieu	9.00		
91. Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties, Oregon, 1977: Beaulieu	8.00		
92. Fossils in Oregon (reprinted from *The Ore Bin*), 1977	4.00		
93. Geology, mineral resources, and rock material of Curry County, Oregon, 1977	7.00		
94. Land use geology of central Jackson County, Oregon, 1977: Beaulieu	9.00		
95. North American ophiolites, 1977	7.00		
96. Magma genesis: AGU Chapman Conference on Partial Melting, 1977	12.50		
97. Bibliography (6th supplement) geology and mineral resources of Oregon, 1971-75, 1978	3.00		
98. Geologic hazards of eastern Benton County, Oregon, 1979: Bela	9.00		
99. Geologic hazards of northwestern Clackamas County, Oregon, 1979: Schlicker and Finlayson	10.00		
100. Geology and mineral resources of Josephine County, Oregon, 1979: Ramp and Peterson	9.00		
101. Geologic field trips in western Oregon and southwestern Washington, 1980	9.00		
102. Bibliography (7th supplement) geology and mineral resources of Oregon, 1976-1979, 1981	4.00		
GEOLOGIC MAPS			
Reconnaissance geologic map of Lebanon quadrangle, 1956	3.00		
Geologic map of Bend quadrangle and portion of High Cascade Mountains, 1957	3.00		
Geologic map of Oregon west of 121st meridian (USGS I-325), 1961	5.50		
Geologic map of Oregon east of 121st meridian (USGS I-902), 1977	5.50		
GMS-4: Oregon gravity maps, onshore and offshore, 1967 (folded)	3.00		
GMS-5: Geologic map of Powers quadrangle, Oregon, 1971	3.00		
GMS-6: Preliminary report on geology of part of Snake River Canyon, 1974	6.50		
GMS-8: Complete Bouguer gravity anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00		
GMS-9: Total field aeromagnetic anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00		
GMS-10: Low- to intermediate-temperature thermal springs and wells in Oregon, 1978	3.00		
GMS-12: Geologic map of the Oregon part of the Mineral quadrangle, 1978	3.00		
GMS-13: Geologic map of the Huntington and part of the Olds Ferry quadrangles, Oregon, 1979	3.00		
GMS-14: Index to published geologic mapping in Oregon, 1898-1979, 1981	7.00		
GMS-15: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, northern Oregon, 1981	3.00		
GMS-16: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, southern Oregon, 1981	3.00		
GMS-17: Total-field aeromagnetic anomaly map, Cascade Mountain Range, southern Oregon, 1981	3.00		
GMS-18: Geology of the Rickreall, Salem West, Monmouth, and Sidney 7½-minute quadrangles, Marion, Polk, and Linn Counties, Oregon, 1981	5.00		
GMS-19: Geology and gold deposits map of the Bourne quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-20: Map showing geology and geothermal resources of the southern half of the Burns 15-minute quadrangle, Oregon, 1982	5.00		
GMS-21: Geology and geothermal resources map of the Vale East 7½-minute quadrangle, Oregon, 1982	5.00		
GMS-22: Geology and mineral resources map of the Mt. Ireland quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-23: Geologic map of the Sheridan quadrangle, Polk and Yamhill Counties, Oregon, 1982	5.00		
GMS-24: Geologic map of the Grand Ronde quadrangle, Polk and Yamhill Counties, Oregon, 1982	5.00		
GMS-25: Geology and gold deposits map of the Granite quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-26: Residual gravity maps of the northern, central, and southern Cascade Range, Oregon, 1982	5.00		
GMS-27: Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1° by 2° quadrangle, 1982	6.00		
GMS-28: Geology and gold deposits map of the Greenhorn quadrangle, Baker and Grant Counties, Oregon, 1983	5.00		
GMS-29: Geology and gold deposits map, NE¼ Bates quadrangle, Baker and Grant Counties, Oregon, 1983	5.00		
OIL AND GAS INVESTIGATIONS			
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well	3.00		
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well, 1973	3.00		
5. Prospects for natural gas production or underground storage of pipeline gas, upper Nehalem River Basin, Columbia-Clatsop Counties, Oregon, 1976	5.00		
6. Prospects for oil and gas in the Coos Basin, western Coos, Douglas, and Lane Counties, Oregon, 1980: Newton and others	9.00		
7. Correlation of Cenozoic stratigraphic units of western Oregon and Washington, 1983	8.00		
NEW! 9. Subsurface biostratigraphy of the east Nehalem Basin, 1983: McKeel	6.00		

Available publications (continued)

SPECIAL PAPERS	Price	No. Copies	Amount
1. Mission, goals, and programs of Oregon Department of Geology and Mineral Industries, 1978	3.00	_____	_____
2. Field geology of SW Broken Top quadrangle, Oregon, 1978: Taylor	3.50	_____	_____
3. Rock material resources of Clackamas, Columbia, Multnomah, and Washington Counties, Oregon, 1978: Gray and others	7.00	_____	_____
4. Heat flow of Oregon, 1978: Blackwell, Hull, Bowen, and Steele	3.00	_____	_____
5. Analysis and forecasts of the demand for rock materials in Oregon, 1979: Friedman and others	3.00	_____	_____
6. Geology of the La Grande area, Oregon, 1980: Barrash and others	5.00	_____	_____
7. Pluvial Fort Rock Lake, Lake County, Oregon, 1979: Allison	4.00	_____	_____
8. Geology and geochemistry of the Mt. Hood volcano, 1980: White	3.00	_____	_____
9. Geology of the Breitenbush Hot Springs quadrangle, Oregon, 1980: White	4.00	_____	_____
10. Tectonic rotation of the Oregon Western Cascades, 1980: Magill and Cox	3.00	_____	_____
11. Theses and dissertations on the geology of Oregon: Bibliography and index, 1899-1982, 1982: Neuendorf and others	6.00	_____	_____
12. Geologic linears of the northern part of the Cascade Range, Oregon, 1980: Venkatakrishnan, Bond, and Kauffman	3.00	_____	_____
13. Faults and lineaments of the southern Cascades, Oregon, 1981: Kienle, Nelson, and Lawrence	4.00	_____	_____
14. Geology and geothermal resources of the Mount Hood area, Oregon, 1982: Priest and Vogt	7.00	_____	_____
15. Geology and geothermal resources of the central Oregon Cascade Range, 1983: Priest and Vogt	11.00	_____	_____
16. Index to the *Ore Bin* (1939-1978) and *Oregon Geology* (1979-1982), 1983: Mahoney and Steere	4.00	_____	_____
SHORT PAPERS			
21. Lightweight aggregate industry in Oregon, 1951: Mason	1.00	_____	_____
24. The Almeda Mine, Josephine County, Oregon, 1967: Libbey	3.00	_____	_____
25. Petrography, type Rattlesnake Formation, central Oregon, 1976: Enlows	3.00	_____	_____
27. Rock material resources of Benton County, 1978: Schlicker and others	4.00	_____	_____
MISCELLANEOUS PAPERS			
1. A description of some Oregon rocks and minerals, 1950: Dole	1.00	_____	_____
5. Oregon's gold placers (reprints), 1954	1.00	_____	_____
8. Available well records of oil and gas exploration in Oregon, rev. 1982: King, Olmstead, and Newton	4.00	_____	_____
11. Collection of articles on meteorites, 1968 (reprints from *The Ore Bin*)	3.00	_____	_____
15. Quicksilver deposits in Oregon, 1971: Brooks	3.00	_____	_____
17. Geologic hazards inventory of the Oregon coastal zone, 1974: Beaulieu, Hughes, and Mathiot	5.00	_____	_____
18. Proceedings of Citizens' Forum on potential future sources of energy, 1975	3.00	_____	_____
19. Geothermal exploration studies in Oregon – 1976, 1977	3.00	_____	_____
20. Investigations of nickel in Oregon, 1978: Ramp	5.00	_____	_____
MISCELLANEOUS PUBLICATIONS			
Landforms of Oregon (17 × 12 inches)	1.00	_____	_____
Mining claims (State laws governing quartz and placer claims)	1.00	_____	_____
Geological highway map, Pacific NW region, Oregon-Washington (published by AAPG)	5.00	_____	_____
Geothermal resources of Oregon map, 1982 (published by NOAA)	3.00	_____	_____
Back issues of *The Ore Bin*	50¢ over the counter; $1.00 mailed	_____	_____
Back issues of *Oregon Geology*	75¢ over the counter; $1.00 mailed	_____	_____
Colored postcard, *Geology of Oregon*	10¢ each; 3 for 25¢; 7 for 50¢; 15 for $1.00	_____	_____
Oregon Landsat mosaic map, 1983 (published by ERSAL, OSU)	$8.00 over the counter; $11.00 mailed	_____	_____

Separate price lists for open-file reports, geothermal energy studies, tour guides, recreational gold mining information, and non-Departmental maps and reports will be mailed upon request.

OREGON GEOLOGY

1005 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

PUBLICATIONS ORDER

Minimum mail order $1.00. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $50.00. Foreign orders: please remit in U.S. dollars.

Fill in appropriate blanks and send sheet to Department.

YOUR NAME ______________________

ADDRESS ______________________

______________________ Zip______

Amount enclosed $______

OREGON GEOLOGY

____ Renewal ____ New Subscription ____ Gift

____ 1 Year ($6.00) ____ 3 Years ($15.00)

NAME ______________________

ADDRESS ______________________

______________________ ZIP ______

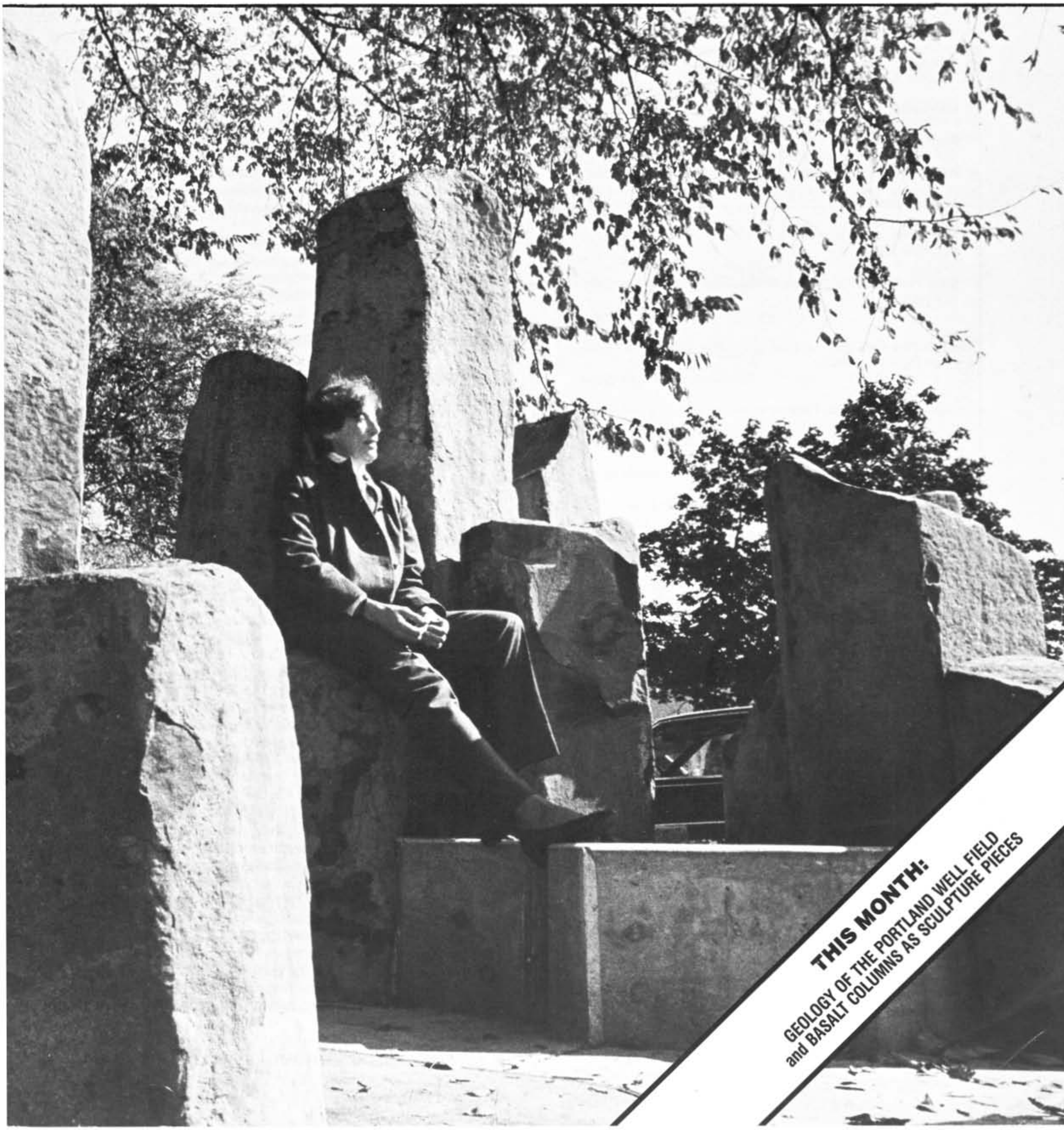
(If Gift, From: ______________________)

OREGON GEOLOGY

published by the

Oregon Department of Geology and Mineral Industries

VOLUME 46, NUMBER 6 JUNE 1984



THIS MONTH:

GEOLOGY OF THE PORTLAND WELL FIELD
and BASALT COLUMNS AS SCULPTURE PIECES

OREGON GEOLOGY

(ISSN 0164-3304)

VOLUME 46, NUMBER 6 JUNE 1984

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

Main Office: 1005 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133.
Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496.
Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039.
Paul F. Lawson, Supervisor

Subscription rates: 1 year, $6.00; 3 years, $15.00. Single issues, $.75 at counter, $1.00 mailed.
Available back issues of *The Ore Bin*: $.50 at counter, $1.00 mailed.

Address subscription orders, renewals, and changes of address to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

Send news, notices, meeting announcements, articles for publication, and editorial correspondence to the editor, Portland office. The Department encourages author-initiated peer review for technical articles prior to submission. Any review should be noted in the acknowledgments.

Second class postage paid at Portland, Oregon.
Postmaster: Send address changes to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

COVER PHOTO

Basalt columns from the Eugene, Oregon, area compose this sculpture in a Corvallis, Oregon, park. The intended practical use of the sculpture is demonstrated here by Corvallis art historian Marie Louise Martignoni. See related article beginning on page 68. (Photo courtesy John Bragg, *Corvallis Gazette-Times*)

To our readers

Many thanks to the over 300 of you who responded to the questionnaire in the April issue of *Oregon Geology*. Your willingness to spend your time and a 20¢ stamp to share your ideas about *Oregon Geology* with us warmed our hearts.

When the questionnaires have been completely tabulated, we will share the results with you. We are about a third of the way through the tabulation, and we have already learned that you are an interesting group filled with all sorts of good ideas. One theme runs through all your comments—you want to learn as much as you can about some or all aspects of the geology of Oregon. We appreciate that desire, and we will try to pack as much as we can into each issue of *Oregon Geology*.

Many of you indicated your understanding of the problem of satisfying both technical and nontechnical audiences in one magazine. You had some good suggestions on ways to do that, and we will try to implement those ideas as the months go by. We try to maintain a balance of technical and nontechnical material in *Oregon Geology*, and as many of our feature articles and announcements come from you, our readers, we invite authors of both types of articles to submit their work to us.

As always, we invite letters, comments, papers, phone calls—any type of communication from you. *Oregon Geology* is your magazine, and we want it to meet your needs. We want it to be a clearing house of geologic information about the state of Oregon, and we need your help for that. □

New geologic map of eastern Oregon gold-mining country released

A new geologic map of the northwest portion of the Bates 15-minute quadrangle in eastern Oregon has just been published by the Oregon Department of Geology and Mineral Industries (DOGAMI). The new map, *Geology and Gold Deposits Map of the Northwest Quarter of the Bates Quadrangle, Baker and Grant Counties, Oregon*, by Mark L. Ferns, Howard C. Brooks, and Greg R. Wheeler, has been released as Map GMS-31 in DOGAMI's Geological Map Series.

This new map is the latest eastern Oregon gold-country geologic map produced by DOGAMI in cooperation with and funded in part by the U.S. Forest Service. Earlier maps of this series, which are also available from DOGAMI, include the Bullrun Rock, Rastus Mountain, Bourne, Mount Ireland, Granite, and Greenhorn 7½-minute quadrangles and the Mineral, Huntington, Olds Ferry, and the northeast portion of the Bates 15-minute quadrangles.

The four-color geologic map of the Bates NW quadrangle is at a scale of 1:24,000. It shows sedimentary, volcanic, and metamorphic geologic units that were deposited or formed over a period of time extending from the present day back to the pre-Permian (more than 280 million years ago). The geology of this area is very complex, and two cross sections are included to show the relationships of the 14 geologic units presented on the map.

Parts of this area have been mineralized, and the map area includes the former New Eldorado mining district. The map shows the locations of numerous mines, prospects, and quartz veins. Also included on the map sheet are one data table of mines and prospects, one table with chemical analyses of rock samples, a discussion of the mineral deposits in this portion of the quadrangle, and a list of references about the area.

The new map, GMS-31, is now available at the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, 1400 SW Fifth Avenue, Portland, OR 97201. The purchase price is $5. Orders under $50 require pre-payment. □

Geology of the Portland Well Field

by W.H. Hoffstetter, Portland Water Bureau, 1120 SW 5th Ave., Portland, OR 97204

INTRODUCTION

The Portland Well Field (Figure 1) is one of the nation's largest ground-water development programs. It is designed to provide emergency water in case something happens to the Bull Run Watershed, the current major source of water, and to meet peak demand for water during periods of heavy usage. Water-right applications have been filed for over forty production wells with a combined yield of over 150 million gallons per day. Twenty production wells have been constructed with capacities ranging from 1,000 to 10,000 gpm (gallons per minute), producing from fluvial-lacustrine aquifers 100 to 600 ft below ground level. The water rights are being obtained by several municipal suppliers including the Portland Water Bureau, the Parkrose Water District, and the Rockwood Water District. The water will be used for both residential and industrial purposes.

The well field is located in east Portland along the ancestral Columbia River flood plain between the Portland Airport and Blue Lake Park. The area is generally below 30 ft in elevation and contains several sloughs and lakes. Aquifers being developed consist of alluvium with particle sizes of fine sand to coarse gravel with boulders. The ages of the deposits range from Miocene to Recent. Transmissivities range from 20,000 to over 1 million gpd/ft (gallons per day per foot).

The water quality has proven to be good for the intended use. Specific conductivities are mostly from 150 to 400 μohms/cm, with calcium, silica, sodium, magnesium, and potassium as the dominant ions. The ground water reportedly has a very good taste.

Geologic and geophysical logging, combined with hydraulic testing, have allowed delineation of the sedimentary deposits. Prior

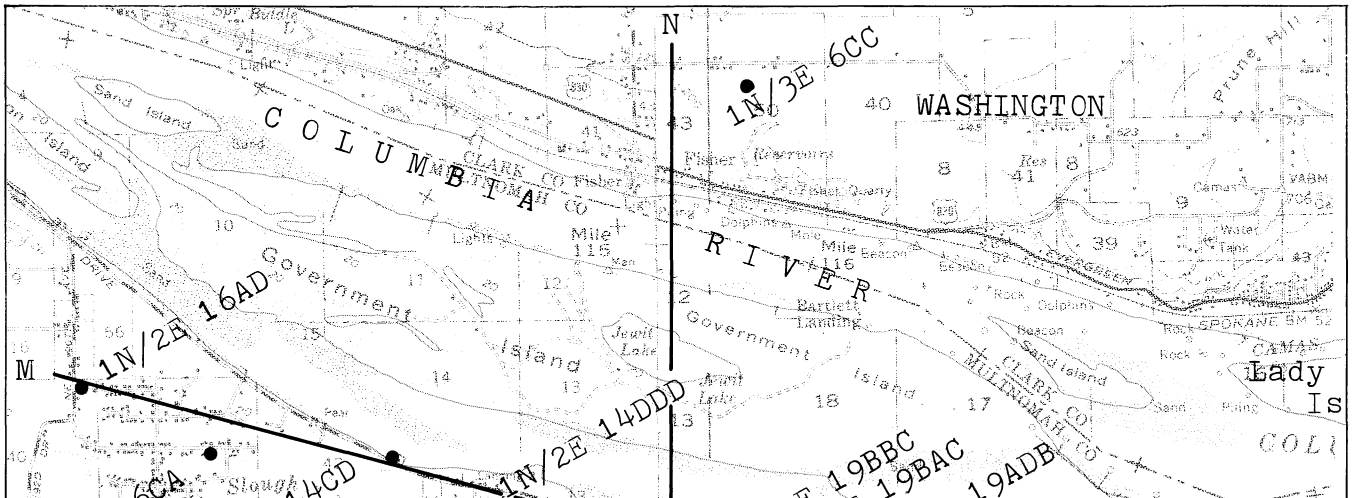


Figure 1. Map showing well locations in the Portland Well Field. Cross sections M-M' and N-S are shown in Figure 3.

to the construction of the well field, a geologic study of the northeast Portland area was completed by Robert Willis and Diane Partch for the Portland Water Bureau exploratory well study (Willis, 1977). Results of this study indicated that the best potential for production wells existed along the ancestral flood plain of the Columbia River. Eleven pilot wells were drilled and test-pumped by the Portland Water Bureau. Detailed cross sections and a geologic study were made by this writer and included in the Portland Water Bureau's pilot well study (Willis, 1979). The cross sections and geology contained in this report include results of more recent well-drilling and test-pumping programs.

WELL-FIELD GEOLOGY

Older bedrock units in the east Portland area consist of Miocene Columbia River Basalt Group flows and Eocene Skamania Volcanics (Figure 2). The Skamania Volcanics crop out on Lady Island to the east of the well field. Although Columbia River basalt has been interpreted to underlie the well field at depth, drilling has reached a depth of over 1,100 ft below mean sea level (MSL) in the well field without encountering any of the flows. The basalt probably underlies the area at a greater depth, unless it is not present due to erosion or initial exclusion from this area. During the deposition of the basalt, a topographic high of Skamania Volcanics which may have existed in the north part of the well-field area could have caused the flood basalts to flow around it to the south. By the end of Columbia River basalt deposition in the Portland area (about 14 million years ago), the topography of the east Portland area probably consisted of a small range of Skamania Volcanics to the north surrounded by a plain of Columbia River basalt. Because of the lack of deep drilling in the Portland Basin, the actual contact between the Skamania Volcanics and the Columbia River basalt has not been located. The contact could be as far north as the Columbia River or slightly farther to the south. The Ladd well (circa 1885, located several miles to the west of the well field) encountered a unit at 1,100 ft below MSL that was originally logged as solid granite. This unit has been interpreted subsequently to be Columbia River basalt and is the basis for Trimble's (1963) cross section of the Portland Basin.

During or after the deposition of the Columbia River basalt, a basin was formed in the Portland area. The basin is structural in origin but could have been locally deepened by erosion along the contact between the basalt and the less competent Skamania Volcanics. The depth of the basin is unknown but is at least 1,100 ft, based on the Ladd well located near SE 39th and Glisan (Hodge, 1938) and on the Portland Water Bureau exploratory well near NE 185th and Marine Drive.

The Portland Basin was filled by fluvial-lacustrine deposits and local lava flows during the Miocene and Pliocene. These deposits, in order of deposition, are the Sandy River Mudstone, the Troutdale Formation, and the Boring Lavas. The sedimentary deposition filled the basin to an elevation of about 700 ft, based on erosional remnants including Mount Tabor, Rocky Butte, and Powell Butte (Allen, 1975).

Erosional forces took control once again in the late Pliocene or early Pleistocene. Much of the Troutdale Formation deposits was removed to an elevation of roughly 100 to 200 ft above present sea level (Mundorff, 1959). Erosion and deposition alternated in the basin as the base level rose and fell during the Pleistocene.

Boring Lava eruptions continued into the Pleistocene, producing numerous volcanic vents and lava flows in the eastern portion of the Portland Basin (Allen, 1975). The lava flows also contributed hyaloclastic material that formed the numerous vitric sand beds in the well field. The Boring Lava flows resisted later erosion and contributed to the formation of the buttes and hills in the eastern portion of the basin. Boring intrusions are associated with these buttes in east Portland. Beeson and Nelson (1979) suggested that geothermal convection within the Troutdale Formation around these vents caused solution and precipitation of silica in the Troutdale Formation, making the vent areas more resistant to erosion.

The most recent episode of erosion and deposition is illustrated by logs of several wells located near the east end of the Portland Airport. These wells encountered a Fraser Glaciation river valley that had been eroded to 300 ft below MSL approximately 15,000 years ago and then had been filled with sand as the sea level rose during the Holocene.

Alluvium	Recent to upper Pleistocene
Boring Lava	Pleistocene to Pliocene
Troutdale Formation.	Pleistocene to Miocene
Sandy River Mudstone	Pliocene to Miocene
Columbia River Basalt Grp. .	Miocene
Skamania Volcanics	Eocene

Figure 2. Major geologic units found in the Portland Well Field and vicinity. Several of these units are subdivided in the text.

The present river geography is similar to that found by the Lewis and Clark expedition and other early explorers. The main channel of the river is controlled to some extent by bed rock in the area to the east of NE 185th Avenue. Resistant beds of the Troutdale Formation and coarse gravel and boulders of the Blue Lake aquifer force the main channel of the river to the northwest near Blue Lake Park. The river is entrenched between outcrops of the Skamania Volcanics near Washougal, Washington. In the study area, the Columbia River is presently an aggrading stream, and tidal fluctuations are measurable in the river adjacent to the well field.

Cross sections and outcrops in the well-field area (Figure 3) indicate a general southwest dip to the older units. It should be noted, however, that part of the apparent structural deformation on the cross sections may be due to normal fluvial processes such as nesting of fills. Outcrops of the Troutdale Formation which occur from Blue Lake to NE 185th Avenue show only poorly developed, wide-spaced jointing without displacement. The jointing is probably from stress release and is not of the magnitude that would indicate faulting in this locality.

GEOLOGIC UNITS

Introduction

The following geologic units were delineated in the well field on the basis of lithology, geophysical logging, and hydraulic testing. Gamma-ray logs were especially useful for differentiating units (Figure 4) and for correlating between wells.

Recent and upper Pleistocene alluvium

Younger alluvium: This unit is represented by (1) flood-plain deposits, (2) a late Pleistocene river valley that was backfilled during the Holocene, and (3) a deposit of coarse-grained fluvial deposits located to the north and east of Blue Lake.

Recent flood-plain deposits: These deposits consist of unconsolidated layers of silt, clayey silt, and sand. The thickness of these deposits is variable, but the unit generally thickens to the north from Sandy Boulevard to the Columbia River. The maximum recorded thickness is 70 ft at well 1N/3E 19BAC. The lower portion of the flood-plain deposits is probably related to the Columbia River sands group as described by Willis (1979).

Columbia River sands aquifer (CRSA): This unit that fills a Pleistocene Columbia River valley is composed of late Pleistocene and Holocene sand. The aquifer was previously considered to be

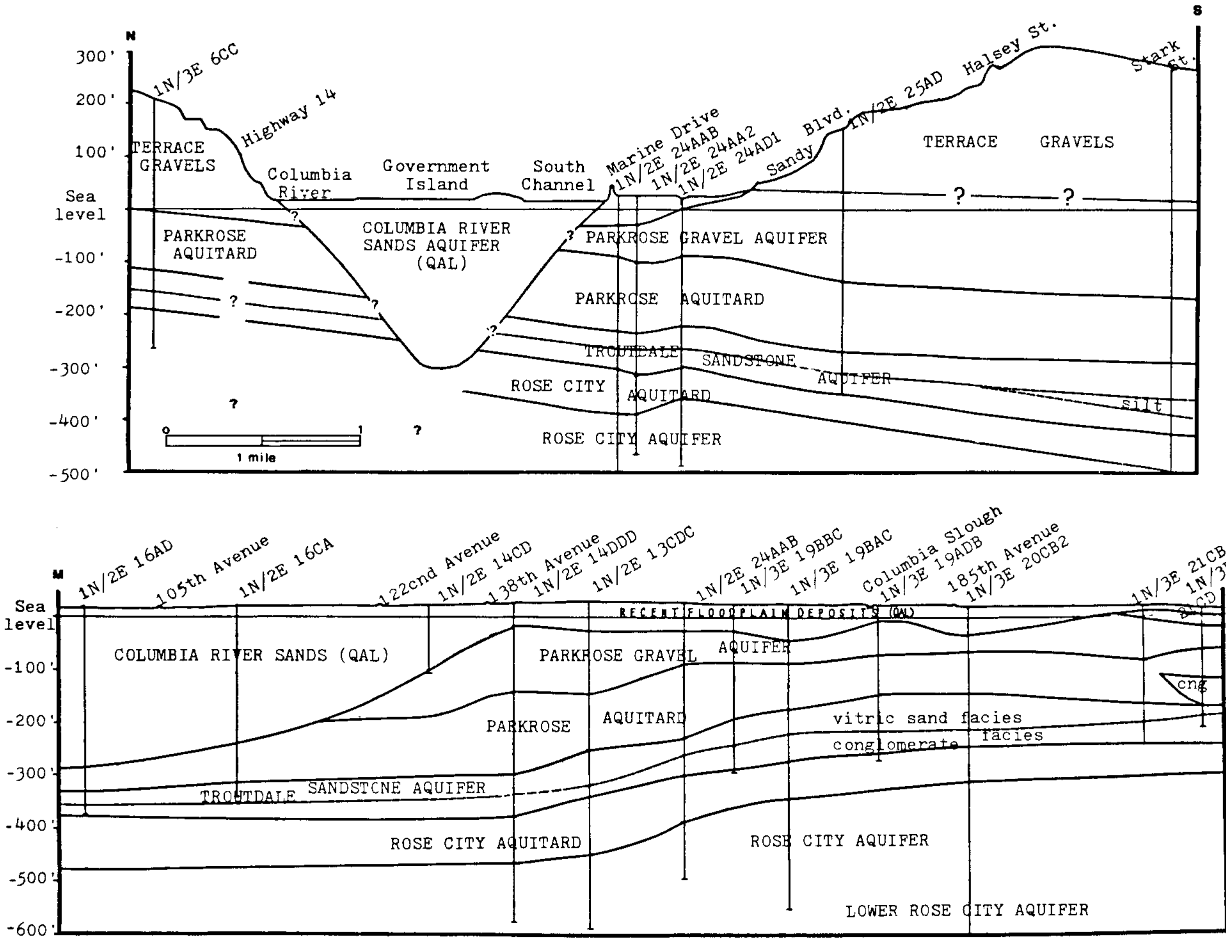


Figure 3. Cross sections N-S and M-M' of the Portland Well Field. Locations of cross-section lines are shown in Figure 1. The unmarked well on the right side of N-S line is well 1N/2E 31CD.

approximately 200 ft thick (Hogenson and Foxworthy, 1965). However, a Portland Water Bureau pilot well (1N/2E 15BC) encountered a thickness of approximately 300 ft. The elevation of the bottom of the CRSA in this well is about 300 ft below MSL, which correlates well with the elevations of Fraser Glaciation erosional valleys along coastlines in other areas (Milliman and Emery, 1968). The CRSA consists of medium sand, with occasional layers of silt, clay, and gravelly zones. The sand is quartzose in composition, and the gravel is basalt, andesite, dacite, and quartzite. A carbon-14 age for a wood sample from Portland Water Bureau well 1N/2E 15BC, depth 200-300 ft, was 8,910±115 years (Willis, 1979).

Blue Lake aquifer: This coarse-grained fluvial deposit contains mostly coarse gravel with some cobbles and boulders. The large grain sizes in the aquifer, combined with the lack of cementing and matrix material, provide a very high permeability, and several wells with yields of up to 10,000 gpm are planned. The thickness of the aquifer increases to the north from Blue Lake to the Columbia River, with a maximum recorded thickness of about 200 ft. The Blue Lake aquifer deposits are distinguishable from older deposits by higher percentages of clasts from the High Cascades, the lack of cementation, and the absence of the thin secondary mineralization present on older clasts. An aquifer of similar composition to the Blue Lake aquifer is used extensively by the Crown Zellerbach paper mill in the Camas-Washougal, Washington, area (Hoffstetter, 1981).

Parkrose gravel aquifer (PGA): This unit consists of a thick layer of coarse-grained fluvial deposits. The unit underlies most of the well field area to the east of NE 122nd Avenue. In the vicinity of the Portland airport, the PGA has been partially to entirely eroded by the Pleistocene Columbia River. The PGA generally thickens from east to west, with the maximum thickness of 125 ft recorded at Portland Water Bureau well 11(1N/2E 14DDD). The aquifer consists of coarse sand and gravel, with zones containing cobbles and boulders. A silty matrix which is present in some areas severely limits the amount of water obtainable from some wells. In other areas, the gravels are open and yield several thousand gallons per minute. The lower portion of the aquifer is commonly partially cemented, and the clasts are similar to those of the Pleistocene terrace gravels. The upper portion of the aquifer has been reworked locally by the Columbia River, and numerous clasts of High Cascade composition occur in some of the reworked gravels.

Troutdale Formation (Miocene-Pleistocene)

Introduction: The Troutdale Formation in the well field consists of Pleistocene, Pliocene, and upper Miocene fluvial-lacustrine deposits of partially cemented sand, sandstone, and conglomerate, with indurated silts and clays. The formation underlies Recent and upper Pleistocene deposits throughout the study area. Two major aquifers and two major aquitards (semiconfining units of low permeability) have been delineated within the Troutdale Formation. The maximum thickness of this sequence in the well field is over 600 ft.

This sequence is identified as part of the Troutdale Formation because of the presence of basalt and quartzite gravels and clasts of vitric composition, the partial cementation, and the low percentage of High Cascade andesite-dacite clasts. Carbon-14 dates show well-field samples from the units identified as Troutdale Formation to be over 40,000 years old, which is the age limit for carbon-14 dating. No fossil correlations have been attempted in the well-field area, and there is some controversy about whether or not the sediments may be younger than the Troutdale Formation. This controversy stems from the fact that the well samples appear less weathered and do not have the yellowish matrix typical of Troutdale Formation outcrops. The absence of the yellowish matrix is possibly caused by the relative reducing environment in the wells as compared to the oxidizing environment at outcrops.

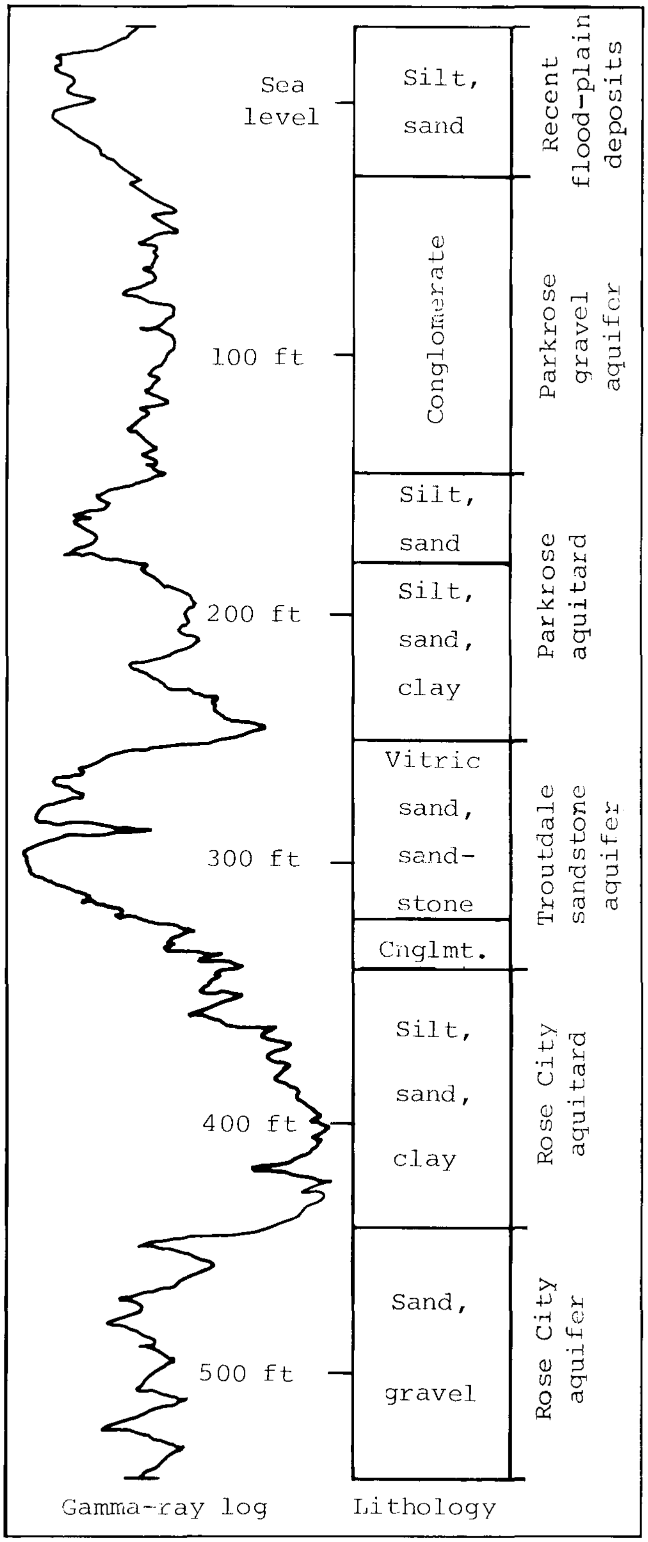


Figure 4. Typical lithologic section located near NE 148th Avenue and Marine Drive.

There is some question about the distinction between Troutdale Formation, Sandy River Mudstone, and younger deposits. Hodge (1938) believed that micaceous sands found in the Ladd well near SE 39th Avenue and Glisan Street indicated that the sequence was post-Troutdale because, as he stated, "Micaceous sands are not found in the Troutdale Formation but are characteristic of the present load of the Columbia River." Trimble (1963) determined that the sequence in this well represented Troutdale Formation underlain by Sandy River Mudstone, with the micaceous sand belonging to the Sandy River Mudstone. Tolan and Beeson (1984) reported micaceous arkosic sands in what they termed the lower member of the Troutdale Formation.

The findings from the well drilling possibly correlate with Tolan and Beeson's (1984) interpretation. That is, the units that are identified as the upper Troutdale Formation contain sand of mostly vitric, basalt-andesite, and quartzite composition, while the lower Troutdale Formation contains mostly micaceous quartzose or arkosic sand. Basalt and quartzite gravels were found in Portland Water Bureau well 1N/3E 20CB2 to a depth of over 1,000 ft below MSL. These findings indicate a possible maximum thickness of over 1,500 ft of Troutdale Formation in the Portland Basin.

The gravels in the well-field samples identified as Troutdale Formation are different from younger gravels in that they have a low percentage of dacite-andesite clasts of the High Cascade composition.

Troutdale sandstone aquifer (TSA): This unit is a relatively uniform deposit of fluvial conglomerate and fluvial-lacustrine vitric sand and sandstone that probably extends throughout a large portion of the basin. The wells proposed for the TSA have yields of 1,000 to 2,000 gpm. Thickness of the TSA varies from 70 to 140 ft, with the lower third of the unit typically consisting of conglomerate and the upper two-thirds consisting of vitric sand and sandstone. Roughly at the midpoint vertically in the aquifer is a thin layer of silt that shows distinctly in gamma-ray logs. This bed separates the aquifer in depositional mode; the vitric sand and sandstone layer above the silt represents a fluvial-lacustrine hyaloclastic deposit, and the lower layer consists of a fluvial conglomerate. The vitric beds interfinger with fine-grained material of the overlying Parkrose aquitard, and it is common for well logs to show several layers of vitric sand or sandstone with silt and clay interbeds in the aquitard. The vitric beds increase in number and thickness in the lower portion of the aquitard.

The vitric beds are composed of clasts of volcanic glass and volcanic crystalline rock ranging in composition from basalt to andesite, with a minor amount of quartz, quartzite, and mica. The glass is usually relatively dense; however, a vesicular, scoriaceous material is occasionally present. Samples of the sand from boreholes typically have a thin, bluish- to greenish-gray coating. The coating is similar to that on the nonvitric basaltic clasts, and beds of over 50 percent vitric material have been passed over in geologic logging in the well field and discovered later by review of gamma logs. Cementing is highly variable. In some boreholes, the vitric material is cemented so tightly that underreaming* must be done to advance casing, while in another zone the sand may be so loose that it heaves up into the casing. The vitric clasts are believed to have originated when lava flowed into water, chilling quickly into glassy fragments that were transported and then deposited by the ancestral Columbia River and its tributaries (Trimble, 1963). An easily seen example of this process is present at an outcrop along

*Underreaming is a drilling operation done when the formation becomes so consolidated that steel casing cannot be driven through it. A special drilling bit that drills an oversize hole is used, thereby allowing the casing to be moved farther down the hole.

Interstate I-84 west of the town of Hood River, where a large volume of lava flowed into the Columbia River, forming a palagonitic tuff that was later partially eroded by the Columbia River (Waters, 1973).

The lava that formed the vitric sand in the well field is probably of early High Cascade and Boring Lava origin; analysis of samples of the vitric sand show that the chemical composition is similar to that of the Boring Lavas (Beeson, personal communication, 1983).

The conglomerate zone of the TSA is composed of basalt and quartzite gravel, with varying amounts of sand. Some cementing is usually visible on the gravel particles, and the same thin, bluish- to greenish-gray coating that occurs on the vitric sand is also present on the gravel clasts.

Although the sand is mostly well sorted and at least partially rounded, both the sorting and rounding vary from one well to another. This is believed to have been caused by variable distances to local volcanic vents contributing material to the sand. This finding is generally in agreement with the conclusions made on the origin of the vitric sand by Trimble (1963).

A wood sample from the TSA was dated by the carbon-14 method at over 40,000 years B.P.

Parkrose and Rose City aquitards: These units are composed of lenticular and interbedded zones of fine-grained, lacustrine deposits of consolidated sand, silt, and clay that act as hydraulic confining layers preventing the rapid movement of water between the Troutdale and Rose City aquifers.

The Parkrose aquitard, which ranges in thickness from about 70 to 150 ft, underlies most of the well field. Consolidation tests were run on samples from the Parkrose aquitard for the Interstate I-205 bridge foundation (CH_2M-Hill, 1979). These tests show that this unit had been previously loaded by at least an additional 700 ft of overburden. The thickness of the ancestral overburden indicates that the Parkrose aquitard was deposited prior to the time the Troutdale Formation reached its maximum thickness in the Portland Basin. The Troutdale Formation is considered to have filled the Portland Basin to a present elevation of approximately 700 ft.

The other major confining layer is the Rose City aquitard, which separates the Troutdale sandstone aquifer and the Rose City aquifer with an average of about 75 ft of consolidated silt, sand, and clay.

Rose City aquifer: This unit consists of discontinuous lenses of sand, gravel, silt, and clay. Pump tests have shown the unit to be continuous throughout the study area, but each well shows a different sequence of materials. Well yields for the Rose City aquifer range from 2,000 to 3,000 gpm.

The unit is several hundred feet thick, and the well samples generally become finer grained with depth. Various mixtures of gravel and sand usually dominate the upper 100 ft of the aquifer, while thick layers of sand with occasional silt and clay beds predominate in the lower portion of the aquifer. This deeper, finer grained portion of the aquifer is referred to as the lower Rose City aquifer.

Most of the sand in the Rose City aquifer is greenish-gray to gray and quartzose, with a minor amount of mica. Vitric sand is found in several wells completed in the Rose City aquifer, but it generally occurs in separate layers rather than being dispersed within the quartzose sand. Two wells (9 1N/3E 19BAC and 16 1N/2E 24CAC) have logs showing a large amount of vitric sand in the Rose City aquifer. Both wells are in the southern portion of the well field, and the presence of more vitric sand in the Rose City aquifer in this location could indicate a nested fill. The distinct difference between the two sands indicates that two separate sources were providing the sand, and the lack of quartzose sand in the Troutdale sandstone aquifer indicates that the source for the quartzose sand may have become unavailable or was highly diluted by vitric sand during the time of deposition of the Troutdale sandstone aquifer.

The gravel in the Rose City aquifer is similar to other gravels in the Troutdale Formation. It consists almost entirely of basalt and quartzite clasts. Some cementing is usually evident on the gravel clasts, and the thin, bluish- to greenish-gray coating is visible. A minor amount of pyrite has been found in samples from the deeper portions of the aquifer. The cementing is apparently less tight than in the Troutdale sandstone aquifer, and the zones that are predominantly sand have caused problems for the drillers because of sand heaving up into the well casing when the hydraulic head is reduced during drilling. The quartzose sand is subrounded to rounded and very well sorted. The sorting is better and more consistent than that of the vitric sand.

CONCLUSIONS

The drilling of over 40 wells in the East Portland area has provided new data on the geology of the Portland Basin and has allowed the definition of several major units. Further work defining the ages and characteristics of the Troutdale Formation, the Sandy River Mudstone, and younger units in light of these new findings will enhance our understanding of the geology of the Portland area.

ACKNOWLEDGMENTS

The writer would like to thank J.E. Allen, M.H. Beeson, L.A. Palmer, and T.L. Tolan for reviewing this paper and making many valuable comments.

REFERENCES CITED

Allen, J.E., 1975, Volcanoes of the Portland area, Oregon: Oregon Department of Geology and Mineral Industries, Ore Bin, v. 37, no. 9, p. 145-157.

Beeson, M.H., and Nelson, D.O., 1979, A model for the geologic history of Mount Tabor, Kelly Butte, and Powell Butte in southeast Portland: Proceedings of the Oregon Academy of Science, v. xiv, p. 142-143.

CH_2M-Hill, 1979, Foundation investigation, I-205 Columbia River bridge: Unpublished report to Sverdrup and Parcel and Associates, 47 p.

Hodge, E.T., 1938, Geology of the lower Columbia River: Geological Society of America Bulletin, v. 49, no. 6, p. 869-929.

Hoffstetter, W.F., 1981, Blue Lake aquifer development potential study: Portland Water Bureau unpublished report, 17 p.

Hogenson, G.M., and Foxworthy, B.L., 1965, Ground water in the east Portland area, Oregon: U.S. Geological Survey Water-Supply Paper 1793, 78 p.

Milliman, J.D., and Emery, K.O., 1968, Sea levels during the past 35,000 years: Science, v. 162, p. 1121-1123.

Mundorff, M.J., 1959, Geology and ground-water resources of Clark County, Washington: U.S. Geological Survey open-file report, 268 p.

Tolan, T.L., and Beeson, M.H., 1984, Intracanyon flows of the Columbia River Basalt Group in the lower Columbia River Gorge and their relationship to the Troutdale Formation: Geological Society of America Bulletin, v. 95, no. 4, p. 463-477.

Trimble, D.E., 1963, Geology of Portland, Oregon, and adjacent areas: U.S. Geological Survey Bulletin 1119, 119 p.

Waters, A.C., 1973, The Columbia River Gorge: basalt stratigraphy, ancient lava dams, and landslide dams, *in* Beaulieu, J.D., field trip chairman, Geologic field trips in northern Oregon and southern Washington: Oregon Department of Geology and Mineral Industries Bulletin 77, p. 133-162.

Willis, R.F., 1977, Ground-water exploratory program, Bureau of Water Works, Portland, Oregon: Portland Water Bureau unpublished report, 287 p.

——— 1979, Pilot well study, Bureau of Water Works, Portland, Oregon: Portland Water Bureau unpublished report, 150 p. □

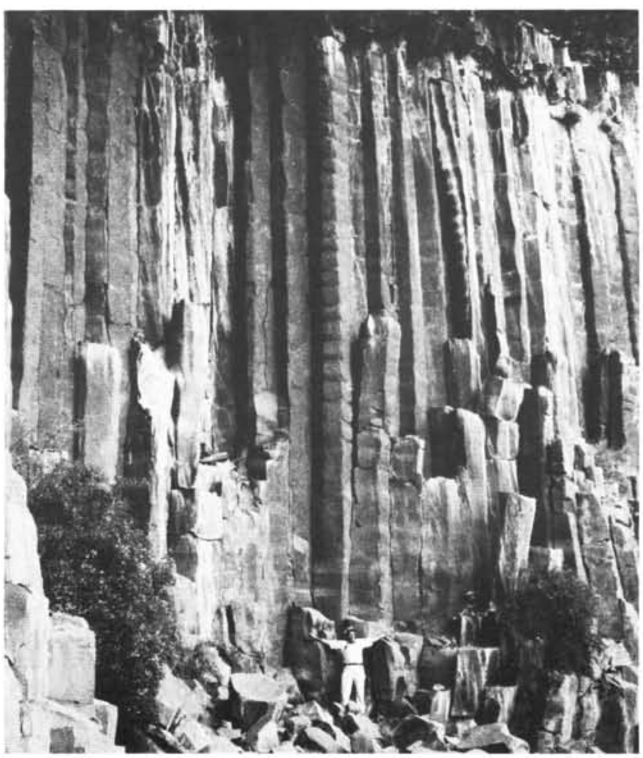
Facts your geology professor never taught you

In "The Geologic Column" (*Geotimes*, August 1982), Robert L. Bates quotes a report by Edwards and Anderson of a recent industrial-minerals Congress: "Unobtainium trioxide is a 'derivative of the ore mineral bewilderite, an accessory mineral in many enigmatite bodies. It is a by-product of enigmatite mining in central Erewhon, and from the new deep-sea mining venture in the republic of Atlantis. It is, withal, a compound of rare provenance.' " □

Basalt columns as sculpture pieces

by Jim Howland, Senior Consultant, CH_2M Hill, Corvallis, Oregon

Ceremonial structure made of basalt columns, Nan Madal, Ponape Island, Micronesia.



Basalt columns in the Crooked River canyon above Prineville, Crook County.

It is a long way, both geographically and culturally, from a prehistoric ceremonial structure on the island of Ponape (Micronesia), far out in the western Pacific, to a park sculpture on Madison Avenue in Corvallis, Oregon. Yet, there is a connection: they are both made of long, narrow basalt columns that form when basaltic magma cools undisturbed and under just the right conditions. And from the Ponape structures came the idea for the Oregon application.

The prehistoric natives on Ponape built islands in a large

Basalt columns beside the North Umpqua River at the Soda Springs Powerhouse, Douglas County.

Basalt column arrangement at SW 8th and Madison, Corvallis, Oregon, under construction.

Designers and builders pose on the finished basalt column sculpture in Corvallis, Oregon.

lagoon formed by coral reefs. First, they filled protective rings of basalt columns with coral and dirt. On top of the fill, they created massive walls by laying up crisscrossed stacks of columns. Legend has it that the stones were transported from the main island to the construction sites by a great chief who flew there with a column under each arm.

My wife and I, with the help of former State Geologist Ralph S. Mason, searched Oregon for suitable columns that could be obtained reasonably and transported to Corvallis. We found beautiful specimens along the North Umpqua River, near the Soda Springs powerhouse, also in the Crooked River canyon above Prineville, and at Skinner Butte Park in Eugene. The columns we found ranged in thickness from a few inches in a roadside quarry above Hills Creek Dam (near Oakridge in Lane County) to several feet in the Crooked River canyon. However, these stones were not available for a variety of reasons. At Hills Creek, the columns were cemented together with quartz and thus could not be removed as columns. Many of the columns found in various locations were fractured every few feet.

Finally, in the spring of 1983, easily available stones were located practically in our backyard, in the S.J. Quam quarry on West 11th Street in Eugene. With a source of columns located, Corvallis landscape architect John Stewart designed and supervised the construction of a small plaza featuring groupings of columns.

The columns are set in a concrete base, with a concrete seat formed in among them. On nice days, there is generally at least one person sitting by the columns. During events in the park, the stones provide elevated seating for numerous spectators.

In the Eugene area, short sections of basalt columns were used as slope paving for an early water reservoir that is still in use on Skinner Butte. Entrance stones to the rhododendron garden in Hendricks Park are basalt columns, as are a number of sign supports and building number displays in Eugene. Basalt columns were used to form water falls at the Spokane World's Fair in 1974. Perhaps the time has come when we will see more use of these distinctive natural shapes in construction and art pieces. □

Summer geology to be presented at the OSU Marine Science Center in Newport, Oregon

Oregon State University's Hatfield Marine Science Center at Newport is offering the following geology presentations and courses in its summer program this year.

Workshops – On July 20 and 21, Guy Rooth, geologist, Western Oregon State College, will conduct a class on coastal fossils. On July 23, 24, and 25, Clara Jarman, Corvallis geologist, will hold a workshop on rock identification.

Van trips – Don Giles, OSU Extension marine education specialist, will lead six one-day tours to survey the natural history and geology of the central Oregon coast. The dates are July 5, 17, and 26 and August 2, 14, and 21.

Talks – On July 11, Bob Bailey, Oregon Land Conservation and Development will speak on "Gorda Ridge – Mining Off Oregon's Coast?". On July 18, Don Hunter, Eugene audiovisual specialist, will present a multimedia show, "The Volcanic Cascades." On August 29, Paul Komar, OSU oceanographer, will present a talk entitled "Coastal Erosion – What to Look For". The talks are free and are presented at 7:00 p.m. on Wednesday evenings in the Hatfield Marine Science Center Auditorium.

The workshops and trips are available for a fee, and space must be reserved. For additional course descriptions, registrations, and further information on the Marine Science Center's summer program, call (503) 867-3011. □

British research ship to visit Coos Bay

The British research ship *Farnella* is due to dock in Coos Bay, Oregon, Monday, July 9, and leave again Wednesday, July 11, for the last leg of its cruise along the West Coast in a joint British-U.S. project called EEZ-SCAN.

EEZ-SCAN is the name of a three-month project of the U.S. Geological Survey (USGS) and the British Institute of Oceanographic Sciences (IOS). It involves sonar scanning of offshore West Coast parts of the Exclusive Economic Zone (EEZ) established last year by presidential proclamation (see related report in this year's February issue of *Oregon Geology*). EEZ-SCAN is the first step in the systematic and comprehensive study and exploration of the EEZ.

The EEZ-SCAN trip by the *Farnella* will involve about 21,000 nautical miles of scanning and cover nearly one million square miles of ocean bottom. It began in San Diego, California, at the end of April, with subsequent stops scheduled for Los Angeles (late May) and San Francisco (mid-June). After the final cruise from Coos Bay to the Canadian border, the ship will return to San Diego in early August.

The scanning system and equipment, named GLORIA for Geological Long-Range Inclined Asdic (sonar), was designed, developed, and operated by the IOS and is the only system of its kind in the world. The images it creates will reveal in broad outlines

*(Continued on page 70, **EEZ-SCAN**)*

OIL AND GAS NEWS

Mist Gas Field: Remedial Work

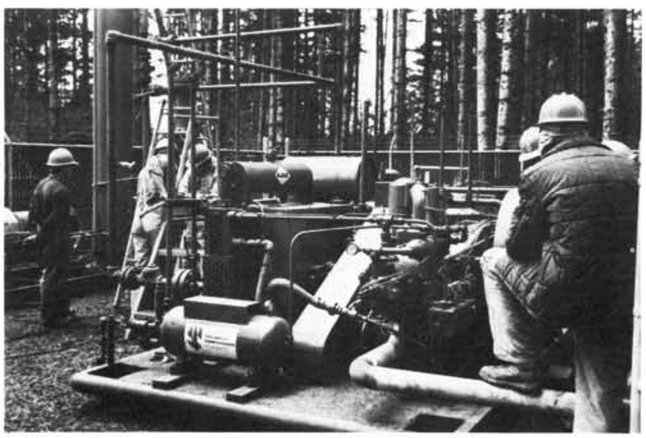
Repair work has been completed on the Reichhold Energy well Paul 34-32. This has eliminated the water-production problem but reduced gas production to about 0.25 to 0.5 MMcfd (million cubic feet per day).

Mist Gas Field: One new producer on line

Since December of last year, Reichhold Energy has completed two new wells in the Mist field, Columbia County 23-22 and Columbia County 43-22. A gathering line has been installed to the new wells, which lie 1.5 mi south of the nearest production, and gas started flowing from Columbia County 23-22 on April 15 at a rate of about 2 MMcfd. Additional treatment equipment is needed to put Columbia County 43-22 on line.

Mist Gas Field: Gas well on compressor

The gathering lines from the two new wells (item above) join the line from the producer Columbia County 4. To bring the output pressure of the older producer up to the level of the new producers, a compressor was installed in April.



Installation of compressor on Reichhold Energy well Columbia County 4, Mist Gas Field.

Mist gas production

Month	Total Mcf	Field avg. Btu	Total therms
January 1984	185,602	970	1,799,901
February 1984	185,281	970	1,795,891
March 1984	185,882	972	1,803,542
Cumulative field production through March 1984	16,984,167		

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
260	Amoco Production Co. Weyerhaeuser 1-26 019-00024	SW¼ sec. 26 T. 25 S., R. 9 W. Douglas County	Application. 15,000
261	Amoco Production Co. Weyerhaeuser 1-34 019-00025	NW¼ sec. 34 T. 25 S., R. 9 W. Douglas County	Application. 15,000
262	Amoco Production Co. Weyerhaeuser 1-1 011-00020	SE¼ sec. 1 T. 25 S., R. 11 W. Coos County	Application. 14,800

□

Stinchfield reappointed to Governing Board

Governor Victor Atiyeh has reappointed Allen P. Stinchfield of North Bend to the Governing Board of the Department of Geology and Mineral Industries (DOGAMI). Stinchfield's new term will begin July 1, 1984, and end June 30, 1988. The term is subject to Senate confirmation.

The three-member DOGAMI Governing Board makes policy for the Department, whose mission it is to develop needed information about the geology and mineral resources of Oregon and to effectively store and disseminate this information so that it can serve as a basis for correct decisionmaking in resource development and land management.

Stinchfield is the retired vice-president of the Menasha Corporation, Land and Timber Division, North Bend. He is also chairman of the board, Posey Manufacturing Company, Hoquiam, Washington, and currently serves on the board of directors, Bay Hospital, Coos Bay.

He is a graduate of the University of Washington (1940) and Grays Harbor College, Aberdeen, Washington. □

Malheur Field Station offers summer courses

Malheur Field Station, one of Oregon's unusual research outposts at Malheur Lake in the Malheur National Wildlife Refuge, Harney County, will offer a great variety of summer courses during a 12-week period from mid-June through August.

The classes offer optional and easily transferable college credit through Pacific University and are taught by instructors from a variety of colleges across the nation. Room and board are, of course, provided.

One-week workshops will be held at the beginning and end of the session. Subjects will include environmental assessment, ecology, natural history, experimental anthropology, aquatic biology, insect studies, bird identification, nature drawing, and watercolor painting. The period in between will offer three sequences of three-week courses on such subjects as animal behavior, marshlands ecology, field botany, flint knapping, fossil excavation, regional geology, natural history, ornithology, solar heating systems, and poetry.

All class sizes will be limited. For a course brochure or other information, write to Malheur Field Station, P.O. Box 260E, Princeton, OR 97721, or call (503) 493-2629. □

(EEZ-SCAN, continued from page 69)

the bathymetry (underwater topography) of the ocean floor. One of the first products of the approximately $2-million program will be an atlas of a mosaic of images of the entire West Coast EEZ, at a scale of 1:500,000.

The public is invited to visit aboard the *Farnella* while the ship is in port. A summary report on proposals and recommendations for developing the offshore mineral and energy resources of the EEZ has been published by the USGS as Circular 929 and is available at the USGS Public Inquiries Office, 678 U.S. Courthouse, West 920 Riverside Avenue, Spokane, WA 99201, phone (509) 456-2524, and at many other USGS offices. □

Send us your change of address

If you move and do not let us know, the post office does not deliver the magazine and charges us 25¢ for your new address. This costs us money and means you do not receive your magazine for that month. Save money and your copy of the magazine by sending us your new address when you move. □

Available publications

BULLETINS	Price	No. Copies	Amount
33. Bibliography (1st supplement) geology and mineral resources of Oregon, 1947: Allen	$ 3.00		
35. Geology of the Dallas and Valsetz quadrangles, rev. 1964: Baldwin (map only)	3.00		
36. Papers on Tertiary foraminifera: Cushman, Stewart, and Stewart, 1949: v. 2	3.00		
44. Bibliography (2nd supplement) geology and mineral resources of Oregon, 1953: Steere	3.00		
46. Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey	3.00		
49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch	3.00		
53. Bibliography (3rd supplement) geology and mineral resources of Oregon, 1962: Steere and Owen	3.00		
61. Gold and silver in Oregon, 1968: Brooks and Ramp	17.50		
62. Andesite Conference guidebook, 1968: Dole	3.50		
65. Proceedings of the Andesite Conference, 1969: (copies)	10.00		
67. Bibliography (4th supplement) geology and mineral resources of Oregon, 1970: Roberts	3.00		
71. Geology of selected lava tubes in Bend area, Oregon, 1971: Greeley (copies)	5.00		
NEW! 77. Geologic field trips in northern Oregon and southern Washington, 1973	5.00		
78. Bibliography (5th supplement) geology and mineral resources of Oregon, 1973: Roberts	3.00		
81. Environmental geology of Lincoln County, 1973: Schlicker and others	9.00		
82. Geologic hazards of Bull Run Watershed, Multnomah, Clackamas Counties, 1974: Beaulieu	6.50		
83. Eocene stratigraphy of southwestern Oregon, 1974: Baldwin	4.00		
84. Environmental geology of western Linn County, 1974: Beaulieu and others	9.00		
85. Environmental geology of coastal Lane County, 1974: Schlicker and others	9.00		
87. Environmental geology of western Coos and Douglas Counties, 1975	9.00		
88. Geology and mineral resources of upper Chetco River drainage, 1975: Ramp	4.00		
89. Geology and mineral resources of Deschutes County, 1976: Peterson and others	6.50		
90. Land use geology of western Curry County, 1976: Beaulieu	9.00		
91. Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties, Oregon, 1977: Beaulieu	8.00		
92. Fossils in Oregon (reprinted from *The Ore Bin*), 1977	4.00		
93. Geology, mineral resources, and rock material of Curry County, Oregon, 1977	7.00		
94. Land use geology of central Jackson County, Oregon, 1977: Beaulieu	9.00		
95. North American ophiolites, 1977	7.00		
96. Magma genesis: AGU Chapman Conference on Partial Melting, 1977	12.50		
97. Bibliography (6th supplement) geology and mineral resources of Oregon, 1971-75, 1978	3.00		
98. Geologic hazards of eastern Benton County, Oregon, 1979: Bela	9.00		
99. Geologic hazards of northwestern Clackamas County, Oregon, 1979: Schlicker and Finlayson	10.00		
100. Geology and mineral resources of Josephine County, Oregon, 1979: Ramp and Peterson	9.00		
101. Geologic field trips in western Oregon and southwestern Washington, 1980	9.00		
102. Bibliography (7th supplement) geology and mineral resources of Oregon, 1976-1979, 1981	4.00		
GEOLOGIC MAPS			
Reconnaissance geologic map of Lebanon quadrangle, 1956	3.00		
Geologic map of Bend quadrangle and portion of High Cascade Mountains, 1957	3.00		
Geologic map of Oregon west of 121st meridian (USGS I-325), 1961	5.50		
Geologic map of Oregon east of 121st meridian (USGS I-902), 1977	5.50		
GMS-4: Oregon gravity maps, onshore and offshore, 1967 (folded)	3.00		
GMS-5: Geologic map of Powers quadrangle, Oregon, 1971	3.00		
GMS-6: Preliminary report on geology of part of Snake River Canyon, 1974	6.50		
GMS-8: Complete Bouguer gravity anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00		
GMS-9: Total field aeromagnetic anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00		
GMS-10: Low- to intermediate-temperature thermal springs and wells in Oregon, 1978	3.00		
GMS-12: Geologic map of the Oregon part of the Mineral quadrangle, 1978	3.00		
GMS-13: Geologic map of the Huntington and part of the Olds Ferry quadrangles, Oregon, 1979	3.00		
GMS-14: Index to published geologic mapping in Oregon, 1898-1979, 1981	7.00		
GMS-15: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, northern Oregon, 1981	3.00		
GMS-16: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, southern Oregon, 1981	3.00		
GMS-17: Total-field aeromagnetic anomaly map, Cascade Mountain Range, southern Oregon, 1981	3.00		
GMS-18: Geology of the Rickreall, Salem West, Monmouth, and Sidney 7½-minute quadrangles, Marion, Polk, and Linn Counties, Oregon, 1981	5.00		
GMS-19: Geology and gold deposits map of the Bourne quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-20: Map showing geology and geothermal resources of the southern half of the Burns 15-minute quadrangle, Oregon, 1982	5.00		
GMS-21: Geology and geothermal resources map of the Vale East 7½-minute quadrangle, Oregon, 1982	5.00		
GMS-22: Geology and mineral resources map of the Mt. Ireland quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-23: Geologic map of the Sheridan quadrangle, Polk and Yamhill Counties, Oregon, 1982	5.00		
GMS-24: Geologic map of the Grand Ronde quadrangle, Polk and Yamhill Counties, Oregon. 1982	5.00		
GMS-25: Geology and gold deposits map of the Granite quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-26: Residual gravity maps of the northern, central, and southern Cascade Range, Oregon, 1982	5.00		
GMS-27: Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1° by 2° quadrangle, 1982	6.00		
GMS-28: Geology and gold deposits map of the Greenhorn quadrangle, Baker and Grant Counties, Oregon, 1983	5.00		
GMS-29: Geology and gold deposits map, NE¼ Bates quadrangle, Baker and Grant Counties, Oregon, 1983	5.00		
NEW! GMS-31: Geology and gold deposits map, NW¼ Bates quadrangle, Baker and Grant Counties, Oregon, 1984	5.00		
OIL AND GAS INVESTIGATIONS			
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well	3.00		
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well, 1973	3.00		
5. Prospects for natural gas production or underground storage of pipeline gas, upper Nehalem River Basin, Columbia-Clatsop Counties, Oregon, 1976	5.00		
6. Prospects for oil and gas in the Coos Basin, western Coos, Douglas, and Lane Counties, Oregon, 1980: Newton and others	9.00		
7. Correlation of Cenozoic stratigraphic units of western Oregon and Washington, 1983	8.00		
9. Subsurface biostratigraphy of the east Nehalem Basin, 1983: McKeel	6.00		

← ORDER FORM — CUT ON DASHED LINE →

Available publications (continued)

SPECIAL PAPERS	Price	No. Copies	Amount
1. Mission, goals, and programs of Oregon Department of Geology and Mineral Industries, 1978	3.00	_____	_____
2. Field geology of SW Broken Top quadrangle, Oregon, 1978: Taylor	3.50	_____	_____
3. Rock material resources of Clackamas, Columbia, Multnomah, and Washington Counties, Oregon, 1978: Gray and others	7.00	_____	_____
4. Heat flow of Oregon, 1978: Blackwell, Hull, Bowen, and Steele	3.00	_____	_____
5. Analysis and forecasts of the demand for rock materials in Oregon, 1979: Friedman and others	3.00	_____	_____
6. Geology of the La Grande area, Oregon, 1980: Barrash and others	5.00	_____	_____
7. Pluvial Fort Rock Lake, Lake County, Oregon, 1979: Allison	4.00	_____	_____
8. Geology and geochemistry of the Mt. Hood volcano, 1980: White	3.00	_____	_____
9. Geology of the Breitenbush Hot Springs quadrangle, Oregon, 1980: White	4.00	_____	_____
10. Tectonic rotation of the Oregon Western Cascades, 1980: Magill and Cox	3.00	_____	_____
11. Theses and dissertations on the geology of Oregon: Bibliography and index, 1899-1982, 1982: Neuendorf and others	6.00	_____	_____
12. Geologic linears of the northern part of the Cascade Range, Oregon, 1980: Venkatakrishnan, Bond, and Kauffman	3.00	_____	_____
13. Faults and lineaments of the southern Cascades, Oregon, 1981: Kienle, Nelson, and Lawrence	4.00	_____	_____
14. Geology and geothermal resources of the Mount Hood area, Oregon, 1982: Priest and Vogt	7.00	_____	_____
15. Geology and geothermal resources of the central Oregon Cascade Range, 1983: Priest and Vogt	11.00	_____	_____
16. Index to the *Ore Bin* (1939-1978) and *Oregon Geology* (1979-1982), 1983: Mahoney and Steere	4.00	_____	_____
SHORT PAPERS			
21. Lightweight aggregate industry in Oregon, 1951: Mason	1.00	_____	_____
24. The Almeda Mine, Josephine County, Oregon, 1967: Libbey	3.00	_____	_____
25. Petrography, type Rattlesnake Formation, central Oregon, 1976: Enlows	3.00	_____	_____
27. Rock material resources of Benton County, 1978: Schlicker and others	4.00	_____	_____
MISCELLANEOUS PAPERS			
1. A description of some Oregon rocks and minerals, 1950: Dole	1.00	_____	_____
5. Oregon's gold placers (reprints), 1954	1.00	_____	_____
8. Available well records of oil and gas exploration in Oregon, rev. 1982: King, Olmstead, and Newton	4.00	_____	_____
11. Collection of articles on meteorites, 1968 (reprints from *The Ore Bin*)	3.00	_____	_____
15. Quicksilver deposits in Oregon, 1971: Brooks	3.00	_____	_____
17. Geologic hazards inventory of the Oregon coastal zone, 1974: Beaulieu, Hughes, and Mathiot	5.00	_____	_____
18. Proceedings of Citizens' Forum on potential future sources of energy, 1975	3.00	_____	_____
19. Geothermal exploration studies in Oregon—1976, 1977	3.00	_____	_____
20. Investigations of nickel in Oregon, 1978: Ramp	5.00	_____	_____
MISCELLANEOUS PUBLICATIONS			
Landforms of Oregon (17 × 12 inches)	1.00	_____	_____
Mining claims (State laws governing quartz and placer claims)	1.00	_____	_____
Geological highway map, Pacific NW region, Oregon-Washington (published by AAPG)	5.00	_____	_____
Geothermal resources of Oregon map, 1982 (published by NOAA)	3.00	_____	_____
Back issues of *The Ore Bin*	50¢ over the counter; $1.00 mailed	_____	_____
Back issues of *Oregon Geology*	75¢ over the counter; $1.00 mailed	_____	_____
Colored postcard, *Geology of Oregon*	10¢ each; 3 for 25¢; 7 for 50¢; 15 for $1.00	_____	_____
Oregon Landsat mosaic map, 1983 (published by ERSAL, OSU)	$8.00 over the counter; $11.00 mailed	_____	_____

Separate price lists for open-file reports, geothermal energy studies, tour guides, recreational gold mining information, and non-Departmental maps and reports will be mailed upon request.

OREGON GEOLOGY

1005 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

PUBLICATIONS ORDER

Minimum mail order $1.00. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $50.00. Foreign orders: please remit in U.S. dollars.

Fill in appropriate blanks and send sheet to Department.

YOUR NAME ____________________

ADDRESS ____________________

____________________ Zip________

Amount enclosed $________

OREGON GEOLOGY

____ Renewal ____ New Subscription ____ Gift

____ 1 Year ($6.00) ____ 3 Years ($15.00)

NAME ____________________

ADDRESS ____________________

____________________ ZIP ________

(If Gift, From: ____________________)

OREGON GEOLOGY

published by the

Oregon Department of Geology and Mineral Industries

VOLUME 46, NUMBER 7 JULY 1984

OREGON GEOLOGY

(ISSN 0164-3304)

VOLUME 46, NUMBER 7 **JULY 1984**

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

Main Office: 1005 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133.
Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496.
Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039.
Paul F. Lawson, Supervisor

Subscription rates: 1 year, $6.00; 3 years, $15.00. Single issues, $.75 at counter, $1.00 mailed.
Available back issues of *The Ore Bin*: $.50 at counter, $1.00 mailed.

Address subscription orders, renewals, and changes of address to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

Send news, notices, meeting announcements, articles for publication, and editorial correspondence to the editor, Portland office. The Department encourages author-initiated peer review for technical articles prior to submission. Any review should be noted in the acknowledgments.

Second class postage paid at Portland, Oregon.
Postmaster: Send address changes to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

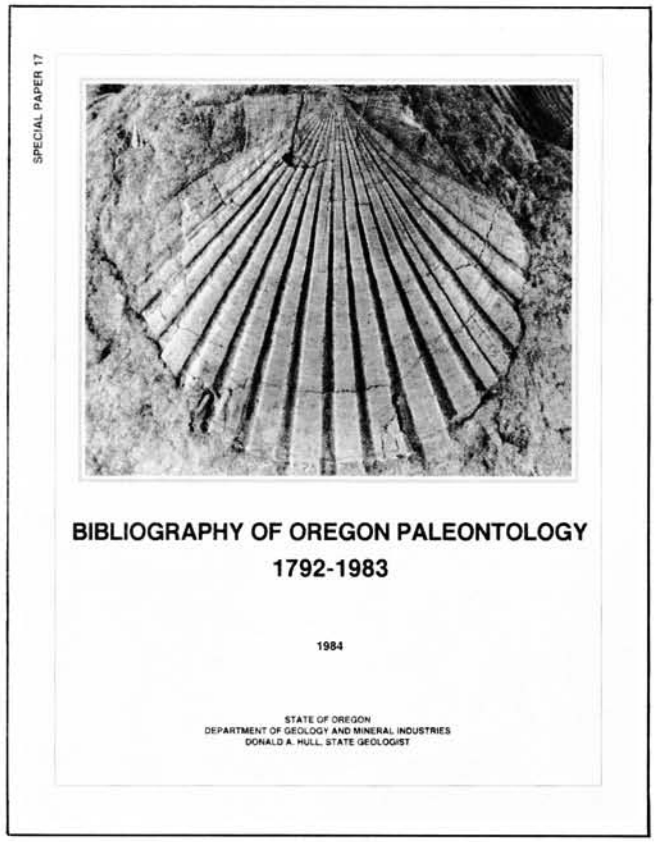
COVER PHOTO

Sandstone pinnacle in Otter Point terrane, upper Sixes River, Curry County, near the Dement Ranch. Article beginning on next page discusses nature of such exotic blocks.

Bibliography of Oregon paleontology released

The Oregon Department of Geology and Mineral Industries (DOGAMI) has released the first comprehensive bibliography of the paleontological literature on Oregon.

Bibliography of Oregon Paleontology, 1792-1983, DOGAMI Special Paper 17, was compiled by Elizabeth L. Orr, Research Librarian in Eugene, Oregon, and William N. Orr, Associate Professor, Department of Geology, University of Oregon. The 82-page publication is the result of six years of research and compilation. It contains approximately 1,200 individual references, including articles from about 160 different serial publications.



Special Paper 17, Bibliography of Oregon Paleontology, by Elizabeth L. and William N. Orr.

The bibliography has two parts: an author index and a subject index. The author entries are annotated, providing information on subject area, location, geologic formation, and similar matters that might not be evident in the title of the entry. The subject index is arranged by formation, county, subject (e.g., Vertebrates), or by a specific name (e.g., Cedar), whenever such a name was used in the title of a reference. Geographic subject terms include broader divisions (e.g., Blue Mountains) as well as smaller subdivisions under the county headings (e.g., Douglas County, Bohemia area). References under individual subject headings also include such geographic subdivisions, so that the literature is accessible through both paleontologic/geologic and geographic subject terms.

The new bibliography, DOGAMI Special Paper 17, is now available at the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, 1400 SW Fifth Avenue, Portland, OR 97201. The purchase price is $6. Orders under $50 require prepayment. □

The origin of olistostromes in the Roseburg Formation in southwestern Oregon

by Ewart M. Baldwin, Department of Geology, University of Oregon, Eugene, Oregon 97403

OLISTOSTROMES AND OLISTOLITHS

Olistostromes, as defined in the American Geological Institute (AGI) geologic dictionary (Bates and Jackson, 1980), are sedimentary deposits consisting of a chaotic mass of intimately mixed heterogeneous material (such as blocks and muds) that accumulated as a semifluid body by submarine gravity sliding and slumping of unconsolidated sediments. An olistolith is an exotic block or other rock in an olistostrome. The terms "megabreccia" and "wildflysch" are sometimes used for exotic blocks of unusually large size. A seismoturbidite is an olistostrome produced by an earthquake, and the slide involved would presumably have taken place along a broad front all at one time, in contrast to more random sliding of individual blocks.

There are many exotic blocks of schists, greenstone, chert, basalt, and sandstone within the Roseburg Formation in the Coquille and Sitkum (15-minute) quadrangles east of Myrtle Point and along the Middle, North, and East Forks of the Coquille River near the communities of Gravelford and Bridge.

The writer's attention was first directed to these blocks when he was mapping the Coos Bay 30-minute quadrangle (Allen and Baldwin, 1944). Diller (1901) had located several of these blocks on his geologic folio. Magoon (1966) discovered others in the area he mapped along the edge of the Coquille and Sitkum quadrangles. When compiling the geologic map of Coos County (Baldwin and others, 1973), the writer noted these and other exotic rocks that had been discovered during the extension of many logging roads.

The Otter Point Formation (Koch, 1966; Dott, 1971) of southwestern Oregon is largely a mélange of Upper Jurassic and Lower Cretaceous sedimentary rocks, submarine flows, and less abundant pods of chert and blueschists. According to the AGI dictionary, a mélange is a mappable body of rock characterized by the inclusion of fragments and blocks of all sizes, both exotic and native, embedded in a fragmental and generally sheared matrix of more tractable material. The definition goes on to speak of a sedimentary mélange that is about the same as an olistostrome. The writer uses the term "mélange" only to refer to tectonically mixed material. The blocks within the mélange are usually more resistant to erosion, so that they stand out as stacks and pinnacles.

Upfaulted blocks of Otter Point terrane are present in the Powers 15-minute quadrangle (Baldwin and Hess, 1971), a short distance south of the Middle Fork of the Coquille River. This terrane contains rocks similar to those now interspersed within the Roseburg Formation and may have provided the source rock for the olistoliths in it.

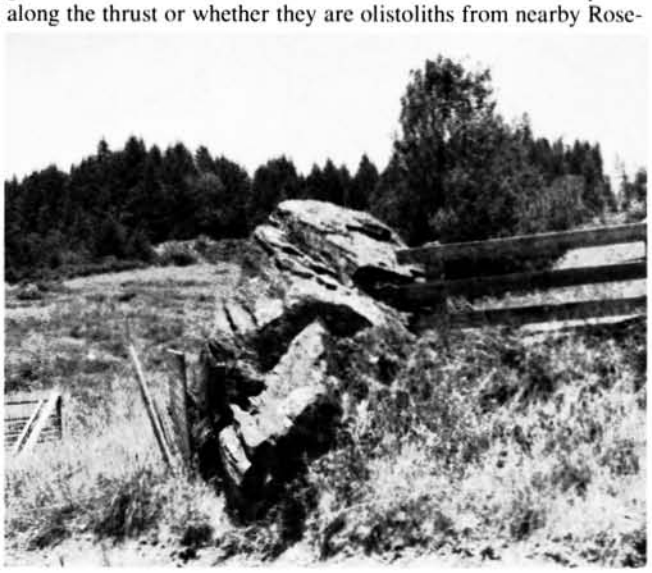
ORIGIN OF EXOTIC ROCKS

The exotic rocks are common to both the Otter Point and Roseburg terranes, and thus there is a problem in determining which is an Otter Point mélange and which is sheared Roseburg along a fault. Such an indeterminate area lies between Powers Junction south of Myrtle Point, Sugarloaf Mountain to the east, and the North Fork of the Coquille River to the north.

The writer mapped a thrust-fault zone extending from the northwest face of Sugarloaf Mountain along the East Fork of the Coquille River to a point just east of the Pleasant Hill School, where it goes under younger and noninvolved Lookingglass sedimentary rocks (Baldwin and others, 1973). Some of the most obvious exotic blocks lie along this zone, and they may be positioned there from thrust Otter Point material or exhumed from nearby Roseburg rock.

Diagram of block movement from the Otter Point terrane to modern sediments.

One large block of greenstone is situated at the south end of the North Fork bridge 2 mi east of Myrtle Point, but it has been largely removed by quarrying. Along the north bank road from this bridge westward to Oregon Highway 42, one soon comes to an outcrop of red chert in the NE¼ sec. 10, T. 29 S., R. 12 W., and, a short distance north of this, an outcrop of yellow sandstone with quartzite-bearing conglomerate which is very close to auger holes that yielded Late Cretaceous microfossils. The other areas between the bridge and the highway are underlain by sheared rock that tends to slide. The writer considered the area to be Roseburg and the exotic rocks to have been introduced by sliding at the time of deposition or by faulting (Baldwin and others, 1973). A greenstone body was present at Kasper's quarry a few miles east of Gravelford, in line with the thrust fault that passes by Sugarloaf Mountain. It is located in the NE¼ sec. 29, T. 28 S., R. 11 W. A few yards down the hill from the quarry are two blocks of schist. Whether both the greenstone and the schist blocks are in Otter Point terrane exposed along the thrust or whether they are olistoliths from nearby Rose-

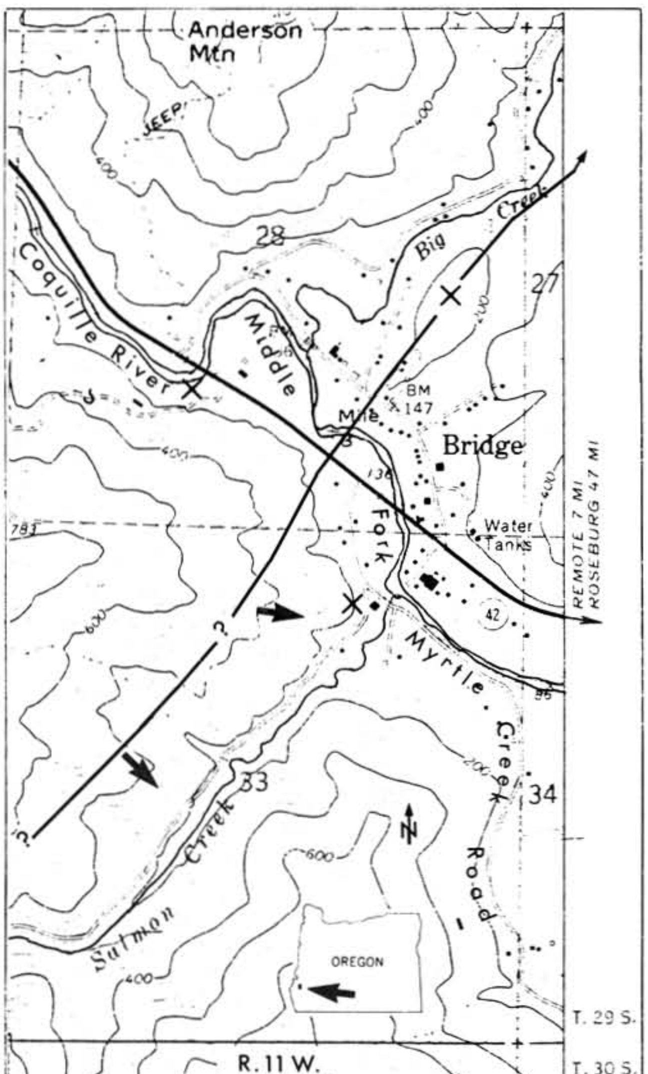


Block of blueschist near Kasper's quarry along the East Fork of the Coquille River.

burg sediments is difficult to determine. Magoon (1966) mapped the area including Kasper's quarry and suggested the possibilities that the rocks were positioned by faulting or by sliding in, during Roseburg deposition, from a nearby Otter Point highland.

OLISTOSTROME AT BRIDGE, OREGON

One of the small exotic blocks mapped by Diller (1901) proved to be a block of schist no more than 8 ft in maximum dimension, on a small ridge just north of the business section in the small community of Bridge. Bridge evidently derived its name from the large covered bridge over the Middle Fork of the Coquille River by the school on the Myrtle Creek road. This bridge was not designed for large logging trucks, so when the State Highway Department straightened Highway 42 at this point, creating two bridges over the Middle Fork of the Coquille, the County extended the Myrtle Creek road across the mouth of Salmon Creek to join the highway farther west, thus eliminating the need for the old covered bridge by the schoolhouse. As the Myrtle Creek road was being relocated, most of the material in a cluster of mica-sheet blocks that had been situated on the west bank of Salmon Creek was removed. Another large block of greenstone, 15 ft or more in diameter and almost



Segment of the Bridge 7½-minute quadrangle showing the olistostrome at Bridge and olistolith locations in the vicinity. Black line=olistostrome. X=olistolith location. Arrows=suggested direction of movement of olistoliths.

metamorphosed to a low-grade blueschist, is situated in the Coquille River just south of the westernmost of the new highway bridges.

The schist block on the small ridge north of the Bridge business section proved to be but one of the exotic rocks in a bed of olistoliths that can be traced to the north across Big Creek and also south to the river bank, then may be projected beneath the alluvial flat and on up the hill southward, paralleling Salmon Creek to the west. There seems to be no doubt as to this bed's being a part of the Roseburg Formation. The bed, which is approximately 4 ft thick, may be seen dipping steeply eastward along the north bank of the river. It contains subrounded to angular blocks of poorly sorted exotic rocks in a sandstone matrix. When projected southward, it goes between the schist blocks at the mouth of Salmon Creek and the large one beneath the highway bridge to the west, but these blocks may have slid from their original positions to where they are now. Other blocks along Salmon Creek probably came from this bed, although some of them may be olistoliths randomly placed in the Roseburg Formation. The writer favors the hypothesis that the olistostrome at Bridge is a seismoturbidite, that is, an olistostrome triggered by an earthquake which caused the olistostrome to form all at one time, in contrast to those singly situated, randomly spaced olistoliths that may have slid into the Roseburg sediments in other parts of the area.

Tor H. Nilsen of the U.S. Geological Survey described the Hilt Bed of the Hornbrook Formation at the Geological Society of America meeting in Indianapolis, November 3, 1983. He traced this bed from Hilt, California, past Ashland, Oregon, and, by projection and intermittent outcrop, to Grave Creek. He considered the Hilt Bed to be a seismoturbidite triggered by an earthquake in Late Cretaceous time. There is a similarity between the Hilt Bed and the one at Bridge, although the latter is not as extensive.

For a modern example of olistostrome formation, we might consider the coastal area south of Humbug Mountain which is underlain by sheared Otter Point terrane (Koch, 1966; Dott, 1971).

Sliding terrane with exotic blocks south of Humbug Mountain, Curry County coast.

Here, the unstable sheared material is sliding seaward, with large exotic blocks reaching the shoreline to beome stacks and eventually migrating seaward by sliding. Studies of sedimentation in other parts of the world indicate that material may slide for a considerable distance on sea bottoms of only a few degrees slope. As the sea erodes inland, the stacks become situated farther from the shore and surrounded by bedded sediments. In both the modern sediments and the Roseburg Formation the exotic blocks almost surely came from such an unstable Otter Point terrane.

(Continued on page 82, **Olistostromes***)*

Petroleum source rock evaluations of outcrop samples from Oregon and northern California

by B.E. Law, D.E. Anders, T.D. Fouch, M.J. Pawlewicz, M.R. Lickus, and C.M. Molenaar,
U.S. Geological Survey, Denver Federal Center, Box 25046, MS 971, Denver, Colorado 80225

ABSTRACT

Petroleum source rock evaluations of carbonaceous sandstone, siltstone, shale, mudstone, and coal samples of various ages collected from surface exposures in Oregon and northern California indicate that the organic matter is predominantly type III kerogen. Most samples contain less than 1.0 weight percent organic carbon; the average organic carbon content is 0.91 weight percent. The thermal maturities of the samples with respect to hydrocarbon generation range from immature in the younger rocks to post-mature in the older rocks. Most of the samples are immature to marginally mature. Based on our evaluation of the type of organic matter contained in these samples, indications are the source rock is capable of generating gas and little or no oil.

INTRODUCTION

There has been sporadic interest in the petroleum potential of the Pacific Northwest for several years. Since the 1979 discovery of

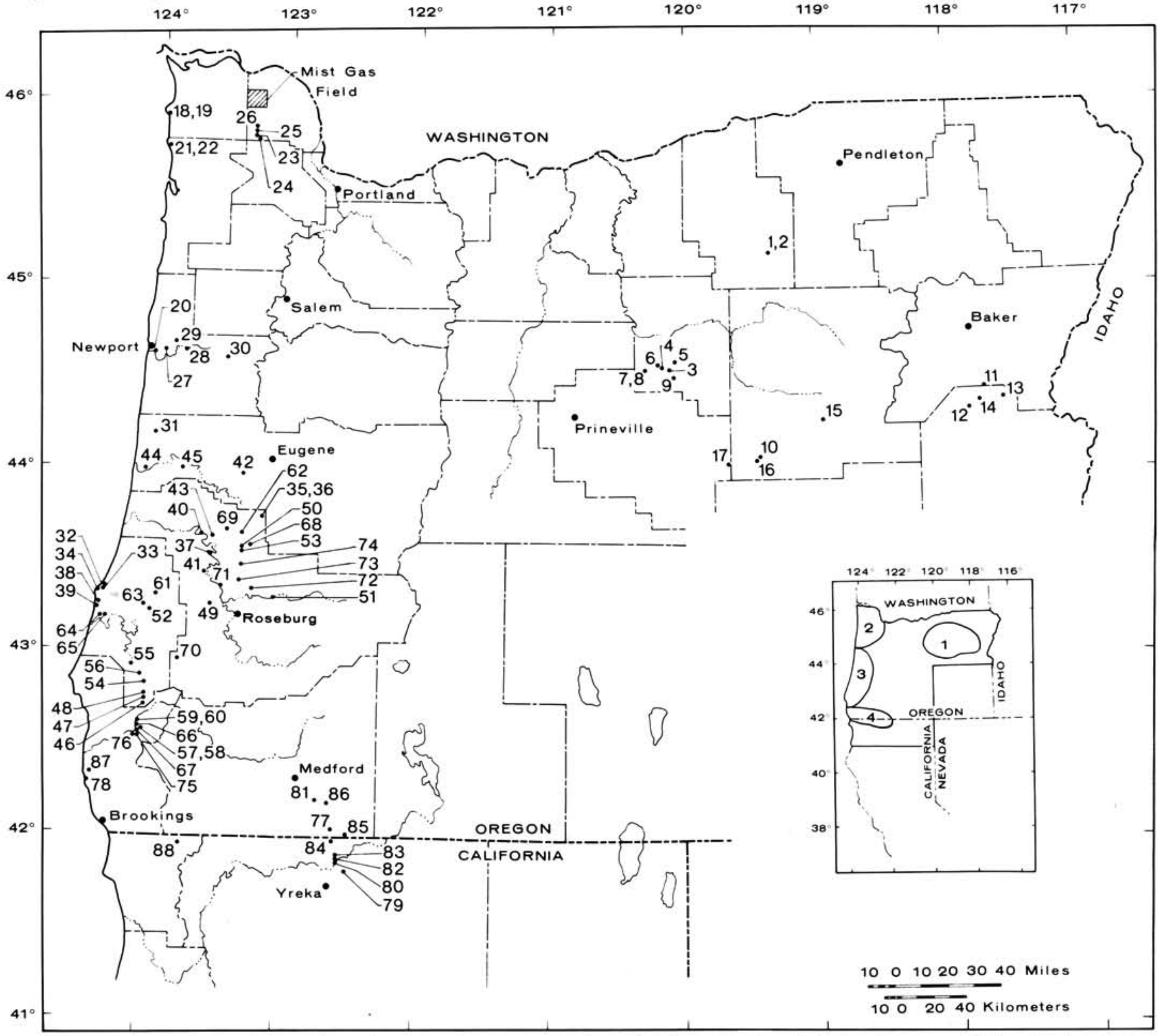


Figure 1. Sample localities and sample areas in Oregon and northern California. Analytical data and more specific locality descriptions for samples are shown in Table 1.

Table 1.--Source-rock analytical data for surface samples from Oregon and northern California

[Tr, Triassic; JTr, Jurassic and Triassic; J, Jurassic; K, Cretaceous; T, Tertiary; argl, argillite; carb, Carbonaceous; clyst, claystone; ms, mudstone; ss, sandstone; sdy, sandy; sh, shale; shy, shaly; sltst, siltstone; slty, silty; -- no data]

Map no. (fig. 1)	Sample no.	Section	Township	Range	County[1]	Age	Stratigraphic unit	Lithology	Vitrinite reflectance, R_o (percent)	Organic carbon (Wt %)	S_1 (mgHC/g)	S_2 (mgHC/g)	S_3 (mgCO_2/g)	T_{max} (°C)	Genetic potential (S_1+S_2)	H_2 index (mgHC/gC)	O_2 index (mgCO_2/gC)	Transformation ratio, (S_1/S_1+S_2)
							Area 1											
1	082TF-15	SW 34	T. 4 S.	R. 28 E.	Morrow	K	pre-Clarno Fm.	carb sh	--	4.72	.044	3.83	2.04	434	3.87	81	43	.01
2	082TF-14	NW 34	T. 4 S.	R. 28 E.	---do---	K	Sandstone (Pre-Clarno Fm.)	ss	.86	.04	.017	--	.29	--	.017	--	717	1
3	082TF-26	6	T. 12 S.	R. 22 E.	Wheeler	K	Hudspeth Formation	sh	--	1.44	0.013	0.093	0.64	448	0.106	6	44	0.13
4	082TF-27	35	T. 11 S.	R. 21 E.	---do---	K	---do---	ms	0.62	.70	.028	.12	.40	430	.15	17	58	.19
5	082TF-28	18	T. 11 S.	R. 22 E.	---do---	K	---do---	ms	.85	.34	.021	.003	.49	449	.024	1	145	.86
6	082TF-30	28	T. 11 S.	R. 21 E.	---do---	K	---do---	ms	.61	1.19	.017	.123	.76	460	.140	10	64	.12
7	082TF-31	3	T. 12 S.	R. 20 E.	---do---	K	---do---	ms	.63	.21	.017	6.95	.54	438	6.97	3	256	.71
8	082TF-32	3	T. 12 S.	R. 20 E.	Wheeler	K	---do---	ms	--	.47	.022	.09	.28	426	.11	20	59	.19
9	082TF-25	21	T. 12 S.	R. 22 E.	---do---	K	Gable Creek Formation	clyst	.84	.84	.014	.006	.53	434	.020	76	63	.69
10	082TF-22	23	T. 17 S.	R. 27 E.	Grant	J	Sedimentary rocks (Walker, 1977)	sh	1.06	--	--	--	--	--	--	--	--	--
11	082TF-16	7	T. 13 S.	R. 41 E.	Baker	JTr	Sedimentary and volcanic rocks (Walker, 1977)	argl	.49	--	--	--	--	--	--	--	--	--
12	082TF-17	19	T. 14 S.	R. 40 E.	Malheur	JTr	---do---	argl	--	.99	.017	--	.35	--	.017	--	35	1
13	082TF-18	NW 32	T. 3 S.	R. 42 E.	Malheur	JTr	---do---	argl	--	1.22	.010	--	.51	--	.010	--	41	1
14	082TF-19	2	T. 14 S.	R. 40 E.	---do---	JTr	---do---	clyst	.50	.22	.009	--	.49	--	.009	--	222	1
15	082TF-20	NW 11	T. 15 S.	R. 31 E.	Grant	Tr	Graywacke and shale (Thayer, 1956)	sh	3.05	1.00	.016	--	.46	--	.016	--	46	1
16	082TF-23	18	T. 17 S.	R. 27 E.	---do---	Tr	Sedimentary and volcanic rocks (Walker, 1977)	sltst	.34	--	--	--	--	--	--	--	--	--
17	082TF-24	25	T. 17 S.	R. 27 E.	Crook	Tr	Marine sedimentary rocks (Walker, 1977)	sdy sh	.58	--	--	--	--	--	--	--	--	--
							Area 2											
18	082TF-1	18	T. 5 N.	R. 10 W.	Clatsop	T	Astoria Formation	clyst	0.36	1.18	0.043	0.21	1.33	437	0.25	18	112	0.17
19	082TF-2	18	T. 5 N.	R. 10 W.	---do---	T	---do---	sdy clyst	.65	1.61	.061	.77	.46	424	.83	48	28	.07
20	081TF-88	SW 9	T. 11 S.	R. 11 W.	Lincoln	T	Nye Shale (middle part)	sltst	.36	1.34	.091	.99	.97	404	1.08	74	72	.08
21	082TF-3	7	T. 3 N.	R. 10 W.	Tillamook	T	Formation at Oswald West	slty clyst	1.78	.65	.089	.02	.22	446	.11	2	34	.86
22	082TF-4	7	T. 3 N.	R. 10 W.	---do---	T	---do---	sltst	1.86	--	--	--	--	--	--	--	--	--
23	082TF-6	27	T. 4 N.	R. 5 W.	Columbia	T	Keasey Formation (Neim and Van Atta, 1973)	slty clyst	.34	.91	.008	.24	.79	418	.25	27	86	.03
24	082TF-5	35	T. 4 N.	R. 5 W.	Columbia	T	Keasey Formation (lower part)	sltst, coal	--	.18	.017	.03	.36	401	.05	14	203	.40
25	082TF-8	15	T. 4 N.	R. 5 W.	---do---	T	---do---	sdy sltst	.29	--	--	--	--	--	--	--	--	--
26	082TF-7	3	T. 4 N.	R. 5 W.	---do---	T	Cowlitz Formation (upper part) (Niem and Van Atta, 1973)	slty ss	.31	--	--	--	--	--	--	--	--	--
27	081TF-86	SE NE 5	T. 11 S.	R. 10 W.	Lincoln	T	Yamhill Formation (Snavely et al., 1980)	clyst	.32	.50	.021	.17	.51	418	.19	35	103	.11
28	081TF-84	SW SW 3	T. 11 S.	R. 9 W.	---do---	T	Tyee Formation	sh	.53	.53	.012	.16	.39	422	.17	31	73	.07
29	081TF-85	SW 24	T. 10 S.	R. 10 W.	---do---	T	---do---	sh	.46	.95	.034	.21	.48	427	.24	23	51	.14
30	081TF-82	SW SW 18	T. 11 S.	R. 6 W.	Benton	T	Umpqua Formation	clyst	.53	.23	.012	--	.25	--	.012	--	107	1
							Area 3											
31	081TF-87	SW NE 10	T. 16 S.	R. 11 W.	Lane	T	Nye Shale	sltst	0.34	1.75	0.046	1.14	0.91	407	1.19	65	52	0.04
32	081M-13	NE SW 3	T. 26 S.	R. 14 W.	Coos	T	Bastendorff Shale (upper part)	slty sh	.32	.94	.087	.99	1.05	418	1.08	106	111	.08
33	081TF-98	NW 9	T. 26 S.	R. 14 W.	---do---	T	Coaledo Formation (middle part)	sh	.51	1.46	.017	.22	.51	425	.24	15	35	.07
34	081TF-97	NE 8	T. 26 S.	R. 14 W.	---do---	T	Coaledo Formation (lower part)	sh	.49	1.44	.016	.39	.76	417	0.41	27	53	.04
35	081M-4	SE NW 16	T. 21 S.	R. 4 W.	Douglas	T	Spencer Formation	clyst, carb sh	.48	4.48	.030	.99	1.61	409	1.02	22	36	.03
36	081M-5	SW SW 16	T. 21 S.	R. 4 W.	---do---	T	---do---	sltst	.45	1.12	.042	1.02	.35	409	1.06	91	31	.04
37	081M-3	NE NW 30	T. 23 S.	R. 7 W.	---do---	T	Elkton Formation	sltst, slty sh	.59	1.35	.026	1.09	.24	436	1.12	81	18	.02
38	081M-6	C 5	T. 27 S.	R. 14 W.	Coos	T	---do---	slty sh	.45	.86	.029	.37	.66	420	.40	43	77	.07
39	081M-7	NW NW 17	T. 27 S.	R. 14 W.	---do---	T	---do---	slty sh	.52	.58	.022	.25	.48	424	.27	44	83	.08
40	081TF-95	NW NW 22	T. 22 S.	R. 8 W.	Douglas	T	---do---	slty sh	.59	.63	.016	.17	.32	420	.19	27	51	.09
41	081TF-120	NE SE 36	T. 24 S.	R. 8 W.	---do---	T	Elkton Formation (Baldwin, 1974)	sh	.59	.91	.018	.51	.33	431	.53	56	36	.03
42	081TF-91	C W½ 29	T. 18 S.	R. 5 W.	Lane	T	Tyee Formation (upper part)	sltst, ss	.49	.62	.051	--	.59	--	.051	--	95	1
43	081TF-94	21	T. 22 S.	R. 7 W.	Douglas	T	---do---	sltst	.60	1.41	.046	.87	.68	436	.92	62	48	.05
44	081TF-89	SE SE 19	T. 18 S.	R. 11 W.	Lane	T	Tyee Formation	sh	.38	.87	.012	.12	.56	427	.13	14	65	.09

Table 1.--Source-rock analytical data for surface samples from Oregon and northern California--continued

Map no. (fig. 1)	Sample no.	Section	Township	Range	County[1]	Age	Stratigraphic unit	Lithology	Vitrinite reflectance, R_o (percent)	Organic carbon (Wt %)	S_1 (mgHC/g)	S_2 (mgHC/g)	S_3 ($mgCO_2$/g)	T_{max} (°C)	Genetic potential (S_1+S_2)	H_2 index (mgHC/gC)	O_2 index ($mgCO_2$/gC)	Transformation ratio, (S_1/S_1+S_2)
								Area 3										
45	081TF-90	NE NE 16	T. 18 S.	R. 9 W.	---do----	T	----do----	slty sh	.54	2.55	.042	.96	.93	435	1.00	37	37	.04
46	081TF-104	NW 21	T. 33 S.	R. 11 W.	Coos-----	T	----do----	sh	.86	.84	.024	.08	.18	435	.10	10	22	.22
47	081TF-106	SW NE 32	T. 32 S.	R. 11 W.	---do----	T	----do----	coal	.55	54.97	.285	147.71	7.03	423	148.00	269	13	.002
48	081TF-109	NE 29	T. 32 S.	R. 11 W.	---do----	T	----do----	coal	.63	36.61	.999	59.69	7.70	416	60.69	163	21	.02
49	081TF-119	SW SW 33	T. 26 S.	R. 7 W.	Douglas--	T	Tyee Formation (lower part)----	sh	.58	1.02	.019	.76	.42	435	.78	75	41	.02
50	081TF-127	SW NW 8	T. 23 S.	R. 5 W.	---do----	T	----do----	sh	.59	.65	.020	.12	.26	430	.14	19	39	.14
51	081TF-117	C N 1/2 17	T. 26 S.	R. 3 W.	---do----	T	Umpqua Formation----	clyst	.52	.22	.008	.05	.27	432	.06	22	122	.15
52	081M-16	C W 1/2 15	T. 27 S.	R. 11 W.	Coos-----	T	Umpqua Formation----	slty sh	.51	.66	.016	.16	.38	427	.18	24	57	.09
53	081TF-126	C SW 20	T. 23 S.	R. 5 W.	Douglas---	T	----do----	slty sh	.61	.31	.019	.02	.75	440	.04	5	243	.54
54	081TF-102	NW 5	T. 32 S.	R. 11 W.	Coos-----	T	----do----	sh	.58	.66	.025	.18	.23	431	.21	27	35	.12
55	081TF-100	C NE 34	T. 30 S.	R. 12 W.	---do----	T	Umpqua Formation---- (=Lookingglass Formation of Baldwin and Beaulieu, 1973)	sh	.46	.89	.019	.11	.47	431	.13	13	52	.14
56	081TF-101	C 19	T. 31 S.	R. 11 W.	---do----	T	----do----	sltst	.61	.61	.017	.13	.33	426	.15	22	54	.12
57	BELO 2082	NE 5	T. 35 S.	R. 11 W.	Curry----	T	Umpqua Formation---- (=Lookingglass Formation of Ahmad, 1981)	slty sh	.75	.77	.016	.09	.23	428	.11	12	30	.14
58	BELO 2182	SW 5	T. 35 S.	R. 11 W.	---do----	T	----do----	slty sh	.63	.48	.017	.11	.41	440	.13	23	85	.13
59	BELO 2382	SE SW 19	T. 34 S.	R. 11 W.	---do----	T	----do----	slty sh	.63	.35	.015	.01	.34	439	.03	3	96	.60
60	BELO 2482	NE SW 19	T. 34 S.	R. 11 W.	---do----	T	----do----	shy sltst	.64	.41	.029	.152	.31	439	.181	37	75	.16
61	081TF-116	C 13	T. 26 S.	R. 4 W.	Coos-----	T	Umpqua Formation---- (=Lower part of Lookingglass-Formation of Baldwin, 1974)	slty sh	.53	.37	.015	.04	.37	428	.06	12	99	.26
62	081M-2	CN 1/2 17	T. 22 S.	R. 5 W.	Douglas--	T	Umpqua Formation----	sh, clyst	.65	.32	.016	.12	.38	422	.14	37	120	.12
63	081M-15	NW SE 5	T. 27 S.	R. 11 W.	Coos-----	T	----do----	slty sh	.53	1.47	.010	.05	.40	428	.06	3	27	.18
64	081M-8	NE 34	T. 27 S.	R. 14 W.	---do----	T	Umpqua Formation---- (=Roseburg Formation of Baldwin and Beaulieu, 1973)	slty sh	.52	.37	.024	.094	.28	447	.118	25	75	.20
65	081M-9	NW 35	T. 27 S.	R. 14 W.	---do----	T	----do----	slty sh	.59	.68	.014	.08	.26	424	.09	12	38	.15
66	BELO 2282	SE NW 31	T. 34 S.	R. 11 W.	Curry----	T	Umpqua Fm. (=Roseburg ---- Formation of Ahmad, 1981)	slty sh	.60	.42	.013	.09	.22	441	.10	22	52	.12
67	BELO 2582	NE NE 7	T. 35 S.	R. 11 W.	---do----	T	----do----	carb shy sltst	1.75	.13	.024	--	.23	--	.024	--	57	1
68	081M-1	SW 2	T. 23 S.	R. 5 W.	Douglas--	T	Umpqua Formation----	slty sh	.60	.43	.009	.007	.46	426	.016	2	107	.56
69	081TF-92	S 1/2 SW 8	T. 22 S.	R. 6 W.	---do----	T	----do----	sh	.76	.41	.021	.05	.66	422	.07	13	161	.27
70	081TF-113	NW 16	T. 30 S.	R. 9 W.	---do----	T	----do----	carb sltst	.48	19.20	.037	11.05	16.66	425	11.09	58	87	.003
71	081TF-121	SE SE 25	T. 25 S.	R. 7 W.	---do----	T	----do----	slty sh	.59	.63	.028	.24	.24	428	.27	38	38	.10
72	081TF-122	NE SW 36	T. 25 S.	R. 5 W.	---do----	T	----do----	sh	.54	.81	.018	.003	.87	442	.021	33	108	.87
73	081TF-124	18	T. 25 S.	R. 5 W.	---do----	T	----do----	sh	.56	.34	.011	.06	.23	431	.07	16	68	.17
74	081TF-125	SW NW 17	T. 24 S.	R. 5 W.	---do----	T	----do----	sh	.64	.84	.015	.14	.25	426	.16	17	30	1
75	BELO 2682	SW NW 18	T. 35 S.	R. 11 W.	Curry----	K	Unnamed Cretaceous rocks	slty sh	.75	2.42	.067	.79	.24	448	.86	33	10	.08
76	BELO 2782	NE 13	T. 35 S.	R. 12 W.	---do----	K	----do----	slty sh	.72	2.48	.040	.36	.62	454	.40	14	25	.10
								Area 4										
77	BELO 1082	NE 32	T. 40 S.	R. 2 E.	Jackson--	T	Colestin Formation---- (Elliott, 1971)	carb slty ms	0.52	0.11	0.002	--	0.31	--	0.002	--	277	1
78	BELO 282	SW SE 18	T. 38 S.	R. 14 W.	Curry----	K	Hornbrook Formation---- (Wells and Peck, 1961)	slty sh	.54	.57	.008	.12	.33	431	.13	21	59	.06
79	BELO 482	SE 23	T. 46 N.	R. 6 W.	Siskiyou (CA)	K	Hornbrook Fm. - Unit b---- (Nilsen et al.,1983	coaly sh	.59	23.61	.120	44.68	5.50	442	44.80	189	23	.003
80	BELC 582	NE 32	T. 47 N.	R. 6 W.	---do----	K	----do----	carb sltst, ss	.51	.93	.026	.25	.19	437	.28	27	21	.09
81	BELO 1482	NW 5	T. 39 S.	R. 1 E.	Jackson--	K	----do----	shly sltst	.77	.64	.012	.04	.33	431	.05	8	65	.21
82	BELC 682	NE NE 29	T. 47 N.	R. 6 W.	Siskiyou (CA)	K	----do----	slty sh	.58	.37	.007	.01	.46	455	.02	3	123	.4
83	BELC 782	NW 20	T. 47 N.	R. 6 W.	---do----	K	----do----	slty sh	.67	.74	.022	.22	.34	438	.24	30	46	.09
84	BELC 882	SE NW 25	T. 48 N.	R. 7 W.	---do----	K	----do----	slty sh	.64	.90	.013	.17	.20	434	.18	19	22	.07
85	BELC 982	SE 14	T. 48 N.	R. 6 W.	---do----	K	----do----	slty sh	.60	.69	.016	.20	.26	431	.22	30	37	.07
86	BELO 1282	12	T. 39 S.	R. 1 E.	Jackson--	K	----do----	slty sh	.52	.64	.009	.01	.83	434	.02	2	129	.39
87	BELO 182	SW SW 32	T. 37 S.	R. 14 W.	Curry----	K	Days Creek Formation---- (Wells and Peck, 1961)	ms	.55	1.08	.015	.03	.65	433	.05	2	60	.36
88	BELC 382	NW 15	T. 18 N.	R. 4 E.	Del Norte (CA)	J	Galice Formation----	slaty sh	5.33	1.14	0	0	.22	--	0	0	19	0

[1]All counties are in Oregon, except as noted.

the Mist Gas Field in northwestern Oregon and encouraging gas shows in wells drilled in central Washington, the region has experienced renewed hydrocarbon exploration activity. However, very little information that might be used to establish the oil and gas source rock potential of the region has been published. The only study in Oregon and northern California is an oil and gas investigation report by Newton (1980) in the Coos Bay, Oregon, area.

The purposes of this study are (1) to report the analytical results of a reconnaissance source rock sampling project in Oregon and northern California and (2) to evaluate the quality, quantity, and thermal maturity of organic matter contained in those samples.

SOURCE ROCK EVALUATION

Eighty-eight samples were collected from outcrops, primarily in road cuts and stream drainages. Sample localities are shown in Figure 1 and are listed in Table 1. Based on the areal distribution of samples, the region was subdivided into four areas (Figure 1). Within each area, the samples are listed in approximate order of increasing age. The age of most samples is Cretaceous or younger. A few pre-Cretaceous rock samples were collected, although rocks older than Cretaceous are commonly metamorphosed. The samples consist of carbonaceous sandstone, siltstone, shale, mudstone, and coal (Table 1) and represent depositional environments ranging from nonmarine to marine. The samples were analyzed for vitrinite reflectance (R_o), total organic carbon (weight percent), and Rock-Eval pyrolysis (Table 1). Vitrinite reflectance and Rock-Eval pyrolysis analyses were conducted by the U.S. Geological Survey (USGS), Denver, Colorado, and organic carbon analyses were conducted by Rinehart Laboratory, Arvada, Colorado.

Rock-Eval pyrolysis includes evaluations of the genetic potential (S_1+S_2), organic matter type (hydrogen index [S_2/organic carbon] versus oxygen index [S_3/organic carbon]), and thermal maturity ($T°S_2$ max. and transformation ratio [S_1/S_1+S_2]). S_1 represents the quantity of volatile hydrocarbons (HC) expelled from rocks held at 250° C for 5 minutes. S_2 measures the quantity of hydrocarbons (HC) released from the rock upon pyrolysis of the kerogen at 250° to 550° C, programmed at 25° C per minute. S_3 is a measure of the amount of pyrolitic carbon dioxide evolved during the heating interval from 250° to 390° C. Detailed explanations of Rock-Eval pyrolysis are given by Espitalié and others (1977) and Tissot and Welte (1978).

The organic matter richness of the samples is generally low. However, the organic matter content of these surface samples may have been significantly reduced by weathering (Leythaeuser, 1973; Clayton and Swetland, 1978). Most samples contain less than 1.0 weight percent organic carbon (Table 1); average organic carbon content, excluding coal, is 0.91 weight percent. According to Dickey and Hunt (1972), a rock must have a minimum organic carbon content of 0.50 weight percent to be an effective hydrocarbon source rock. Organic matter occurs in most samples as disseminated flakes and plant fragments. The more organic-rich rocks are the coals and carbonaceous shales and mudstones.

Hydrogen and oxygen indices from Rock-Eval pyrolysis are plotted in Figure 2. These results show that the organic matter in the analyzed samples is mainly type III kerogen. The three samples that are in proximity to the merged types I and II evolutionary paths are coal and coaly shale (map numbers 47 and 48 from the Eocene Tyee Formation and 79 from the Cretaceous Hornbrook Formation, Figure 1 and Table 1). Some variation in the hydrogen and oxygen indices may result from different proportions of the organic matter types in the rocks. The hydrogen index is also affected by the organic carbon content of the samples; low organic carbon values commonly give artificially low hydrogen index values due to adsorption of the pyrolysis products by mineral matter in the rock. In general, the more hydrogen-rich kerogens (types I and II) are oil and gas source rocks, and the hydrogen-deficient kerogens (type III) are gas source rocks. Thus, nearly all of the samples from this

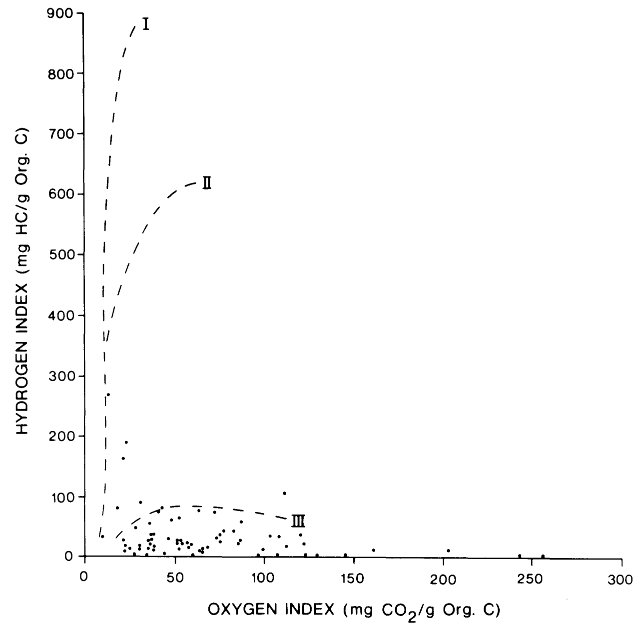


Figure 2. Modified van Krevelen diagram (Tissot and Welte, 1978) of hydrogen and oxygen indices of samples from Oregon and northern California.

study are gas source rocks with little or no potential for oil.

The genetic potential (S_1+S_2 in Table 1) is a measure of the generation capacity of the rock in milligrams of hydrocarbon per gram (mg/g), which is equivalent to kilograms per metric ton (kg/t). Tissot and Welte (1978) have suggested that samples with values less than 2 kg/t have low hydrocarbon potential, samples from 2 to 6 kg/ton have moderate source rock potential, and samples with more than 6 kg/t have good source rock potential. Based on these generation potential values, most of the analyzed samples are poor source rocks, and only a few could be classified as moderate to good source rocks.

The level of thermal maturity at which thermal generation of hydrocarbons starts is variable. The initiation of thermogenic hydrocarbons is largely dependent on the quality of organic matter. According to Tissot and Welte (1978), the top of the "oil window" is between vitrinite reflectance (R_o) values of 0.5 and 0.7 percent, and the bottom of the "oil window" is 1.3 percent. Less is known about the generation of thermogenic gas from type III kerogen, but it is known that significant gas generation begins at a slightly higher level of organic maturation than in types I and II kerogens (Tissot and Welte, 1978; Hunt, 1979). Source rock studies of type III kerogens from Cretaceous and Tertiary rocks in the Greater Green River Basin of Wyoming, Colorado, and Utah (Law and others, 1979, 1980; Law, 1984) indicate that the generation of thermogenic gas begins at a vitrinite reflectance (R_o) value of about 0.80 percent (range is 0.74-0.86 percent). The vitrinite reflectance values of most analyzed samples in this study are below 0.70 percent, indicating that these samples are immature or marginally mature with respect to gas generation.

Temperature maximum (T_{max} in Table 1) data are in fair agreement with vitrinite reflectance data. According to Espitalié and others (1977), temperature maximums in the range of 400° to 435° C correspond to immature source rocks, and temperatures between 435° and 460° C correspond to mature source rocks. The transformation ratio (S_1/S_1+S_2 in Table 1) is another measure of thermal maturity. The transformation ratio generally increases with increasing thermal maturity. Values in the range of 0.1 to 0.4 are considered to be in the oil generation zone (Tissot and Welte, 1978). Coal rank data reported for several coal fields in Oregon by Brownfield (1981) are also in general agreement with the vitrinite reflectance data.

CONCLUSIONS

A source rock evaluation of surface samples collected in Oregon and northern California indicates that the organic matter is predominantly type III kerogen and therefore has the potential of generating gas and little or no oil. The sampling density is insufficient to evaluate the source rock characteristics of any particular stratigraphic unit, but the analyses provide insight into the hydrocarbon potential of the region.

In general, most samples are organically lean, containing less than 1.0 weight percent organic carbon. Thermal maturities of the samples are highly variable. However, most samples are immature to marginally mature with respect to gas generation.

REFERENCES CITED

Ahmad, R., 1981, Stratigraphy, structure, and petrology of the Lookingglass and Roseburg Formations, Agness-Illahe area, southwest Oregon: Eugene, Oreg., University of Oregon master's thesis, 150 p.

Baldwin, E.M., 1974, Eocene stratigraphy of southwestern Oregon: Oregon Department of Geology and Mineral Industries Bulletin 83, 40 p.

Baldwin, E.M., and Beaulieu, J.D., 1973, Geology of Coos County, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 80, p. 1-40.

Brownfield, M.E., 1981, Oregon's coal and its economic future: Oregon Department of Geology and Mineral Industries, Oregon Geology, v. 43, no. 5, p. 59-67.

Clayton, J.L., and Swetland, P.J., 1978, Subaerial weathering of sedimentary organic matter: Geochimica et Cosmochimica Acta, v. 42, p. 305-312.

Dickey, P.A., and Hunt, J.M., 1972, Geochemical and hydrogeologic methods of prospecting for stratigraphic traps: American Association of Petroleum Geologists Memoir 16, p. 136-167.

Elliott, M.A., 1971, Stratigraphy and petrology of the Late Cretaceous rocks near Hilt and Hornbrook, Siskiyou County, California, and Jackson County, Oregon: Corvallis, Oreg., Oregon State University doctoral dissertation, 171 p.

Espitalié, J., Laporte, J.L., Madec, M., Marquis, F., Leplat, P., Paulet, J., and Boutefeu, A., 1977, Rapid method for source rock characterization and for evaluating their petroleum potential and their degree of evolution (English translation): Institut Français Du Pétrole, v. 32, p. 23-42.

Hunt, J.M., 1979, Petroleum geochemistry and geology: San Francisco, Calif., W.H. Freeman and Co., 617 p.

Law, B.E., 1984, Relationships of source rock, thermal maturity, and overpressuring to gas generation and occurrence in low-permeability Upper Cretaceous and lower Tertiary rocks, Greater Green River basin, Wyoming, Colorado, and Utah, *in* Woodward, J., Clayton, J., and Meissner, F., eds., Symposium on sources for oil and gas in the Rocky Mountain area: Rocky Mountain Association of Geologists [in press].

Law, B.E., Spencer, C.W., and Bostick, N.H., 1979, Preliminary results of organic maturation, temperature, and pressure studies in the Pacific Creek area, Sublette County, Wyoming, *in* 5th DOE Symposium on Enhanced Oil and Gas Recovery and Improved Drilling Methods, vol. 3—Oil and Gas Recovery: Tulsa, Okla., Petroleum Publishing Co., p. K-2/1-K-2/13.

——— 1980, Evaluation of organic matter, subsurface temperature, and pressure with regard to gas generation in low-permeability Upper Cretaceous and lower Tertiary strata in the Pacific Creek area, Sublette and Sweetwater Counties, Wyoming: Mountain Geologist, v. 17, no. 2, p. 23-35.

Leythaeuser, D., 1973, Effects of weathering on organic matter in shales: Geochimica et Cosmochimica Acta, v. 37, p. 113-120.

Newton, V.C., Jr., 1980, Prospects for oil and gas in the Coos Basin, western Coos, Douglas, and Lane Counties, Oregon: Oregon Department of Geology and Mineral Industries Oil and Gas Investigation 6, 74 p.

Niem, A.R., and Van Atta, R.O., 1973, Cenozoic stratigraphy of northwestern Oregon and adjacent southwestern Washington, *in* Beaulieu, J.D., field trip committee chairman, Geologic field trips in northern Oregon and southern Washington: Oregon Department of Geology and Mineral Industries Bulletin 77, p. 75-132.

Nilsen, T.H., Barats, G.M., Elliott, M.A., and Jones, D.L., 1983, Geologic map of the outcrop area of the Hornbook Formation, Oregon and California: U.S. Geological Survey Open-File Report 83-373, scale 1:62,500.

Snavely, P.D., Jr., MacLeod, N.S., Wagner, H.C., and Lander, D.L., 1980, Geology of the west-central part of the Oregon Coast Range, *in* Oles, K.F., Johnson, J.G., Niem, A.R., and Niem, W.A., eds., Geologic field trips in western Oregon and southwestern Washington: Oregon Department of Geology and Mineral Industries Bulletin 101, p. 39-76.

Thayer, T.P., 1956, Preliminary geologic map of the John Day quadrangle, Oregon: U.S. Geological Survey Mineral Investigations Field Studies Map MF-51, scale 1:62,500.

Tissot, B.P., and Welte, D.H., 1978, Petroleum formation and occurrence: Berlin, Springer-Verlag, 527 p.

Walker, G.W., 1977, Geologic map of Oregon east of the 121st meridian: U.S. Geological Survey Miscellaneous Investigations Series Map I-902, scale 1:500,000.

Wells, F.G., and Peck, D.L., 1961, Geologic map of Oregon west of the 121st meridian: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-323, scale 1:500,000. □

GSOC meetings announced

The Geological Society of the Oregon Country (GSOC) holds noon luncheon meetings in the Standard Plaza Building, 1100 SW Sixth Ave., Portland, Oregon, in Room A adjacent to the third-floor cafeteria, and 8 p.m. evening lectures at Portland State University, Room 371, Cramer Hall. Upcoming meetings, topics, and speakers are:

July 6 (lecture)—*Rocks, Minerals, and Scenery of Australia*, by Lew and Mura Birdsall, members OAMS and GSOC.

July 13 (lecture)—*Channeled Scablands*, by John Whitmer, M.D., GSOC member.

July 20 (luncheon)—*1984 President's Campout, August 18-26, Lewiston, Idaho*, by Lloyd Wilcox, chairman.

July 27 (lecture)—*Mount St. Helens*, by Bud Beachwood, Public Affairs producer, KOIN-Television.

August 10 (lecture)—*Same topic as July 20: President's Campout*.

For additional information about the lectures or luncheons, contact Viola L. Oberson, GSOC president, phone (503) 282-3685. □

State Capitol mineral display provided by Eugene Mineral Club

The Eugene Mineral Club installed a varied and beautiful display in the State Capitol display case of the Oregon Council of Rock and Mineral Clubs on June 1. Dean and Betty Axtell and Louie and Sibyl Redfern arranged the exhibit provided by 19 members of the club. Lyle Riggs, agent for the Council, and Florence Riggs assisted.

Fourteen Oregon counties are represented by the approximately 70 displayed specimens: Baker, Crook, Grant, Harney, Jackson, Jefferson, Lake, Lane, Lincoln, Linn, Malheur, Sherman, Wasco, and Wheeler Counties.

The display includes three obsidian carvings (a fish, an eagle, and a bear reclining on a small log), petrified wood and limb casts, Paiute agate, natrolite crystal, sagenite, tempskya fern, thunder eggs, Owyhee picture jasper, beach agates, tumbled and faceted sunstones, an agatized clam, carnelian, sunset agate, and a large slab of Chief Paulina agate.

The Eugene Mineral Club display will remain on exhibit until the end of August. □

OIL AND GAS NEWS

Mist Gas Field

Reichhold Energy has extended its exploration activity to the southeast of production by drilling Crown Zellerbach 34-28 in sec. 28, T. 6 N., R. 4 W. The well was spudded April 30 and drilled to a total depth of 3,654 ft. Plugging took place on May 11, 1984.

Columbia County 43-22, completed on February 29, 1984, was put on line May 14, at a rate of approximately 1 MMcfd (million cubic feet per day).

Amoco to explore southwest Oregon

On May 25, 1984, the Oregon Department of Geology and Mineral Industries granted three permits to drill to Amoco Production Company (table in June issue) for wells in Douglas and Coos Counties. The wells, two in T. 25 S., R. 9 W. and one in T. 25 S., R. 11 W., are proposed for 15,000 ft and 14,800 ft, respectively. The wells will likely encounter lower to middle Eocene rocks such as the Roseburg and Flournoy Formations. The proposed locations are on land leased from Weyerhaeuser Company.

Columbia County

Champlin Petroleum Company of Denver has been issued a permit to drill in Columbia County (table below). Drilling may start this month (July).

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
263	Champlin Petroleum Co. Puckett 13-36 009-00128	SW¼ sec. 36 T. 8 N., R. 5 W. Columbia County	Location; 3,500.

□

OSU geology class holds 50th reunion

The first geology class to be graduated from Oregon State University (OSU) met for its fiftieth alumni reunion on June 7, 1984, in Corvallis. As part of the reunion of the OSU class of 1934, the geology graduates met for a social hour at the Dawes House and dinner at the Black Swan Restaurant. Graduates attending included Wayne Felts, Morris Eisenbrey, Leslie Richards, and Robert Gamer. Also attending were geology faculty members including Ira Allison, who was one of the professors for the Class of 1934. □

(**Olistostromes**, *continued from page 76*)

The Curry County coastline gives us a clue as to how the exotic Otter Point blocks slid into the Roseburg Formation, as the early Eocene seas lapped against the Otter Point highlands.

REFERENCES

Allen, J.E., and Baldwin, E.M., 1944, Geology and coal resources of the Coos Bay quadrangle: Oregon Department of Geology and Mineral Industries Bulletin 27, 157 p.

Baldwin, E.M., Beaulieu, J.D., Ramp, L., Gray, J.J., Newton, V.C., Jr., and Mason, R.S., 1973, Geology and mineral resources of Coos County, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 80, 82 p.

Baldwin, E.M., and Hess, P.D., 1971, Geology of the Powers quadrangle: Oregon Department of Geology and Mineral Industries Geologic Map Series GMS-5.

Bates, R.L., and Jackson, J.A., eds., 1980, Glossary of geology, 2nd. ed.: Falls Church, Va., American Geological Institute, 749 p.

Diller, J.S., 1901, Coos Bay folio, Oregon, folio 73 *of* Geologic Atlas of the United States: U.S. Geological Survey.

Dott, R.H., Jr., 1971, Geology of the southwestern Oregon coast west of the 124th meridian: Oregon Department of Geology and Mineral Industries Bulletin 69, 63 p.

Quartzville Corridor saved for recreational mining

Opened officially on May 14, 1984, the Quartzville Recreation Corridor is now reserved for recreational mining and other recreational uses such as camping and fishing. The corridor is a stretch nearly 20 mi along Quartzville Creek in Linn County, beginning at Rocky Top Road on the northeast arm of Green Peter Reservoir and extending upstream to Freezeout Creek Road. It consists mainly of the creek and the land between it and the road which parallels it. Most important for the allowed recreational use of the corridor is the fact that permission for most forms of placering is not needed for the west half of the corridor.

This form of recreational mining in an area that has a rich tradition of mining for gold and silver had been protected in the past by a "mineral withdrawal" provision of the U.S. Bureau of Land Management (BLM) by which the area was kept free of mining claims. As the provision was expiring this year, seven public and private owners and operators of the land involved collaborated to save the corridor for recreation use. The BLM, U.S. Forest Service, Oregon Department of Forestry, City of Sweet Home, and Champion International Corporation, all property owners or managers of the land involved, were brought together with the Linn County Parks Department by the Western Mining Council to work out an arrangement under which Linn County now leases the west half of the corridor and keeps it free of mining claims.

Representatives from several cooperating agencies were on hand for the formal opening of the Quartzville Recreation Corridor. Pictured above, from left to right, are Dave Monson, Public Works Director for the City of Sweet Home; Dave Cooper, Linn County Commissioner; Russell J. Anderson, District Land Manager, Champion International; Jerry Gray (kneeling), resource person for the Western Mining Council; and Merle Marshall, Santiam Area Manager for the Bureau of Land Management. Photo courtesy of The New Era, *Sweet Home.*

At the entrance to the corridor, a large information sign has been put up by the BLM. Near it, a box contains copies of a brochure printed by Champion International describing the corridor, guidelines for its use, and the mining history of the area.

For additional information about the Quartzville Recreation Corridor, contact the Western Mining Council, Gerald Ullman, 122 Chemawa Road N., Keizer, Oregon 97303, phone (503) 390-3497. □

Koch, J.G., 1966, Late Mesozoic stratigraphy and tectonic history, Port Orford-Gold Beach area, southwestern Oregon coast: American Association of Petroleum Geologists Bulletin, v. 50, no. 1, p. 25-71.

Magoon, L.B., III, 1966, Geology of T. 28 S., R. 11 W., of the Coquille and Sitkum quadrangles, Oregon: Eugene, Oreg., University of Oregon master's thesis, 73 p. □

Available publications

BULLETINS	Price	No. Copies	Amount
33. Bibliography (1st supplement) geology and mineral resources of Oregon, 1947: Allen	$ 3.00		
35. Geology of the Dallas and Valsetz quadrangles, rev. 1964: Baldwin (map only)	3.00		
36. Papers on Tertiary foraminifera: Cushman, Stewart, and Stewart, 1949: v. 2	3.00		
44. Bibliography (2nd supplement) geology and mineral resources of Oregon, 1953: Steere	3.00		
46. Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey	3.00		
49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch	3.00		
53. Bibliography (3rd supplement) geology and mineral resources of Oregon, 1962: Steere and Owen	3.00		
61. Gold and silver in Oregon, 1968: Brooks and Ramp	17.50		
62. Andesite Conference guidebook, 1968: Dole	3.50		
65. Proceedings of the Andesite Conference, 1969: (copies)	10.00		
67. Bibliography (4th supplement) geology and mineral resources of Oregon, 1970: Roberts	3.00		
71. Geology of selected lava tubes in Bend area, Oregon, 1971: Greeley (copies)	5.00		
NEW! 77. Geologic field trips in northern Oregon and southern Washington, 1973	5.00		
78. Bibliography (5th supplement) geology and mineral resources of Oregon, 1973: Roberts	3.00		
81. Environmental geology of Lincoln County, 1973: Schlicker and others	9.00		
82. Geologic hazards of Bull Run Watershed, Multnomah, Clackamas Counties, 1974: Beaulieu	6.50		
83. Eocene stratigraphy of southwestern Oregon, 1974: Baldwin	4.00		
84. Environmental geology of western Linn County, 1974: Beaulieu and others	9.00		
85. Environmental geology of coastal Lane County, 1974: Schlicker and others	9.00		
87. Environmental geology of western Coos and Douglas Counties, 1975	9.00		
88. Geology and mineral resources of upper Chetco River drainage, 1975: Ramp	4.00		
89. Geology and mineral resources of Deschutes County, 1976: Peterson and others	6.50		
90. Land use geology of western Curry County, 1976: Beaulieu	9.00		
91. Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties, Oregon, 1977: Beaulieu	8.00		
92. Fossils in Oregon (reprinted from *The Ore Bin*), 1977	4.00		
93. Geology, mineral resources, and rock material of Curry County, Oregon, 1977	7.00		
94. Land use geology of central Jackson County, Oregon, 1977: Beaulieu	9.00		
95. North American ophiolites, 1977	7.00		
96. Magma genesis: AGU Chapman Conference on Partial Melting, 1977	12.50		
97. Bibliography (6th supplement) geology and mineral resources of Oregon, 1971-75, 1978	3.00		
98. Geologic hazards of eastern Benton County, Oregon, 1979: Bela	9.00		
99. Geologic hazards of northwestern Clackamas County, Oregon, 1979: Schlicker and Finlayson	10.00		
100. Geology and mineral resources of Josephine County, Oregon, 1979: Ramp and Peterson	9.00		
101. Geologic field trips in western Oregon and southwestern Washington, 1980	9.00		
102. Bibliography (7th supplement) geology and mineral resources of Oregon, 1976-1979, 1981	4.00		
GEOLOGIC MAPS			
Reconnaissance geologic map of Lebanon quadrangle, 1956	3.00		
Geologic map of Bend quadrangle and portion of High Cascade Mountains, 1957	3.00		
Geologic map of Oregon west of 121st meridian (USGS I-325), 1961	5.50		
Geologic map of Oregon east of 121st meridian (USGS I-902), 1977	5.50		
GMS-4: Oregon gravity maps, onshore and offshore, 1967 (folded)	3.00		
GMS-5: Geologic map of Powers quadrangle, Oregon, 1971	3.00		
GMS-6: Preliminary report on geology of part of Snake River Canyon, 1974	6.50		
GMS-8: Complete Bouguer gravity anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00		
GMS-9: Total field aeromagnetic anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00		
GMS-10: Low- to intermediate-temperature thermal springs and wells in Oregon, 1978	3.00		
GMS-12: Geologic map of the Oregon part of the Mineral quadrangle, 1978	3.00		
GMS-13: Geologic map of the Huntington and part of the Olds Ferry quadrangles, Oregon, 1979	3.00		
GMS-14: Index to published geologic mapping in Oregon, 1898-1979, 1981	7.00		
GMS-15: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, northern Oregon, 1981	3.00		
GMS-16: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, southern Oregon, 1981	3.00		
GMS-17: Total-field aeromagnetic anomaly map, Cascade Mountain Range, southern Oregon, 1981	3.00		
GMS-18: Geology of the Rickreall, Salem West, Monmouth, and Sidney 7½-minute quadrangles, Marion, Polk, and Linn Counties, Oregon, 1981	5.00		
GMS-19: Geology and gold deposits map of the Bourne quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-20: Map showing geology and geothermal resources of the southern half of the Burns 15-minute quadrangle, Oregon, 1982	5.00		
GMS-21: Geology and geothermal resources map of the Vale East 7½-minute quadrangle, Oregon, 1982	5.00		
GMS-22: Geology and mineral resources map of the Mt. Ireland quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-23: Geologic map of the Sheridan quadrangle, Polk and Yamhill Counties, Oregon, 1982	5.00		
GMS-24: Geologic map of the Grand Ronde quadrangle, Polk and Yamhill Counties, Oregon, 1982	5.00		
GMS-25: Geology and gold deposits map of the Granite quadrangle, Baker and Grant Counties, Oregon, 1982	5.00		
GMS-26: Residual gravity maps of the northern, central, and southern Cascade Range, Oregon, 1982	5.00		
GMS-27: Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1° by 2° quadrangle, 1982	6.00		
GMS-28: Geology and gold deposits map of the Greenhorn quadrangle, Baker and Grant Counties, Oregon, 1983	5.00		
GMS-29: Geology and gold deposits map, NE¼ Bates quadrangle, Baker and Grant Counties, Oregon, 1983	5.00		
NEW! GMS-31: Geology and gold deposits map, NW¼ Bates quadrangle, Baker and Grant Counties, Oregon, 1984	5.00		
OIL AND GAS INVESTIGATIONS			
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well	3.00		
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well, 1973	3.00		
5. Prospects for natural gas production or underground storage of pipeline gas, upper Nehalem River Basin, Columbia-Clatsop Counties, Oregon, 1976	5.00		
6. Prospects for oil and gas in the Coos Basin, western Coos, Douglas, and Lane Counties, Oregon, 1980: Newton and others	9.00		
7. Correlation of Cenozoic stratigraphic units of western Oregon and Washington, 1983	8.00		
9. Subsurface biostratigraphy of the east Nehalem Basin, 1983: McKeel	6.00		

ORDER FORM — CUT ON DASHED LINE

Available publications (continued)

SPECIAL PAPERS	Price	No. Copies	Amount
1. Mission, goals, and programs of Oregon Department of Geology and Mineral Industries, 1978	3.00		
2. Field geology of SW Broken Top quadrangle, Oregon, 1978: Taylor	3.50		
3. Rock material resources of Clackamas, Columbia, Multnomah, and Washington Counties, Oregon, 1978: Gray and others	7.00		
4. Heat flow of Oregon, 1978: Blackwell, Hull, Bowen, and Steele	3.00		
5. Analysis and forecasts of the demand for rock materials in Oregon, 1979: Friedman and others	3.00		
6. Geology of the La Grande area, Oregon, 1980: Barrash and others	5.00		
7. Pluvial Fort Rock Lake, Lake County, Oregon, 1979: Allison	4.00		
8. Geology and geochemistry of the Mt. Hood volcano, 1980: White	3.00		
9. Geology of the Breitenbush Hot Springs quadrangle, Oregon, 1980: White	4.00		
10. Tectonic rotation of the Oregon Western Cascades, 1980: Magill and Cox	3.00		
11. Theses and dissertations on the geology of Oregon: Bibliography and index, 1899-1982, 1982: Neuendorf and others	6.00		
12. Geologic linears of the northern part of the Cascade Range, Oregon, 1980: Venkatakrishnan, Bond, and Kauffman	3.00		
13. Faults and lineaments of the southern Cascades, Oregon, 1981: Kienle, Nelson, and Lawrence	4.00		
14. Geology and geothermal resources of the Mount Hood area, Oregon, 1982: Priest and Vogt	7.00		
15. Geology and geothermal resources of the central Oregon Cascade Range, 1983: Priest and Vogt	11.00		
16. Index to the *Ore Bin* (1939-1978) and *Oregon Geology* (1979-1982), 1983: Mahoney and Steere	4.00		
NEW! 17. Bibliography of Oregon Paleontology, 1792-1983, 1984: E.L. and W.L. Orr	6.00		
SHORT PAPERS			
21. Lightweight aggregate industry in Oregon, 1951: Mason	1.00		
24. The Almeda Mine, Josephine County, Oregon, 1967: Libbey	3.00		
25. Petrography, type Rattlesnake Formation, central Oregon, 1976: Enlows	3.00		
27. Rock material resources of Benton County, 1978: Schlicker and others	4.00		
MISCELLANEOUS PAPERS			
1. A description of some Oregon rocks and minerals, 1950: Dole	1.00		
5. Oregon's gold placers (reprints), 1954	1.00		
8. Available well records of oil and gas exploration in Oregon, rev. 1982: King, Olmstead, and Newton	4.00		
11. Collection of articles on meteorites, 1968 (reprints from *The Ore Bin*)	3.00		
15. Quicksilver deposits in Oregon, 1971: Brooks	3.00		
17. Geologic hazards inventory of the Oregon coastal zone, 1974: Beaulieu, Hughes, and Mathiot	5.00		
18. Proceedings of Citizens' Forum on potential future sources of energy, 1975	3.00		
19. Geothermal exploration studies in Oregon – 1976, 1977	3.00		
20. Investigations of nickel in Oregon, 1978: Ramp	5.00		
MISCELLANEOUS PUBLICATIONS			
Landforms of Oregon (17 × 12 inches)	1.00		
Mining claims (State laws governing quartz and placer claims)	1.00		
Geological highway map, Pacific NW region, Oregon-Washington (published by AAPG)	5.00		
Geothermal resources of Oregon map, 1982 (published by NOAA)	3.00		
Back issues of *The Ore Bin*	50¢ over the counter; $1.00 mailed		
Back issues of *Oregon Geology*	75¢ over the counter; $1.00 mailed		
Colored postcard, *Geology of Oregon*	10¢ each; 3 for 25¢; 7 for 50¢; 15 for $1.00		
Oregon Landsat mosaic map, 1983 (published by ERSAL, OSU)	$8.00 over the counter; $11.00 mailed		

Separate price lists for open-file reports, geothermal energy studies, tour guides, recreational gold mining information, and non-Departmental maps and reports will be mailed upon request.

OREGON GEOLOGY

1005 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

PUBLICATIONS ORDER

Minimum mail order $1.00. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $50.00. Foreign orders: please remit in U.S. dollars.

Fill in appropriate blanks and send sheet to Department.

YOUR NAME ____________________

ADDRESS ____________________

____________________ Zip ________

Amount enclosed $ ________

OREGON GEOLOGY

____ Renewal ____ New Subscription ____ Gift

____ 1 Year ($6.00) ____ 3 Years ($15.00)

NAME ____________________

ADDRESS ____________________

____________________ ZIP ________

(If Gift, From: ____________________)

OREGON GEOLOGY

published by the
Oregon Department of Geology and Mineral Industries

VOLUME 46, NUMBER 8 AUGUST 1984

THIS MONTH:
NEOGENE HISTORY OF THE COLUMBIA RIVER:
COLUMBIA RIVER GORGE FIELD TRIP GUIDE, PART I

OREGON GEOLOGY
(ISSN 0164-3304)

VOLUME 46, NUMBER 8 AUGUST 1984

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

Main Office: 1005 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133. Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496. Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039. Paul F. Lawson, Supervisor

Second class postage paid at Portland, Oregon. Subscription rates: 1 year, $6.00; 3 years, $15.00. Single issues, $.75 at counter, $1.00 mailed. Available back issues of *Ore Bin*: $.50 at counter, $1.00 mailed. Address subscription orders, renewals, and changes of address to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201. Permission is granted to reprint information contained herein. Credit given to the Oregon Department of Geology and Mineral Industries for compiling this information will be appreciated. POSTMASTER: Send address changes to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

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

Looking to the northeast at the southwestern end of the Columbia River Gorge. Crown Point (right side of photo) is located on one of the ancient channels of the Columbia River discussed in two-part article and field trip guide beginning on next page. (Photo courtesy Oregon State Highway Division)

NEW DOGAMI PUBLICATIONS

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 86. Prepayment is required for all orders under $50.

Released June 29, 1984:
GEOLOGIC MAP OF THE WILHOIT QUADRANGLE, OREGON, by P.R. Miller and W.N. Orr. DOGAMI Geological Map Series GMS-32, $4.00.

The new geologic map describes geologic formations south of Molalla, Clackamas County, and east of Silverton, Marion County, that reveal sea-shore environments of approximately 20-40 million years ago.

At a scale of 1:24,000, the two-colored map covers the 7½-minute quadrangle that centers around the former resort community of Wilhoit in the foothills of the Western Cascades. It identifies nine bedrock geologic units of Tertiary age, emphasizing aspects of sedimentation and paleontology and reconstructing paleoenvironments of the Oligocene and early Miocene epochs. The explanatory material on the map sheet includes two geologic cross sections and an innovative graphic presentation of the geometry of the middle-Tertiary geologic units—a three-dimensional "exploded view" of these units and their relationships.

The Wilhoit quadrangle map is the first in a series of three maps of the area. The other two, the Scotts Mills and Stayton NE 7½-minute quadrangles, will be completed later this year.

Released July 20, 1984:
BIOSTRATIGRAPHY OF EXPLORATORY WELLS IN WESTERN COOS, DOUGLAS, AND LANE COUNTIES, OREGON, by D.R. McKeel. DOGAMI Oil and Gas Investigation 11, $6.00.

This biostratigraphic study of nine southwest Oregon wells contains valuable new data for correlating Eocene and older geologic units in the subsurface. Detailed biostratigraphic data for six of the wells had not been available up to now.

Using analyses of nearly 800 samples, the 19-page report provides, for each well, an introductory summary, sample-by-sample listings of fossil and key lithologic highest occurrences, and concluding interpretations of the age and paleoenvironment for each distinctive well interval. Included in the report is a subsurface illustration which contains a surface location map and key fossil correlations for all the wells in the form of two separate generally north-south cross sections.

A striking result of the study is that the fossil record points to a shoaling event, a sudden and very short-lived change (geologically speaking) of the generally continuous deep-water deposition to a shallow-water environment during early Eocene time. This event may have been regional over the west coast of the United States. Another noteworthy conclusion is the previously unpublished presence of Paleocene marine sediments overlying volcanic rocks within the Roseburg Formation. Evidence for this was found in four of the wells. □

Open-file reports available

This is just a reminder to you that the Oregon Department of Geology and Mineral Industries (DOGAMI) has approximately 70 of its open-file reports available for purchase and another 20 that are out of print but available for in-library use.

Please feel free to request a copy of the list of open-file reports from the DOGAMI Portland office. □

Exploring the Neogene history of the Columbia River: Discussion and geologic field trip guide to the Columbia River Gorge

Part I. Discussion

by Terry L. Tolan and Marvin H. Beeson, Portland State University, Portland, Oregon 97207, and Beverly F. Vogt, Oregon Department of Geology and Mineral Industries, Portland, Oregon 97201*

The following field trip guide is designed to let you see firsthand the rocks that reveal evidence of the dynamic history of the ancestral Columbia River. It is based largely on information presented in a recently published paper by Tolan and Beeson (1984). It will be printed in two parts: Part I in this issue discusses the geology, stratigraphy, and geologic history of the Columbia River Gorge and the ancestral and present-day Columbia River; Part II, which will appear in next month's issue, contains the actual trip log and map of the route. References used in both parts of the paper appear at the end of Part I.

Due to space limitations, it is not possible for this guide to provide a review of all aspects of the geology of the Columbia River Gorge. However, there are two other published field trip guides that can fill this role. The first guide, by Aaron C. Waters (1973), describes the general geology of the Gorge and focuses on ancient lava and landslide dams that have blocked the Columbia River in the recent geologic past. The second guide, by John E. Allen (1979), is a comprehensive layman's guide to the geology, natural setting, and history of man in the Gorge. The guide by Waters may be purchased from the Portland office of the Oregon Department of Geology and Mineral Industries (DOGAMI); the book by Allen may be purchased from local bookstores.

More detailed maps of the Gorge are also available. The U.S. Forest Service sells a topographic trail map, *Forest Trails of the Columbia Gorge*. Local map dealers and DOGAMI sell topographic maps of the area. Finally, a geologic map of The Dalles 1° by 2° quadrangle (Bela, 1982) covers the eastern area of this trip guide and may be purchased from DOGAMI.

Road distances are given in miles, and all the other measurements are in metric units. Approximate conversion factors are as follows: 1 centimeter =0.4 inch, 1 meter=3.3 feet; 1 kilometer=0.6 mile; 1 cubic kilometer=0.24 cubic mile. —*Ed.*

INTRODUCTION

The evolution of the spectacular gorge of the lower Columbia River has fascinated many geologists over the years (Williams, 1916; Bretz, 1917; Buwalda and Moore, 1927, 1929; Barnes and Butler, 1930; Allen, 1932, 1979; Hodge, 1933, 1938; Warren, 1941; Treasher, 1942; Lowry and Baldwin, 1952; Waters, 1955, 1973; Trimble, 1963). Geologists have not agreed on all aspects of its development, however, such as relative locations of paths of the ancestral Columbia River and the modern-day river and the significance of fluvial sediments exposed within the Gorge area.

These differences of opinion on the locations of the courses of the ancestral Columbia have been extreme. For example, Hodge (1938, p. 847) suggested that the path of the ancestral Columbia lay south of the present-day Mount Hood and that the fluvial sediments exposed in the present-day Gorge were deposited by southerly or westerly flowing tributary streams. He hypothesized that lava flows from Cascade volcanoes eventually forced the ancestral Columbia River northward to its present-day path. In contrast, Lowry and Baldwin (1952) contended that the ancestral Columbia River has always been more or less in its present-day position.

These opposing views arose because various workers interpreted and correlated the Miocene-age and younger rocks differently (Figure 1). Most of the above-mentioned authors noted that it was difficult to trace with confidence individual stratigraphic units, particularly flows of the Miocene Columbia River Basalt Group which comprise most of the exposed section in the Gorge. Most were forced to treat the apparently uniform Columbia River basalt flows as an undifferentiated unit. Since the early 1960's, however, major advances in the understanding of the Columbia River Basalt Group have enabled geologists to identify and confidently map individual and/or groups of flows, and as a result, new insights have been gained into the overall history of the ancestral Columbia River. It is now believed that the position of the river has changed

*Current address: Geosciences Group, Rockwell International, Richland, Washington 99352

SYSTEM/SERIES		UNIT	DESCRIPTION
QUATERNARY		SEDIMENTARY DEPOSITS	Alluvium, talus, active landslides, and flood deposits.
TERTIARY	PLIOCENE	BORING AND HIGH CASCADE LAVAS	Chiefly olivine/plagioclase phyric, high alumina basalt flows erupted from small shield volcanoes, cinder cones, and fissures. In the western end of the gorge and the Portland-Vancouver area these rocks are called the Boring Lavas.
	MIOCENE	TROUTDALE FORMATION	Fluvial conglomerates, sandstones, and siltstones deposited by the ancestral Columbia River. East of the axis of the Cascades in Washington, these sediments are considered part of the Ellensburg Formation. Thickness: 0 to + 365 m.
		RHODODENDRON FORMATION	Chiefly andesitic to dacitic lahars, mudflows, and agglomerates produced by Cascadian volcanism. Thickness: 0 to 200 m.
		COLUMBIA RIVER BASALT GROUP	Tholeiitic flood - basalt flows which were erupted from fissures in the eastern portion of the Columbia Plateau from 16.5 to 12 m.y. B.P. Thickness: 0 to + 1300 m.
		UNCONFORMITY	
		EAGLE CREEK FORMATION	Interstratified fluvial conglomerates and andesitic lahars/mudflows. Thickness: 150 to 365 m.
		FIFES PEAK FORMATION	Chiefly porphyric andesite flows with interstratified laharic breccias. Exposed only north of the Columbia River. In gorge called ' Lava flows of Three - Corner Rock ' by Hammond(1980). Thickness: 1000 m.
	OLIGOCENE	STEVENS RIDGE FORMATION	Chiefly light - colored massive beds of rhyolitic to dacitic ash - flow tuffs with lesser amounts of air - fall tuffs, volcaniclastics, and lithic - pumice beds. Exposed only north of the Columbia River Gorge. Thickness: 50 to 1500 m.
		UNCONFORMITY	
		OHANAPECOSH FORMATION	Basaltic to rhyolitic lava flows, lahars, tuffs, and volcaniclastic rocks which display a variable degree of alteration. Exposed north of the Columbia River. Believed to represent earliest deposits of Cascadian volcanism and are intercalated with marine sediments north of Wind River, Washington (Wise, 1970). Thickness: 900 to 5000 m.
	EOCENE		

Figure 1. Generalized stratigraphy of the Columbia River Gorge. Modified from Trimble (1963), Wise (1970), Waters (1973), and Hammond (1979, 1980).

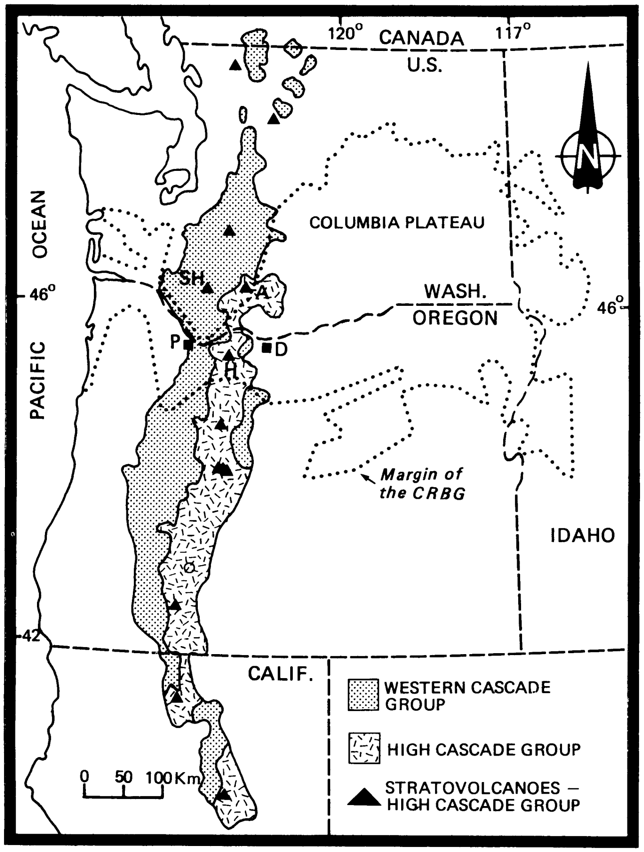


Figure 2. Generalized map of Washington, Oregon, and northern California showing distribution of the Western Cascade, High Cascade, and Columbia River Basalt Groups. P=Portland, D=The Dalles, H=Mount Hood, SH=Mount St. Helens, A=Mount Adams, CRBG=Columbia River Basalt Group. Modified from Hammond (1979, p. 220).

several times during the last 15 million years (m.y.) because (1) Columbia River basalt flows completely filled and thereby obliterated two of the canyons through which it flowed, (2) Cascadian volcanism created debris that eventually filled another canyon, and (3) uplift and folding influenced the location and depth of the river's present-day channel.

This field trip guide is designed to let you conduct a self-guided geologic field trip to see firsthand the rocks that reveal the dynamic history of the ancestral Columbia. This introductory text provides (1) a brief description of the different stratigraphic units that will be seen during the course of the trip and (2) an overview of the history of the ancestral Columbia River as we currently understand it. The road log will allow you to see important features that have helped us to decipher and interpret the history of the ancestral Columbia River.

STRATIGRAPHIC UNITS

PRE-COLUMBIA RIVER BASALT GROUP UNITS

The pre-Columbia River basalt units in the Gorge area (Figure 1) consist of middle Eocene to lower Miocene lava flows and volcaniclastic rocks (the Ohanapecosh, Stevens Ridge, Fifes Peak, and Eagle Creek Formations) (Wise, 1970; Hammond, 1980) that represent deposits from volcanoes which belonged to an ancestral Western Cascade Range that was active long before the High Cascades we see today (Figure 2). These older Western Cascade Group rocks (Hammond, 1979), which are exposed far more extensively on the Washington side of the Gorge than they are along the Oregon side, have been estimated to have a thickness of more than 6,000 m (Wise, 1970).

Although these oldest exposed units are important to our understanding of the geologic history of this area, they do not directly play an important part in the Neogene paleodrainage history of the ancestral Columbia River. Readers who are interested in more information about these rocks are referred to papers by Wise (1970), Waters (1973), and Hammond (1979, 1980).

COLUMBIA RIVER BASALT GROUP

The Columbia River basalt flows found in the Columbia River Gorge are some of the tholeiitic basalt flows of the Miocene Columbia River Basalt Group (Figure 3) that cover an area of roughly 200,000 km² in Oregon, Washington, and Idaho (Waters, 1962) with an estimated volume of over 382,000 km³ (Reidel and others, 1982). Radiometric age determinations suggest that flows of the Columbia River Basalt Group were erupted during a period from 17 to 6 m.y. ago, with more than 99 percent by volume being erupted in a 3.5-m.y. span from 17 to 13.5 m.y. ago (McKee and others, 1977, 1981).

Columbia River basalt flows were erupted from north-northwest-trending fissures or linear vents in northeastern Oregon, eastern Washington, and western Idaho. The vent system which fed individual flows probably consisted of a network of closely spaced dikes whose active eruptive lengths were on the order of many tens of kilometers (Swanson and others, 1975; Swanson and Wright, 1981). Individual flows typically had volumes of 10 to 30 km³, but some individual flows are known to have exceeded 600 km³ in volume (Swanson and Wright, 1981). It is thought that the duration

SERIES		GROUP	SUB-GROUP	FORMATION	MEMBER	K-Ar age (m.y.)	MAGNETIC POLARITY
MIOCENE	UPPER	COLUMBIA RIVER BASALT GROUP	YAKIMA BASALT SUBGROUP	SADDLE MOUNTAINS BASALT	LOWER MONUMENTAL MEMBER	6	N
					Erosional Unconformity		
					ICE HARBOR MEMBER		
					Basalt of Goose Island	8.5	N
					Basalt of Martindale	8.5	R
					Basalt of Basin City	8.5	N
					Erosional Unconformity		
					BUFORD MEMBER		R
	MIDDLE				ELEPHANT MOUNTAIN MEMBER	10.5	N, T
					Erosional Unconformity		
					POMONA MEMBER		R
					Erosional Unconformity		
					ESQUATZEL MEMBER		N
					Erosional Unconformity		
					WEISSENFELS RIDGE MEMBER		
					Basalt of Slippery Creek		N
					Basalt of Lewiston Orchards		N
					ASOTIN MEMBER		N
					Local Erosional Unconformity		
					WILBER CREEK MEMBER		N
					UMATILLA MEMBER	13.5	N
					Local Erosional Unconformity		
				WANAPUM BASALT	PRIEST RAPIDS MEMBER		R_3
					ROZA MEMBER		T, R_3
					FRENCHMAN SPRINGS MEMBER		N
					ECKLER MOUNTAIN MEMBER		
					Basalt of Shumaker Creek		N_2
					Basalt of Dodge		N_2
					Basalt of Robinette Mountain		N_2
	LOWER			GRANDE RONDE BASALT		15.5 - 16.5	N_2
							R_2
				PICTURE GORGE BASALT	Basalt of Dayville Basalt of Monument Mountain Basalt of Twickenham	(14.6-15.8)	N_1
							R_1
				IMNAHA BASALT			R_1
							T
							N_0
							R_0

Figure 3. Stratigraphic nomenclature, age, and magnetic polarity for the Columbia River Basalt Group, as revised by Swanson and others (1979b) and modified by the authors. N=normal magnetic polarity, R=reversed magnetic polarity, T=transitional magnetic polarity, m.y.=million years. Black bar in right-hand column indicates units known to be present in the Columbia River Gorge region.

of an eruption of a Columbia River basalt flow perhaps lasted from several days to as long as several weeks (Swanson and others, 1975; Swanson and Wright, 1981).

The combination of large volume and low viscosity of the erupting lavas enabled them to cover large areas and distances. The lava flows, which are called flood basalts because they covered such large areas, flowed into lowland areas, following existing stream or river channels when the chance arose. As they cooled and solidified within these channels, they also preserved the channels, making it possible for present-day geologists to determine Miocene drainage patterns.

Columbia River basalt flows entered western Oregon and Washington through a broad low which existed where the northern Oregon Cascades are found today (Beeson and Moran, 1979). The northern boundary of this lowland was just north of the present-day Columbia River Gorge; the southern boundary was in the vicinity of the Clackamas River (Anderson, 1978). Some of the westward-flowing Columbia River basalt flows that crossed the ancestral Cascade Range into western Oregon and Washington succeeded in also crossing the Miocene Coast Range, eventually reaching the ocean (Beeson and others, 1979) and probably flowing out onto the continental shelf (Snavely and others, 1980).

Not all of the flows from the various Columbia River Basalt Group units flowed as far as western Oregon and Washington (Figure 3). Those that are present in the Columbia River Gorge are denoted by the black bar on Figure 3 and are discussed below.

Grande Ronde Basalt

The Grande Ronde Basalt (Figure 4A) was erupted in a series of flows from fissures in the eastern portion of the Columbia Plateau (Figure 2) from about 16.5 to 15.5 m.y. ago (McKee and others, 1977; Long and Duncan, 1982). This formation has an approximate volume of 275,000 km^3 (Reidel and others, 1982), making it the most voluminous of all the Columbia River basalt formations. The greatest known thickness of Grande Ronde Basalt occurs in the Pasco Basin in south-central Washington, where more than 3 km was encountered in a deep borehole (Reidel and others, 1982). The thickest known section of Grande Ronde Basalt in western Oregon/Washington, over 1.3 km, is found at Dog Mountain in Washington on the eastern edge of the Gorge (J.L. Anderson, personal communication, 1980). More commonly, the Grande Ronde section in western Oregon and Washington ranges from 55 to 120 m in thickness (Beeson and Tolan, in preparation).

The Grande Ronde Basalt has been formally divided into four magnetostratigraphic units (Figure 3). These units consist of a series of flows that have the same remanent paleomagnetic polarity. In the geologic past, the Earth's magnetic poles have "flipped," or changed polarity, many times. As a basalt flow cools below the Curie point (~ 500° C), magnetic domains within the iron minerals (e.g., magnetite) present in the flow adopt the orientation of the Earth's magnetic field as it exists at that place and time. If the polarity of the Earth's magnetic field recorded at the time the flow cooled below the Curie point was the same as that of our present-day field, we term the flow "normal" ("N" below); if it had the opposite polarity of our present-day field, it is termed "reversed" ("R" below). The Grande Ronde Basalt magnetostratigraphic units have been numbered R_1, N_1, R_2, and N_2, with R_1 being the oldest unit. The paleomagnetic polarity of a flow is commonly determined in the field by checking the remanent magnetic polarity of oriented hand samples using a small, portable instrument called a fluxgate magnetometer.

In addition to the formal magnetostratigraphic units, the Grande Ronde Basalt in the Gorge area has been informally subdivided into two compositional types, called high MgO and low MgO, based on the relative concentrations of magnesium oxide (Beeson and Moran, 1979; Anderson, 1980; Tolan, 1982). Two or more high MgO flows (Table 1, column 2) are commonly found at the top of the N_2 magnetostratigraphic unit in the western portion of the Columbia Plateau (Bentley and others, 1980a; Anderson, 1980) as well as throughout western Oregon and Washington (Beeson and Moran, 1979; Beeson and Tolan, in preparation). These high MgO flows have higher amounts of MgO and CaO and lower amounts of SiO_2, K_2O, and TiO_2 than the low MgO Grande Ronde flows (Table 1, column 1) that comprise the bulk of the Grande Ronde section throughout the Gorge area. The jointing of N_2 high MgO Grande Ronde flows is commonly blocky to columnar, and in hand sample, the rocks are medium to coarse grained. In contrast, the jointing of the low MgO flows is characterized by the presence of both entablatures and colonnades (see Figure 5 for diagrammatic representation of various jointing features), and the low MgO rocks are glassy to fine grained. These differences in jointing and texture between N_2 high MgO and low MgO Grande Ronde flows are usually reliable enough to be used as criteria for mapping these flows in the western portion of the Columbia Plateau (Powell, 1978; Bentley and others, 1980a) and in western Oregon (Beeson and Tolan, in preparation).

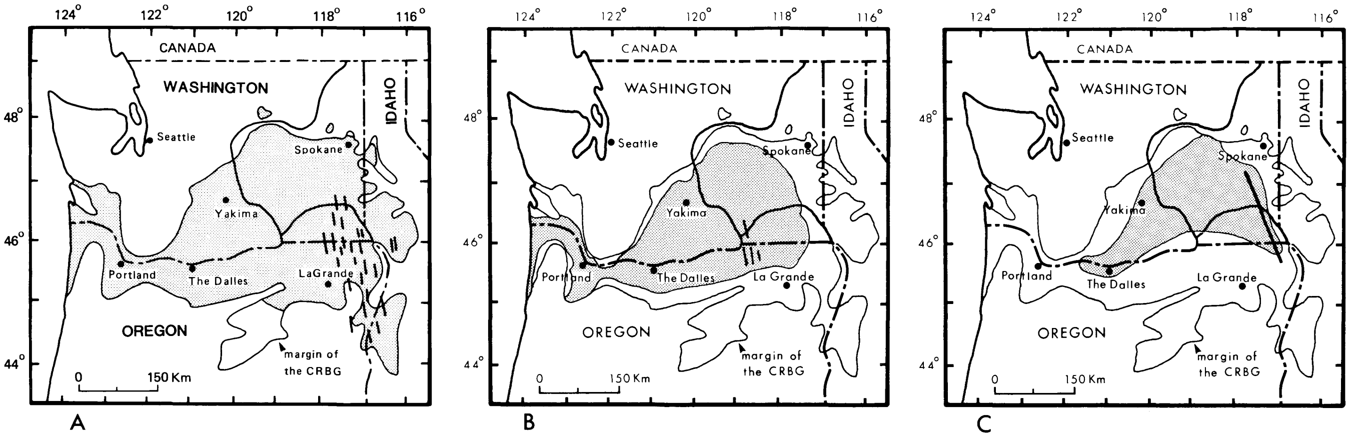
High MgO Grande Ronde flows are not exclusive to the N_2 magnetostratigraphic unit in the Gorge area. Several high MgO flows have been found in the R_2 and N_1 magnetostratigraphic horizons and are compositionally indistinguishable from N_2 high MgO Grande Ronde flows.

Wanapum Basalt

The Wanapum Basalt, which constitutes only approximately 3 percent by volume of the Columbia River Basalt Group (Reidel and others, 1983), is divided into four members (Figure 3), of

Table 1. *Average major-oxide compositions of Columbia River Basalt Group units in the Columbia River Gorge. All concentrations are in weight percent. All analyses are XRF determinations by P.R. Hooper, Washington State University, Pullman, WA 99164. Numbers in parentheses indicate numbers of analyses used in computing averages.* FeO = FeO + 0.9(Fe_2O_3).

Oxide	Grande Ronde Basalt		Wanapum Basalt				Saddle Mts. Basalt
	Low MgO (23)	High MgO (23)	Frenchman Springs Member (49)	Roza Member (9)	Priest Rapids Member: Rosalia flow (20)	Priest Rapids Member: Lolo flow (5)	Pomona Member (5)
SiO_2	55.23	53.73	51.66	51.22	50.17	49.62	52.37
Al_2O_3	14.91	15.31	14.65	14.11	14.01	14.26	15.70
TiO_2	2.14	1.89	2.97	3.16	3.54	3.09	1.63
FeO	12.18	11.59	13.87	13.93	14.91	14.34	10.45
MnO	0.20	0.20	0.22	0.22	0.24	0.25	0.18
CaO	7.01	8.50	8.12	8.27	8.38	9.01	10.36
MgO	3.56	4.80	4.24	4.73	4.29	5.05	6.79
K_2O	1.70	1.17	1.23	1.25	1.23	1.04	0.57
Na_2O	2.53	2.32	2.32	2.31	2.36	2.41	1.51
P_2O_5	0.33	0.29	0.52	0.59	0.68	0.64	0.23



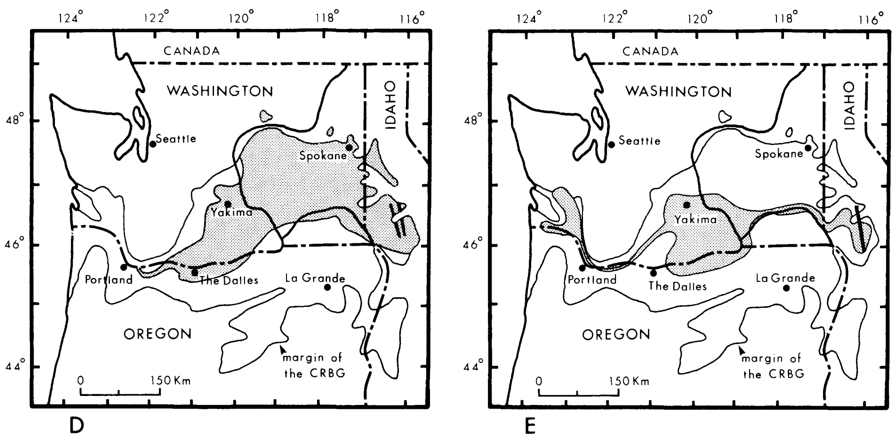


Figure 4. Maps showing distribution of selected Columbia River Basalt Group units and known source dikes. A. Grande Ronde Basalt. Modified from Snavely and others (1973) and Swanson and others (1979b). B. Frenchman Springs Member. Modified from Snavely and others (1973) and Swanson and others (1979b). C. Roza Member. Modified from Swanson and others (1979b). D. Priest Rapids Member. Data from Swanson and others (1979b, 1981), Vogt (1981), and Tolan (1982). E. Pomona Member. Modified from Snavely and others (1973), Anderson (1980), Swanson and others (1981), and Tolan (1982).

which only three, the Frenchman Springs, Roza, and Priest Rapids Members, have been found in the Gorge area (Anderson, 1979, 1981; Beeson and Moran, 1979).

Flows of Wanapum Basalt commonly overlie Grande Ronde Basalt, with the two formations generally separated by a local erosional unconformity or by an interbed called the Vantage Member on the Plateau and informally the "Vantage horizon" in this area (Beeson and Moran, 1979; Swanson and others, 1979b; Bentley and others, 1980a). The erosional unconformity or interbed between these formations has been interpreted to represent a significant hiatus (perhaps several hundred thousand years or much longer) between the end of the Grande Ronde volcanism and the general onset of Wanapum volcanism (Swanson and Wright, 1981).

Frenchman Springs Member: The Frenchman Springs Member consists of more than a dozen flows which were erupted from a northerly trending dike system in southeastern Washington and northeastern Oregon (Figure 4B). The total volume of this member has been estimated by Swanson and Wright (1981) to be 3,000 to 5,000 km^3.

Flows of the Frenchman Springs Member (Figure 3) overlie Grande Ronde Basalt and are generally overlain by flows of the Roza or Priest Rapids Members throughout much of the western portion of the Columbia Plateau (Anderson, 1979, 1981). In western Oregon and Washington, however, flows of the Frenchman Springs Member are commonly the last Columbia River Basalt Group unit to have been deposited over large areas, and they are usually unconformably overlain by younger non-Columbia River basalt units (Beeson and Moran, 1979; Beeson and Tolan, in preparation).

Frenchman Springs flows are commonly blocky to columnar jointed (Beeson and Moran, 1979; Bentley and others, 1980a), but in the Columbia Gorge area, an entablature/colonnade-style jointing similar to low MgO Grande Ronde flows is displayed by some flows (Tolan, 1982; Beeson and Tolan, in preparation). Frenchman Springs flows commonly contain clear to amber-colored plagioclase phenocrysts and/or glomerocrysts that range from 0.5 to 3 cm in size. The abundance of these plagioclase phenocrysts/glomerocrysts varies among flows, ranging from nearly none to more than several hundred per square meter. Frenchman Springs flows have a distinctive major oxide composition (Table 1, column 3) that distinguishes them from other Columbia River Basalt Group flows in the Gorge area. Frenchman Springs flows also have normal paleomagnetic polarity.

Roza Member: The Roza Member (Figure 3) was erupted from a narrow, 165-km-long linear vent system in southeastern Washington and northeastern Oregon (Swanson and others, 1975; Figure 4C). This unit is found throughout much of the central and western portions of the Columbia Plateau (Figure 4C) but apparently failed to cross the Miocene Cascade Range into western Oregon and Washington. In most areas where the Roza is present, it consists of one or two blocky- to columnar-jointed flows, but near the vent system up to four flows or "cooling units" have been reported (Swanson and others, 1979b).

The Roza Member is easily recognized in the field by its abundant small plagioclase phenocrysts (commonly less than 1 cm in size), which commonly exceed several hundred per square meter (Swanson and others, 1979b; Bentley and others, 1980a). These single, tabular plagioclase crystals and less common plagioclase glomerocrysts are usually evenly distributed throughout the entire flow. Phyric Frenchman Springs flows could be confused with Roza flows locally, but careful examination of the underlying and overlying flows usually establishes the true identity of a particular unit. The Roza Member is considered a good stratigraphic marker in the western half of the Columbia Plateau.

Chemically, the Roza Member is nearly identical to the Frenchman Springs Member (Table 1, column 4). The Roza Member has transitional paleomagnetic polarity (Swanson and others, 1979b).

Priest Rapids Member: The Priest Rapids Member (Figure 3) was erupted from dikes in western Idaho (Taubeneck and others, *in* Swanson and others, 1979b; Camp, 1981) and flowed westward into western Oregon (Figure 4D) via the channel of the ancestral Columbia River (Waters, 1973; Vogt, 1981; Tolan and Beeson, 1984) approximately 14 m.y. ago.

The Priest Rapids Member is subdivided into two compositional types: (1) an older one, the Rosalia type, which has high FeO and TiO_2 concentrations (Table 1, column 5) and, (2) a younger one, the Lolo type, which has lower FeO and TiO_2 and higher MgO concentrations (Table 1, column 6). Flows of both compositional types commonly display columnar to blocky jointing and are coarse grained in the central and western portions of the Columbia Plateau (Mackin, 1961; Bentley and others, 1980a). The older Rosalia flows are commonly aphyric, while the younger Lolo compositional type contains scattered plagioclase phenocrysts.

The Priest Rapids Member consists of up to four paleomagnetically reversed flows or flow lobes in some portions of the Columbia Plateau (Swanson and others, 1979a); more commonly, however, two flows are found in the western portion of the Plateau (Bentley and others, 1980a), and only a single intracanyon flow (Rosalia chemical type) has been found in western Oregon (Vogt, 1981; Tolan and Beeson, 1984).

Saddle Mountains Basalt

The Saddle Mountains Basalt consists of 10 chemically diverse members (Swanson and others, 1979b) and is the youngest formation within the Columbia River Basalt Group (Figure 3). Members of this formation were erupted intermittently during the final phase of Columbia River Basalt Group volcanism, which lasted from approximately 13.5 to 6 m.y. ago (McKee and others, 1977). The total volume of the Saddle Mountains Basalt has been estimated to be 3,000 km^3 (Swanson and Wright, 1981), much less than 1 percent of the total volume of the entire Columbia River Basalt Group.

Distribution of this formation is limited, with many of its members confined to structural lows or river canyons as intracanyon flows (Swanson and others, 1979a; Fecht and others, in press). Only the Pomona Member of the Saddle Mountains Basalt appears to have entered western Oregon and Washington.

Pomona Member: The Pomona Member, which in most areas consists of a single flow, was erupted from dikes in the Clearwater Embayment of western Idaho (Camp, 1979, 1981) about 12 m.y. ago (McKee and others, 1977). As the Pomona Member flowed from its source area, it was generally confined to the ancestral Clearwater/Snake River canyons (Camp, 1981), spreading laterally only in the central portion of the Columbia Plateau (Figure 4E). It continued to flow westward along the path of the ancestral Columbia River, crossing into western Washington and Oregon and eventually reaching the Pacific Ocean (Anderson, 1980; Tolan and Beeson, 1984). The distance from the source area of the Pomona Member to its distal end exceeds 500 km.

The distinctive physical characteristics of the Pomona Member make it an excellent stratigraphic marker (Swanson and others, 1979b). The Pomona flow commonly displays an easily recognized entablature-like jointing pattern that consists of apparently intertwining small-diameter columns. Pomona rocks are distinctive, in that they contain small tabular and equant plagioclase phenocrysts as well as clots of olivine that are generally less than 1 cm in size (Bentley and others, 1980a; Anderson, 1980; Tolan, 1982). The Pomona major-oxide composition separates it from other Columbia River Basalt Group flows in the Gorge area (Table 1, column 7). The Pomona Member also has reversed paleomagnetic polarity.

RHODODENDRON FORMATION

The Rhododendron Formation (Figure 1) consists of middle Miocene andesitic to dacitic volcaniclastic rocks (i.e., lahars, pyroclastic flows and fluvial deposits) and lava flows that were produced during a phase of explosive volcanism in the ancestral Cascade Mountains of northern Oregon (Peck and others, 1964; Priest and others, 1982). The Rhododendron Formation was originally described by Barnes and Butler (1930) in the Zigzag Mountain area west of Mount Hood and later formally named by Hodge (1933) after the town of Rhododendron, Oregon, which is located at the southwestern foot of Zigzag Mountain. The distribution of the Rhododendron Formation in the northern Oregon Cascades is localized; where present, the unit can reach thicknesses greater than 245 m (Beaulieu, 1977).

Rhododendron Formation rocks have been found interbedded with flows of the Columbia River Basalt Group in recently drilled deep geothermal exploratory wells on the western flank of Mount Hood (Priest and others, 1982). Reported K-Ar radiometric age determinations and stratigraphic relationships suggest the Rhododendron Formation in the northern Oregon Cascades was deposited from approximately 16 to 7 m.y. ago (Wise, 1969; Hammond, 1980; Priest and others, 1982).

The Rhododendron volcanoes in the western and central portions of the present-day Mount Hood area shed volcanic debris in all directions. To the north and east, Rhododendron lahars, mudflows, pyroclastic flows, and fluvial deposits collected in the northeast-trending Dalles and Mosier synclines (Figure 6). These volcaniclastic rocks were called the Dalles Formation by Newcomb (1966, 1969) and were more recently redefined by Farooqui and others (1981) as the Chenoweth Formation of the Dalles Group. Recent work by Gannett (1982) has demonstrated compositional similarities between the Rhododendron and Chenoweth Formations, providing compelling evidence that the rocks of the Chenoweth Formation are simply the distal equivalent of the Rhododendron Formation.

TROUTDALE FORMATION

The middle Miocene to Pliocene fluvial siltstones, sandstones, and conglomerates that are found through much of northern Oregon were formally named the Troutdale Formation by Hodge (1938, p. 873) after the town of Troutdale, Oregon, which is located at the

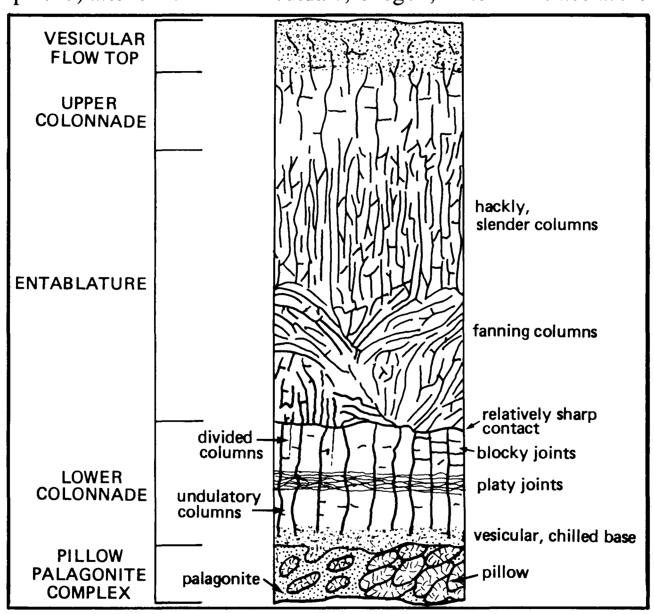


Figure 5. Diagrammatic representation of jointing patterns and flow features commonly found in Columbia River basalt. Not all features are present in all flows. The basal pillow-palagonite complex is found only in units that have flowed into water. Palagonite is an alteration product of basaltic glass (hyaloclastite). Modified from Swanson (1967) and Long and Davidson (1981).

western end of the Columbia River Gorge adjacent to cliff exposures of this formation along the lower Sandy River.

The Troutdale Formation, as originally defined by Hodge (1938) and subsequently mapped by other geologists, consists of two separate and distinct lithologic facies. The first facies is characterized by conglomerates that contain foreign clasts such as quartzite, schist, granite, and rhyolite for which no local sources can be found. This facies, which represents deposits of an ancestral Columbia River (Williams, 1916; Lowry and Baldwin, 1952; Trimble, 1963; Waters, 1973), is generally found in proximity to the modern-day Columbia River and is confined to the northern portion of the Willamette Valley (Figure 7). The Troutdale deposits found in the type area along the lower Sandy River southwest of the Gorge belong to this ancestral Columbia River facies of the Troutdale Formation (Tolan and Beeson, 1984). The other facies of the Troutdale Formation, which is characterized by conglomerates that contain only locally derived clasts, represents deposits of local Cascadian streams that drained into the Willamette lowland (Lowry and Baldwin, 1952; Baldwin, 1981).

In the Gorge area, the ancestral Columbia River facies of the Troutdale Formation can be divided into two lithologically distinct members (Tolan and Beeson, 1984): (1) a lower member of chiefly quartzite-bearing conglomerates and micaceous arkosic sandstone beds and (2) an upper member which contains mostly pebbly to cobbly vitric sandstones with basaltic conglomerate interbeds containing high-alumina basalt clasts from Boring and High Cascade lavas and less common foreign clasts.

The age of the ancestral Columbia River facies of the Trout-

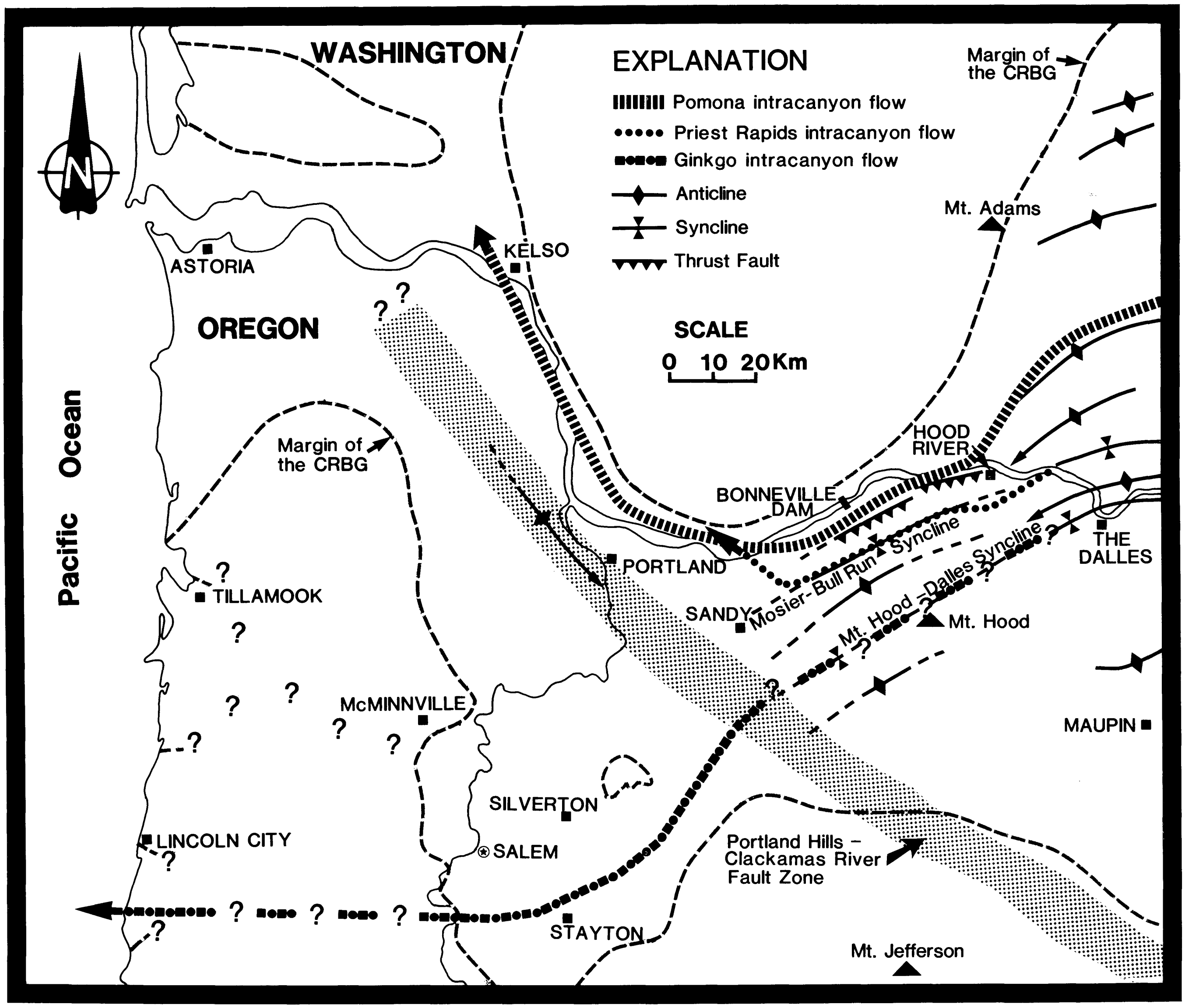


Figure 6. Sketch map showing selected major structures and the pathways of Columbia River basalt intracanyon flows in western Oregon and Washington. Northeast-trending faults and folds shown on the map are the extension of the Yakima Fold Belt through the Cascade Range (Vogt, 1981; Beeson and others, 1982; Beeson and Tolan, 1984). Most of these structures appear to die out just east of the Portland Hills-Clackamas River fault zone. Intracanyon flows of the Columbia River Basalt Group mark the former courses of the ancestral Columbia River through the Cascade Range. The Ginkgo intracanyon flow (Frenchman Springs Member) preserves the oldest ancestral Columbia River course identified to date (Beeson and Tolan, unpublished data, 1981). Note the northward jump in position of the subsequent Priest Rapids Member and Pomona Member intracanyon flows.

Columbia River basalt is known to crop out along the Oregon coast south of the margin indicated on the map. Dashed lines indicate limits of known outcrops of Columbia River basalt along the coast; question marks indicate possible flow pathways followed by the basalt as it flowed toward the coast.

dale Formation is constrained by the presence of lower member conglomerates which underlie the Pomona Member intracanyon flow (Anderson, 1980; Tolan and Beeson, 1984), which has a radiometric age of approximately 12 m.y. (McKee and others, 1977), and by high-alumina basalt flows which are interbedded with, and overlie the upper member of, the Troutdale Formation and which may be only 1 to 2 m.y. old (Tolan and Beeson, 1984). Thus it appears that deposition of the ancestral Columbia River facies of the Troutdale Formation probably spanned a period of greater than 10 m.y. in the Gorge area.

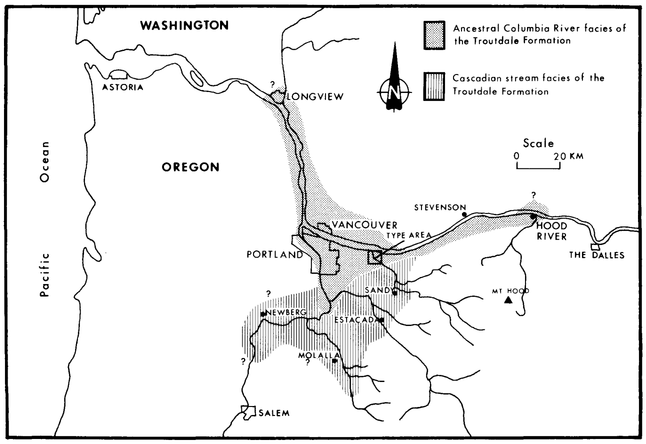


Figure 7. Map showing distribution of the ancestral Columbia River and Cascadian stream facies of the Troutdale Formation. From Tolan and Beeson (1984, p. 474).

BORING AND HIGH CASCADE LAVAS

Many of the conical and rounded hills which are found throughout the greater Portland-Vancouver area and the northern Oregon/southern Washington Cascade Range (Allen, 1975; Tolan and Beeson, 1984) represent volcanic vents that erupted primarily high-alumina basaltic lava flows. More than 90 such vents have been identified in this area (Allen, 1975), but they have not been extensively studied.

The high-alumina basalt flows in the Portland area (Table 2) have been named the Boring Lavas by Treasher (1942, p. 10) after a cluster of these volcanic vents and attendant flows that form the Boring Hills east of Portland. On the basis of lithology and stratigraphic position, Peck and others (1964) informally grouped the Boring Lavas with flows produced by High Cascade volcanism. Major-oxide analyses of Boring Lavas and High Cascade lavas from northern Oregon/southern Washington (Table 2) show that both are high-alumina basalts.

These high-alumina basalts are significant in that the presence or absence of Boring and High Cascade basalt clasts and vitric sands divides the ancestral Columbia River facies of the Troutdale Formation into two members. In the lower Gorge area, two high-alumina basalt flows (Table 2, columns 2 and 5) are found interbedded with the upper member of the Columbia River facies of the Troutdale Formation. Elsewhere in the lower Gorge area, high-alumina basalt flows are more often found overlying the Troutdale Formation (Trimble, 1963; Tolan, 1982).

The stratigraphic relationships of these rocks indicate that eruption of high-alumina basalts in the Gorge area probably began 6 to 4 m.y. ago (Tolan and Beeson, 1984) and continued episodically until the present (Hammond, 1980).

GEOLOGIC HISTORY – A SUMMARY

As noted above, the Neogene history of the ancestral Columbia River in northwestern Oregon has been the focus of much discussion and debate over the years. Regional geologic investigations, both in western Oregon and Washington and on the Columbia Plateau, have uncovered a wealth of new information on this region's paleodrainage history from middle Miocene time to the present. When these new data are combined with the observations and data from earlier investigators, a regional paleodrainage model that can be tested and built upon begins to emerge.

It is clear that the evolution of the Columbia River system has been shaped by the dynamic interplay of geologic events that occurred both in the Cascade Mountains and on the Columbia Plateau to the northeast. Since this field guide concentrates on the Gorge region, we will only briefly mention those geologic events and conditions occurring on the Columbia Plateau which we know to have had a significant impact on the evolution of the ancestral Columbia River system in western Oregon. For an excellent summary of information about the Neogene paleodrainage history of the Columbia Plateau, the reader is referred to a paper by Fecht and others (in press).

VANTAGE-FRENCHMAN SPRINGS TIME

To set the stage for the story of the ancestral Columbia River in the vicinity of the present-day Gorge, we must digress for a moment and describe the oldest identified course of the ancestral Columbia River in western Oregon. This course was established during "Vantage time," the hiatus between the last eruption of Grande Ronde flows and the first flows of the Frenchman Springs Member (Figure 3). During "Vantage time," the ancestral Columbia River appears to have followed the southwest-trending Mount Hood syncline (Figure 6) into western Oregon. This channel is known to have extended southwestward to near Salem, Oregon, where it probably turned westward and crossed the Miocene Coast Range to the Pacific Ocean (Beeson and Tolan, in preparation). The first Frenchman Springs flows to enter western Oregon followed this channel. Subsequent Frenchman Springs flows, probably combined with volcanic debris shed into the Mount Hood syncline by erupting Rhododendron volcanoes, succeeded in defeating the ancestral Columbia River along this course and in closing this route to the west (Beeson and Tolan, in preparation).

Because of their wide distribution, flows of the Frenchman Springs Member not only inundated and destroyed the ancestral Columbia River channel in western Oregon but also destroyed the existing and developing drainage systems throughout most of the Columbia Plateau (Figure 4B). However, the existing rivers and streams on the highlands surrounding the Columbia Plateau continued to drain onto the plateau surface, creating a system of shallow interconnected lakes whose waters eventually were drained from the Plateau via the Mosier-Bull Run syncline (Figure 6) which lay north of the closed-off Mount Hood syncline route.

ROZA TIME

From the end of Frenchman Springs volcanism to the eruption of the first Priest Rapids flow (Figure 3), the ancestral Columbia River re-established itself and, by headward erosion, whereby the river lengthened its course by erosion of its uplands at the head of its channel, created a new canyon in the Mosier-Bull Run syncline (Figure 6). During this period of time, the Roza Member was erupted onto the Columbia Plateau (Figure 4C). The Roza Member, like the Frenchman Springs flows before it, inundated a very large area, thereby halting any development of a drainage system in the central and western portions of the Columbia Plateau. Once again shallow interconnected lakes dotted the Plateau. Because the Roza Member apparently failed to reach the ancestral Columbia River channel, the ancestral Columbia River continued unabated the headward erosion of its canyon, eventually reaching the vicinity of Mosier, Oregon, before the first Priest Rapids flow was erupted.

PRIEST RAPIDS TIME

About 14 m.y. ago, the first flow of the Priest Rapids Member (Rosalia chemical type) was erupted (McKee and others, 1977) in the eastern portion of the Plateau (Figure 4D). Because of the geographic configuration of the land between the westernmost lake

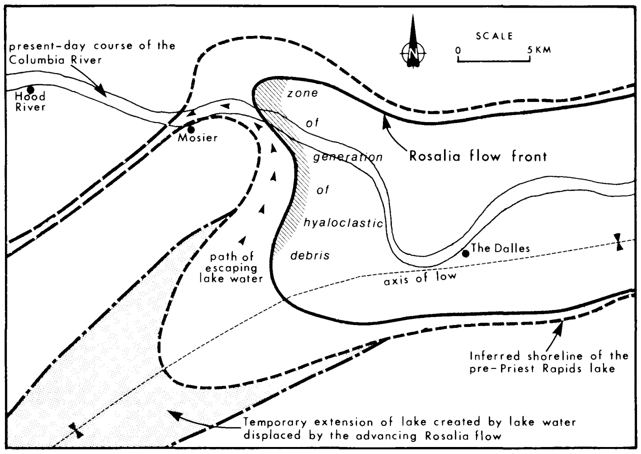


Figure 8. Sketch map showing approximate location of the lake and the head of the ancestral Columbia River channel that existed when the first Priest Rapids flow (Rosalia chemical type) entered the area. Arrows indicate path of escaping lake water where hyaloclastic debris was generated and transported when the Priest Rapids flow (flow front depicted on map) moved westward across the area. From Tolan and Beeson (1984, p. 470).

that occupied the Mount Hood-Dalles syncline and its outlet into the ancestral Columbia River canyon near Mosier, a unique situation developed when the Priest Rapids lava flow approached this area (Figure 8). As the Priest Rapids lava flow front advanced into the lake, it displaced a large amount of lake water. This water could not escape rapidly enough through the outlet of the lake and began to back up into the Mount Hood-Dalles syncline. The pent-up water eventually escaped across the active flow front of the Priest Rapids Member. The escaping water chilled the molten lava causing it to violently break up (phreatic brecciation), creating sand- to cobble-size fragments of glassy lava (hyaloclastite) that were carried in slurry-like surges into and down the ancestral Columbia River canyon. More than 8 km^3 of hyaloclastite was probably generated and flushed in advance of the lava flow into the ancestral Columbia River canyon, where it began to accumulate (Tolan and Beeson, 1984). This great amount of hyaloclastic debris drastically reduced the capacity of the canyon to contain the oncoming Priest Rapids lava, and the lava filled and overtopped the confines of the canyon along nearly its entire known length. The final result was the total obliteration of this course of the ancestral Columbia River.

TROUTDALE TIME

The destruction of the ancestral Columbia River pathway through the Mosier-Bull Run syncline by the Priest Rapids Member forced the river to move northward again (Figure 6) and establish yet another pathway through the Miocene Cascade Mountains. This new pathway, the Bridal Veil channel (Tolan and Beeson, 1984), was longer lived than its predecessors in that the river remained in it for probably more than 10 m.y. The ancestral Columbia River which occupied the Bridal Veil channel deposited the sands and gravels of the ancestral Columbia River facies of the Troutdale Formation.

The establishment of the Bridal Veil channel through the Miocene Cascade Mountains in post-Priest Rapids time was possible because apparently no known Saddle Mountains Basalt flow prior to the Pomona Member (Figure 3) had sufficient volume to reach this channel (Fecht and others, in press). This meant that the ancestral Columbia River had probably more than 1 m.y. from Priest Rapids time to Pomona time to incise the Bridal Veil channel. At Mitchell Point, approximately 5 mi west of Hood River, the Bridal Veil channel was at least 70 m deep (Anderson, 1980), while farther west at Bridal Veil, Oregon, this same channel was approximately 244 m deep and 2.4 km wide (Tolan and Beeson, 1984).

Approximately 12 m.y. ago, the Pomona Member was erupted from fissures in western Idaho (Camp, 1979, 1981) and entered the central portion of the Columbia Plateau as an intracanyon flow, spreading laterally when it encountered structural lows along its path (Figure 4E). The Pomona Member exited from the Plateau via the Bridal Veil channel through the Miocene Cascades and eventually reached the Pacific Ocean (Figure 4E). Because the Pomona Member did not fill or destroy the Bridal Veil channel, the ancestral Columbia River remained in the Bridal Veil channel in post-Pomona time.

For the next 6 m.y. following the eruption of the Pomona Member, the portion of the ancestral Columbia River and its major tributary streams located on the Columbia Plateau experienced major changes and reorganization in their courses and drainage patterns caused by waning Saddle Mountains Basalt volcanism, regional structural uplift and subsidence, and local volcanism (Fecht and others, in press). It appears the opposite is true for that

Table 2. *Major-oxide composition of selected Boring and High Cascade high-alumina basalt flows and dikes from northern Oregon and southern Washington. All concentrations are in weight percent. All analyses are XRF determinations by P.R. Hooper, Washington State University, Pullman, WA 99614.* $FeO = FeO + 0.9 (Fe_2O_3)$. *From Tolan and Beeson (1984).*

Column	1	2	3	4	5	6	7	8	9	10	11	12
Oxide												
SiO_2	53.17	50.58	50.05	55.95	49.72	51.19	56.91	49.06	52.63	51.94	50.53	55.12
Al_2O_3	18.19	17.41	17.09	18.65	18.07	16.78	18.17	17.57	18.33	17.04	17.23	17.71
TiO_2	1.42	1.33	1.50	1.15	1.32	1.57	0.95	1.23	1.23	1.72	1.33	1.65
$FeO^{\dagger}$	7.70	11.37	12.83	6.72	11.13	9.33	6.01	11.14	7.70	10.24	11.08	8.42
MnO	0.14	0.18	0.23	0.14	0.18	0.16	0.11	0.18	0.14	0.17	0.17	0.14
CaO	8.68	8.55	8.76	8.12	9.53	8.70	7.22	9.47	8.27	8.65	8.62	7.95
MgO	6.62	7.79	7.40	5.76	7.19	7.81	5.03	8.80	6.83	7.43	7.92	3.80
K_2O	1.13	0.20	0.09	0.79	0.04	1.14	1.32	0.00	1.11	0.62	0.59	1.26
Na_2O	2.39	2.27	1.73	2.28	2.46	2.76	3.80	2.20	3.27	1.70	2.11	3.32
P_2O_5	0.38	0.14	0.14	0.23	0.16	0.36	0.27	0.14	0.28	0.29	0.21	0.42

Column number	*Location*
1	Flow, NE¼NW¼ sec. 6, T. 1 N., R. 1 E., Portland quadrangle, Oregon. Collected along West Burnside Road east of Mount Calvary cemetery
2	Flow, NW¼SW¼ sec. 30, T. 1 N., R. 5 E., Bridal Veil quadrangle, Oregon. Collected above Old Scenic Highway west of Crown Point
3	Flow, center sec. 28, T. 1 N., R. 5 E., Bridal Veil quadrangle, Oregon. Collected at 120-m elevation on old logging road between Sheppard's Dell Park and Barr Road
4	Flow, SW¼SE¼ sec. 17, T. 1 N., R. 5 E., Bridal Veil quadrangle, Washington. Collected in road-cut on Highway 14 east of unnamed creek
5	Flow, NE¼NE¼ sec. 27, T. 1 N., R. 5 E., Bridal Veil quadrangle, Oregon. Collected at 365-m elevation on Palmer Mill Road
6	Flow, NW¼NW¼ sec. 26, T. 1 N., R. 5 E., Bridal Veil quadrangle, Oregon. Collected at 390-m elevation above Palmer Mill Road
7	Flow, NE¼SW¼ sec. 17, T. 1 N., R. 6 E., Bridal Veil quadrangle, Oregon. Collected at 480-m elevation in Multnomah Creek along the Larch Mountain trail (#441)
8	Flow, NE¼NW¼ sec. 7, T. 1 N., R. 7 E., Bonneville Dam quadrangle, Oregon. Collected at 640-m , elevation on Nesmith Point trail (#428)
9	Dike(?), SE¼NE¼ sec. 22, T. 2 N., R. 7 E., Bonneville Dam quadrangle, Oregon. Collected at 61-m elevation on the Eagle Creek campground road
10	Dike, T. 1 S., R. 8 E., Cherryville quadrangle, Oregon. Collected at the 550-m elevation in Blazed Alder Creek, Bull Run Watershed
11	Flow, SE¼SE¼ sec. 35, T. 4 S., R. 5 E., Fish Creek quadrangle, Oregon.
12	Dike, SE¼NW¼ sec. 22, T. 1 N., R. 9 E., Hood River quadrangle, Oregon. Collected at 370-m elevation along the Hood River below the Hood River Highway.

portion of the ancestral Columbia River that occupied the Bridal Veil channel through the Miocene Cascade Mountains. During this period of time, from approximately 12 to 6 m.y. ago, the ancestral Columbia River quietly deposited lower member Troutdale sands and gravels in the Bridal Veil channel to which it was confined. During the same period, Rhododendron volcanic activity in the Cascade Mountains episodically produced several lahars which found their way into the Bridal Veil channel and were subsequently covered and preserved by lower member Troutdale gravels (Figure 9). Overall, however, this phase of Cascadian volcanism had little discernible impact on the Bridal Veil channel.

This quiet period ended between 6 to 4 m.y. ago with the onset of High Cascade and Boring volcanism that produced high-alumina basalt flows that repeatedly reached the Bridal Veil channel. Phreatic brecciation of the basaltic lavas flowing into the ancestral Columbia River produced vast amounts of the hyaloclastic debris that now defines the upper member of the Troutdale Formation. This repeated influx of hyaloclastic debris resulted in the rapid aggradation of the Bridal Veil channel that eventually allowed the ancestral Columbia River to escape the confines of the Bridal Veil channel. Continued local basaltic volcanism eventually forced the ancestral Columbia River to the north of the Bridal Veil channel and finally capped this former course.

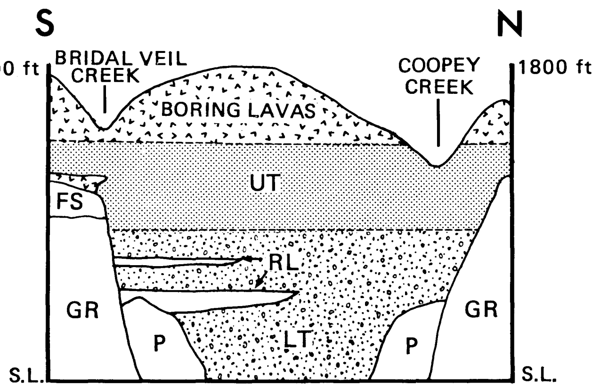


Figure 9. Generalized cross section through the Bridal Veil channel at Bridal Veil, Oregon. Stratigraphic units: GR = Grande Ronde Basalt, FS = Frenchman Springs Member of the Wanapum Basalt, P = Pomona Member of the Saddle Mountains Basalt, RL = Rhododendron lahars, LT = lower Troutdale member, UT = upper Troutdale member. From Tolan and Beeson (1984, p. 474).

PRESENT-DAY GORGE

The incision of the present-day Columbia River Gorge, which began with the onset of uplift related to the present-day High Cascades (Lowry and Baldwin, 1952; Trimble, 1963; Baldwin, 1981), marked the end of Troutdale deposition. Field relationships tentatively suggest that the onset of Cascadian uplift may have begun as late as 2 m.y. ago.

West of the rising High Cascades, the Columbia River began to cut its present-day canyon near where the more resistant Columbia River basalt laps out against older, less resistant volcanic and sedimentary rocks. The Columbia River was prevented from reoccupying and incising a new canyon in its former site by the high-alumina basalt flows that capped this pathway. East of the rising Cascades, the Columbia River appears to have begun to incise its canyon along the northern margin of the Bridal Veil channel. Thus the present-day course of the Columbia River was established.

The Columbia River Gorge was widened in Pleistocene time by catastrophic floods that resulted from the failure of glacial dams which had created ice marginal lakes northeast of the Columbia Plateau (Bretz and others, 1956; Baker and Nummedal, 1978). Other than widening and sculpting the Gorge, these floods had no lasting impact on the course of the Columbia River through the Cascades.

ACKNOWLEDGMENTS

We would like to thank Steven P. Reidel and Ann Tallman for reviewing this portion of the field trip guide and making helpful comments and suggestions.

A portion of the field work conducted in the Columbia River Gorge by T.L. Tolan and M.H. Beeson during 1980-1981 was supported by the U.S. Geological Survey (USGS) under USGS-U.S. Department of Energy (USDOE) Interagency Agreement EY-78-2-06-1078. This field work was part of the regional geologic studies effort of the Basalt Waste Isolation Project administered by Rockwell Hanford Operations for USDOE. All major-oxide analyses reported in this study were provided by the Rockwell Hanford Operation.

REFERENCES CITED

Allen, J.E., 1932, Contributions to the structure, stratigraphy, and paleontology of the lower Columbia River Gorge: Eugene, Oreg., University of Oregon master's thesis, 96 p.

——— 1975, Volcanoes of the Portland area, Oregon: Ore Bin, v. 37, no. 9, p. 145-157.

——— 1979, The magnificent gateway: A layman's guide to the geology of the Columbia River Gorge: Forest Grove, Oreg., Timber Press, 144 p.

Anderson, J.L., 1978, The structure and stratigraphy of the Columbia River basalt in the Clackamas River drainage: Portland, Oreg., Portland State University master's thesis, 136 p.

——— 1979, [Pendleton and The Dalles 1°×2° quadrangles], *in* Swanson, D.A., Anderson, J.L., Bentley, R.D., Byerly, G.R., Camp, V.E., Gardner, J.N., and Wright, T.L., Reconnaissance geologic map of the Columbia River Basalt Group in eastern Washington and northern Idaho: U.S. Geological Survey Open-File Report 79-1363, sheets 11 and 12.

——— 1980, Pomona Member of the Columbia River Basalt Group: An intracanyon flow in the Columbia River Gorge, Oregon: Oregon Geology, v. 42, no. 12, p. 195-199.

——— 1981, [The Dalles 1°×2° quadrangle], *in* Swanson, D.A., Anderson, J.L., Camp, V.E., Hooper, P.R., Taubeneck, W.H., and Wright, T.L., Reconnaissance geologic map of the Columbia River Basalt Group, northern Oregon and western Idaho: U.S. Geological Survey Open-File Report 81-797, sheet 1.

Baker, V.R., and Nummedal, D., eds., 1978, The Channeled Scabland. A guide to the geomorphology of the Columbia Basin, Washington, prepared for the Comparative Planetary Geology Field Conference held in the Columbia Basin, June 5-8, 1978: Washington, D.C., National Aeronautics and Space Administration, 186 p.

Baldwin, E.M., 1981, 3rd ed., Geology of Oregon: Dubuque, Iowa, Kendall/Hunt Publishing Company, 147 p.

Barnes, F.F., and Butler, W., 1930, The structure and stratigraphy of the Columbia River Gorge and Cascade Mountains in the vicinity of Mount Hood: Eugene, Oreg., University of Oregon master's thesis, 73 p.

Beaulieu, J.D., 1977, Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 91, 95 p.

Beeson, M.H., Fecht, K.R., Reidel, S.P., and Tolan, T.L., in preparation, Stratigraphy of the Frenchman Springs Member of the Wanapum Basalt of the Columbia River Basalt Group.

Beeson, M.H., and Moran, M.R., 1979, Columbia River Basalt Group stratigraphy in western Oregon: Oregon Geology, v. 41, no. 1, p. 11-14.

Beeson, M.H., Moran, M.R., Anderson, J.L., and Vogt, B.F., 1982, The relationship of the Columbia River Basalt Group to the geothermal potential of the Mount Hood area, Oregon, *in* Priest, G.R., and Vogt, B.F., eds., Geology and geothermal resources of the Mount Hood area, Oregon: Oregon Department of Geology and Mineral Industries Special Paper 14, p. 43-46.

Beeson, M.H., Perttu, R., and Perttu, J., 1979, The origin of the Miocene basalts of coastal Oregon and Washington: An alternative hypothesis: Oregon Geology, v. 41, no. 10, p. 159-166.

Beeson, M.H., and Tolan, T.L., in preparation, Stratigraphy of the Columbia River Basalt Group in the Willamette Valley and northwestern portion of the Cascade Range, Oregon.

Bela, J.L., compiler, 1982, Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1°×2° quadrangle: Oregon Department of Geology and Mineral Industries Geological Map Series GMS-27.

Bentley, R.D., Anderson, J.L., Campbell, N.P., and Swanson, D.A., 1980a, Stratigraphy and structure of the Yakima Indian Reservation, with emphasis on the Columbia River Basalt Group: U.S. Geological Survey Open-File Report 80-200, 76 p.

Bentley, R.D., Powell, J., Anderson, J.L., and Farooqui, S.M., 1980b, Geometry and tectonic evolution of the Columbia Hills anticline, Washington and Oregon [abs.]: Geological Society of America Abstracts with Programs, v. 12, no. 3, p. 97.

Bretz, J.H., 1917, Satsop formation of Washington and Oregon: Journal of Geology, v. 25, p. 446-458.

Bretz, J.H., Smith, H.T.U., and Neff, G.E., 1956, Channeled scablands of Washington: New data and interpretations: Geological Society of America Bulletin, v. 67, no. 8, p. 957-1049.

Buwalda, J.P., and Moore, B.N., 1927, Age of the "Satsop" and Dalles formations of Oregon and Washington: Science, v. 66, p. 236.

——— 1929, The Dalles and Hood River formations and the Columbia River Gorge: Carnegie Institution of Washington Publication 404, p. 11-26.

Camp, V.E., 1979, [Pullman 1°×2° quadrangle], *in* Swanson, D.A., Anderson, J.L., Bentley, R.D., Byerly, G.R., Camp, V.E., Gardner, J.N., and Wright, T.L., Reconnaissance geologic map of the Columbia River Basalt Group in eastern Washington and northern Idaho: U.S. Geological Survey Open-File Report 79-1363, sheet 8.

——— 1981, Geologic studies of the Columbia Plateau: Part II. Upper Miocene basalt distribution, reflecting source locations, tectonism, and drainage history in the Clearwater embayment, Idaho: Geological Society of America Bulletin, v. 92, no. 9, p. 669-678.

Farooqui, S.M., Beaulieu, J.D., Bunker, R.C., Stensland, D.E., and Thoms, R.E., 1981, Dalles Group: Neogene formations overlying the Columbia River Basalt Group in north-central Oregon: Oregon Geology, v. 43, no. 10, p. 131-140.

Fecht, K.R., Reidel, S.P., and Tallman, A.M., in press, Paleodrainage of the Columbia River system on the Columbia Plateau of Washington state: Geology of Washington Symposium Volume, Department of Natural Resources.

Free, M.R., 1976, Evidence for magma assimilation in several diorites of the middle Columbia River Gorge: Salt Lake City, Utah, University of Utah master's thesis, 66 p.

Gannett, M.W., 1982, A geochemical study of the Rhododendron and the Dalles Formations in the area of Mount Hood, Oregon: Portland, Oreg., Portland State University master's thesis, 70 p.

Hammond, P.E., 1979, A tectonic model for evolution of the Cascade Range, *in* Armentrout, J.M., Cole, M.R., and TerBest, H., Jr., eds., Cenozoic paleogeography of the western United States: Pacific Coast Paleogeography Symposium 3, Anaheim, Calif., Society of Economic Paleontologists and Mineralogists, Pacific Section, p. 219-237.

——— 1980, Reconnaissance geologic map and cross-sections of southern Washington Cascade Range, latitude 45°30′-47°15′N., longitude 120°45′-122°22.5′W.: Portland, Oreg., Geology Department, Portland State University.

Hodge, E.T., 1933, Age of the Columbia River and lower canyon [abs.]: Geological Society of America Bulletin, v. 44, pt. 1, p. 156-157.

——— 1938, Geology of the lower Columbia River: Geological Society of America Bulletin, v. 49, no. 6, p. 831-930.

Long, P.E., and Davidson, N.J., 1981, Lithology of the Grande Ronde Basalt with emphasis on the Umtanum and McCoy Canyon flows, *in* Myers, C.W., and Price, S.M., eds., Subsurface geology of the Cold Creek syncline: Richland, Wash., Rockwell Hanford Operations RHO-BWI-ST-14, p. 5.1-5.5.

Long, P.E., and Duncan, R.A., 1982, $^{40}Ar/^{39}Ar$ ages of Columbia River basalt from deep boreholes in south-central Washington [abs.]: Proceedings of the 33rd Alaska Science Conference, Fairbanks, Alaska, p. 119.

Lowry, W.D., and Baldwin, E.M., 1952, Late Cenozoic geology of the lower Columbia River valley, Oregon and Washington: Geological Society of America Bulletin, v. 63, no. 1, p. 1-24.

Mackin, J.H., 1961, A stratigraphic section in the Yakima Basalt and Ellensburg Formations in south-central Washington: Washington Division of Mines and Geology Report of Investigations 19, 45 p.

McKee, E.H., Swanson, D.A., and Wright, T.L., 1977, Duration and volume of Columbia River Basalt volcanism, Washington, Oregon and Idaho [abs.]: Geological Society of America Abstracts with Programs, v. 9, no. 4, p. 463-464.

McKee, E.H., Hooper, P.R., and Kleck., W.D., 1981, Age of Imnaha Basalt—oldest basalt flows of the Columbia River Basalt Group, northwest United States: Isochron/West, no. 31, p. 31.

Newcomb, R.C., 1966, Lithology and eastward extension of the Dalles Formation, Oregon and Washington: U.S. Geological Survey Professional Paper 550-D, p. D59-D63.

——— 1969, Effect of tectonic structure on the occurrence of ground water in the basalt of the Columbia River Group of The Dalles area, Oregon and Washington: U.S. Geological Survey Professional Paper 383-C, 33 p.

Peck, D.L., Griggs, A.B., Schlicker, H.G., Wells, F.G., and Dole, H.M., 1964, Geology of the central and northern part of the western Cascade Range in Oregon: U.S. Geological Survey Professional Paper 449, 56 p.

Priest, G.R., Beeson, M.H., Gannett, M.W., and Berri, D.A., 1982, Geology, geochemistry and geothermal resources of the Old Maid Flat area, Oregon, *in* Priest, G.R., Vogt, B.F., eds., Geology and geothermal resources of the Mount Hood area, Oregon: Oregon Department of Geology and Mineral Industries Special Paper 14, p. 16-30.

Reidel, S.P., in press, The Saddle Mountains: The evolution of a Yakima fold: American Journal of Science.

Reidel, S.P., Cross, R.W., and Fecht, K.R., 1983, Constraints on tectonic models as provided from strain rates, *in* Caggiano, J.A., and Duncan, D.W., eds., Preliminary interpretation of the tectonic stability of the reference repository location, Cold Creek syncline, Hanford Site: Richland, Wash., Rockwell Hanford Operations, RHO-BW-ST-19 P, chapter 5.

Reidel, S.P., Long, P.E., Myers, C.W., and Mase, J., 1982, New evidence for greater than 3.2 km of Columbia River basalt beneath the Central Columbia Plateau: EOS (American Geophysical Union Transactions), v. 63, p. 173.

Snavely, P.D., Jr., MacLeod, N.S., and Wagner, H.C., 1973, Miocene tholeiitic basalts of coastal Oregon and Washington and their relations to coeval basalts of the Columbia Plateau: Geological Society of America Bulletin, v. 84, no. 2, p. 378-424.

Snavely, P.D., Jr., Wagner, H.C., and Lander, D.L., 1980, Geologic cross section of the central Oregon continental margin: Geological Society of America Map and Chart Series MC-28J, 8 p.

Swanson, D.A., 1967, Yakima Basalt of the Tieton River area, south-central Washington: Geological Society of America Bulletin, v. 78, no. 9, p. 1077-1109.

Swanson, D.A., Anderson, J.L., Bentley, R.D., Byerly, G.R., Camp, V.E., Gardner, J.N., and Wright, T.L., 1979a, Reconnaissance geologic map of the Columbia River Basalt Group in eastern Washington and northern Idaho: U.S. Geological Survey Open-File Report 79-1363, scale 1:250,000.

Swanson, D.A., Anderson, J.L., Camp, V.E., Hooper, P.R., Taubeneck, W.H., and Wright, T.L., 1981, Reconnaissance geologic map of the Columbia River Basalt Group, northern Oregon and western Idaho: U.S. Geological Survey Open-File Report 81-797, scale 1:250,000.

Swanson, D.A., and Wright, T.L., 1981, Guide to geologic field trips between Lewiston, Idaho, and Kimberly, Oregon, emphasizing the Columbia River Basalt Group, *in* Johnston, D.A., and Donnelly-Nolan, J., eds., 1981, Guides to some volcanic terranes in Washington, Idaho, Oregon, and northern California: U.S. Geological Survey Circular 838, p. 1-28.

Swanson, D.A., Wright, T.L., and Helz, R.T., 1975, Linear vent systems and estimated rates of magma production and eruption for the Yakima Basalt on the Columbia Plateau: American Journal of Science, v. 275, no. 8, p. 877-905.

Swanson, D.A., Wright, T.L., Hooper, P.R., and Bentley, R.D., 1979b, Revisions in stratigraphic nomenclature of the Columbia River Basalt Group: U.S. Geological Survey Bulletin 1457-G, 59 p.

Tolan, T.L., 1982, The stratigraphic relationships of the Columbia River Basalt Group in the lower Columbia River Gorge of Oregon and Washington: Portland, Oreg., Portland State University master's thesis, 151 p.

Tolan, T.L., and Beeson, M.H., 1984, Intracanyon flows of the Columbia River Basalt Group in the lower Columbia River Gorge and their relationship to the Troutdale Formation: Geological Society of America Bulletin, v. 95, no. 4, p. 463-477.

Treasher, R.C., 1942, Geologic history of the Portland area: Oregon Department of Geology and Mineral Industries Short Paper 7, 17 p.

Trimble, D.E., 1963, Geology of Portland, Oregon, and adjacent areas: U.S. Geological Survey Bulletin 1119, 119 p.

Vandiver-Powell, L., 1978, The structure, stratigraphy and correlation of the Grande Ronde basalts on Tygh Ridge, Wasco County, Oregon:

Moscow, Idaho, University of Idaho master's thesis, 57 p.
Vogt, B.F., 1981, The stratigraphy and structure of the Columbia River Basalt Group in the Bull Run Watershed, Oregon: Portland, Oreg., Portland State University master's thesis, 151 p.
Warren, C.R., 1941, Course of the Columbia River in south-central Washington: American Journal of Science, v. 239, p. 106-127.
Waters, A.C., 1955, Geomorphology of south-central Washington, illustrated by the Yakima East quadrangle: Geological Society of America Bulletin, v. 66, no. 6, p. 663-684.
——— 1962, Basalt magma types and their tectonic associations—Pacific Northwest of the United States, *in* The crust of the Pacific Basin: American Geophysical Union Geophysical Monograph 6, p. 158-170.
——— 1973, The Columbia River Gorge; basalt stratigraphy, ancient lava dams, and landslide dams, *in* Beaulieu, J.D., Field Trip Chairman, Geologic field trips in northern Oregon and southern Washington: Oregon Department of Geology and Mineral Industries Bulletin 77, p. 133-162.
Wilkinson, W.D., Lowry, W.D., and Baldwin, E.M., 1946, Geology of the St. Helens quadrangle, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 31, 39 p.
Williams, I.A., 1916, The Columbia River Gorge: its geologic history interpreted from the Columbia River Highway: Oregon Bureau of Mines and Geology, Mineral Resources of Oregon, v. 2, no. 3, 130 p.
Wise, W.S., 1969, Geology and petrology of the Mt. Hood area: A study of High Cascade volcanism: Geological Society of America Bulletin, v. 80, no. 6, p. 969-1006.
——— 1970, Cenozoic volcanism in the Cascade Mountains of southern Washington: Washington Division of Mines and Geology Bulletin 60, 45 p. □

NEXT MONTH: FIELD TRIP GUIDE

Publications available from AGI

One revised directory and one new publication are available from the American Geological Institute (AGI), 4220 King Street, Alexandria, VA 22302, phone (800) 336-4764.

The **Directory of Geoscience Departments, United States and Canada**, 22nd edition, fall 1983 ($16.50), includes 28 new departments (for a total of 804) and 503 more faculty names, plus major museum listings and expanded field course/camp information.

A Writer's Guide to Periodicals in Earth Science ($3.50) was published in cooperation with the Association of Earth Science Editors and edited by Wendell Cochran and Mimi Braverman. The aim of the Guide is "to help you find the right journal the first time, and to submit the manuscript in a form the journal's editor is most likely to accept." The Guide lists pertinent information from about 50 earth-science journals. A supplemental list gives the names and addresses for some 70 more international earth-science periodicals. □

NWMA announces annual convention

The 90th annual convention of the Northwest Mining Association (NWMA) will be held in Spokane, Washington, on December 6-8, 1984. The meeting theme will be the long-term future of mining in the United States. Over 2,500 participants are expected. The approximately 80 speakers will address technical, environmental, and management aspects of current concern in the minerals industry.

A pre-convention short course will be held in Spokane on December 3-5, 1984. The course will present the anatomy of a mine feasibility study in a workshop course using ten or more industry experts. The purpose is to provide the participants with a working understanding of the decisions and decision-making means for the development of an ore body from discovery to production.

Further information is available from NWMA, 633 Peyton Building, Spokane, WA 99201, phone (509) 624-1158. □

OIL AND GAS NEWS

Columbia County

Champlin Petroleum Company (Denver, Colo.) has begun drilling their well in northern Columbia County. The well, Puckett 13-36, was spudded June 24 and has a proposed depth of 3,500 ft. The location is 7 mi north of gas production in the Mist Gas Field, in sec. 36, T. 8 N., R. 5 W. The target is Cowlitz Formation, from which production occurs at Mist.

Lane County

The first oil and gas exploratory well in Lane County in nearly thirty years is being drilled near the town of Creswell. Leavitt Exploration and Drilling, a local company, is drilling Maurice Brooks 1 in sec. 34, T. 19 S., R. 3 W. Working one shift per day, progress will be slow to a proposed depth of 3,000 ft.

Douglas County

Hutchins and Marrs have begun work on Great Discovery 2 in early July in sec. 20, T. 30 S., R. 9 W. Proposed depth is 3,500 ft.

Mist gas production

Month	Total Mcf	Field avg. Btu	Total therms
April 1984	162,809	969	1,577,168
May 1984	221,886	968	2,113,191
Cumulative field production through May 1984	17,368,862		

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
264	Reichold Energy Corp. Columbia County 11-10 009-00129	NW¼ sec. 10 T.6 N., R.5 W. Columbia County	Application; 3,500
265	Reichold Energy Corp. Columbia County 43-27 009-00127	SE¼ sec. 27 T.6 N., R.5 W. Columbia County	Application; 2,600

□

GSOC meetings announced

The Geological Society of the Oregon Country (GSOC) holds noon luncheon meetings in the Standard Plaza Building, 1100 SW Sixth Ave., Portland, Oregon, in Room A adjacent to the third-floor cafeteria, and 8 p.m. evening lectures at Portland State University, Room 371, Cramer Hall. Upcoming meetings, topics, and speakers are:

September 7 (luncheon)—*Confucian Country Revisited after 52 Years*, by Hazel Newhouse, geography teacher, retired.

September 14 (lecture)—*Who Is Watching?* by Sally Russell, Friends of the Columbia River Gorge.

September 21 (luncheon)—*Morocco*, by Irma Greisel, science teacher, and Marianne Ott, photographer.

September 28 (lecture)—*Geology Work at Mount St. Helens and Spirit Lake*, by John Sager, chief geologist, U.S. Army Corps of Engineers.

For additional information about the lectures or luncheons, contact Viola L. Oberson, GSOC president, phone (503) 282-3685. □

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.

GEOLOGY AND HYDROTHERMAL ALTERATION, GLASS BUTTES, SOUTHEAST OREGON, by Dulcy Annette Berri (M.S., Portland State University, 1982)

The Glass Buttes volcanic complex consists of many domes and individual vents that erupted both rhyolitic and basaltic lavas during the late Miocene to early Pliocene. The east half of the complex, in the vicinity of Little Glass Butte, contains interfingering, finely flow-banded rhyolite and black obsidian flows. The youngest unit, an obsidian, has been dated at 4.9 m.y. East of Little Glass Butte lie two northwest-trending ridges, Antelope and Cascade Ridges, composed of two or more overlapping exogenous domes that formed along northwest-trending faults.

The Brothers fault zone dominates local structure. Fault trends observed are northwesterly, and northeast trends may be conjugate fractures. The concentration of volcanism at Glass Buttes may be due to intersection of the Brothers fault zone with a west-northwest-trending silicic volcanic zone. Ensuing volcanism was bimodal, including glassy rhyolite, and the igneous body fostered a hydrothermal system.

Rhyolites are peraluminous, and silica content ranges from 73 to 79 percent. Growth of spherulites occurred during devitrification of the glassy rhyolites, with slight silica-enrichment during vapor-phase alteration. Hydration and groundwater leaching depleted soda, alumina, and silica in the glass. The plateau surrounding the buttes consists of olivine basalt, and a feldspathic basalt interfingers with rhyolite flows within the complex.

Hydrothermal alteration of rhyolite flows and glass was concentrated along faults in the eastern Glass Buttes. Massive cinnabar-bearing opalite was deposited from rising silica-rich geothermal waters accompanied by mercury-bearing vapors. Silicification occurred into footwall material, and irregular argillic alteration resulted from downward-percolating acidified groundwater.

The hydrothermal system has since cooled off or been plugged by opalite deposits. Eruption of lavas continued after alteration, further sealing the system. Late-stage fumarolic alteration indicates that limited escape of gases occurred through faults in the opalite.

The geothermal reservoir is 600 m or more below the surface. Repeated fracturing and resultant boiling of fluids suggest the potential for precious-metal deposits. Low-temperature fluids producing surface alteration could not transport most epithermal elements that subsequently were concentrated below the opalite cover. The steeply inclined zones of alteration imply a deep hydrothermal system and great depths to potentially economic mineral deposits.

A GEOPHYSICAL STUDY OF THE NORTH SCAPPOOSE CREEK-ALDER CREEK-CLATSKANIE RIVER LINEAMENT, ALONG THE TREND OF THE PORTLAND HILLS FAULT, COLUMBIA COUNTY, OREGON, by Nina Haas (M.S., Portland State University, 1983)

The Portland Hills fault forms a strong northwest-trending lineament along the east side of the Tualatin Mountains. An en-echelon lineament follows North Scappoose Creek, Alder Creek, and the Clatskanie River along the same trend, through Columbia County, Oregon. The possibility that this lineament follows a fault or fault zone was investigated in this study. Geophysical methods were used, with seismic-refraction, magnetic, and gravity lines run perpendicular to the lineament. The seismic-refraction models indicate the near-surface basalt is broken in many places, with 15-30 m (50-100 ft) vertical displacement down to the west at Bunker Hill along the Alder Creek fault. Gravity models required a faulted zone approximately two km wide across the lineament. The proposed fault zone is more clearly defined in the south, becoming more diffuse and branching in the northern part of the study area. The Bouguer gravity values from this study distort the −40 milligal contour farther to the northwest than is shown on the *Complete Bouguer Gravity Anomaly Map of Oregon* by J.W. Berg and J.V. Thiruvathukal, 1967 (Oregon Department of Geology and Mineral Industries Geological Map Series GMS-4b). The existence of sharp topographic features and the geophysical evidence indicate fault activity along the zone.

TRACE ELEMENTS IN VEINS OF THE BOHEMIA MINING DISTRICT, OREGON, by Laurence Stewart Istas (Ph.D., University of Washington, 1983)

Over 200 samples of quartz, rock, and sulfides were collected from the epithermal veins of the Bohemia mining district, Oregon for analysis by neutron activation and electron microprobe. Three major types of vein quartz exist at Bohemia. Type I is 5 percent of the total and has under 150 ppm Al and a few amorphous opaque inclusions. Type II is 85 percent of the total and has over 600 ppm Al, a few amorphous opaque inclusions, and Al micro-impurity zones. Type III is 10 percent of the total and has over 600 ppm Al, a few amorphous opaque inclusions, Al and K micro-impurity zones, and microscopic inclusions of rutile, kaolinite, and sericite. The rutile carries considerable Th, Sc, Hf, V, REE, and other oxide-forming elements. The rutile and silicate inclusions are relict from volcanic rock. All quartz contains fluid inclusions which contain Na and much less than stoichiometric Cl.

Types I and II intergrew on a micron scale. The intergrowth of Types I and II mixes with Type III on a grain-size scale. Type I quartz is interpreted as slow-growth, open-space quartz. Type II quartz is interpreted as fast-growth, open-space quartz. Type III quartz is interpreted as replacement quartz.

The Al in Type I quartz is a lattice substituent and its concentration is controlled by temperature. For Type I quartz, lattice Al is an accurate geothermometer, at least in the range of 250° to 325° C. Ti and Fe enter the quartz lattice at higher temperatures, as in plutonic quartz. Radiation-induced red-orange cathodoluminescence indicates low Al content in vein quartz. Inherent, weak blue, cathodoluminiscence indicates a non-aluminum lattice impurity, probably Ti. As and Sb are lattice substituents in vein quartz from Bohemia and other districts in the Cascades.

Three parameters have positive correlations with higher grades of gold ore: (1) gold content in quartz, (2) presence of low-Al quartz (Type I), and (3) kaolinite/sericite in microscopic inclusions in Type III quartz greater than 2/3. The location of ore at Bohemia is largely controlled by faults and their relationship to the stock. Impurities in quartz do not form zones either in individual veins or over the district, except as indirectly affected by structural control of intensity of alteration and mineralization. Fluids were probably dilute carbonate or bicarbonate solutions with very small amounts of gold. Large volumes of solution were circulated through the veins by convection, driven by plutonic heat. High-grade ore deposits require that the veins be open for long periods, although not necessarily continuously.

Even at this early stage of development, exploration methods based on Type I quartz and kaolinite/sericite in quartz appear to be competitive with and complementary to existing exploration methods using rock alteration or soil analysis for metals. Exploration based on trace gold in quartz and on vein K-feldspar needs to be tested on larger samples. □

AVAILABLE DEPARTMENT PUBLICATIONS

GEOLOGICAL MAP SERIES

		Price	No. copies	Amount
GMS-4:	Oregon gravity maps, onshore and offshore. 1967	$ 3.00		
GMS-5:	Geologic map, Powers 15-minute quadrangle, Coos and Curry Counties. 1971	3.00		
GMS-6:	Preliminary report on geology of part of Snake River canyon. 1974	6.50		
GMS-8:	Complete Bouguer gravity anomaly map, central Cascade Mountain Range, Oregon. 1978	3.00		
GMS-9:	Total-field aeromagnetic anomaly map, central Cascade Mountain Range, Oregon. 1978	3.00		
GMS-10:	Low- to intermediate-temperature thermal springs and wells in Oregon. 1978	3.00		
GMS-12:	Geologic map of the Oregon part of the Mineral 15-minute quadrangle, Baker County. 1978	3.00		
GMS-13:	Geologic map, Huntington and part of Olds Ferry 15-minute quadrangles, Baker and Malheur Counties. 1979	3.00		
GMS-14:	Index to published geologic mapping in Oregon, 1898-1979. 1981	7.00		
GMS-15:	Free-air gravity anomaly map and complete Bouguer gravity anomaly map, north Cascades, Oregon. 1981	3.00		
GMS-16:	Free-air gravity anomaly map and complete Bouguer gravity anomaly map, south Cascades, Oregon. 1981	3.00		
GMS-17:	Total-field aeromagnetic anomaly map, south Cascades, Oregon. 1981	3.00		
GMS-18:	Geology of Rickreall, Salem West, Monmouth, and Sidney 7½-minute quads., Marion/Polk Counties. 1981	5.00		
GMS-19:	Geology and gold deposits map, Bourne 7½-minute quadrangle, Baker County. 1982	5.00		
GMS-20:	Map showing geology and geothermal resources, southern half, Burns 15-minute quad., Harney County. 1982	5.00		
GMS-21:	Geology and geothermal resources map, Vale East 7½-minute quadrangle, Malheur County. 1982	5.00		
GMS-22:	Geology and mineral resources map, Mount Ireland 7½-minute quadrangle, Baker/Grant Counties. 1982	5.00		
GMS-23:	Geologic map, Sheridan 7½-minute quadrangle, Polk/Yamhill Counties. 1982	5.00		
GMS-24:	Geologic map, Grand Ronde 7½-minute quadrangle, Polk/Yamhill Counties. 1982	5.00		
GMS-25:	Geology and gold deposits map, Granite 7½-minute quadrangle, Grant County. 1982	5.00		
GMS-26:	Residual gravity maps, northern, central, and southern Oregon Cascades. 1982	5.00		
GMS-27:	Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1°×2° quadrangle. 1982	6.00		
GMS-28:	Geology and gold deposits map, Greenhorn 7½-minute quadrangle, Baker/Grant Counties. 1983	5.00		
GMS-29:	Geology and gold deposits map, NE¼ Bates 15-minute quadrangle, Baker/Grant Counties. 1983	5.00		
GMS-31:	Geology and gold deposits map, NW¼ Bates 15-minute quadrangle, Grant County. 1984	5.00		
GMS-32:	Geologic map, Wilhoit 7½-minute quadrangle, Clackamas/Marion Counties. 1984	4.00		

OTHER MAPS

	Price	No. copies	Amount
Reconnaissance geologic map, Lebanon 15-minute quadrangle, Linn/Marion Counties. 1956	3.00		
Geologic map, Bend 30-minute quad., and reconnaissance geologic map, central Oregon High Cascades. 1957	3.00		
Geologic map of Oregon west of 121st meridian (U.S. Geological Survey Map I-325). 1961	5.50		
Geologic map of Oregon east of 121st meridian (U.S. Geological Survey Map I-902). 1977	5.50		
Landforms of Oregon (relief map, 17×12 in.)	1.00		
Oregon Landsat mosaic map (published by ERSAL, OSU). 1983	$8.00 over the counter; $11.00 mailed		
Geothermal resources of Oregon (map published by NOAA). 1982	3.00		
Geological highway map, Pacific Northwest region, Oregon/Washington/part of Idaho (published by AAPG). 1973	5.00		

BULLETINS

		Price	No. copies	Amount
33.	Bibliography of geology and mineral resources of Oregon (1st supplement, 1937-45). 1947	3.00		
35.	Geology of the Dallas and Valsetz 15-minute quadrangles, Polk County (map only). Revised 1964	3.00		
36.	Papers on foraminifera from the Tertiary (v.2 [parts VI-VIII] only). 1949	3.00		
44.	Bibliography of geology and mineral resources of Oregon (2nd supplement, 1946-50). 1953	3.00		
46.	Ferruginous bauxite deposits, Salem Hills, Marion County. 1956	3.00		
49.	Lode mines, Granite mining district, Grant County. 1959	3.00		
53.	Bibliography of geology and mineral resources of Oregon (3rd supplement, 1951-55). 1962	3.00		
61.	Gold and silver in Oregon. 1968	17.50		
62.	Andesite Conference guidebook. 1968	3.50		
65.	Proceedings of the Andesite Conference. 1969	10.00		
67.	Bibliography of geology and mineral resources of Oregon (4th supplement, 1956-60). 1970	3.00		
71.	Geology of selected lava tubes, Bend area, Deschutes County. 1971	5.00		
77.	Geologic field trips in northern Oregon and southern Washington. 1973	5.00		
78.	Bibliography of geology and mineral resources of Oregon (5th supplement, 1961-70). 1973	3.00		
81.	Environmental geology of Lincoln County. 1973	9.00		
82.	Geologic hazards of Bull Run Watershed, Multnomah and Clackamas Counties. 1974	6.50		
83.	Eocene stratigraphy of southwestern Oregon. 1974	4.00		
84.	Environmental geology of western Linn County. 1974	9.00		
85.	Environmental geology of coastal Lane County. 1974	9.00		
87.	Environmental geology of western Coos and Douglas Counties. 1975	9.00		
88.	Geology and mineral resources, upper Chetco River drainage, Curry and Josephine Counties. 1975	4.00		
89.	Geology and mineral resources of Deschutes County. 1976	6.50		
90.	Land use geology of western Curry County. 1976	9.00		
91.	Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties. 1977	8.00		
92.	Fossils in Oregon. A collection of reprints from the *Ore Bin*. 1977	4.00		
93.	Geology, mineral resources, and rock material of Curry County. 1977	7.00		
94.	Land use geology of central Jackson County. 1977	9.00		
95.	North American ophiolites (IGCP project). 1977	7.00		
96.	Magma genesis. AGU Chapman Conference on Partial Melting. 1977	12.50		
97.	Bibliography of geology and mineral resources of Oregon (6th supplement, 1971-75). 1978	3.00		
98.	Geologic hazards of eastern Benton County. 1979	9.00		
99.	Geologic hazards of northwestern Clackamas County. 1979	10.00		
100.	Geology and mineral resources of Josephine County. 1979	9.00		
101.	Geologic field trips in western Oregon and southwestern Washington. 1980	9.00		
102.	Bibliography of geology and mineral resources of Oregon (7th supplement, 1976-79). 1981	4.00		

SHORT PAPERS

		Price	No. copies	Amount
21.	Lightweight aggregate industry in Oregon. 1951	1.00		
24.	The Almeda Mine, Josephine County. 1967	3.00		
25.	Petrography of Rattlesnake Formation at type area, central Oregon. 1976	3.00		
27.	Rock material resources of Benton County. 1978	4.00		

AVAILABLE DEPARTMENT PUBLICATIONS (continued)

MISCELLANEOUS PAPERS	Price	No. copies	Amount
1. A description of some Oregon rocks and minerals. 1950	$ 1.00		
5. Oregon's gold placers. 1954	1.00		
8. Available well records of oil and gas exploration in Oregon. Revised 1982	4.00		
11. Collection of articles on meteorites (reprints from *Ore Bin*). 1968	3.00		
15. Quicksilver deposits in Oregon. 1971	3.00		
17. Geologic hazards inventory, Oregon coastal zone. 1974	5.00		
18. Proceedings of Citizens' Forum on Potential Future Sources of Energy. 1975	3.00		
19. Geothermal exploration studies in Oregon, 1976. 1977	3.00		
20. Investigations of nickel in Oregon. 1978	5.00		
SPECIAL PAPERS			
1. Mission, goals, and programs of the Oregon Department of Geology and Mineral Industries. 1978	3.00		
2. Field geology, SW Broken Top quadrangle. 1978	3.50		
3. Rock material resources, Clackamas, Columbia, Multnomah, and Washington Counties. 1978	7.00		
4. Heat flow of Oregon. 1978	3.00		
5. Analysis and forecasts of the demand for rock materials in Oregon. 1979	3.00		
6. Geology of the La Grande area. 1980	5.00		
7. Pluvial Fort Rock Lake, Lake County. 1979	4.00		
8. Geology and geochemistry of the Mount Hood volcano. 1980	3.00		
9. Geology of the Breitenbush Hot Springs quadrangle. 1980	4.00		
10. Tectonic rotation of the Oregon Western Cascades. 1980	3.00		
11. Theses and dissertations on geology of Oregon: Bibiliography and index, 1899-1982. 1982	6.00		
12. Geologic linears of the northern part of the Cascade Range, Oregon. 1980	3.00		
13. Faults and lineaments of the southern Cascades, Oregon. 1981	4.00		
14. Geology and geothermal resources of the Mount Hood area. 1982	7.00		
15. Geology and geothermal resources of the central Oregon Cascade Range. 1983	11.00		
16. Index to the *Ore Bin* (1939-1978) and *Oregon Geology* (1979-1982). 1983	4.00		
17. Bibliography of Oregon paleontology, 1792-1983. 1984	6.00		
OIL AND GAS INVESTIGATIONS			
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well. 1973	3.00		
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well. 1973	3.00		
5. Prospects for natural gas, upper Nehalem River basin. 1976	5.00		
6. Prospects for oil and gas, Coos Basin. 1980	9.00		
7. Correlation of Cenozoic stratigraphic units of western Oregon and Washington. 1983	8.00		
9. Subsurface biostratigraphy, east Nehalem Basin. 1983	6.00		
11. Biostratigraphy of exploratory wells, western Coos, Douglas, and Lane Counties. 1984	6.00		
MISCELLANEOUS PUBLICATIONS			
Mining claims (State laws governing quartz and placer claims)	1.00		
Back issues of *Ore Bin*	50¢ over the counter; $1.00 mailed		
Back issues of *Oregon Geology*	75¢ over the counter; $1.00 mailed		
Colored postcard: Geology of Oregon	0.10		

Separate price lists for open-file reports, geothermal energy studies, tour guides, recreational gold mining information, and non-Departmental maps and reports will be mailed upon request.

OREGON GEOLOGY

1005 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

PUBLICATIONS ORDER

Fill in appropriate blanks and send sheet to Department.
Minimum mail order $1.00. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $50.00. Foreign orders: Please remit in U.S. dollars.

NAME ______________________

ADDRESS ______________________

______________________ ZIP ________

Amount enclosed $ ______________________

OREGON GEOLOGY

____ Renewal ____ New Subscription ____ Gift

____ 1 Year ($6.00) ____ 3 Years ($15.00)

NAME ______________________

ADDRESS ______________________

______________________ ZIP ________

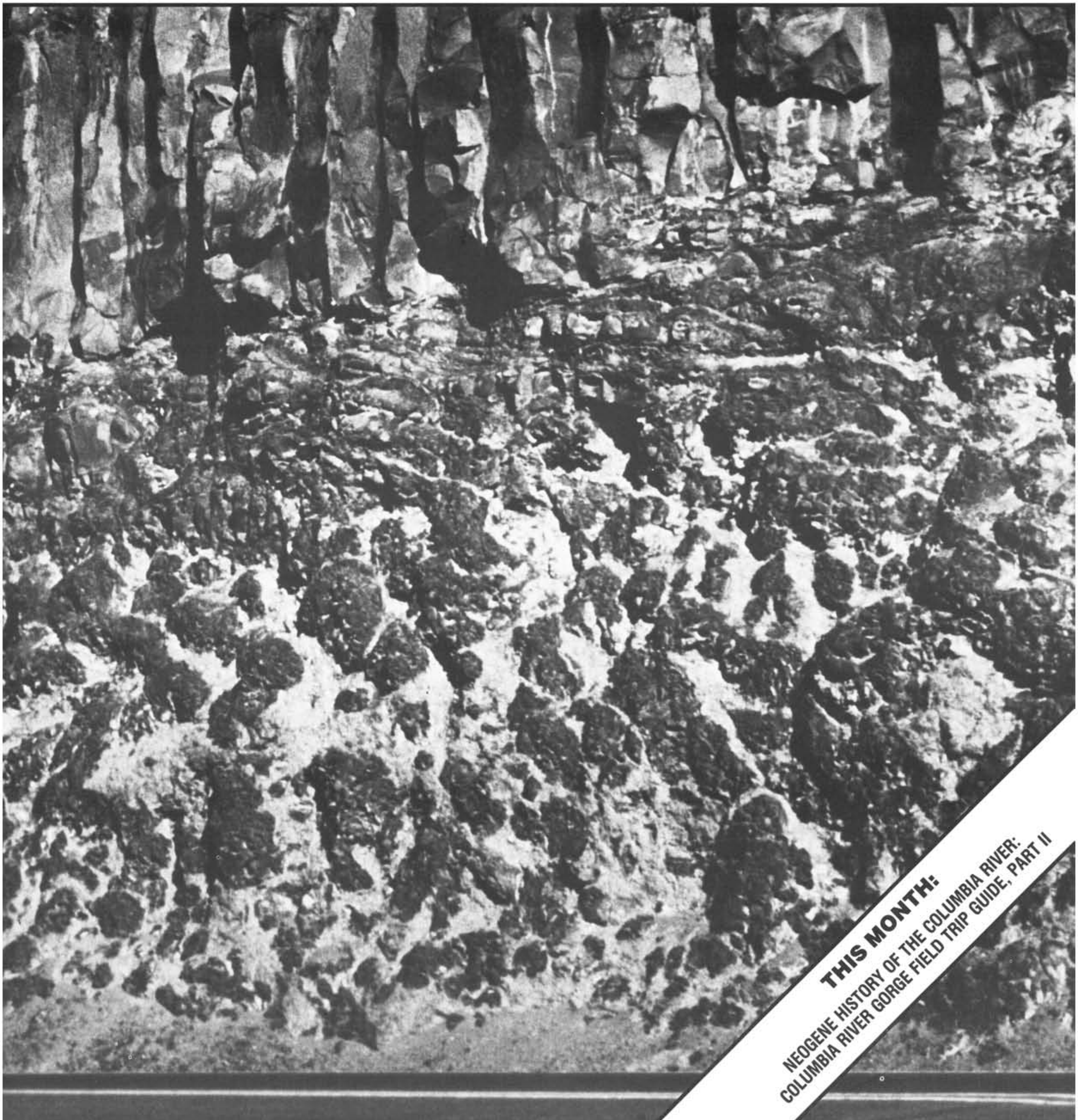
If gift: From ______________________

OREGON GEOLOGY

published by the

Oregon Department of Geology and Mineral Industries

VOLUME 46, NUMBER 9 SEPTEMBER 1984



THIS MONTH:

NEOGENE HISTORY OF THE COLUMBIA RIVER:
COLUMBIA RIVER GORGE FIELD TRIP GUIDE, PART II

OREGON GEOLOGY
(ISSN 0164-3304)

VOLUME 46, NUMBER 9 SEPTEMBER 1984

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

Main Office: 1005 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133. Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496. Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039. Paul F. Lawson, Supervisor

Second class postage paid at Portland, Oregon. Subscription rates: 1 year, $6.00; 3 years, $15.00. Single issues, $.75 at counter, $1.00 mailed. Available back issues of *Ore Bin*: $.50 at counter, $1.00 mailed. Address subscription orders, renewals, and changes of address to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201. Permission is granted to reprint information contained herein. Credit given to the Oregon Department of Geology and Mineral Industries for compiling this information will be appreciated. POSTMASTER: Send address changes to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

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

Westwardly dipping, foreset-bedded pillow complex at The Dalles, on U.S. Highways 197 and 30, just south of the I-84 interchange. This exposure of pillow basalt provides evidence for the history of the Columbia River Gorge at Columbia River basalt time. See discussion in last month's issue and field trip stop 13 in road log beginning on next page.

OIL AND GAS NEWS

Columbia County

Champlin Petroleum's Puckett 13-36, located in sec. 36, T. 8 N., R. 5 W., was spudded June 24. The well was drilled to total depth and was plugged and abandoned August 15. No report on findings has been released.

Mist Gas Field

Reichhold Energy Corporation has added another producing gas well, the 14th, to the Mist Gas Field. The well, Busch 14-15, located in sec. 15, T. 6 N., R. 5 W., was spudded August 2. It was drilled to a total depth of 2,258 ft and was completed August 11, flowing at a rate of 3 MMcfd. The Busch well is ½ mi north of Columbia County 23-22, a new producer since May.

Douglas County

Hutchins and Marrs started drilling Great Discovery 2 on July 5. The well, located in sec. 20, T. 30 S., R. 9 W., has a proposed total depth of 3,500 ft. A.M. Jannsen Well Drilling Company is the contractor.

Lane County

Drilling continues on Leavitt Exploration and Drilling well Maurice Brooks 1, located in sec. 34, T. 19 S., R. 3 W.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
266	Reichhold Energy Corp. Columbia County 23-4 009-00130	SW¼ sec. 4 T.6 N., R.5 W. Columbia County	Location; 3,000.
267	Amoco Production Co. Weyerhaeuser 1-6 019-00026	SW¼ sec. 6 T.25 S., R.8 W. Douglas County	Application; 13,500.
268	Amoco Production Co. Weyerhaeuser 1-13 019-00027	SW¼ sec. 13 T.25 S., R.9 W. Douglas County	Application; 13,500.
269	Reichhold Energy Corp. Longview Fibre 13-23 009-00131	SW¼ sec. 23 T.6 N., R.5 W. Columbia County	Application; 2,600.
270	Hutchins & Marrs Great Discovery 3 019-00028	SW¼ sec. 20 T.30 S., R.9 W. Douglas County	Application; 3,500.
271	Hutchins & Marrs Great Discovery 4 019-00029	SW¼ sec. 20 T.30 S., R.9 W. Douglas County	Application; 3,500.
272	Hutchins & Marrs Great Discovery 5 019-00030	SW¼ sec. 20 T.30 S., R.9 W. Douglas County	Application; 3,500.

□

Former Washington State Geologist dies

Vaughn Edward (Ted) Livingston, State Geologist and head of the Division of Geology and Earth Resources in the Washington Department of Natural Resources from 1971 to 1982, died on July 9, 1984, at the age of 56 years.

Livingston was born in 1928 in Hayward, California. He studied at Brigham Young University, where he received his bachelor of science degree in geology in 1954 and his master of science degree in geology in 1955. He served the Washington State geologic division for nearly 26 years. Following his service as State Geologist, Livingston worked briefly for the Lands Division of the Washington Department of Natural Resources before his retirement in 1982. □

Exploring the Neogene history of the Columbia River: Discussion and geologic field trip guide to the Columbia River Gorge

Part II. Road log and comments

by Terry L. Tolan and Marvin H. Beeson, Portland State University, Portland, Oregon 97207, and Beverly F. Vogt, Oregon Department of Geology and Mineral Industries, Portland, Oregon 97201*

The following field trip guide is designed to let you see many of the geologic features related to the courses of the ancestral Columbia River discussed in last month's issue of *Oregon Geology*. The trip is long, covering more than 155 mi, and will take a long day to complete. You may choose instead to spend two days on the trip. Included are several optional side trips that direct you to points of geologic interest away from the main highways. The mileage for these optional side trips is not added into the mileage for the main portion of the road log. References used either in Part I (last month's issue) or in Part II (this issue) appear at the end of Part I.

The field trip route, which is shown on pages 106-107, starts in Portland and follows along the Oregon (southern) side of the Columbia River to The Dalles. It returns to Portland via the Washington (northern) side of the river. The starting point is Lewis and Clark State Park, which is located approximately 18 mi east of downtown Portland. The park is reached by going east on I-84 from Portland, taking exit 18, turning left from the off ramp, and following the road under a railroad bridge to the parking area at the entrance to the park.

We wish to remind you to be careful of traffic and to exercise caution at field trip stops along the main highways. *—Editor*

Total miles — Road log and comments

0.0 **Lewis and Clark State Park parking area.** *Begin the trip by turning left on the Old Scenic Highway (also called Crown Point Highway on some signs) and driving upstream along the Sandy River. At the Sandy River bridge intersection, turn left and continue on the Old Scenic Highway toward Corbett.* Note the outcrops of upper member Troutdale Formation exposed along the left side of the road.

2.7 Pull over and park on the right side of the road just before the bridge.
STOP 1. Upper member sands and gravels of the ancestral Columbia River facies of the Troutdale Formation at Stark Street Bridge. Note the lithic and vitric sandstone beds and the high-alumina basalt clasts related to Boring-High Cascade Lavas volcanism along the ancestral Columbia River that are characteristic of the upper member of the Troutdale Formation. The lithic sandstone is gray, whereas the vitric sandstone is usually reddish due to alteration of the basaltic glass shards. Note also the occasional quartzite and other exotic pebbles in the conglomerate beds, the lens-shaped beds of sandstone and conglomerate, and the presence of cross-bedding that together indicate fluvial deposition by a stream carrying exotic clasts from distant sources. Note the large subangular boulders near the top of the outcrop; these are mostly high-alumina basalt from a nearby Boring Lavas vent. *Proceed along Old Scenic Highway.*

3.1 Dabney State Park, right side of road.

3.3 Intersection. *Stay right.*

4.4 Intersection. *Stay right.*

4.5 Intersection. *Turn left toward Corbett.*

5.4 Intersection. *Stay left.*

6.6 Corbett.

6.9 Intersection. *Turn left here toward Corbett Station and I-84 for Optional Side Trip A or continue along Old Scenic Highway for main trip.*

OPTIONAL SIDE TRIP A

Base of Crown Point via Corbett Station. Opportunity to examine Frenchman Springs Member flows and bedded Priest Rapids hyaloclastite.

[0.0] *Turn left from Old Scenic Highway (mile point 6.9 of main trip). Proceed north toward Corbett Station.*

[0.7] Frenchman Springs flows are exposed from here to the quarry at Corbett Station. The uppermost flow is an aphyric, Wallula Gap flow displaying hackly jointing (entablature). The lower flows are massive to blocky-jointed, sparsely plagioclase-phyric Sand Hollow flows.

MEMBER	UNIT	MAGNETIC POLARITY
FRENCHMAN SPRINGS	Basalt of Lyons Ferry	N
	Basalt of Wallula Gap	N
	Basalt of Oregon City	N
	Basalt of Sand Hollow	N
	Basalt of Silver Falls	E? N
	Basalt of Ginkgo	E

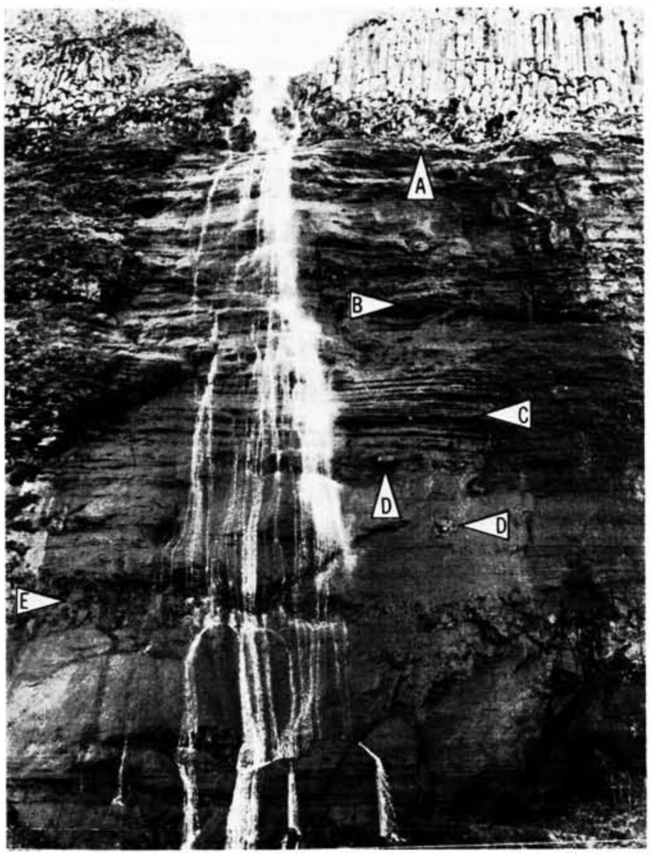
Informal stratigraphy of the Frenchman Springs Member in western Oregon. These units have been defined on the basis of major-oxide and trace-element chemistry, paleomagnetic polarity, lithology, and stratigraphic position. N=normal polarity; E=excursional polarity.

[1.3] **Corbett Station Quarry.** This is the westernmost exposure of Columbia River basalt on the Oregon side of the Gorge and is a sparsely plagioclase-phyric Frenchman Springs flow of the Oregon City type. This flow contains amber to reddish-orange plagioclase glomerocrysts which

**Current address: Geosciences Group, Rockwell International, Richland, Washington 99352* range from 0.5 to 2 cm in size. You may want to collect a small, fresh piece of this flow (with a glomerocryst if you can) to compare to other Columbia River basalt flows you will see on this trip. Based on surface exposure and subsurface data from an Oregon Department of Geology and Mineral Industries (DOGAMI) heat-flow well drilled in this quarry, this flow is approximately 50 m thick. The great thickness of this flow and the presence of scattered pillowed zones throughout the exposure suggest that it may be an intracanyon flow.

[1.4] *Turn onto I-84 eastbound toward Hood River.* N_2 high MgO Grande Ronde flows are exposed along the railroad track from here to the railroad tunnel. Crown Point is the prominence to the right, Rooster Rock is the pinnacle to the left.

[3.4] **Base of Crown Point**. *Stop at the gate on the right directly across from Rooster Rock (0.2 mi past milepost 24). Do not block the gate.* From the road you can see the Priest Rapids hyaloclastite below the Priest Rapids intracanyon flow. You may also walk over to the base of Crown Point for a better view, but watch out for poison oak and trains. Crown Point is an excellent exposure of the thick Priest Rapids (Rosalia chemical type) intracanyon flow overlying a bedded hyaloclastite (also Rosalia chemical type). If you walk over to the base of Crown Point, collect a small, fresh sample of the Priest Rapids flow and hyaloclastite to compare to samples from exposures of this same flow at Stops 13 and 15. The lack of pillows at the lava/hyaloclastite contact suggests that the hyaloclastite was not excessively wet when the lava flowed over it. The combined thickness of the lava flow and hyaloclastite exceeds 215 m. A few large, subangular boulders of Columbia River basalt and "Skamania Volcanics" suggest flood or lahar transport. Note the graded bedding, local cross-bedding, and the degree of rounding of the clasts in the hyaloclastite seen here and compare this outcrop to the massive Rosalia hyaloclastite exposure at Stop 15. *Continue east on I-84.*



North face of Crown Point showing features of the Priest Rapids hyaloclastite deposit (Optional Side Trip A). A=contact between the columnar Priest Rapids basalt and the hyaloclastite complex. B=foreset-bedded hyaloclastite. C=parallel-bedded hyaloclastite. Differences in degree of induration between individual beds and resulting differences in susceptibility to weathering allow some of the beds to stand out in relief, producing the horizontal ridges seen here. D=scattered foreign boulders and cobbles of "Skamania Volcanics," Grande Ronde, and Frenchman Springs lithologies. The local availability of the rock types constituting the foreign clasts, their generally poor degree of rounding, and their relatively large size in comparison to the Priest Rapids hyaloclastic debris indicate that they were derived locally from the sides of the ancestral Columbia River canyon and not transported far. E=foreign boulder conglomerate.

[3.8] Rooster Rock exit. *Take Rooster Rock exit (Exit 25), cross over freeway, turn left before park entrance, and proceed west on I-84.*

[6.9] *Take Exit 22 to Corbett to return to main part of trip log.*

[8.6] Intersection with Old Scenic Highway (mile point 6.9 of main trip). Turn left toward Crown Point to resume main trip route.

END OF OPTIONAL SIDE TRIP A

7.4 Intersection. *Stay left on Old Scenic Highway.*

8.5 **STOP 2. Womens Forum State Park**. View former paths of the Columbia River. All three Columbia River channels (Priest Rapids at Crown Point, Bridal Veil in the next hillside beyond Crown Point, and modern Columbia River) intersect in this area. *Continue east on Old Scenic Highway.*

9.0 Junction. *Stay left on the road toward Crown Point.*

9.3 **STOP 3. West side of Crown Point**. *Stop at any of the small turnouts near milepost 11.* A Boring Lavas flow is intercalated with the upper member of the Troutdale Formation here. This Boring Lavas flow is a gray, open-textured basalt that is easily distinguished from the Columbia River basalt. It appears to have followed a small channel in this area; no pillows occur at the base. Note the red baked contact below this flow. Look carefully to see reddish-colored upper member Troutdale Formation vitric sandstone above the lava flow. Note also that in the Troutdale Formation here there are almost no quartzite pebbles and that most of the basaltic clasts are of the High Cascades-Boring Lavas type, with few Columbia River basalt clasts. This part of the upper member of the Troutdale Formation was deposited during a time of fairly intensive volcanism during which the Columbia River was being challenged by local volcanic eruptions. *Continue east on Old Scenic Highway.*

9.8 **OPTIONAL STOP. Vista House**. Several features can be seen better here than from Womens Forum State Park. The Pomona intracanyon flow is exposed in the quarry along the railroad tracks on the Washington side of the river. The Bridal Veil channel on the Oregon side of the river lies just east of the Bridal Veil exit from the freeway. Here at Vista House on Crown Point you are standing directly on top of the Priest Rapids intracanyon flow, more than 215 m above the former canyon bottom (155 m of lava flow on top of more than 60 m of hyaloclastite). Note the Boring Lavas shield volcanoes above the cliffs of Columbia River basalt on both sides of the river.

View from Womens Forum State Park (Stop 2). A=Crown Point, a portion of the Priest Rapids intracanyon flow which totally destroyed a former course of the ancestral Columbia River approximately 14 m.y. ago. B=Rooster Rock landslide block. C=Crown Point landslide. Slide plane is probably the contact between the Columbia River basalt and older "Skamania Volcanics." D=remnant of the Pomona Member intracanyon flow located on the north side of the westerly trending Bridal Veil channel. Directly north of Womens Forum State Park is the point where the projections of the Priest Rapids and Bridal Veil channels intersect with the modern-day river (see Part I, Figure 6). E=Grande Ronde Basalt flows near Cape Horn which formed the northern canyon wall of the Bridal Veil channel. The southern portion of the Bridal Veil channel was destroyed by the modern-day river. F=lower member sandstones and conglomerates of the Troutdale Formation that were deposited within the confines of the Bridal Veil channel. G=Mount Zion, a Boring Lavas volcano that postdates the Troutdale Formation. H=small basaltic-andesite intracanyon flow from Mount Zion. I=location of the Bridal Veil channel on the Oregon side. J=Beacon Rock, a volcanic neck.

10.3 *Park in the small turnout on the left side of the road and watch for traffic.*

STOP 4. Priest Rapids pillows on east side of Crown Point. Watch out for traffic. Walk around the corner from the turnout to see pillow basalts that were formed when lava flowed into water. Note the typical features of pillow lavas such as radial jointing, oval shapes, and glassy rinds. These pillows of Priest Rapids basalt occur above the level of bedded hyaloclastite and far above the bottom of the pre-Priest Rapids canyon. We think that the hyaloclastite deposit and the capping lava flow dammed up small tributaries, thereby creating ponded water where these pillows were formed. Remember the characteristics of these pillows and compare them to those of the invasive Priest Rapids lobes to be seen later on this trip at Stop 15.

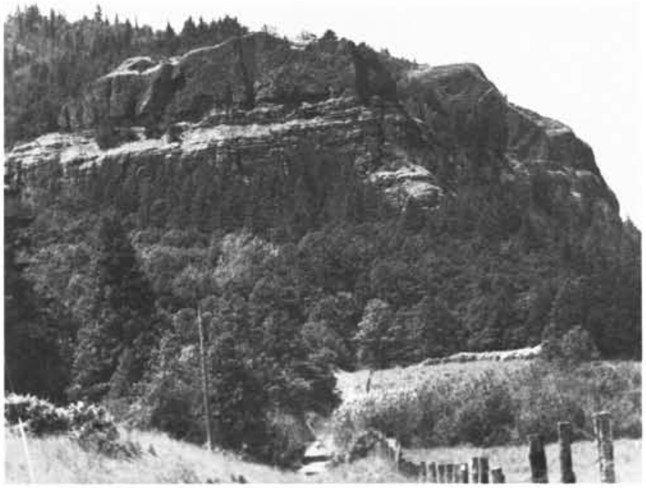
10.5 The contact between the Priest Rapids intracanyon flow and the older rocks we call "Skamania Volcanics" is exposed here. These older rocks are exposed from here to just west of Shepperds Dell State Park where Columbia River basalt again crops out. We use the term "Skamania Volcanics" (Trimble, 1963; Tolan, 1982) for these rocks, but as they have not been radiometrically dated, we cannot at this time confidently place them into the proper pre-Columbia River basalt formation.

11.8 *Turn left off Old Scenic Highway onto Latourell Road just west of Latourell Park.* Pre-Columbia River Basalt Group rocks are exposed along this road.

12.1 Junction. Latourell Henry Road and Park Street. *Turn left onto Latourell Henry Road and drive toward the end of the road.*

12.4 *Park in the area before the private driveway.*

STOP 5. View west toward east side of Crown Point showing Priest Rapids lava/hyaloclastite contact. The Priest Rapids channel here is located at the contact between



View of the east side of Crown Point (Stop 5). Note contact between Priest Rapids lava and bedded hyaloclastite below.

earlier Columbia River basalt flows and the older "Skamania Volcanics." Streams apparently commonly develop along such contacts. *Return to Old Scenic Highway.*

12.9 Junction. *Turn left onto Old Scenic Highway.*

13.2 **STOP 6. Latourell Falls Park.** Walk up the short path to view lower Latourell Falls. This is an N_2 high MgO flow that probably filled an old stream valley developed at the margin of the preceding Columbia River basalt flows and the older volcanic rocks. Note the large stream boulders exposed at the base of the flow just below the colonnade. This flow does not have blocky jointing typical of most N_2 high MgO flows but instead has a well-developed entablature like most of the low MgO flows in western Oregon. The atypical jointing probably developed because this flow cooled within a canyon. Almost flat-lying Skamania dacite is exposed at the parking lot and on the path leading to the base of the falls. As dacite is very viscous and does not move far from its source, this outcrop may represent a vent area that was one source of volcaniclastic deposits and mudflows of the Eagle Creek Formation exposed farther east in the axis of the Cascade arch. The "Skamania Volcanics" in the Crown Point area formed a paleotopographic high which the Columbia River basalt flows did not cover. *Return to car and continue east on Old Scenic Highway or follow trail for Optional Side Trip B.*

OPTIONAL SIDE TRIP B

Upper Latourell Falls. The easy-to-hike trail which continues upward from the viewpoint goes to upper Latourell Falls. This trail is about half a mile long, with an elevation gain of about 400 ft. Along the trail above lower Latourell Falls are several exposures of entablature-jointed Frenchman Springs flows (Sand Hollow type). At the upper falls, water cascades over a Priest Rapids Member entablature/colonnade. *Return to car to resume main trip route.*

END OF OPTIONAL SIDE TRIP B

13.6 Skamania basalt outcrops on the right side of the road.

14.4 Shepperds Dell. N_2 low MgO Grande Ronde Basalt outcrops.

15.2 Bridal Veil State Park.

15.4 **STOP 7. Bridal Veil Creek.** *Park in the turnout to the left of the highway just before the bridge.* A slide block of Pomona Member basalt is exposed along the highway near milepost 16. Note the small plagioclase phenocrysts that are typical of Pomona lithology. You may want to collect a small, fresh sample to compare to nonintracanyon exposures of Pomona Member at Stop 11. Bridal Veil Creek here flows approximately along the contact between the Pomona intracanyon flow and R_2 Grande Ronde Basalt formerly exposed by stream erosion during the Miocene along this Bridal Veil channel. *Continue east on Old Scenic Highway.*

15.8 Palmer Mill Road junction. *Turn right here for Optional Side Trip C or continue on Old Scenic Highway.*

OPTIONAL SIDE TRIP C

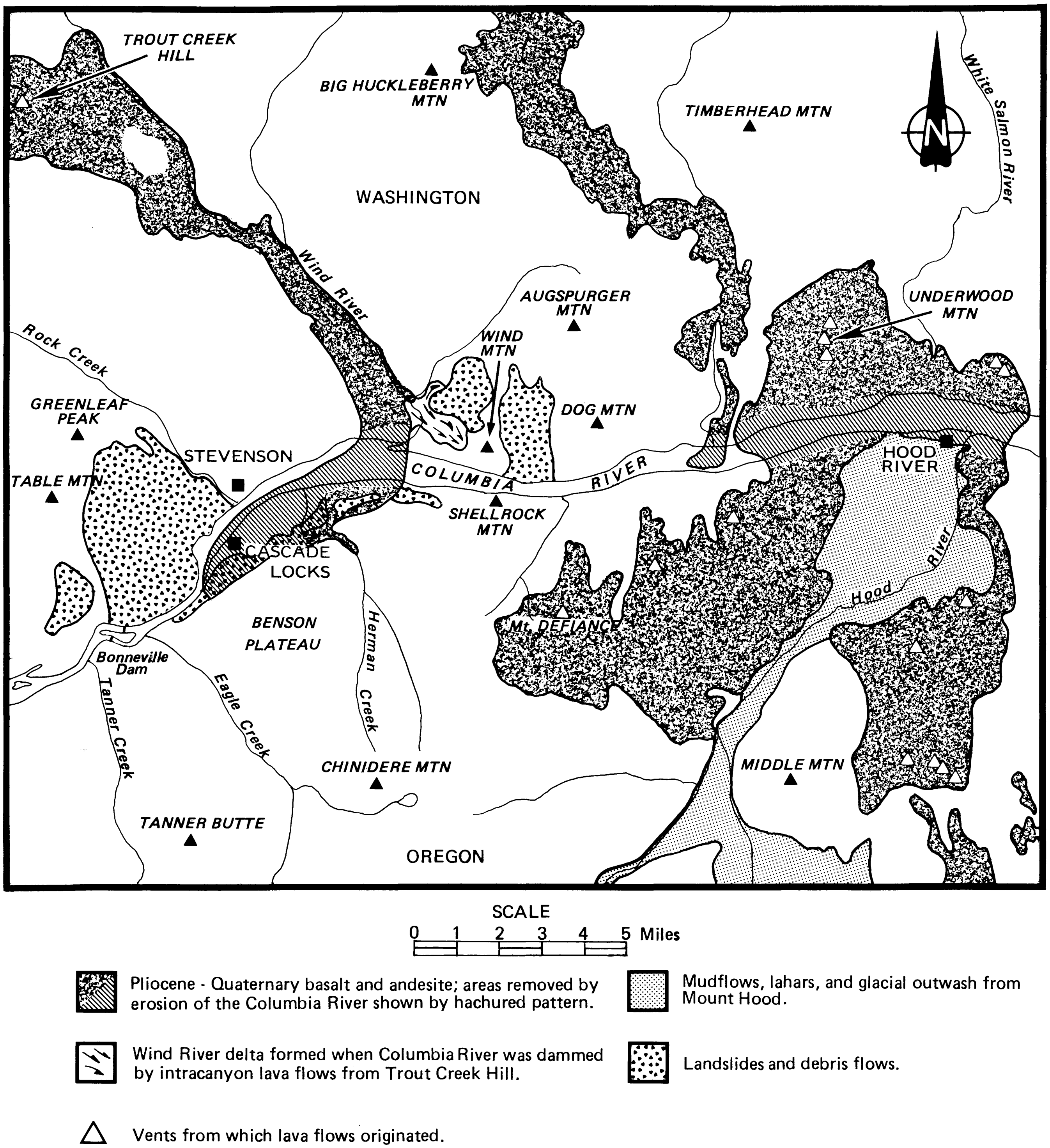
[0.0] **Palmer Mill Road.** On this side trip you can see Pomona intracanyon basalt, Rhododendron lahars, lower and upper member Troutdale Formation, and high-alumina basalt. A note of caution: This is a narrow, steep road that is not scenic but is geologically interesting. There is a place to turn around at the top of the hill, and it is safer to stop and look at outcrops on the way back down the hill. For that reason mileages of stops are given for both going up the road and coming down.

[0.3] Mound-shaped outcrop of Pomona intracanyon flow on the right. Many Columbia River basalt intracanyon flows are characterized by an entablature style of jointing that weath-

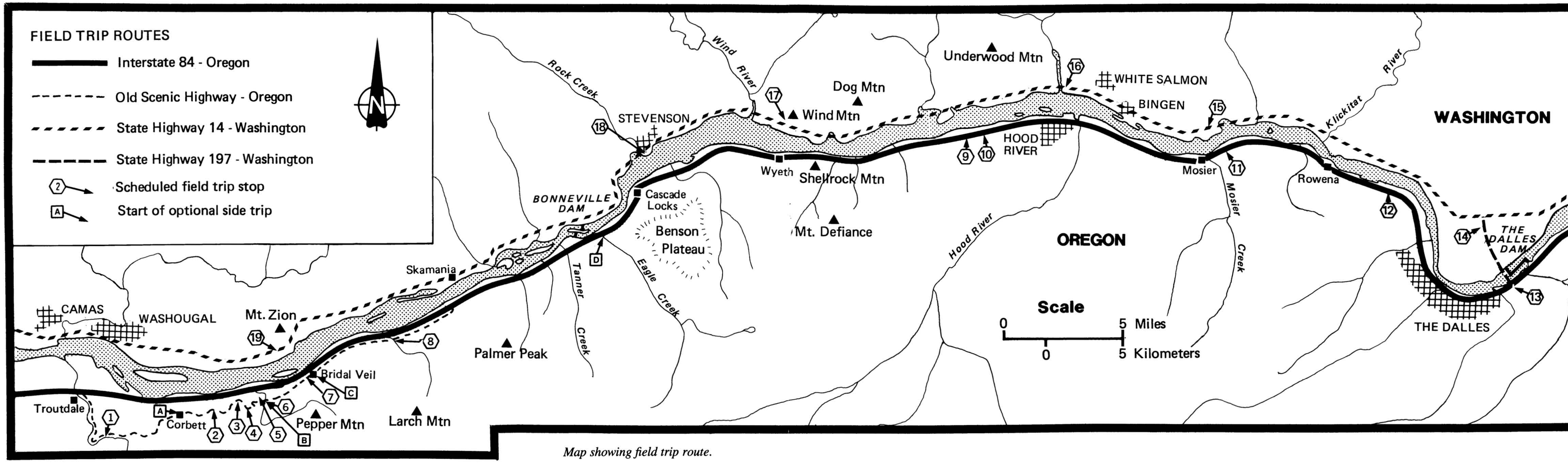
Lower Latourell Falls (Stop 6). This is an N_2 high MgO flow that appears to have been channelized at this point. The flow overlies a boulder conglomerate that is exposed at the base of the falls.

ers into these rounded tops. Overlying the Pomona here is a Rhododendron lahar. It is very poorly exposed in the road bank on the left. You may have to scrape a layer of soil or vegetation off to reveal it. (If you do, please be careful to keep the drainage ditch clear of debris.) The lahar consists of hornblende dacite clasts in a clay matrix (Tolan, 1982; Tolan and Beeson, 1984). This lahar is overlain by gravels and sands of the lower member of the Troutdale Formation.

[0.8] Outcrops of sands and gravels to this point belong to the lower member of the Troutdale Formation. Find a convenient spot to pull off the road and examine outcrops of these sands and gravels. The lower member of the Troutdale Formation here consists of micaceous arkosic sands and basaltic gravels (primarily Columbia River basalt) which contain between 5 to 12 percent exotic clasts (e.g., quartzite, schist, rhyolite; Tolan, 1982). Note the typical



Lava dam and landslide map showing former Pliocene-Quaternary lava dams and active landslides in the western part of the Columbia River Gorge. From Waters (1973, p. 146).



Map showing field trip route.

lack of cementation (lithification) of lower member sands and gravels. Exposures of the lower member of the Troutdale Formation are limited because these sands and gravels were confined to the paleocanyon of an ancestral Columbia River (Bridal Veil channel).

[1.2] A thin, deeply weathered Boring Lavas-type lava flow is exposed here. Note the vesicular flow top.

[1.3] **SIDE TRIP STOP.** Walk back down the road to observe the Boring Lavas flow (where road grade steepens). This high-alumina basalt flow is plagioclase phyric and quite vesicular. Regular cooling joints are not well developed, making this exposure difficult to recognize as a lava flow at first. From this point to the parking spot, upper member lithic sandstone of the Troutdale Formation is exposed in the road cut on the east (left) side of the road, and Frenchman Springs basalt (Sand Hollow type) crops out about 15 ft below the road in the canyon wall on the west side (at about 1,150- to 1,200-ft elevation). This marks the southwestern edge of the Bridal Veil channel. All of the Troutdale Formation above about 800-ft elevation is upper member, containing lithic and vitric sands produced from eruption of high-alumina basalts of the Boring-High Cascade Lavas. Notice the large subangular boulders of high-alumina basalt that are exposed above the lithic sands. The top of the Troutdale Formation is about 100 ft above the road at this point and is capped by high-alumina basalt flows. *Continue driving up the road to the intersection to turn around.*

[1.6] Turnaround. *Turn off on the road to the right and turn your car around. Return to Palmer Hill Road and start down the hill.*

[1.9] *Pass the last stop area.*

[2.2] Outcrop of upper member vitric sandstone.

[2.4] Lower member gravels (uphill point [0.8]).

[2.8] Pomona mound on left side of road (uphill point [0.3]).

[3.2] Junction with Old Scenic Highway. *Turn right to resume main trip route.*

END OF OPTIONAL SIDE TRIP C

16.0 Junction. *Continue toward Multnomah Falls.*

18.5 Wahkeenah Falls.

19.0 **STOP 8. Multnomah Falls** (rest rooms). Eleven low MgO Grande Ronde flows are exposed along Multnomah Creek, including one N_1, five R_2, and five N_2 flows. Six of these flows crop out from the river to the top of the upper falls; the rest are exposed upstream above the two falls you see here. Note a pillow sequence near the lip of the upper falls.

Observations of waterfalls occurring over Columbia River basalt (M.H. Beeson, unpublished data, 1978) have shown that falls often occur where flows are flat lying or dipping upstream. This condition allows blocks produced by vertical joints to be stable until support is withdrawn by erosion of softer interflow material at the base of individual flows. The rate of erosion of interflow areas probably largely controls the rate of retreat of the falls. Two falls are produced here because of a more easily eroded zone at the base of the upper falls. Furthermore, the amphitheater-shaped valley common to many of the falls within the Gorge is due to freeze-thaw action of water from the splash mist that penetrates the joints.

The contact between the Columbia River basalt and the underlying Eagle Creek Formation is exposed to the north, on the Washington side of the river, about midway up the side of the canyon; because of the regional dip to the south, however, the Eagle Creek Formation is not exposed here on the Oregon side. This is partly due to the southerly dip of the flows and partly due to the thinning Columbia River basalt section at the northern margin of the structural low through the ancestral Cascades that confined these flows. *Continue east on Old Scenic Highway.*

21.3 Oneonta Gorge.

21.6 Horsetail Falls.

22.0 Ainsworth State Park.

22.8 *Rejoin I-84 eastbound.*

25.5 McCord Creek. The Eagle Creek Formation is exposed here.

27.8 Fish Hatchery and Bonneville Dam exit (Exit 40).

29.1 Eagle Creek Park. *Take Exit 41 and turn right here for Optional Side Trip D or continue on I-84.*

OPTIONAL SIDE TRIP D

Eagle Creek Formation. *Park along the right side of the road just after leaving I-84.* The Eagle Creek Formation consists of mudflows and volcaniclastic rocks from andesite stratovolcanoes. One such source may be the Skamania lava flows exposed at Latourell Falls. The recent explosive eruption and subsequent mudflows at Mount St. Helens provide a modern analog that helps us to understand how this formation was produced. In these exposures of Eagle Creek Formation are subangular andesite clasts, petrified and carbonized wood, and lignite stringers. Look north across the river to see head scarps of the large Bonneville landslide to the right (east) of Table Mountain. The Bonneville landslide, the largest landslide in the gorge, may have dammed the Columbia River during Holocene time, probably giving rise to the Indian legend of the Bridge of the Gods (Waters, 1973). *Leave park and continue right on I-84 eastbound to resume main route.*

END OF OPTIONAL SIDE TRIP D

31.1 Cascade Locks. Notice the good view of the Bonneville landslide and scarp.

32.3 Fan-shaped columnar jointing in high-alumina basalt flow.

34.5 Quarry in Government Cove diorite intrusion exposed on the left.

36.2 Note the flat-topped Wind River intracanyon flow on the Washington side of the Columbia River. More than 35,000 years ago, a series of lava flows came down the Wind River canyon as intracanyon flows, entering the Columbia River on a 1-mi-wide front and damming the river (Waters, 1973). The dam lasted long enough for the Wind River to build a delta 150 ft thick and 1 mi long into the temporary lake (Waters, 1973, p. 145). The cone-shaped mountain ahead on the Washington side of the river is Wind Mountain, an intrusion.

37.0 Weigh station.

42.3 Starvation Creek State Park (optional rest stop). Dog Mountain, containing the thickest exposed section of low MgO Grande Ronde Basalt in this area (Anderson, personal communication, 1980), is across the river.

45.6 **STOP 9. West of Mitchell Point on I-84 eastbound (milepost 58).** Pre-Pomona lower member Troutdale gravels overlying Frenchman Springs flows exposed at road level. These gravels consist of mainly basaltic cobbles in a well-cemented sandstone matrix (Anderson, 1980). This conglomerate contains rare quartzite pebbles, suggesting that the ancestral Columbia River that deposited them in the Bridal Veil channel extended across the Columbia Plateau and was transporting exotic pebbles from drainage areas to

OREGON GEOLOGY, VOLUME 46, NUMBER 9, SEPTEMBER 1984 109

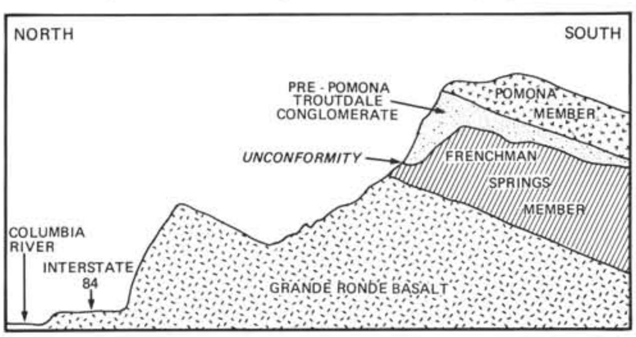
Pre-Pomona lower member Troutdale Formation exposed at road level (Stop 9). Here the Troutdale directly overlies Frenchman Springs Basalt.

the north and east into this area. If you took Optional Side Trip C, Palmer Mill Road, note the difference in appearance between this pre-Pomona Troutdale conglomerate and the lower member gravels exposed above the Pomona Member on Palmer Mill Road.

45.9 *Take exit to Mitchell Point Park.*

46.2 **STOP 10. Parking lot at Mitchell Point Park.** A view of Mitchell Point is to the right above the parking lot; the rocks immediately in front of the parking lot are Grande Ronde Basalt. Mitchell Point preserves the southern portion of the Bridal Veil channel; the northern portion was destroyed by the present-day Columbia River when it began incising the Gorge. This exposure of Pomona Member and pre-Pomona Troutdale was first recognized by J.L. Anderson (1980) and marks the eastern end of the Bridal Veil channel (Tolan and Beeson, 1984) where the river began to cut into the Cascade Range. The lower member Troutdale conglomerates seen underlying the Pomona Member here are the same as those just seen at Stop 9. The difference in elevation is an indication of the considerable structural deformation that has affected this area in the past 12 million years (m.y.). *Return to I-84 and continue east.*

48.4 Note the thick pillow-palagonite complex at the base of a post-Columbia River basalt high-alumina basalt flow exposed on both sides of the freeway. (*Do not attempt to stop and get off I-84 eastbound lanes here!*) We think that the interaction between lava flows, such as this one, and the Columbia River in the Bridal Veil channel produced the vast quantities of vitric sand which characterize the upper member of the Troutdale Formation. Across the Columbia River is the Underwood Mountain shield volcano. Note the angular unconformity between the flat-lying Underwood



Diagrammatic cross section through Mitchell Point (Stop 10), showing the preserved southern portion of the Bridal Veil channel of the ancestral Columbia River. From Anderson (1980, p. 197).

lava flows and the steeply-dipping Columbia River basalt flows. Flows from Underwood Mountain may have temporarily dammed the Columbia River, as did the Wind River flows, in Holocene time (see lava dam and landslide map, above).

52.1 Hood River. (Highway 35 goes south to Mount Hood).

53.2 Across the river you can see the Bingen anticline.

56.5 You are passing through the Mosier syncline.

57.3 Mosier exit.

59.7 **STOP 11. East of Mosier on I-84 (milepost 72).** Exposure of Pomona Member basalt. Compare its texture here and at Bridal Veil Creek (Stop 7). Note that there are more plagioclase phenocrysts in the Bridal Veil intracanyon occurrence than in the sheet flow here.

Typical jointing of the Pomona Member (Stop 11).

60.4 Rest area.

65.7 **STOP 12. Ortley anticline.** *Stop near milepost 78.* View the natural cross section through the Ortley anticline exposed on the Washington side of the river. This fold is a thrust-faulted, asymmetrical anticline that is part of the southwestward continuation of the Columbia Hills anticline, which in turn is part of the Yakima Fold Belt. Here at Ortley the major features of a Yakima fold are well exposed. Field evidence suggests that Yakima folds began to grow at least 16 m.y. ago (Bentley and others, 1980b; Vogt, 1981; Reidel, in press). The extension of these developing anticlinal ridges and their broad intervening synclinal lows through the Miocene Cascade Range (Beeson and others, 1982; Beeson and Tolan, 1984) was one of the major factors controlling the various positions of the ancestral Columbia River in the Miocene Cascade Range.

68.3 Entering the Dalles syncline.

71.5 City Center, The Dalles.

74.3 *Take Exit 87 and turn right at the stop sign onto U.S. 197. Cross the railroad bridge and stop at the large turnout on the right side of the road just before Highways 197 and 30 divide.*

74.7 **STOP 13. The Dalles bridge junction. Priest Rapids flows.** This pillow-palagonite complex lies at the base of a Rosalia flow which is in turn overlain by a younger Lolo flow. Both flows are part of the Priest Rapids Member. The pillow complex overlies lake-bed deposits (diatomite) elsewhere in this area and here displays a westward imbrication. This evidence indicates that the Priest Rapids flow was advancing toward the west across a shallow lake that occupied the broad low centered where the Dalles syncline now lies. The ratio of hyaloclastite (now altered to palagonite) to pillows increases westward toward Mosier. We think that the increasing ratio of hyaloclastite to pillows indicates an environment of increasingly turbulent or rapidly moving water into which the Priest Rapids lava flowed. The evidence observed in this area, then, indicates to us that the head of the ancestral Columbia River canyon which the Priest Rapids Member entered must lie to the west (see discussion of Priest Rapids time in last month's issue, p. 93-94).

If you collected a sample of the Rosalia Priest Rapids flow at the base of Crown Point, compare it to a fresh sample from the colonnade overlying the pillow complex in the Rosalia flow here. Note the extreme differences in texture between the intracanyon and sheet portions of this same flow. *Turn around and drive across The Dalles bridge to Washington.* Note the scabland along the river that was formed by removal of soil cover and some bed rock during the Missoula floods.

78.0 **STOP 14. Roza flow.** *Pull off Highway 197 onto the narrow shoulder on the right side of the road.* Outcrops of vesicular, blocky-jointed Roza Member occur on both sides of the highway. The best exposures are on the left (west) side. The Roza Member consists of a single flow in this area. Find a clean, fresh surface on the outcrop. Note the great abundance of small, individual plagioclase phenocrysts. If you have collected samples of Frenchman Springs and Priest Rapids basalt, compare them to Roza samples. You can see why the Roza Member with its great abundance of phenocrysts makes such an excellent stratigraphic marker.

78.3 Junction of Highways 197 and 14. *Turn left on Highway 14 and proceed west toward Bingen and Vancouver.*

79.6 Large, platy Priest Rapids columns on the right.

83.5 Close-up view of the fault zone that you saw from across the river at Stop 13.

85.1 Lyle.

85.9 Klickitat River.

87.7 Rest area.

89.0 Pomona basalt.

91.3 **STOP 15. Priest Rapids hyaloclastite exposed in road cuts on the right.** Compare this massive deposit of Rosalia hyaloclastite to the bedding features occurring in the Rosalia deposit to the west at the base of Crown Point (Optional Side Trip A). If you collected a sample of the hyaloclastite at the base of Crown Point, compare it to a sample from this exposure. The angular shape of clasts in this deposit indicates little or no fluvial transport. Note the "pseudo-bedding" caused by post-depositional cementation patterns that have been accentuated by differential erosion. Invasive lobes of Priest Rapids lava and fragments of broken or incipient pillows are also exposed here. The hyaloclastite here fills a canyon eroded into the underlying Frenchman Springs flows seen along the highway at the western end of the hyaloclastite exposures. This is the easternmost known occurrence of Rosalia hyaloclastite filling a river canyon and probably represents the head of the pre-Priest Rapids canyon where displaced lake water and lava dynamically interacted and produced the hyaloclastic debris.

94.6 Bingen.

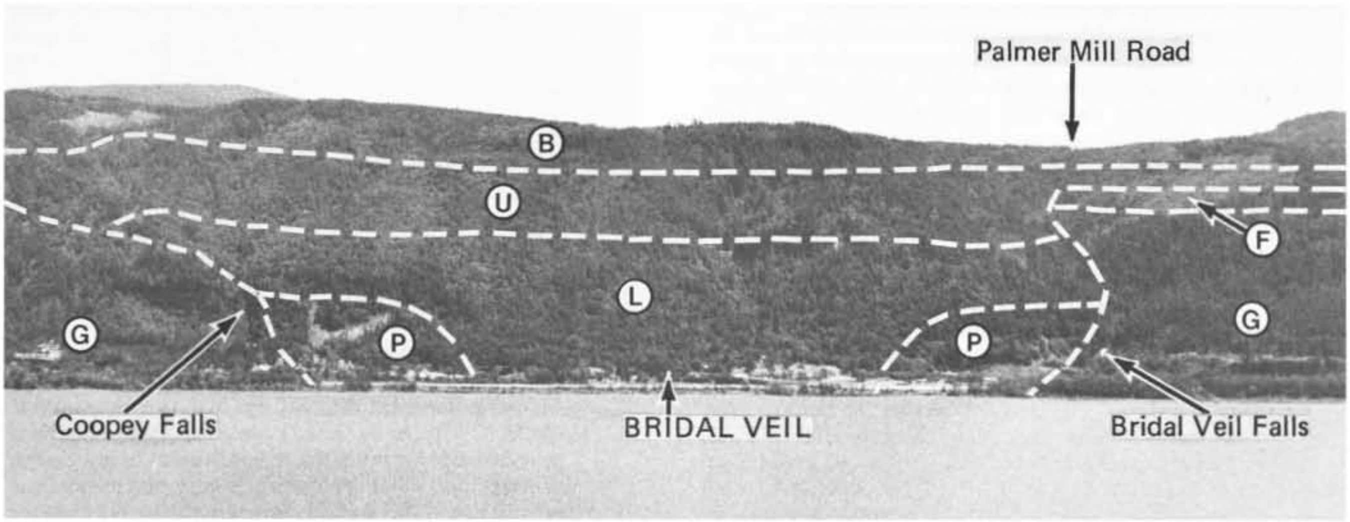
96.5 Hood River toll bridge. *Stay on Highway 14.*

98.4 **STOP 16. Snipes Mountain conglomerate west of Underwood.** Quartzite-bearing gravels and sands exposed here belong to the Snipes Mountain conglomerate of the Ellensburg Formation (Bela, 1982). The gravels and sands were deposited by the ancestral Columbia River when it followed the Bridal Veil channel in post-Pomona time. These sediments are correlative with the post-Pomona lower member of the Troutdale Formation. This is a good place to contemplate the complex and confusing problem of what to name this unit. The fluvial sediments exposed here have been called the "Hood River Formation" (Buwalda and Moore, 1927, 1929), Dalles Formation (Hodge, 1938), Troutdale Formation (Allen and Hammond, *in* Allen, 1979) and, finally, Snipes Mountain conglomerate—Ellensburg Formation (Bela, 1982). With the exception of Hodge (1938), all of these geologists believed that this exposure represented deposits of the ancestral Columbia River, but the exact age of the unit was open to question. With our increased knowledge of the geology and paleodrainage history of this region, we now have a general understanding of the depositional history, distribution, and relative age of this deposit. However, we have a complex problem of what name to give it! We can eliminate Dalles Formation (Chenoweth Formation) from consideration, as it has been redefined, with origin and source totally different from the fluvial sediments under consideration. The names Snipes Mountain conglomerate (Ellensburg Formation) and Troutdale Formation are both perfectly valid for this deposit. At this point, some geologists have employed what might be called "territorial usage" of formational names, that is, deposits on the Washington side of the river are said to belong to the Ellensburg Formation, while similar deposits across the river in Oregon are assigned to the Troutdale Formation. This knotty problem is only one of many such complex nomenclature problems which exist for the Miocene-Pliocene sediments of the western and central Columbia Plateau.

107.7 Dog Mountain. Thickest (> 1.3 km) exposed unrepeated section of Columbia River basalt in western Washington (J.L. Anderson, personal communication, 1980).

110.0 **STOP 17. Wind Mountain quarry.** Wind Mountain is one of several microdioritic intrusions in this area (e.g., Government Cove and Shellrock Mountain across the river in Oregon; Free, 1976). Fragments of Columbia River basalt (xenoliths) have been found in almost all of these intrusives (Free, 1976), indicating that they are younger than the Columbia River basalt (specifically, Grande Ronde Basalt). Most geologists who have studied these intrusions believe that magma from them reached the surface and formed

Massive Priest Rapids hyaloclastite (Stop 15). This "pseudo-bedding" is the result of secondary cementation of fractures.



Cross section through the Bridal Veil channel (Bridal Veil, Oregon), as seen from Stop 19 on the Washington side of the river. The modern-day Columbia River has dissected a path oblique to the axis of the westerly trending Bridal Veil channel of the ancestral Columbia River. Grande Ronde Basalt (G) and Frenchman Springs Member (F) flows form the former canyon walls. Remnants of the Pomona Member intracanyon flow (P) indicate that it only partly filled the canyon, thereby allowing the ancestral Columbia River to remain in this channel in post-Pomona time. After the ancestral Columbia River had cut down through the Pomona Member, it began to deposit sands and gravels of the lower member (L) of the Troutdale Formation. Indurated lower member sandstones and conglomerates are well exposed in the cliff face behind and to the right of the town of Bridal Veil. The onset of voluminous high-alumina basaltic volcanism in the Cascades approximately 6 m.y. ago and the dynamic interaction between these lava flows and the ancestral Columbia River produced the tremendous amount of clastic and hyaloclastic debris that now characterizes the upper member (U) of the Troutdale Formation. The contact between the lower and upper members of the Troutdale Formation at Bridal Veil is gradational and is shown in a generalized manner on the photograph. Together, the lower and upper members of the Troutdale Formation at Bridal Veil have a thickness of over 335 m. We think they were deposited over a period of about 10 m.y. –from 12 to 2 m.y. ago. The ancestral Columbia River was forced from the Bridal Veil channel by high-alumina basalt flows (B) that eventually capped the channel and prevented the river from reoccupying it when the Cascades were uplifted about 2 m.y. ago.

volcanic edifices that were subsequently removed by erosion (Hodge, 1938; Lowry and Baldwin, 1952). Also consider that we now know that the long-lived Bridal Veil channel (from approximately 14 to 2 m.y. ago) of the ancestral Columbia River lay only a mile or less south of these intrusions. Were these intrusions emplaced after the establishment of the Bridal Veil channel, and did volcanoes erupt close by? If this did take place, how did it affect the ancestral Columbia River? To date, we have not been able to find volcanic debris within the Troutdale Formation that we can conclusively say originated from volcanic vents associated with these intrusives. Trace-element compositions of clasts from the Rhododendron lahars intercalated with the Troutdale Formation at Bridal Veil (Beeson and Maywood, *in* Tolan and Beeson, 1984) show no chemical similarity to these intrusives in the Gorge, yet the lahar clasts are compositionally indistinguishable from Rhododendron lava flows northwest of Mount Hood. Another possibility is that these intrusions were emplaced prior to the time of establishment of the Bridal Veil channel, a period of approximately 15.5 to 14 m.y. ago. The age of these intrusions is a key question, and radiometric age determinations are needed to help unravel this problem.

110.0 Home Valley.

112.0 Wind River bridge.

114.6 Pre-Columbia River Basalt Group Ohanapecosh lava flows exposed along here.

115.0 Stevenson.

117.1 **STOP 18. Stevenson.** *Turn left at the flashing signal onto Russell Ave. and drive toward the Columbia River to Water Front Park at Stevenson Landing. Park your car and walk to the water front.* Look directly across the river at the high-alumina basalt/hyaloclastite complex (red colored) exposed high along the north face of Benson Plateau. We know this hyaloclastite deposit was formed by dynamic interaction between a lava flow and turbulent water. But how could such a great volume of water have existed at that elevation? We think that the complex probably formed near present river level when the river was invaded by high-alumina basalt lava flows and was later elevated by Cascade upwarping while the river incised the Columbia River Gorge. Hyaloclastite generated along the ancestral Columbia River in this way was the source for the vitric sands in the upper member of the Troutdale Formation. *Turn around and return to Highway 14 by going left on First Street and right on Seymour Ave.*

117.4 Highway 14. *Continue west.*

119.9 Bridge of the Gods. *Stay on Highway 14.*

121.9 New Bonneville Dam power house view point.

126.6 Beacon Rock, a volcanic neck (optional rest stop).

136.5 **STOP 19. Cape Horn View Point (milepost 25).** *Be careful here. Stop at the narrow turnout on the left side of the highway. Watch for traffic. From here you have an excellent view of the Bridal Veil channel across the river.*

138.3 Crown Point view point.

138.6 Troutdale gravels are exposed all along the road in this area.

143.0 Washougal.

154.3 I-205 exit. *Take this exit south to I-84 and Portland.*

END OF GUIDED TRIP

Year of the Ocean, 1984-1985

A "Year of the Ocean" has been proclaimed to draw attention to the great significance the seas have for the life of the nation. In June, Governor Victor Atiyeh proclaimed 1984-1985 as "THE YEAR OF THE OCEAN" in Oregon. In his proclamation, the Governor said:

> The power of the ocean is reflected in our rugged and beautiful coastline and its life-giving rains in our lush green forests. We come down to the sea to rest, to play, and to be renewed. Nourishing ocean waters support our vital, yet threatened, fisheries. The ocean highway links our ports and hinterlands to neighbors nearby and far across the sea. Exploration for offshore minerals, oil, and gas is on the horizon.
>
> In recognition of these growing uses and demands for ocean resources, in 1983 President Reagan proclaimed a United States Exclusive Economic Zone for all resources out to a 200-mile limit. His action presents us with both an opportunity and a challenge: an opportunity to develop hitherto-unclaimed resources for the benefit of humankind and a challenge to do it with wisdom and stewardship.

At Coos Bay and Newport, Year of the Ocean kickoff celebrations were held in July. October and November will see a film festival at Oregon State University (OSU), with excellent films on marine mammals, aquaculture, estuaries, ocean resources, and similar subjects in a weekly series. OSU also makes such films available to the public (contact Candy Lavelle at OSU Sea Grant Communications in Corvallis, phone 754-2716).

More activities and events are planned on the national scene. A congressional resolution declaring 1984-1985 Year of the Ocean was signed by President Reagan on July 2. A news series is planned, various talk shows will focus on the subject, a cancellation stamp will go on sale, a national calendar is being assembled, and an ocean directory is being compiled. To get involved in such activities, you may contact Jim Good, College of Oceanography, Oregon State University, Corvallis, OR 97331, phone (503) 754-3771, or county Sea Grant Marine Extension agents in Astoria, Tillamook, Newport, Coquille, Gold Beach, and Portland. □

Gorda Ridge Technical Task Force meets

A technical Task Force appointed by Governor Vic Atiyeh met early in August with representatives from the State of California and Federal agencies to continue the evaluation of environmental, engineering, and economic impacts of possible leasing of polymetallic minerals on Gorda Ridge, a major geologic structure which lies off the coast of Oregon and northern California.

The Task Force met at the Marine Research Facility operated by the University of Southern California on Catalina Island, California, to adopt working guidelines and prepare a multi-year program of studies that will be undertaken to evaluate the geology and biology of Gorda Ridge and re-examine the need for Federal leasing of offshore minerals in the area. Later investigations will include an evaluation of related socio-economic impacts and land use along the coast of Oregon, California, and Washington state. The results of these studies will be used to re-evaluate the impacts of mining before a decision for leasing is made. The two-day meeting at Catalina included a review of ocean mining technology, a discussion of the results of recent preliminary exploration earlier this year by the submersible Alvin, and remarks by Carol Hallett, Assistant to Secretary of the Interior William Clark. Hallett indicted that the possibility of mining on the Gorda Ridge is very unlikely before the year 2000.

Oregon representatives on the Task Force are Jack Dymond and William Pearcy, both professors at the College of Oceanography at Oregon State University; Don Oswalt, Coastal Plan Analyst for the Department of Land Conservation and Development; Jay Rasmussen, Executive Director of the Oregon Coastal Zone Management Association; and Don Hull, State Geologist.

The next quarterly meeting of the Task Force will be held in the fall at Newport, Oregon, to visit the Mark O. Hatfield Marine Science Center and continue the assessment of the effects of offshore mineral leasing. □

Does Crater Lake have a discernible outlet?

Analyses of water samples from numerous cold springs near Crater Lake, Oregon, and of waters from the lake itself failed to turn up evidence of any obvious outlet for Crater Lake, according to U.S. Geological Survey scientists J.M. Thompson and L.D. White. They reported, at the fall meeting of the American Geophysical Union (AGU) in San Francisco in December 1983, that the lake in the crater of ancient Mount Mazama apparently has stabilized. The lake level is reasonably constant and water does not appear to be rising in the lake.

The cold spring waters sampled on the flanks of Mount Mazama contained minimal amounts of telltale Crater Lake components when analyzed. In fact, all the analyzed cold spring waters are derived from snowmelt and rain water. If there is subsurface leakage anywhere from Crater Lake, it may be entering the Rogue River or some other river where its small contribution is not discernible.

The following is the abstract of the presentation by Thompson and White at the AGU meeting in San Francisco:

Crater Lake, occupying the 10-km-diameter caldera in Mount Mazama, has no surface outlet. Because the surface elevation of the water is essentially constant, evaporation and subsurface discharge of lake water must equal recharge. Earlier investigators have estimated the subsurface discharge at 1.64 to 2.36 m^3/s (58-83 ft^3/s). Crater Lake water contains nearly 10 mg chlorine (Cl) per liter. In contrast, nearby Diamond Lake, located 14 km north of Crater Lake, contains less than 0.5 mg Cl per liter. This elevated Cl in Crater Lake, relative to other High Cascade lakes, is thought to indicate a component of hydrothermal fluid introduced through the lake bottom. Any local spring water that contains more than 1 mg Cl per liter may have a component of Crater Lake water. Waters from springs discharging at elevations less than mean annual lake level (1,882 m) and a few selected springs discharging above lake level were collected and chemically analyzed. One major spring, 21 km south-southwest of Crater Lake, the source of the Wood River, has an anomalously high Cl concentration (3.0 mg Cl per liter); the others contain less than 0.5 mg Cl per liter.

To verify this possible outlet of Crater Lake, high-discharging-spring water samples that were collected were analyzed for deuterium (D) and oxygen isotope 18 (^{18}O). All spring waters that were analyzed, including the Wood River sample, plot along the meteoric water line (typically -98.9 for D and -13.78 for ^{18}O) while samples from Crater Lake do not. Consequently, the Wood River, even though it has an anomalously high Cl concentration, cannot be an outlet for Crater Lake. No sampled spring analysis presents evidence of containing more than 10 percent Crater Lake water. Subsurface leakage from Crater Lake may enter the Rogue River or some other river where its small contribution cannot be discerned. □

Earth Science Editors to meet in Portland in October

The Association of Earth Science Editors (AESE) will hold its annual convention at the Portland Hilton on October 8-10, 1984. Featured will be sessions on editing publications, editing and preparing geologic illustrations and maps, preparing slides, starting a newsletter, and managing resources and planning strategically for publications. As part of the convention, a geologic field trip up the Columbia River Gorge and dinner at Timberline Lodge are scheduled for the afternoon and evening of October 9.

For additional information about AESE or the convention, contact Beverly F. Vogt, Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, OR 97201, phone (503) 229-5580. □

Help wanted in meteorite search

The Scientific Event Alert Network (SEAN) of the Smithsonian Institution is asking for help in determining the path of a large fireball that was seen during daylight on the West Coast. The fireball was first reported in Redding, California, at about 2:50 p.m. PDT on July 20, 1984. It was seen at slightly later times in Ukiah, California, and Medford, Oregon.

The very large fireball was brilliant in the daylight, dropping sparks and leaving a white smoke trail that lasted for several minutes. It was apparently moving to the northeast and descending at an angle of approximately 45°. Sonic booms were reported.

A fireball of this size may have produced fragments that survived the fall to earth. Additional information about the path of the fireball would help in the search for these meteorites. Anyone who saw the fireball is asked to call Dick Pugh at home (503/287-6733) or at Cleveland High School (503/233-6441). A message may also be left with Beverly Vogt, Oregon Department of Geology and Mineral Industries (503/229-5580), who will see that Pugh gets the information. □

USGS appoints new Western Regional Geologist

Carroll Ann Hodges of Woodside, California, research geologist with the U.S. Geological Survey (USGS), Department of the Interior, has been appointed Assistant Chief Geologist for the Western Region, headquartered in Menlo Park, California. She succeeds G. Brent Dalrymple, who has returned to research studies in isotope geology at Western Region headquarters after serving as Assistant Chief Geologist for three years.

Hodges joined the USGS Branch of Astrogeologic Studies in Menlo Park in 1970. Her research has consisted mainly of topical studies and mapping projects on the Moon and Mars. She was a principal investigator in Apollo 16 geologic analyses, both before and after the lunar mission.

Since 1982 she has served with the Survey's Branch of Western Mineral Resources as chief of an international minerals resource assessment project, evaluating the potential for occurence of mineral deposits in Colombia.

In her new post as Assistant Chief Geologist, Hodges will coordinate all USGS Geologic Division programs and manage division facilities in the Western Region states of Alaska, Arizona, California, Hawaii, Idaho, Nevada, Oregon, and Washington.

The Geologic Division includes scientists engaged in earthquake and volcanic research, marine geology, environmental and mineral resource studies, planetary geology, and other earth science investigations. □

Some mineral rights to revert to Federal Government

Time is running short for some who sold their land to the Federal Government during the 1930's depression. At the time, they retained mineral rights on their property, usually for 50 years, after which the rights were to revert to the Federal Government.

However, mineral-rights owners, their lessees, or other parties of interest may apply to extend their rights under "future interest" leasing before the 50-year deadline.

From 1911 to the start of World War II, the United States bought several million acres of private lands, either to promote conservation or to take marginal farmlands out of agricultural production during the Dust Bowl days. The sellers were allowed to retain mineral rights, usually for 50 years. The automatic rights transfers to the Federal Government will start on a large scale beginning next year and continuing into the 1990's.

Lands purchased under the 1937 Bankhead-Jones act are located in National Forests and Grasslands throughout the country. About two million acres were transferred to the Bureau of Land Management (BLM) in 1958.

As a courtesy, BLM is trying to identify parcels where the rights will revert, so rights owners can be notified. The agency is asking industry and the public to send the following information to the BLM office managing the geographic area for any parcel that might have changed mineral ownerships: (1) Copy of the conveyance document—usually a warranty deed. (2) Copy of the title opinion. (3) Abstract of title, listing transactions that have occurred. (4) Legal description of the parcel. For additional information, contact the local BLM office.

—*BLM News, Oregon and Washington*

Fireballs sighted

The following fireball sightings in Oregon were reported in the recent past:

July 15, 1984, observation by Aleta and Lewis Woodruff at 10:23 p.m. PDT, northeast of Portland. The fireball was first seen in the southeastern sky at 60° above the horizon, coming over the trees. It passed directly overhead and was last seen in the northwestern sky at 45° where it disappeared again behind trees. The duration of the event was 1 second, and the flight appeared to be parallel to the earth's surface. The size of the fireball was one-third the size of the full moon. The fireball was white and had a white tail which stretched along the entire observed flight path. No breakup or sound was observed, but the fireball did cast a shadow.

August 6, 1984, observation by Jean Frost at 9:45 p.m. PDT, 1 mi north of the St. John's bridge. The fireball, which had a halo around it, was first seen in the east at an altitude of 40° and last seen in the north at an altitude of 40°. The path of the flight appeared to be parallel to the earth's surface, and the very bright white fireball, which was one-fourth the size of the full moon, was visible for 4 to 5 seconds. Sparks appeared to come off the fireball, but no sound, breakup, or shadow was observed.

A different fireball was observed outside of the Portland area by Sue Cleis at 8:30 p.m. PDT (twilight) on August 7, 1984, about 5 mi north of Bend. The yellow-white fireball was first seen 40° east of north at an altitude of 45° and last seen on the same bearing at an altitude of 10°. The yellow-white fireball, which was about the size of Venus, was visible for 3 to 4 seconds. During its flight, it wobbled first to the east, flared, wobbled to the west, flared again, and then went straight down until burning out above the horizon. The fireball had a 35°-long, yellow-white tail and left a 1 to 2 second afterglow. No sound, breakup, or shadow was observed. □

AVAILABLE DEPARTMENT PUBLICATIONS

GEOLOGICAL MAP SERIES	Price	No. copies	Amount
GMS-4: Oregon gravity maps, onshore and offshore. 1967	$ 3.00	_____	_____
GMS-5: Geologic map, Powers 15-minute quadrangle, Coos and Curry Counties. 1971	3.00	_____	_____
GMS-6: Preliminary report on geology of part of Snake River canyon. 1974	6.50	_____	_____
GMS-8: Complete Bouguer gravity anomaly map, central Cascade Mountain Range, Oregon. 1978	3.00	_____	_____
GMS-9: Total-field aeromagnetic anomaly map, central Cascade Mountain Range, Oregon. 1978	3.00	_____	_____
GMS-10: Low- to intermediate-temperature thermal springs and wells in Oregon. 1978	3.00	_____	_____
GMS-12: Geologic map of the Oregon part of the Mineral 15-minute quadrangle, Baker County. 1978	3.00	_____	_____
GMS-13: Geologic map, Huntington and part of Olds Ferry 15-minute quadrangles, Baker and Malheur Counties. 1979	3.00	_____	_____
GMS-14: Index to published geologic mapping in Oregon, 1898-1979. 1981	7.00	_____	_____
GMS-15: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, north Cascades, Oregon. 1981	3.00	_____	_____
GMS-16: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, south Cascades, Oregon. 1981	3.00	_____	_____
GMS-17: Total-field aeromagnetic anomaly map, south Cascades, Oregon. 1981	3.00	_____	_____
GMS-18: Geology of Rickreall, Salem West, Monmouth, and Sidney 7½-minute quads., Marion/Polk Counties. 1981	5.00	_____	_____
GMS-19: Geology and gold deposits map, Bourne 7½-minute quadrangle, Baker County. 1982	5.00	_____	_____
GMS-20: Map showing geology and geothermal resources, southern half, Burns 15-minute quad., Harney County. 1982	5.00	_____	_____
GMS-21: Geology and geothermal resources map, Vale East 7½-minute quadrangle, Malheur County. 1982	5.00	_____	_____
GMS-22: Geology and mineral resources map, Mount Ireland 7½-minute quadrangle, Baker/Grant Counties. 1982	5.00	_____	_____
GMS-23: Geologic map, Sheridan 7½-minute quadrangle, Polk/Yamhill Counties. 1982	5.00	_____	_____
GMS-24: Geologic map, Grand Ronde 7½-minute quadrangle, Polk/Yamhill Counties. 1982	5.00	_____	_____
GMS-25: Geology and gold deposits map, Granite 7½-minute quadrangle, Grant County. 1982	5.00	_____	_____
GMS-26: Residual gravity maps, northern, central, and southern Oregon Cascades. 1982	5.00	_____	_____
GMS-27: Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1°×2° quadrangle. 1982	6.00	_____	_____
GMS-28: Geology and gold deposits map, Greenhorn 7½-minute quadrangle, Baker/Grant Counties. 1983	5.00	_____	_____
GMS-29: Geology and gold deposits map, NE¼ Bates 15-minute quadrangle, Baker/Grant Counties. 1983	5.00	_____	_____
GMS-31: Geology and gold deposits map, NW¼ Bates 15-minute quadrangle, Grant County. 1984	5.00	_____	_____
NEW! GMS-32: Geologic map, Wilhoit 7½-minute quadrangle, Clackamas/Marion Counties. 1984	4.00	_____	_____ ←

OTHER MAPS	Price	No. copies	Amount
Reconnaissance geologic map, Lebanon 15-minute quadrangle, Linn/Marion Counties. 1956	3.00	_____	_____
Geologic map, Bend 30-minute quad., and reconnaissance geologic map, central Oregon High Cascades. 1957	3.00	_____	_____
Geologic map of Oregon west of 121st meridian (U.S. Geological Survey Map I-325). 1961	5.50	_____	_____
Geologic map of Oregon east of 121st meridian (U.S. Geological Survey Map I-902). 1977	5.50	_____	_____
Landforms of Oregon (relief map, 17×12 in.)	1.00	_____	_____
Oregon Landsat mosaic map (published by ERSAL, OSU). 1983	$8.00 over the counter; $11.00 mailed	_____	_____
Geothermal resources of Oregon (map published by NOAA). 1982	3.00	_____	_____
Geological highway map, Pacific Northwest region, Oregon/Washington/part of Idaho (published by AAPG). 1973	5.00	_____	_____

BULLETINS	Price	No. copies	Amount
33. Bibliography of geology and mineral resources of Oregon (1st supplement, 1937-45). 1947	3.00	_____	_____
35. Geology of the Dallas and Valsetz 15-minute quadrangles, Polk County (map only). Revised 1964	3.00	_____	_____
36. Papers on foraminifera from the Tertiary (v.2 [parts VI-VIII] only). 1949	3.00	_____	_____
44. Bibliography of geology and mineral resources of Oregon (2nd supplement, 1946-50). 1953	3.00	_____	_____
46. Ferruginous bauxite deposits, Salem Hills, Marion County. 1956	3.00	_____	_____
49. Lode mines, Granite mining district, Grant County. 1959	3.00	_____	_____
53. Bibliography of geology and mineral resources of Oregon (3rd supplement, 1951-55). 1962	3.00	_____	_____
61. Gold and silver in Oregon. 1968	17.50	_____	_____
62. Andesite Conference guidebook. 1968	3.50	_____	_____
65. Proceedings of the Andesite Conference. 1969	10.00	_____	_____
67. Bibliography of geology and mineral resources of Oregon (4th supplement, 1956-60). 1970	3.00	_____	_____
71. Geology of selected lava tubes, Bend area, Deschutes County. 1971	5.00	_____	_____
77. Geologic field trips in northern Oregon and southern Washington. 1973	5.00	_____	_____
78. Bibliography of geology and mineral resources of Oregon (5th supplement, 1961-70). 1973	3.00	_____	_____
81. Environmental geology of Lincoln County. 1973	9.00	_____	_____
82. Geologic hazards of Bull Run Watershed, Multnomah and Clackamas Counties. 1974	6.50	_____	_____
83. Eocene stratigraphy of southwestern Oregon. 1974	4.00	_____	_____
84. Environmental geology of western Linn County. 1974	9.00	_____	_____
85. Environmental geology of coastal Lane County. 1974	9.00	_____	_____
87. Environmental geology of western Coos and Douglas Counties. 1975	9.00	_____	_____
88. Geology and mineral resources, upper Chetco River drainage, Curry and Josephine Counties. 1975	4.00	_____	_____
89. Geology and mineral resources of Deschutes County. 1976	6.50	_____	_____
90. Land use geology of western Curry County. 1976	9.00	_____	_____
91. Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties. 1977	8.00	_____	_____
92. Fossils in Oregon. A collection of reprints from the *Ore Bin*. 1977	4.00	_____	_____
93. Geology, mineral resources, and rock material of Curry County. 1977	7.00	_____	_____
94. Land use geology of central Jackson County. 1977	9.00	_____	_____
95. North American ophiolites (IGCP project). 1977	7.00	_____	_____
96. Magma genesis. AGU Chapman Conference on Partial Melting. 1977	12.50	_____	_____
97. Bibliography of geology and mineral resources of Oregon (6th supplement, 1971-75). 1978	3.00	_____	_____
98. Geologic hazards of eastern Benton County. 1979	9.00	_____	_____
99. Geologic hazards of northwestern Clackamas County. 1979	10.00	_____	_____
100. Geology and mineral resources of Josephine County. 1979	9.00	_____	_____
101. Geologic field trips in western Oregon and southwestern Washington. 1980	9.00	_____	_____
102. Bibliography of geology and mineral resources of Oregon (7th supplement, 1976-79). 1981	4.00	_____	_____

SHORT PAPERS	Price	No. copies	Amount
21. Lightweight aggregate industry in Oregon. 1951	1.00	_____	_____
24. The Almeda Mine, Josephine County. 1967	3.00	_____	_____
25. Petrography of Rattlesnake Formation at type area, central Oregon. 1976	3.00	_____	_____
27. Rock material resources of Benton County. 1978	4.00	_____	_____

AVAILABLE DEPARTMENT PUBLICATIONS (continued)

MISCELLANEOUS PAPERS

	Price	No. copies	Amount
1. A description of some Oregon rocks and minerals. 1950	$ 1.00	_____	_____
5. Oregon's gold placers. 1954	1.00	_____	_____
8. Available well records of oil and gas exploration in Oregon. Revised 1982	4.00	_____	_____
11. Collection of articles on meteorites (reprints from *Ore Bin*). 1968	3.00	_____	_____
15. Quicksilver deposits in Oregon. 1971	3.00	_____	_____
17. Geologic hazards inventory, Oregon coastal zone. 1974	5.00	_____	_____
18. Proceedings of Citizens' Forum on Potential Future Sources of Energy. 1975	3.00	_____	_____
19. Geothermal exploration studies in Oregon, 1976. 1977	3.00	_____	_____
20. Investigations of nickel in Oregon. 1978	5.00	_____	_____

SPECIAL PAPERS

	Price	No. copies	Amount
1. Mission, goals, and programs of the Oregon Department of Geology and Mineral Industries. 1978	3.00	_____	_____
2. Field geology, SW Broken Top quadrangle. 1978	3.50	_____	_____
3. Rock material resources, Clackamas, Columbia, Multnomah, and Washington Counties. 1978	7.00	_____	_____
4. Heat flow of Oregon. 1978	3.00	_____	_____
5. Analysis and forecasts of the demand for rock materials in Oregon. 1979	3.00	_____	_____
6. Geology of the La Grande area. 1980	5.00	_____	_____
7. Pluvial Fort Rock Lake, Lake County. 1979	4.00	_____	_____
8. Geology and geochemistry of the Mount Hood volcano. 1980	3.00	_____	_____
9. Geology of the Breitenbush Hot Springs quadrangle. 1980	4.00	_____	_____
10. Tectonic rotation of the Oregon Western Cascades. 1980	3.00	_____	_____
11. Theses and dissertations on geology of Oregon: Bibiliography and index, 1899-1982. 1982	6.00	_____	_____
12. Geologic linears of the northern part of the Cascade Range, Oregon. 1980	3.00	_____	_____
13. Faults and lineaments of the southern Cascades, Oregon. 1981	4.00	_____	_____
14. Geology and geothermal resources of the Mount Hood area. 1982	7.00	_____	_____
15. Geology and geothermal resources of the central Oregon Cascade Range. 1983	11.00	_____	_____
16. Index to the *Ore Bin* (1939-1978) and *Oregon Geology* (1979-1982). 1983	4.00	_____	_____
NEW! 17. Bibliography of Oregon paleontology, 1792-1983. 1984	6.00	_____	_____

OIL AND GAS INVESTIGATIONS

	Price	No. copies	Amount
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well. 1973	3.00	_____	_____
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well. 1973	3.00	_____	_____
5. Prospects for natural gas, upper Nehalem River basin. 1976	5.00	_____	_____
6. Prospects for oil and gas, Coos Basin. 1980	9.00	_____	_____
7. Correlation of Cenozoic stratigraphic units of western Oregon and Washington. 1983	8.00	_____	_____
9. Subsurface biostratigraphy, east Nehalem Basin. 1983	6.00	_____	_____
NEW! 11. Biostratigraphy of exploratory wells, western Coos, Douglas, and Lane Counties. 1984	6.00	_____	_____

MISCELLANEOUS PUBLICATIONS

	Price	No. copies	Amount
Mining claims (State laws governing quartz and placer claims)	1.00	_____	_____
Back issues of *Ore Bin*	50¢ over the counter; $1.00 mailed	_____	_____
Back issues of *Oregon Geology*	75¢ over the counter; $1.00 mailed	_____	_____
Colored postcard: Geology of Oregon	0.10	_____	_____

Separate price lists for open-file reports, geothermal energy studies, tour guides, recreational gold mining information, and non-Departmental maps and reports will be mailed upon request.

OREGON GEOLOGY

1005 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

PUBLICATIONS ORDER

Fill in appropriate blanks and send sheet to Department.
Minimum mail order $1.00. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $50.00. Foreign orders: Please remit in U.S. dollars.

NAME ______________________________

ADDRESS ______________________________

______________________________ ZIP __________

Amount enclosed $ ______________________________

OREGON GEOLOGY

_____ Renewal _____ New Subscription _____ Gift

_____ 1 Year ($6.00) _____ 3 Years ($15.00)

NAME ______________________________

ADDRESS ______________________________

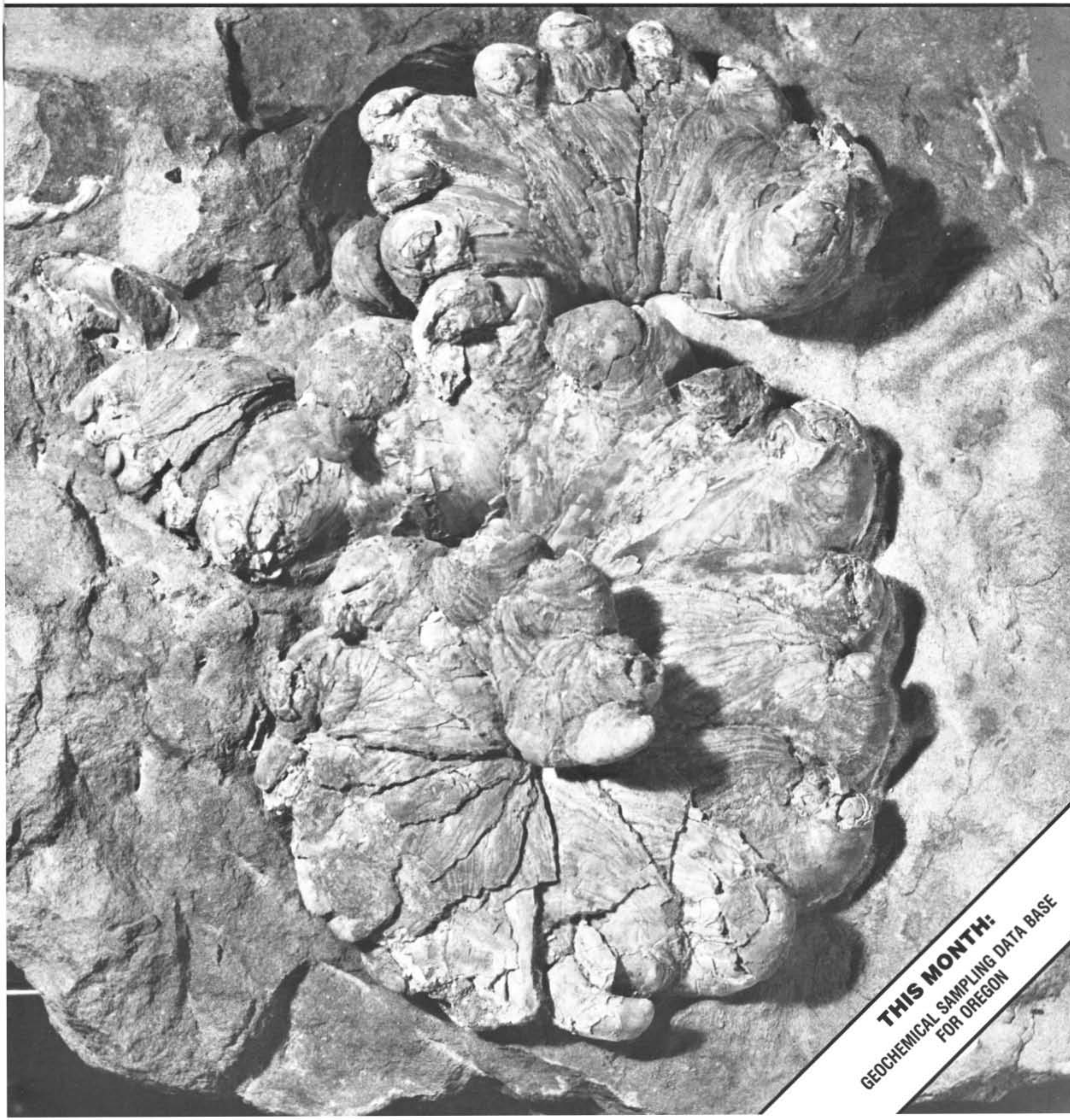
______________________________ ZIP __________

If gift: From ______________________________

OREGON GEOLOGY

published by the
Oregon Department of Geology and Mineral Industries

VOLUME 46, NUMBER 10 OCTOBER 1984



OREGON GEOLOGY
(ISSN 0164-3304)

VOLUME 46, NUMBER 10 OCTOBER 1984

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

Main Office: 1005 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133. Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496. Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039. Paul F. Lawson, Supervisor

Second class postage paid at Portland, Oregon. Subscription rates: 1 year, $6.00; 3 years, $15.00. Single issues, $.75 at counter, $1.00 mailed. Available back issues of *Ore Bin*: $.50 at counter, $1.00 mailed. Address subscription orders, renewals, and changes of address to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201. Permission is granted to reprint information contained herein. Credit given to the Oregon Department of Geology and Mineral Industries for compiling this information will be appreciated. POSTMASTER: Send address changes to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

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

A natural accumulation cluster of the "slipper shell" *Crepidula princeps* Conrad. Specimens are from the lower Empire Formation at Coos Bay, Oregon, and are assigned to the Graysian Molluscan Stage (late Miocene). The snail *Crepidula* occurs in clusters for reproduction purposes and because, as a filter feeder who must live above the sediment-water interface, it settles and grows on the shells of other *Crepidula* individuals. Usually the clusters form neat circles of 20-30 cm in diameter with some 20-25 individuals in an imbricate (fallen-domino) configuration. This cluster of 43 individuals in an S-shape is exceptionally large and reflects low sedimentation rates in low-energy, shallow marine water. Photo by John M. Armentrout, Mobil Oil Co., Dallas, Texas, made available by William N. Orr, University of Oregon.

OIL AND GAS NEWS

Mist Gas Field

Only 21 days after completion of Busch 14-15, Reichhold Energy completed another well at Mist Gas Field. Columbia County 43-27, in SE¼ sec. 27, T. 6 N., R. 5 W., was tested on September 1, 1984 at a rate of 1.4 MMcfd of gas. Total depth of the well is 2,441 ft. This is the fourth completed well in the south extension of the field.

Two Taylor Drilling Company rigs have been busy at Mist for the past several weeks. While one drilled and completed Columbia County 43-27, the other drilled Adams 32-34 in NE¼ sec. 34, T. 7 N., R. 5 W. The well was a dry hole with a total depth of 3,284 ft but is now being redrilled.

Reichhold is also redrilling another well at Mist, this one a former producer. The well, Paul 34-32 in SE¼ sec. 32, T. 7 N., R. 5 W., produced 469 MMcf of gas from April 1983 to June 1984. Water production became a problem, so the redrill was started the week of September 9.

Douglas County

Hutchins and Marrs Great Discovery 2, in NW¼ sec. 20, T. 30 S., R. 9 W., was drilled to 3,510 ft and is now idle. The operator may deepen the well.

Meanwhile, Amoco Production Company has moved a Peter Bawden rig to the Weyerhaeuser 1-13 location in SW¼ sec. 13, T. 25 S., R. 9 W. The drilling of this 13,500-ft well will occur concurrently with the drilling of the company's Grays Harbor, Washington well.

Mist gas production

Month	Total Mcf	Field avg. Btu	Total therms
April 1984	162,808	969	1,577,168
May 1984	221,884	952	2,113,191
June 1984	253,489	955	2,421,239
July 1984	268,749	961	2,566,107
Cumulative field production through July 1984	17,891,097		

□

State Capitol mineral display features Oregon fossils

The Newport Agate Society has provided and installed a display of Oregon fossils that can now be seen in the State Capitol display case of the Oregon Council of Rock and Mineral Clubs. Contributions from 16 members of the Society were arranged in 47 groups by Julia Hughes, Lynn Weimer, and Henry Norman.

The display of fossils includes Chione and Andara clams, shark's teeth, mammal and dolphin vertebrae, a turtle, a crab, a scallop, coral, Toredo worm holes in carbonized wood, and a large specimen of crystallized fish replacement. Most of the fossils are from Lincoln County, but Clatsop, Polk, and Wasco Counties are also represented.

The display will remain on exhibit the usual three-month period, until the end of November, and will be followed by displays from the Columbia-Willamette Faceters' Guild of Portland, the Portland Earth Science Organization, and the Roxy Ann Gem and Mineral Club of Medford. □

Geochemical sampling data base for Oregon

by J.J. Gray, Oregon Department of Geology and Mineral Industries

This report lists the references constituting the data base of geochemical sampling in Oregon. The location map identifies the sampled areas and keys them to the references or groups of references in the list.

Geochemical sampling data of value to mineral exploration in Oregon have been collected and published for almost the last twenty years by several Federal agencies and by the Oregon Department of Geology and Mineral Industries (DOGAMI). From some sampling programs, only summaries or abbreviated reports were published. In those cases, raw data should be available through the authors of the reports from the publishing agencies.

Most of the published reports and some unpublished data are on file and available for inspection at the DOGAMI office, 1005 State Office Building, Portland, OR 97201, phone (503) 229-5580. Use this address also to purchase published DOGAMI reports. Obtain copies of publications or data from other agencies at the following addresses:

U.S. Bureau of Land Management: *Unpublished data:* U.S. Bureau of Land Management, P.O. Box 2965, Portland, OR 97208, phone (503) 231-6951. Contact person, Durga Rimal.

U.S. Bureau of Mines: *Published reports:* Branch of Production and Distribution, Division of Publication, U.S. Bureau of Mines, 4800 Forbes Avenue, Pittsburgh, PA 15213, phone (412) 621-4500. *Unpublished data:* Western Field Operations Center, U.S. Bureau of Mines, East 360 Third Avenue, Spokane, WA 99202, phone (509) 456-5350.

U.S. Department of Energy, National Uranium Resource Evaluation (NURE) program: *Published reports and maps:* Open-File Services Section, Building 41, MS 306, P.O. Box 25046, U.S. Geological Survey, Federal Center, Denver, CO 80225, phone (303) 236-7476. *Magnetic tapes (Airborne Radiometric and Magnetic Survey data; Hydrogeochemical and Stream Sediment Reconnaissance data):* USGS EROS Data Center, User Services, Sioux Falls, SD 57198. Contact person, B.F. Molnia, phone (605) 594-6142.

U.S. Geological Survey: *Published open-file reports:* Open-File Services Section, Branch of Distribution, U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225, phone (303) 236-7476. *All other publications:* Public Inquiries Office, U.S. Geological Survey, 678 U.S. Courthouse, West 920 Riverside Avenue, Spokane, WA 99201, phone (509) 456-2524. (This is the northwest regional office; many other USGS offices throughout the nation offer the same services.) *Unpublished data;* U.S. Geological Survey, 345 Middlefield Road, Mail Stop 93, Menlo Park, CA 94025, phone (415) 323-8111.

The currently available 13,000-15,000 geochemical analyses are from only about one-third of the land area in Oregon. The remainder of the state has not been sampled. In the available studies, the density of sampling, thoroughness of analysis, and level of detection vary from study to study.

TABLE OF REFERENCES

SA = Number of samples assayed
EA = Maximum number of elements assayed
NR = No raw data published; see introduction

AREA 1
Causey, J.D., 1982, Mineral resources of the Mount Hood Wilderness, Clackamas and Hood River Counties, Oregon: U.S. Bureau of Mines Open-File Report MLA 37-82. (NR)

Keith, T.E.C., Bargar, K.E., and Beeson, M.H., 1982, Geochemical map of the Mount Hood Wilderness, Clackamas and Hood River Counties, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1379-C. (Raw data in following reference)

Keith, T.E.C., Beeson, M.H., Bargar, K.E., and Marsh, S.P., 1980, Geochemical data for rock, stream sediment, and panned concentrate samples, Mount Hood Wilderness area, Oregon: U.S. Geological Survey Open-File Report 80-839. (SA 154; EA 30)

AREA 2
Wollenberg, H.A., Brown, R.E., Bowman, H.R., and Strisower, B., 1979, Geochemical studies of rocks, water, and gases at Mt. Hood, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-79-2. (SA 43; EA 31)

White, C., 1980, Geology and geochemistry of Mt. Hood Volcano: Oregon Department of Geology and Mineral Industries Special Paper 8. (SA 62; EA 28)

AREA 3
Rimal, D., 1983, Preliminary geochemical data on some BLM-administered lands including Wilderness Study Areas in Oregon and Washington: U.S. Bureau of Land Management, Portland, Oregon, unpublished report. (SA 302; EA 21)

AREA 4
Munts, S.R., 1983, Mineral resources of the Wenaha-Tucannon Wilderness Study Area (FS), Asotin, Columbia, and Garfield Counties, Washington, and Wallowa County, Oregon--Summary Report: U.S. Bureau of Mines Open-File Report MLA 20-83. (NR)
Swanson, D.A., and Wright, T.L., 1983, Semiquantitative spectrographic analyses of stream-sediment samples from the Wenaha-Tucannon Wilderness, Washington and Oregon: U.S. Geological Survey Open-File Report 83-297. (SA 20; EA 29)

AREA 5
Close, T.J., Federspiel, F.E., Leszcykowski, A., and Hyndman, P.C., 1982, Mineral resources of the Hells Canyon Study Area, Adams, Idaho, and Nez Perce Counties, Idaho, and Wallowa County, Oregon: U.S. Bureau of Mines Open-File Report MLA 41-82. (NR)

Simmons, G.C., Sutley, S.J., Forn, C., Viets, J.G., Hopkins, D.M., Negri, J.C., and Curtis, C.A., 1984, Analytical data for the Hells Canyon study area, Wallowa County, Oregon, and Idaho and Adams Counties, Idaho: U.S. Geological Survey Open-File Report 84-499. (SA 4,757 [includes data for Idaho]; EA 28)

AREA 6
Weis, P.L., Gualtieri, J.L., Cannon, W.F., Tuchek, E.T., McMahan, A.B., and Federspiel, F.E., 1976, Mineral resources of the Eagle Cap Wilderness and adjacent areas, Oregon: U.S. Geological Survey Bulletin 1385-E. (NR)

AREA 7
Conyac, M.D., 1981, Summary of mineral resources of the Lake Fork RARE II area (Study area 6290), Baker and Wallowa Counties, Oregon: U.S. Bureau of Mines Open-File Report MLA 1-81. (NR)

Evans, J.G., Conyac, M.D., Hyndman, P.C., and Mayerle, R.T., 1983, Mineral resource potential of the Homestead, Lake Fork, and Lick Creek Roadless Areas, Baker and Wallowa Counties, Oregon: U.S. Geological Survey Open-File Report 83-409. (NR)

Hyndman, P.C., 1983, Mineral investigation of the Homestead RARE II area (No. 8291), Baker and Wallowa Counties, Oregon: U.S. Bureau of Mines Open-File Report MLA 76-83. (NR)

Mayerle, R.T., 1982, Mineral investigation of the Lick Creek RARE II area (No. 6285), Wallowa and Baker Counties, Oregon: U.S. Bureau of Mines Open-File Report MLA 120-82. (NR)

AREA 8
Oregon Department of Geology and Mineral Industries, 1976, Stream-sediment geochemistry, northeastern Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-76-4. (SA 1005; EA 5)

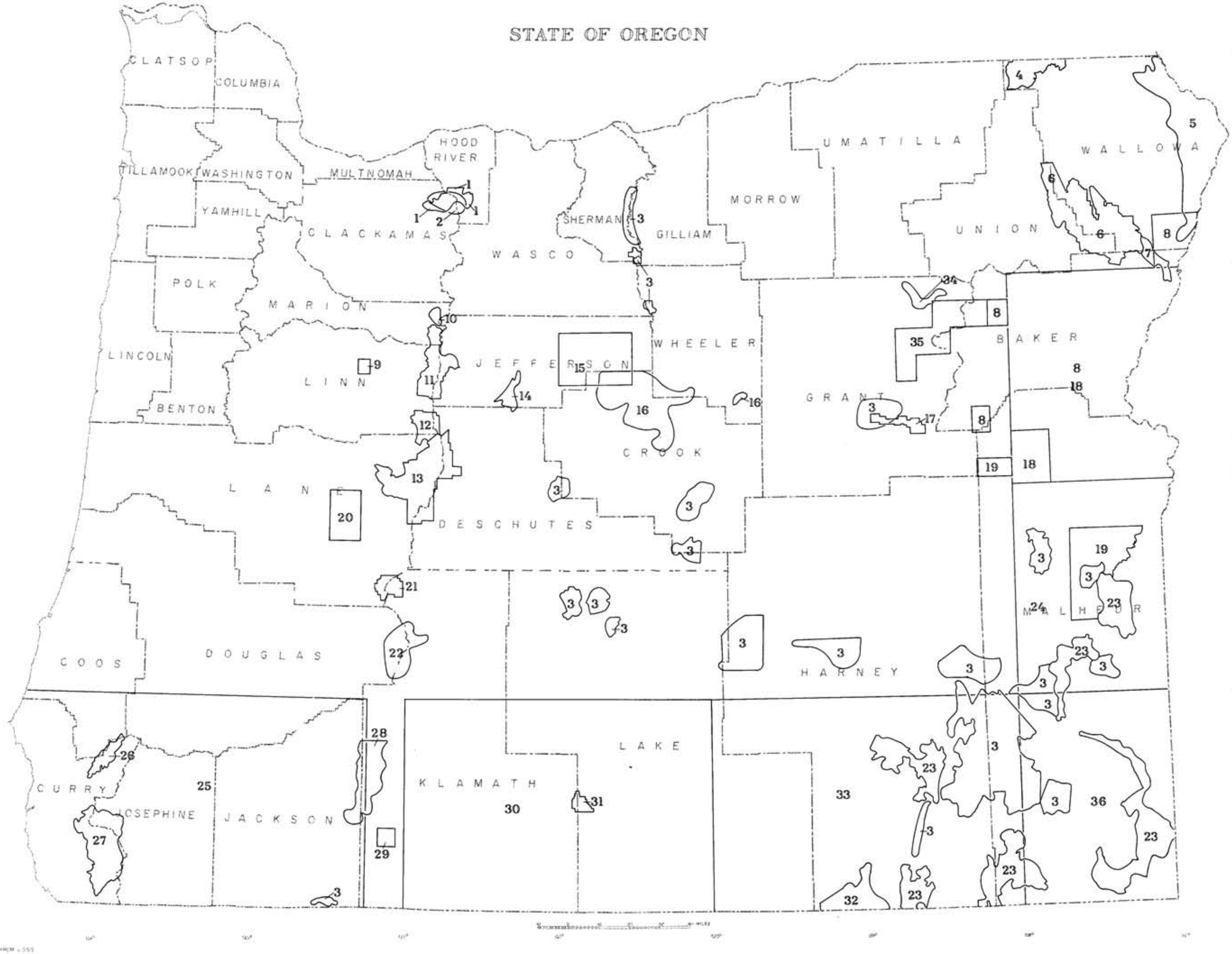
AREA 9
Munts, S.R., 1981, Reconnaissance geochemical study of the Quartzville mining district, Linn County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-81-8. (SA 141; EA 5)

AREA 10
Neuman, T.R., 1983, Mineral investigation of the Olallie RARE II area (No. 6099), Marion and Jefferson Counties, Oregon: U.S. Bureau of Mines Open-File Report MLA 23-83. (NR)

Walker, G.W., 1982, Mineral resource potential of the Olallie Roadless Area, Marion and Jefferson Counties, Oregon: U.S. Geological Survey Open-File Report 82-885. (NR)

AREA 11
Walker, G.W., Greene, R.C., and Pattee, E.C., 1966, Mineral resources of the Mount Jefferson primitive area, Oregon: U.S. Geological Survey Bulletin 1230-D, p. D1-D32. (NR)

AREA 12
Causey, J.D., 1982, Mineral resources of the Mount Washington Wilderness, Deschutes, Lane, and Linn Counties, Oregon: U.S. Bureau of Mines Open-File Report MLA 38-82. (NR)



Oregon's geochemical sampling data base. Numbers correspond to area numbers in Table of References.

Taylor, E.M., Causey, J.D., and MacLeod, N.S., 1983, Geology and mineral resource potential map of the Mount Washington Wilderness, Deschutes, Lane, and Linn Counties, Oregon: U.S. Geological Survey Open-File Report 83-662. (NR)

AREA 13
Causey, J.D., and Willett, S.L., 1981, Mineral resources of the Three Sisters Wilderness, Deschutes, Lane, and Linn Counties, Oregon: U.S. Bureau of Mines Open-File Report MLA 22-82. (NR)

MacLeod, N.S., Taylor, E.M., Sherrod, D.R., Walker, G.W., Causey, J.D., and Willett, S.L., 1983, Mineral resource potential map of the Three Sisters Wilderness, Deschutes, Lane, and Linn Counties, Oregon: U.S. Geological Survey Open-File Report 83-659. (NR)

AREA 14
Walker, G.W., and Winters, R.A., 1983, Mineral resource potential of the Deschutes Canyon Roadless Area, Jefferson and Deschutes Counties, Oregon: U.S. Geological Survey Open-File Report 83-375. (NR)

Winters, R.A., 1983, Mineral investigation of the Deschutes Canyon Rare II area (No. 6321), Jefferson and Deschutes Counties, Oregon: U.S. Bureau of Mines Open-File Report MLA 6-83. (NR)

AREA 15
Gray, J.J., in preparation, Geological-geochemical survey of a portion of eastern Jefferson and northern Crook Counties, Oregon: Oregon Department of Geology and Mineral Industries Special Paper 18. (SA 400; EA 8)

AREA 16
Ferns, M.L., and Brooks, H.C., 1983, Geochemical survey of the western part of the Ochoco National Forest, Crook and Wheeler Counties, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report 0-83-4. (SA 375; EA 8)

AREA 17
Thayer, T.P., Case, J.E., and Stotelmeyer, R.B., 1981, Mineral resources of the Strawberry Mountain Wilderness and adjacent areas, Grant County, Oregon: U.S. Geological Survey Bulletin 1498. (NR)

U.S. Geological Survey, 1977, Mineral resources of the Strawberry Mountain Wilderness and adjacent areas, Grant County, Oregon: U.S. Geological Survey Open-File Report 77-420. (SA 363; EA 12)

AREA 18
Cook, J.R., 1981, Baker 1°x 2° NTMS area, Oregon and Idaho, data report (abbreviated), hydrogeochemical and stream-sediment reconnaissance: National Uranium Resource Evaluation Program Report GJBX-231 (81). (SA 1,410 [includes data for Idaho]; EA 17)

Cook, J.R., and Fay, W.M., 1982, Data report: Western United States hydrogeochemical and stream-sediment reconnaissance: National Uranium Resource Evaluation Program Report GJBX-132 (82). (SA 1,424 [includes data for Idaho]; EA 41.

Fay, W.M., and Cook, J.R., 1982, Gold analyses by neutron activation from SRL NURE samples: National Uranium Resource Evaluation Program Report GJBX-135 (82). (SA 28; EA 1)

AREA 19
Meyer, W.T., in preparation, Geology and energy minerals resource assessment of the central part of Northern Malheur Resource Area, Vale District, Malheur County, Oregon: Report to U.S. Bureau of Land Management, Portland, Oregon. (SA 700; EA 13)

AREA 20
Gray, J.J., and Berri, D.A., 1983, Mineral potential of the Fall Creek mining district: A geological-geochemical survey: Oregon Department of Geology and Mineral Industries Open-File Report 0-83-5. (SA 124; EA 8)

AREA 21
Moyle, P.R., and Rumsey, C.M., 1981, Mineral resources of the Diamond Peak Wilderness and proposed addition, Lane and Klamath Counties, Oregon: U.S. Bureau of Mines Open-File Report MLA 23-82. (NR)

Sherrod, D.R., Moyle, P.R., Rumsey, C.M., and MacLeod, N.S., 1983, Geology and mineral resource potential map of the Diamond Peak Wilderness, Lane and Klamath Counties, Oregon: U.S. Geological Survey Open-File Report 83-661. (NR)

AREA 22
Benham, J.R., 1981, Mineral resources of the Windigo-Thielsen RARE II area (No. 6132), Douglas and Klamath Counties, Oregon: U.S. Bureau of Mines Open-File Report MLA 11-81. (NR)

Sherrod, D.R., Benham, J.R., and MacLeod, N.S., 1983, Geology and mineral resource potential map of the Windigo-Thielsen Roadless Area, Douglas and Klamath Counties, Oregon: U.S. Geological Survey Open-File Report 83-660. (NR)

AREA 23
Gray, J.J., Peterson, N.V., Clayton, J., and Baxter, G., 1983, Geology and mineral resources of 18 BLM Wilderness Study Areas, Harney and Malheur Counties, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report 0-83-2. (SA 1,491; EA 17)

Lovell, J., in preparation, Geochemical and mineralogical study of heavy mineral stream-sediment samples from Wilderness Study Areas in Burns, Vale, and Prineville Districts, southeast Oregon: Report to U.S. Bureau of Land Management, Portland, Oregon. (SA 1,200; EA 7. Note that study contained data for 100 samples from AREA 3.)

AREA 24
Oak Ridge Gaseous Diffusion Plant, 1982, Hydrogeochemical and stream-sediment reconnaissance basic data for Boise quadrangle, Oregon/Idaho: National Uranium Resource Evaluation Program Report GJBX-60 (82). (SA 1,281 [includes data for Idaho]; EA 32)

AREA 25
Bowen, R.G., 1969, Analyses of stream-sediment samples from southwestern Oregon west of longitude 122° and south of latitude 43°: Oregon Department of Geology and Mineral Industries Open-File Report 0-69-1. (SA 2,500 [estimate]; EA 30)

AREA 26
Gray, F., and McKee, E.H., 1981, New K-Ar data from the Wild Rogue Wilderness, southwestern Oregon: Isochron/West, no. 32, p. 27-29. (NR)

Gray, F., Miller, M.S., Gaps, R.S., Peterson, J.A., Blakely, R.H., and Senior, L., 1983, Mineral resource potential map of the Wild Rogue Wilderness, Coos and Curry Counties, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1381-D. (Raw data in following reference)

Gray, F., and Peterson, J.A., 1982, Geochemical analyses of rock and stream-sediment samples from the Wild Rogue Wilderness area, Coos, Curry, and Douglas Counties, Oregon: U.S. Geological Survey Open-File Report 82-186. (SA 296; EA 32)

Peterson, J.A., and Gray, F., 1982, Geochemical map and rock and stream-sediment data from the Wild Rogue Wilderness, Coos and Curry Counties, southwestern Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1381-B. (Raw data in preceding reference)

AREA 27
Carlson, C.A., Page, N.J., Grimes, D.J., and Leinz, R.W., 1982, Geochemical characteristics of rock samples from the Kalmiopsis Wilderness, southwestern Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1240-C. (Raw data in following reference)

Carlson, R.R., Carlson, C.A., Grimes, D.J., Leinz, R.W., and Page, N.J., 1982, Geochemical analyses for platinum-group elements in rock samples from the Kalmiopsis Wilderness, southwestern Oregon: U.S. Geological Survey Open-File Report 82-948. (SA 1,307; EA 33)

Page, N.J., Carlson, R.R., Miller, M.S., Gray, F., and Carlson, C.A., 1983, Map showing characteristics of platinum-group elements and gold in rock samples from the Kalmiopsis Wilderness, southwestern Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1240-F. (Raw data in preceding reference)

AREAS 28 and 29
Smith, J.G., Benham, J.R., and Johnson, F.L., 1983, Mineral resource potential map of the Sky Lakes Roadless Area and Mountain Lakes Wilderness, Jackson and Klamath Counties, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1507-B. (NR)

AREA 30
Butz, T.R., Tieman, D.J., Vreeland, J.L., Bard, C.S., Leimer, H.W., Helgerson, R.N., Grimes, J.G., and Pritz, P.M., 1980, Hydrogeochemical and stream-sediment detailed geochemical survey for Lakeview, Oregon: National Uranium Resource Evaluation Program Report GJBX-141 (80). (SA 881; EA 34)

Cook, J.R., and Fay, W.M., 1982, Data report: Western United States hydrogeochemical and stream-sediment reconnaissance: National Uranium Resource Evaluation Program Report GJBX-132 (82). (SA 1,406; EA 41)

Fay, W.M., and Cook, J.R., 1982, Gold analyses by neutron activation from SLR NURE samples: National Uranium Resource Evaluation Program Report GJBX-135 (82). (SA 62; EA 1)

Koller, G.R., 1980, Klamath Falls 1°x 2° NTMS area, Oregon data report (abbreviated), hydrogeochemical and stream-sediment reconnaissance: National Uranium Resource Evaluation Program Report GJBX-171 (80). (SA 1,412; EA 34)

AREA 31
Ridenour, J., 1982, Mineral resources of the Gearhart Mountain Wilderness and RARE II area 6225, Klamath and Lake Counties, Oregon: U.S. Bureau of Mines Open-File Report MLA 33-82. (NR)

Walker, G.W., and Ridenour, J., 1982, Mineral resource potential of the Gearhart Mountain Wilderness and Roadless Area (6225), Lake and Klamath Counties, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1367. (NR)

AREA 32
Rimal, D., Simontacchi, D., and Brown, G., 1980, Reconnaissance geochemical stream survey of the Hawks Mountain and the Lone Mountain areas, Harney County, Oregon: U.S. Bureau of Land Management, Portland, Oregon, unpublished report. (SA 52; EA 15)

AREA 33
Cook, J.R., and Fay, W.M., 1982, Data report: Western United States hydrogeochemical and stream-sediment reconnaissance: National Uranium Resource Evaluation Program Report GJBX-132 (82). (SA 1,243; EA 41)

Dayvault, R.D., 1983, Data release for parts of the eastern Adel quadrangle, Oregon: National Uranium Resource Evaluation Program Report GJBX-38 (83). (SA 40; EA 34)

Oak Ridge Gaseous Diffusion Plant, 1982, Hydrogeochemical and stream-sediment reconnaissance basic data for Adel quadrangle, Oregon: National Uranium Resource Evaluation Program Report GJBX-57 (82). (SA 1,243; EA 32)

AREA 34
Conyac, M.D., 1983, Mineral investigations of the North Fork John Day River RARE II area (No. B6253), Grant County, Oregon: U.S. Bureau of Mines Open-File Report MLA 34-83. (NR)

Evans, J.G., and Conyac, M.D., 1983, Mineral resource potential map of the North Fork John Day River Roadless Area, Grant County, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1581-A. (NR)

AREA 35
Ferns, M.L., Brooks, H.C., and Avery, D.G., 1984, Geochemical data for Bates NE, Bates NW, Bates SW, Bourne, Granite, Greenhorn, and Mount Ireland quadrangles, Grant and Baker Counties, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report 0-84-3. (SA 26C; EA 8)

AREA 36
Cook, J.R., and Fay, W.M., 1982, Data report: Western United States hydrogeochemical and stream-sediment reconnaissance: National Uranium Resource Evaluation Program Report GJBX-132 (82). (SA 1,207 [includes data for Idaho]; EA 41)

Oak Ridge Gaseous Diffusion Plant, 1982, Hydrogeochemical and stream-sediment reconnaissance basic data for Jordan Valley quadrangle, Oregon/Idaho: National Uranium Resource Evaluation Program Report GJBX-58 (82). (SA 1,207 [includes data for Idaho]; EA 30)

Understanding thermal energy and dynamic processes in subduction-related volcanic arcs: Proposed studies in the Cascades

by George R. Priest, Oregon Department of Geology and Mineral Industries, and David D. Blackwell, Southern Methodist University, Dallas, Texas 75275

INTRODUCTION

It is hard to overstate the importance of subduction-related volcanic arcs in the geologic record and in the record of historic earthquakes and volcanic eruptions. Subduction-related terranes appear to be represented in the geologic record from the Archeozoic to modern times and account for much of the world's volcanic activity. Convergent plate margins stretching for thousands of miles around the Pacific, the Caribbean, the Indian Ocean, and the Mediterranean have some of the most active volcanoes and largest geothermal systems in the world. Many of the world's largest hydrothermal ore deposits are associated with calc-alkaline magmas injected into the crust as a result of the subduction process. The enormous deposits in the Andes, Indonesia, Japan, western North America, and other areas around the Pacific Ocean are examples.

The Cascade Range is the only presently active subduction-related volcanic arc in the conterminous United States. Active volcanoes related to the arc occur over a distance of over 1,300 km from British Columbia to northern California. The most destructive historic volcanic eruption in the United States occurred in 1980 at Mount St. Helens in the Washington part of the range. Partly because of its unique status, the Cascade Range is also one of the most completely studied volcanic arcs in the world. In spite of the extensive geologic and geophysical data available for the range, the detailed subsurface geology is essentially unknown, because the thick sequences of young volcanic rocks effectively mask structures. The high porosity, permeability, and resistivity and the low seismic velocity of young volcanic rocks in the most active part of the arc make geophysical sounding very difficult.

The only part of the Cascades that has been relatively easy to explore by geophysical techniques is the Western Cascade Range. This Miocene and older volcanic terrane has been diagenetically and hydrothermally altered, greatly decreasing the porosity and permeability of the rocks. Consequently, geophysical techniques have been much more successful in the Western Cascades than in the young volcanic rocks of the High Cascade Range to the east.

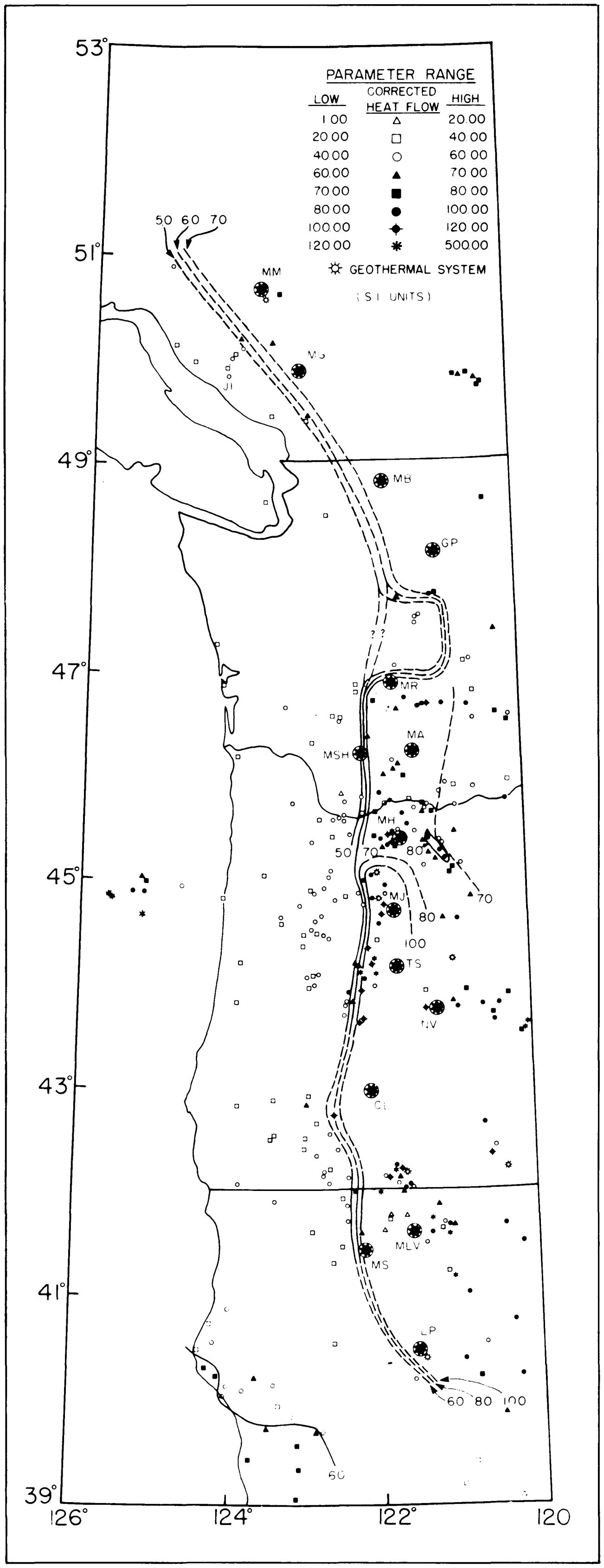
One of the most significant findings from studies of the Western Cascade Range is in the area of heat flow. The results of heat-flow measurements in numerous drill holes indicate that there is a characteristic heat-flow anomaly with a half-width of approximately 10 km on the western side extending from northern California to southern British Columbia (Blackwell and Steele, 1983). Heat flow increases by as much as a factor of 2 or more across the western side of this anomaly, while average geothermal gradients within the main part of the anomaly in the Oregon Cascade Range are about 65° C/km (Blackwell and others, 1978, 1982). Based on interpretation of these data, it appears that temperatures appropriate for partial melting of granitic material should occur at depths on the order of 7 to 10 km under the easternmost part of the Western Cascade Range in Oregon (Blackwell and others, 1978, 1982). These depths are similar to depths estimated for partially molten granitic bodies under silicic volcanic centers such as the Yellowstone, Long Valley, and Valles calderas. Temperatures at equivalent depths beneath the High Cascade Range may be even higher, but thus far, attempts to measure heat flow in the High Cascades have been thwarted by the rapidly circulating shallow ground water that washes away heat flow in the carapace of young volcanic rocks. Lack of reliable heat-flow data in the High Cascade Range is one of the principal reasons that it is not generally included in estimates of the accessible geothermal resource base for the United States. If geothermal systems are present in a significant part of this enormous province, they could dwarf the geothermal potential estimated for the largest silicic volcanic centers in the United States.

RATIONALE FOR SCIENTIFIC DEEP DRILLING IN THE CASCADES

The previously mentioned problems presented by the cover of young volcanic rocks in the Cascades can be solved only by drilling. Experience in drilling in areas such as Newberry Volcano in Oregon has shown that drill holes must generally be 1 km or deeper in order to make meaningful measurements of heat flow in the youngest part of the volcanic arc. Drill holes deeper than 1 km are almost completely lacking in the young volcanic rocks of the High Cascades. In order to directly test the hypothesis that temperatures near the melting point of granitic rocks occur at depths of 7 to 10 km, it would be necessary to drill to these depths. Should the hypothesis prove to be correct, it would have far-reaching consequences for estimates of geothermal potential and for physical models of subduction-related volcanic arcs throughout the world. It would mean that regional zones of very high temperature, possibly molten rock, occur at relatively shallow crustal levels under the entire length of active arcs regardless of the presence or absence of single large volcanoes. Measurements in drill holes in the Cascades would allow calibration of the extensive surface geological and geophysical surveys which could then be applied to other, less well-studied areas of the world. The drilling program would thus test a fundamental hypothesis and provide a standard data base for investigating other similar regions throughout the world.

PROGRAM FOR SCIENTIFIC DRILLING IN THE CASCADES

In recognition of the need for deep scientific drilling in the Cascades, a group of scientists who are actively pursuing research in the province have met several times to plan a proposal. A formative meeting was held at the American Geophysical Union (AGU) conference in San Francisco last December, and a proposal is now in preparation for submission in early 1985. The essential thrust of the proposed project will be a coordinated program of drilling and surface geological and geophysical surveys aimed at a series of east-west transects across the full width of the Cascade Range. The drilling will occur primarily in the young volcanic terrane of the High Cascades and will be completed in two phases. The bulk of the drilling during the first phase will be aimed at reaching depths of between 1.2 and 2.7 km in two transects of four wells each across two contrasting parts of the arc. Some surface surveys and shallower drilling projects are also contemplated during the first phase to characterize two lower-priority east-west transects. The four transects are targeted on the southern Washington Cascades, two localities in the central Oregon Cascade Range, and the northern California Cascades. The first phase would



Heat-flow map of the Cascade Range and adjoining areas (1 Mcal/cm² sec = 41.84 mWm⁻²). From Blackwell and Steele (1983, p. 234).

allow direct testing and modeling of the hydrothermal systems, measurement of the amplitude of the heat-flow anomaly in the High Cascades, and direct sampling of basement rocks to determine the structure, state of stress, and other physical properties. The first phase will also include geologic mapping and a full range of geophysical surveys across both the High Cascades and the Western Cascades to investigate the overall geologic framework of the arc, including the configuration of the subducting oceanic plate and the development of the arc through time. The second phase would be aimed at directly penetrating the source of the regional heat-flow anomaly at depths of 7 to 10 km. The second phase would be an extraordinary scientific and engineering accomplishment and would necessarily be preceded by a lengthy period of research and development. Whereas the proposal currently being prepared deals conceptually with the second phase, work only on the first phase will be addressed in the initial proposal.

The extensive knowledge gained from the proposed research in the Cascade Range will, when combined with similar data from the proposed Trans-Alaska Lithosphere Investigation (TALI), give an accurate representation of the configuration of the major subducting plates and associated volcanism along the western margin of North America. TALI was recently organized by the U.S. Geological Survey (USGS) and other groups to plan for drilling and areal studies along a north-south transect 1,400 km long across the full width of Alaska.

This article is partly intended as an announcement to tell various funding agencies and potential colleagues of the existence of the organizing group for Cascade scientific drilling. We invite participation from other scientists at this time or in the future as the activities become more specific. A proposal submission is planned for January or February 1985. Anyone interested in participating in this project can obtain information from George R. Priest, Oregon Department of Geology and Mineral Industries (1005 State Office Building, Portland, OR 97201, 503/229-5580). The following persons are coordinating other aspects of the project: (1) Hydrology—Edward A. Sammel, USGS, 345 Middlefield Road, MS 39, Menlo Park, CA 94025. (2) Water chemistry—Robert H. Mariner, USGS, 345 Middlefield Road, MS 27, Menlo Park, CA 94025. (3) Hydrothermal alteration: Geologic studies in the northern California Cascades—Terry E.C. Keith, USGS, MS 910, Branch of Igneous and Geothermal Processes, 345 Middlefield Road, Menlo Park, CA 94025. (4) All work in the southern Washington Cascades—Craig Weaver, USGS Geophysics Program AK-50, University of Washington, Seattle, WA 98195. (5) Heat flow—David D. Blackwell, Geothermal Laboratory, 253 Heroy Building, Southern Methodist University, Dallas, TX 75275. (6) Seismic surveys—Walter Mooney, USGS, MS 77, 345 Middlefield Road, Menlo Park, CA 94025. (7) Gravity and aeromagnetic surveys—Richard Couch, Department of Geophysics, College of Oceanography, Oregon State University, Corvallis, OR 97331. (8) Electrical surveys—Harve Waff, Department of Geology, University of Oregon, Eugene, OR 97403. (9) Electrical surveys—Norman Goldstein, Lawrence Berkeley Laboratory, University of California, Building 50, Room 1140, Berkeley, CA 94720. (10) Well logging—Richard Traeger, Sandia National Laboratory, Division 6241, Albuquerque, NM 87815. (11) Teleseismic residual studies and general seismology—H.M. Iyer and Doug Stauber, USGS, MS 977, 345 Middlefield Road, Menlo Park, CA 94025.

REFERENCES

Blackwell, D.D., Bowen, R.G., Hull, D.A., Riccio, J.F., and Steele, J.L., 1982, Heat flow, arc volcanism, and subduction in northern Oregon: Journal of Geophysical Research, v. 87, no. B10, p. 8735-8754.

Blackwell, D.D., Hull, D.A., Bowen, R.G., and Steele, J.L., 1978, Heat flow of Oregon: Oregon Department of Geology and Mineral Industries Special Paper 4, 42 p.

Blackwell, D.D., and Steele, J.L., 1983, A summary of heat-flow studies in the Cascade Range: Geothermal Resources Council Transactions, v. 7, p. 233-236. □

Book review: Geology, 1884 style

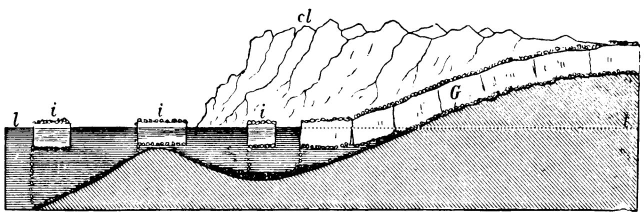
by Ralph S. Mason, former State Geologist

A Compend of Geology, by Joseph Le Conte, Appleton's Science Text Books, American Book Company, New York, 1884, 399 p. $1.20.

The above line of type contains no typographical errors. The 1884 date is correct, and the price was certainly right for the time the book was published. The book, of course, is no longer available, unless you are lucky enough to find one in a used-book store as I did. This work by Le Conte appeared exactly 100 years ago, just two years after the death of Charles Darwin and 11 years after the passing of Louis Agassiz. In it, Le Conte tries to make geology interesting to the pupil by "...directing his attention to the various geological phenomena and geological agencies at work now and on every side, and in the most familiar things." *A Compend of Geology* strives mightily to accomplish these goals and, given the strictures of the times, succeeds quite admirably.

Joseph Le Conte was born in Georgia of Huguenot descendants. After his graduation from Franklin College, he received a degree in medicine from the New York College of Physicians and Surgeons in 1845. Four years later, however, he entered Harvard, where he began studying natural history under Louis Agassiz and became interested in geology. After teaching at various universities, Le Conte was appointed professor of geology and natural history at the University of California in 1851, remaining there until his death in 1901. Le Conte's *Elements of Geology*, first published in 1878, went through five editions and was generally regarded as the standard geologic text during its long life. His *Compend* is derived almost entirely from this earlier and far more detailed work and is directed to students that are not geology majors. The term "compend" comes from the Latin for "a saving" or "a short way," a brief summary in comparison to the voluminous *Elements*.

Illustrations for *Compend* are all copper plate and consist for the most part either of scenic views at ground level or of hypothetical cross-sections. One charming picture shows a large glacier entering the sea and "calving" perfectly rectangular blocks of ice, each capped with a layer of even-size "bowlders." Any views approximating present-day low-angle oblique aerial photographs are labeled "perspective." Many hours must have been spent creating the illustrations, and various geologic features are presented in such a manner that the reader will have little difficulty in identifying what is being highlighted. In these figures, most extraneous material has been deleted, and, as further insurance against misunderstanding, the point of interest is also given an identifying symbol. All of this effort to clarify the point is in contrast to some of the muddy black-and-white photographs blown up from 35-mm slides that are used in some current textbooks to explain geologic phenomena. On the other hand, it is doubtful that many students of a century ago would have been able to identify a geologic feature in the field after viewing the often highly stylized rendition of it appearing in Le Conte's text.



Ideal section of a fiord and glacier, forming icebergs. l,l,sea level; G, glacier; i,i,i, icebergs; cl, cliffs. (From Le Conte, 1884, p. 56)

The Nineteenth Century: A time of discovery

"It was the best of times,
It was the worst of times,
It was the age of wisdom,..."

These lines from Charles Dickens' *A Tale of Two Cities*, written in 1859, seem prophetic indeed, coinciding as they do with Charles Darwin's publication of his monumental *Origin of Species* near the half-way point of a century of profound advances in scientific thought. Modern geologic theory developed largely from work done in two cultural centers during this period—Paris and London—also the two cities referred to in Dickens' work.

The Chronology shown below includes only a few of the dozens of significant events related to geology that occured during the nineteenth century.

CHRONOLOGY

1795	Hutton	Published theory of the Earth
1807	———	Geological Society of London formed
1815	Lamarck	Established invertebrate phylum
1815	William Smith	Geologic map of England completed
1821	Cuvier	Founder of vertebrate paleontology
1830	Lyell	Published *Principles of Geology*
1840	Agassiz	Published studies on glaciers
1841	Forbes	Invented first practical seismometer
1855	Maury	Founded science of oceanography
1859	Darwin	Published *Origin of Species*
1869	Powell	Published report on trip down Colorado
1877	Dana	Published first edition of *Textbook of Mineralogy*
1878	Le Conte	Published *Elements of Geology*
1879	———	U.S. Geological Survey founded
1884	Le Conte	Published *A Compend of Geology*
1888	———	Geological Society of America founded
1894	Brunton	Patented Brunton pocket transit
1898	Curie	Discovered radium

Oregon is mentioned in the book: Le Conte talks, for example, of the Tertiary coal found in Coos Bay. In another section, he ends his discussion of basalt columns found at various places around the world with this statement: "But the finest (basalt columns) in this country are the basaltic cliffs of the Columbia and Des Chutes Rivers in Oregon." He is, of course, describing columns developed in flows of the Columbia River Basalt Group.

The first chapter of *Compend* is devoted to the "Atmospheric Agencies," geologic processes often relegated to the latter pages of modern texts on physical geology. Le Conte apparently gauged his readers correctly, realizing that many of them had close ties to the soil through agrarian pursuits and rural living. Weathering and formation of soil are discussed in detail, with one cross-section, for example, bearing labels of (a) "sound rock" and (b) "rotten rock." Subsequent chapters, all under the general heading of "Dynamical Geology," include aqueous, organic, and igneous agencies. As luck would have it, Le Conte missed including one of the biggest volcanic eruptions of modern times when Krakatau erupted in August 1883. His manuscript was completed in September 1882 and was undoubtedly being set by hand at the time (Ottmar Mergenthaler's Linotype was not patented until 1885).

Le Conte entitles his last chapter "Psychozoic Era—Age of

Man." He starts with the following statement: "In all previous ages there ruled brute force and ferocity. In this (age) alone appears Reason as ruler. The order of Nature must be adjusted to this keynote. Therefore, the great ruling mammals of the previous age must become extinct, and the mammalian class become subordinate; noxious animals and plants must diminish, and useful ones be preserved." Obviously some of those undesirable elements never got around to reading Le Conte.

In light of the great effort currently being expended in the determination of the origins of man, it is interesting to note that Le Conte gives little space to this subject and in the closing paragraphs of his book has this to say: "The amount of time that has elapsed since man first appeared is still doubtful. The question should not be regarded as of any importance, except as a question of science." It should be noted that the first fossil remains of man were yet to be discovered when Le Conte wrote those words.

Le Conte published both *Elements* and *Compend* during a period of rapid flowering of geological interest by such early-day giants as Hutton, Lemarck, Cuvier, William Smith, Agassiz, and the Danas. The main branches of the science were already established, and considerable knowledge had been assembled on the fossil record (nearly 40 percent of *Compend* is given over to historical geology). Le Conte was able to assemble geologic information contained in relatively inaccessible technical papers and to translate it into a language readily understandable by the nonprofessional. A modern version of Le Conte's type of book, *Principles of Physical Geology*, by Arthur Holmes, was published in 1944. Holmes, however, tends to cite a preponderance of British examples in his 1,250-page text, while Le Conte resolutely uses as many American examples of geology as possible. Perhaps Le Conte's greatest contribution was to alert the American public to its great geological heritage.

In summary, *Compend* provides not only a revealing view of the state of the art of physical and historical geology a century ago but also an eloquent plea for all who would study geology to simply look about them and to observe – most carefully. □

EEZ contains large amounts of valuable mineral and energy resources

The Exclusive Economic Zone (EEZ) off U.S. and territorial coasts contains extensive deposits of valuable mineral and energy resources, such as cobalt, manganese, titanium, phosphorus, copper, zinc, gold, silver, oil,and gas, scientists for the U.S. Geological Survey (USGS), said in Washington, D.C.

The Pacific EEZ contains a variety of hard mineral resources, with sand and gravel and associated placer deposits of heavy minerals being the most likely to be developed in the near future. Deposits of phosphorite and sulfides, ferromanganese crusts enriched in cobalt, and deep-ocean manganese nodules are likely to be developed later, according to David Howell, a USGS geologist in Menlo Park, California.

Howell and two other USGS scientists outlined potential mineral resources of the offshore zone in papers presented to a special EEZ symposium being held at the Oceans 84 conference and exposition in September in Washington, D.C. The EEZ proclaimed in March 1983 by President Reagan provides U.S. jurisdiction for living and non-living resources in the EEZ, which extends to 200 nautical miles (230 mi) off the coasts.

Howell, who spoke on mineral resources of the Pacific EEZ, reported that manganese nodules are most promising off Hawaii and Pacific Island territories and that the recent discovery of high cobalt concentrations in ferromanganese crusts on top of several mid-Pacific seamounts suggests that extensive resources of cobalt may lie within the central Pacific EEZ.

The West Coast continental shelf alone contains an estimated 2.7 billion cubic yards of heavy mineral sand of various composition and grade, but this is less than 1 percent of the heavy mineral resources of the Pacific EEZ. There are indications that heavy mineral deposits off Alaska may far exceed those of the other areas.

Sand and gravel production from onshore areas is a $3 billion a year industry, but deposits are becoming progressively more difficult to use because of land-use restrictions, especially near large metropolitan areas where demand by the construction industry is greatest. This means that offshore production will become more attractive. Furthermore, cost of transportation is a significant factor in sand and gravel prices, and barge transportation for offshore production would be cheaper than trucking used for onshore production of sand and gravel, especially for coastal cities. Los Angeles, San Francisco,and San Diego are already experiencing shortages of sand and gravel. Promising deposits are located off Imperial Beach, Calif., in close proximity to the Los Angeles and San Diego markets, and near Grays Harbor off central Washington, close to the Seattle and Portland markets. – *USGS news release*

USGS publishes data and results of Klamath Falls geothermal study

A study of the geothermal resource at Klamath Falls, Oregon, by the U.S. Geological Survey (USGS), the Oregon Institute of Technology, Lawrence Berkeley Laboratory, and Stanford University has shown that thermal water occurs in an extensive, heterogeneous aquifer beneath an area of nearly 2 mi^2 at depths of a few hundred to nearly 2,000 ft. Highest temperatures measured in wells are more than 130° C. Chemical and isotopic analyses suggest that the aquifer water is a mixture of water derived from rain and snow that has low concentrations of chloride and silica and thermal water from a deep source with a temperature of about 190° C and moderately high concentrations of chloride and silica. The thermal water enters the shallow aquifer through a fault zone on the northeast border of Klamath Falls. The water spreads southwestward in the aquifer, losing heat as it moves, to supply more than 450 wells that tap the aquifer for space heating in homes and businesses.

The results of the study have now been published in USGS Water-Resources Investigation Report 84-4216, *Analysis and Interpretation of Data Obtained in Tests of the Geothermal Aquifer at Klamath Falls, Oregon*, edited by E.A. Sammel. Data collected during the summer of 1983 specifically for the aquifer test have been published in graphical and tabular form in USGS Open-File Report 84-146, *Data from Pumping and Injection Tests and Chemical Sampling in the Geothermal Aquifer at Klamath Falls, Oregon*, by S.M. Benson and others. Both reports are on file at the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, 1400 SW Fifth Avenue, Portland, OR 97201. Copies may be purchased from the Open-File Services Section, U.S. Geological Survey, Western Branch of Distribution, P.O. Box 25425, Federal Center, Denver, CO 80225. Paper copy price for the Water-Resources Investigation Report is $22, for the Open-File Report $14.25. Microfiche copies of both reports are available for $3.50 each. All orders require prepayment.

– *USGS news releases*

Metals and Minerals Conference announced

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

In memoriam: Laurie L. Hoagland, 1897–1984

The Oregon Department of Geology and Mineral Industries mourns the death of Laurie L. Hoagland ("Hoagie"), former chemist and assayer of the Department, who passed away shortly before his 87th birthday.

Laurie L. Hoagland

Hoagland had served the Department faithfully and ably for 25 years, before he retired in 1967. He had joined the Department staff when he moved to Portland in 1943, after working for 10 years with the C&H Sugar Company in Crockett, California. He was a member of the American Chemical Society and the American Institute of Mining Engineers.

Surviving are his wife, Winnie, three sons, seven grandchildren, and three great-grandchildren. □

GSOC meetings announced

The Geological Society of the Oregon Country (GSOC) holds noon luncheon meetings in the Standard Plaza Building, 1100 SW Sixth Ave., Portland, Oregon, in Room A adjacent to the third floor cafeteria, and evening lectures (8 p.m.) at Portland State University, Room 371, Cramer Hall. Upcoming meetings, topics, and speakers are:

October 19 (luncheon)—*The 1984 President's Golden Anniversary Campout*. Slide review by Clair Stahl, Virgil Scott, Don Parks, William Kennedy, Dr. Ruth Keen, Phyllis Bonebrake, and Effie Hall. Exhibit of indigenous rocks in campout area of Lewiston, Idaho: Obersons, Bonebrakes, Parks, and others.

October 26 (lecture)—*A Geological and Scenic Look at New Zealand*, Dr. Robert S. Yeats, professor and chairman of geology at Oregon State University.

November 2 (luncheon)—*Trout Creek Mountains: A Proposed BLM Wilderness Area*, by Minda S. Craig, BLM wilderness coordinator for the Portland Audubon Society.

November 9 (lecture)—*Oil and Gas Potential in the Northwest*, by Dr. Tom Benson, professor of geology, Portland State University.

November 16 (luncheon)—*An Elderhostel at Hancock Field Station*, by Donald D. Barr, instructor and naturalist.

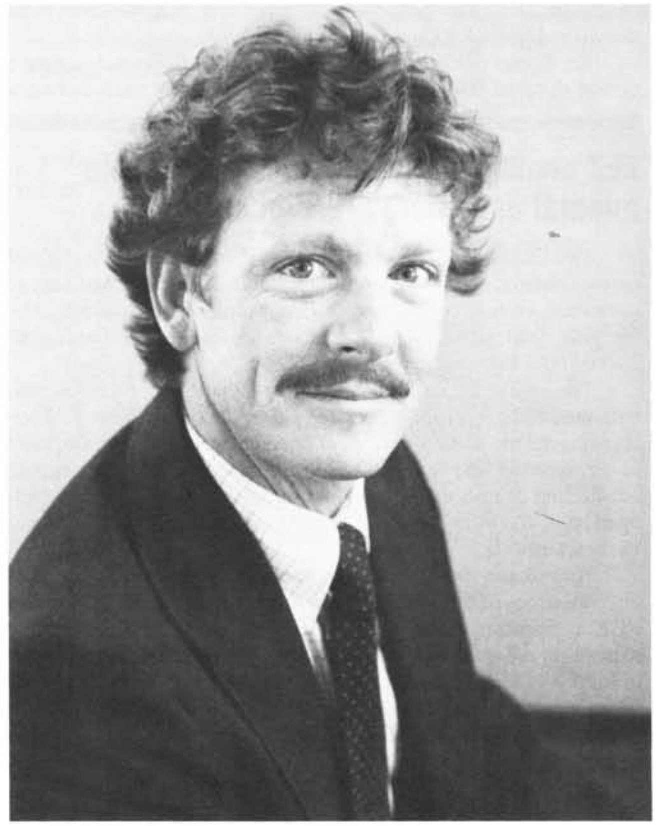
December 7 (luncheon)—*Basic Principles I've Found in Strange Places*, by Dr. John Eliot Allen, professor emeritus of geology, Portland State University.

December 14 (lecture)—*Natural History of Sandy River Gorge*, by Tom McAllister, sports outdoor writer for *The Oregonian*.

For additional information about the lectures or luncheons, contact Viola L. Oberson, GSOC president, phone (503) 282-3685.

McMurray becomes Marine Minerals Program Coordinator

Gregory McMurray joined the staff of the Oregon Department of Geology and Mineral Industries as Marine Minerals Program Coordinator on September 10, 1984. His duties include the coordination of activities of the Oregon members of the Gorda Ridge Working Group, the preparation and management of contracts with non-Department groups that are analyzing the economic and environmental impacts of offshore mineral resource exploration and development, the compilation of scientific information, the monitoring of current marine research, and other related tasks.



Gregory McMurray

A biological oceanographer, McMurray received his bachelor's degree in zoology from Ohio University, his master's degree in biology (limnology) from the University of Akron, and his doctor's degree in oceanography from Oregon State University. He was most recently on the staff of VTN Oregon, Inc., where he was a project manager and principal investigator for physical, chemical, and biological oceanographic studies of the Pacific coast estuaries and fjords. His data collection and analysis included hydrography, water chemistry, and the ecology of phytoplankton, zooplankton, ichthyoplankton, and micronekton. He spent a year with the U.S. Geological Survey, studying the phytoplankton ecology of San Francisco Bay and the lower Sacramento River. He has also served as a consultant for ARAMCO, conducting a study of periphyton community structure related to distance from outfalls near Ras Tanura Refinery in Saudi Arabia.

McMurray is author and coauthor of numerous papers and reports based on his biological studies in Alaska, California, Oregon, and Ohio. He has also been the recipient of a travel grant to New Zealand, where he attended and addressed the Fifteenth Pacific Science Congress in 1983. □

AVAILABLE DEPARTMENT PUBLICATIONS

GEOLOGICAL MAP SERIES

	Price	No. copies	Amount
GMS-4: Oregon gravity maps, onshore and offshore. 1967	$ 3.00	_____	_____
GMS-5: Geologic map, Powers 15-minute quadrangle, Coos and Curry Counties. 1971	3.00	_____	_____
GMS-6: Preliminary report on geology of part of Snake River canyon. 1974	6.50	_____	_____
GMS-8: Complete Bouguer gravity anomaly map, central Cascade Mountain Range, Oregon. 1978	3.00	_____	_____
GMS-9: Total-field aeromagnetic anomaly map, central Cascade Mountain Range, Oregon. 1978	3.00	_____	_____
GMS-10: Low- to intermediate-temperature thermal springs and wells in Oregon. 1978	3.00	_____	_____
GMS-12: Geologic map of the Oregon part of the Mineral 15-minute quadrangle, Baker County. 1978	3.00	_____	_____
GMS-13: Geologic map, Huntington and part of Olds Ferry 15-minute quadrangles, Baker and Malheur Counties. 1979	3.00	_____	_____
GMS-14: Index to published geologic mapping in Oregon, 1898-1979. 1981	7.00	_____	_____
GMS-15: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, north Cascades, Oregon. 1981	3.00	_____	_____
GMS-16: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, south Cascades, Oregon. 1981	3.00	_____	_____
GMS-17: Total-field aeromagnetic anomaly map, south Cascades, Oregon. 1981	3.00	_____	_____
GMS-18: Geology of Rickreall, Salem West, Monmouth, and Sidney 7½-minute quads., Marion/Polk Counties. 1981	5.00	_____	_____
GMS-19: Geology and gold deposits map, Bourne 7½-minute quadrangle, Baker County. 1982	5.00	_____	_____
GMS-20: Map showing geology and geothermal resources, southern half, Burns 15-minute quad., Harney County. 1982	5.00	_____	_____
GMS-21: Geology and geothermal resources map, Vale East 7½-minute quadrangle, Malheur County. 1982	5.00	_____	_____
GMS-22: Geology and mineral resources map, Mount Ireland 7½-minute quadrangle, Baker/Grant Counties. 1982	5.00	_____	_____
GMS-23: Geologic map, Sheridan 7½-minute quadrangle, Polk/Yamhill Counties. 1982	5.00	_____	_____
GMS-24: Geologic map, Grand Ronde 7½-minute quadrangle, Polk/Yamhill Counties. 1982	5.00	_____	_____
GMS-25: Geology and gold deposits map, Granite 7½-minute quadrangle, Grant County. 1982	5.00	_____	_____
GMS-26: Residual gravity maps, northern, central, and southern Oregon Cascades. 1982	5.00	_____	_____
GMS-27: Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1°×2° quadrangle. 1982	6.00	_____	_____
GMS-28: Geology and gold deposits map, Greenhorn 7½-minute quadrangle, Baker/Grant Counties. 1983	5.00	_____	_____
GMS-29: Geology and gold deposits map, NE¼ Bates 15-minute quadrangle, Baker/Grant Counties. 1983	5.00	_____	_____
GMS-31: Geology and gold deposits map, NW¼ Bates 15-minute quadrangle, Grant County. 1984	5.00	_____	_____
GMS-32: Geologic map, Wilhoit 7½-minute quadrangle, Clackamas/Marion Counties. 1984	4.00	_____	_____
NEW! GMS-33: Geologic map, Scotts Mills 7½-minute quadrangle, Clackamas/Marion Counties. 1984	4.00	_____	_____

OTHER MAPS

	Price	No. copies	Amount
Reconnaissance geologic map, Lebanon 15-minute quadrangle, Linn/Marion Counties. 1956	3.00	_____	_____
Geologic map, Bend 30-minute quad., and reconnaissance geologic map, central Oregon High Cascades. 1957	3.00	_____	_____
Geologic map of Oregon west of 121st meridian (U.S. Geological Survey Map I-325). 1961	5.50	_____	_____
Geologic map of Oregon east of 121st meridian (U.S. Geological Survey Map I-902). 1977	5.50	_____	_____
Landforms of Oregon (relief map, 17×12 in.)	1.00	_____	_____
Oregon Landsat mosaic map (published by ERSAL, OSU). 1983	$8.00 over the counter; $11.00 mailed	_____	_____
Geothermal resources of Oregon (map published by NOAA). 1982	3.00	_____	_____
Geological highway map, Pacific Northwest region, Oregon/Washington/part of Idaho (published by AAPG). 1973	5.00	_____	_____

BULLETINS

	Price	No. copies	Amount
33. Bibliography of geology and mineral resources of Oregon (1st supplement, 1937-45). 1947	3.00	_____	_____
35. Geology of the Dallas and Valsetz 15-minute quadrangles, Polk County (map only). Revised 1964	3.00	_____	_____
36. Papers on foraminifera from the Tertiary (v.2 [parts VI-VIII] only). 1949	3.00	_____	_____
44. Bibliography of geology and mineral resources of Oregon (2nd supplement, 1946-50). 1953	3.00	_____	_____
46. Ferruginous bauxite deposits, Salem Hills, Marion County. 1956	3.00	_____	_____
49. Lode mines, Granite mining district, Grant County. 1959	3.00	_____	_____
53. Bibliography of geology and mineral resources of Oregon (3rd supplement, 1951-55). 1962	3.00	_____	_____
61. Gold and silver in Oregon. 1968	17.50	_____	_____
62. Andesite Conference guidebook. 1968	3.50	_____	_____
65. Proceedings of the Andesite Conference. 1969	10.00	_____	_____
67. Bibliography of geology and mineral resources of Oregon (4th supplement, 1956-60). 1970	3.00	_____	_____
71. Geology of selected lava tubes, Bend area, Deschutes County. 1971	5.00	_____	_____
77. Geologic field trips in northern Oregon and southern Washington. 1973	5.00	_____	_____
78. Bibliography of geology and mineral resources of Oregon (5th supplement, 1961-70). 1973	3.00	_____	_____
81. Environmental geology of Lincoln County. 1973	9.00	_____	_____
82. Geologic hazards of Bull Run Watershed, Multnomah and Clackamas Counties. 1974	6.50	_____	_____
83. Eocene stratigraphy of southwestern Oregon. 1974	4.00	_____	_____
84. Environmental geology of western Linn County. 1974	9.00	_____	_____
85. Environmental geology of coastal Lane County. 1974	9.00	_____	_____
87. Environmental geology of western Coos and Douglas Counties. 1975	9.00	_____	_____
88. Geology and mineral resources, upper Chetco River drainage, Curry and Josephine Counties. 1975	4.00	_____	_____
89. Geology and mineral resources of Deschutes County. 1976	6.50	_____	_____
90. Land use geology of western Curry County. 1976	9.00	_____	_____
91. Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties. 1977	8.00	_____	_____
92. Fossils in Oregon. A collection of reprints from the *Ore Bin*. 1977	4.00	_____	_____
93. Geology, mineral resources, and rock material of Curry County. 1977	7.00	_____	_____
94. Land use geology of central Jackson County. 1977	9.00	_____	_____
95. North American ophiolites (IGCP project). 1977	7.00	_____	_____
96. Magma genesis. AGU Chapman Conference on Partial Melting. 1977	12.50	_____	_____
97. Bibliography of geology and mineral resources of Oregon (6th supplement, 1971-75). 1978	3.00	_____	_____
98. Geologic hazards of eastern Benton County. 1979	9.00	_____	_____
99. Geologic hazards of northwestern Clackamas County. 1979	10.00	_____	_____
100. Geology and mineral resources of Josephine County. 1979	9.00	_____	_____
101. Geologic field trips in western Oregon and southwestern Washington. 1980	9.00	_____	_____
102. Bibliography of geology and mineral resources of Oregon (7th supplement, 1976-79). 1981	4.00	_____	_____

SHORT PAPERS

	Price	No. copies	Amount
21. Lightweight aggregate industry in Oregon. 1951	1.00	_____	_____
24. The Almeda Mine, Josephine County. 1967	3.00	_____	_____
25. Petrography of Rattlesnake Formation at type area, central Oregon. 1976	3.00	_____	_____
27. Rock material resources of Benton County. 1978	4.00	_____	_____

AVAILABLE DEPARTMENT PUBLICATIONS (continued)

MISCELLANEOUS PAPERS	Price	No. copies	Amount
1. A description of some Oregon rocks and minerals. 1950	$ 1.00	_____	_____
5. Oregon's gold placers. 1954	1.00	_____	_____
8. Available well records of oil and gas exploration in Oregon. Revised 1982	4.00	_____	_____
11. Collection of articles on meteorites (reprints from *Ore Bin*). 1968	3.00	_____	_____
15. Quicksilver deposits in Oregon. 1971	3.00	_____	_____
17. Geologic hazards inventory, Oregon coastal zone. 1974	5.00	_____	_____
18. Proceedings of Citizens' Forum on Potential Future Sources of Energy. 1975	3.00	_____	_____
19. Geothermal exploration studies in Oregon, 1976. 1977	3.00	_____	_____
20. Investigations of nickel in Oregon. 1978	5.00	_____	_____
SPECIAL PAPERS			
1. Mission, goals, and programs of the Oregon Department of Geology and Mineral Industries. 1978	3.00	_____	_____
2. Field geology, SW Broken Top quadrangle. 1978	3.50	_____	_____
3. Rock material resources, Clackamas, Columbia, Multnomah, and Washington Counties. 1978	7.00	_____	_____
4. Heat flow of Oregon. 1978	3.00	_____	_____
5. Analysis and forecasts of the demand for rock materials in Oregon. 1979	3.00	_____	_____
6. Geology of the La Grande area. 1980	5.00	_____	_____
7. Pluvial Fort Rock Lake, Lake County. 1979	4.00	_____	_____
8. Geology and geochemistry of the Mount Hood volcano. 1980	3.00	_____	_____
9. Geology of the Breitenbush Hot Springs quadrangle. 1980	4.00	_____	_____
10. Tectonic rotation of the Oregon Western Cascades. 1980	3.00	_____	_____
11. Theses and dissertations on geology of Oregon: Bibiliography and index, 1899-1982. 1982	6.00	_____	_____
12. Geologic linears of the northern part of the Cascade Range, Oregon. 1980	3.00	_____	_____
13. Faults and lineaments of the southern Cascades, Oregon. 1981	4.00	_____	_____
14. Geology and geothermal resources of the Mount Hood area. 1982	7.00	_____	_____
15. Geology and geothermal resources of the central Oregon Cascade Range. 1983	11.00	_____	_____
16. Index to the *Ore Bin* (1939-1978) and *Oregon Geology* (1979-1982). 1983	4.00	_____	_____
17. Bibliography of Oregon paleontology, 1792-1983. 1984	6.00	_____	_____
OIL AND GAS INVESTIGATIONS			
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well. 1973	3.00	_____	_____
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well. 1973	3.00	_____	_____
5. Prospects for natural gas, upper Nehalem River basin. 1976	5.00	_____	_____
6. Prospects for oil and gas, Coos Basin. 1980	9.00	_____	_____
7. Correlation of Cenozoic stratigraphic units of western Oregon and Washington. 1983	8.00	_____	_____
NEW! 8. Subsurface stratigraphy of the Ochoco Basin, Oregon. 1984	7.00	_____	_____ ←
9. Subsurface biostratigraphy, east Nehalem Basin. 1983	6.00	_____	_____
11. Biostratigraphy of exploratory wells, western Coos, Douglas, and Lane Counties. 1984	6.00	_____	_____
MISCELLANEOUS PUBLICATIONS			
Mining claims (State laws governing quartz and placer claims)	1.00	_____	_____
Back issues of *Ore Bin*	50¢ over the counter; $1.00 mailed	_____	_____
Back issues of *Oregon Geology*	75¢ over the counter; $1.00 mailed	_____	_____
Colored postcard: Geology of Oregon	0.10	_____	_____

Separate price lists for open-file reports, geothermal energy studies, tour guides, recreational gold mining information, and non-Departmental maps and reports will be mailed upon request.

OREGON GEOLOGY

1005 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

PUBLICATIONS ORDER

Fill in appropriate blanks and send sheet to Department.
Minimum mail order $1.00. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $50.00. Foreign orders: Please remit in U.S. dollars.

NAME ______________________________

ADDRESS ______________________________

______________________________ ZIP __________

Amount enclosed $ ______________________________

OREGON GEOLOGY

____ Renewal _____ New Subscription _____ Gift

_____ 1 Year ($6.00) _____ 3 Years ($15.00)

NAME ______________________________

ADDRESS ______________________________

______________________________ ZIP __________

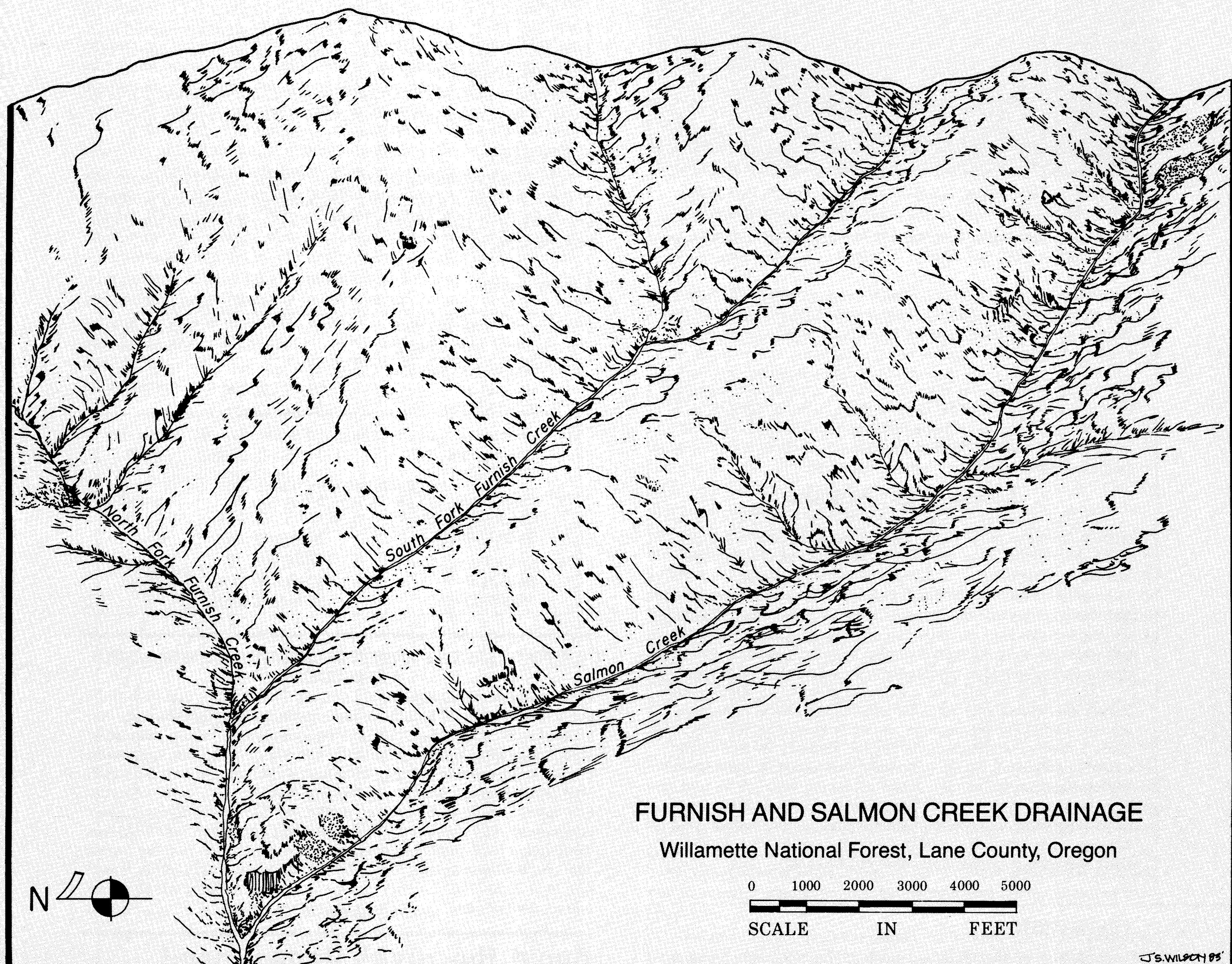
If gift: From ______________________________

OREGON GEOLOGY

published by the

Oregon Department of Geology and Mineral Industries

VOLUME 46, NUMBER 11 **NOVEMBER 1984**



THIS MONTH:

PLEISTOCENE INTERGLACIAL VOLCANISM IN THE CENTRAL OREGON HIGH CASCADES

OREGON GEOLOGY

(ISSN 0164-3304)

VOLUME 46, NUMBER 11 NOVEMBER 1984

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

Main Office: 1005 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133. Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496. Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039. Paul F. Lawson, Supervisor

Second class postage paid at Portland, Oregon. Subscription rates: 1 year, $6.00; 3 years, $15.00. Single issues, $.75 at counter, $1.00 mailed. Available back issues of *Ore Bin*: $.50 at counter, $1.00 mailed. Address subscription orders, renewals, and changes of address to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201. Permission is granted to reprint information contained herein. Credit given to the Oregon Department of Geology and Mineral Industries for compiling this information will be appreciated. POSTMASTER: Send address changes to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

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

Sketch of the drainage area of Furnish and Salmon Creeks near Oakridge, Lane County, Oregon. In the ridge between Salmon Creek and South Fork Furnish Creek, informally known as Quick Ridge, lava flows have been found interlayered with glacial deposits. See article beginning on next page. (Diagram by Jeff S. Wilson, ASLA)

OIL AND GAS NEWS

Columbia County—Mist Gas Field

The redrill of Reichhold Energy Corporation's Adams 32-34 in NE¼ sec. 34, T. 7 N., R. 5 W., was dry and was abandoned September 14, 1984, at total depth of 3,109 ft.

Concurrently with the activity at the Adams well, Reichhold was also redrilling Paul 34-32, in SE¼ sec. 32, T. 7 N., R. 5 W., a former producer that developed water problems. Two redrills, to 2,915 and 2,719 ft, were unsuccessful. The well was plugged and abandoned September 26, 1984.

Douglas County

Amoco Production Company's Weyerhaeuser 1-13, located in SW¼ sec. 13, T. 25 S., R. 9 W., is drilling ahead to a projected total depth of 13,500 ft. Amoco has recently changed the name of this well to 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 & Drilling's Maurice Brooks 1 in sec. 34, T. 19 S., R. 3 W., a 3,000-ft test, encountered mechanical problems after drilling to a total depth of 952 ft. Operator is preparing to plug and abandon.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
273	Oregon Nat. Gas Dev. Corp. Buck 44-16 36-047-00016	SE¼ sec. 16 T. 5 S., R. 2 W. Marion County	Location; 3,500.
274	Oregon Nat. Gas Dev. Corp. Cunningham 32-21 36-047-00017	NE¼ sec. 21 T. 5 S., R. 2 W. Marion County	Location; 3,500.
275	Oregon Nat. Gas Dev. Corp. Catchpole 13-22 36-047-00018	SW¼ sec. 22 T. 5 S., R. 2 W. Marion County	Location; 3,500.
276	Steele Energy Corp. Keys #1 36-069-00008	NW¼ sec. 28 T. 9 S., R. 23 E. Wheeler County	Location; 8,000.

□

U.S. POSTAL SERVICE STATEMENT OF OWNERSHIP, MANAGEMENT, AND CIRCULATION

Publication title: OREGON GEOLOGY, no. 600040; filing date 10-1-1984. Published monthly, 12 issues per year, annual subscription price $6. Address of publication office, publisher's business office, editor, and owner: 1005 State Office Building, Portland, OR 97201. Publisher and owner: Oregon Department of Geology and Mineral Industries; editor: Beverly F. Vogt. No managing editor or bondholders. Purpose, etc., of the organization has not changed. Circulation during last 12 months/of single issue, respectively: Net press run 3250/3250; paid circulation 260/220; mail subscription 1604/1689; total paid circulation 1864/1909; free distribution 164/190; total distribution 2028/2099; not distributed 1222/1151; returns 0/0; total 3250/3250. I certify that the statements made by me above are correct and complete. Klaus K. Neuendorf, Editor.

Avoid the rush! Renew now!

Please note that the cover page of this issue bears a REMINDER TO RENEW, if your subscription expires in December. Most subscriptions expire in that month, so make sure yours is not lost in the shuffle and RENEW NOW! And—while you're at it—why not consider *Oregon Geology* as a Christmas gift subscription? □

Pleistocene interglacial volcanism: Upper Salmon Creek drainage, Lane County, Oregon

by Michael T. Long and Mark A. Leverton, U.S. Forest Service, Willamette National Forest, South Engineering Zone, 49098 Salmon Creek Road, Oakridge, Oregon 97463

INTRODUCTION

The lava flows and glacial deposits described in this paper are located in the upper Salmon Creek drainage, approximately 12 mi east of Oakridge, Lane County, Oregon, in secs. 35 and 36, T. 20 S., R. 5 E.; and secs. 1 and 2, T. 21 S., R. 5 E. (Figure 1). The area lies above an elevation of 2,500 ft within the High Cascade province, which was formed by the Quaternary eruptions of the High Cascade volcanoes (Williams, 1957). Remnants of alpine glacial activity, in the form of till deposits in road cuts, ground and end moraines, outwash sediments, proglacial lake deposits, and several cirques in the upper valleys of the adjoining Black and Ranger Creeks (Figure 2), are prominent in the area.

In this study, the authors have attempted to bracket the age of two early glacial advances in the study area by means of radiometric dating, paleomagnetic measurements, and petrographic analyses of samples taken from three interglacial lava flows which lie above and beneath till deposits of these advances. A third glacial advance, the most recent to occur, was also identified, and the date of this advance was inferred by (1) stratigraphic position, (2) correlation with periods of high ice accumulation as determined by Birchfield and others (1981) from the oxygen-isotope record obtained from equatorial Pacific drill core, and (3) correlation with the Cascade glacial advances identified by other workers. The study is site specific in nature, and it is the intent of the authors to expand the area of study in a future project.

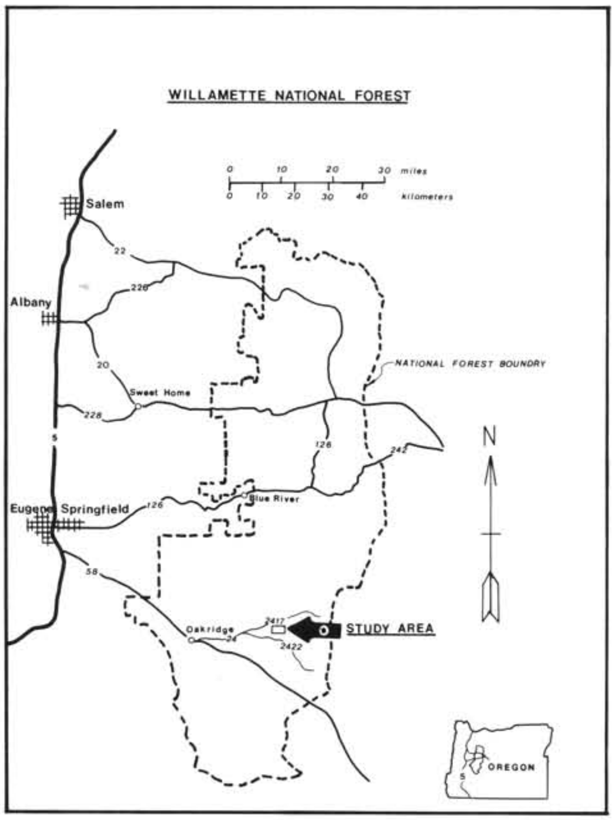


Figure 1. Map showing location of study area.

Figure 2. Upper Salmon Creek basin, showing glacially contoured topography and collapsed slopes due to removal of lateral support after ice recession.

PREVIOUS WORK

During the Quaternary, the topography of the Cascade Range in Oregon and Washington was altered by igneous activity and glacial processes. At least three Pleistocene periods of major alpine glacial advance have been identified by previous workers. Thayer (1939) described three Pleistocene glacial periods which occurred in the North Santiam River Basin of western Oregon. He named these periods the Mill City, Detroit, and Tunnel Creek (late Wisconsin) glaciations. The Mill City advance, which was the most extensive, left till ranging in thickness from 175 to 200 ft. Thayer described such glacial features as outwash gravels, varved lake silts, terminal moraines, and glacial erratics. He estimated ice thickness in the High Cascades to have been between 500 and 1,000 ft. Page (1939) also recognized three main glacial advances, the Peshastin, Leavenworth, and Stuart glaciations, in his study of the Wenatchee Valley area of eastern Washington. Such alpine glacial features as cirques, striated rock surfaces, lakes which were not filled with sediments, swamps, meadows, and abandoned stream valleys filled with glacial deposits were noted in his study area. He estimated ice thickness in the area to have been greater than 1,000 ft.

Mackin (1941) showed that the alpine glaciers of western Washington did not contribute to the Puget Lowland glacier that was part of the continental ice sheet. He recognized and described bedded clay and silt deposits in the Snoqualmie Valley, interpreting them as varves. These varves were interfingered with and overlapped by till and outwash gravels, which Mackin interpreted as evidence of several oscillations of the ice front. He also concluded that the earlier glacial stages were larger and more extensive than later ones.

From differences in the degree of weathering of till deposits, Crandell (1965) inferred the existence of three periods of glaciation in the Olympic Mountains during the Pleistocene. He also postulated that an extensive Pleistocene ice sheet had covered the High Cascades of Oregon from Olallie Butte in the north to Mount McLoughlin in the south.

During the last 20 years, more advanced and readily available dating and stratigraphic techniques—such as potassium-argon

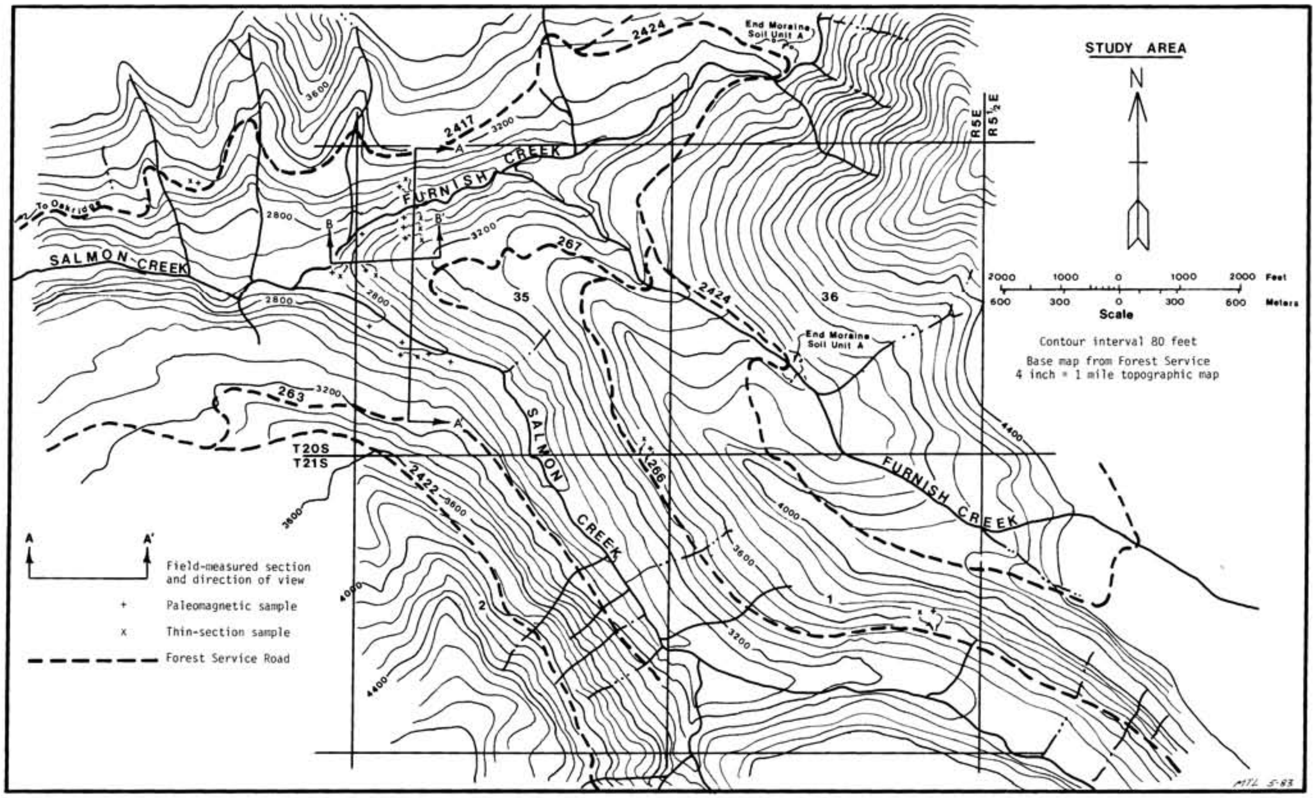


Figure 3. Map of study area showing locations of features discussed in text. Cross sections appear in Figure 4.

(K-Ar) dating, paleomagnetism, atomic-absorption spectrophotometry, and the oxygen-isotope record used to infer periods of high ice accumulation – have made it possible for workers to assign tentative ages to the various Cascade alpine glacial stages. Porter (1975) developed a method by which the weathering rind on the rock fragments within a till deposit could be measured and statistically correlated with other local deposits. He used this method, as well as several other techniques, to describe and correlate three glacial advances (Thorp, Kittitas, Lakedale) in the Yakima Valley of southern Washington (Porter, 1976). Porter found the Thorp Drift to be older than 700,000 years, based on paleomagnetic evidence. He assigned the Kittitas Drift a tentative age of greater than 120,000 years, based on the global marine record of glacial and interglacial stages and correlated it with the Salmon Springs Drift of the Puget Lowland of western Washington. The Salmon Springs Drift was first described by Crandell and others (1958) and had been used by other workers to correlate glacial events that occurred before the last advance of the continental ice sheet. Although the Salmon Springs Drift had been considered to be early Wisconsin (Easterbrook and others, 1967; Easterbrook, 1969; Birkeland and others, 1971; Porter, 1971), Porter (1976) noted that, based upon current evidence, a pre-Wisconsin date could not be ruled out. Easterbrook and others (1981) have recently dated the tephra beds within the Salmon Springs Drift by fission-track methods at 840,000$\pm$210,000 years before the present (B.P.). They also noted that the overlying silt beds are reversely magnetized, indicating that the Salmon Springs glacial advance occurred more than 730,000 years ago. The Lakedale Drift of Porter's (1976) study in the Yakima Valley is believed to be between 13,500 and 15,000 years old, based on radiocarbon dating of wood found within glacial gravel, and can be correlated to the Vashon Drift of the Puget Lowland.

Scott (1977) reported evidence of three major glacial advances in the Metolius River area on the eastern side of the High Cascades in Oregon. He observed igneous extrusions and pyroclastic depositions that occurred during two Pleistocene interglacial periods. Scott's methods of dating included statistical analysis of weathering rinds, soil development on moraine crests, and atomic-absorption spectrophotometry of the free iron oxide within the soil profile on till layers. Based on the oxygen-isotope record of the equatorial Pacific, he assigned tentative ages of less than 30,000 years to the Cabot Creek glaciation, 40,000 to 200,000 years to the Jack Creek glaciation, and 200,000 to 900,000 years to the Abbott Butte glaciation. He stated that it was "unlikely, although remotely possible that Abbott Butte glaciation is as young as 120,000 to 200,000 years... but it could have occurred at any time during the high ice periods from 120,000 to 1 million years" (Scott, 1977).

EXPLORATION

A ridge at the confluence of Salmon and Furnish Creeks, informally known as Quick Ridge (Figure 3), was initially investigated by the Geotechnical Group of the Willamette National Forest Supervisor's Office for potential use as a rock quarry for road construction material. The exploration, which was conducted May 28, 1981, to June 18, 1981, consisted of a site survey, area mapping, and diamond core drilling (Long, 1981). Additional field work was done in 1982.

Site survey

The site was surveyed with a Brunton compass, clinometer, and cloth tape. A baseline and two field-measured cross sections (Figure 4) were completed, and a topographic map of the area was constructed from the data at a scale of 1 in. =50 ft. Vertical control was established by setting a temporary bench mark on a 5-ft stump on the south side of Forest Service Road 2424267 near the west edge of an existing clear cut. The temporary bench mark elevation (3,120 ft) was taken from the nearest 80-ft contour line of a Forest Service topographic base map (scale: 4 in. =1 mi).

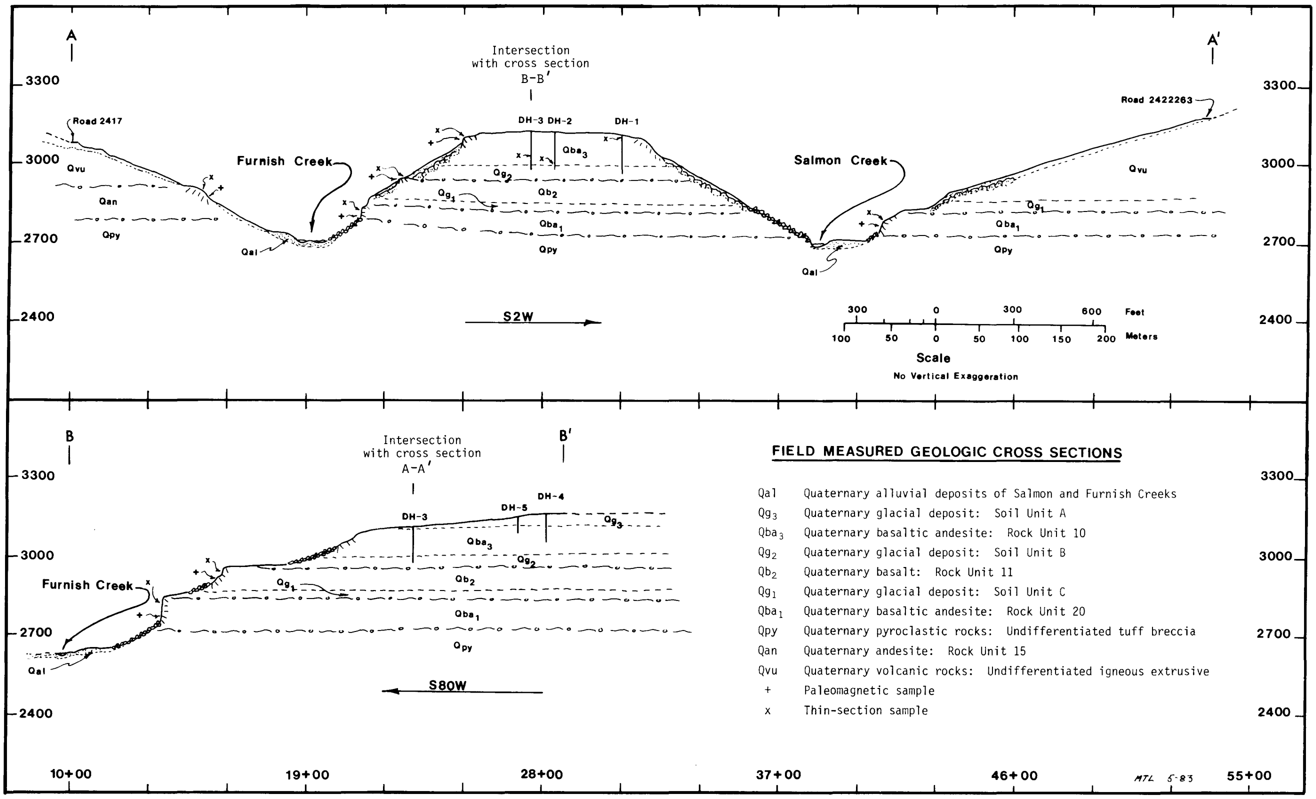


Figure 4. Field-measured cross sections. Locations of lines A-A' and B-B' are shown in Figure 3.

Area mapping

During the site survey, it was noted that Quick Ridge was composed of a series of lava flows, which were designated Rock Units 10, 11, and 20 (also referred to as RU-10, RU-11, RU-20) in descending order of elevation, as each would be encountered in the drilling operation. (Rock Unit 20 was assigned a number out of sequence in order to identify it as visually distinct from the overlying units.) These flows are separated from each other by deposits of glacial till which were similarly designated Soil Units A, B, and C (also referred to as SU-A, SU-B, SU-C) (Figures 4 and 5).

ROCK UNITS

High Cascade volcanism has occurred during the past 2 to 3 million years with a high episodic maximum occurring during the last 1.5 million years (McBirney and others, 1974). Priest and others (1982) informally termed this volcanic episode "the late High Cascade episode" and dated its beginning at 4 million years ago. The authors' work in the study area suggests that RU-10, -11, and -20 of Quick Ridge were extruded from late High Cascade volcanoes from approximately 600,000 to more than 730,000 years ago.

In this report, classification of these rock units is based on the Ab/An ratio of the plagioclase phenocrysts, assuming that the average composition of plagioclase in basalts is more calcic than Ab_1An_1, while in andesites it is more sodic. When chemical analysis is available, a silica content less than 52 percent denotes basaltic composition (Williams and others, 1954). Classification of RU-10 was confirmed by silica content (Table 1).

Natural remanent magnetism of all rock units was measured at the outcrop by fluxgate magnetometer. Oriented samples were measured in the laboratory for confirmation of field readings. RU-10 and RU-11 were determined to have normal magnetic polarity. RU-20 was found to have reversed magnetic polarity, which indicates an age greater than 730,000 years (Mankinen and Dalrymple, 1979). A K-Ar date of 675,000 ± 12,000 years B.P. was obtained from RU-10. This date provided a means to bracket events between 730,000 and 675,000 years. Age, thickness, and petrography of each rock unit are included in Table 2.

Table 1. *Chemical composition of Rock Unit 10 in weight percent (X-ray fluorescence analysis by University of Oregon. All iron as Fe_2O_3)*

SiO_2	52.19
TiO_2	0.88
Al_2O_3	17.14
MgO	7.09
Fe_2O_3	7.95
MnO	0.12
CaO	8.84
Na_2O	3.62
K_2O	0.75
P_2O_5	0.24
Loss	0.20
Total	99.02

Table 2. *Rock unit data*

Rock Unit 10 (RU-10)	
Rock type:	Basaltic andesite (see Table 1)
Magnetic polarity:	Normal
Age:	675,000 ± 12,000 years
Thickness:	Approximately 120 ft
Description:	Outcrops are exposed along Quick Ridge and Forest Service Road 2424266. A local strike and dip of N. 25° E. 2° NW. was measured from the bottom contact exposed in the roadcut. In hand sample, RU-10 is visually distinct from RU-11 and RU-20, being light gray with phenocrysts of plagioclase and olivine.
Petrography:	RU-10 contains up to 62 percent plagioclase laths, ranging in length from 0.1 to 1 mm. Composition of the plagioclase grains ranges from An_{38-28} near the top of the flow to An_{67-52} near the bottom of the flow.

Table 2. *Rock unit data – continued*

	Glomerocrysts of plagioclase grains with olivine are common, occasionally with granular pyroxene. Small amounts of brown interstitial glass are found between some plagioclase grains. Olivine (up to 10 percent) is anhedral to subhedral, ranging from 0.1 to 1 mm in size. Near the top of the flow, olivine is cracked and deeply embayed, with extensive alteration to iddingsite and magnetite. Orthopyroxene rims are common, and partial to total replacement by magnetite occurs in some grains, particularly groundmass olivine. Near the bottom of the flow, olivine grains are anhedral to subhedral and somewhat embayed. Magnetite inclusions and orthopyroxene rims are scarce, and groundmass olivine is relatively unaltered. Hypersthene (up to 15 percent) occurs in the groundmass and as microphenocrysts (Figure 6).
Rock Unit 11 (RU-11)	
Rock type:	Basalt
Magnetic polarity:	Normal
Inferred age:	715,000 ± 15,000 years. This age has been inferred from the following evidence: (1) RU-11 lies between Soil Units B and C, which are assumed to have been deposited during periods of high ice accumulation and which have been assigned inferred ages of 685,000-700,000 years and 730,000-750,000 years, respectively. (2) RU-11 is bracketed by the age of RU-10 and the paleomagnetic polarity boundary of 730,000 years B.P. (3) This age correlates with the $^{16}O/^{18}O$ record of Schackleton and Opdyke (1973).
Description:	RU-11 is exposed on the north side of Quick Ridge and at the confluence of Furnish and Salmon Creeks. Outcrops are medium gray and blocky jointed, and rocks are fine grained in hand sample.
Petrography:	RU-11 is characterized by abundant olivine (up to 8 percent) occurring with calcic plagioclase. The olivine grains are anhedral to subhedral and are typically cracked and embayed. Iddingsite and magnetite are common and were observed as reaction rims and embayments in the cracks. Plagioclase (up to 61 percent) occurs as laths ranging from 0.1 to 0.5 mm in length. The composition is generally An_{52-54}. Up to 15 percent of RU-11 is composed of subophitic augite up to 2 mm in diameter.
Rock Unit 20 (RU-20)	
Rock type:	Basaltic andesite
Magnetic polarity:	Reversed
Minimum age:	775,000 years, based on the paleomagnetic reversal boundary and the inferred age of overlying SU-C.
Thickness:	80 ft
Description:	RU-20 has reversed magnetic polarity. Outcrops are found along the north side of Quick Ridge, the south bank of the Salmon Creek flood plain, and the confluence of Furnish and Salmon Creeks. The dip is approximately 8° WSW., with the bottom contact exposed for 200 ft along Furnish Creek. RU-20 outcrops are medium gray with columnar jointing, and rocks are fine grained in hand sample. Slope collapse has obscured the nature of the underlying rock unit, but small exposures in the creek beds along the north bank of Furnish Creek indicate a pyroclastic origin.
Petrography:	In thin section, RU-20 contains up to 9 percent olivine, ranging from 0.1 to 1 mm long, with inclusions of magnetite less than 0.1 mm in size. Olivine is anhedral to subhedral, with the margins typically iddingsitized. Plagioclase (up to 60 percent) ranges from 0.1 to 0.4 mm in length and shows normal zoning (An_{55-40}). Cloudy brown glass is found in many interstices between plagioclase laths and accounts for 2 percent of the rock. Subophitic augite with plagioclase laths is common and ranges up to 0.3 mm in size.

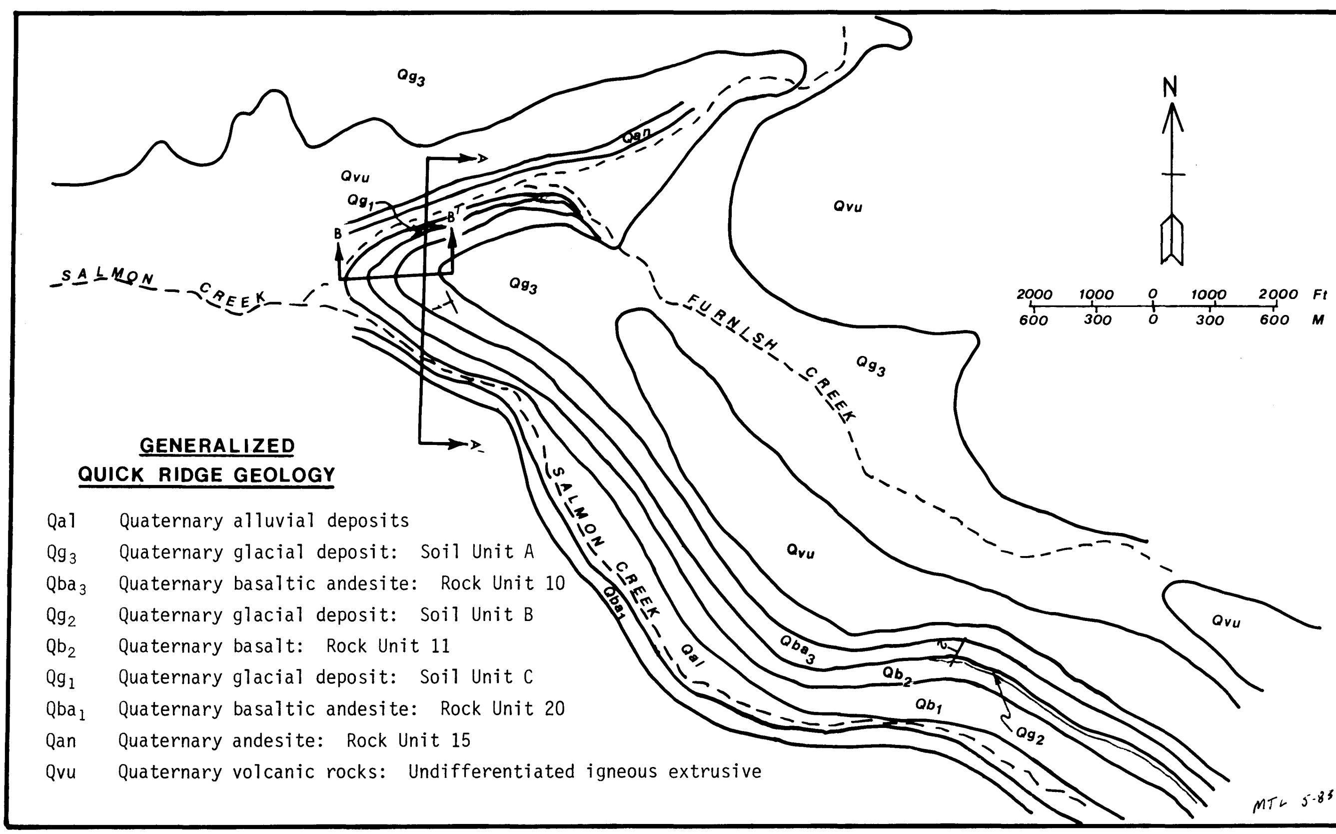


Figure 5. Geologic map of Quick Ridge.

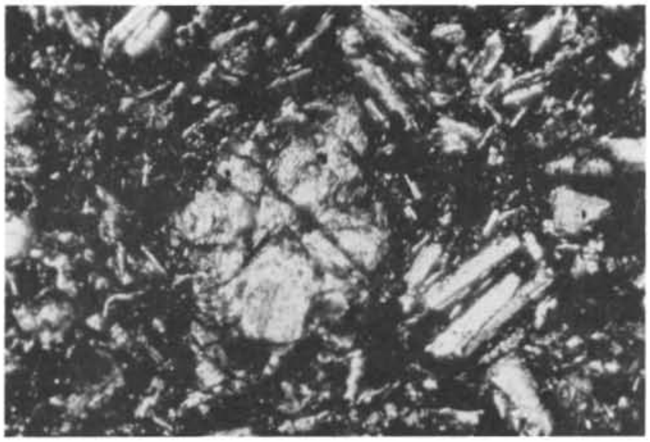


Figure 6. Photomicrograph of sample from Rock Unit 10. Actual size of large olivine phenocryst=0.25 mm.

Figure 8. End moraine near Furnish Creek bridge (Soil Unit A).

SOIL UNITS

The area above an elevation of 3,000 ft is covered by a layer of glacial till which ranges in thickness from 3 to 40 ft. This upper layer was designated Soil Unit A (SU-A) and is found in extensive deposits (Figure 7). An end moraine was recognized in the Furnish Creek valley on Road 2424 immediately west of the Furnish Creek bridge (Figure 8). Approximately 2 mi south, another end moraine is present on Road 2424 (Figure 3). The channel of the south fork of Furnish Creek has been filled with deposits from the most recent glacial advance. This is evident from the asymmetry of Quick Ridge and the extensive erosion of the south side by Salmon Creek. Page (1939) described a similar feature in the Chiwaukum Creek (eastern Washington) area of his study.

Approximately 2.2 mi southeast of the drilling site used in the exploration, in a roadcut on Forest Service Road 2424266 at the 3,500-ft elevation, a basaltic andesite flow (RU-10) approximately 90 ft thick was observed overlying a second layer of glacial till (Figure 9). This layer was designed Soil Unit B (SU-B) and was also observed below 2,800 ft along Forest Service Road 2417 in consolidated deposits of till and proglacial lake sediments. Within these sediments, grain size increases toward the top, from clay and silt to cobble and boulder size. In addition to cut-and-fill stratification (Figure 10), rafted fragments are evident in silt-varved sediments (Figure 11). Porter (1976) described similar features in Kittitas deposits of eastern Washington and inferred that increasing grain size toward the top was a response to the advance of the glacial front. The local strike and dip (N. 25° E. 2° NW.) of the RU-10 outcrop on Road 2424266 was noted, and a trace projection was made from the lower contact elevation (3,500 ft) so that an intercept depth could be predicted and correlation be made between the outcrop and the drill hole. Correlation was later confirmed by drill hole contact (RU-10/SU-B), stratigraphic position, mass attitude (by three-point analysis and trace projection), paleomagnetic data, and petrographic analyses of the outcrop and drill core.

A third layer of glacial till was observed during the survey of cross section A-A′ (Figure 4) between Furnish and Salmon Creeks. This layer, designated Soil Unit C (SU-C), lies between Rock Units 11 and 20. SU-C was not observed at any other location in the Upper Salmon Creek basin. Description of the soil units encountered in the study area are included in Table 3. Soil units were classified according to the Unified Soil Classification (American Society for Testing Materials, 1969).

Table 3. *Soil unit data*

Soil Unit A (SU-A)	
Soil type:	Silty sandy gravel with rock fragments
Unified Soil Classification:	GM
Inferred age:	13,500 to 15,000 years
Thickness:	3 to 40 ft
Description:	1- to 12-in., subrounded to rounded, fresh-state to stained-state (Williamson, 1980) rock fragments of High Cascade origin in a strong-brown (7.5 YR 4/6) silty sand (SM) matrix, nonplastic, loose to compact, low dry strength, quick dilatancy.
Soil Unit B (SU-B)	
Soil type:	Silty gravel with rock fragments
Unified Soil Classification:	GW-GM

Figure 7. Soil Unit A – typical ground moraine.

Figure 9. Rock Unit 10 overlying Soil Unit B.

Figure 10. Cut-and-fill stratification along Forest Service Road 2417.

Table 3. *Soil unit data – continued*

Inferred age:	685,000 to 700,000 years
Thickness:	40 to 50 ft
Description:	1- to 18-in., angular to subrounded, stained-state to partially decomposed state rock fragments in a dark-brown (7.5 YR 4/4) silty sand (SM) matrix, plastic, stiff, medium dry strength, medium dilatancy.
Soil Unit C (SU-C)	
Soil type:	Silty gravel with rock fragments
Unified Soil Classification:	GW
Inferred age:	730,000 to 750,000 years
Thickness:	25 to 30 ft
Description:	1- to 12-in., subrounded to rounded, stained-state to completely decomposed-state rock fragments in a very dark grayish brown (10 YR 3/3) sandy silt (ML) matrix, plastic, stiff, medium dry strength, medium dilatancy.

DRILLING

Subsurface exploration was restricted to RU-10 and was accomplished by using a track-mounted core drill with a 2¾-in. diamond bit and an NQ wireline inner barrel. Three holes were drilled to an average depth of 142 ft to confirm the mass attitude (interpreted from plan and cross-section analysis), rock quality and quantity, and vertical and horizontal distribution of materials. Four additional holes were drilled to an average depth of 67 ft to determine the depth of SU-A and the excavation limits (Figure 12).

Figure 11. Proglacial lake sediments along Forest Service Road 2417, with ice-rafted fragment. Increasing grain size toward top indicates glacial advance.

Figure 12. Quick Ridge at confluence of Salmon and Furnish Creeks. This view is to the north toward Forest Service Road 2417. Drilling exploration occurred at ridge top in clear cut (right center).

The contact between RU-10 and underlying SU-B was penetrated at a depth of 114 ft in drill hole 1, 122 ft in drill hole 2, and 124 ft in drill hole 3, with corresponding elevations of 2,993 ft, 3,000 ft, and 2,997 ft, respectively. These contacts were used to compute a site mass attitude of N. 28° W. 1° SW. An average mass attitude of N. 14° E. 2.5 ° NW. for the Quick Ridge extrusive series was calculated from the elevation of drill-hole contacts and the elevation of the outcrop contact on Road 2424266. This is consistent with an average thalweg of 2.6° (240 ft/mi) for Salmon Creek from 2,800-ft to 2,500-ft elevations. A comparison of the site mass attitude of the Quick Ridge extrusive series supports the conclusion that an erosional surface exists between SU-B and RU-10 and is related to the past Salmon Creek drainage.

AGE DETERMINATION

In order to chronologically bracket the glacial advances in the study area that correspond to SU-B and SU-C, we obtained a K-Ar date for a sample taken from RU-10, took oriented samples from each rock unit at several locations, and measured the natural remanent magnetism of the rock samples with a fluxgate magnetometer. All rock units were identified by petrographic analysis and stratigraphic position in the field-measured sections. The oxygen-isotope record from Pacific drill core was used to assign tentative dates to soil units, based upon periods of high ice accumulation which would imply glacial conditions of deposition.

The sample of RU-10 taken from a core sample from 70 ft below the surface in drill hole 3 (SE¼ SW¼ NW¼ sec. 35, T. 20 S., R. 5 E., at the end of Forest Service Road 2424267) was sent to the School of Oceanography at Oregon State University for K-Ar radiometric dating. The test, which was conducted from October to November 1982, yielded an age of 675,000 ± 12,000 years.

MAGNETIC POLARITY

Paleomagnetism (natural remanent magnetism) is based upon electron spin direction and magnetic moments within the atoms that comprise the magnetic minerals within a rock. As an igneous rock congeals from liquid to solid state, the magnetic minerals within the magma cool through the Curie point, which is the temperature at which the electron spin directions and magnetic moments align themselves within the polarity of the existing magnetic field (Irving, 1964). The polarity of the Earth's magnetic field has reversed at intervals throughout geologic time. The last complete reversal occurred 730,000 years B.P. (Bruhnes-Matuyama polarity boundary) (Mankinen and Dalrymple, 1979).

Four samples, weighing approximately 10 lb each, were oriented with a Brunton compass and taken from outcrops within each rock unit, and the natural remanent magnetic polarity was measured with a fluxgate magnetometer (Doell and Cox, 1967). RU-10 and RU-11 were recorded as normal. Constant reversed meter deflections confirmed that RU-20 was magnetically reversed. This indicates an origin prior to the Bruhnes-Matuyama polarity boundary of 730,000 years B.P.

OXYGEN-ISOTOPE RECORD

The oxygen-isotope ($^{16}O/^{18}O$) record provides a means by which to infer the paleoclimate as it pertains to ice-mass accumulation. The ratio of the isotopes ^{16}O and ^{18}O found in sea water can be determined by measuring the amounts of each isotope contained in the calcium carbonate of planktonic foraminifera tests. $H_2{}^{16}O$, having a higher vapor pressure than $H_2{}^{18}O$, evaporates more easily at lower temperatures; therefore, during periods of widespread glaciation as the temperature decreases, the oceans are enriched with $H_2{}^{18}O$, and $H_2{}^{16}O$ is stored in glacial ice as a result of increased evaporation and precipitation. This results in ^{18}O-rich calcium carbonate secretions in the tests of foraminifera during periods of high ice accumulation. Glacial melt, the result of increased world-wide temperature, increases the amount of ^{16}O present in sea water. This results in ^{16}O-rich calcium secretions during such periods (Flint, 1971).

Schackleton and Opdyke (1973) analyzed drill core from the Pacific Ocean floor and correlated six glacial and interglacial stages with those of Emiliani (1955) in the Caribbean. The correlations of Schackleton and Opdyke were based upon a uniform rate of sedimentation (17.1 cm/10^4 years), magnetic polarity boundaries, and the oxygen-isotope ratio in foraminifera tests. More recently, Birchfield and others (1981) have formulated a model that enables prediction of the growth and decay of ice sheets on a 100,000-year periodicity, based on insolation (solar radiation) anomalies caused by changes in the earth's orbit. Their findings correlate well with the oxygen-isotope record. By referencing RU-10, -11, and -20 to the model of Birchfield and others (1981), a tentative date may be inferred for SU-B and SU-C, based on periods of high ice accumulation (Figure 13).

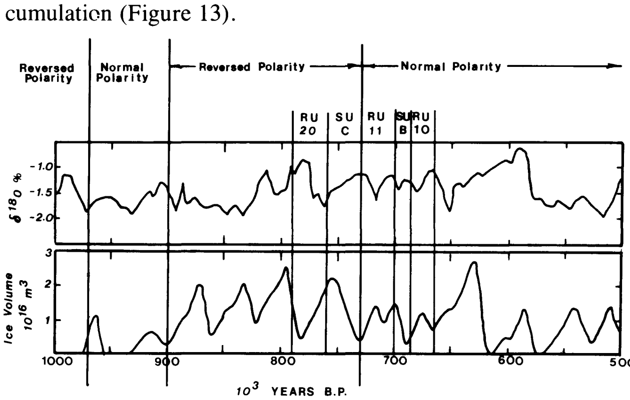


Figure 13. Oxygen-isotope record (top); ice volume prediction (bottom). After Birchfield and others (1981).

CONCLUSION

Based upon K-Ar dating, paleomagnetic stratigraphy, and the indirect correlation with periods of high ice accumulation from the oxygen-isotope record, the glacial advances represented by Soil Units A, B, and C, in the Upper Salmon Creek drainage are assigned the following tentative dates: SU-A, 13,500-15,000 years B.P.; SU-B, 685,000-700,000 years B.P.; SU-C, 730,000-760,000 years B.P. The relationship between these dates and those of other studies is shown in Table 4.

Davie's (1980) study of the Three Fingered Jack area and Avramenko's (1981) study of the Echo Mountain area, both in the central Oregon Cascades, described rock units similar to RU-10, -11, and -20 of this study. Avramenko (1981) correlated his Bunchgrass Ridge unit with the Jorn Lake unit of Davie. This correlation was based upon a K-Ar age of 680,000 years (Lauresen and Hammond, 1978) and normal magnetic polarity. Both of these rock units overlie rock units of reversed polarity (the plateau lavas of Avramenko and the Suttle Lake unit of Davie). Based upon age, magnetic polarity, and petrographic analysis, RU-10, -11, and -20 can be reasonably correlated with the Bunchgrass/Jorn Lake (normal polarity) and plateau lavas/Suttle Lake (reversed polarity) units of Avramenko and Davie.

Davie (1980) also inferred that erosional disconformities may exist between the Suttle Lake unit and Jorn Lake unit and between the Jorn Lake unit and the overlying lower summit series. These disconformities are represented by distinct breaks in the topography and the lack of an intimate contact between the rock units. In the present study, during cross-section analysis, the authors observed that soil and rock unit boundaries occurred at radical slope changes, similar to those described by Davie, and that erosion of the underlying lower strength material resulted in a vertical rock-slope collapse of the overlying rock unit and concealment of the underlying layers beneath a talus slope. This condition may exist in the erosional disconformities of Davie's study.

Soil Unit A is similar in weathering characteristics (rock fragments from fresh to stained state), morphology (distinguishable end and lateral moraines), and geographical location (above 3,000 ft) to other late Wisconsin glacial deposits of Washington and Oregon and can be correlated with the Cabot Creek Glaciation of Scott (1977), the Lakedale Drift of Porter (1976), and the Tunnel Creek Glaciation of Thayer (1939). Soil Unit B may be generally equivalent to the Kittitas Drift of Porter (1976) and the Abbott Butte Glaciation of Scott (1977). Soil Unit C may be generally equivalent to the Thorp Drift of Porter (1976), the lower Portland Hills Silt (Lentz, 1981), and the Salmon Springs Drift of Easterbrook and others (1981).

Refinement of the ages of Soil Units A, B, and C may be made by further study of the area and the adjacent valley of the North Fork Willamette River and by obtaining K-Ar dates from the remaining lava flows in the study area.

Table 4. *Quick Ridge glaciation age correlation with previous studies.*

Years B.P.	Unit of this study	Unit of previous studies	
13,500			
	SU-A	Cabot Creek Glaciation (Scott, 1977) Lakedale Drift (Porter, 1976) Tunnel Creek Glaciation (Thayer, 1939)	
15,000			
665,000			
	RU-10	Bunchgrass Ridge unit (Avramenko, 1981) Jorn Lake unit (Davie, 1980)	
685,000			
	SU-B	Kittitas Drift (Porter, 1976) Abbott Butte Glaciation (Scott, 1977)	
700,000			
	RU-11	Bunchgrass Ridge unit (Avramenko, 1981) Jorn Lake unit (Davie, 1980)	
730,000	-----------	Bruhnes-Matuyama Magnetic Polarity Boundary	(normal) ------------ (reversed)
	SU-C	Thorp Drift (Porter, 1976) Lower Portland Hills Silt (Lenz, 1981)	
760,000			
	RU-20	Plateau lava unit (Avramenko, 1981) Suttle Lake unit (Davie, 1980)	
790,000			
840,000 ±210,000		Salmon Springs Drift (Easterbrook and others, 1981)	
900,000	-----------	Jarmillo Magnetic Polarity Boundary	(reversed) ------------ (normal)

ACKNOWLEDGMENTS

The authors would like to thank Douglas A. Williamson, Supervisory Engineering Geologist, Willamette National Forest, and Edward M. Taylor, Department of Geology, Oregon State University, for their advice and critical review of this paper. Gratitude is also extended to Caren Tracy for editing and typing the manuscript; Jeff Wilson, American Society of Landscape Architects, for the block diagram; John Fauth (State University of New York College at Cortland) for help in preparation of photomicrographs; Harve Waff (University of Oregon) for the use of the fluxgate magnetometer; and the Willamette National Forest for encouraging professional development. A special thanks to Fred, Clancy, Holly, and Elmer for their patience.

REFERENCES CITED

American Society for Testing Materials, 1969, Classification of soils for engineering purposes, ASTM Standard D2487-66T, *in* American Society for Testing Materials Standards, Part 11: American Society for Testing Materials.

Avramenko, W., 1981, Volcanism and structure in the vicinity of Echo Mountain, central Oregon Cascade Range: Eugene, Oreg., University of Oregon master's thesis, 175 p.

Birchfield, G.E., Weertman, J., and Lunde, A.T., 1981, Paleoclimate model of northern Hemisphere ice sheets: Quaternary Research, v. 15, p. 126-142.

Birkeland, P.W., Crandell, D.R., and Richmond, G.M., 1971, Status of correlation of Quaternary stratigraphic units in the western conterminous United States: Quaternary Research, v. 1, no. 2, p. 208-227.

Crandell, D.R., 1965, The glacial history of western Washington and Oregon, *in* Wright, H.E., Jr., and Frey, D.G., eds., The Quaternary of the United States: Princeton, N.J., Princeton University Press, p. 341-353.

Crandell, D.R., Mullineaux, D.R., and Waldron, H.H., 1958, Pleistocene sequence in the southeastern part of the Puget Lowland, Washington: American Journal of Science, v. 256, p. 384-398.

Davie, E.I., II, 1980, The geology and petrology of Three Fingered Jack, a High Cascade volcano in central Oregon: Eugene, Oreg., University of Oregon master's thesis, 138 p.

Doell, R.R., and Cox, A., 1967, Measurement of natural remanent magnetization at the outcrop, *in* Collinson, D.W., and Creer, K.M., eds., Development in solid earth geophysics, methods in paleomagnetism: London, Elsevier, p. 159-162.

Easterbrook, D.J., 1969, Pleistocene chronology of the Puget Lowland and San Juan Islands, Washington: Geological Society of America Bulletin, v. 80, no. 11, p. 2273-2286.

Easterbrook, D.J., Briggs, N.D., Westgate, J.A., and Gorton, M.P., 1981, Age of the Salmon Springs Glaciation in Washington: Geology, v. 9, no. 2, p. 87-93.

Easterbrook, D.J., Crandell, D.R., and Leopold, E.B., 1967, Pre-Olympia Pleistocene stratigraphy and chronology in the central Puget Lowland, Washington: Geological Society of America Bulletin, v. 78, no. 1, p. 13-20.

Emiliani, C., 1955, Pleistocene temperatures: Journal of Geology, v. 63, no. 6, p. 538-578.

Flint, R.F., 1971, Glacial and Quaternary geology: New York, John Wiley and Sons, 892 p.

Irving, E., 1964, Paleomagnetism and its application to geological and geophysical problems: Sydney, John Wiley and Sons, 320 p.

Lauresen, J.M., and Hammond, P.E., 1978, Summary of radiometric ages of Oregon rock, supplement 1: July 1972 through December 1976: Isochron/West, no. 23, p. 1.

Lentz, R.T., 1981, The petrology and stratigraphy of the Portland Hills Silt–a Pacific Northwest loess; Oregon Geology, v. 43, no. 1, p. 3-10.

Long, M.T., 1981, Quick rock source investigation: Willamette National Forest, unpublished report.

Mackin, J.H., 1941, Glacial geology of the Snoqualmie-Cedar area, Washington: Journal of Geology, v. 49, no. 5, p. 449-481.

Mankinen, E.A., and Dalrymple, G.B., 1979, Revised geomagnetic polarity time scales for the interval 0-5 m.y. B.P.: Journal of Geophysical Research, v. 84, p. 615-626.

McBirney, A.R., Sutter, J.P., Naslund, H.R., Sutton, K.G., and White, C.M., 1974, Episodic volcanism in the central Oregon Cascade Range: Geology, v. 2, no. 12, p. 585.

Page, B.M., 1939, Multiple alpine glaciation in the Leavenworth area, Washington: Journal of Geology, v. 47, p. 785-815.

Porter, S.C., 1971, Fluctuations of late Pleistocene alpine glaciers in western North America, *in* Turekian, K.K., ed., The late Cenozoic glacial ages: New Haven, Conn., Yale University Press, p. 307-329.

——— 1975, Weathering rinds as a relative-age criterion: Application to subdivision of glacial deposits in the Cascade Range: Geology, v. 3, no. 3, p. 101-104.

——— 1976, Pleistocene glaciation in the southern part of the North Cascade Range, Washington: Geological Society of America Bulletin, v. 87, no. 1, p. 61-75.

Priest, G.R., Woller, N.M., Black, G.L., and Evans, S.H., 1982, Overview of the geology and geothermal resources of the central Oregon Cascades, *in* Priest, G.R., and Vogt, B.F., eds., Geology and geothermal resources of the Cascades, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-82-7, p. 5-70.

Scott, W.E., 1977, Quaternary glaciation and volcanism, Metolius River area, Oregon: Geological Society of America Bulletin, v. 88, no. 1, p. 113-124.

Schackelton, N.J., and Opdyke, N.D., 1973, Oxygen isotope and paleomagnetic stratigraphy of equatorial Pacific core V28-238; oxygen isotope temperatures and ice volumes on a 10^5 and 10^6 year scale: Quaternary Research, v. 3, p. 39-55.

Thayer, T.P., 1939, Geology of the Salem Hills and North Santiam River Basin, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 15, 40 p.

Williams, H., 1957, A geologic map of the Bend quadrangle, Oregon, and a reconnaissance geologic map of the central portion of the High Cascade Mountains: Oregon Department of Geology and Mineral Industries map.

Williams, H., Turner, F., and Gilbert, C., 1954, Petrography: An introduction to the study of rocks in thin section: San Francisco, W.H. Freeman, 425 p.

Williamson, D.A., 1980, Unified Rock Classification System, Transportation Research Board 783: Transportation Research Board, National Academy of Sciences, Washington, D.C. □

DOGAMI releases new publications

The Oregon Department of Geology and Mineral Industries (DOGAMI) has released a number of publications during the past few months. Space limitations have kept us so far from giving you detailed information about the following releases:

August 31: **Oil and Gas Investigation 8**, *Subsurface Stratigraphy of the Ochoco Basin, Oregon*, by G.G. Thompson, J.R. Yett, and K.R. Green. Price $7.

September 10: **GMS-33**, *Geologic Map of the Scotts Mills Quadrangle, Oregon*, by P.R. Miller and W.N. Orr. Price $4.

September 27: **Open-File Report O-84-5**, *Bench Testing of Silica Sand from Deposits in Clatsop and Morrow Counties, Oregon*, by J.J. Gray. Price $4.

October 4: **GMS-35**, *Geology and Gold Deposits Map of the Southwest Quarter of the Bates Quadrangle, Grant County, Oregon*, by H.C. Brooks, M.L. Ferns, and D.G. Avery. Price $5.

October 11: **GMS-30**, *Geologic Map of the Southeast Quarter of the Pearsoll Peak Quadrangle, Curry and Josephine Counties*, Oregon, by L. Ramp. Price $8.

October 18: **Oil and Gas Investigation 12**, *Biostratigraphy of Exploratory Wells, Northern Willamette Basin, Oregon*, by D.R. McKeel. Price $6.

November 1: **GMS-34**, *Geologic Map of the Stayton NE Quadrangle, Oregon*, by W.N. Orr and P.R. Miller, Price $4.

Please watch for more specific descriptions of these publications in next month's magazine. In the meantime, see the publication list at the end of this issue for price and ordering information.

—Editor

REMEMBER TO RENEW YOUR SUBSCRIPTION!

AVAILABLE DEPARTMENT PUBLICATIONS

GEOLOGICAL MAP SERIES	Price	No. copies	Amount
GMS-4: Oregon gravity maps, onshore and offshore. 1967	$ 3.00	____	____
GMS-5: Geologic map, Powers 15-minute quadrangle, Coos and Curry Counties. 1971	3.00	____	____
GMS-6: Preliminary report on geology of part of Snake River canyon. 1974	6.50	____	____
GMS-8: Complete Bouguer gravity anomaly map, central Cascade Mountain Range, Oregon. 1978	3.00	____	____
GMS-9: Total-field aeromagnetic anomaly map, central Cascade Mountain Range, Oregon. 1978	3.00	____	____
GMS-10: Low- to intermediate-temperature thermal springs and wells in Oregon. 1978	3.00	____	____
GMS-12: Geologic map of the Oregon part of the Mineral 15-minute quadrangle, Baker County. 1978	3.00	____	____
GMS-13: Geologic map, Huntington and part of Olds Ferry 15-minute quadrangles, Baker and Malheur Counties. 1979	3.00	____	____
GMS-14: Index to published geologic mapping in Oregon, 1898-1979. 1981	7.00	____	____
GMS-15: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, north Cascades, Oregon. 1981	3.00	____	____
GMS-16: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, south Cascades, Oregon. 1981	3.00	____	____
GMS-17: Total-field aeromagnetic anomaly map, south Cascades, Oregon. 1981	3.00	____	____
GMS-18: Geology of Rickreall, Salem West, Monmouth, and Sidney 7½-minute quads., Marion/Polk Counties. 1981	5.00	____	____
GMS-19: Geology and gold deposits map, Bourne 7½-minute quadrangle, Baker County. 1982	5.00	____	____
GMS-20: Map showing geology and geothermal resources, southern half, Burns 15-minute quad., Harney County. 1982	5.00	____	____
GMS-21: Geology and geothermal resources map, Vale East 7½-minute quadrangle, Malheur County. 1982	5.00	____	____
GMS-22: Geology and mineral resources map, Mount Ireland 7½-minute quadrangle, Baker/Grant Counties. 1982	5.00	____	____
GMS-23: Geologic map, Sheridan 7½-minute quadrangle, Polk/Yamhill Counties. 1982	5.00	____	____
GMS-24: Geologic map, Grand Ronde 7½-minute quadrangle, Polk/Yamhill Counties. 1982	5.00	____	____
GMS-25: Geology and gold deposits map, Granite 7½-minute quadrangle, Grant County. 1982	5.00	____	____
GMS-26: Residual gravity maps, northern, central, and southern Oregon Cascades. 1982	5.00	____	____
GMS-27: Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1°×2° quadrangle. 1982	6.00	____	____
GMS-28: Geology and gold deposits map, Greenhorn 7½-minute quadrangle, Baker/Grant Counties. 1983	5.00	____	____
GMS-29: Geology and gold deposits map, NE¼ Bates 15-minute quadrangle, Baker/Grant Counties. 1983	5.00	____	____
NEW! GMS-30: Geologic map, SE¼ Pearsoll Peak 15-minute quadrangle, Curry/Josephine Counties. 1984	8.00	____	____
GMS-31: Geology and gold deposits map, NW¼ Bates 15-minute quadrangle, Grant County. 1984	5.00	____	____
GMS-32: Geologic map, Wilhoit 7½-minute quadrangle, Clackamas/Marion Counties. 1984	4.00	____	____
GMS-33: Geologic map, Scotts Mills 7½-minute quadrangle, Clackamas/Marion Counties. 1984	4.00	____	____
NEW! GMS-34: Geologic map, Stayton NE 7½-minute quadrangle, Marion County. 1984	4.00	____	____
NEW! GMS-35: Geology and gold deposits map, SW¼ Bates 15-minute quadrangle, Grant County. 1984	5.00	____	____

OTHER MAPS	Price	No. copies	Amount
Reconnaissance geologic map, Lebanon 15-minute quadrangle, Linn/Marion Counties. 1956	3.00	____	____
Geologic map, Bend 30-minute quad., and reconnaissance geologic map, central Oregon High Cascades. 1957	3.00	____	____
Geologic map of Oregon west of 121st meridian (U.S. Geological Survey Map I-325). 1961	5.50	____	____
Geologic map of Oregon east of 121st meridian (U.S. Geological Survey Map I-902). 1977	5.50	____	____
Landforms of Oregon (relief map, 17×12 in.)	1.00	____	____
Oregon Landsat mosaic map (published by ERSAL, OSU). 1983. $8.00 over the counter; $11.00 mailed		____	____
Geothermal resources of Oregon (map published by NOAA). 1982	3.00	____	____
Geological highway map, Pacific Northwest region, Oregon/Washington/part of Idaho (published by AAPG). 1973	5.00	____	____

BULLETINS	Price	No. copies	Amount
33. Bibliography of geology and mineral resources of Oregon (1st supplement, 1937-45). 1947	3.00	____	____
35. Geology of the Dallas and Valsetz 15-minute quadrangles, Polk County (map only). Revised 1964	3.00	____	____
36. Papers on foraminifera from the Tertiary (v.2 [parts VI-VIII] only). 1949	3.00	____	____
44. Bibliography of geology and mineral resources of Oregon (2nd supplement, 1946-50). 1953	3.00	____	____
46. Ferruginous bauxite deposits, Salem Hills, Marion County. 1956	3.00	____	____
49. Lode mines, Granite mining district, Grant County. 1959	3.00	____	____
53. Bibliography of geology and mineral resources of Oregon (3rd supplement, 1951-55). 1962	3.00	____	____
61. Gold and silver in Oregon. 1968	17.50	____	____
62. Andesite Conference guidebook. 1968	3.50	____	____
65. Proceedings of the Andesite Conference. 1969	10.00	____	____
67. Bibliography of geology and mineral resources of Oregon (4th supplement, 1956-60). 1970	3.00	____	____
71. Geology of selected lava tubes, Bend area, Deschutes County. 1971	5.00	____	____
77. Geologic field trips in northern Oregon and southern Washington. 1973	5.00	____	____
78. Bibliography of geology and mineral resources of Oregon (5th supplement, 1961-70). 1973	3.00	____	____
81. Environmental geology of Lincoln County. 1973	9.00	____	____
82. Geologic hazards of Bull Run Watershed, Multnomah and Clackamas Counties. 1974	6.50	____	____
83. Eocene stratigraphy of southwestern Oregon. 1974	4.00	____	____
84. Environmental geology of western Linn County. 1974	9.00	____	____
85. Environmental geology of coastal Lane County. 1974	9.00	____	____
87. Environmental geology of western Coos and Douglas Counties. 1975	9.00	____	____
88. Geology and mineral resources, upper Chetco River drainage, Curry and Josephine Counties. 1975	4.00	____	____
89. Geology and mineral resources of Deschutes County. 1976	6.50	____	____
90. Land use geology of western Curry County. 1976	9.00	____	____
91. Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties. 1977	8.00	____	____
92. Fossils in Oregon. A collection of reprints from the *Ore Bin*. 1977	4.00	____	____
93. Geology, mineral resources, and rock material of Curry County. 1977	7.00	____	____
94. Land use geology of central Jackson County. 1977	9.00	____	____
95. North American ophiolites (IGCP project). 1977	7.00	____	____
96. Magma genesis. AGU Chapman Conference on Partial Melting. 1977	12.50	____	____
97. Bibliography of geology and mineral resources of Oregon (6th supplement, 1971-75). 1978	3.00	____	____
98. Geologic hazards of eastern Benton County. 1979	9.00	____	____
99. Geologic hazards of northwestern Clackamas County. 1979	10.00	____	____
100. Geology and mineral resources of Josephine County. 1979	9.00	____	____
101. Geologic field trips in western Oregon and southwestern Washington. 1980	9.00	____	____
102. Bibliography of geology and mineral resources of Oregon (7th supplement, 1976-79). 1981	4.00	____	____

SHORT PAPERS	Price	No. copies	Amount
21. Lightweight aggregate industry in Oregon. 1951	1.00	____	____
24. The Almeda Mine, Josephine County. 1967	3.00	____	____
25. Petrography of Rattlesnake Formation at type area, central Oregon. 1976	3.00	____	____
27. Rock material resources of Benton County. 1978	4.00	____	____

AVAILABLE DEPARTMENT PUBLICATIONS (continued)

MISCELLANEOUS PAPERS	Price	No. copies	Amount
1. A description of some Oregon rocks and minerals. 1950	$ 1.00	_____	_____
5. Oregon's gold placers. 1954	1.00	_____	_____
8. Available well records of oil and gas exploration in Oregon. Revised 1982	4.00	_____	_____
11. Collection of articles on meteorites (reprints from *Ore Bin*). 1968	3.00	_____	_____
15. Quicksilver deposits in Oregon. 1971	3.00	_____	_____
18. Proceedings of Citizens' Forum on Potential Future Sources of Energy. 1975	3.00	_____	_____
19. Geothermal exploration studies in Oregon, 1976. 1977	3.00	_____	_____
20. Investigations of nickel in Oregon. 1978	5.00	_____	_____
SPECIAL PAPERS			
1. Mission, goals, and programs of the Oregon Department of Geology and Mineral Industries. 1978	3.00	_____	_____
2. Field geology, SW Broken Top quadrangle. 1978	3.50	_____	_____
3. Rock material resources, Clackamas, Columbia, Multnomah, and Washington Counties. 1978	7.00	_____	_____
4. Heat flow of Oregon. 1978	3.00	_____	_____
5. Analysis and forecasts of the demand for rock materials in Oregon. 1979	3.00	_____	_____
6. Geology of the La Grande area. 1980	5.00	_____	_____
7. Pluvial Fort Rock Lake, Lake County. 1979	4.00	_____	_____
8. Geology and geochemistry of the Mount Hood volcano. 1980	3.00	_____	_____
9. Geology of the Breitenbush Hot Springs quadrangle. 1980	4.00	_____	_____
10. Tectonic rotation of the Oregon Western Cascades. 1980	3.00	_____	_____
11. Theses and dissertations on geology of Oregon: Bibiliography and index, 1899-1982. 1982	6.00	_____	_____
12. Geologic linears of the northern part of the Cascade Range, Oregon. 1980	3.00	_____	_____
13. Faults and lineaments of the southern Cascades, Oregon. 1981	4.00	_____	_____
14. Geology and geothermal resources of the Mount Hood area. 1982	7.00	_____	_____
15. Geology and geothermal resources of the central Oregon Cascade Range. 1983	11.00	_____	_____
16. Index to the *Ore Bin* (1939-1978) and *Oregon Geology* (1979-1982). 1983	4.00	_____	_____
17. Bibliography of Oregon paleontology, 1792-1983. 1984	6.00	_____	_____
OIL AND GAS INVESTIGATIONS			
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well. 1973	3.00	_____	_____
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well. 1973	3.00	_____	_____
5. Prospects for natural gas, upper Nehalem River basin. 1976	5.00	_____	_____
6. Prospects for oil and gas, Coos Basin. 1980	9.00	_____	_____
7. Correlation of Cenozoic stratigraphic units of western Oregon and Washington. 1983	8.00	_____	_____
8. Subsurface stratigraphy of the Ochoco Basin, Oregon. 1984	7.00	_____	_____
9. Subsurface biostratigraphy, east Nehalem Basin. 1983	6.00	_____	_____
11. Biostratigraphy of exploratory wells, western Coos, Douglas, and Lane Counties. 1984	6.00	_____	_____
NEW! 12. Biostratigraphy of exploratory wells, northern Willamette Basin. 1984	6.00	_____	_____
MISCELLANEOUS PUBLICATIONS			
Mining claims (State laws governing quartz and placer claims)	1.00	_____	_____
Back issues of *Ore Bin*	50¢ over the counter; $1.00 mailed	_____	_____
Back issues of *Oregon Geology*	75¢ over the counter; $1.00 mailed	_____	_____
Colored postcard: Geology of Oregon	0.10	_____	_____

Separate price lists for open-file reports, geothermal energy studies, tour guides, recreational gold mining information, and non-Departmental maps and reports will be mailed upon request.

OREGON GEOLOGY

1005 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

PUBLICATIONS ORDER

Fill in appropriate blanks and send sheet to Department.
Minimum mail order $1.00. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $50.00. Foreign orders: Please remit in U.S. dollars.

NAME ______________________

ADDRESS ______________________

______________________ ZIP ________

Amount enclosed $ ______________________

OREGON GEOLOGY

____ Renewal ____ New Subscription ____ Gift

____ 1 Year ($6.00) ____ 3 Years ($15.00)

NAME ______________________

ADDRESS ______________________

______________________ ZIP ________

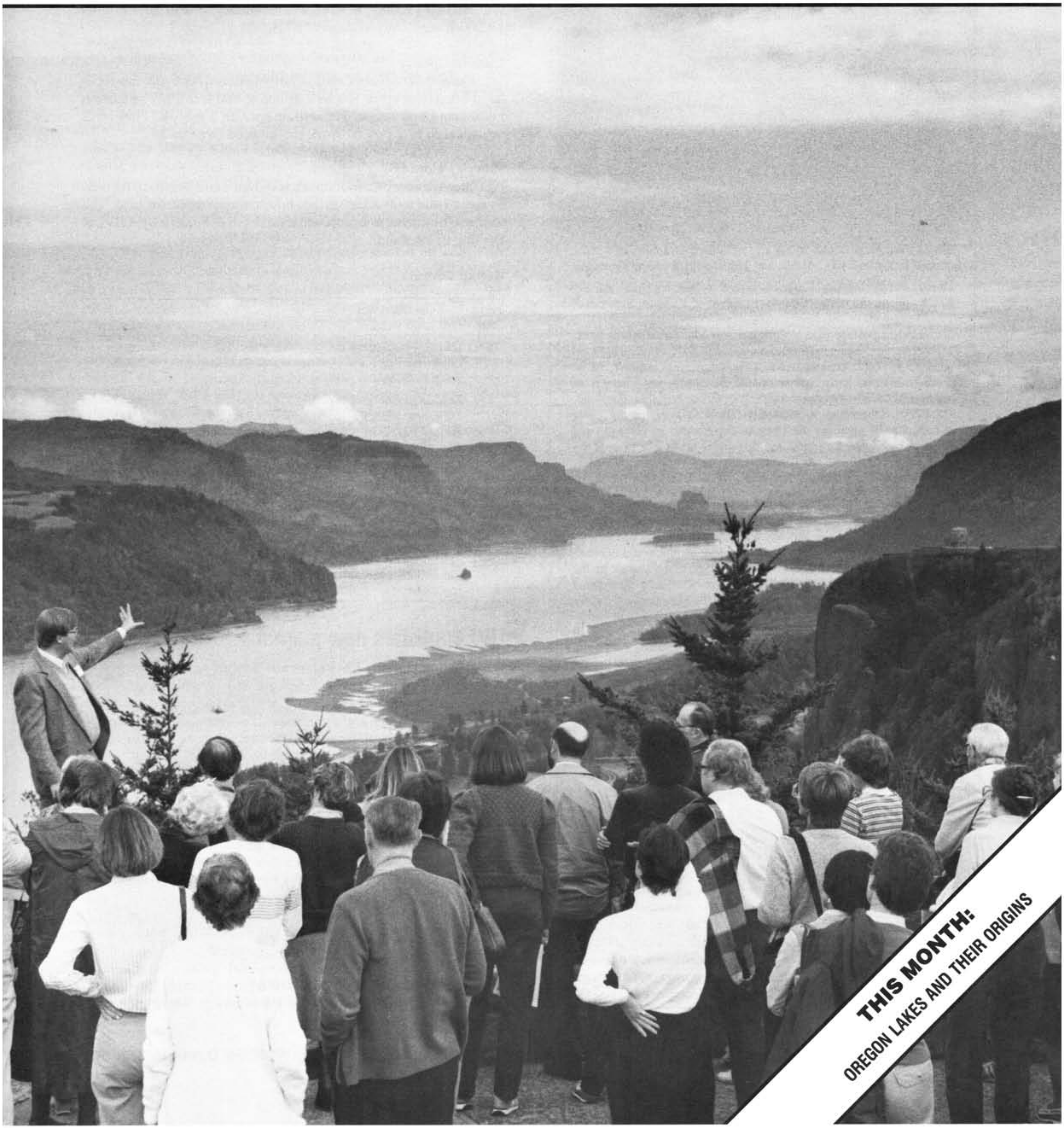
If gift: From ______________________

OREGON GEOLOGY

published by the

Oregon Department of Geology and Mineral Industries

VOLUME 46, NUMBER 12 DECEMBER 1984



THIS MONTH:
OREGON LAKES AND THEIR ORIGINS

OREGON GEOLOGY

(ISSN 0164-3304)

VOLUME 46, NUMBER 12 DECEMBER 1984

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

Main Office: 1005 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133. Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496. Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039. Paul F. Lawson, Supervisor

Second class postage paid at Portland, Oregon. Subscription rates: 1 year, $6.00; 3 years, $15.00. Single issues, $.75 at counter, $1.00 mailed. Available back issues of *Ore Bin*: $.50 at counter, $1.00 mailed. Address subscription orders, renewals, and changes of address to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201. Permission is granted to reprint information contained herein. Credit given to the Oregon Department of Geology and Mineral Industries for compiling this information will be appreciated. POSTMASTER: Send address changes to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

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

View east into Columbia River Gorge from Womens Forum State Park. Group of participants in field trip of American Earth Science Editors convention is guided here by Terry L. Tolan (left), co-author of field trip guide published in August and September issues of *Oregon Geology*. Compare this modern view with historical photo on page 145 of article on Oregon lakes beginning on next page. (Photo courtesy of Robert C. Haney, *Geotimes*)

OIL AND GAS NEWS

Columbia County—Mist Gas Field

Reichhold spudded Polak 31-12 on November 1 in sec. 12, T. 6 N., R. 5 W. The well is located about 1 mi from the nearest producer and is proposed for a depth of 3,000 ft.

Douglas County

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

Lincoln County

Damon Petroleum Company of Woodburn, Oregon, has reentered Longview Fibre 1, a well drilled to 800 ft in 1981 by Ehrens Petroleum Corporation. The well, in sec. 20, T. 9 S., R. 11 W., will be deepened to 2,000 ft. Work commenced October 24.

Wheeler County

Steele Energy Corporation has moved a small drilling rig onto its Keys 1 site to drill the surface hole and run conductor pipe. The well will be drilled to a proposed total depth of 8,000 ft by ROVOR Drilling of Portland.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
167D	Damon Petroleum Co. Longview Fibre 1 36-041-00004	NE¼ sec. 20 T. 9 S., R. 11W. Lincoln County	Location; 2,000.
277	Reichhold Energy Corp. Longview Fibre 23-36 36-009-00132	SW¼ sec. 36 T. 6 N., R. 5 W. Columbia County	Application; 4,000.
278	Reichhold Energy Corp. Investment Mgt. 22-20 36-009-00133	NW¼ sec. 20 T. 6 N., R. 4 W. Columbia County	Application; 2,500.
279	Reichhold Energy Corp. Longview Fibre 42-22 36-009-00134	NE¼ sec. 22 T. 6 N., R. 5 W. Columbia County	Application; 2,600.
280	Reichhold Energy Corp. Columbia County 44-10 36-009-00135	SE¼ sec. 10 T. 6 N., R. 5 W. Columbia County	Application; 3,000.

□

UW publishes new journal

The Institute for Environmental Studies at the University of Washington has started a brand-new publication which will serve as a forum for research and analysis of the environmental issues of the Pacific Northwest. *The Northwest Environmental Journal* is intended for a broad audience of researchers, educators, public and corporate decisionmakers, and concerned citizens.

In the new journal, "Northwest" includes the region from Alaska to Oregon and east to the continental divide (encompassing the Canadian Northwest as well as the U.S. Northwest). The first issue contains articles on Northwest electric power planning, Idaho river protection, Mount St. Helens research, and the decision-making process of two major Northwest cities (Seattle and Tacoma) in trying to decide whether to buy into two nuclear power plants. Authors include government researchers, biologists, political scientists, an attorney, and a U.S. Senator.

Subscriptions to the new journal are $12 U.S. for one year (two issues) and are available from: *The Northwest Environmental Journal*, c/o Institute for Environmental Studies, Engineering Annex FM-12, University of Washington, Seattle, WA 98195. Checks should be made out to the University of Washington. □

Oregon lakes and their origins

by John Eliot Allen, Department of Geology, Portland State University, P. O. Box 751, Portland, OR 97207

INTRODUCTION

Forty-five years ago, a 23-page paper on the lakes of Oregon was written by Warren D. Smith, geology professor at the University of Oregon, and Wilbur Greenup, one of his students (Smith and Greenup, 1939). It represented the "state of the art" at that time and was a major step in the understanding of the origin, distribution, and characteristics of Oregon lakes.

I have just had the privilege of reading the manuscript of the most recent update of our knowledge of Oregon lakes, a new publication entitled *Atlas of Oregon Lakes*, by Daniel M. Johnson, associate professor of geography at Portland State University (PSU), and four other contributors: Richard Peterson, Department of Biology, PSU; Richard Lycan, Department of Geography, PSU; James Sweet, consulting limnologist; and Andrew Schaedel, Oregon Department of Environmental Quality (DEQ). The 350-page study, which was conducted in cooperation with the DEQ, is to be published early in 1985 by the Oregon State University Press (Johnson and others, in press).

The new book will give detailed information on 202 of the Oregon lakes with an area of over 50 acres and reservoirs containing over 5,000 acre-feet of water. Exhaustive information (two to four pages) is given for 53 lakes, generally those with major recreational facilities.

I too have long been interested in Oregon lakes and was able to update with data from Johnson's book some of the following information I have been collecting for years. Water now covers over 500,000 acres (797 mi^2), or somewhat less than one percent of the state. (During the ice age, water covered at least 10,000 mi^2, or more than 10 percent of the state – more about this later.) Currently, we know of over 6,000 bodies of standing water in Oregon. Only slightly more than 1,400 of them have been given a name.*

*The most recent complete listing of such names is the *Geographic Names Information System* (GNIS) of the U.S. Geological Survey. It covers all geographic names used on major topographic maps and is available for the state of Oregon in a two-volume, spiral-bound printout for $29 from U.S. Geological Survey, NCIC, 507 National Center, Reston, VA 22092.

Anthony Lake, in the Blue Mountains west of North Powder, a glacier-produced tarn. (State Highway Division photo)

Oregon's deepest lake, Crater Lake with a depth of 1,932 ft, is the second deepest lake on the North American continent, exceeded only (by a mere 83 ft) by Great Slave Lake in Athabaska, Canada. In Oregon, Waldo Lake follows Crater Lake in depth with 420 ft, then Blue in the Cascades (314 ft), Wallowa (299 ft), Odell (282 ft), Crescent in the Cascades (265 ft), and Paulina (250 ft) Lakes. (There are no "bottomless" lakes – if they were bottomless, the water would run out!)

Malheur Lake has grown to be Oregon's largest body of water, currently covering approximately 280 mi^2. Goose Lake, near Lakeview, averages 152 mi^2 in area, but two-thirds of it is in California. Next largest are the combined Upper Klamath and Agency Lakes, covering 141 mi^2. Abert Lake follows with 57 mi^2, then Harney (41 mi^2), Summer (39 mi^2), Crater (20 mi^2), Agency (14 mi^2), Crump in the Warner Valley (12 mi^2), and Waldo (10 mi^2)

Suttle Lake, near Santiam Pass in the High Cascades, is located in a valley scoured out by glaciers and was dammed by glacial moraines. Black Butte is in the background. (State Highway Division photo)

Lakes. Each of the remaining lakes covers less than 10 mi². The continuing rise of Malheur Lake has brought the water level to within approximately 10 ft of spilling over into the South Fork Malheur River. Several plans are currently being considered to drain off the excess water.

Note that all but two of these large lakes lie in the Great Basin of southeastern Oregon, where faulting of the originally horizontal lavas produced a series of seven uplifted, north-south-trending blocks with intervening downdropped basins.

During the ice age, these lakes of the Great Basin were immensely larger (see Morrison, 1965). Many of the more than 150 closed basins were occupied by lakes, the largest of which were Lake Bonneville (19,940 mi², almost the size of Lake Michigan) and Lake Lahontan (8,665 mi²).

Ira S. Allison, emeritus professor at Oregon State University, mapped the ancient shorelines of two of these ice-age lakes: pluvial Fort Rock Lake (Allison, 1979), which covered nearly 1,400 mi² of northern Lake County, and pluvial Lake Chewaucan (Allison, 1982), which covered 500 mi² in southern Lake County. Samuel N. Dicken, emeritus professor of geography at the University of Oregon, described pluvial Lake Modoc (Dicken, 1980), which covered 1,069 mi² in the Klamath basins and extended into California. Other basins in Oregon formerly occupied by lakes were the Malheur (900 mi²), Alvord (550 mi²), Warner and Catlow (500 mi² each), Alkali Lake (300 mi²), Goose (250 mi² in Oregon), Elgin (180 mi²) and Guano (75 mi²) basins.

There were also two temporary lakes filled by the Bretz floods at the end of the ice age (12,000 to 14,000 years ago): Lake Condon in the Umatilla Basin (1,000 mi²) and Lake Allison in the Willamette Valley (3,000 mi²).

Most lakes are ephemeral, geologically speaking. They are usually eliminated over a few tens of thousands of years by filling up with sediments or by cutting down the outlets by erosion. Those in southeastern Oregon are the oldest lakes, since they occupy fault-block valleys, or grabens, and there is no outlet to be cut down at present. In the past they were much larger, as we will see, and did overflow.

Oregon owes its abundance of lakes to the relatively recent action of glaciers that formed them, the lava flows that dammed them, or the faulting that produced the basins they occupy. We may not have the 10,000 lakes of Minnesota or the 55,000 of Finland (its Finnish name is "Suomi," meaning "Land of Lakes"), but we certainly have more than our share.

Crump Lake in southeastern Lake County, one of the many lakes in Oregon's Basin and Range province that occupy downdropped fault blocks or grabens. It is also one of several remnants of pluvial Warner Lake. (State Highway Division photo)

ORIGIN OF OREGON LAKES

Lakes in Oregon have been formed by (A) glaciers, (B) earth movements, (C) volcanic activity, (D) deposition of sediments, (E) erosion, (F) organic and human activity, and (G) thermal springs, in about that order of abundance. Lakes are also infrequently caused by meteor impact, but not in Oregon. Within the above seven categories, there are 26 sub-headings, and there are lakes in Oregon that fit into all but five of these.

A. Glacial lakes

1. Eroded by ice. These are the dozens of cirque lakes, or tarns, in the Wallowa Mountains especially. The Enterprise, Joseph, Eagle Cap, and Cornucopia topographic quadrangles alone show the following lakes: In the East Fork Wallowa River drainage are Aneroid, Roger, and Jewett Lakes. In the West Fork drainage there are Ice, Razz, Unit, Horseshoe, Lily, Lee, Craig, Crescent, Douglas, Moccasin, Mirror, Pocket, Glacier, Prospect, Frazier, and Little Frazier Lakes. In the Hurricane Creek drainage are Deadman, Echo, and Billy Jones Lakes. In the Lostine River drainage there are Little Storm, Wood, Hobo, Chimney, Laverty, Frances, Maxwell, Minam, Blue, and Upper Lakes. In the Minam River drainage are Bear, John Henry, North Minam, Green, Long, Steamboat, Swamp, Cheval, Diamond, and Tombstone Lakes. In the Eagle Creek drainage are Hidden, Moon, Eagle, Cached, Arrow, Heart, Bear, Culver, Lookingglass, Traverse, Echo, and Olive Lakes. In the Imnaha River drainage are Dollar, Crater, and Pine Lakes.

2. Formed behind glacial moraines. Wallowa Lake is the outstanding example (perhaps even in the entire United States). Horse Lake on the Lake Fork of the Imnaha River is the only other example known with certainty. In the Cascades, Bull Run, Crescent, Odell, and Suttle Lakes occupy valleys scoured by ice, but the lakes themselves are dammed by morainal deposits.

3. Lakes filling irregularities on a surface of glacial debris. Although abundant in the Middle West, these are rare in Oregon. In the Imnaha drainage in the Wallowa Mountains, Bonny, Frances, Warm, Fish, Twin, and Duck Lakes probably fit into this category.

4. Kettle holes left by melting of buried ice. Several examples are present in glacial deposits in the Wallowa Mountains, but they are too small to have been given names.

5. Lakes formed when ice dams failed and catastrophic floods scoured the landscape. Many lakes were formed in the scablands of eastern Washington by ice-age floods first described by Bretz (1923); a few in Oregon, such as Lake Oswego, the lakes around Tonquin, and Crystal Springs Lake were so formed. Toward the end of the Pleistocene, glacial ice dammed meltwater in the Clark Fork River drainage in western Montana and eastern Idaho, forming glacial Lake Missoula. The ice dams periodically failed, producing catastrophic floods downstream in western Washington and along the Columbia River and associated drainages. Ephemeral Lake Condon east of The Dalles and Lake Allison in the Willamette Valley were produced by "hydraulic dams". So much water came down through the Columbia River that it could not get through the narrows below The Dalles and below Portland fast enough.

Ancient "pluvial lakes," produced by the increased precipitation during the Pleistocene, once filled many of the basins in eastern Oregon. From west to east, they included Lake Modoc, Fort Rock Lake, Lake Chewaucan, Goose Lake, Alkali Lake, Warner Lake, Guano Lake, Catlow Lake, Malheur Lake, Alvord Lake, and Lake Elgin.

B. EARTH MOVEMENTS

1. Warping of the crust to form a lake-filled basin. Malheur Lake is the only lake in Oregon that may fall into this category, although its basin may have been formed by an ancient caldera, and its present drainage is also dammed by a lava flow.

2. Block faulting of the crust, with lakes forming on the subsided blocks. Most of the lakes in southeastern Oregon, from

Klamath Lake on the west to Alvord Lake on the east, lie in downdropped blocks or grabens. They were much larger during the ice age. Examples of similar lakes around the world are Lake Tahoe in California, Lake Baikal in Siberia, and Lakes Tanganyika and Nyassa in Africa. Past lakes of this origin are also Lake Bonneville in Utah (Great Salt Lake is a remnant) and Lake Lahontan in Nevada (Pyramid Lake is a remnant).

Lakes of Oregon formed by block faulting, listed from north to south in each basin, include: (a) Klamath Basin – Klamath Marsh, Agency, and Upper Klamath Lakes; (b) Winter Rim, Abert, and Goose Lake Basins – Silver, Alkali, Bottomless, Thorne, Summer, Abert, and Goose Lakes; (c) Warner Valley Basin – Bluejoint, Stone Corral, Campbell, Flagstaff, Mugwump, Swamp, Anderson, Hart, Crump, and Pelican Lakes; (d) Catlow Valley – Guano, Shallow, and Catlow (dry) Lakes; (e) Alvord Basin – Mann, Alvord, and Tumtum Lakes; and (f) Grande Ronde Basin – Elgin Lake.

C. VOLCANIC ACTIVITY

1. Maars. These are small circular depressions caused by explosion of steam coming into contact with hot volcanic rocks. In other countries such as Germany, for example, such depressions are occupied by lakes, but in the dry, high desert country of eastern Oregon the maars known as Big Hole and Hole-in-the-Ground do not have water. However, 314-ft-deep Blue Lake just west of Suttle Lake on the Santiam Pass is believed to be a maar. Little Crater Lake (east of Timothy Lake) and North and South Twin Lakes in the Deschutes Basin may also be maars.

Blue Lake, in the High Cascades near Santiam Pass, is believed to be a maar. View is approximately south, with Mount Washington in background. (State Highway Division photo)

2. Crater lakes. There is only one true crater lake in Oregon, lying at an elevation of 10,000 ft in the crater of the South Sister is the highest lake in Oregon.

3. Caldera lakes. Oregon has perhaps the outstanding example of a caldera lake in the world in Crater Lake. It covers 20 mi^2 at an elevation of 6,176 ft and, with a depth of nearly 2,000 ft, is the deepest in the United States and the second deepest in the western hemisphere; only Great Slave Lake in Canada is a few feet deeper. Crater Lake was formed only 6,845 years ago by the explosion and collapse of Mount Mazama. Oregon also has at least three other caldera lakes: Paulina and East Lakes in the Newberry caldera southeast of Bend, and Harney Lake south of Burns, which many geologists now believe also occupies a large, low, ancient caldera.

4. Lakes formed by lava-flow barriers. These are perhaps the most abundant types of lakes in the High Cascades. Clear, Crescent, Cultus, Davis, Diamond, Elk, Lost, and Marion Lakes and Lake of the Woods were all formed by lava dams, as were Cow and Malheur Lakes in eastern Oregon.

5. Lakes formed by mudflow barriers. None are known in Oregon, but Spirit Lake in Washington is an outstanding example.

D. DEPOSITION OF SEDIMENTS

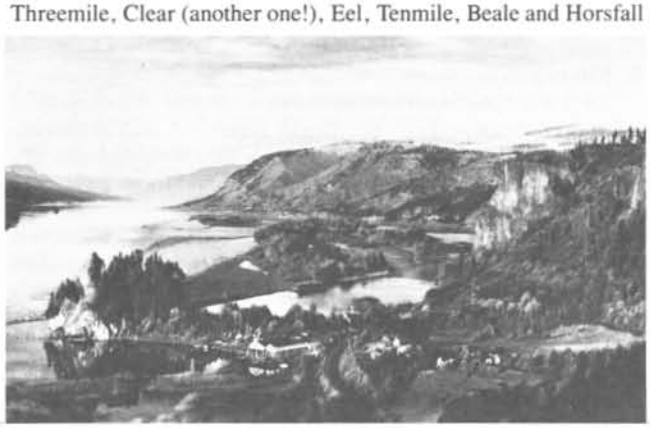
1. Landslide lakes. Triangle Lake in western Lane County was caused by a large landslide which produced a lake once much larger than the small remnant of today. Loon Lake south of Scottsburg in northwestern Douglas County was similarly formed, possibly by an earthquake in 490 A.D., according to carbon-14 analysis. Numerous lakes formed about 1260 A.D. on the surface of the great Bonneville landslide on the Washington side of the Columbia River Gorge.

2. Lakes produced by river deposits *(a) Alluvial fans:* Although the basin occupied by Lake Oswego was scoured by the Bretz floods, its west end was dammed by an alluvial fan deposited by the flood. This same deposit also formed a prehistoric lake at Onion Flat, a few miles to the west. Several of the smaller lakes in the Great Basin of eastern Oregon (such as Mann and Juniper Lakes in the Alvord Basin) have been dammed by alluvial fans deposited by tributaries flowing into the grabens. *(b) Cut-off meander loops or oxbow lakes*: There are several examples of oxbow lakes along the meandering courses of the Willamette River and its tributaries. The Pudding River west of Canby has particularly good examples of these mostly unnamed lakes. *(c) Lakes formed by natural levees and bars*: Old maps show numerous lakes along the Columbia River, such as Ramsey, Bybee, Smith, Force, Mud, and Switzler Lakes, that were enclosed by levees and bars. Most of these have been filled and no longer exist. Guild Lake in northwest Portland was dammed by the natural levee, but it was filled for the Lewis and Clark Exposition in 1905.

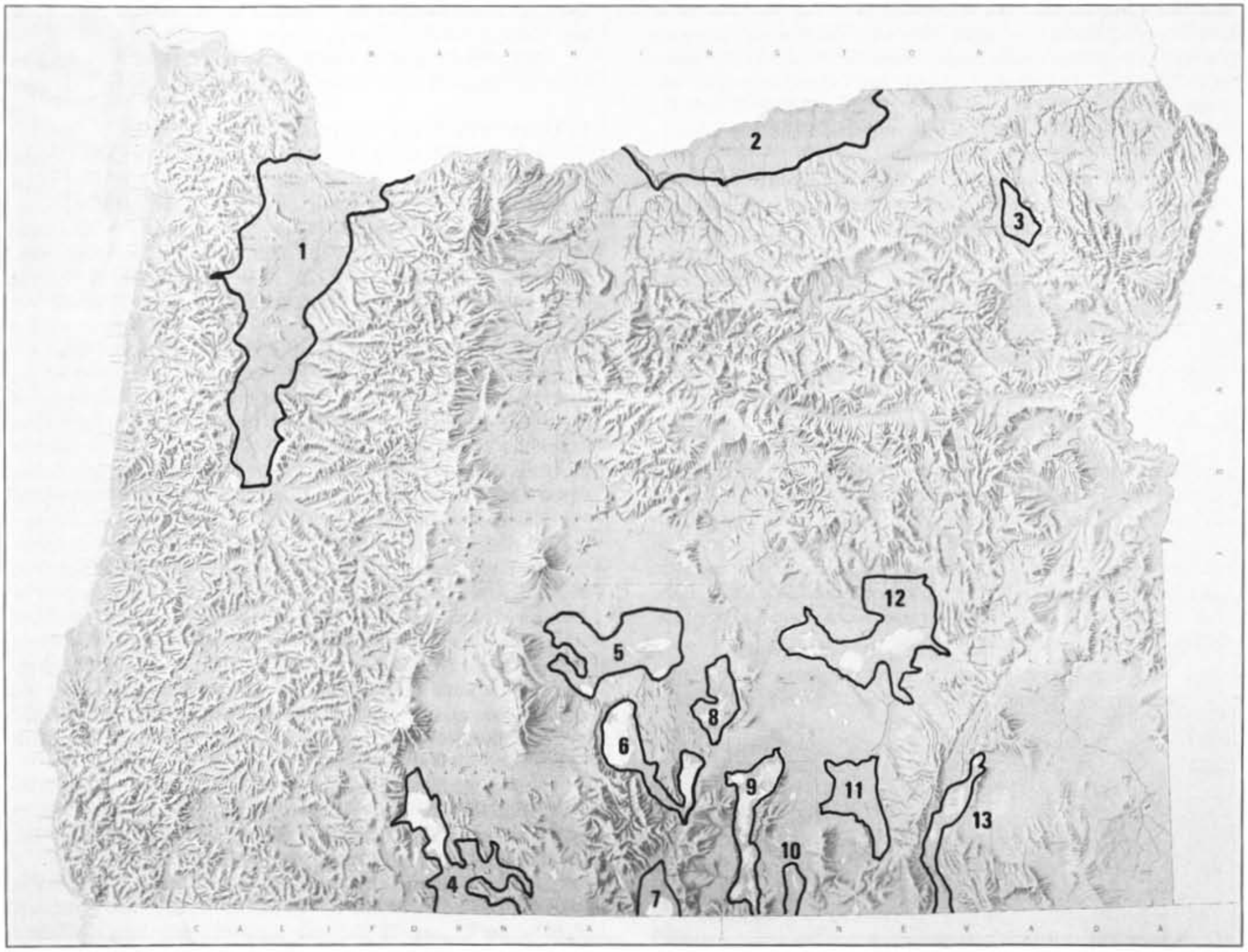
Vancouver Lake in Washington is the largest of such lakes on the Columbia River. The best examples in Oregon are the lakes on Sauvie Island: Sturgeon, Little Sturgeon, Mouse Island, Marquam, and Dry Lakes, and many others unnamed.

3. Lakes formed by wind deposits. Many of the Oregon coastal lakes were formed by advancing sand dunes, especially those on the Clatsop Plains, such as Coffenbury, Smith, Slusher, Sunset, Cullaby, and Stanley Lakes. Lakes farther down the coast were originally formed by marine deposits such as offshore and barrier bars (and are discussed later), but have also been moved inland by advancing dunes.

4. Lakes formed by marine deposits. The area around Florence and farther south has the greatest concentration of such lakes on the coast. From north to south, they are Sutton, Mercer, Collard, Clear, Munsel, Cleawox, Woahink, Siltcoos, Tahkenitch, Elbow, Threemile, Clear (another one!), Eel, Tenmile, Beale and Horsfall



Historical view of the Columbia River Gorge, looking east, with Crown Point and Rooster Rock in the foreground. The center of the photo illustrates how lakes are formed by natural levees and bars along a river. (Photo courtesy Oregon Historical Society)



Pleistocene lakes of Oregon. 1. Lake Allison and 2. Lake Condon were ephemeral lakes produced by jökulhlaups (glacier outburst flood) from glacial Lake Missoula in Montana, 12,000-14,000 years ago. The remaining ones were pluvial lakes: 3. Elgin, 4. Modoc, 5. Fort Rock, 6. Chewaucan, 7. Goose, 8. Alkali, 9. Warner, 10. Guano, 11. Catlow, 12. Malheur, 13. Alvord.

Lakes. South of Coos Bay, they are Round, Fahys, Bradley, Laurel, Croft, New, Floras, and Garrison Lakes.

5. Lakes produced by glacial deposits. These have been discussed under **A**.

E. EROSION

1. Lakes produced by solution of limestone. Although these are very common in areas underlain by limestone, such as Florida, they are absent in Oregon, which has few limestone deposits.

2. Lakes produced by glacial erosion. These have been discussed under **A**.

3. Lakes produced by wind erosion. The soft lake deposits in pluvial Fort Rock Lake are easily excavated by the wind to produce basins with ephemeral lakes such as Fossil Lake and possibly Christmas Lake in central Oregon.

F. ORGANIC AND HUMAN ACTIVITY

1. Coral reef lagoons. Such lakes are formed only within 30 degrees latitude of the equator.

2. Lakes produced by beaver dams. These were formerly quite important and numerous but are now very rare and usually too small to be named.

3. Lakes produced by man-made dams. There are over 60 dams in Oregon. The lakes produced by those dams containing more than 5,000 acre-feet of water are discussed in detail in Dan Johnson's new book but will not be covered here.

G. THERMAL SPRINGS

Borax Lake in the Alvord Basin, Hot Lake east of La Grande, and Hunter's Hot Spring Lake just north of Lakeview are all fed by hot springs.

REFERENCES CITED

Allison, I.S., 1979, Pluvial Fort Rock Lake, Lake County, Oregon: Oregon Department of Geology and Mineral Industries Special Paper 7, 72 p.

– – – 1982, Geology of pluvial Lake Chewaucan, Lake County, Oregon: Corvallis, Oreg., Oregon State University Press, 79 p.

Bretz, J H., 1923, The Channeled Scabland of the Columbia Plateau, Journal of Geology, v. 31, p. 617-649.

Dicken, S.N., 1980, Pluvial Lake Modoc, Klamath County, Oregon, and Modoc and Siskiyou Counties, California: Oregon Department of Geology and Mineral Industries, Oregon Geology, v. 42, no. 11, p. 179-187.

Johnson, D.M., Peterson, R.R., Lycan, D.R., Sweet, J.N., and Schaedel, A.L., in press, Atlas of Oregon lakes: Corvallis, Oreg., Oregon State University Press.

Morrison, R.B., 1965, Quaternary geology of the Great Basin *in* Wright, H.E., Jr., and Frey, D.G., eds., The Quaternary of the United States: Princeton, N.J., Princeton University Press, p. 265-285. □

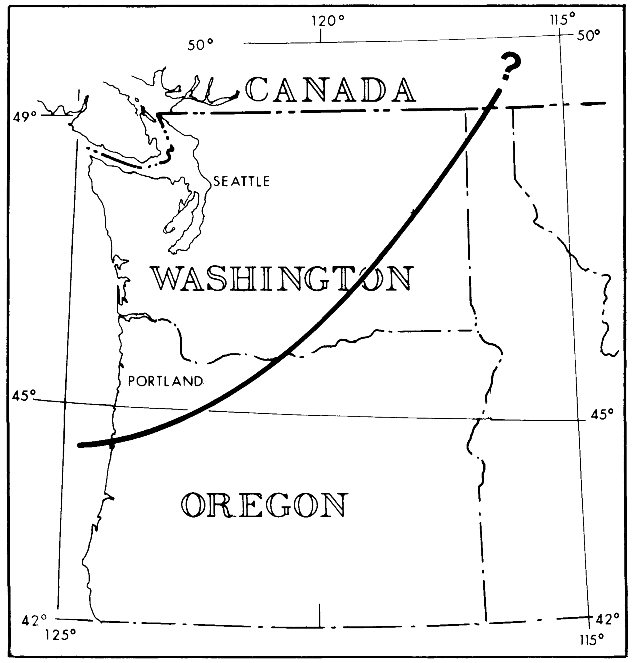
Large fireball sighted in Pacific Northwest: More information needed

A large, bright, long-duration fireball entered the earth's atmosphere over the central Oregon coast at 2:35 a.m. PDT on September 17, 1984. The fireball was first seen along the coast from a number of locations ranging from Westport, Washington, on the north to Roseburg, Oregon, on the south. Despite the fact that the fireball appeared in the middle of the night when there are relatively few observers, it was reported to the Smithsonian Scientific Event Alert Network (SEAN) by at least 24 observers. This author received twenty different reports of sightings, most of which are tabulated below.

The most easterly sighting in Oregon was at Pine Mountain, which is east of Bend. There Dan Kraus, Assistant Astronomer at Pine Mountain Observatory, reported that the fireball came straight at him from the west for 20 seconds, getting larger and brighter. It then appeared to skip 15° to the north, and after about five seconds broke into six orange fragments with tails that were visible for an additional five seconds.

The fireball was observed at Spokane, Washington, where a heavy sonic boom was also reported, and at Sandpoint, Idaho, where the fireball was last seen disappearing below the horizon to the northwest. The Washington and Idaho reports are from Eileen Starr, Planetarium Director, Eastern Washington University, Cheney, Washington, who is also a member of the SEAN team.

SEAN officials believe the fireball probably came down in southeast British Columbia or the extreme northeast corner of Washington State and are contacting Canadian scientists for any additional information.



Map showing possible path of September 17, 1984, fireball.

Table 1. *Summary of fireball sightings reported to author*

Place	Location	Path	Color	Angle of descent	Duration	Description
12 mi. W. of Westport, Wash.	46°52′ 124°20′	W. to E.	Orange/blue	Parallel	45 sec.	Very bright like full moon, yellow tail, fragments coming off every few seconds, total of 12 fragments.
10 mi. N. of Roseburg, Oreg.	43°19′ 123°47′	W. to E.	White	15°	7 sec.	⅓ full moon, very bright, cast shadow, 10-15 fragments dropping out of fireball at steep angle.
Sutherlin, Oreg.	43°23′ 123°30′	W. to E.	Green	10°	10 sec.	Long green tail, glowing trail, cast shadow.
Portland, Oreg.	45°15′ 122°50′	W. to E.	White	10°	10 sec.	⅕ full moon, yellow to red short tail, many fragments, like sparkler, cast shadow.
Portland, Oreg.	45°32′ 122°46′	W. to E.	Blue/white	15°	6 sec.	¼ full moon, eight fragments, glowing train, cast shadow.
Camas, Wash.	45°37′ 122°44′	W. to E.	White	5°	5 sec.	2 times size of Venus, short white tail, four fragments, glowing train.
Camas, Wash.	45°37′ 122°44′	W. to E.	Orange	15°	5 sec.	2 times size of Venus, 20° orange tail, five fragments following fireball, glowing train, cast shadow.
Portland, Oreg.	45°37′ 122°42′	W. to E.	Yellow/white	10°	4 sec.	2 times size of Venus, short yellow-white tail, one fragment, 2-sec. glowing train.
Estacada, Oreg.	45°17′ 122°24′	W. to E.	Red/orange	10°	1-2 sec.	½ full moon, very long red/orange tail, 12 fragments, cast shadow, lit up whole sky, swishing sound.
Lake Oswego, Oreg.	45°21′ 122°41′	W. to E.	Yellow/orange	Parallel	3 sec.	¼ full moon, tear-drop shaped orange tail, one large, several small fragments, glowing train.
Portland, Oreg.	45°31′ 122°33′	W. to E.	Blue/white	5°	4 sec.	2 times size of Venus, 30° red/orange tail, several fragments, smoke trail.
Clackamas, Oreg.	45°26′ 122°32′	W. to E.	White	10°	2 sec.	10 times size of Venus, no tail, four fragments plus many sparks dropping toward ground. Bright as full moon.
Clackamas, Oreg.	45°26′ 122°32′	W. to E.	Green/blue	Parallel	3 sec.	⅓ full moon, very long blue/green tail, six fragments, smoke trail, cast shadow, fast.
Portland, Oreg.	45°32′ 122°32′	W. to E.	Red/orange/ yellow	10°-15°	4-5 sec.	Went below horizon, ⅕ full moon, short yellow tail, four fragments with tails.
Bend, Oreg.	44° 0′ 121°29′	NW.	–	–	–	Observer awakened by bright light. Saw bright streak in sky.
Pine Mt. Observatory, Oreg.	43°47′ 120°56′	W. to ENE.	White/yellow-orange	10°	30 sec.	½ full moon, 30-40° tail, yellow/orange, five to six fragments, cast shadow.
Pine Mt. Observatory, Oreg.	43°47′ 120°56′	W., change direction to moving 15° W. of N.	White	–	30 sec.	Observation by Dan Kraus, Asst. Astronomer, described in article.

Anyone with any additional information about this fireball is urged to contact this author, because scientists hope to recover fragments of the meteorite. At least 50 to 100 good observations are required before there is much chance for recovery. The sonic boom, which generally occurs at low altitudes as a meteorite is slowing and approaching the earth, indicates that fragments may have survived their fiery plunge through the atmosphere and are now on the ground where they may be found.

Three other fireballs occurring within a few days of the event described above were also reported to this author. The first was reported by Linda Jackson, who observed a fireball from between Salem and Portland at lat. 45°8′ N., long. 123°0′ W., on September 16, 1984, at 11:30 p.m. PDT. The fireball was first seen 40° W. of N. at an altitude of 45° and was last seen 10° W. of N., dropping at a 45° angle until it disappeared below the horizon. The duration of the flight was 8 seconds. The fireball, which was very bright, was about half the diameter of a full moon. It appeared to increase in size and brightness as it fell. It was white with a short, yellow-white tail and left a glowing smoke trail that lasted for a few seconds.

The second fireball was sighted on September 17, 1984, at 8:15 p.m. PDT from Battleground, Washington, at lat. 45°45′ N., long. 122°40′ W. by John Enright. It was observed moving from north to south, descending at an angle of 35° for 1 second. The color was orange. The sun had set, but the sky was still orange, and the orange color of the fireball was probably due to the sunset. This fireball is significant because it was essentially a daylight fireball.

The third fireball was reported by Sarah Frost from just north of Lincoln City, lat. 45°3′ N., long. 124°6′ W. on September 22, 1984, at 8:00 p.m. PDT. This fireball was first seen 45° E. of N. at an altitude of 50° and was last seen 30° E. of N. at an altitude of 20°. The angle of descent was 30°; the duration was 4 seconds. The fireball was white with a short white tail, three times the diameter of Venus, and very bright. It broke up into three or four pieces. There was no sound or shadow.

The occurrence of these three fireballs plus the large one reported above suggests that the four may have been related and that they may have been part of a group of meteoroids that were traveling together through space in orbit around the sun.

—Dick Pugh, Science Teacher
Cleveland High School
3400 SE 26th Ave.
Portland, OR 97202
Phone (503) 233-6441

DOGAMI releases new publications

The Oregon Department of Geology and Mineral Industries (DOGAMI) has released a number of publications during the past few months. Space limitations have kept us so far from giving you detailed information about the following releases:

GMS-30: The geology and mineral deposits of a mineral-rich southwest Oregon region are described in a new geologic map of the Oregon Department of Geology and Mineral Industries (DOGAMI).

Geologic Map of the Southeast Quarter of the Pearsoll Peak Quadrangle, Curry and Josephine Counties, Oregon, presents the results of a study conducted by DOGAMI geologist Len Ramp and funded in part by the U.S. Forest Service. Published as Map GMS-30 in DOGAMI's Geological Map Series, it covers an area that straddles the Curry/Josephine county line as well as the eastern edge of the Kalmiopsis Wilderness in the Siskiyou National Forest. "The map includes the area of greatest chromite production and probably the greatest chromite resource potential in the State of Oregon," explained author Len Ramp.

The first of the two sheets of GMS-30 contains a full-color geologic map (scale 1:24,000) with cross sections, a discussion of the geology and mineral deposits, and a table with basic data on 79 mines and prospects identified in the quadrangle. On the second sheet, a sample location map and a table of analytical data provide information on 178 rock samples from the area, approximately one-third of them collected at mine or prospect sites. The samples were assayed for ten metallic elements.

The rocks identified in this quadrangle are approximately 150-200 million years old. Their nature and structure suggest a complex geologic history. Originally formed on or under an ancient ocean floor, they were affected by two separate geologic environments: The volcanism of an island arc and the underthrusting and uplift associated with partial melting.

Purchase price of GMS-30 is $8.

GMS-33 and -34: The second and third maps in a planned series of three maps showing Tertiary seashore environments of approximately 20-40 million years ago in the Western Cascade foothills near Silverton are now available to the public.

Map GMS-33, *Geologic Map of the Scotts Mills Quadrangle, Oregon*, by Paul R. Miller and William N. Orr, covers the Scotts Mills 7½-minute quadrangle that straddles the Clackamas-Marion county line just to the northeast of the town of Silverton. The two-color map (scale 1:24,000) shows eight surficial and bedrock geologic units, the area's geologic structure, and two cross sections. Supporting the study's emphasis on aspects of sedimentation and paleontology and the reconstruction of paleoenvironments, an additional sketch map outlines the depositional environments of the middle Tertiary (Oligocene and Miocene) geologic units in and around the area covered by the map.

Map GMS-34, *Geologic Map of the Stayton NE Quadrangle, Oregon*, by William N. Orr and Paul R. Miller, covers the 7½-minute quadrangle to the southwest of the Scotts Mills quadrangle (GMS-33). This two-color map (scale 1:24,000) is similar in format to GMS-33. In addition, it contains a diagram showing the characteristic invertebrate fossils and the representative map units from seven mid-Tertiary environments in the Western Cascades.

The first map of this series, the Wilhoit quadrangle map, was released in June as GMS-32. All three maps are available at DOGAMI at a price of $4 each.

GMS-35: A new geologic map of the southwest portion of the Bates 15-minute quadrangle in eastern Oregon has just been released as Map GMS-35, *Geology and Gold Deposits Map of the Southwest Quarter of the Bates Quadrangle, Grant County, Oregon*, by Howard C. Brooks, Mark L. Ferns, and Dan G. Avery.

This new map is the latest eastern Oregon gold-country geologic map produced by DOGAMI in cooperation with and funded in part by the U.S. Forest Service. Earlier maps of this series, which are also available from DOGAMI, cover the Bullrun Rock, Rastus Mountain, Bourne, Mount Ireland, Granite, Greenhorn, Bates NW, and Bates NE 7½-minute quadrangles and the Mineral, Huntington, and Olds Ferry 15-minute quadrangles.

The four-color geologic map of the Bates SW quadrangle is at a scale of 1:24,000. It shows sedimentary, volcanic, and metamorphic geologic units that were deposited or formed over a period extending from the present day back to pre-Permian time (more than 280 million years ago). The complex geology of this area is further explained by two cross sections that show the relationships of the 17 geologic units presented on the map. One of these units is formally introduced here with a new stratigraphic name: The Dixie Butte Meta-andesite of Triassic to Permian age.

Parts of this area have been mineralized, and the map shows the location of numerous mines, prospects, and quartz veins, many of them in the historic Quartzburg mining district located in this quadrangle. Also included on the map sheet are data tables of mines, prospects, and sample analyses; a discussion of the mineral deposits in the quadrangle; and a list of literature references.

Purchase price of GMS-35 is $5.

OGI-8: Oil and Gas Investigation 8, *Subsurface Stratigraphy of the Ochoco Basin, Oregon*, by G.G. Thompson, J.R. Yett, and K.E. Green, summarizes the results of a study of samples from four deep wells in southern Crook County, Oregon. The 22-page text discusses stratigraphic interpretations and presents summaries and detailed lithologic descriptions for each of the wells. Charts on the seven plates that accompany the text show palynomorphic and foraminiferal distributions and palynology correlations.

Subsurface geologic knowledge in central Oregon is limited to these four deep test wells that have penetrated a substantial section of Cretaceous marine and nonmarine clastic sediments beneath the Tertiary volcanic cover. This report documents the distribution of microfossils in samples from the wells and interprets the age and depositional environments of the rocks penetrated. Selected ditch and core samples were analyzed for pollen, spores, microplankton, foraminifera, radiolaria, and calcareous nannoplankton. The presence of Upper Cretaceous Albian through Campanian strata supports the authors' conclusion that there may be an extensive Upper Cretaceous basin, informally named the Ochoco Basin, with the potential for containing hydrocarbon-bearing reservoirs.

Purchase price of OGI-8 is $7.

OGI-12: The results of a study of nine wells drilled in the north Willamette Basin have been released as Oil and Gas Investigation 12, *Biostratigraphy of Exploratory Wells, Northern Willamette Basin, Oregon*, by Daniel R. McKeel. The 19-page report presents correlations of fossils and lithology and is based on the analysis of 918 samples from nine wells drilled in Washington, Yamhill, Marion, and Polk Counties to depths ranging from approximately 5,000 to over 9,000 feet. The publication is the third in a series of biostratigraphic studies published by DOGAMI. Earlier reports were on 15 wells in the adjacent Mist Gas Field area (Oil and Gas Investigation 9) and on nine wells in southwest Oregon (Oil and Gas Investigation 11).

Section I of the new report contains a summarizing overview, including a composite chart showing the subsurface stratigraphy and a paleobathymetric curve. Section II presents sample-by-sample descriptions of rock types and marine fossils for each well. These identifications are used to determine the age, water depth, and paleoenvironment for each distinctive well interval. Included with the report is a separate illustration sheet containing a surface location map for the wells and selected subsurface correlations for all but one of the wells in the form of a generally north-south-oriented cross section.

Cost of OGI-12 is $6. The earlier reports in this series, OGI-9 and -11, are also available at a price of $6 each.

OFR O-84-4: Two Cascade Range maps that were developed during earlier geologic investigations and that will aid further geologic and geothermal research have been re-released independently now: *Heat-Flow Map of the Cascade Range of Oregon and Index Map of Mapping in the Oregon Cascades*, DOGAMI Open-File Report O-84-4.

The first of the two blackline maps is a heat-flow map of the Cascade Range, produced by G.L. Black, D.D. Blackwell, and J.L. Steele. It originally appeared in DOGAMI Open-File Report O-82-7, *Geology and Geothermal Resources of the Cascades, Oregon*, which is now almost out of print. It was also included, at a smaller scale, in DOGAMI Special Paper 15, *Geology and Geothermal Resources of the Central Oregon Cascade Range* (1983). This heat-flow map has now been published at a scale of 1:500,000, showing heat-flow contours and the locations of all heat-flow data points for the Oregon Cascades.

The second map, an index to geologic mapping in the Oregon Cascades at scales larger than 1:250,000, by N.M. Woller and G.R. Priest, was also included originally in DOGAMI Open-File Report O-82-7. Reproduced now in Open-File Report O-84-4, this index map outlines the areas covered by geologic mapping in DOGAMI and U.S. Geological Survey studies and in master's and doctoral theses. For optimal clarity, the indexed mapping is distributed on three side-by-side repetitions of the base map. Full bibliographic references for all indexed maps are also included.

Purchase price of Open-File Report O-84-4 is $5.

OFR O-84-5: The results of a study in which samples from Clatsop and Morrow Counties were collected and analyzed for their potential as silica sand resources have been released as Open-File Report O-84-5, *Bench Testing of Silica Sand from Deposits in Clatsop and Morrow Counties, Oregon*, by Jerry J. Gray, in cooperation with the Port of Morrow, the Mineral Resource Institute of the University of Alabama, and a private industrial firm. This study identifies three deposits in Morrow County from which a silica sand product can be produced.

The areas from which samples were collected are along the course of the Columbia River and contain deposits of sandstone, fluvioglacial sand and gravel, dunes, and silt and sand of a glacial lake. The testing for silica sand potential was based on standards for the most stringent silica sand markets. Each sample was assayed, sized, subjected to magnetic and gravity separation, and re-assayed. The results of the tests are presented in tabular form in the 12-page report.

This open-file report may be purchased for $4.

All of the above-mentioned publications are available over the counter and by mail from the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, OR 97201. Orders under $50 require prepayment. □

Lectureship in Vancouver, B.C., offered

The Cordilleran Section of the Geological Association of Canada is sponsoring a three-month position for a visiting lecturer in Vancouver, British Columbia, and invites applications or nominations.

The Charlie Ney Visiting Lectureship is intended to bring prominent earth scientists to Vancouver's large geological community made up of exploration, government, and university geologists. It is aimed at, but is not restricted to, those on sabbatical leave and is tenable for three months, beginning at any time from September 1985 to February 1986. The lectureship carries an honorarium of $8,000 (Canadian), and office facilities will be made available at the University of British Columbia and the Geological Survey of Canada.

The Ney Lecturer is expected to contribute lectures to a pertinent course or courses at the University and to conduct a short course or series of lectures for the downtown mineral exploration community.

Applications or nominations will be accepted by Paul L. Smith, President of the Cordilleran Section, Geological Association of Canada, P.O. Box 398-Station A, Vancouver, B.C., V6C 2N2, Canada, before March 30, 1985. □

To our readers:

Many *Oregon Geology* subscriptions expire at the end of the year. If yours is one of those, and if you have not already renewed your subscription, we urge you to do so today. Then you will not miss any issues, and you will continue to be informed about what is going on in geology in the state of Oregon.

If you have any questions about the status of your subscription, please contact our office for that information. Keep in touch with us, because we want to keep in touch with you. □

Index to OREGON GEOLOGY, volume 46, 1984

AVAILABLE DEPARTMENT PUBLICATIONS

GEOLOGICAL MAP SERIES

	Price	No. copies	Amount
GMS-4: Oregon gravity maps, onshore and offshore. 1967	$ 3.00		
GMS-5: Geologic map, Powers 15-minute quadrangle, Coos and Curry Counties. 1971	3.00		
GMS-6: Preliminary report on geology of part of Snake River canyon. 1974	6.50		
GMS-8: Complete Bouguer gravity anomaly map, central Cascade Mountain Range, Oregon. 1978	3.00		
GMS-9: Total-field aeromagnetic anomaly map, central Cascade Mountain Range, Oregon. 1978	3.00		
GMS-10: Low- to intermediate-temperature thermal springs and wells in Oregon. 1978	3.00		
GMS-12: Geologic map of the Oregon part of the Mineral 15-minute quadrangle, Baker County. 1978	3.00		
GMS-13: Geologic map, Huntington and part of Olds Ferry 15-minute quadrangles, Baker and Malheur Counties. 1979	3.00		
GMS-14: Index to published geologic mapping in Oregon, 1898-1979. 1981	7.00		
GMS-15: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, north Cascades, Oregon. 1981	3.00		
GMS-16: Free-air gravity anomaly map and complete Bouguer gravity anomaly map, south Cascades, Oregon. 1981	3.00		
GMS-17: Total-field aeromagnetic anomaly map, south Cascades, Oregon. 1981	3.00		
GMS-18: Geology of Rickreall, Salem West, Monmouth, and Sidney 7½-minute quads., Marion/Polk Counties. 1981	5.00		
GMS-19: Geology and gold deposits map, Bourne 7½-minute quadrangle, Baker County. 1982	5.00		
GMS-20: Map showing geology and geothermal resources, southern half, Burns 15-minute quad., Harney County. 1982	5.00		
GMS-21: Geology and geothermal resources map, Vale East 7½-minute quadrangle, Malheur County. 1982	5.00		
GMS-22: Geology and mineral resources map, Mount Ireland 7½-minute quadrangle, Baker/Grant Counties. 1982	5.00		
GMS-23: Geologic map, Sheridan 7½-minute quadrangle, Polk/Yamhill Counties. 1982	5.00		
GMS-24: Geologic map, Grand Ronde 7½-minute quadrangle, Polk/Yamhill Counties. 1982	5.00		
GMS-25: Geology and gold deposits map, Granite 7½-minute quadrangle, Grant County. 1982	5.00		
GMS-26: Residual gravity maps, northern, central, and southern Oregon Cascades. 1982	5.00		
GMS-27: Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1°×2° quadrangle. 1982	6.00		
GMS-28: Geology and gold deposits map, Greenhorn 7½-minute quadrangle, Baker/Grant Counties. 1983	5.00		
GMS-29: Geology and gold deposits map, NE¼ Bates 15-minute quadrangle, Baker/Grant Counties. 1983	5.00		
NEW! GMS-30: Geologic map, SE¼ Pearsoll Peak 15-minute quadrangle, Curry/Josephine Counties. 1984	8.00		
GMS-31: Geology and gold deposits map, NW¼ Bates 15-minute quadrangle, Grant County. 1984	5.00		
GMS-32: Geologic map, Wilhoit 7½-minute quadrangle, Clackamas/Marion Counties. 1984	4.00		
GMS-33: Geologic map, Scotts Mills 7½-minute quadrangle, Clackamas/Marion Counties. 1984	4.00		
NEW! GMS-34: Geologic map, Stayton NE 7½-minute quadrangle, Marion County. 1984	4.00		
NEW! GMS-35: Geology and gold deposits map, SW¼ Bates 15-minute quadrangle, Grant County. 1984	5.00		

OTHER MAPS

	Price	No. copies	Amount
Reconnaissance geologic map, Lebanon 15-minute quadrangle, Linn/Marion Counties. 1956	3.00		
Geologic map, Bend 30-minute quad., and reconnaissance geologic map, central Oregon High Cascades. 1957	3.00		
Geologic map of Oregon west of 121st meridian (U.S. Geological Survey Map I-325). 1961	5.50		
Geologic map of Oregon east of 121st meridian (U.S. Geological Survey Map I-902). 1977	5.50		
Landforms of Oregon (relief map, 17×12 in.)	1.00		
Oregon Landsat mosaic map (published by ERSAL, OSU). 1983	$8.00 over the counter; $11.00 mailed		
Geothermal resources of Oregon (map published by NOAA). 1982	3.00		
Geological highway map, Pacific Northwest region, Oregon/Washington/part of Idaho (published by AAPG). 1973	5.00		

BULLETINS

	Price	No. copies	Amount
33. Bibliography of geology and mineral resources of Oregon (1st supplement, 1937-45). 1947	3.00		
35. Geology of the Dallas and Valsetz 15-minute quadrangles, Polk County (map only). Revised 1964	3.00		
36. Papers on foraminifera from the Tertiary (v.2 [parts VI-VIII] only). 1949	3.00		
44. Bibliography of geology and mineral resources of Oregon (2nd supplement, 1946-50). 1953	3.00		
46. Ferruginous bauxite deposits, Salem Hills, Marion County. 1956	3.00		
49. Lode mines, Granite mining district, Grant County. 1959	3.00		
53. Bibliography of geology and mineral resources of Oregon (3rd supplement, 1951-55). 1962	3.00		
61. Gold and silver in Oregon. 1968	17.50		
62. Andesite Conference guidebook. 1968	3.50		
65. Proceedings of the Andesite Conference. 1969	10.00		
67. Bibliography of geology and mineral resources of Oregon (4th supplement, 1956-60). 1970	3.00		
71. Geology of selected lava tubes, Bend area, Deschutes County. 1971	5.00		
77. Geologic field trips in northern Oregon and southern Washington. 1973	5.00		
78. Bibliography of geology and mineral resources of Oregon (5th supplement, 1961-70). 1973	3.00		
81. Environmental geology of Lincoln County. 1973	9.00		
82. Geologic hazards of Bull Run Watershed, Multnomah and Clackamas Counties. 1974	6.50		
83. Eocene stratigraphy of southwestern Oregon. 1974	4.00		
84. Environmental geology of western Linn County. 1974	9.00		
85. Environmental geology of coastal Lane County. 1974	9.00		
87. Environmental geology of western Coos and Douglas Counties. 1975	9.00		
88. Geology and mineral resources, upper Chetco River drainage, Curry and Josephine Counties. 1975	4.00		
89. Geology and mineral resources of Deschutes County. 1976	6.50		
90. Land use geology of western Curry County. 1976	9.00		
91. Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties. 1977	8.00		
92. Fossils in Oregon. A collection of reprints from the *Ore Bin*. 1977	4.00		
93. Geology, mineral resources, and rock material of Curry County. 1977	7.00		
94. Land use geology of central Jackson County. 1977	9.00		
95. North American ophiolites (IGCP project). 1977	7.00		
96. Magma genesis. AGU Chapman Conference on Partial Melting. 1977	12.50		
97. Bibliography of geology and mineral resources of Oregon (6th supplement, 1971-75). 1978	3.00		
98. Geologic hazards of eastern Benton County. 1979	9.00		
99. Geologic hazards of northwestern Clackamas County. 1979	10.00		
100. Geology and mineral resources of Josephine County. 1979	9.00		
101. Geologic field trips in western Oregon and southwestern Washington. 1980	9.00		
102. Bibliography of geology and mineral resources of Oregon (7th supplement, 1976-79). 1981	4.00		

SHORT PAPERS

	Price	No. copies	Amount
21. Lightweight aggregate industry in Oregon. 1951	1.00		
24. The Almeda Mine, Josephine County. 1967	3.00		
25. Petrography of Rattlesnake Formation at type area, central Oregon. 1976	3.00		
27. Rock material resources of Benton County. 1978	4.00		

AVAILABLE DEPARTMENT PUBLICATIONS (continued)

MISCELLANEOUS PAPERS	Price	No. copies	Amount
1. A description of some Oregon rocks and minerals. 1950	$ 1.00	_____	_____
5. Oregon's gold placers. 1954	1.00	_____	_____
8. Available well records of oil and gas exploration in Oregon. Revised 1982	4.00	_____	_____
11. Collection of articles on meteorites (reprints from *Ore Bin*). 1968	3.00	_____	_____
15. Quicksilver deposits in Oregon. 1971	3.00	_____	_____
18. Proceedings of Citizens' Forum on Potential Future Sources of Energy. 1975	3.00	_____	_____
19. Geothermal exploration studies in Oregon, 1976. 1977	3.00	_____	_____
20. Investigations of nickel in Oregon. 1978	5.00	_____	_____
SPECIAL PAPERS			
1. Mission, goals, and programs of the Oregon Department of Geology and Mineral Industries. 1978	3.00	_____	_____
2. Field geology, SW Broken Top quadrangle. 1978	3.50	_____	_____
3. Rock material resources, Clackamas, Columbia, Multnomah, and Washington Counties. 1978	7.00	_____	_____
4. Heat flow of Oregon. 1978	3.00	_____	_____
5. Analysis and forecasts of the demand for rock materials in Oregon. 1979	3.00	_____	_____
6. Geology of the La Grande area. 1980	5.00	_____	_____
7. Pluvial Fort Rock Lake, Lake County. 1979	4.00	_____	_____
8. Geology and geochemistry of the Mount Hood volcano. 1980	3.00	_____	_____
9. Geology of the Breitenbush Hot Springs quadrangle. 1980	4.00	_____	_____
10. Tectonic rotation of the Oregon Western Cascades. 1980	3.00	_____	_____
11. Theses and dissertations on geology of Oregon: Bibiliography and index, 1899-1982. 1982	6.00	_____	_____
12. Geologic linears of the northern part of the Cascade Range, Oregon. 1980	3.00	_____	_____
13. Faults and lineaments of the southern Cascades, Oregon. 1981	4.00	_____	_____
14. Geology and geothermal resources of the Mount Hood area. 1982	7.00	_____	_____
15. Geology and geothermal resources of the central Oregon Cascade Range. 1983	11.00	_____	_____
16. Index to the *Ore Bin* (1939-1978) and *Oregon Geology* (1979-1982). 1983	4.00	_____	_____
17. Bibliography of Oregon paleontology, 1792-1983. 1984	6.00	_____	_____
OIL AND GAS INVESTIGATIONS			
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well. 1973	3.00	_____	_____
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well. 1973	3.00	_____	_____
5. Prospects for natural gas, upper Nehalem River basin. 1976	5.00	_____	_____
6. Prospects for oil and gas, Coos Basin. 1980	9.00	_____	_____
7. Correlation of Cenozoic stratigraphic units of western Oregon and Washington. 1983	8.00	_____	_____
8. Subsurface stratigraphy of the Ochoco Basin, Oregon. 1984	7.00	_____	_____
9. Subsurface biostratigraphy, east Nehalem Basin. 1983	6.00	_____	_____
11. Biostratigraphy of exploratory wells, western Coos, Douglas, and Lane Counties. 1984	6.00	_____	_____
NEW! 12. Biostratigraphy of exploratory wells, northern Willamette Basin. 1984	6.00	_____	_____
MISCELLANEOUS PUBLICATIONS			
Mining claims (State laws governing quartz and placer claims)	1.00	_____	_____
Back issues of *Ore Bin*	50¢ over the counter; $1.00 mailed	_____	_____
Back issues of *Oregon Geology*	75¢ over the counter; $1.00 mailed	_____	_____
Colored postcard: Geology of Oregon	0.10	_____	_____

Separate price lists for open-file reports, geothermal energy studies, tour guides, recreational gold mining information, and non-Departmental maps and reports will be mailed upon request.

OREGON GEOLOGY

1005 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

PUBLICATIONS ORDER

Fill in appropriate blanks and send sheet to Department.
Minimum mail order $1.00. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $50.00. Foreign orders: Please remit in U.S. dollars.

NAME ____________________

ADDRESS ____________________

____________________ ZIP ________

Amount enclosed $ ____________________

OREGON GEOLOGY

____ Renewal ____ New Subscription ____ Gift

____ 1 Year ($6.00) ____ 3 Years ($15.00)

NAME ____________________

ADDRESS ____________________

____________________ ZIP ________

If gift: From ____________________