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THIS MONTH:

ORIGIN OF THE WILLAMETTE METEORITE

and annual summary:

GEOTHERMAL EXPLORATION IN OREGON, 1985

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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 the 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

Willamette meteorite in front of the Johnson farm in the town of Willamette, a part of the southern outskirts of Portland. The meteorite at this point was being moved from the original finder's property toward the Willamette River for transportation to Portland and, ultimately, New York. Related article beginning on next page discusses a new hypothesis concerning the meteorite's origin. Photo courtesy Harold Johnson.

OIL AND GAS NEWS

Columbia County lease sale rescheduled

The lease sale originally scheduled for June 11 has been rescheduled for July 28. The delay was brought about by an early June discussion of the lease terms with industry representatives and representatives of taxing districts. Changes now being made include those regarding ownership of gas storage wells, commitment to drill offset wells, and the definition of the starting date of drilling.

The lease sale will be held in the Old Courthouse, First Street, St. Helens, Oregon, at 10 a.m. Additional information is available from the Board of Commissioners, phone (503) 397-4322.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft), use
362	ARCO Columbia County 21-11 009-00199	NW¼ sec. 11 T. 5 N., R. 3 W. Columbia County	Application; 11,500.
363	Oregon Natural Gas OM 44D-3 009-00200	SE¼ sec. 3 T. 6 N., R. 5 W. Columbia County	Application 3,400; Gas storage.
364	Oregon Natural Gas OM 12C-3 009-00201	NW¼ sec. 3 T. 6 N., R. 5 W. Columbia County	Application; 3,400; Gas storage.
365	Oregon Natural Gas OM 12D-10 009-00202	NW¼ sec. 10 T. 6 N., R. 5 W. Columbia County	Application; 3,000; Gas storage.
366	Oregon Natural Gas OM 41A-10 009-00203	NE¼ sec. 10 T. 6 N., R. 5 W. Columbia County	Application; 3,100; Gas storage.
367	Oregon Natural Gas OM 14A-3 009-00204	SW¼ sec. 3 T. 6 N., R. 5 W. Columbia County	Application; 3,400; Gas storage. □

Circum-Pacific Council announces energy summit

The largest display of energy data on the Pacific ever assembled is planned for the fourth Circum-Pacific Energy and Mineral Resources Conference to be held August 17-22, 1986, in Singapore.

Under the auspices of the Circum-Pacific Council for Energy and Mineral Resources, which was founded in 1972 by Michel T. Halbouty and has been affiliated with the American Association of Petroleum Geologists since 1982, 120 speakers are expected to address an international audience, 60 percent of which will be from countries other than the United States. At least 50 different data displays covering over 100 regions and contributed by approximately 170 scientists from 30 nations are scheduled to be shown to earth scientists and representatives of government and industry.

According to Halbouty, the conference is considered an energy "summit" that will set the stage for future exploration in the Pacific region. Further information may be obtained from Anthony P. Hatch, Public Affairs Chairman, Circum-Pacific Council, c/o Times/Mirror, Times Mirror Square, Los Angeles, CA 90053, phone (213) 972-3727; and, during the conference, from the Circum-Pacific Conference Press Office, Westin Raffles City Convention Center, 2, Stamford Road, Singapore, phone 338-8585.

— *Circum-Pacific Council news release*

Origin of the Willamette meteorite: An alternate hypothesis

by Richard N. Pugh, Science Department, Cleveland High School, 3400 S.E. 26th Street, Portland, OR 97202; and John Eliot Allen, Department of Geology, Portland State University, P.O. Box 751, Portland, Oregon 97207

INTRODUCTION

The Willamette meteorite was found in 1902 on the east side of the Tualatin Valley 2 mi northwest of West Linn, Oregon. It weighs 31,107 lbs, or slightly over 5½ tons. It is the largest meteorite ever found in the United States and the sixth largest ever found in the world (Lange, 1962). Did it really fall in Oregon?

HISTORY

Ellis Hughes found the meteorite in the fall of 1902 while he was cutting wood on land belonging to the Oregon Iron and Steel Company. In describing the find he said, "I sat down on the rock. It was about 1½ ft above the ground and very flat." Bill Dale came by and said, "Hughes, have you seen this rock before?" "Yes," I said, "I saw it yesterday. Then I picked up a large white stone and started to hammer on the rock. It rang like a bell." "Hughes," Dale said to me, "I'll bet it is a meteor" (Lange, 1962).

With the aid of his wife, his son, and a horse, Hughes was able to move the bell-shaped meteorite in a secretive manner the nearly three-quarters of a mile to his own property. This task took three months of sweat and toil and included the building of a road through the forest in order to transport the meteorite on a handmade, wooden-wheeled cart. Once Hughes got the meteorite on his land, he built a shed over it and charged sightseers 25¢ to view the space rock (Lange, 1958).

An attorney for the Oregon Iron and Steel Company was one of those who paid his quarter to see the meteorite. He also noted the road from the company's land. On November 27, 1903, the company sued Hughes, and after three court trials, the last in the Oregon Supreme Court, it was ruled that "Meteorites, though not imbedded in the earth, are real estate, and consequently belong to the owner of the land on which they are found" (Lange, 1962).

The meteorite was then transported to the Willamette River, where it was barged to Portland and exhibited at the 1905 Lewis and Clark Exposition. It was subsequently purchased by Mrs. William A. Dodge II of New York, who gave it to the American Museum of Natural History. When the Hayden Planetarium was added to the museum in 1936, it became the home of the Willamette meteorite.

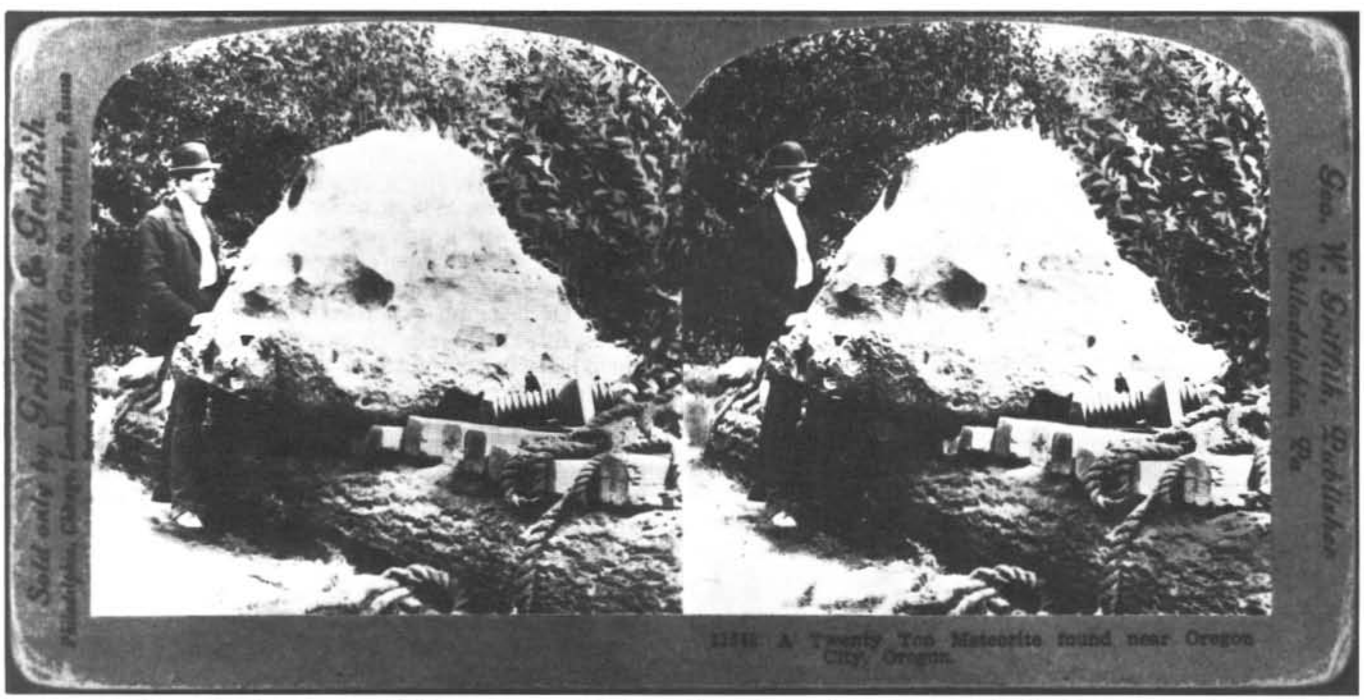
DESCRIPTION

The measurements (Ward, 1904) are: length, 10 ft, 3½ in.; breadth across the base, 7 ft; vertical height, 4 ft; circumference around the base, 25 ft, 4 in. The shape is that of the broad cone of an "oriented meteorite" (it is the largest one known). It is generally believed that this shape is the result of its orientation when it entered the atmosphere and the subsequent ablation as it came down point first through the air.

The meteorite is classified as a medium octahedrite, with a chemical composition of 91.5 percent iron, 7.62 percent nickel, and 0.45 percent cobalt, which places it in the chemical group IIIA. It went through two episodes of recrystallization and annealing before entering the earth's atmosphere (Buchwald, 1975).

The shallow pit from which the meteorite was removed still exists. It is lined with several inches of rust caused by the weathering. Several years ago, Russel A. Morley, research geologist of Salem, collected specimens and also soil samples for several feet around the crater. They gave positive tests for nickel, showing that the nickel leached from the meteorite had been deposited in the surrounding soil (Lange, 1965).

It has been calculated that at least 6 tons of the meteorite had rusted away during the last 13,000 years. This would mean that its weight when it first fell would have been in excess of 20 tons (Buchwald, 1975).



Stereopair photographs of Willamette meteorite in front of the Johnson farm. Photo supplied by Harry Czyzewski.

Willamette meteorite on wagon made by Ellis Hughes. Photo from Ward (1904).

Willamette meteorite in front of the Johnson farm. Photo supplied by Harry Czyzewski

The Willamette meteorite is unique for its great hollows, deep pits, basins, and holes, some of which pass entirely through the meteorite. "These excavations in our meteorite are clearly the result of the action of water " (Ward, 1904).

The number of solution holes and basins (some of them the size of small bathtubs) in the upper flat surface are the result of the acid action of decaying vegetable matter and the heavy Oregon rains. One of the components of the meteorite is triolite, or iron sulfide, which weathers to produce sulfuric acid and accelerates the corrosion. It is probable that some of the holes and basins once contained larger amounts of triolite than the rest of the meteorite.

ORIGIN

A lobe of the continental ice sheet, coming down the Purcell trench and up the Clark Fork River southeast of Lake Pend Oreille, Idaho, formed 2,500-ft-high ice dams that repeatedly impounded up to 500 cu mi of water in ice-age Lake Missoula.

Each time the water in the lake reached a height sufficient to float and undermine the ice in the dams, they shattered and broke up, releasing tremendous amounts of water that roared across eastern Washington and down the Columbia River. This occurred at least 40 times at intervals of about every 55 years for over 2,000 years.

These cataclysmic floods, which swept through the Oregon City area and on up the Willamette Valley as far south as Eugene between 15,000 and 12,800 years ago, reached an elevation of nearly 400 ft. In them, floating icebergs from the ice dams carried frozen within them thousands of blocks of rock and debris that had been carried down by the ice lobe from Canada.

Willamette meteorite showing bowl-shaped cavities. Photo from Ward (1904).

As each flood receded, some of the icebergs were stranded, and they melted and released their loads. More than 300 "erratic" boulders and rocks of granite, granodiorite, gneiss, and other rocks from Canada were found and mapped 50 years ago within the Willamette Valley by Ira Allison (1935) of Oregon State University.

The largest such erratic found in Oregon is the one on a spur at 302-ft elevation between Sheridan and McMinnville, in Oregon's smallest state park. It originally weighed 160 tons, nearly eight times as much as the original 21-ton weight of the Willamette meteorite.

The location of the Willamette meteorite, 2 mi from the mouth of the Tualatin River near the top of a spur at 380 ft elevation, is near the center of sec. 27, T. 2 S., R. 1. E. The location formerly cited in the literature is in error by nearly 5 mi; the accurate location is lat. 45° 22′ 6″ N., long. 122° 40′ 7″ W.

Since this is an ideal spot for one of the icebergs, coming up the Tualatin Valley in a side eddy from the main flood in the Willamette, to have been stranded and to have dropped its load, both the authors, for 20 years, have toyed with the hypothesis that the meteorite was rafted in, frozen in an iceberg.

The original weight of the meteorite was 21 tons. Simple calculations show that it could have been floated within an iceberg cube only 25 ft on a side.

Until a few months ago, this idea was just a hypothesis, a suggestion derived from circumstantial evidence. Last year, Pugh, with the help of Carole Lange, was able to relocate the site where the meteorite was found. In digging around near the almost-filled shallow hole from which it was taken, Pugh again found the abundant fragments of iron rust from the weathered surface of the meteorite (Allen, 1936), but he also found something much more important.

While walking around the area he found, 600 ft directly down the slope, a 12-inch boulder composed of granodiorite, which does not occur in bedrock within the Willamette Valley. Later, after clearing brush, poison oak, and blackberries from the hole, he found dozens of small erratic pebbles of granite within 3 ft of the depression. Remember that Ellis Hughes refers to picking up a "white rock" at the site which he used to pound on the meteorite.

Pugh suggests that, since a cone-shaped meteorite falls point down, the Willamette meteorite would have imbedded itself in

*(Continued on page 85, **Meteorite**)*

Geothermal exploration in Oregon, 1985

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

LEVEL OF GEOTHERMAL EXPLORATION

Introduction

Despite signs of improvement in the nation's financial conditions, the geothermal industry in general has been negatively influenced by falling petroleum prices and an overall power surplus in the Pacific Northwest. The results in Oregon have been a decline in the number of lease applications filed, the amount of acreage leased, and the level of exploration drilling.

Drilling activity

Figure 1 shows the number of geothermal wells drilled and geothermal drilling permits issued in Oregon. Table 1 lists new geothermal drilling permits issued in 1985. The apparent increase to 11 permits (as compared to six for 1984) is somewhat misleading, as eight of the 11 issued permits are actually renewals of expired permits. The permits in this group of renewals were filed by California Energy Corporation for sites along the east margin of Crater Lake National Park and Newberry volcano.

The remaining three permits listed in Table 1 were issued to GEO Operator Corporation. Two of their permit applications are for holes on the flanks of Newberry volcano and are part of the U.S. Department of Energy's industry-coupled drilling program. GEO Operator's N-1 hole, located on the south flank, has been drilled to 1,387 m and is discussed in a later section. The N-3 hole, located on the north flank, is scheduled for drilling in 1986. The third GEO Operator Corporation permit was issued for a hole in the Vale Known Geothermal Resource Area (KGRA).

Plans were also announced for the drilling of two other wells in the Cascades as part of the cost-sharing agreement between the U.S. Department of Energy (USDOE) and industry. Thermal Power will drill a 1,524-m-deep well in the Olallie Butte-Sisi Butte area (northwest of Mount Jefferson) in the summer of 1986. This site was permitted in early 1986 and therefore is not listed in Table 1. John Hook and Associates have also been accepted as participants in the USDOE program and are expected to drill in the Blue Lake area of Santiam Pass in the fall of 1986, pending further negotiations with USDOE

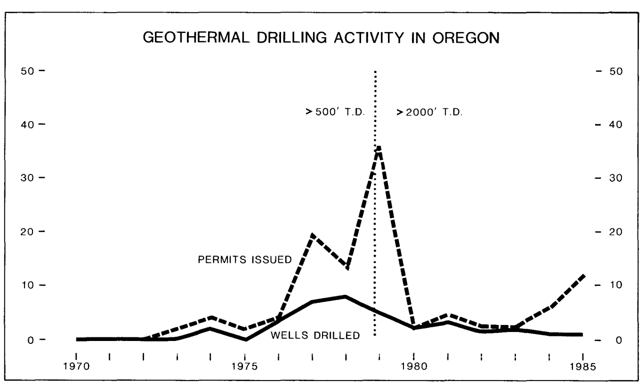


Figure 1. Geothermal well drilling in Oregon. Vertical line indicates time when definition of geothermal well was changed to a depth greater than 2,000 ft. Note that eight of the 11 new permits are for previously permitted sites (under different permit numbers).

Table 1. *Permits for geothermal drilling in 1985*

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
113	California Energy MZI-3 035-90011	SW¼, sec. 12 T. 30 S., R. 6 E. Klamath County	Application; 4,000.*
114	California Energy MZI-9 035-90012	NW¼, sec. 11 T. 31 S., R. 7½ E. Klamath County	Application; 4,000.*
115	California Energy MZI-11 035-90013	SW¼, sec. 15 T. 31 S., R. 7½ E. Klamath County	Application; 4,000.*
116	California Energy MZI-11A 035-90014	SW¼, sec. 10 T. 31 S., R. 7½ E. Klamath County	Application; 4,000.*
117	California Energy MZII-1 035-90015	SE¼, sec. 13 T. 32 S., R. 6 E. Klamath County	Application; 4,000.*
118	GEO Operator N-1 017-90013	NW¼, sec. 25 T. 22 S., R. 12 E. Deschutes County	Suspended; 4,550.
119	GEO Operator N-3 017-90014	NW¼, sec. 24 T. 20 S., R. 12 E. Deschutes County	Application pending; 4,000.
120	California Energy CE-NB-1 017-90015	NW¼, sec. 16 T. 22 S., R. 12 E. Deschutes County	Application; 4,000.*
121	California Energy CE-NB-2 017-90016	SE¼, sec. 18 T. 22 S., R. 13 E. Deschutes County	Application; 4,000.*
122	California Energy CE-NB-3 017-90017	NW¼, sec. 16 T. 22 S., R. 13 E. Deschutes County	Application; 4,000.*
123	GEO Operator VF #1 045-90006	NW¼, sec. 11 T. 19 S., R. 45 E. Malheur County	Application; 10,000.

* *New application on expired permit*

(John Hook, personal communication, 1986).

Figure 2 shows that virtually no prospect holes (shallower than 152 m in depth) were drilled in 1985. This reflects both the general decline of geothermal exploration in Oregon and also the fact that areas that are undergoing active geothermal exploration in the Cascade Range must be drilled to depths of 600 to 1,500 m in order to yield meaningful temperature-gradient and heat-flow data.

Leasing

Figure 3 shows the change of pattern of active geothermal leases of federal lands in Oregon from 1974 through 1985. Both it and Table 2 indicate that the total number of federal leases declined by 15 percent in 1985. The greatest decrease (in acres) is in noncompetitive leases on lands administered by the U.S. Forest Service (USFS). This decrease in leased Forest Service lands is partially a result of Sunedco Development Corporation's abandonment of its Cascade lease positions despite the generally favorable results of its geothermal exploration program. The Sunedco 58-28 well, drilled in the Breitenbush area in 1981, encountered a hot aquifer (115° C from a thermistor probe; 136° C from a maximum-reading thermometer) at 752 m. Geologic and temperature data in preparation by Oregon Department of Geology and Mineral Industries (DOGAMI) personnel and by Albert Waibel of Columbia

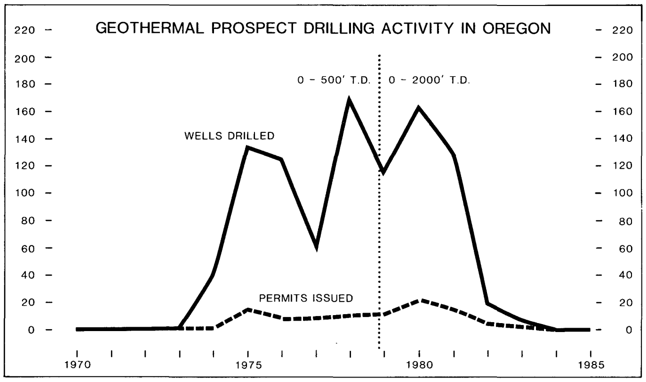


Figure 2. Geothermal prospect-well drilling in Oregon. Vertical line indicates time when definition of prospect well was changed to a depth less than 2,000 ft.

Geoscience indicate that the aquifer dips to the east and consequently may be encountered at greater depths and higher temperatures in poten-tial drill sites to the east. Well 58-28 was drilled to a total depth of 2,457 m. Bottom-hole temperatures from maximum-reading thermometers suggest that the average gradient for the hole is very close to the estimated regional gradient for the Cascade heat-flow anomaly (60° C/km, Blackwell and others, 1978, 1982).

Table 2. *Geothermal leases in Oregon, 1985*

Types of leases	Numbers	Acres	
Federal active leases:			
Noncompetitive, BLM	41	59,027	
Noncompetitive, USFS	242	461,426	
KGRA, BLM	9	24,062	
KGRA, USFS	2	1,400	
Changes during 1985:			
Total 1/1/85	343	641,499	
Noncompetitive, BLM	-6	-14,533	(-20%)
Noncompetitive, USFS	-32	-60,739	(-12%)
KGRA, BLM	-6	-11,920	(-33%)
KGRA, USFS	-5	-8,391	(-86%)
Subtotal	-49	-95,583	(-15%)
Total 12/31/85	294	545,916	
Federal leases relinquished:			
Noncompetitive, BLM	219	346,220	
Noncompetitive, USFS	68	131,788	
Competitive, BLM	49	89,185	
Competitive, USFS	7	11,565	
Federal leases pending:			
Noncompetitive, BLM	0	0	
Noncompetitive, USFS	213	No data	
State leases:			
Total active in 1985	No data	No data	
Total applications pending (1985)	No data	No data	
Private leases:			
Total active in 1985	No data	No data	

Results of new drilling at Newberry volcano

GEO Operator drilled a hole (N-1) on the south flank of Newberry volcano (Figure 4) to a total depth of 1,387 m. The cost of drilling the upper 1,219 m was shared by USDOE, while the lower 168 m of the hole was funded solely by GEO Operator Corporation. The information collected from the surface to 1,219 m is therefore available to the public and is partially presented here. The information collected from the last 168 m is the property of GEO Operator. Core was collected from 148 to 1,355 m.

The temperature profile presented in Figure 5 is from data collected one week after completion of the hole and is therefore not yet stable. The mud circulated during drilling has the effect of warming the upper portion of the hole and cooling the lower portion. Mud circulation is therefore a moderating influence on the thermal gradient. It is expected that the stable temperature profile (to be collected in the summer of 1986) will have a somewhat higher bottom-hole temperature and gradient than presented here.

The profile for N-1 (Figure 5) is essentially isothermal to a depth of 800 m. This isothermal zone is characterized by andesites, basalts, and basaltic andesites. The drill log reports circulation losses for portions of this interval, and it is probable that circulation of meteoric water and air has "washed out" the normal temperature gradient in this zone. From 800 m to 1,000 m, the temperature slowly increases, and the gradient for this zone increases from 26° C/km in the upper part to 69.5° C/km in the lower part.

At 1,000 m, the gradient is very high, marked by a rapid increase in temperature from 17° to 45° C. From 1,040 m to approximately 1,160 m, the gradient is 129.5° C/km. From 1,180 m to 1,219 m, the average gradient decreases slightly to 90.7° C/km. The gradient from 1,207 m to 1,219 m is 86° C/km. Therefore it appears the gradient is in transition and decreasing in the lower part of the well.

Blackwell and Steele (1983) suggested that the background gradients and heat flow for Newberry volcano are 40°-65° C/km and 1.9-2.5 heat-flow units (HFU), respectively. Although the gradients in the lower part of the N-1 well are decreasing, all are above the regional background gradient expected for this area. Once heat-flow values are determined from conductivity measurements and stabilized temperature profiles, a more definitive interpretation will be possible.

KGRA SALES

No KGRA lands were offered for bid in 1985.

DOGAMI RESEARCH

Total-field aeromagnetic anomaly maps for the northern Cascade Range were published by DOGAMI in 1985 as GMS-40 (Couch and others, 1985). The maps were authored by R.W. Couch, M. Gemperle, and R. Peterson of the Oregon State University Geophysics Group. Publication of these maps completes aeromagnetic coverage of the Oregon Cascade Range.

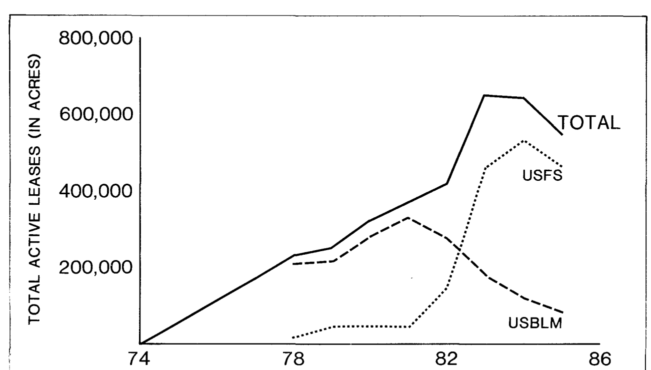


Figure 3. Active geothermal leases on federal lands in Oregon from the inception of leasing in 1974 through December 1985. Note changes in pattern over time.

DOGAMI geothermal staff completed mapping in the Breitenbush River and Coffin Butte areas of the central Oregon Cascade Range. Two maps, each encompassing the area of a standard 15-minute quadrangle, are scheduled for publication in late 1986. Field work for the 1986 field season will consist primarily of mapping in the McKenzie Bridge quadrangle in the central Oregon Cascades. This map is scheduled for release in 1987. Some additional mapping will be completed in the vicinity of the Thermal Power drillhole, which is scheduled to be drilled this summer northwest of Olallie Butte.

In addition to the two maps mentioned above, several other geothermal-related publications are scheduled for release by DOGAMI in 1986. Work has progressed on the plan for deep drilling in the central Cascades. A nontechnical summary, *A Program for Scientific Drilling in the Cascades, Northern California, Oregon, and Washington,* was published in March 1986. A more detailed technical discussion of the plan for deep drilling will be published as a DOGAMI open-file report later in 1986.

Additional publications include a recently released openfile report (O-86-2) that summarizes all heat-flow data generated by DOGAMI since 1982 and two upcoming publications—a publication containing a geologic map of the northwest quarter of the Broken Top quadrangle by E.M. Taylor of Oregon State University and an *Oregon Geology* article on hydrothermal alteration in Sandia Laboratories Newberry volcano drill hole RDO-1 by T.E.C. Keith, U.S. Geological Survey (USGS); M.W. Gannett, Columbia Geoscience and now Oregon Department of Water Resources; J.C. Eichelberger, Sandia National Laboratories; and A.F. Waibel, Columbia Geoscience.

U.S. GEOLOGICAL SURVEY ACTIVITIES

The USGS continued to work on Cascade projects during 1985. The USGS program in Oregon has consisted chiefly of surface geological and geophysical surveys of young Cascade volcanoes.

Preliminary results from the Newberry seismic experiment in 1984 were presented to the Geothermal Resources Council in August 1985 (Stauber and others, 1985). The high-resolution seismic imaging experiment discovered a ring of high-*P*-velocity material in the upper 2 km around the caldera ring-fault system. A low-velocity zone was found in the center of the caldera. Stauber and others (1985) concluded that the "low-velocity zone in the center of the caldera is inferred to extend somewhat deeper than the high-velocity ring and is a possible source region for the high-silica rhyolitic magmas which have erupted in the caldera several times in the last 6,000 years." This statement stops short of saying that the low-velocity zone is in fact a silicic magma chamber with substantial percentages of molten rock. Further experiments, perhaps concentrating on seismic shear wave analysis, may help to determine if there is a molten magma body under the caldera (Stauber, personal communication, 1986). In view of the high expense of the shear wave experiments (Stauber, personal communication, 1986) and the shallow depth of the anomaly, drilling into the low-velocity zone may be the best means of determining if it is molten or not.

In May 1985, the USGS sponsored a workshop at its Menlo Park, California, headquarters on the geothermal resources of the Cascades. Numerous Cascade researchers, chiefly from the USGS, gave papers summarizing their research in Oregon, California, and Washington. The proceedings were published as USGS Open-File Report 85-521 (Guffanti and Muffler, 1985). Many of the papers presented summaries of old data. New geophysical models of electrical data from Mount Hood and presentation of a new geothermometer were highlights of the meeting. The electrical data at Mount Hood showed a number of conductive zones that could be geothermal reservoirs under the volcano (Goldstein, 1985). Robert Mariner (1985) presented a new geothermometer based on anhydrite saturation. Anhydrite-estimated reservoir temperatures for Austin Hot Springs (186° C), Breitenbush Hot Springs (174° C), Bigelow Hot Springs (155° C), Belknap Hot Springs (152° C), Rider Creek Hot Springs (135° C), Wall Creek Hot Springs (160° C), McCredie Hot Springs (130° C), and Kitson Hot Springs (134° C) are comparable to values of the sulfate-water geothermometer but much higher than estimates by most other standard geothermometers. Mariner (1985) also determined that the headwaters of the Metolius River and the Spring River contribute anomalously high amounts of chloride to streams flowing out of the east-central High Cascades. Similar high chloride contents were measured in Blue Lake, a young explosion crater near Santiam Pass on the eastern slope of the High Cascades (Johnson and others, 1985). This high chloride content may be indicative of geothermal resources at depth.

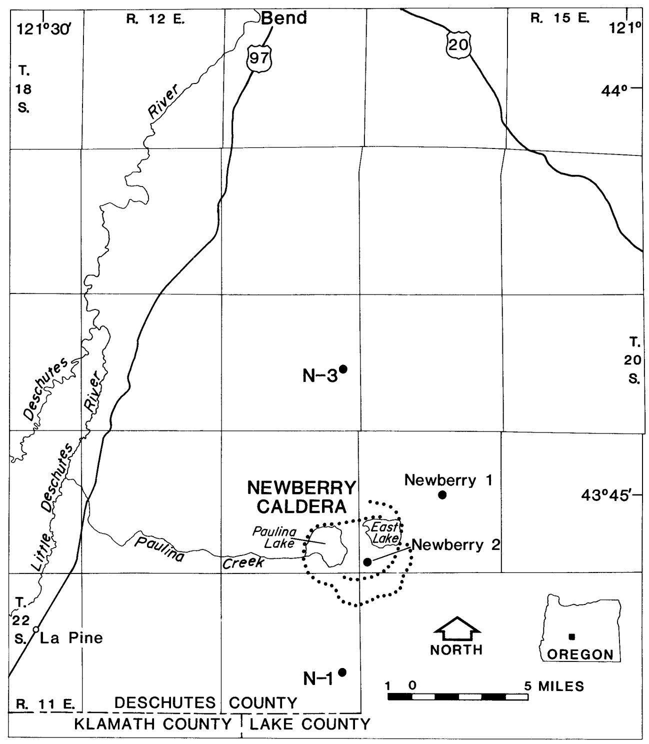


Figure 4. Location of GEO Operator Corporation wells on the flanks of Newberry volcano.

The Water Resources Division of the USGS started work on the hydrology of the central Oregon Cascades in 1985. The project is continuing in 1986 and includes an examination of surface waters from the Clackamas River south through the McKenzie River drainage. Samples are being taken for complete chemical and isotopic analysis. A complete well inventory and the acquisition of additional heat-flow data are also part of the study (Steve Ingebritsen, personal communication, 1986).

Other projects for 1986 include the publication of a paper on the flow test at the Newberry 2 drill hole. Authors are S.E. Ingebritsen, W.W. Carothers, R.H. Mariner, J.S. Gudmundsson, and E.A. Sammel. Sammel is also back from retirement working under contract on hydrologic modeling of Newberry volcano (Steve Ingebritsen, personal communication, 1986).

ACTIONS OF REGULATORY AGENCIES CONCERNING GEOTHERMAL EXPLORATION

The Oregon Land Use Board of Appeals ruled against proposed development of a patented claim in the interior of Newberry caldera. The affected claim, involving 157 acres in the central pumice cone, is owned by La Pine Pumice Company. The claim is totally surrounded by the resort area of Newberry caldera, which comprises two lakes, numerous campsites, and horse and hiking trails. The area is administered by the Fort Rock Ranger District of the Deschutes National Forest. The entire caldera is banned from geothermal development by the draft Deschutes National Forest Plan. The proposed development was valued at $15 million.

The decision was appealed and upheld by the Oregon Court of Appeals. In April, the Oregon Supreme Court denied a petition for review of the lower court decision, apparently killing any prospect for geothermal development inside Newberry caldera in the near future.

The U.S. Bureau of Land Management (BLM) has granted Geothermal Resources International, Inc. (GRI), a unitized claim on geothermal resources in the area surrounding Newberry caldera. The geothermal resource unit includes 240,000 acres, of which GRI has the geothermal rights on about 170,000 acres.

An appeal filed by the Sierra Club has led to the suspension of open leasing on 541,000 acres in the Bend and Crescent Ranger Districts of the Deschutes National Forest. The areas involved surround the Cascade Lakes Highway and proposed research natural areas and wetlands. The appeal suspended 19 existing leases. The USFS originally completed environmental impact statements (EIS) for the involved areas and decided to open the lands to geothermal leasing. The BLM, which handles geothermal leasing for the USFS, was satisfied with the USFS assessment and approved leasing. The Sierra Club contended, however, that BLM was required to complete its own environmental assessment before issuing leases. The Interior Board of Land Appeals supported the position of the Sierra Club. BLM must either complete an environmental assessment before reissuing the leases or reissue the leases with a no-surface occupancy proviso until the EIS is completed. At this time, the leases have not been reissued.

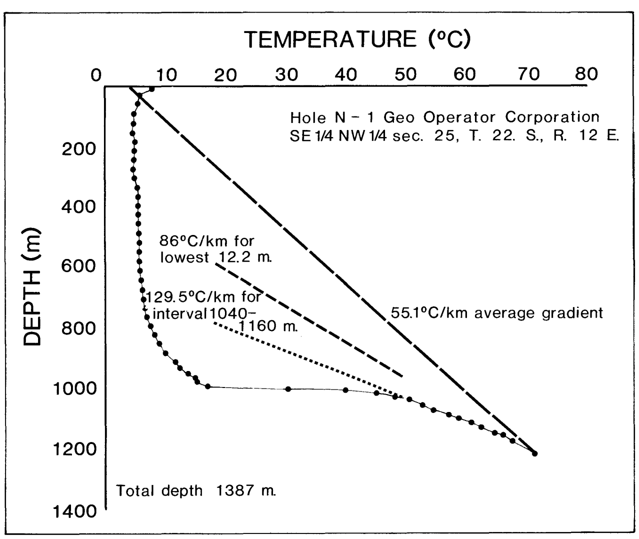


Figure 5. Temperature-depth profile of the upper 1,219 m of GEO Operator Corporation hole N-1, located on the south flank of Newberry volcano.

LOW-TEMPERATURE UTILIZATION

Klamath Falls

A geothermal resource management act was passed by the City of Klamath Falls in an effort to effectively develop and manage the low-temperature geothermal resource. Geothermal space heating is currently used in Klamath Falls to heat many public municipal buildings, Oregon Institute of Technology (OIT) campus buildings, and many private residences. The act (1) requires permitting of all new geothermal wells, (2) implements a free, voluntary registration of all privately owned geothermal wells, with the data to be stored in the recently formed Geothermal Data Center, and (3) requires discontinuance of surface discharge of geothermal waters within five years.

Consultants hired by the City of Klamath Falls to study recent drops in ground-water levels and to determine the feasibility of expanding the geothermal space heating base submitted their findings in late 1985. They found (1) the City heating system, which supplies heat to nine municipal buildings, had only minor impact on the geothermal aquifer, and continued usage of the system would not have much effect on the aquifer; (2) the decline in the aquifer was due to surficial discharge of thermal waters and/or increased demand on the aquifer in recent cold winters; (3) the considerable horizontal and vertical permeability in the geothermal system minimized the need to reinject water into specific zones of the system; and (4) surficial discharge could feasibly be used to expand district heating in the College Industrial Park and Mills addition, where 150 to 200 more homes could be added to the system. They also found that the city's two production wells could bear substantially increased loads.

The City of Klamath Falls has just started construction of a system to heat buildings on E. Main Street. The basic system will consist of a collection main that will supply heat to a secondary heat exchanger. A secondary supply loop will actually heat the buildings. Water for the collection system will be obtained from wells presently discharging into the storm sewer system. There are approximately 100 potential wells available to supply the system. Waste water from the collection main will be reinjected into the museum well, which is the reinjection well for the main Klamath Falls downtown heating system.

The U.S. Department of Housing and Urban Development (HUD) made funds available to private residences to tie into the existing geothermal system. The funds were originally in the form of low-interest loans, but the program eventually evolved into outright grants to homeowners who wished to take part in the program when the public response was very sluggish. When it became clear that there was still no significant public response, the City of Klamath Falls was forced to return $100,000 of the original $125,000 grant to HUD in early 1986.

Vale

Oregon Trail Mushrooms is producing mushrooms with geothermal heating at Vale. 110° C water is used to develop a compost which will support a strain of bacteria used by the mushrooms. The raw materials in the compost are straw, poultry manure, gypsum, and water, and the compost matures in four to five weeks. The plant is capable of producing 3.5 million pounds of mushrooms per year.

OREGON INSTITUTE OF TECHNOLOGY

The Oregon Institute of Technology (OIT) in 1985 continued with its technical assistance program which has been funded since the early 1970's by grants from USDOE. The program publishes a quarterly bulletin, provides speakers and tours on the direct use of geothermal energy, and provides up to 64 hours of feasibility analysis for small-scale geothermal developers. Funding for the program ran out on June 30, 1986, but it is hoped that funding for the program will be renewed (Paul Lienau, personal communication, 1986).

In 1985, OIT also continued its program of feasibility studies for direct-use projects in the State of California. The program is two years old and will continue in 1986.

Other projects planned for this year include a feasibility study of heating the Industrial Park with waste water from the OIT campus and from the Merle West Medical Center and an evaluation of the binary generator at the Wabuska, Nevada, geothermal site.

At the present time, the OIT campus discharges 400-600 gallons per minute (gpm), and the Merle West Medical Center discharges an average of 150 gpm (300 gpm peak) of 140°-150° F waste water into the storm sewer system. The OIT study will determine if three existing wells in the industrial park are suitable as injection wells. These wells, ranging in depth from 400 to 1,500 ft, were originally drilled as geothermal production wells but were cold. The ultimate plan is to use waste water to heat buildings in the industrial park and then to discard the waste water in injection wells (Paul Lienau, personal communication, 1986).

The evaluation of the binary ORMAT generator at the Wabuska, Nevada, site is a joint project in cooperation with Engineering Power Research Institute, ORMAT Systems, Sierra Pacific, and Tads Enterprises. Funding is provided by a grant from the Oregon Department of Energy (ODOE).

OREGON DEPARTMENT OF ENERGY ACTIVITIES

In 1985, ODOE supported some OIT activities, subcontracted a number of studies to OIT, and responded to inquiries on geothermal energy and development from the public. Other ODOE functions include reviews of applications for state tax credits for geothermal heating development and technical support for the Northwest Power Planning Council. These activities are expected to continue in 1986.

ODOE, in cooperation with the Washington State Energy Office (WSEO), recently completed a study for the Bonneville Power Administration (BPA). The purpose of the study was to verify economic assumptions identified in the BPA four-state study. The primary focus was on ownership and financing relationships. The report has been submitted to BPA (Alex Sifford, personal communication, 1986).

In the fall of 1986, ODOE will publish a study of the district heating potential in the state. The study will include all potential heating sources (Alex Sifford, personal communications, 1986).

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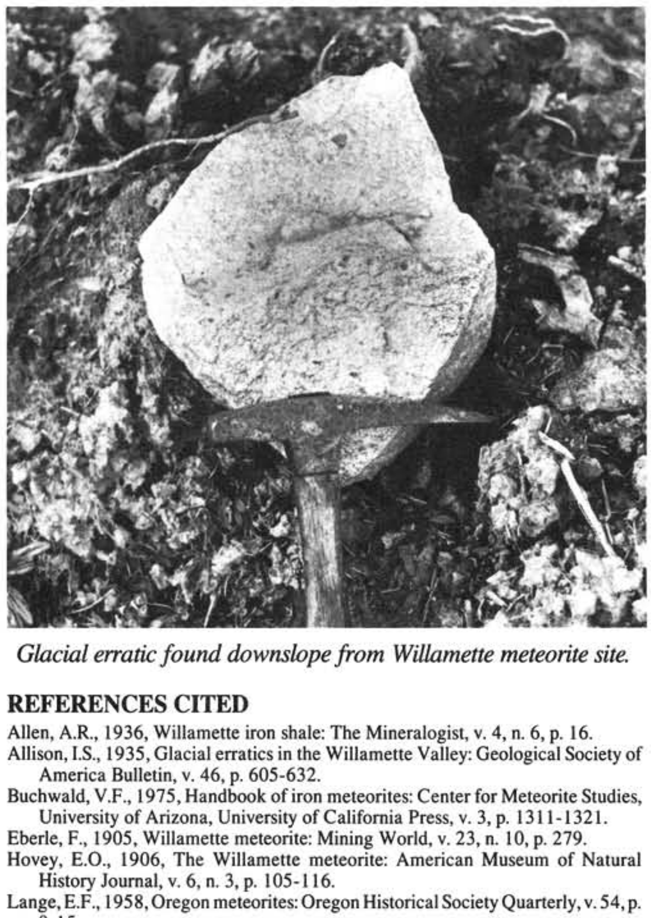
***(Meteorite**, continued from page 80)*

the Cordilleran ice sheet in Canada in this position. During the flood, it would have acted as ballast within the iceberg, keeping the same position as it floated down the Columbia in the flood. When the iceberg stranded and melted, the meteorite would gently sink into the soil and remain in an oriented position with the flat side up.

There now appears to be reasonable doubt that the Willamette meteorite fell in Oregon. Instead, it could have come to Oregon from Canada via the ice sheet, making the final long journey from northern Idaho frozen in an iceberg.



Glacial erratic found downslope from Willamette meteorite site.

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Wermiel joins DOGAMI staff as petroleum geologist

Dan E. Wermiel has joined the staff of the Oregon Department of Geology and Mineral Industries (DOGAMI) as petroleum geologist. He earned a Bachelor of Science degree from the University of Miami, Florida, and a Master of Science degree from Arizona State University, Tempe, Arizona. Wermiel was employed with Barrett Resources in Denver, Colorado, as Vice-President of Geology.

Dan E. Wermiel

During his career, Wermiel has directed exploratory and development drilling programs, done surface and subsurface geology and petrophysical analysis of well logs, and prepared and reviewed drilling permits and programs.

His responsibility with DOGAMI will be the evaluation of proposed drilling programs, interpretation and application of Oregon rules and statutes, and field inspections of drilling operations. □

DOGAMI geologist co-authors USGS map

Len Ramp, Resident Geologist in the Grants Pass field office of the Oregon Department of Geology and Mineral Industries (DOGAMI), and Barry Moring, geologist with the U.S. Geological Survey (USGS), have collaborated on the recent publication of USGS Miscellaneous Field Studies Map MF-1735, *Reconnaissance Geologic Map of the Marial Quadrangle, Southwestern Oregon* (1986).

The map covers the geologically most interesting section of the Wild and Scenic Rogue River area and helps explain some of the more hazardous riffles such as Blossom Bar. The Marial quadrangle, situated on the border between northeast Curry County and northwest Josephine County, represents a previously unmapped area covering much of the Shasta Costa Creek drainage and a portion of the Mule Creek, Indigo Creek, and Silver Creek drainages.

The black-and-white map at a scale of 1:62,500 describes 21 rock units, most of them of Cretaceous and Jurassic age, as well as the geologic structure of the area. It outlines areas of sheeted diabasic dikes exposed along the Rogue River, Mule Creek, and Shasta Costa Creek that were described by Len Ramp and Floyd Gray in a 1980 article in *Oregon Geology* (v. 42, no. 7, p. 119-124).

The map is available for purchase from usual USGS outlets or from DOGAMI's Portland office. The price is $1.50. □

Coos Bay club displays minerals in Salem

On June 7th, the Far West Lapidary and Gem Society of Coos Bay installed a new exhibit in the display case of the Oregon Council of Rock and Mineral Clubs at the State Capitol Building in Salem. Fifteen Oregon counties provided more than 90 separate items in 32 groupings for this display, which was arranged by Bert Sanne and Jeanne Larson of the Coos Bay club, assisted by George Larson, Cecelia Haines, and Lyle Riggs, who is the Council's agent for the display case.

Featured in the center of the exhibit is a hanging lamp made with several kinds of obsidian from Harney County. The arrangements include plume, tube, and snake skin agate; jade; Biggs jasper; thundereggs; serpentine; sagenite; carnelian; rhodonite; vistaite; fossils; petrified wood; limb casts; opal fashioned into bracelets; and faceted sunstones. Newly installed fluorescent lights have added to the beauty of the exhibit.

The current display will remain at the Capitol until early September, when the Eugene Mineral Club will present its display. Capitol Building hours are 8 a.m. to 5 p.m. on weekdays, 9 a.m. to 4 p.m. on Saturdays, and noon to 4 p.m. on Sundays. □

Correction

Two errors marred the printing of last month's article on the Simtustus Formation (*Oregon Geology*, v. 48, no. 6, p. 63-72). In order to correct them, we are reprinting here photo B from page 67, which suffered from excessive cropping, and three references from "References Cited" that got somewhat tangled:

Lower Simtustus Formation at Pelton Dam. Arrow points to air-fall tuff within tuffaceous mudstone.

Farooqui, S.M., Beaulieu, J.D., Bunker, R.C., Stensland, D.E., and, Thoms, R.E., 1981a, Dalles Group: Neogene formations overlying the Columbia River Basalt Group in north-central Oregon: Oregon Department of Geology and Mineral Industries, Oregon Geology, v. 43, no. 10, p. 131-140.

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