OREGON GEOLOGY

formerly THE ORE BIN

published by the Oregon Department of Geology and Mineral Industries

VOLUME 42, NUMBER 4 APRIL 1980

OREGON GEOLOGY
(ISSN 0164-3304)

VOLUME 42, NUMBER 4 APRIL 1980

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

Main Office: 1069 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.
Standley L. Ausmus, Supervisor

Subscription rates: 1 year, $4.00; 3 years, $10.00. Single issues, $.40 at counter, $.50 mailed.
Available back issues of *The Ore Bin:* $.25 at counter, $.50 mailed.

Address subscription orders, renewals, and changes of address to *Oregon Geology,* 1069 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,* 1069 State Office Building, Portland, OR 97201.

COVER PHOTO

Temperature-gradient drilling on southern flanks of Mt. Hood, Oregon. Article beginning on next page summarizes geothermal exploration activities within the State during 1979.

Department of Geology begins mid-Willamette Valley rock resource study

The Oregon Department of Geology and Mineral Industries (DOGAMI) has initiated a two-year study of the rock material resources of Marion, Polk, Yamhill, and Linn Counties. The study is sponsored by DOGAMI, the Pacific Northwest Regional Commission, and the Oregon Land Conservation and Development Commission.

Because of the significance of rock material in the regional economy, the Department is giving high priority to the development of supply assessments, and the mid-Willamette Valley represents an economic market area of particular importance.

The study will provide basic supply data on land with potential for sand, gravel, and stone production, including a geological unit base map and an inventory of approximately 800 pits and quarries. By combining inventory information with geologic maps and by addressing demand as well, it will establish a broad framework for policy formulation and decision-making in land use and resource management.

Contact person for this study is Jerry J. Gray, Oregon Department of Geology and Mineral Industries, 1129 S.E. Santiam Road, Albany, Oregon 97321, phone (503) 967-2039. □

CONTENTS

NEXT MONTH

Miocene Stratigraphy and Fossils, Cape Blanco, Oregon, by Warren Addicott, U.S. Geological Survey

Geothermal exploration in Oregon, 1979

by Joseph F. Riccio, Geothermal Specialist, and Dennis L. Olmstead, Geologist, Oregon Department of Geology and Mineral Industries

ABSTRACT

Government agencies and university researchers continued their geothermal research effort in Oregon during 1979. The Oregon Department of Geology and Mineral Industries placed emphasis on the evaluation of Oregon's low-temperature resource areas and the geothermal potential of the central Cascades.

Industrial exploration decreased, and no major discoveries were reported. The major effort by industry was the drilling of the 10,050-ft well at Ontario, Malheur County, by Ore-Ida Foods, Inc. During the year, the Department issued permits for 201 temperature-gradient holes less than 500 ft deep and for 35 holes more than 500 ft deep. Ninety shallow and 29 deep holes were actually drilled.

INDUSTRY ACTIVITY

Oregon's deepest geothermal test well (depth 10,050 ft) to date was drilled in Ontario, Malheur County (Figure 1), at a cost of $4.8 million, by Ore-Ida Foods, Inc., in conjunction with the U.S. Department of Energy (USDOE). The well was spudded on August 19, 1979, by Montgomery Drilling Company of Bakersfield, California. Temperatures approximating 400°F were reported from this hole; however, the amount of geothermal fluid recovered from an initial drill-stem test was not sufficient in volume to warrant completion of the well. The hole is currently shut-in, pending further geologic and engineering analyses and additional testing.

The Eugene Water and Electric Board (EWEB) initiated and completed the drilling of six temperature-gradient holes in the central Cascades (Figure 2). Maximum depth of exploration was 1,960 ft. This undertaking was in conjunction with Southland Royalty Company and Sunoco Energy Development Company. Funding, in part, was by USDOE.

The remainder of the exploration effort by industry (Tables 1 and 2) was restricted to the drilling of temperature-gradient holes to depths ranging from 500 to 2,000 ft. Prior to September 1, 1979, prospect wells included only those drilled to 500 ft or less. According to the present Oregon law relating to geothermal exploration and development, however, the term "prospect well" includes any geophysical test well, seismic shot hole, mineral exploration drilling, core drilling, or temperature-gradient test well that is less than 2,000 ft in depth and is drilled during the prospecting for geothermal resources. This change in the law influenced the 1979 trends shown on the graphs in Figures 3 and 4 and the data presented in the abstract.

Old Maid Flat 1, the geothermal exploratory test well drilled on the flanks of Mt. Hood by Northwest Geothermal Corporation, is still shut-in. Plans are currently being formulated to obtain fluid samples for geochemical analyses from several of the potentially producing aquifers. If these tests prove successful, flow testing of the well may be considered for late summer of 1980.

Leasing

Acquisition of geothermal leases continued in Oregon during 1979. The total Federal acreage leased

Figure 1. Ore-Ida Foods, Inc., Well 1, Ontario, Malheur County, Oregon.

Table 1. *Geothermal permits and drilling activity in Oregon, 1979*

Permit no.	Operator	Well name	Location	Total depth (ft)	Status
37	Anadarko Production	Alvord Valley Hole A-7	SW¼ sec. 18 T. 33 S., R. 36 E. Harney County	–	Location, proposed depth 2,000 ft.
38	Anadarko Production	Alvord Valley Hole A-8	SE¼ sec. 14 T. 33 S., R. 35 E. Harney County	–	Location, proposed depth 2,000 ft.
39	Anadarko Production	Alvord Valley Hole A-26	NE¼ sec. 29 T. 34 S., R. 34 E. Harney County	–	Location, proposed depth 2,000 ft.
40	Anadarko Production	Alvord Valley Hole A-31	SW¼ sec. 34 T. 34 S., R. 34 E. Harney County	–	Location, proposed depth 2,000 ft.
41	Anadarko Production	Alvord Valley Hole A-34	NE¼ sec. 8 T. 35 S., R. 34 E. Harney County	–	Location, proposed depth 2,000 ft.
42	Anadarko Production	Alvord Valley Hole B-56	SE¼ sec. 10 T. 37 S., R. 33 E. Harney County	–	Location, proposed depth 2,000 ft.
43	Anadarko Production	Alvord Valley Hole B-61	SW¼ sec. 13 T. 37 S., R. 33 E. Harney County	–	Location, proposed depth 2,000 ft.
44	Anadarko Production	Alvord Valley Hole B-64	NW¼ sec. 22 T. 37 S., R. 33 E. Harney County	–	Location, proposed depth 2,000 ft.
45	U.S. Geological Survey	Newberry Crater 2	SW¼ sec. 31 T. 21 S., R. 13 E. Deschutes County	2,076	Drilling suspended October 1979; will deepen to 3,000 ft in 1980.
46	Ore-Ida Foods, Inc.	Well 1	NE¼ sec. 3 T. 18 S., R. 47 E. Malheur County	10,050	Well suspended for monitoring.
47	Ore-Ida Foods, Inc.	Well 2	SE¼ sec. 3 T. 18 S., R. 47 E. Malheur County	–	Drilling postponed pending evaluation of Well No. 1.
48	Chevron Resources	Neals-Bully Creek 79-2	SE¼ sec. 32 T. 17 S., R. 43 E. Malheur County	–	Location, proposed depth 2,000 ft.
49	Chevron Resources	Neals-Bully Creek 79-4	SW¼ sec. 33 T. 17 S., R. 43 E. Malheur County	2,010	Temperature-gradient well.
50	Chevron Resources	Neals-Bully Creek 79-5	NE¼ sec. 4 T. 18 S., R. 43 E. Malheur County	–	Location, proposed depth 2,000 ft.
51	Chevron Resources	Neals-Bully Creek 79-6	SE¼ sec. 8 T. 18 S., R. 43 E. Malheur County	–	Location, proposed depth 2,000 ft.
52	Chevron Resources	Neals-Bully Creek 79-7	NW¼ sec. 3 T. 18 S., R. 43 E. Malheur County	–	Location, proposed depth 2,000 ft.
53	Chevron Resources	Neals-Bully Creek 79-8	NW¼ sec. 28 T. 17 S., R. 43 E. Malheur County	–	Location, proposed depth 2,000 ft.
54	Chevron Resources	Neals-Bully Creek 79-10	NE¼ sec. 15 T. 18 S., R. 43 E. Malheur County	1,868	Temperature-gradient well.
55	Chevron Resources	Neals-Bully Creek 79-11	NW¼ sec. 9 T. 18 S., R. 43 E. Malheur County	–	Location, proposed depth 2,000 ft.

Table 1. *Geothermal permits and drilling activity in Oregon, 1979 (continued)*

Permit no.	Operator	Well name	Location	Total depth (ft)	Status
56	Union Oil Company	Brooks Scanlon 1	NW¼ sec. 2 T. 24 S., R. 11 E. Klamath County	705	Abandoned, temperature-gradient well.
57	Union Oil Company	Brooks Scanlon 2	SW¼ sec. 5 T. 23 S., R. 11 E. Klamath County	550	Abandoned, temperature-gradient well.
58	Union Oil Company	Brooks Scanlon 3	SW¼ sec. 29 T. 23 S., R. 11 E. Klamath County	–	Will not be drilled.
59	Union Oil Company	Brooks Scanlon 4	NE¼ sec. 15 T. 26 S., R. 12 E. Lake County	–	Will not be drilled.
60	Union Oil Company	Brooks Scanlon 5	SW¼ sec. 36 T. 26 S., R. 12 E. Lake County	975	Abandoned, temperature-gradient well.
61	Union Oil Company	Brooks Scanlon 6	SW¼ sec. 32 T. 25 S., R. 12 E. Lake County	1,010	Abandoned, temperature-gradient well.
62	Union Oil Company	Brooks Scanlon 7	NE¼ sec. 12 T. 17 S., R. 10 E. Deschutes County	–	Will not be drilled.
63	Union Oil Company	Brooks Scanlon 8	SE¼ sec. 30 T. 17 S., R. 11 E. Deschutes County	840	Abandoned, temperature-gradient well.
64	Union Oil Company	Brooks Scanlon 9	NE¼ sec. 27 T. 16 S., R. 10 E. Deschutes County	860	Abandoned, temperature-gradient well.
65	Northwest Natural Gas	Jct. Highways 26 and 35	NE¼ sec. 30 T. 3 S., R. 9 E. Clackamas County	965	Suspended, temperature-gradient well.
66	Northwest Natural Gas	Zigzag 1	NW¼ sec. 14 T. 3 S., R. 8 E. Clackamas County	940	Suspended, temperature-gradient well.
67	Northwest Natural Gas	Still Creek 1	NW¼ sec. 35 T. 3 S., R. 8 E. Clackamas County	–	Location, temperature-gradient well.
68	Eugene Water and Electric Board	Road 075	NE¼ sec. 4 T. 13 S., R. 7 E. Linn County	–	Location, temperature-gradient well.
69	Eugene Water and Electric Board	Sisi Creek	SW¼ sec. 6 T. 8 S., R. 8 E. Clackamas County	1,505	Suspended, temperature-gradient well.
70	U.S. Geological Survey	Pucci Chairlift	SE¼ sec. 7 T. 3 S., R. 9 E. Clackamas County	2,000	To be deepened to approximately 3,000 ft in 1980.
71	Francana Resources, Inc.	Glass Buttes 1	NW¼ sec. 31 T. 22 S., R. 23 E. Lake County	2,000	Abandoned, temperature-gradient well.
72	Francana Resources, Inc.	Glass Buttes 2	SW¼ sec. 17 T. 23 S., R. 23 E. Lake County	–	Location, proposed depth 2,000 ft.
73	Eugene Water and Electric Board	Fish Lake Creek	SE¼ sec. 32 T. 13 S., R. 7 E. Clackamas County	1,837	Suspended, temperature-gradient well.
74	Eugene Water and Electric Board	Twin Meadows	SE¼ sec. 9 T. 12 S., R. 7 E. Clackamas County	1,960	Suspended, temperature-gradient well.

Table 1. *Geothermal permits and drilling activity in Oregon, 1979 (continued)*

Permit no.	Operator	Well name	Location	Total depth (ft)	Status
75	Eugene Water and Electric Board	Poop Creek	SE¼ sec. 5 T. 7 S., R. 8 E. Clackamas County	870	Suspended, temperature-gradient well.
76	Eugene Water and Electric Board	Cinder Cone	NE¼ sec. 10 T. 7 S., R. 8 E. Clackamas County	1,160	Suspended, temperature-gradient well.
77	Eugene Water and Electric Board	Tarzan Spring	SE¼ sec. 4 T. 7 S., R. 7 E. Clackamas County	710	Suspended, temperature-gradient well.
78	Eugene Water and Electric Board	Pinhead	NE¼ sec. 35 T. 7 S., R. 8 E. Clackamas County	–	Location, temperature-gradient well.
79	Eugene Water and Electric Board	Crescent Creek	SE¼ sec. 13 T. 13 S., R. 6 E. Clackamas County	–	Location, temperature-gradient well.
80	Chevron Resources	Jordan 55	NW¼ sec. 9 T. 18 S., R. 43 E. Malheur County	–	Drilling at 2,600 ft, January 1980.

Table 2. *Geothermal prospect permits and drilling activity in Oregon, 1979*

Permit no.	Operator	Issue date	Locations	Comments and status
38	Phillips Petroleum Company	May 1978	Brothers Fault Zone, Lake and Harney Counties	Drilled 17 more 500-ft gradient holes in 1979, continuing the 1978 program.
47	Northwest Natural Gas	Nov. 1978	Mt. Hood Clackamas County	Summit Meadows well drilled to 1,115 ft. Lost Creek well drilled to 431 ft. Clear Fork well drilled to 495 ft.
48	Chevron Resources	April 1979	Bully Creek Malheur County	Drilled two 500-ft and two 2,000-ft gradient holes.
49	Technology International	April 1979	Vale Malheur County	Location, temperature-gradient well.
50	Phillips Petroleum Company	July 1979	Lakeview Harney County	Drilled 24 500-ft gradient holes in 1979.
51	Francana Resources	July 1979	Glass Buttes Lake County	Drilled one hole to 2,000 ft, suspended to monitor temperature.
52	Chevron Resources	July 1979	South Crump Lake Lake County	Drilled 14 500-ft gradient holes in 1979.
53	Chevron Resources	July 1979	Bully Creek Malheur County	Drilled four 500-ft gradient holes in 1979.
54	Oregon Department of Geology and Mineral Industries	Aug. 1979	Cascades Clackamas County	Drilled eight 500-ft gradient holes in 1979.
55	U.S. Geological Survey	Aug. 1979	Mt. Hood Clackamas County	Drilled two wells in 1979; deepest 1,002 ft.
56	Republic Geothermal	Aug. 1979	Vale Malheur County	Drilled four wells in 1979; three to depth of 500 ft and one to 1,500 ft.
57	Anadarko Production Company	Sept. 1979	Alvord Valley Harney County	Drilled six 500-ft and one 900-ft gradient holes in 1979.
58	Union Oil Company	Oct. 1979	Alvord Valley Harney County	Location, temperature-gradient well.
59	Eugene Water and Electric Board	Sept. 1979	Breitenbush Linn County	Location, temperature-gradient well.
60	Oregon Department of Geology and Mineral Industries	Nov. 1979	Lakeview Lake County	Drilled eight 500-ft gradient holes in 1979.
61	Oregon Department of Geology and Mineral Industries	Nov. 1979	La Grande Union County	Drilled two 500-ft gradient holes in 1979.

was a little greater than in 1978. Totals of Federal and State leases in Oregon are shown in Table 3. The acreage noted for the private leases is an estimate because confirmation is difficult.

Table 3. *Geothermal leases in Oregon, 1979*

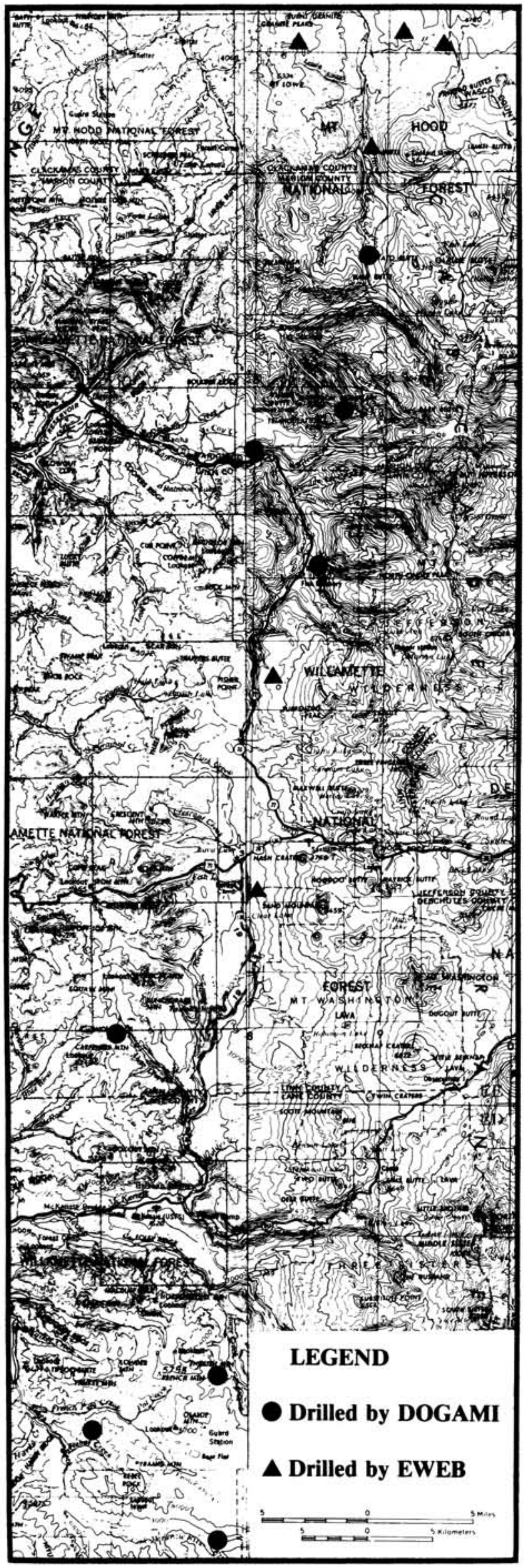
Type of leases	Number	Acres
Federal		
Noncompetitive	113 USBLM*	165,678
	23 USFS**	38,872
Competitive	21 USBLM*	43,082
	4 USFS**	5,818
Applications pending	123 USBLM*	
	368 USFS**	
Total		253,450
State		
Leases active in 1979		8,934
Applications pending		3
Private		
Leases active in 1979 (est.)		160,000

* U.S. Bureau of Land Management
** U.S. Forest Service

There were no U.S. Bureau of Land Management (USBLM) lease sales in calendar year 1979. However, four energy companies—Anadarko Production Company, Hunt Oil Company, Intercontinental Energy Corporation, and Union Oil Company—were successful bidders on the sale held January 8, 1980, on six parcels of Federal land in Oregon in the following KGRA's: Alvord, Breitenbush, Crump, and Klamath Falls (Table 4). Sixty-two parcels were offered by the Federal government. Forty-nine parcels received no bids, and seven others were withdrawn. The withdrawn parcels and those that did not receive bids will be re-offered as part of a geothermal lease sale planned for April 29, 1980.

After the April 29 sale, the USBLM will probably recommend to the U.S. Geological Survey (USGS) that those parcels which received no bids at this and several previous sales be removed from KGRA classification.

A sale of parcels in Oregon in the Belknap-Foley Hot Springs, McCredie, and Newberry Caldera KGRA's is tentatively planned for October 23, 1980, contingent upon the forwarding of leasing recommendations by the USGS.



← *Figure 2. Location of temperature-gradient holes drilled by Eugene Water and Electric Board and Oregon Department of Geology and Mineral Industries, 1979.*

Table 4. *U.S. Bureau of Land Management KGRA lease sales, January 8, 1980*

Parcel	Acreage	Area	Company	Amount
13	2,280	Alvord	Anadarko	$236,367.60
14	2,463	Alvord	Anadarko	90,605.33
33	1,029	Breitenbush	Union Oil	10,341.45
39	118	Klamath Falls	Intercontinental	917.53
50	2,371	Crump	Hunt Oil	4,833.35
51	2,344	Crump	Hunt Oil	4,828.58

RESEARCH

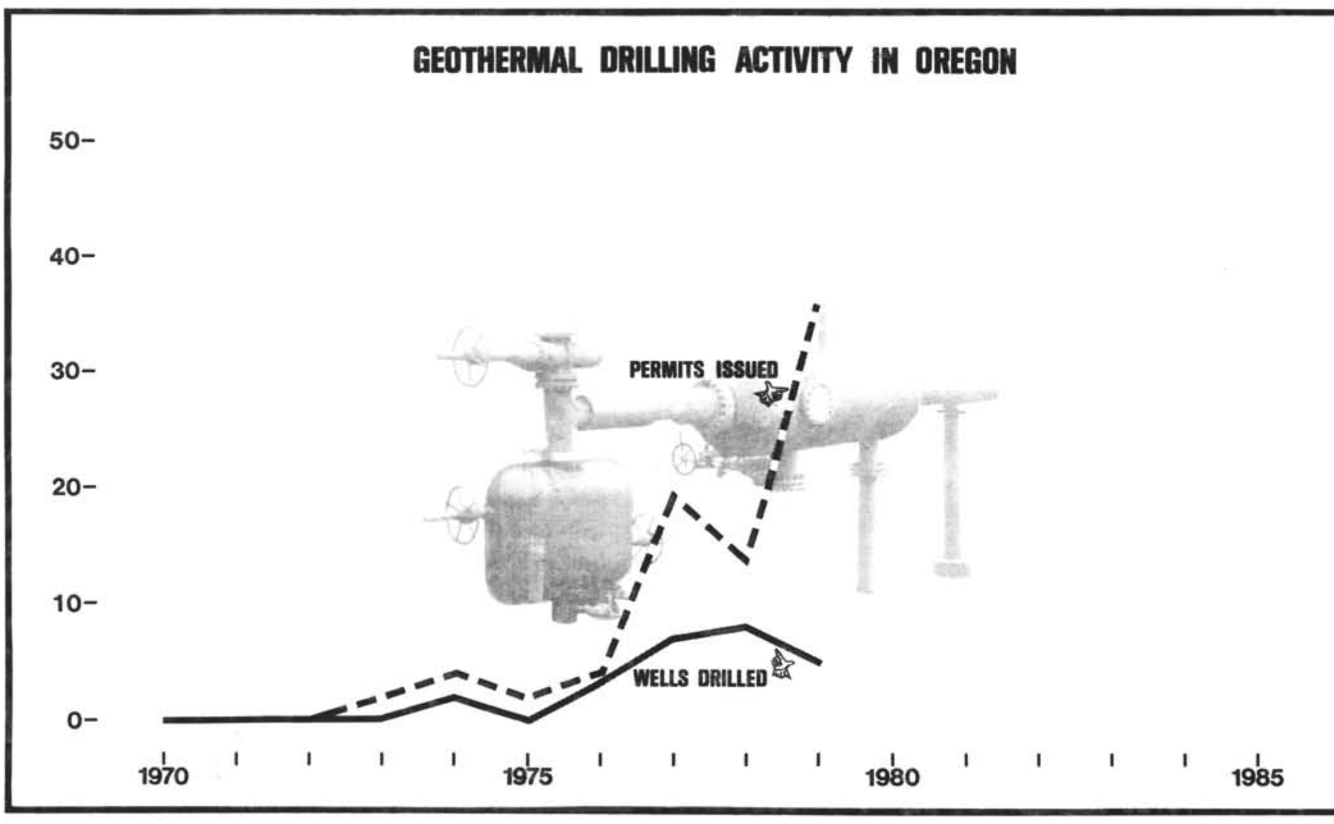
Low-temperature geothermal resources

The first phase of the statewide inventory of low-temperature geothermal resources (geothermal waters with a temperature of 90°C or less) was begun by the Oregon Department of Geology and Mineral Industries (DOGAMI) in July 1977 and completed in June 1979. The inventory consisted of two parts: (1) a compilation of chemical data on thermal springs and wells in Oregon, and (2) an identification of potential low-temperature resource areas on the basis of geochemical, temperature-gradient, heat-flow, geological, and geophysical data. These studies were funded by USDOE.

Forty-seven chemical analyses of thermal waters from Oregon springs or wells, based on both field sampling and literature research, were submitted to the USGS for inclusion in their GEOTHERM data base. These data and 142 others by the USGS are included in Open-File Report 0-79-3, *Chemical Analyses of Thermal Springs and Wells in Oregon*, authored jointly by USGS and DOGAMI. The locations of these thermal springs and wells, as well as others previously identified by DOGAMI, are shown on the Geological Map Series map GMS-10 (1978), which is an update of previously published Miscellaneous Paper 14, *Thermal Springs and Wells in Oregon* (1970).

During the second part of the study, thirty potential geothermal-field areas were identified, and pertinent data about them submitted to the USGS for inclusion in

Figure 3. Geothermal drilling activity in Oregon, 1979.



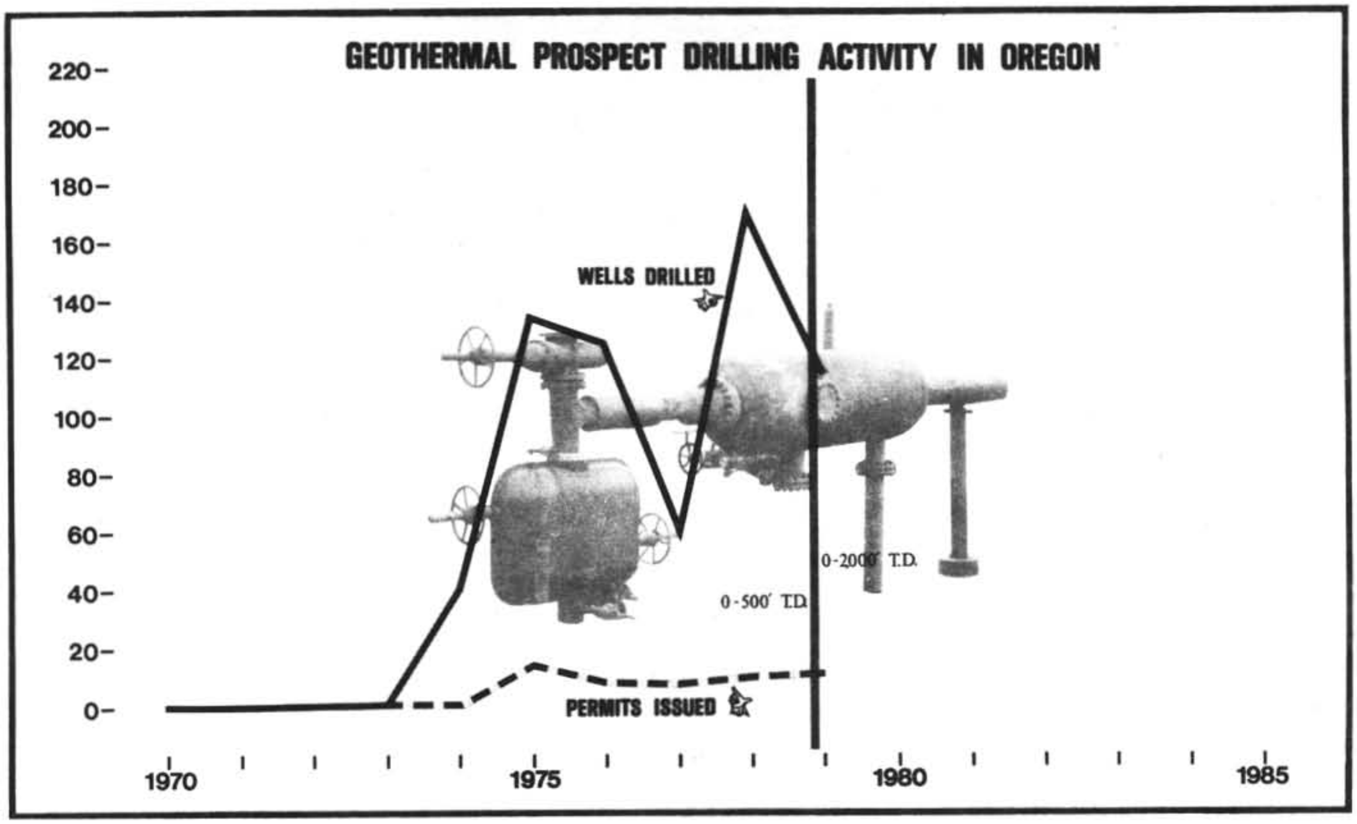


Figure 4. Geothermal prospect drilling activity in Oregon, 1979.

the GEOTHERM data base. Of these areas, nine that are totally in Oregon and three that are partially in Oregon-Idaho, Oregon-Nevada, and Oregon-Washington are favorable for the potential development of low-temperature geothermal resources and are detailed in USGS Circular 790, *Assessment of Geothermal Resources of the United States—1978* (1979). These areas are Belknap-Foley Hot Springs, Willamette Pass, Craig Mountain-Cove (La Grande), Glass Buttes, Northern Harney Basin, Southern Harney Basin, Alvord Desert, Lakeview, Klamath Falls, Western Snake River Basin, McDermitt, and Walla Walla.

Completion of the initial phase of the low-temperature study led to two major Department publications in 1979. GMS-11, *Preliminary Geothermal Resource Map of Oregon* (scale 1:500,000), relates the aforementioned resource areas to pertinent Pleistocene-Holocene geology, geologic structure, heat flow, and thermal springs and wells. Special Paper 4, *Heat Flow of Oregon*, contains extensive newly acquired heat-flow and geothermal-gradient data for the State. These data are presented on a contour map of heat flow (20 mW/m^2 interval) at a scale of 1:1,000,000. The text also contains maps of heat flow and temperatures at a depth of 1 km for $1° \times 1°$ intervals. Histograms and averages of geothermal gradient and heat flow for the various physiographic provinces within the State are also included.

The second phase of the low-temperature study, site evaluation, which commenced in 1979 also through a USDOE contract, consists, in part, of geologic mapping by DOGAMI of the Belknap-Foley Hot Springs area (one 15-minute quadrangle), Willamette Pass area (two 15-minute quadrangles), Lakeview area (portions of three 15-minute quadrangles), and Northern and Southern Harney Basins (four 15-minute quadrangles) (Figure 5). Mapping is in various stages of completion. Mapping of the Craig Mountain-Cove (La Grande) area by Geoscience Research Consultants of Moscow, Idaho, under contract to DOGAMI, has been completed, and results of the study will be published as Special Paper 6 in 1980. The four 7½-minute quadrangles covered by this study include the southwestern portion of the Grande Ronde Valley and adjacent uplands.

Eight temperature-gradient holes were drilled to a maximum depth of 400 ft in the Lakeview area (Figures 6 and 7). Thermal waters collected from springs, wells, and temperature-gradient holes were analyzed, and chemical data were submitted to USGS for inclusion in the GEOTHERM data base.

The westerly two of the four temperature-gradient holes programmed for the La Grande area were drilled in 1979 (Figure 8). Chemical analysis of thermal waters collected from the area's thermal springs and wells is currently under way.

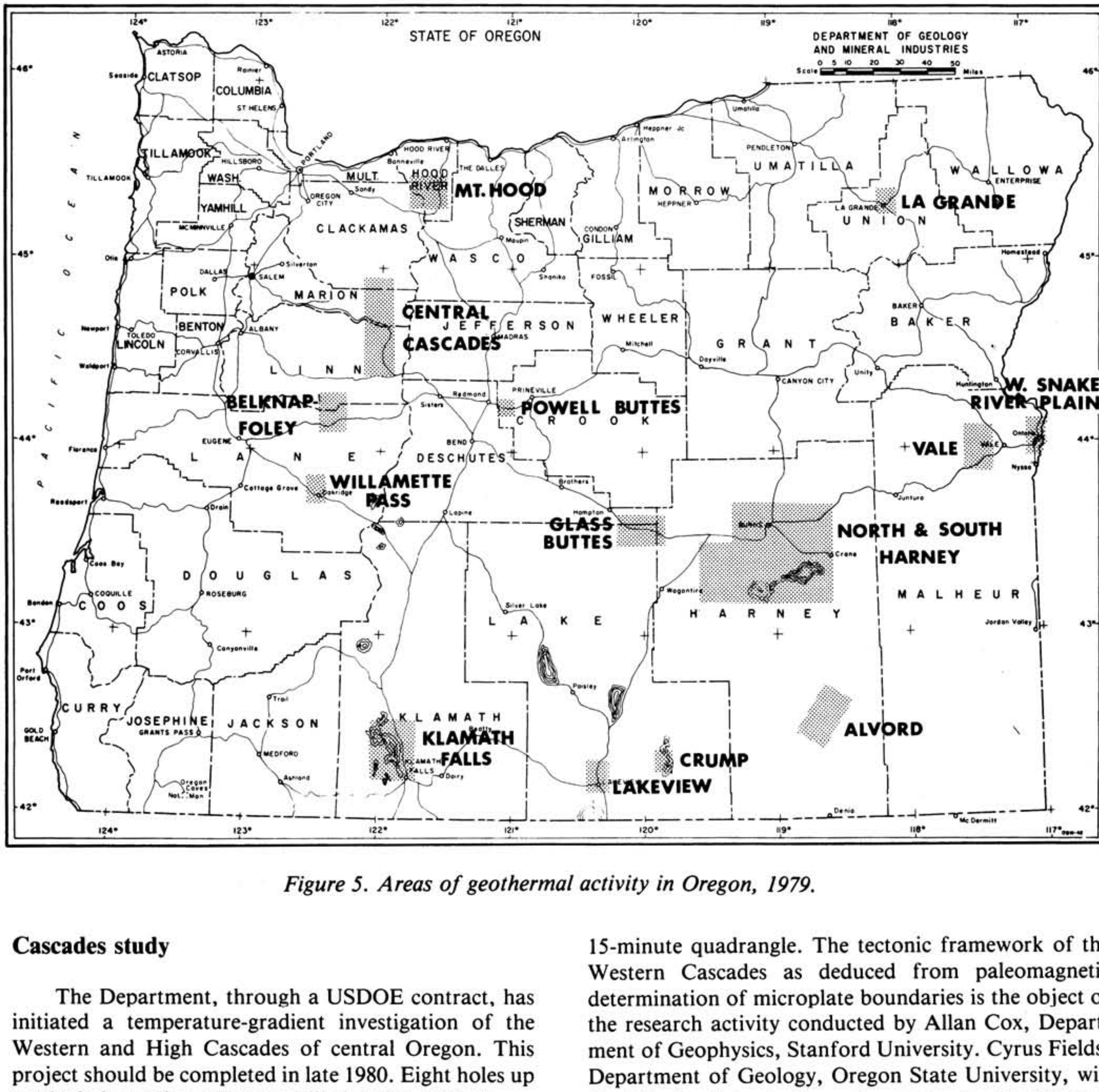


Figure 5. Areas of geothermal activity in Oregon, 1979.

Cascades study

The Department, through a USDOE contract, has initiated a temperature-gradient investigation of the Western and High Cascades of central Oregon. This project should be completed in late 1980. Eight holes up to 500 ft deep (Figure 2) were drilled during 1979; the remaining fourteen (not shown on map) are to be drilled in 1980. Geologic mapping, approximately 1 sq mi in extent, has been completed at each site drilled.

Also, as part of this overall project, several subcontracts to universities have been issued by DOGAMI. Richard Couch and Michael Gemperle, School of Oceanography, Oregon State University, will initiate aeromagnetic and gravity measurements in both the southern and northern Oregon Cascades. Craig White, Department of Geology, University of Oregon, is compiling a stratigraphic, structural, and petrological index of the Breitenbush 15-minute quadrangle and that area included in the drainage of the upper portion of the Molalla River in the northern part of the Mill City 15-minute quadrangle. The tectonic framework of the Western Cascades as deduced from paleomagnetic determination of microplate boundaries is the object of the research activity conducted by Allan Cox, Department of Geophysics, Stanford University. Cyrus Fields, Department of Geology, Oregon State University, will identify fossil hydrothermal systems in the Western Cascades.

Figure 6. Location of temperature-gradient holes, Lakeview area, Oregon.

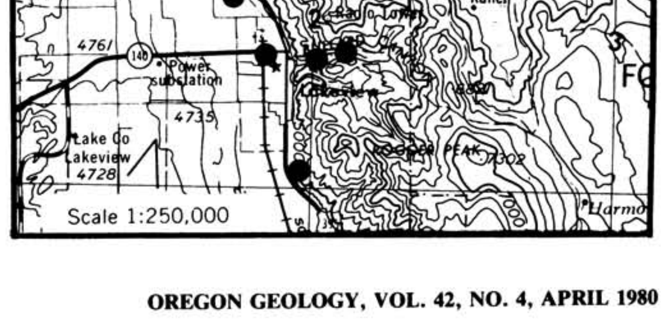


Figure 7. Hunter Hot Springs "Geyser," located north of the city of Lakeview, began erupting in October 1923 while a well was being drilled at this site.

U.S. Geological Survey

As part of the continuing Mt. Hood geothermal assessment program, the USGS has drilled four temperature-gradient holes (Tables 1 and 2) on the south and west flanks of Mt. Hood to a maximum depth of 2,000 ft. The hole at the base of the Pucci Chairlift (35S/9E-7ad) is to be deepened to approximately 3,000 ft in the summer of 1980.

Detailed field mapping and petrological and mineralogical studies of selected areas of hydrothermal alteration associated with active and fossil geothermal systems in the Western and High Cascades was initiated by the USGS in 1979 and will continue into 1980.

The July 1979 issue of *Oregon Geology* (v. 41, no. 7) contains a complete listing of all USGS geothermal research programs relating to the Cascade Range of Oregon.

Oregon Institute of Technology

The Geo-Heat Utilization Center at OIT reports that under the Federal technical assistance program the Center can provide up to 100 hours of free geothermal consultation. The program is intended to provide assistance to persons with little or no experience in geothermics in order to promote the rapid development of geothermal resources.

Other studies in which the Center is currently involved include an inventory and study of potential uses of geothermal resources in Oregon, Washington, Idaho, Montana, Alaska, and Wyoming; a study for the Bonneville Power Administration (BPA) to determine the potential for additional production of electricity through the use of geothermal energy in the BPA service area; an aquaçulture project whereby prawns are raised in geothermal waters from existing wells on the geo-

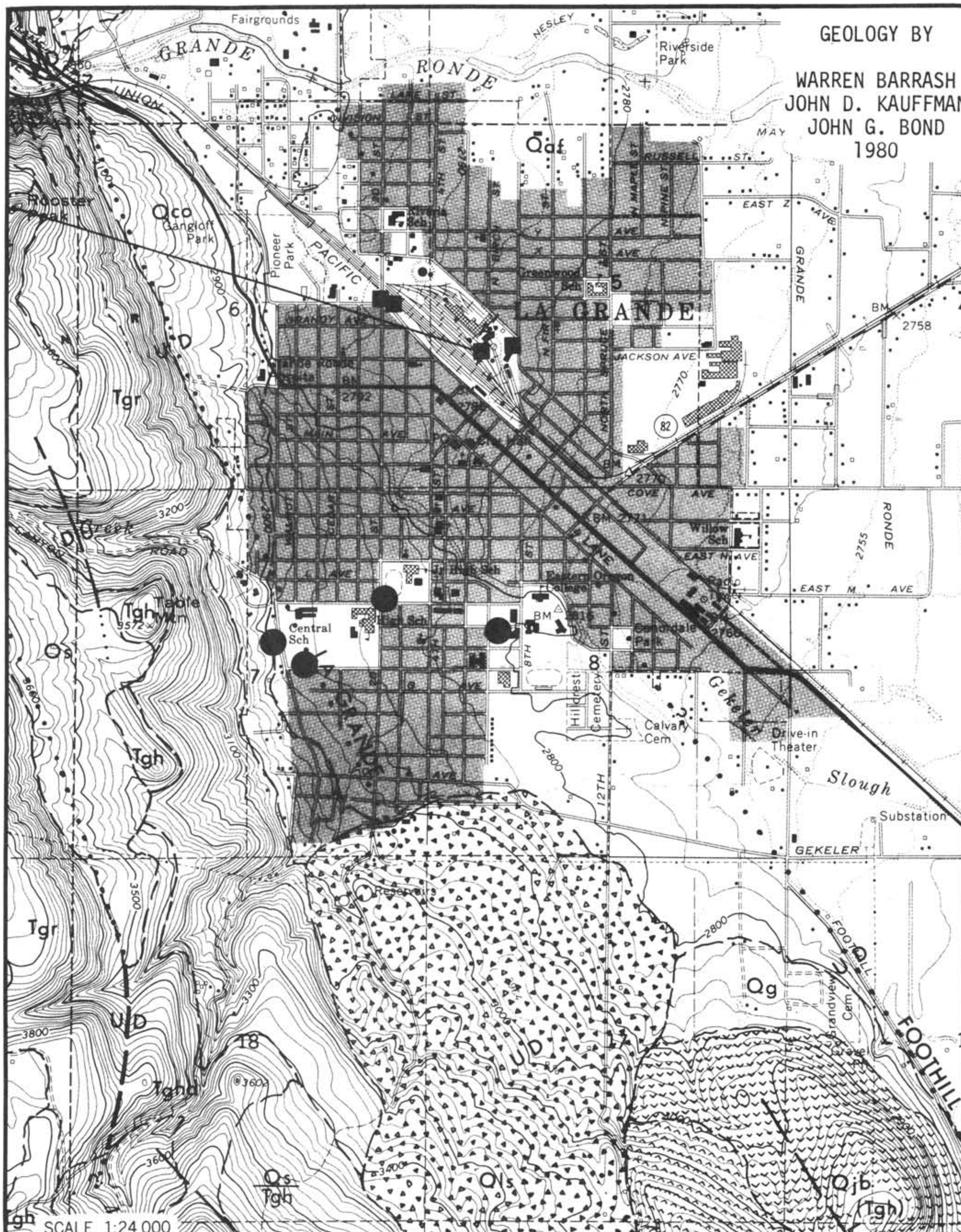


Figure 8. Location of temperature-gradient holes, La Grande area, Oregon.

(See **Geothermal exploration,** *p. 69)*

Abstracts of Department papers given at OAS

These abstracts of papers given at the Oregon Academy of Science, February 23, 1980, at Chemeketa Community College in Salem, summarize some of the findings of the Oregon Department of Geology and Mineral Industries' current research on low-temperature geothermal assessment and geothermal potential assessment of the Western and High Cascades.

HEAT FLOW ALONG THE HIGH CASCADE-WESTERN CASCADE TRANSITION ZONE, OREGON *by George Priest, Joseph Riccio, Neil Woller, and Don Gest, Oregon Department of Geology and Mineral Industries, Geothermal Section, 1069 State Office Building, Portland, Oregon 97201; and Steven Pitts, School of Oceanography, Oregon State University, Corvallis, Oregon 97331.*

Heat flow analysis by DOGAMI indicates that the Western Cascades-High Cascades transition zone is an area of anomalously high heat flow. Heat flow generally increases from the Willamette Valley to the transition zone where numerous hot springs occur, but no reliable data have heretofore been available on the east side of the transition zone. Several 150- to 600-m temperature-gradient holes have been recently completed by both DOGAMI and EWEB on the eastern margin of the transition zone. Preliminary temperature-gradient data indicate that heat flow may decrease both east and west of the transition zone. Thus: (1) there is a local heat source under only the transition zone, or (2) convective downflow occurs over areas east of the hot springs belt over a region of high heat flow with convective upflow along permeable zones at the transition zone. Permeable zones may correspond to high-angle faults which appear to control the distribution of hot springs in the transition zone. Correspondence of a very short-wavelength residual Bouguer gravity low of regional extent along the hot-springs belt supports the interpretation of major high-angle faults in the transition zone. The youthful age of volcanism in the High Cascades implies a major heat source beneath the High Cascade axis. These preliminary findings support model 2; however, the data are too sparse to disprove any model.

RECONNAISSANCE GEOLOGY OF THE OAKRIDGE-WILLAMETTE PASS AREA, CENTRAL CASCADES, OREGON *by David E. Brown, Gary D. McLean, Don Gest, Neil M. Woller, and Gerald Black, Oregon Department of Geology and Mineral Industries, Geothermal Section, 1069 State Office Building, Portland, Oregon 97201.*

Reconnaissance mapping of bedrock units and structures in the Oakridge-Willamette Pass area defines the extent of several geologic units. Included are the Oligocene to Miocene Little Butte Volcanics, a widespread Miocene (?) rhyolite sequence, the Miocene to Pliocene Sardine Volcanics, a Pliocene to Pleistocene High Cascades dacite sequence of limited areal extent, and the Pliocene to Pleistocene High Cascades andesitic lavas. Two major trends of high-angle faults were mapped. One is aligned in a north 5° to 35° west orientation, and the second, and more minor, is aligned north 5° to 45° east. No obvious difference of trends is noted on opposite sides of the Eugene-Denio lineament, which bisects the study area along Kittson Ridge in an approximate north 45° west trend. Of major interest are several lineaments recognizable on SLAR and Landsat imagery. These lineaments, reflected on the surface by pyritization and parallel high-angle faulting, appear to be closely associated with hot springs and hydrothermal alteration. □

Major Public Lands Map of Oregon now available from Forestry Department

The multi-colored 1:1,000,000 scale Major Public Lands Map is now available for distribution. The map is available with and without the State Forest Protection District boundaries.

The print includes ten ownership/administration classes, including Board of Forestry, State Land Board, State Parks, State Fish and Wildlife, U.S. Forest Service, Wilderness Area, National Parks, National Wildlife Refuge, Bureau of Land Management, and Lands Managed by Agreement by OSFD. BIA/Tribal Trust Lands will also be noted but have private designation.

The price has been set at $1.25 each. Bulk lots of 1,000 or more will be sold at $.85 each ($850/1,000). Please submit purchase order or payment as follows:

1. Send to: Oregon State Forestry Department
   2600 State Street
   Salem, OR 97310
2. Write order stating type of map and number requested. □

(**Geothermal exploration,** *from p. 68)*

thermally heated OIT campus; and a cooperative project with Oregon State University in which a greenhouse is heated by waste waters from the OIT campus heating system, enabling year-round growth of flowers and vegetables. □

Ausmus enters Federal service

Standley L. Ausmus, Supervisor of the Mined Land Reclamation Program of the Oregon Department of Geology and Mineral Industries since 1974 (see *Oregon Geology*, v. 41, no. 11, p. 182), left the Department to become Program Director, Abandoned Mined Lands, Office of Surface Mining, U.S. Department of the Interior, Denver, Colorado, on March 3, 1980. There he will serve as principal staff officer for Federal reclamation programs in the Regional Office of Surface Mining. In this capacity, he will provide information on the reclamation of Federal lands and the conduct of the Federal reclamation programs to governmental agencies, industry, and the public. Among his other responsibilities will be the development of guidelines for the evaluation of various Federal projects such as those related to (1) the protection of life, health, and property from the adverse effects of coal-mining practices, and (2) the restoration of land and water degraded by previous coal-mining practices.

During his years with the Oregon Department of Geology and Mineral Industries, the Mined Land Reclamation Program came into being, and Ausmus worked in its administration to develop standards and procedures based on actual field case histories and experiences. The result is a program whose procedures are keyed to Oregon's rather unique reclamation needs. The standards and procedures address reclamation practices, cooperation with other agencies, and land-resource constraints.

The present body of law relative to surface mined land reclamation has been evolving under Ausmus' guidance, and the Department is now promulgating rules and regulations formalizing the administration of the Mined Land Reclamation Act (see p. 54 in the March 1980 issue of *Oregon Geology*). □

DOE issues airborne geophysical surveys

The Grand Junction, Colorado, Office, U.S. Department of Energy (DOE) has placed on open file two aerial geophysical surveys that include parts of Oregon.

Report GJBX-10(80) is an aerial gamma-ray and magnetic survey including the Boise quadrangle, Oregon/Idaho. Report GJBX-20(80) is an aerial radiometric and magnetic survey of the Oregon part of the Klamath Falls quadrangle. The surveys were flown by helicopters during 1978 and 1979 and serve to detect and assess uranium resources.

Both reports are available for inspection at the Portland office of the Oregon Department of Geology and Mineral Industries. □

AAPG 1980 convention to be held in Denver

"What's New – Advances in Exploration Science" is the theme for the 65th Annual Convention of the American Association of Petroleum Geologists and its divisions, the Society of Economic Paleontologists and Mineralogists, the Energy Minerals Division, and the Division of Professional Affairs, to be held June 8-11, 1980, in Denver, Colorado.

The three-day technical program comprises over 50 sessions and includes such topics as Petroleum Geology of China, Stratigraphic Geophysics, Heat Flow and Petroleum Generation/Maturity in Relation to Plate Tectonic Settings, World-Wide Thrust Belt and Foreland-Basin Exploration, Tidal and Near-Shore Sediments and Processes, Petroleum Potential of Deep-Sea Fans, Nuclear Fuels, and Deep Continental Drilling. Poster sessions, short courses, and field trips round out the program. The fifteen field trips include visits to the Wyoming-Utah-Idaho thrust and fold belt and to many of the alternate energy sources in the Rockies.

Of special interest for OSU graduates will be the OSU Alumni Party on Monday, June 9, 5:30-7:30 p.m., at the Denver Hilton Hotel. The party is being organized by Clint Goodwin (M.S. 1972), Bill Hanson (Ph.D. 1976), and Jill Schlaefer (M.S. 1978). Those in attendance will have an opportunity to meet OSU Geology Department Chairman Robert S. Yeats and other OSU faculty members. A sign-up sheet will be at the Alumni Activities Desk in the registration area. □

" YOUR FUTURE LOOKS DARK AND MURKY... LIKE CRUDE OIL..! "

Fossil bear tracks in Lake County, Oregon

by Earl L. Packard and Ira S. Allison, Emeriti Professors of Geology, Oregon State University, Corvallis, Oregon

ABSTRACT

A series of large, five-toed mammal tracks exhibit two undivided foot pads, three distinct anterior claw marks, and two widely divergent outer-claw positions on the forward imprint on a consolidated mudflow deposit in Lake County, Oregon. The tracks evidently were made by a huge extinct bear, comparable in size to the widely occurring *Arctotherium*. Their age is probably Pliocene or early Pleistocene.

Local residents years ago discovered a series of mammalian tracks and reported them to Luther S. Cressman, University of Oregon archeologist, who in turn led us to the find, where we made measurements and took plaster casts. The tracks occur about 500 ft (150 m) south of the north line of the NE¼ sec. 20, T. 39 S., R. 18 E., about 15 mi (24 km) west of Lakeview, Oregon, at an elevation of about 5,000 ft (1,500 m) above sea level.

GEOLOGY

The region is a faulted terrain composed mainly of Cenozoic volcanic rocks (Walker, 1973). The fossil track locality is a gently sloping rock surface beside a shallow, intermittent stream channel. The rock immediately underlying the tracks is a coarse-grained, indurated mudflow composed of angular particles as much as several centimeters in diameter and set in a fine-grained tuffaceous matrix. The bed dips 16°

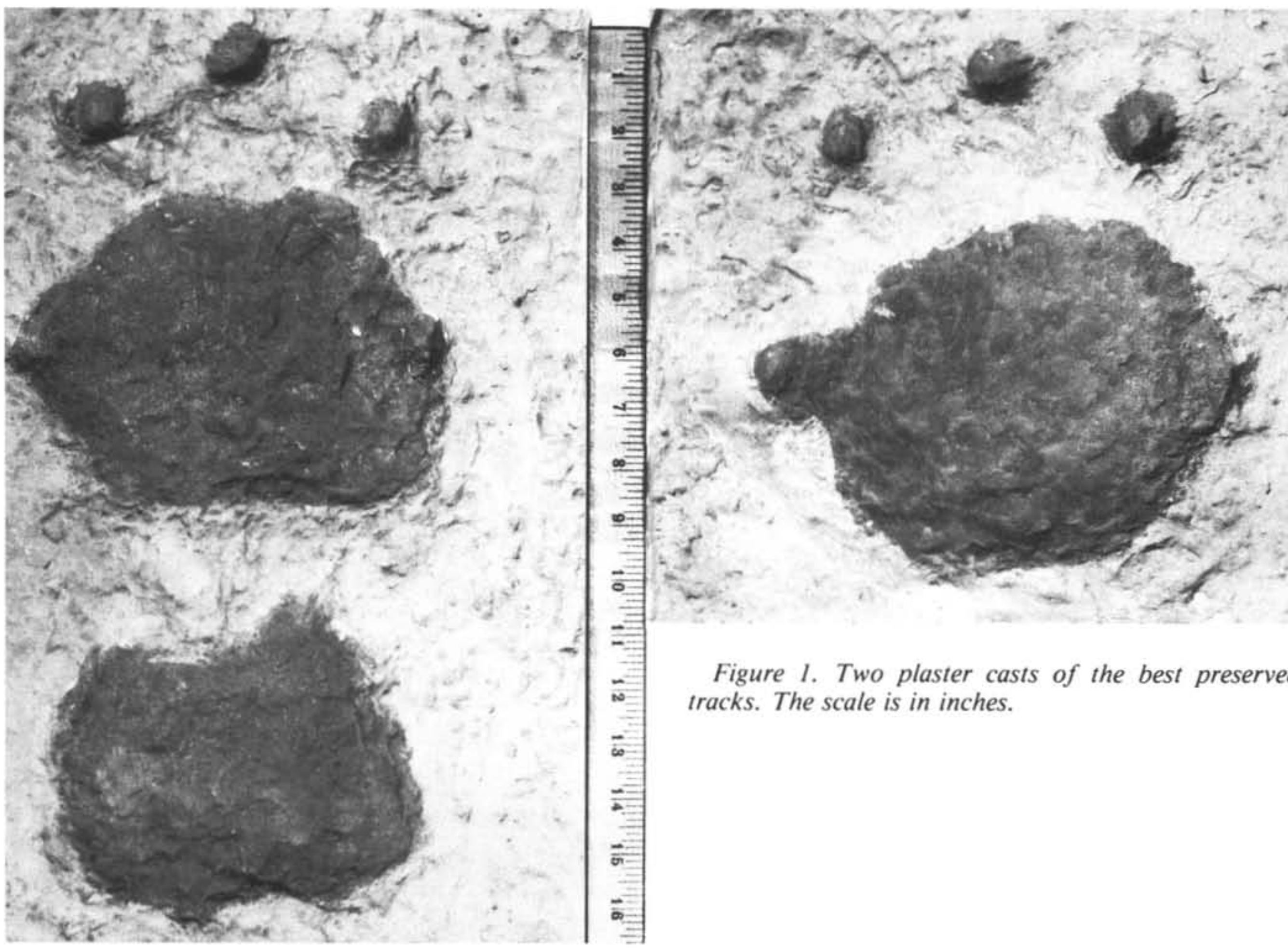


Figure 1. Two plaster casts of the best preserved tracks. The scale is in inches.

westerly and strikes N. 15-20° W. Differential weathering of the mudflow has produced a small-scale roughness and mutilated part of the tracks. The tracks were preserved by an original claw-mark filling and a cover of easily weathered, brown, silty material about 2 in. (5 cm) thick, possibly a basaltic ash fall, part of which remains in some tracks. Still coarser mudflows underlie the fossil bed. Above it are finer grained, light-colored, tuffaceous sandstones and siltstones with fluviatile cross-bedding.

THE TRACKS

The fossil tracks form an alternating series of footprints extending northwesterly for a distance of about 15 ft (5 m), beyond which the tracks become faint, show a few possible claw marks, then turn left downdip for about 12 ft (4 m), and seem to pass under a rocky ledge about 3 ft (1 m) thick. The tracks are spaced about 50 in. (125 cm) apart, indicating a stride considerably greater than that of a man. They are 16 in. (40 cm) apart laterally—clearly those of a large animal. The main prints on each side are double oval-shaped impressions of the soles of the feet. The anterior of each pair also has three central claw marks and a smaller claw mark on each side (Figure 1). There is no suggestion of any toe pads.

The maximum depth of the imprints as measured in the field is about 1.2 in. (30 mm). The claw marks are irregular holes, somewhat modified by weathering, as much as 1 in. (25 mm) deep, with steep posterior margins which indicate their origin from claws rather than from the ends of toes or from hoofs. The anterior track is slightly larger than the posterior. The absence of claw marks on the posterior track is interpreted to indicate that the hind foot overstepped the forefoot in walking—a habit of bears.

The position of the claw marks complicate the identification of the responsible animal species. The central one of the three evenly spaced claw marks, spaced about 3 in. (75 mm) in front of each anterior foot-pad impression, denotes the axial line of the foot. The other two forward claw imprints diverge from the central axis consistently by about 35° and therefore are not from accidental spreading of the toes. The positions of the two lateral claw marks are especially puzzling, as they diverge by about 80° from the axis of the foot.

The lengths of the toes indicated by the tracks correspond closely to the toe bones known from the large extinct fossil bear *Arctotherium,* the only known Pliocene or Pleistocene mammal capable of making such tracks. To our knowledge, however, the amount of spreading of the toes of any arctothere has not been determined. The imprints are larger than those of living bears or extinct true ursids.

POSSIBLE AFFINITIES

The short-faced arctotheres diverged from true ursids in early Cenozoic time. They are represented in the Miocene of Eurasia by *Hyaenarctos* and in the Pliocene by *Indoarctos.* Related forms migrated to South America during late Pliocene and Pleistocene time. An *Indoarctos* possibly occurs in the Pliocene Rattlesnake Formation of the John Day Valley of central Oregon, where it was named *Indoarctos*? *oregonensis* by Merriam, Stock, and Moody (1916). The Rattlesnake fossils include teeth, limb bones, a fifth metacarpal, a second metatarsal, and several phalanges.

Arctotherium is known from the Rancho La Brea deposits of mid-Pleistocene age (Merriam, 1911); the Potter Creek Cave of Northern California (Cope, 1879, 1891); the Port Kennedy Fissure, Pennsylvania (Cope, 1879); and the Yukon (Lambe, 1911). Measurements of several foot bones from the Rancho La Brea and Potter Creek Cave deposits, as given by Merriam and Stock (1925), indicate foot sizes suited to make the Lake County bear tracks.

Because the arctothere foot structure is not fully known, no species reference for the bear that left these tracks is possible at this time.

REFERENCES CITED

Cope, E.D., 1879, The cave bear of California: American Naturalist, v. 13, p. 791.

——— 1891, The California cave bear: American Naturalist, v. 25, p. 997-999.

Lambe, L.M., 1911, On *Arctotherium* from the Pleistocene of Yukon: Ottawa Naturalist, v. 25, p. 21-26.

Merriam, J.C., 1911, Note on a gigantic bear from the Pleistocene of Rancho La Brea, California: University of California Publications, Bulletin of the Department of Geology, v. 6, no. 6, p. 163-166.

Merriam, J.C., and Stock, C., 1925, Relationships and structure of the short-faced bear, *Arctotherium,* from the Pleistocene of California: Carnegie Institution of Washington Publication 347, p. 1-35.

Merriam, J.C., Stock, C., and Moody, C.L., 1916, An American Pliocene bear: University of California Publications, Bulletin of the Department of Geology, v. 10, no. 7, p. 87-109.

Walker, G.W., 1973, Preliminary geologic and tectonic maps of Oregon east of the 121st meridian: U.S. Geological Survey Miscellaneous Field Studies Map MF-495, 2 sheets, scales 1:500,000 and 1:1,000,000. □

USGS leaflet explains Richter, Mercalli earthquake scales

A leaflet explaining how the severity of an earthquake is expressed by two commonly used but highly different methods—the Richter scale and the modified Mercalli intensity scale—has been published by the U.S. Geological Survey (USGS), Department of the Interior, and is available for public distribution.

The leaflet, written in nontechnical terms, is part of a series of popular publications prepared by the USGS to answer inquiries about a variety of earth science subjects. It was prepared to help clarify confusing concepts related to the measurement of earthquakes. Earthquakes can be measured in terms of either the energy released (magnitude) or the effects (intensity). The former is based on instrument recordings; the latter on personal observations. The two methods, expressed by highly differing scales, are often confused by the public.

Single copies of the 15-page illustrated leaflet, titled "The Severity of an Earthquake," may be obtained free upon request from the U.S. Geological Survey's Branch of Distribution, 1200 South Eads St., Arlington, Va. 22202.

A few "briefs" from the leaflet:

- The *intensity* of an earthquake is based on observed effects of ground shaking on people, buildings, and natural features. It varies from place to place within the disturbed region depending on the location of the observer with respect to the earthquake epicenter. Intensity is expressed by the modified Mercalli intensity scale.

- The *magnitude* of an earthquake—expressed by the Richter scale—is related to the amount of seismic energy released at the focal depth of an earthquake. It is based on the amplitude of earthquake waves recorded on instruments which have a common calibration.

- Earthquakes are the result of forces deep within the Earth's interior. The energy from these forces is stored in a variety of ways within the rocks. When this energy is released suddenly, for example, by shearing movements along faults in the Earth's crust, an earthquake results. The area of the fault where the sudden rupture takes place is called the focus or hypocenter of the earthquake. The point on the Earth's surface directly above the focus is called the epicenter of the earthquake.

- Seismic waves, earthquake vibrations that travel through the Earth, are recorded on instruments called seismographs. The instruments record a zigzag trace that shows the varying amplitude of ground oscillations beneath the instrument. Sensitive seismographs, which greatly magnify these ground motions, can detect strong earthquakes from sources anywhere in the world. The time, location, and magnitude of an earthquake can be determined from the data recorded by seismograph stations.

- The Richter scale was developed in 1935 by Charles F. Richter, the California Institute of Technology. On his mathematical scale, which is open-ended, magnitude is expressed in whole numbers and decimals. For example, a magnitude 5.3 might be computed for a moderate earthquake, and a strong earthquake might be rated as magnitude 6.3. Because of the logarithmic basis of the scale, each whole number increase in magnitude represents a tenfold increase in measured amplitude; thus, as an estimate of energy, each whole number step in the scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

- Earthquakes with magnitude of about 2.0 or less are usually called microearthquakes; they are not commonly felt by people and are generally recorded only on local seismographs. Events with magnitudes of about 4.5 or greater—there are several thousand such shocks annually—are strong enough to be recorded by sensitive seismographs all over the world. Great earthquakes, such as the 1906 San Francisco earthquake and the 1964 Good Friday earthquake in Alaska, have magnitudes of 8.0 or higher. On the average, one earthquake of such size occurs somewhere in the world each year. Although the Richter scale has no upper limit, the largest known shocks have had magnitudes in the 8.8 to 8.9 range.

- The Richter scale is not used to express damage. An earthquake in a densely populated area which results in many deaths and considerable damage may have the same magnitude as a shock in a remote area that does nothing more than frighten wildlife.

- The modified Mercalli intensity scale is composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction designated by Roman numerals (I to XII). It does not have a mathematical basis; instead, it is an arbitrary ranking based on observed effects. The modified Mercalli intensity scale provides a more meaningful measure of severity to the nonscientist than magnitude because it refers to effects actually experienced.

- The following is an abbreviated description of the 12 levels of the modified Mercalli intensity scale:

I Not felt except by a very few under especially favorable conditions.

II Felt only by a few persons at rest, especially on upper floors of buildings.

III Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Duration estimated.

IV Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sounds. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

V Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.

VI Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.

VII Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.

VIII Damage slight in specially designed structures. Considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.

IX Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.

X Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

XI Few, if any, (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.

XII Damage total. Lines of sight and level are distorted. Objects thrown into the air. □

Geothermal Resources Council annual meeting set for September

The Geothermal Resources Council's 1980 annual meeting will be held September 9-11, 1980, at the Hotel Utah, Salt Lake City, Utah. There will be three days of technical, poster, and special sessions, along with commercial and educational exhibits, optional luncheons, a special Alpinefest banquet, and a guests program. In addition, both pre- and post-meeting trips have been scheduled. Interesting special sessions will be devoted to particular topics, such as direct applications of geothermal resources and hot dry rock geothermal energy.

The meeting is intended to provide a forum for exchange of new and significant information on all aspects of the development and use of geothermal resources. Papers are solicited for both the technical and poster sessions, and if accepted, will be printed in the *Transactions* of the Geothermal Resources Council. Deadline for submission of papers in the special summary format required by the Council is Tuesday, May 27, 1980.

For more information, contact Geothermal Resources Council, 1980 Annual Meeting Program, P.O. Box 98, Davis, CA 95616, phone: (916) 758-2360. □

GSOC luncheon programs announced

The Geological Society of the Oregon Country announces the following luncheon program schedule. All luncheon programs will take place at noon in Room A adjacent to the cafeteria on the third floor of the Standard Plaza Building, 1100 SW 6th Ave., Portland.

April 18	Subject:	Hydroelectric power installations at the Bull Run Dams
	Speaker:	James L. Doane, Manager, Bureau of Hydroelectric Power, City of Portland
May 2	Subject:	The State of Oregon Department of Geology and Mineral Industries
	Speaker:	Dr. John D. Beaulieu, Deputy State Geologist
May 16	Subject:	The Western Forestry Center
	Speaker:	Penny Wrobel, Membership Manager, Western Forestry Center
June 6	Subject:	Natural history of Steens Mountain
	Speaker:	Donald D. Barr, biologist-naturalist.

For further information, contact the luncheon program chairperson, Viola L. Oberson, phone 282-3685. □

PUBLICATIONS ORDER

Omission of price indicates publication is in press. Minimum mail order 50¢. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $20.00.

Fill in appropriate blanks and send sheet to Department (see address on reverse side).

YOUR NAME ____________________

ADDRESS ____________________

____________________ Zip________

Amount enclosed $__________

OREGON GEOLOGY

____ Renewal ____ Subscription ____ Gift

____ 1 Year ($4.00) ____ 3 Years ($10.00)

NAME ____________________

ADDRESS ____________________

____________________ ZIP ________

(If Gift, From: ____________________)

← ORDER FORM - CUT ON DASHED LINE ←

Available publications

MISCELLANEOUS PAPERS	Price	No. Copies	Amount
1. A description of some Oregon rocks and minerals, 1950: Dole	$ 1.00		
4. Laws relating to oil, gas, and geothermal exploration and development in Oregon			
Part 1. Oil and natural gas rules and regulations, 1977, rev. 1979	1.00		
Part 2. Geothermal resources rules and regulations, 1977, rev. 1979	1.00		
5. Oregon's gold placers (reprints), 1954	.50		
6. Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton	3.00		
8. Available well records of oil and gas exploration in Oregon, rev. 1973: Newton	1.00		
11. Collection of articles on meteorites, 1968 (reprints from *The Ore Bin*)	1.50		
13. Index to *The Ore Bin*, 1950-1974	1.50		
14. Thermal springs and wells, 1970: Bowen and Peterson (with 1975 supplement)	1.50		
15. Quicksilver deposits in Oregon, 1971: Brooks	1.50		
16. Mosaic of Oregon from ERTS-1 imagery, 1973	2.50		
18. Proceedings of Citizens' Forum on potential future sources of energy, 1975	2.00		
19. Geothermal exploration studies in Oregon—1976, 1977	3.00		
20. Investigations of nickel in Oregon, 1978: Ramp	5.00		
GEOLOGIC MAPS			
Geologic map of Galice quadrangle, Oregon, 1953	1.50		
Geologic map of Albany quadrangle, Oregon, 1953	1.00		
Reconnaissance geologic map of Lebanon quadrangle, 1956	1.50		
Geologic map of Bend quadrangle and portion of High Cascade Mountains, 1957	1.50		
Geologic map of Oregon west of 121st meridian, 1961	2.25		
Geologic map of Oregon east of 121st meridian, 1977	3.75		
GMS-3: Preliminary geologic map of Durkee quadrangle, Oregon, 1967	2.00		
GMS-4: Oregon gravity maps, onshore and offshore, 1967 (folded)	3.00		
GMS-5: Geologic map of Powers quadrangle, Oregon, 1971	2.00		
GMS-6: Preliminary report on geology of part of Snake River Canyon, 1974	6.50		
GMS-7: Geology of the Oregon part of the Baker quadrangle, Oregon, 1976	3.00		
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	2.50		
GMS-11: Preliminary geothermal resource map of Oregon (upon written request only)	free	(one copy per customer)	
GMS-12: Geologic map of the Oregon part of the Mineral quadrangle	2.00		
OIL AND GAS INVESTIGATIONS			
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well	2.00		
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well, 1973	2.00		
5. Prospects for natural gas production or underground storage of pipeline gas	5.00		
MISCELLANEOUS PUBLICATIONS			
Landforms of Oregon (17 × 12 inches)	.50		
Mining claims (State laws governing quartz and placer claims)	.50		
Geological highway map, Pacific NW region, Oregon-Washington (published by AAPG)	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*	25¢ over the counter; 50¢ mailed		
Colored postcard, *Geology of Oregon*	10¢ each; 3 for 25¢; 7 for 50¢; 15 for 1.00		

OREGON GEOLOGY

1069 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

Available publications (continued)

BULLETINS	Price	No. Copies	Amount
33. Bibliography (1st supplement) geology and mineral resources of Oregon, 1947: Allen	1.00		
36. Papers on Tertiary foraminifera: Cushman, Stewart and Stewart, 1949: v. 2	1.25		
39. Geology and mineralization of Morning Mine region, 1948: Allen and Thayer	1.00		
44. Bibliography (2nd supplement) geology and mineral resources of Oregon, 1953: Steere	2.00		
46. Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey	1.25		
49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch	1.00		
53. Bibliography (3rd supplement) geology and mineral resources of Oregon, 1962: Steere and Owen	3.00		
57. Lunar Geological Field Conference guidebook, 1965: Peterson and Groh, editors	3.50		
62. Andesite Conference guidebook, 1968: Dole	3.50		
63. Sixteenth biennial report of the Department, 1966-1968	1.00		
64. Mineral and water resources of Oregon, 1969 (unbound, without maps and tables)	2.00		
65. Proceedings of Andesite Conference, 1969: (copies)	10.00		
67. Bibliography (4th supplement) geology and mineral resources of Oregon, 1970: Roberts	3.00		
68. Seventeenth biennial report of the Department, 1968-1970	1.00		
71. Geology of selected lava tubes in Bend area, Oregon, 1971: Greeley	2.50		
76. Eighteenth biennial report of the Department, 1970-1972	1.00		
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		
86. Nineteenth biennial report of the Department, 1972-1974	1.00		
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	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, 1979: Bela	9.00		
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		
SPECIAL PAPERS			
1. Mission, goals, and purposes of Oregon Department of Geology and Mineral Industries, 1978	2.00		
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	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	3.00		
7. Pluvial Fort Rock Lake, Lake County, Oregon	4.00		
SHORT PAPERS			
18. Radioactive minerals prospectors should know, 1976: White, Schafer, Peterson	.75		
21. Lightweight aggregate industry in Oregon, 1951: Mason	.25		
24. The Almeda Mine, Josephine County, Oregon, 1967: Libbey	3.00		
25. Petrography, type Rattlesnake Formation, central Oregon, 1976: Enlows	2.00		
27. Rock material resources of Benton County, 1978: Schlicker and others	4.00		