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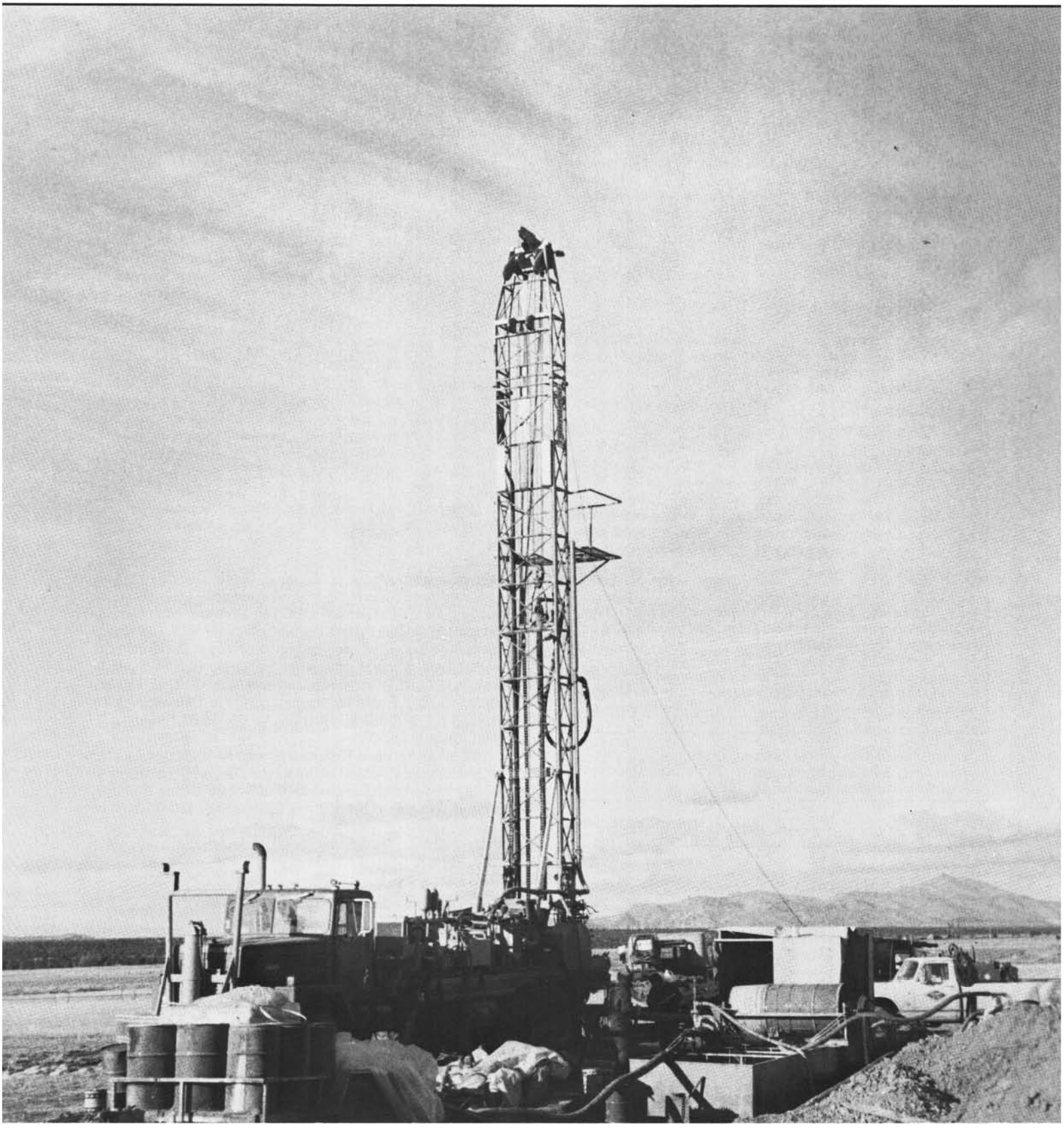

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COVER PHOTO

Powell Buttes 1, intermediate-depth geothermal gradient hole drilled for the Oregon Department of Geology and Mineral Industries on the west side of Powell Buttes, Crook County, by Janssen Drilling Co., Aloha. Drilled during the winter of 1980-81, the hole was suspended at 1,512 ft, with a bottom-hole temperature of 57°C (134°F). Article beginning on next page summarizes geothermal exploration activity in Oregon during 1980.

Geothermal open-file reports available

During 1979 and 1980, the Oregon Department of Geology and Mineral Industries (DOGAMI) conducted a U.S. Department of Energy/State of Oregon-funded low-temperature geothermal-resource assessment of nine areas in Oregon. Summaries of the results of studies in four areas are now available as open-file reports that contain raw and interpreted geothermal-gradient data, radiometric ages of selected rocks, chemical analyses of spring and well waters, calculated minimum reservoir temperatures, extensive bibliographies, and a variety of geological and geophysical maps.

Open-File Report 0-80-2 (Belknap-Foley area of the central Western Cascades) is 58 pages long, contains a two-color geologic map (scale 1:62,500), and sells for $5.00. Open-File Report 0-80-3 (Willamette Pass area of the central Western Cascades) is 65 pages in length, contains a two-color geologic map (scale 1:62,500), and also costs $5.00.

Open-File Report 0-80-6 (northern Harney Basin) is 52 pages long and has a two-color geologic map (scale 1:62,500) of the northern Harney Basin and gravity, aeromagnetic, and lineament maps (scale 1:250,000) of the entire Harney Basin.

Open-File Report 0-80-7 (southern Harney Basin) is 90 pages long and contains four two-colored geologic maps (scale 1:62,500) and an aeromagnetic map (scale 1:250,000) of the southern Harney Basin and aeromagnetic, gravity, and lineament maps (scale 1:250,000) of the entire Harney Basin. This report is available for $10.00.

DOGAMI has released the logs from Old Maid Flat well 7A as Open-File Reports 0-81-2A and 0-81-2B. The well is located west of Mount Hood and was drilled to a total depth of 6,027 ft. The reports contain directional surveys and fracture identification, temperature, variable density, dipmeter, sonic, gamma ray, formation density, and dual induction logs. Open-File Reports 0-81-2A and -2B may be purchased as one set for $100.00.

DOGAMI has also released 1978, 1979, and 1980 geothermal-gradient data for Oregon as Open-File Reports 0-81-3A, -3B, and -3C, respectively. The reports contain tabular and graphic compilations of temperature measurements and temperature gradients at depth intervals of 5 m. These data were collected from numerous wells throughout the State and then entered into GEOTHERM, the computerized information storage system maintained by the U.S. Geological Survey. The data were compiled for the Oregon Department of Geology and Mineral Industries by D.D. Blackwell, G.L. Black, and G.R. Priest under contract with the U.S. Department of Energy. Prices for the reports are as follows: 0-81-3A (1978, 63 p.), $4.00; 0-81-3B (1979, 98 p.), $6.00; and 0-81-3C (1980, 374 p.), $12.00.

All of these open-file reports may be inspected or purchased from the Portland office of the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, Oregon 97201. Orders for less than $20.00 must be prepaid. □

CONTENTS

Geothermal exploration in Oregon, 1980

by George R. Priest, Geothermal Specialist, and Dennis L. Olmstead, Petroleum Engineer, Oregon Department of Geology and Mineral Industries

ABSTRACT

Geothermal exploration continued at a moderate level in 1980, and acquisition of geothermal leases on Federal lands rose by 73 percent, generating about $1.5 million in revenue. Four geothermal wells (greater than 2,000 ft) and 127 prospect wells (less than 2,000 ft) were drilled in 1980. Five geothermal-well permits and 19 prospect-well permits were issued. No major new discoveries were reported, although plans continue to move ahead for geothermal-heating districts in Lakeview (Northwest Geothermal Corporation, with U.S. Department of Energy [USDOE]), Klamath Falls (private, State, and Federal funds), and Oakridge (probable Federal funding).

The Oregon Department of Geology and Mineral Industries (DOGAMI) continued its evaluation of geothermal resources by drilling 31 temperature-gradient holes, mapping, and performing chemical analyses of ground water in various parts of eastern Oregon and the north-central Cascades. DOGAMI recently drilled a 1,512-ft well southwest of Powell Buttes into a promising thermal anomaly which was discovered by the Department's geothermal group. A bottom-hole temperature of 57°C (134°F) was measured in the hole.

LEVEL OF GEOTHERMAL EXPLORATION

Most of Oregon's Known Geothermal Resource Areas (KGRA's) have been explored to some degree by government and industry. However, many broad areas with anomalous numbers of hot springs have yet to be investigated beyond the reconnaissance, or Phase-I, level (Figure 1).

Exploration of one of the main areas, the High Cascades province, has lagged behind all others. This area is environmentally sensitive and is composed of bed rock which has proven very difficult to drill. Furthermore, numerous industrial sources have indicated that slow processing of U.S. Forest Service leases has tended to inhibit further leasing in both the Western and High Cascades. The future of potential electric power development by industry in the High Cascades, where research by the Oregon Department of Geology and Mineral Industries has shown anomalously high heat flow, will depend upon ending the lease backlog in the U.S. Forest Service and solving the engineering problems associated with High Cascade drilling.

One exception to the above generalizations about industrial activity in the Cascades is the intense level of exploration by Sunoco Energy Development Company in the northwestern Cascades. Sunoco has been aggressively pursuing exploration of both the Breitenbush Hot Springs and Belknap-Foley Hot Springs areas for the past few years (Figure 1). In addition, Atlantic Richfield (ARCO) has begun preliminary work in the Oakridge-McCredie Hot Springs area near Willamette Pass (Figure 1).

DRILLING ACTIVITY

Type of drilling

Geothermal drilling by government and industry continued during 1980. Drilling of prospect wells (now defined by law as those wells less than 2,000 ft deep) continued at a reasonably high level, but drilling of geothermal wells (greater than 2,000 ft deep) was relatively minor (Figures 2 and 3; Tables 1 and 2).

Most of the activity continued to be focused on drilling of relatively cheap temperature-gradient holes, although an increasingly large proportion of these wells were drilled deeper than 500 ft. The tendency to drill somewhat deeper prospect wells is a reflection of two factors: (1) deeper wells have been found to yield superior temperature gradients in areas with porous sediments or in rocks with active shallow ground-water systems; and (2) many exploration programs have progressed to the point of intermediate-level (2,000-ft) drilling, now that shallow (500-ft) drilling arrays are complete. As thermal reservoirs become more completely defined, a larger number of deep wells (greater than 2,000 ft) will be drilled.

Table 1. *Geothermal permits and drilling activity in Oregon, 1980*

Permit no.	Operator	Well name	Location	Total depth (ft)	Status
70	U.S. Geological Survey	Pucci Chairlift	SE¼ sec. 7 T. 3 S., R. 9 E. Clackamas County	4,003	Deepened in 1980; suspended.
80	Chevron Resources Co.	Jordan 55	NW¼ sec. 9 T. 18 S., R. 43 E. Malheur County	2,820	Abandoned.
81	Northwest Natural Gas Co.	Old Maid Flat 7A	NE¼ sec. 15 T. 2 S., R. 8 E. Clackamas County	6,027	Suspended.
82	Oregon Dept. of Geology and Mineral Industries	Powell Buttes 1	SW¼ sec. 10 T. 16 S., R. 14 E. Crook County	1,512	Suspended.
83	Chevron Resources Co.	South Crump 46-4	Center sec. 4 T. 41 S., R. 24 E. Lake County	2,975	Suspended.

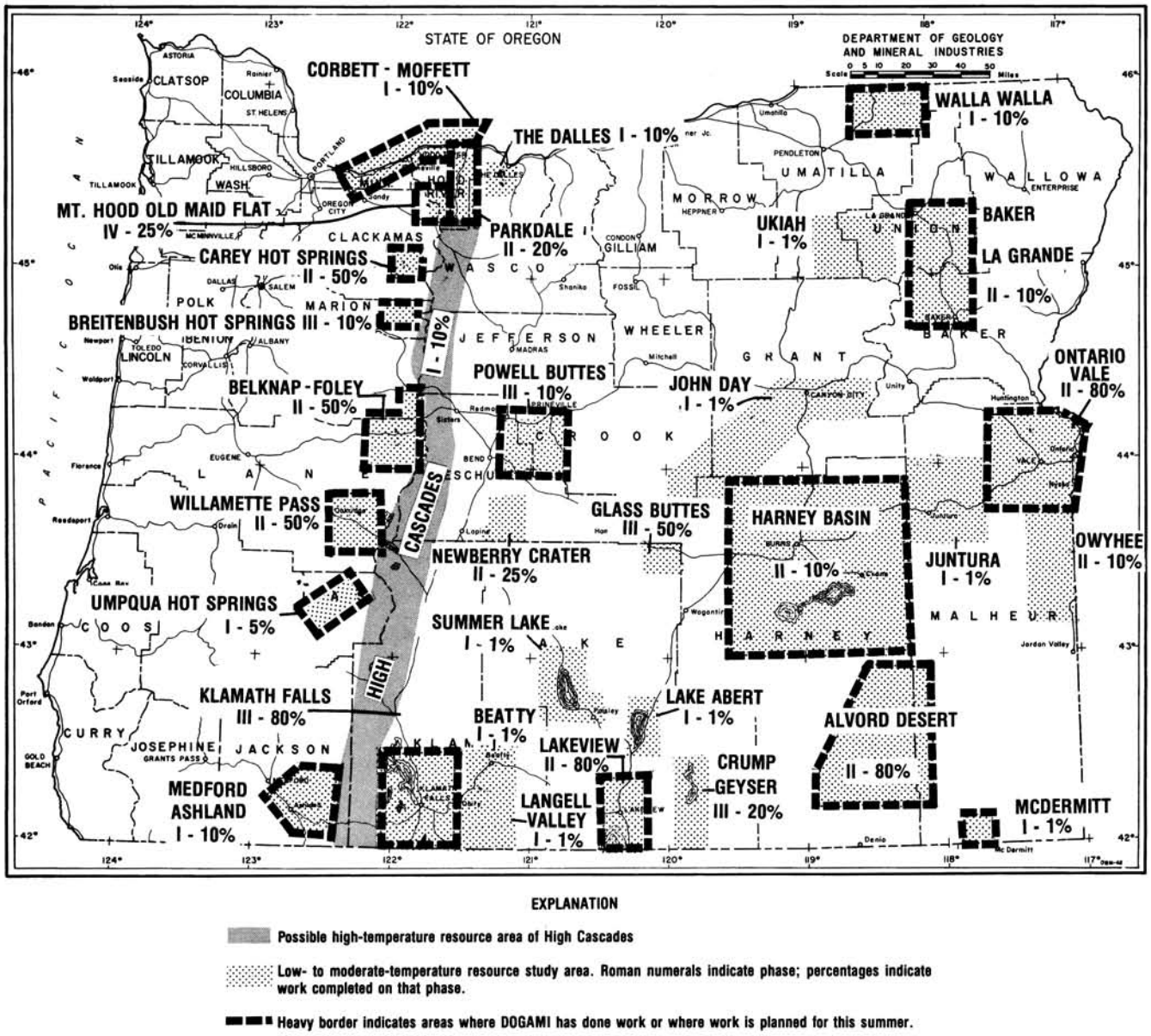

Figure 1. Exploration levels for geothermal resource areas in Oregon. Qualitative estimates of percent completed in each area are based on the following phase classifications: Phase I—reconnaissance work, no drilling. Phase II—shallow drilling of temperature-gradient wells. Phase III—intermediate- to deep-level drilling. Phase IV—deep drilling for reservoir assessment.

According to new Oregon law, holes deeper than 2,000 ft (versus 500 ft in the old law) are now considered geothermal production test wells. Shallower wells are considered prospect tests. This has greatly facilitated the process of obtaining permits for intermediate-level (500- to 2,000-ft) drilling. This may also be a factor in the increased percentage of 2,000-ft wells. The Department issued five geothermal-well permits (Table 1) and 19 prospect-well permits (Table 2) in 1980. A total of four geothermal wells and 127 prospect wells were actually drilled.

Government-sponsored deep drilling

The U.S. Department of Energy (USDOE) funded and managed a program of deep drilling and flow-testing for direct-use thermal water in Old Maid Flat, west of Mount Hood, on leases owned by Northwest Geothermal Corporation (Figure 5). This project involved drilling a 6,027-ft well (OMF-7A) and flow-testing it and a previously drilled 4,003-ft well (OMF-1). Very little thermal fluid was found in either hole, although temperatures were adequate for direct-use applications.

Utilizing USDOE funds, the U.S. Geological Survey (USGS) deepened the Pucci Chairlift hole (Figure 5) on Mount Hood from 2,000 to 4,003 ft and is conducting a flow test. Results of the flow test are not, as yet, complete, although J.H. Robison of the USGS has commented that the hydraulic head on the deep thermal water is not as high as was hoped.

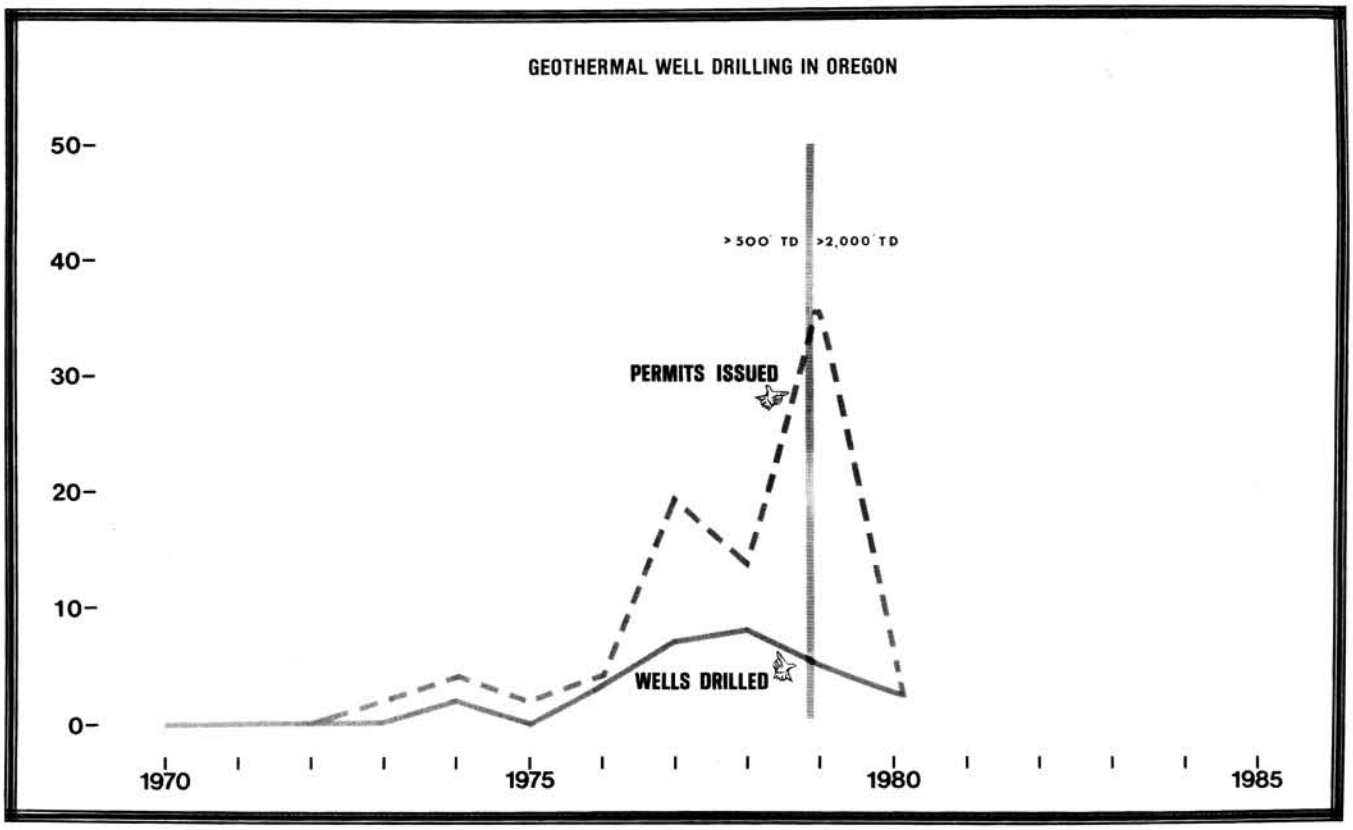

Figure 2. Geothermal well drilling in Oregon. Vertical line indicates time when definition of geothermal well was changed to a depth greater than 2,000 ft.

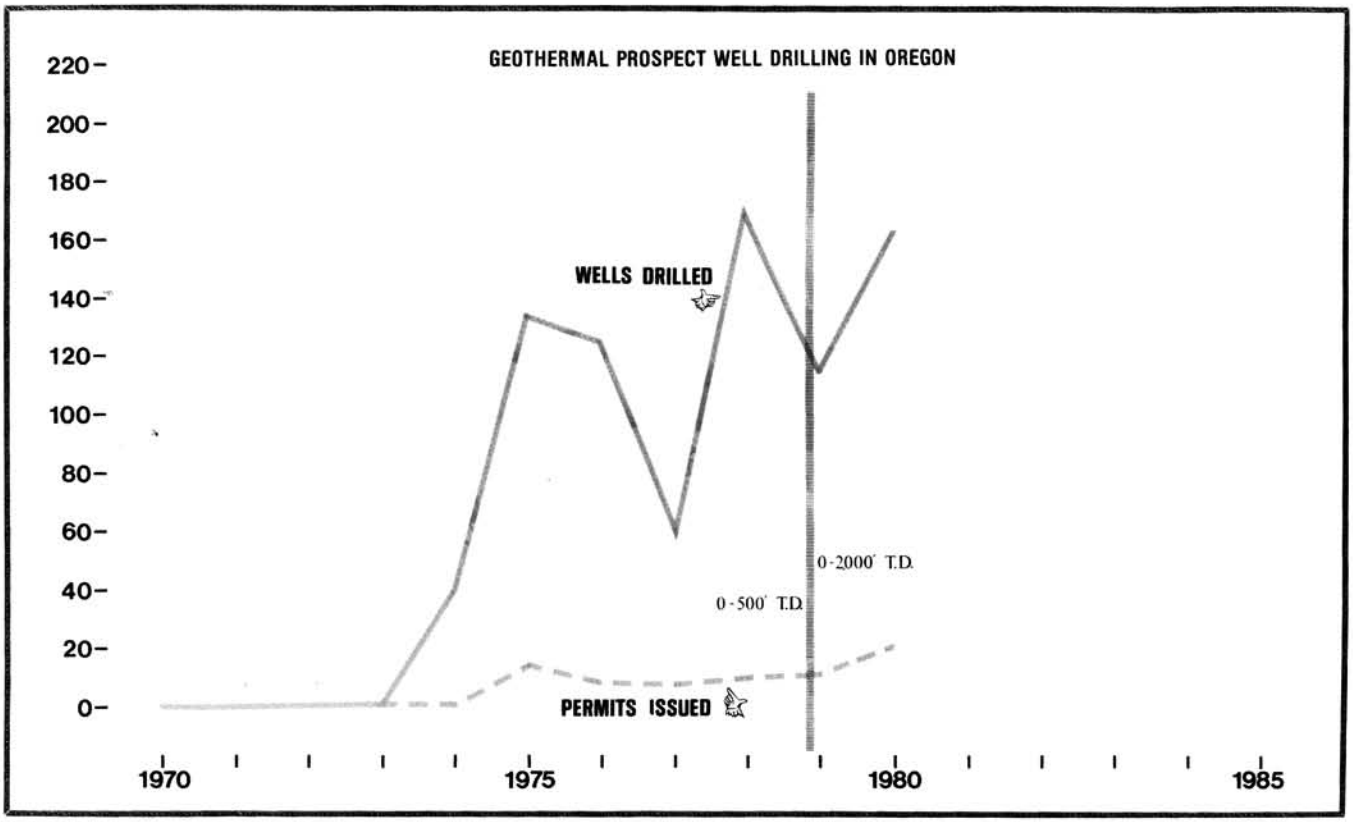

Figure 3. Geothermal prospect well drilling in Oregon. Vertical line indicates time when definition of prospect well was changed to a depth less than 2,000 ft.

Table 2. *Geothermal prospect permits and drilling activity in Oregon, 1980*

Permit no.	Operator	Issue date	Location(s)	Comments and status
35	Sunoco Energy Development Co.	July 1979	Breitenbush and Belknap Hot Springs, Marion, Linn, Lane Counties	Drilled twenty-three 500-ft gradient holes.
50	Phillips Petroleum Co.	July 1979	Cox Flat Lake County	Drilled four gradient holes to 260 ft.
54	Oregon Dept. of Geology and Mineral Industries	Aug. 1979	Western Cascades Lane, Linn, Jefferson Counties	Drilled sixteen gradient holes to 500 ft.
55	U.S. Geological Survey	Aug. 1979	Mt. Hood area Clackamas County	Deepened one hole, drilled four holes, deepest to 1,163 ft.
58	Union Oil Co. of California	Sept. 1979	Alvord Desert Harney County	Drilled one hole to 2,000 ft.
62	Chevron Resources Co.	Feb. 1980	Alvord Desert Harney County	Program canceled.
63	Robert Dollar Co.	Mar. 1980	Klamath Lake Klamath County	Location, one gradient hole.
64	AMAX Exploration, Inc.	Mar. 1980	Bully Creek Malheur County	Program canceled.
65	Anadarko Production Co.	April 1980	Alvord Desert Harney County	Drilled eleven holes, deepest to 1,810 ft.
66	Phillips Petroleum Co.	May 1980	Glass Buttes Lake County	Drilled five holes, deepest to 1,945 ft.
67	Hunt Energy Corp.	June 1980	Lake Owyhee Malheur County	Drilled seven holes to 500 ft.
68	Oregon Dept. of Geology and Mineral Industries	June 1980	Parkdale Hood River County	Location, three gradient holes.
69	Chevron Resources Co.	June 1980	Warner Valley Lake County	Drilled twenty-one holes to 500 ft.
70	Chevron Resources Co.	June 1980	Warner Valley Lake County	Drilled nine holes to 500 ft, one to 2,000 ft.
71	Oregon Dept. of Geology and Mineral Industries	Aug. 1980	Oakridge Lane County	Deepened one hole to 1,130 ft, drilled one to 500 ft.
72	Phillips Petroleum Co.	Sept. 1980	Cox Flat Lake County	Drilled three holes, deepest to 1,555 ft.
73	Oregon Dept. of Geology and Mineral Industries	Nov. 1980	Hood River Valley Hood River County	Location, four gradient holes.
74	Oregon Dept. of Geology and Mineral Industries	Nov. 1980	Powell Buttes Crook County	Drilled eight holes to 500 ft.
75	Oregon Dept. of Geology and Mineral Industries	Nov. 1980	Burns area Harney County	Drilled four holes, deepest to 615 ft.

Industrial deep drilling

Chevron Resources Company was the only company involved in significant deep drilling (below 2,000 ft). They lost a 2,820-ft well near Vale and completed a 2,979-ft well at Crump Lake, near Lakeview (Figure 1). Both wells were drilled for high-temperature fluid to generate electricity.

LEASING

The level of geothermal leasing increased dramatically in 1980. There was a 73 percent increase in leased Federal acreage, most of which was non-KGRA land (Table 3). No accurate data are available for private leases, but a similar increase probably occurred in that sector as well. This dramatic increase in leasing may herald a major increase in exploration efforts for the next few years.

Three U.S. Bureau of Land Management (USBLM) lease sales were held in 1980. Anadarko Production Company, Union Oil Company, Intercontinental Energy Corporation, Hunt Oil Company, Getty Oil Company, Chevron Resources, and Al-Aquitaine Exploration bid a total of $1,530,692.34 on 32,641 acres of land in KGRA's (Table 4). No further lease sales are planned for 1981.

Most geothermal leases continue to be located in either the Basin and Range province of southeastern Oregon or the Western Cascades of northwestern Oregon. The most extensive holdings are at the following areas: Vale-Owyhee, Alvord Desert, Crump Geyser, Lakeview, Paisley, Klamath Falls, Newberry Caldera, Belknap-Foley Hot Springs, Breitenbush

Table 3. *Geothermal leases, 1980*

Type of leases	Net gain since 1979 Numbers		Net gain since 1979 Acres		Relinquished since 1979 Numbers	Relinquished since 1979 Acres
Federal leases						
Noncompetitive, USBLM	76	(+67%)*	41,709.81	(+74%)*	2	2,566.58
Noncompetitive, USFS	2	(+12%)*	1,282.36	(+ 3%)*	0	0
KGRA, USBLM	16	(+76%)*	30,280.75	(+70%)*	3	6,322.56
KGRA, USFS	0		0.00		0	0
Total	94	(+58%)*	73,272.92	(+73%)*	5	8,889.14
Federal leases pending						
Noncompetitive, USBLM	36	(+29)*	72,955.50			
Noncompetitive, USFS	73	(+20)*	156,069.81			
KGRA, USBLM	1		2,360.00			
KGRA, USFS	0		0.00			
Total	110	(+23%)*	231,385.31			
State						
Total leases active in 1980	13		9,687			
Total applications pending	3		2,010			
Private						
Total leases active (est.)	No data		~250,000			

* Based on total of all leases as of 1-2-80.

Table 4. *1980 U.S. Bureau of Land Management KGRA sales*

Tract no.	Date (1980)	Company	Area	Acreage	Amount ($)
13	Jan. 8	Anadarko Pro. Co.	Alvord	2,280	$ 236,367.60
14	Jan. 8	Anadarko Pro. Co.	Alvord	2,463	90,605.33
33	Jan. 8	Union Oil	Breitenbush	1,040	10,341.45
39	Jan. 8	Intercontinental	Klamath Falls	119	917.53
50	Jan. 8	Hunt Oil	Crump Geyser	2,371	4,833.35
51	Jan. 8	Hunt Oil	Crump Geyser	2,344	4,828.58
4	April 29	Getty Oil	Alvord	2,563	30,117.37
28	April 29	Getty Oil	Alvord	1,830	61,751.70
29	April 29	Getty Oil	Alvord	2,542	44,478.35
33	April 29	Anadarko	Alvord	2,400	149,664.00
34	April 29	Anadarko	Alvord	2,560	397,516.80
35	April 29	Getty Oil	Alvord	40	630.00
36	April 29	Anadarko	Alvord	2,520	227,379.60
37	April 29	Getty Oil	Alvord	2,560	44,802.28
59	April 29	Chevron	Crump Geyser	2,568	5,785.00
60	April 29	Chevron	Crump Geyser	81	1,057.00
1	Oct. 23	Al-Aquitaine Explor.	Alvord	2,360	249,617.20
			Total	32,641	$1,530,692.34

Hot Springs, Austin (Carey) Hot Springs, and Mount Hood.

Atlantic Richfield (ARCO) has acquired a significant land position around the Kitson-McCredie Hot Springs area. This is the first time ARCO has shown interest in the Cascades, and they plan to do preliminary geophysical and geological studies and water sampling in this area during the upcoming field season.

Northeastern Oregon and the Ashland-Medford area continue to be largely ignored by industry, although both areas have low- to moderate-temperature geothermal resources. This may be blamed on the general tendency for most larger companies to concentrate on high-temperature resources for electrical power production.

RESEARCH

Low-temperature geothermal resources

The Department is continuing its USDOE-funded low-temperature geothermal-resource assessment program. The second year of this study has culminated in preparation of resource assessment open-file reports on the following areas (Figure 1):

Belknap-Foley—Open-File Report 0-80-2*
Willamette Pass—Open-File Report 0-80-3*
Craig Mountain-Cove (La Grande)—Open-File Report 0-80-4
Western Snake River Plain (Vale)—Open-File Report 0-80-5
Northern Harney Basin (Burns)—Open-File Report 0-80-6*
Southern Harney Basin—Open-File Report 0-80-7*
Powell Buttes—Open-File Report 0-80-8
Lakeview—Open-File Report 0-80-9
Alvord Desert—Open-File Report 0-80-10

* Already available for sale from the Portland office of the Oregon Department of Geology and Mineral Industries.

All of these reports contain compilations of chemical analyses of spring and well waters, reservoir-temperature calculations, temperature-gradient measurements, calculated heat flow, and all available geologic and geophysical maps of each area. New, previously unpublished data in nearly every category have been either generated by the Department or borrowed from industrial sources. All of these studies are, as yet, preliminary and will be complemented by final reports of the most promising areas.

Considerable drilling was also completed under the low-temperature assessment program. In 1980, 13 holes were drilled for temperature-gradient measurements to depths of less than 600 ft. These prospect wells were drilled near Oakridge (Figure 6), Burns (Figure 7), and Powell Buttes (Figure 8). The Oakridge city well was deepened from 420 to 1,130 ft, and one well (PB-1) has just been completed to a depth of 1,512 ft into a thermal anomaly at Powell Buttes (Figure 8). This thermal anomaly, discovered by the Department in 1978, is marked by temperature gradients as high as 164°C/km (527°F/mi). A bottom-hole temperature of 57°C (134°F) in the 1,512-ft hole indicates that high gradients extend at least to that depth. This hole will be deepened if funds can be found.

The Department plans to do limited shallow (500-ft) drilling of temperature-gradient wells in the Parkdale area northeast of Mount Hood and in the Corbett-Camp Collins area near Portland in 1981 if funds are available.

Cascades study

The Department has continued to pursue geothermal research in the north-central Cascades with support from USDOE. Sixteen shallow (500-ft) temperature-gradient wells were drilled during 1980 to complete the program of 22 holes (Figure 9). Raw temperature-gradient data for these wells and all other wells probed by DOGAMI in Oregon since 1978 are available as Open-File Reports 0-81-3A (1978 data), 0-81-3B (1979 data), and 0-81-3C (1980 data).

Detailed geologic mapping and K/Ar dating was accomplished by the Department as part of the Cascades study in 1979 and 1980. Most of the mapping effort was focused on the following areas: (1) Devil's Creek area near Breitenbush Hot Springs, (2) Cougar Reservoir area at Terwilliger Hot Springs, (3) Southern Lookout Point Reservoir, and (4) Pinto Creek-Tumblebug Creek area near Diamond Peak. A geologic map (scale 1:24,000) of the Cougar Reservoir area will be published during the spring or summer of 1981, and a brief geological summary was presented at the annual Oregon Academy of Science meeting on February 28, 1981.

The Department has also supervised several subcontracted studies of the Oregon Cascades with USDOE support. C.M. White of Boise State University completed a study published as the *Geology of the Breitenbush Hot Springs Quadrangle, Oregon* (DOGAMI Special Paper 9). J.R. Magill and A.V. Cox of Stanford University summarized paleomag-

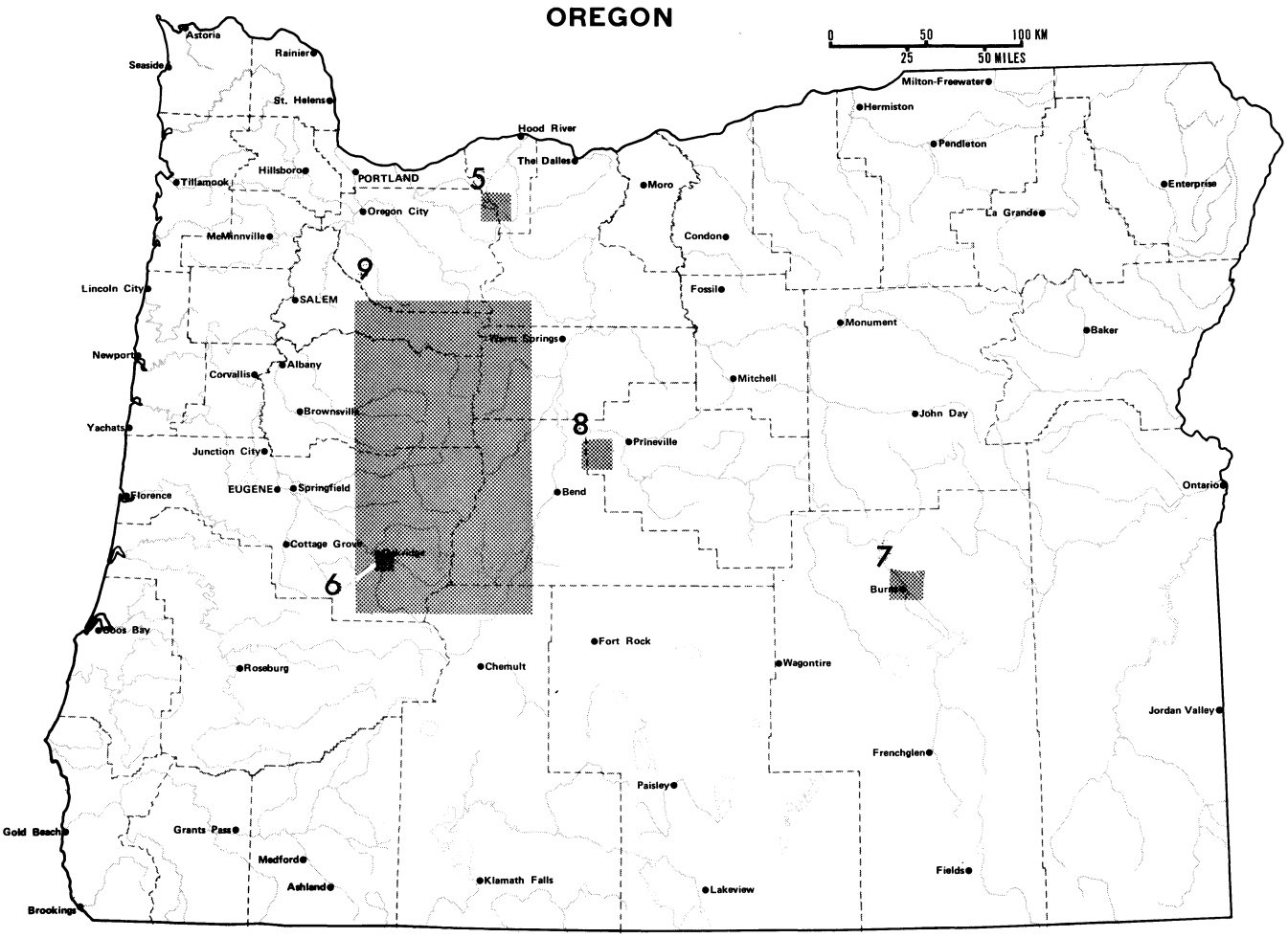

Figure 4. Map showing locations of areas covered by Figures 5, 6, 7, 8, and 9.

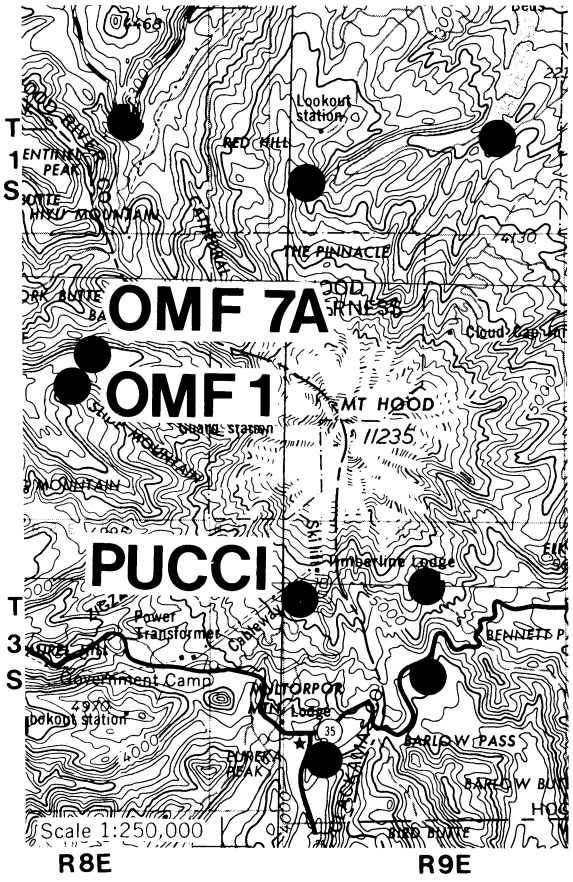

Figure 5. Geothermal drilling in the Mount Hood area, 1980. The Pucci Chairlift hole and unlabeled holes were drilled by the USGS. The Pucci hole was deepened from 2,000 to 4,003 ft. The OMF-1 hole was flow-tested and abandoned by the USDOE. OMF-7A was drilled by the USDOE to 6,027 ft.

netic data on the Cascades in their paper *Tectonic Rotation of the Oregon Western Cascades* (DOGAMI Special Paper 10). The Oregon State University Geophysics Group has completed a regional gravity and aeromagnetic survey of the entire Oregon Cascades, which will be released this spring as part of the Department's Geological Map Series. C.W. Field and S.G.P. Storch of the Oregon State University Department of Geology are working on a summary report on ancient hydrothermal systems of the Western Cascades. Foundation Sciences is currently finishing a lineament study of the southern Cascades to complement the recently published DOGAMI Special Paper 12, *Geological Linears of the Northern Part of the Cascade Range, Oregon*, by R. Venkatakrishnan, J.G. Bond, and J.D. Kauffman.

Old Maid Flat 1, Clackamas County

The Northwest Geothermal Corporation's deep exploratory well, Old Maid Flat 1, located in the SE ¼ SW ¼ sec. 15, T. 2 S., R. 8 E., at Old Maid Flat west of Mount Hood (Figure 5), was completed to a depth of 4,003 ft in 1978 and flow-tested in June 1980. Funding for drilling and testing was provided primarily by USDOE. No significant fluid was recovered from the well, and it was plugged and abandoned. A complete set of geophysical logs for OMF-1, including temperature data, is available from the Oregon Department of Geology and Mineral Industries as Open-File Report 0-78-6.

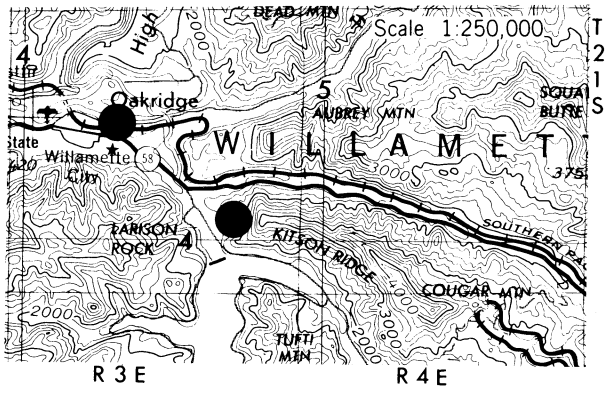

Figure 6. Geothermal drilling, Willamette Pass-Oakridge, 1980. Two holes were drilled in this area by the Oregon Department of Geology and Mineral Industries under the USDOE low-temperature geothermal-resource assessment program. The Oakridge city well was deepened to 1,130 ft, and a 500-ft temperature-gradient well was drilled south of town.

Old Maid Flat 7A

The USDOE-State-coupled geothermal exploration program for low-temperature direct-use geothermal water funded the drilling of a deep (6,027-ft) test well at Old Maid Flat, west of Mount Hood. The Old Maid Flat 7A test well (OMF-7A, Figure 5), located in the SW¼ NE¼ sec. 15, T. 2 S., R. 8 E., at an elevation of 2,760 ft, was completed in October 1980. The property is under lease by Northwest Geothermal Corporation, an affiliate of Northwest Natural Gas Corporation.

The well was designed to test the reservoir characteristics of the Columbia River Basalt Group where that unit is intercepted by a normal fault. The hole was drilled at 24 in. to 96 ft and lined with 18-in. casing, then drilled to 1,191 ft at 14.75 in. and lined with 10.75-in. casing. The well was rotary-drilled at a diameter of 9.88 in. to 6,011 ft and diamond-drilled at 4 in. to 6,027 ft. Other diamond cores were also drilled at 1,595 to 1,624 ft, 2,914 to 2,920 ft, 3,381 to 3,399 ft, 4,394 to 4,417 ft, and 5,122 to 5,152 ft. All cores and cuttings are available for examination at the Oregon Department of Geology and Mineral Industries in Portland.

Approximately 6,000 ft of 2.88-in. temperature observation pipe was put in the hole after flow tests proved disappointing (less than one gallon per minute from all thermal aquifers). The hole will be plugged and abandoned by August 31, 1981, if no further uses can be found for it. It is hoped, however, that some scientific purpose such as geophysical monitoring will be found for this very expensive well. DOGAMI and M.H. Beeson of the USGS are now seeking groups interested in scientific uses for this hole.

A complete suite of Schlumberger geophysical logs and lithologic logs is available for Old Maid Flat 7A as Open-File Reports 0-80-11, 0-81-2A, and 0-81-2B. In addition, M.J. Holdaway of Southern Methodist University is preparing a complete analysis of alteration mineralogy encountered, and M.H. Beeson of Portland State University will analyze samples from all the volcanic units for both major- and trace-element composition. D.D. Blackwell of Southern Methodist University is measuring various geophysical parameters of cores and cuttings for quantitative correlation to the geophysical logs. Publications summarizing these investigations and some geological work by the Department will be available some time in the summer or fall of 1981.

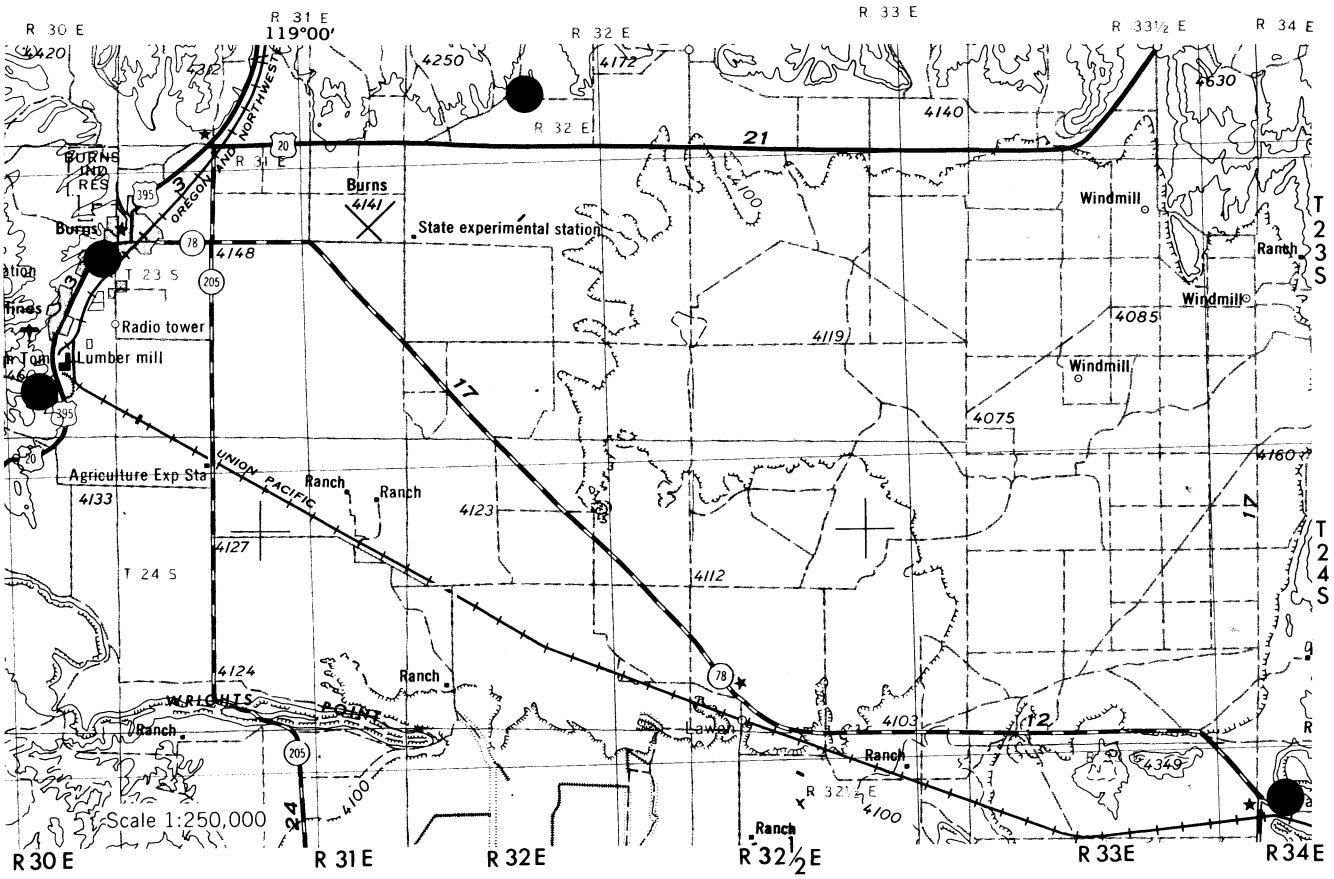

Figure 7. Geothermal drilling, Harney Basin, 1980. Drilling of 500- to 600-ft temperature-gradient wells was undertaken by the Oregon Department of Geology and Mineral Industries as part of the USDOE low-temperature geothermal-resource assessment program.

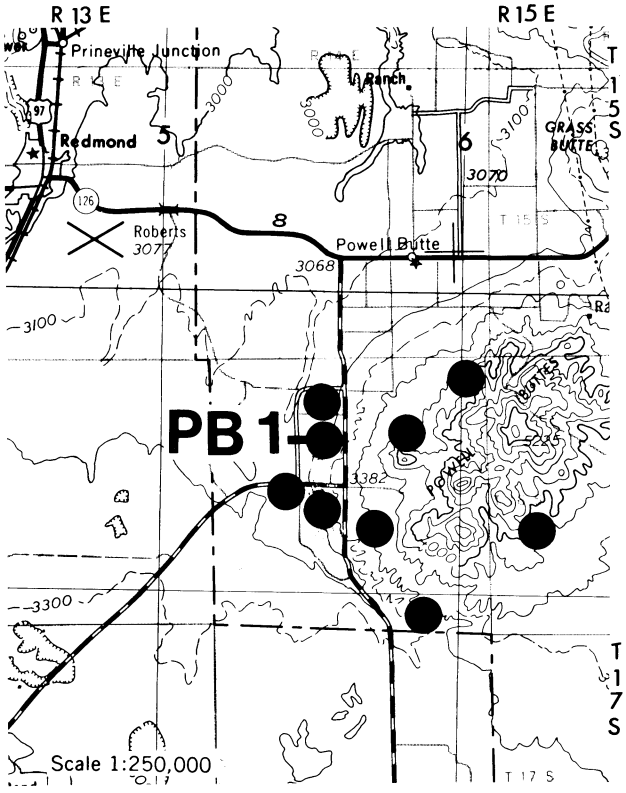

Figure 8. Geothermal drilling, Powell Buttes, 1980. Temperature-gradient wells, 500 ft and one 1,500 ft (PB-1), were drilled by the Oregon Department of Geology and Mineral Industries as part of the USDOE low-temperature geothermal-resource assessment program.

USGS exploration at Mount Hood

With the support of USDOE funds, the USGS completed an ambitious program of intermediate to deep geothermal drilling around Mount Hood this last fall (Figure 5). The exploration program was managed by J.H. Robison and focused on fluid chemistry, temperature gradients, and stratigraphic analysis. M.H. Beeson of the USGS will conduct an analysis of hydrothermal alteration in the holes at Mount Hood and other parts of the Cascades.

Four holes were drilled around the flanks of Mount Hood this season to depths of 800 to 2,000 ft (Figure 5). In addition, the Pucci Chairlift hole near Timberline Lodge was deepened to 4,003 ft and tested for recharge in the thermal zone (see section on government-sponsored deep drilling). The thermal water table is 1,891 ft below the surface. Temperature gradients vary from 30° to 84°C/km (138° to 295°F/mi); temperature in the production zone is expected to be more than 70°C (158°F). A production test is planned for 1981.

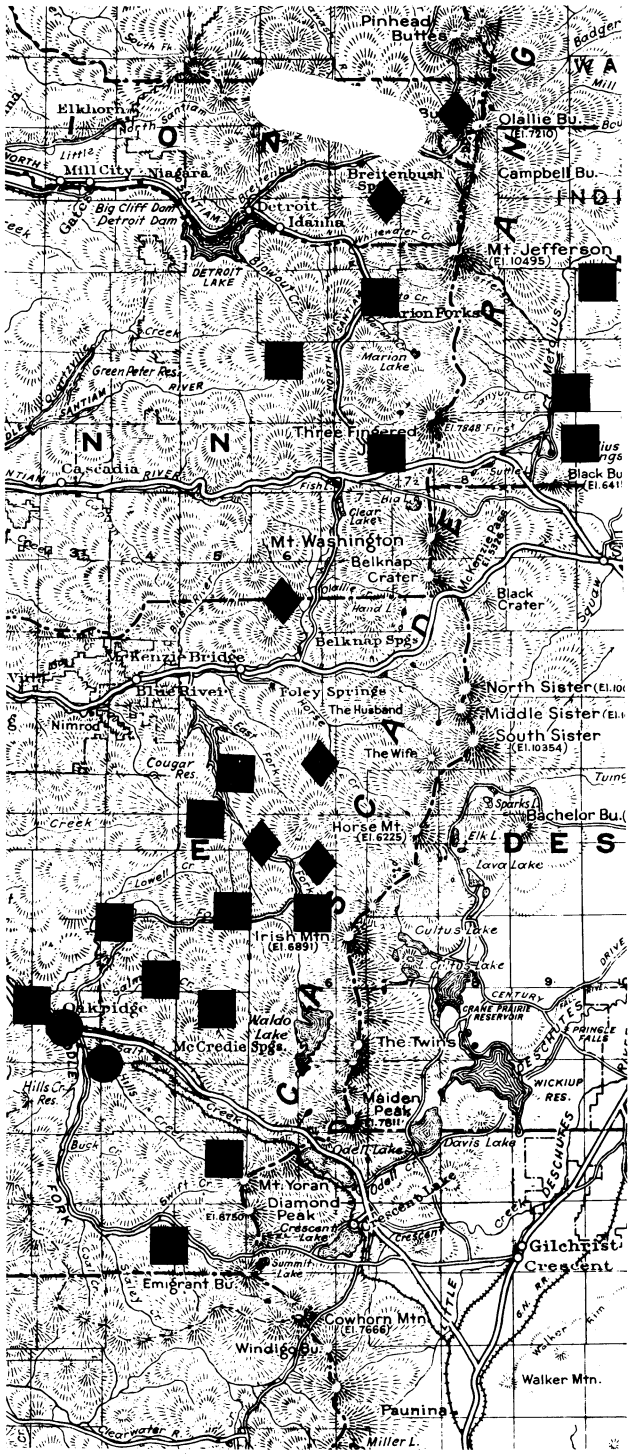

Figure 9. DOGAMI Western Cascades geothermal-resource study, 1979-1980. Map shows locations of 500-ft temperature-gradient wells drilled as part of the USDOE geothermal-resource assessment of the Cascades. Also indicated are holes drilled for the low-temperature geothermal-resource assessment program (see Figure 6).

USGS exploration in the central and southern Oregon Cascades

Most of the USGS work in the central and southern Cascades of Oregon has centered on the young and potentially active volcanic centers at Crater Lake and Newberry Caldera. Crater Lake work has included heat-flow measurements in bottom sediments, water sampling, seismic reflection profiling, and detailed mapping of the wall of the caldera. Geophysical work is under the coordination of D.L. Williams of the Denver, Colorado, office; and C.R. Bacon of the Menlo Park, California, office is conducting the geologic investigation.

The geothermal evaluation of Newberry Caldera has been supervised by N.S. MacLeod of the Menlo Park office. He has completed mapping and is currently conducting petrochemical and isotopic studies. During 1979, hydrologic and heat-flow studies including drilling of two holes, 2,100 and 2,000 ft deep, in the caldera. One of these holes was lost because of drilling problems during that year, but the other will be deepened in 1981, according to a recent USGS newsletter.

Publication last year of USGS Professional Paper 1044-G, *Hydrogeologic Appraisal of the Klamath Falls Geothermal Area, Oregon*, by Edward A. Sammel was a major contribution to the understanding of the Klamath Falls geothermal system. Sammel will also be involved in evaluation of the Newberry hydrologic system.

Oregon Institute of Technology

The Oregon Institute of Technology (OIT) continues to operate the Geo-Heat Utilization Center to further the development of geothermal energy in the Pacific Northwest. The Center can provide up to 100 hours or $5,000 of free geothermal consultation on direct-heat applications. The Center has published a great deal of information about the use of geothermal energy and the state of geothermal development in the Northwest as part of its regional coordination program for the northwestern United States. The Geo-Heat Center will select twelve communities for major heating-district feasibility studies this spring. This program is above and beyond the 100-hour consultation program and will be focused on municipalities with known resources that have little possibility of industrial support.

The Geo-Heat Center has recently given consultation help to Northwest Geothermal Corporation on their heating-district project for Lakeview. Similar consultations have been given to various groups in Klamath Falls, La Grande, Vale, and Oakridge. All of these cities are moving ahead into exploratory phases of heat utilization as funding is secured. □

OMSI announces summer paleoecology program

The Oregon Museum of Science and Industry is preparing a summer program designed to introduce high school students to the paleobotany and vertebrate paleontology of Tertiary geologic units in the John Day basin of central Oregon. The National Science Foundation-supported program will include team field projects, individual studies, and lectures. The eight-week course starts June 19, 1981, and will be based at OMSI's Hancock Field Station, Fossil, Oregon. The $650 tuition covers cost of food, lodging, transportation, and instruction. Financial-need scholarships are available. Interested persons should contact Bruce Hansen, Research Center, OMSI, 4015 S.W. Canyon Road, Portland, Oregon 97221. □

Surface mined land reclamation in Oregon, 1980

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

During 1980, Oregon's program for the reclamation of surface mined land continued to evolve. The number of professional staff of the Mined Land Reclamation Program fluctuated between one and three during the year, with three at year's end. With this field staff and with office support of one clerical specialist and one part-time clerical assistant, 681 field inspections were conducted and recorded, and in most cases other actions concerning the sites were accomplished.

Of particular satisfaction is the observation that several sizable sites have been or are being reclaimed on a volunteer basis. These are sites where either mining was completed before the law existed or the area was exempted from mandatory reclamation under the provisions of ORS 517.770(1)(a)(c). All of these sites are expensive investments. One is a landscaped lake-park completed by a city for esthetic and safety reasons. The others were done by private enterprise for the enhancement of real estate and profit. The existence of these voluntarily reclaimed sites illustrates a growing awareness of the values of reclamation—an attitude that is in strong contrast to the past practices of either abandoning the land or reclaiming it only because the law required it. This growing awareness is leading to more cooperation with the program's goals: to extract needed mineral resources, to leave the mined site reasonably safe and nonpolluting, and to achieve a future "beneficial use" for the mined land, thereby desirably enhancing its value.

The costs of reclamation continue to escalate. Another State of Oregon agency which frequently does the same kinds of tasks required for surface mined land reclamation quotes figures charged it by contractors for fertilizing, seeding, and mulching—not including contouring or seed-bed preparation. For areas over 5 acres and in conjunction with a larger contract, quotations slightly exceed $500 per acre. When the acreage is less than 5 acres and the job is not part of a larger contract, quotations reach $1,000 per acre. A large amount of detailed data assembled from the Bureau of Land Management, the U.S. Forest Service, and commercial sources further forcefully illustrates the rising costs of services and equipment. From this it is apparent that the Department must take action to insure that bonding to guarantee reclamation keep pace with costs, that reclamation be carefully planned even prior to the beginning of mining to insure the most economical practices, and that all details of reclamation be appropriate to the site.

Not surprisingly, a substantial proportion of new sites are gold placers. By their nature and usually by location as well, placer operations have an inherent capacity to turn many yards of earth into a "mud soup" in the nearest stream. Yet, in most cases, it is possible for a reasonably careful operator to wash for gold with a closed, recirculating system of reservoir and settling ponds without affecting a nearby watercourse.

CURRENT STATUS

The following figures and data depict the present scope and trends of Oregon's Mined Land Reclamation Program.

As of December 31, 1980, a total of 443 acres had been reclaimed. Of that total, acreage was reclaimed for the following uses as indicated: agriculture, 251 acres; forestry, 7 acres; housing, 37 acres; and other,* 148 acres. Of the 443 acres, 106 acres were reclaimed in 1980. Not included with these figures, because it is impossible to keep up to date, is additional concurrent reclamation completed within sites still operating.

As of December 31, 1980, 2,173 acres are under security with approved reclamation plans on 269 sites. Many of these sites contain additional grandfathered acreage. Experience indicates that some of the grandfathered acreage will be reclaimed voluntarily.

Of the total "bonded" acreage, 84 percent is secured by performance bonds; the remainder is secured by various other types of security.

Because of the inflation in reclamation costs, bonds for 73 percent of all sites with reclamation requirements have been brought up to the authorized ceiling of $500 per acre, as opposed to 45 percent at the beginning of 1980. Nearly 17 percent of reclaimable sites are bonded at around $300 per acre. The remaining 10 percent are bonded at several levels above and below $300 per acre. Bonding on most sites will increase to the present ceiling; however, rates per acre may be expected to be reduced on sites where reclamation is substantially underway.

In order to insure that adequate funds will be available to guarantee reclamation in the event the operator defaults, the Department is seeking an increase to $1,500 in the authorized bonding ceiling. The maximum would not be assessed against every site. Such a ceiling will insure a greater likelihood that, if necessary, the State can pay for the reclamation the operator contracted to perform. It will perhaps further encourage concurrent reclamation, as the total bond may be reduced at each year's review if the net affected acreage decreases.

Presently operating sites with reclamation plans have lands scheduled to be reclaimed to the following uses: agriculture, 125 sites; forestry, 63 sites; housing, 23 sites; and other,* 88 sites. These figures exceed the total number of sites with reclamation plans because some sites will reclaim lands in more than one category.

In 1980, 46 new surface-mining permits (requiring reclamation plans) were issued, and 19 surface-mining permit sites were closed, reclaimed. Thirty-four new limited-exemption (grandfathered) sites were opened; four were closed. Forty-six new total-exemption sites were opened; three were closed. A few sites changed status from one to another of the above categories.

At year's end, there were 333 sites permitted under Grants of Limited Exemption and 571 sites under Grants of Total Exemption.

* "Other" as used above includes water impoundments (for recreational fishing, irrigation, stock pond, commercial aquaculture, marina, etc.), fish and duck hunting preserve, landfill, demolition disposal, industrial-commercial construction sites, log deck sites, wildlife management, stockpile site, and one fossil collecting site. □

Correction

The name of Morse Brothers, Inc., was placed in the wrong sentence in the last paragraph on page 34 in the March 1981 issue of *Oregon Geology*. The sentences should have read: "Limestone marketing in the Willamette Valley has been changed by the importation by barge of limestone from Texada Island, B.C., to Newport (Point 7) by Morse Brothers, Inc. Prior to this time, limestone was supplied to the valley by barge from Texada Island to Portland, then south by rail." □

Comment and Reply on "The petrology and stratigraphy of the Portland Hills Silt—a Pacific Northwest loess"

Comment

Roger B. Parsons, West Technical Service Center, Soil Conservation Service, U.S. Department of Agriculture, 511 N.W. Broadway, Portland, Oregon 97209

I read with interest and general agreement the article by R.T. Lentz about the Portland Hills Silt in the January 1981 *Oregon Geology* (v. 43, no. 1, p. 3-10). However, some of the questions remaining unstudied and unanswered are:

1. Why does the Portland Hills Silt, if loess, thin from 80 to 120 in. on stable summits of the Chehalem Mountains to 0 on the Red Hills of Dundee only about 4 mi to the southwest? Theisen and Knox (1959) and Lentz limited the areal extent of their studies, and apparently recon, to the Chehalem-Tualatin Mountain areas. In most "loess" studies, the work has covered larger areas. Why is there no loess on the Red Hills of Dundee, Salem Hills, etc.? Generally, loess does not thin so drastically on stable summits (Eo1a geomorphic surface).

2. The 14C age of 34,410 ± 3,450 y.a. reported by Glenn (1965) came from organics in sediments under the early Holocene Winkle geomorphic surface, not the Calapooyia surface—the late Pleistocene main valley floor. All wood samples we have obtained from the Willamette Formation under the Calapooyia surface have been beyond reach of 14C dating techniques.

3. The Irish Bend Member of the Willamette Formation (Balster and Parsons, 1969) near St. Paul has bedding with a dip and strike toward the Chehalem Mountains, suggesting post-late Pleistocene upwarp. The Irish Bend usually has horizontal bedding. Early Holocene stream displacement has been documented in the area (Parsons, 1969).

4. There are two unconforming fragipans in the Tualatin Mountains that are not coextensive with the upper soil horizons (an umbric epipedon and a cambic) or the ground surface. The mineralogy and particle size of two silt units was reported by Whittig and others (1957). It is unfortunate Lentz did not review and cite this work.

5. As yet there is no explanation of why the erratic (exotic if from the Troutdale Formation) pebbles in the Portland Hills Silt so often occur at the contact between the cambic (B) horizon and the fragipans (IICx or Bx horizons). Is it possible the pebbles are a stoneline? Stonelines have been observed in the paleosol under the silt.

6. To date there is no known reason why Laurelwood soils (Ultic Haploxeralfs, fine-silty, mixed, mesic) on the Chehalem Mountains lack fragipans, while Cascade soils (Typic Fragiumbrepts, fine-silty, mixed, mesic) just across the Tualatin Valley syncline have fragipans. Supposedly the "loess" is the same, yet the soil-stratigraphy is different.

Perhaps we should, at least briefly, entertain the thought that the Portland Silts, due to their limited areal extent to the southwest plus problems listed above, could be displaced, reworked former Irish Bend-like (formerly Willamette Silts) sediments.

The area could use a coordinated soil-geologic project to resolve some of these remaining questions.

January 29, 1981

Reply

Rodney T. Lentz, Bureau of Land Management, P.O. Box 194, Battle Mountain, Nevada 89821

Thank you for the opportunity to respond to some of the questions raised by Dr. Parsons. I'm glad the article has surfaced an interest in the Portland Hills Silt (PHS) by the soils profession. Because of the very nature of the deposit, a closer look at its soil stratigraphy would be of real benefit.

The article presented in *Oregon Geology* indicated that it was a summary of a master's thesis completed in 1977. I would direct Dr. Parsons to this work for a more thorough discussion of the topic, including previous work, field methods, and data collection and analysis. I might add that the physical limits of the detailed study and reconnaissance for the project were determined largely by time limitations and by previous investigations. A literature review indicated that the unique deposit was, in fact, very limited in areal extent and that a much expanded study was not warranted.

Although information concerning total depth of the PHS in the Tualatin Mountains is limited, the data indicate a maximum thickness of 100+ ft. The thickness in the Chehalem Mountains, some 18 mi away, may be up to 10 ft. Assuming a direct relationship between distance and thickness, these values suggest a rate of decrease in total depth of about 5 ft per mile. Though admittedly simplified, this model would easily account for the absence of PHS on the Red Hills, about 5 mi further southwest.

The *Oregon Geology* article notes that the stratigraphic relationship between PHS and the Willamette Silt was determined in the Tualatin Valley. PHS near Springville Road was unconformably overlain by sediments correlated with the Willamette Silt. If the unconformity detected was indeed that of the Calapooyia surface, the upper age limit for the PHS may be pushed back from ~35,000 to >40,000 years B.P. However, I don't believe that this has a serious impact upon the concepts which I presented.

Except for minor differences in the heavy mineral suite, the mineral composition of the PHS and Willamette Silt (Irish Bend member of Balster and Parsons, 1968) is very similar, thus indicating a common provenance. However, after examining hundreds of PHS outcrops I am convinced that rare, out-sized clasts ("erratic" or "exotic" pebbles) in the silt are the result only of colluvial or alluvial contamination (sometimes forming stone lines) during or after deposition. In addition, I found that the PHS is truly devoid of *primary* depositional structures associated with fluvial or lacustrine deposits. For these, and other important reasons, which are discussed at length in my thesis, it appears very unlikely that PHS was originally waterlaid and subsequently uplifted or displaced.

March 3, 1981

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Glenn, J.L., 1965, Late Quaternary sedimentation and geologic history of the north Willamette Valley, Oregon: Corvallis, Oreg., Oregon State University doctoral dissertation, 231 p.

Parsons, R.B., 1969, Geomorphology of the Lake Oswego area, Oregon: Oregon Department of Geology and Mineral Industries, The Ore Bin, v. 31, no. 9, p. 187-192.

Theisen, A.A., and Knox, E.G., 1959, Distribution and characteristics of loessial soil parent material in northwestern Oregon: Proceedings of the Soil Science Society of America, v. 23, no. 5, p. 385-388.

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Pacific Northwest Metals and Minerals Conference to meet in April

The Pacific Northwest Metals and Mineral Conference will be held April 27-29, 1981, at the Red Lion Inn, 1000 N.E. Multnomah, Portland, Oregon. Hosts for the meeting are the Oregon chapters of the American Society for Metals; American Welding Society; American Institute of Mining, Metallurgical and Petroleum Engineers; and National Association of Corrosion Engineers.

Theme of the Monday morning keynote session will be "Minerals, Metals, and Energy in the 80's." Other sessions include gold and money, gold technical, gold mining, small mining, geology of the Northwest, regional mineral developments of the Northwest, ASM metallurgy/materials science, resource and process development, innovations in welding research, rare metals, applications of welding to engineering structures, and corrosion.

Cost of registration for the entire session, including two luncheons and Tuesday evening banquet, is $65. Single-day registration fees are: Monday, $28; Tuesday, $42; and Wednesday, $18. Student registration (sessions only) is $5.

To register, contact Patrick M. Wall, c/o Stark Steel and Supply Co., 6330 N. Basin, Portland, OR 97217; phone (503) 285-5251. For copies of the program, contact Steve O'Hare, U.S. Bureau of Mines, P.O. Box 70, Albany, OR 97321; phone (503) 967-5894. □

Geothermal meeting set for May

The Geothermal Resources Council, Washington State Energy Office, and the Oregon Department of Energy are sponsoring a geothermal meeting to be held May 19-22, 1981, at the Thunderbird Motor Inn, Jantzen Beach, in Portland. The meeting will be held in two parts: Part I—Geothermal Systems in the Cascades: Evidence from Recent Field Studies (May 19-20); and Part II—Geothermal Exploration and Development in the Cascades (May 21-22).

The purpose of this meeting is twofold: 1. To publicize geothermal energy as an existing alternative energy source in the Pacific Northwest and a response to the requirements in the Pacific Northwest Electric Power Planning and Conservation Act; and 2. To present potential developers and users of energy with information on the nature of the resource and its occurrence in the area, the results of recent field studies, an outline of the various uses of geothermal energy, and state and federal policies affecting geothermal development as well as its place in overall land use planning programs of the Cascade region.

Weather permitting, two field trips are planned in conjunction with the meeting. The first is a flight over Mount St. Helens on the morning of May 19. The second is an overnight trip to see geothermal exploration at Meagher Creek, Vancouver, B.C., on May 23 and 24.

For more information, contact Elaine Clark, Geothermal Resources Council, PO Box 98, Davis, CA 95617; phone (916) 758-2360. □

In 1980, a total of 1,443 new oil and gas fields were discovered in the United States.

—Petroleum Information Corporation

USGS publishes field trip guidebook to volcanic terranes

The U.S. Geological Survey (USGS) announces the release of Circular 838, *Guides to Some Volcanic Terranes in Washington, Idaho, Oregon, and Northern California*, guides for field trips held in conjunction with the Pacific Northwest American Geophysical Union meeting held September 1979 in Bend, Oregon.

The 189-page book contains field trip guides for (1) Columbia River basalt between Lewiston, Idaho, and Kimberly, Oregon; (2) the area between Kimberly and Bend, Oregon; (3) central High Cascades, Bend, Sisters, McKenzie Pass, and Santiam Pass, Oregon; (4) Newberry Volcano, Oregon; (5) High Lava Plains, Brothers Fault Zone to Harney Basin, Oregon; (6) Fort Rock-Christmas Valley Basin, Oregon; (7) Medicine Lake Highland, Oregon-California; (8) Captain Jack's Stronghold, Lava Beds National Monument, California; and (9) the northern and western margins of the Medicine Lake Highland.

This volume is dedicated to editor David A. Johnston, USGS volcanologist killed in the May 18, 1980, eruption of Mount St. Helens, "...in grateful remembrance of the effect that Dave's enthusiasm, diligence, and vitality had on so many of us." Co-editor Julie Donnelly-Nolan completed the editorial work left unfinished by Dave's death and was instrumental in seeing that the volume was published as a memorial to him.

USGS Circular 838 is available free of charge to the public. A limited number of copies are available, one to a customer and over the counter only, at the business office of the Oregon Department of Geology and Mineral Industries, 906 State Office Building, in Portland. Free copies may be obtained by mail from the USGS, 604 S. Pickett St., Alexandria, VA 22304. Free copies are also available over the counter at USGS Public Inquiries offices in Los Angeles, San Francisco, and Spokane. □

CORRESPONDENCE

March 2, 1981

Editor:

I read with interest the account of the naming of Oregon's southernmost glacier which appeared on page 20 of the February 1981 issue of *Oregon Geology* (v. 43, no. 2).

However, the photograph accompanying the article does not show the northeast side of Mt. Thielsen.... The photograph you ran shows the east and southeast faces, with the Cottonwood Creek drainage running off to the right and the Tiny Creek drainage running toward the bottom of the photograph....

In addition, I have written a third article on our observations of the glacier entitled "Mt. Thielsen's Glacierettes: A Five-Year Update," which was published in the 1976 Mazama *Annual* (v. 58, no. 13, p. 17-20). One additional point is that Ted Lathrop died on May 20, 1979, not May 29.

Ralph H. Nafziger
2015 S.W. Ferry Street
Albany, Oregon 97321

Our apologies to Leonard Delano for misreading the information on the back of his most excellent photograph of Mt. Thielsen. —Ed.

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