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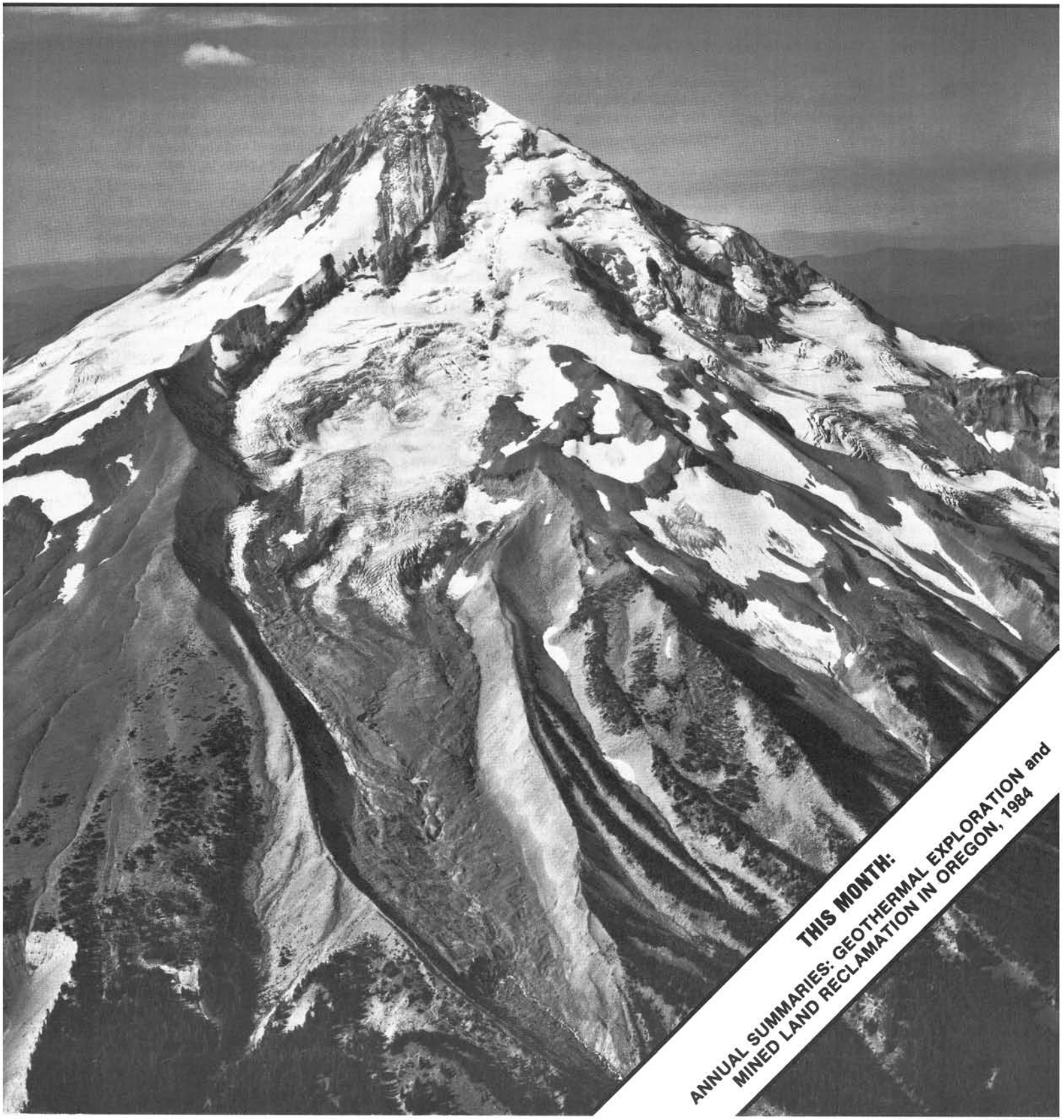

THIS MONTH:
ANNUAL SUMMARIES: GEOTHERMAL EXPLORATION and MINED LAND RECLAMATION IN OREGON, 1984

OREGON GEOLOGY

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Information for contributors

Oregon Geology is designed to reach a wide spectrum of readers interested in the geology and mineral industry of Oregon. Manuscript contributions are invited on both technical and general-interest subjects relating to Oregon geology. Two copies of the manuscript should be submitted, typed double-spaced throughout (including references) and on one side of the paper only. Graphic illustrations should be camera-ready; photographs should be black-and-white glossies. All figures should be clearly marked, and all figure captions should be typed together on a separate sheet of paper.

The style to be followed is generally that of U.S. Geological Survey publications (see the USGS manual *Suggestions to Authors*, 6th ed., 1978). The bibliography should be limited to "References Cited." Authors are responsible for the accuracy of their bibliographic references. Names of reviewers should be included in the "Acknowledgments."

Authors will receive 20 complimentary copies of the issue containing their contribution. Manuscripts, news, notices, and meeting announcements should be sent to Beverly F. Vogt, Publications Manager, at the Portland office of DOGAMI.

COVER PHOTO

View of the northeast slope of Mount Hood, showing Eliot Glacier in center of picture. See related article discussing U.S. Geological Survey study of ice and snow volumes on Cascade volcanoes on page 70 of this issue. (Photo courtesy U.S. Geological Survey.)

OIL AND GAS NEWS

Columbia County — Mist Gas Field

ARCO drilled its Banzer 34-16 to a total depth of 4,902 ft and plugged the well on April 17. The company has another application to drill in sec. 19, T. 6 N., R. 5 W. (see recent permits, below).

Reichhold Energy spudded Crown Zellerbach 34-26 in sec. 26, T. 5 N., R. 4 W., near the community of Pittsburg on April 21. The proposed depth is 5,500 ft.

Reichhold Energy is also drilling Columbia County 33-8 in sec. 8, T. 6 N., R. 5 W. The well was spudded April 30 and has a proposed depth of 3,300 ft.

Clatsop County

The Nehama and Weagant well Jewell 1-23 was drilled to a total depth of 3,190 ft and then plugged and abandoned on April 23. The company has not announced plans for further drilling.

Production: Mist Gas Field

1979-1984 cumulative:	19,219,335 Mcf
January 1985:	271,717 Mcf
February 1985:	242,077 Mcf
March 1985:	301,885 Mcf

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
295	ARCO Columbia County 23-19 009-00142	SW¼ sec. 19 T. 6 N., R. 5 W. Columbia County	Application; 3,200.
296	Reichhold Energy Crown Zellerbach 21-1 009-00143	NW¼ sec. 1 T. 5 N., R. 5 W. Columbia County	Application; 2,500.
297	Hutchins & Marrs Georgia Pacific 1 011-00021	NE¼ sec. 14 T. 30 S., R. 10 W. Coos County	Application; 6,000. □

Supreme Court rules on mining claims

The U.S. Supreme Court has ruled that annual filings of proof of assessment work are required to maintain claims on federal land. The action affects more than 8,000 claims in Oregon and Washington where claimants have not filed. They will be notified by letter that, by law, their claims are considered abandoned.

The 1872 Mining Law requires a claimant to do at least $100 worth of development work each year to maintain a claim.

The requirement to file with the U.S. Bureau of Land Management (BLM) the so-called proof of labor is included in the Federal Land Policy and Management Act of 1976. BLM administers the mining laws on federal lands. The 1976 law was upheld on appeal from the U.S. District Court in Nevada in the case of United States vs. Locke and others.

The federal recording system is designed to rid federal lands of "stale" mining claims and to provide federal land managers with up-to-date information so they can make informed land-management decisions.

Before December 31 each year, to hold their claims, claimants must file with state officials and with BLM a notice of intention to hold their claims, an affidavit of assessment work performed on the claims, or detailed reporting forms.

— BLM news

Geothermal exploration in Oregon, 1984

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

ABSTRACT

In 1984, as in 1983, geothermal drilling in Oregon was at a very low level and was centered chiefly on Newberry Volcano. Drilling by California Energy in the Crater Lake area was delayed when the National Park Service (NPS) voiced concerns about possible negative environmental impacts. The total acreage of leased geothermal lands in Oregon decreased by 18 percent as developers winnowed out the less attractive prospects or left geothermal exploration in Oregon in response to unfavorable market and regulatory conditions.

Pump testing and monitoring of wells in Klamath Falls continued as the city finally began to utilize the geothermal district heating system constructed earlier by U.S. Department of Energy (USDOE) funds. The thermal aquifer at Klamath Falls seems to be little affected by the large-scale pumping.

Data from an 8,080-ft (2,463-m) well drilled in 1981 near Breitenbush Hot Springs by Sunedco were put in the public domain. The well intercepted sheared tuffs carrying fluids with temperatures in excess of 136° C from 2,467 ft (752 m) to 2,566 ft (782 m). Temperature-gradient surveys in the area indicate that this aquifer may dip to the east where even higher temperature fluids probably occur. Temperatures were in excess of 141° C at 8,060 ft (2,457 m), resulting in a probable conductive gradient in excess of 56° C/km. These data support the following hypotheses: (1) the High Cascade heat-flow anomaly inferred from shallow gradient data is representative of deep conductive heat flow, (2) the heat-flow anomaly affects a significant part of the Western Cascade Range, and (3) significant geothermal resources may exist in the Western Cascades far removed from the major High Cascade volcanoes.

LEVEL OF GEOTHERMAL EXPLORATION

The level of geothermal exploration in 1984 was similar to the low level in 1983. The power surplus in the Pacific Northwest and various legal and institutional barriers have combined to cause companies to hesitate to risk large amounts of capital on expensive drilling programs.

DRILLING ACTIVITY

Drilling of shallow prospect wells ceased in 1984, but drilling of deeper wells continued at a low level (Table 1; Figures 1 and 2). The number of permits for geothermal wells increased in 1984 relative to 1983 (Figure 1) as a result of the ambitious plans of California Energy to explore the area surrounding Crater Lake National Park (Table 1). California Energy's plans were, however, delayed as a result of concerns voiced by the National Park Service (NPS) about possible detrimental effects of drilling on Crater Lake National Park. NPS approached the Forest Service (USFS) and Bureau of Land Management (BLM) in May 1984, causing the two agencies to suspend approval of California Energy's drilling permits during the 1984 field season. BLM and USFS decided to allow California Energy to proceed with drilling in 1985 on four of the original 24 sites.

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

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
97	Occidental Geothermal, Inc. Well 72-03 017-90006	NE¼ sec. 3 T. 22 S., R. 12 E. Deschutes County	(1983 permit, re-entered in 1984) Suspended; 4,500
107	California Energy Company, Inc. CE-NB-1 017-90007	NW¼ sec. 16 T. 22 S., R. 12 E. Deschutes County	Application; 4,000.
108	California Energy Company, Inc. CE-NB-2 017-90008	SE¼ sec. 18 T. 22 S., R. 13 E. Deschutes County	Application; 4,000.
109	California Energy Company, Inc. CE-NB-3 017-90009	NW¼ sec. 16 T. 22 S., R. 13 E. Deschutes County	Application; 4,000.
110	Occidental Geothermal, Inc. Newberry Crater 1 017-90010	NW¼ sec. 28 T. 21 S., R. 12 E. Deschutes County	Suspended; 4,000.
111	Union Oil Company of California Well No. 24-15 017-90011	SE¼ sec. 15 T. 21 S., R. 13 E. Deschutes County	Application; 3,000.
112	Union Oil Company of California Well No. 62-12 017-90012	SW¼ sec. 12 T. 21 S., R. 12 E. Deschutes County	Application; 3,000.

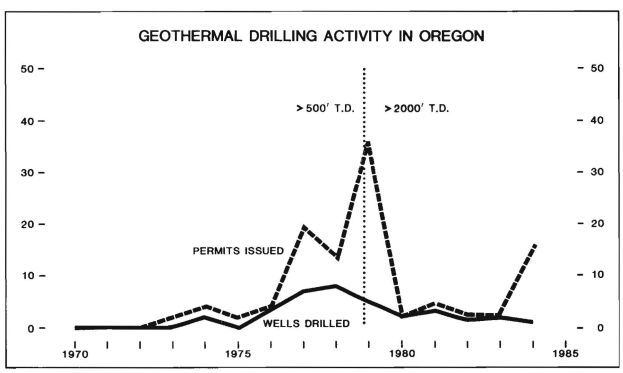

Figure 1. Geothermal well drilling in Oregon. Vertical line indicates time when definition of geothermal well was changed to a depth greater than 2,000 ft.

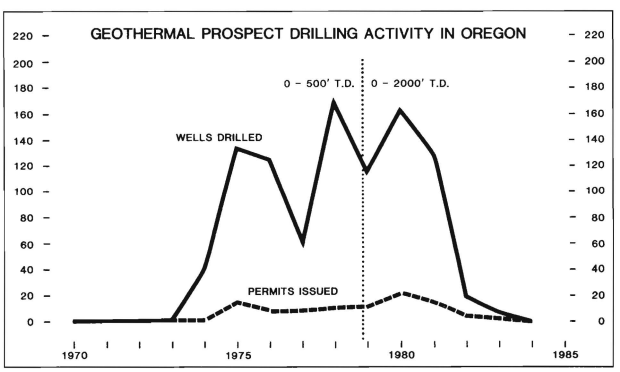

Figure 2. Geothermal prospect-well drilling in Oregon. Vertical line indicates time when definition of prospect well was changed to a depth less than 2,000 ft.

As in recent years, exploration continues to be centered on Newberry Volcano and the High Cascade Range. In order to obtain accurate temperature data in these young volcanic terranes, explorationists have found they must drill to depths in excess of 2,000 ft (610 m). For permitting purposes, state laws and rules define a geothermal well as (1) any geothermal production well to any depth and (2) any temperature-gradient or geophysical test well to 2,000 ft or more. Likewise, a prospect well is defined as any well drilled as a geophysical or temperature-gradient test well to less than 2,000 ft. The emphasis on drilling in the Cascades and at Newberry has thus resulted in no new "prospect" wells in 1984, although, in reality, all of the wells drilled were exploratory wells in that they were small-diameter holes rather than large-diameter production wells.

LEASING

The total acreage of leased federal lands decreased by about 18 percent during 1984 (Figure 3, Table 2). The decline in leased acreage was spread about equally over BLM and USFS lands (Table 2). Because of the increase last year in leased geothermal lands in the Cascades, the total amount of leased geothermal acreage for the USFS is much larger than for BLM. The statistical result of this difference in total leased lands is that the BLM suffered a much larger percentage drop in its leased geothermal acreage than did the USFS (Table 2). If this trend continues, it is possible that geothermal leases outside of the Cascade Province could decrease to insignificant levels in the next few years.

The dramatic decrease in geothermal exploration and leasing on BLM lands is puzzling. It is true that the very high temperatures discovered at Newberry Volcano (Sammel, 1981) have caused a natural increase in interest in all lands in the Cascade Province. It is also true that some lease holders, because of the acreage limitation on federal lands, must trade away some of their BLM leases in order to obtain new USFS leases in the Cascades. Nevertheless, most of the known hydrothermal systems in Oregon are located on BLM lands in the Basin and Range Province of southeastern Oregon. Also, major geothermal fields have been discovered in the Basin and Range of Nevada and Utah — areas that are geologically identical to much of the Basin and Range of Oregon. Why then the precipitous decline in leased BLM acreage? The only factor that seems likely to explain the trend is the perception of the geothermal industry that higher quality resources may reside in the Cascades. Higher quality resources might result in lower production costs and a more competitive price for geothermally derived electricity — a critical factor in Oregon where, unlike Nevada and Utah, geothermal energy must compete with abundant, relatively cheap hydropower resources.

Table 2. *Geothermal leases in Oregon, 1984*

Types of leases	Numbers	Acres
Federal active leases:		
Total, 1/1/84	359	783,351
Changes during 1984		
Noncompetitive, BLM	-36	-57,600 (-44%)
Noncompetitive, USFS	+30	-65,974 (-11%)
KGRA, BLM	-10	-18,278 (-28%)
KGRA, USFS	0	0
Subtotal	-16	-141,852 (-18%)
Total, 12/31/84	343	641,499
Federal leases relinquished:		
Noncompetitive, BLM	212	331,367
Noncompetitive, USFS	42	76,720
Competitive, BLM	8	18,512
Competitive, USFS	2	4,706
Federal leases pending:		
Noncompetitive, BLM	0	0
Noncompetitive, USFS	233	No data
State leases:		
Total active in 1984	5	19,329
Total applications pending in 1984	0	0
Private leases:		
Total active in 1984	No data	No data

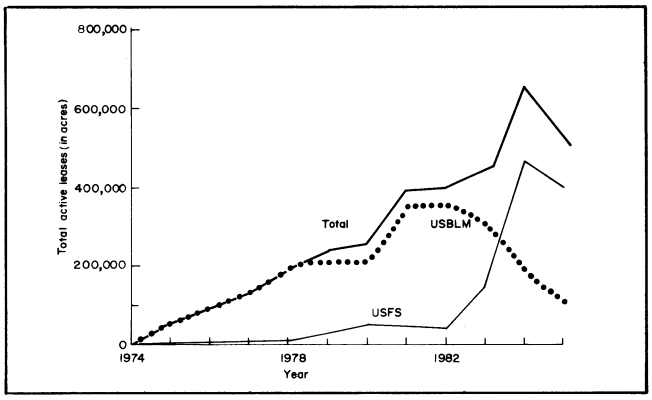

Figure 3. Change of pattern of active geothermal leases on federal lands in Oregon from the inception of leasing in 1974 through December 1984.

KGRA SALES

On April 24, 1984, KGRA lands at Vale, Breitenbush Hot Springs, and Carey (Austin) Hot Springs were put up for bid by BLM. Trans/Pacific Geothermal submitted bids totaling $41,896 on 4,804.93 acres at the Vale KGRA. No other bids were received.

DOGAMI RESEARCH

Geothermal research by the Oregon Department of Geology and Mineral Industries (DOGAMI) was limited to geologic mapping of two areas on the western margin of the High Cascade Range (Figure 4). These maps are scheduled for publication in June 1986. The work for the southernmost map is entirely supported by a grant from USDOE. This same USDOE grant will make possible publication of a detailed geologic map of the northwest quarter of the Broken Top quadrangle completed by Edward M. Taylor of Oregon State University. Additional funding from USDOE for completion of a detailed geologic map of the McKenzie Bridge quadrangle (Figure 4) is also anticipated. These maps, when combined with unpublished mapping of Taylor and the U.S. Geological Survey (USGS), will complete geologic map coverage of the High Cascades and adjacent parts of the Western Cascade Range in central Oregon.

Because of lack of funds, no geothermal research drilling was done by DOGAMI during 1984. The search for drilling funds continues, but little success is anticipated in a time of severe cuts in the level of domestic spending by the federal government. In the meantime, DOGAMI is trying to mobilize Cascade researchers toward a major initiative for scientific drilling in the Cascade Range (e.g., Priest and Blackwell, 1984 a, b; Priest, 1985). The only drilling support that is likely to materialize in the near future is connected with the federally sponsored Continental Scientific Drilling Program (CSDP). At present the Cascades and the rest of the Pacific Northwest have

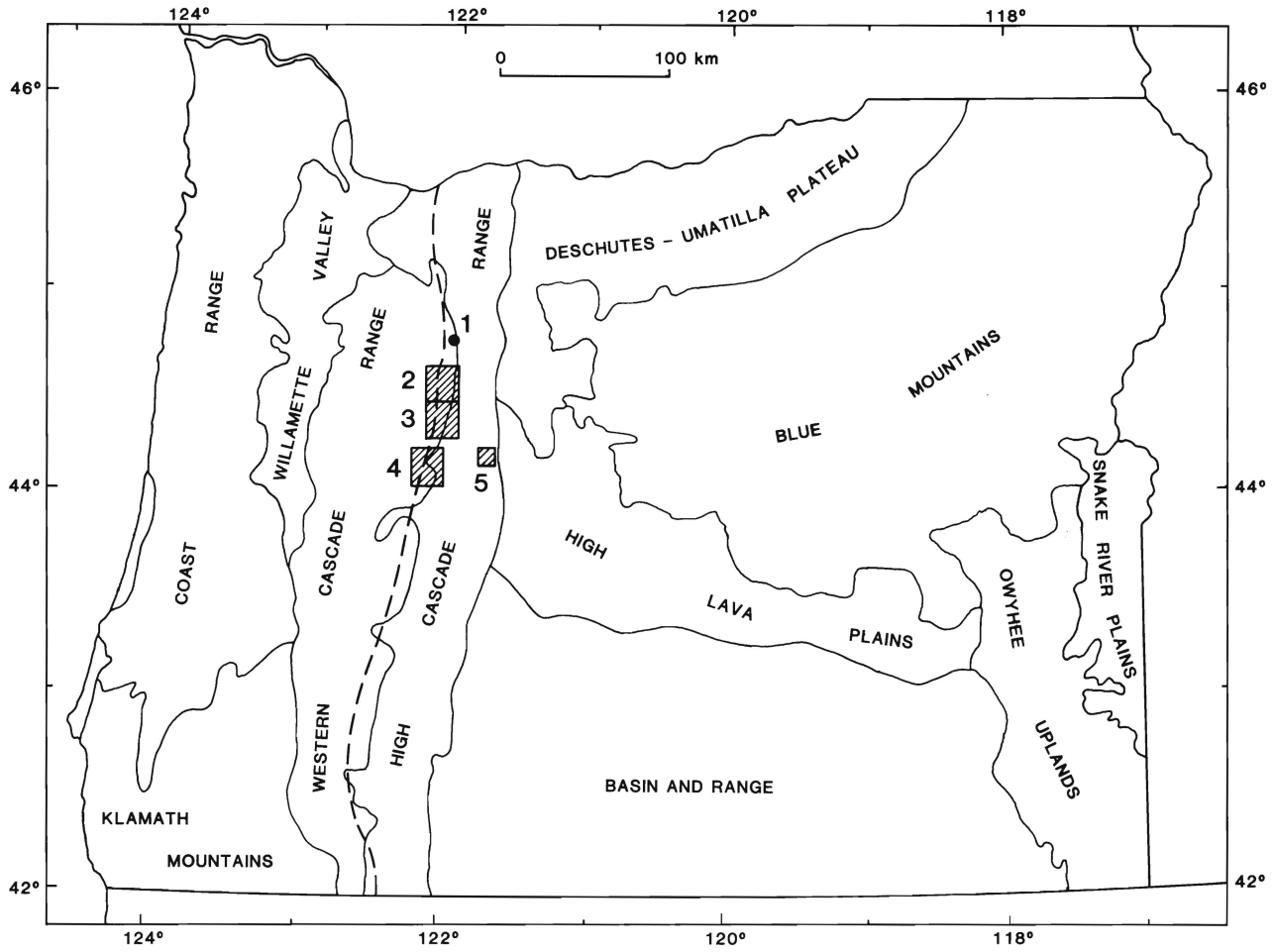

Figure 4. Physiographic provinces of Oregon (after Dicken, 1950), showing areas of DOGAMI-supported geologic mapping. Areas numbered 2 through 4 are being mapped by DOGAMI personnel; area 5 is being done by Edward M. Taylor, Oregon State University. Work in areas 2 and 3 will be completed by the end of this year; work in areas 4 and 5 will occur next year. Also shown are the edge of the High Cascade heat-flow anomaly from Black and others (1983) and the location of Sunedco well 58-28.

been completely left out of this program. DOGAMI will continue to try to redress this serious omission from the CSDP by helping to organize efforts to develop a coherent plan for scientific drilling in the Cascade Range. DOGAMI will be soliciting help from a wide variety of Cascade researchers and explorationists to aid in development of this plan.

OIT GEO-HEAT UTILIZATION CENTER

During 1984, the Oregon Institute of Technology (OIT) Geo-Heat Utilization Center offered free feasibility analyses and consulting services amounting to as much as 64 hours per site to developers. A referral service identifying organizations that can be contacted for particular information and services was also provided at no charge. Other services offered by the Center are a speaker's bureau for geothermal conferences, quarterly bulletin, monthly newsletter, library, and tour program. These services are offered through a grant by USDOE and should continue in 1985. The Geo-Heat Center is particularly valuable to developers interested in direct heating applications for low-temperature geothermal waters.

The Geo-Heat Utilization Center has also been cooperating with the city of Klamath Falls and the USGS in monitoring the ongoing test of a geothermal district heating system for the city. Results of the test have been very encouraging and appear to indicate that the production wells utilized by the city have not significantly affected other wells in the area (Sammel, 1984).

U.S. GEOLOGICAL SURVEY

Geothermal research in Oregon by the USGS continued at a minimal level. A few projects involving surface geophysical and geological surveys were completed, however, in 1984.

As previously mentioned, the USGS has provided continued technical support in evaluation of the ongoing test of the district heating system in Klamath Falls. Edward A. Sammel, a well-known expert on the hydrology of the Klamath Basin, should be congratulated on his important contribution to the success of the geothermal demonstration at Klamath Falls. At the expense of many other pressing research interests, Sammel has, at the request of the City of Klamath Falls, supervised the pump tests and provided testimony at public meetings when the fate of the district heating system was very much in doubt. During the controversy surrounding the Klamath Falls test, all sides in the debate found that they could rely on Sammel's impartial scientific advice when emotions and other factors clouded the real issues. Sammel recently retired from the USGS.

The USGS conducted a seismic refraction test and additional electrical geophysical surveys at Newberry Volcano during the summer of 1984.

George W. Walker completed reconnaissance geologic mapping of the Salem 1° by 2° sheet. This will be published in the near future. Work is continuing on the Roseburg 1° by 2° sheet. These maps and other 1:250,000-scale maps currently in preparation will provide a good geologic framework for geothermal exploration.

NEW DATA FROM THE SUNEDCO WELL NEAR BREITENBUSH HOT SPRINGS

Sunedco Development Company recently released data from its deep geothermal test well number 58-28. The well was drilled to 8,080 ft (2,463 m) in the Western Cascade Range within the regional heat-flow high associated with the High Cascades (Blackwell and others, 1978, 1982; Black and others, 1982, 1983; Figure 5). The well intercepted an aquifer with a minimum temperature of 136° C at 2,467 ft (752 m) to 2,566 ft (782 m) in highly sheared and fractured welded tuffs (see interval of 752 m to 782 m in Figure 5) (Waibel, in preparation). Temperature-gradient surveys indicate that the aquifer dips to the east where it may reach much higher temperatures (Waibel, in preparation). The minimum conductive gradient, free of the effects of the warm aquifer, can be estimated by drawing a line from the last recorded temperature of 141° C at 8,060 ft (2,457 m) to the ambient surface temperature of 3° C. The result is about 56° C/km, very close to the gradient of about 60° C/km predicted by the regional heat-flow model of Blackwell and others (1978, 1982).

The gradient at the Sunedco site could be much more than 56° C/km. The series of temperatures taken at the bottom of the well were from a Pruett Kuster tool that had not reached complete thermal equilibrium (Waibel, in preparation). Figure 6 illustrates that the temperature readings were increasing in a nearly linear fashion when the last reading was taken. These gradients are exactly as predicted by the heat-flow model and very close to gradients from other deep Cascade wells with measured heat flow in excess of 100 mW/m² (Figure 5). The Sunedco data provide strong evidence for the contention of Blackwell and others (1978, 1982) and Black and others (1982, 1983) that (1) shallow temperature gradients in the Western Cascade Range are often the result of deep conductive heat flow; (2) a regional heat-flow anomaly, probably related to High Cascade volcanism, affects a significant part of the old volcanic terrane of the Western Cascade Range; and (3) economically interesting geothermal systems are associated with convection of fluids in the anomaly. In terms of geothermal development, this means that temperatures of about 190° C probably occur at

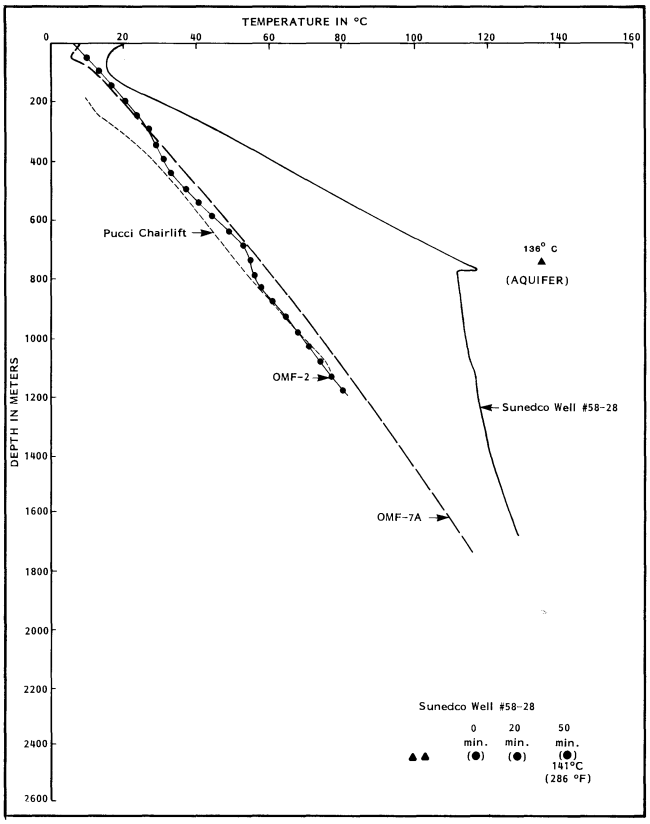

Figure 5. Temperature-depth data from the four deepest Cascade wells in the United States. Sources of data as follows: Pucci Chairlift (3S, 9E, 7Ad), Blackwell and others (1982); OMF-2 (2S, 8E, 15Dd), Blackwell and others (1981); OMF-7A (2S, 8E, 15Dd), Blackwell and others (1982); Sunedco 58-28 (9S, 7E, 28Dcc), solid line is a thermistor log (unpublished data of D.D. Blackwell), triangles are maximum reading thermometer values immediately after the end of drilling (Waibel, in preparation), dots with parentheses are from a Pruett Kuster tool read three times beginning 48 hours after circulation (Waibel, in preparation).

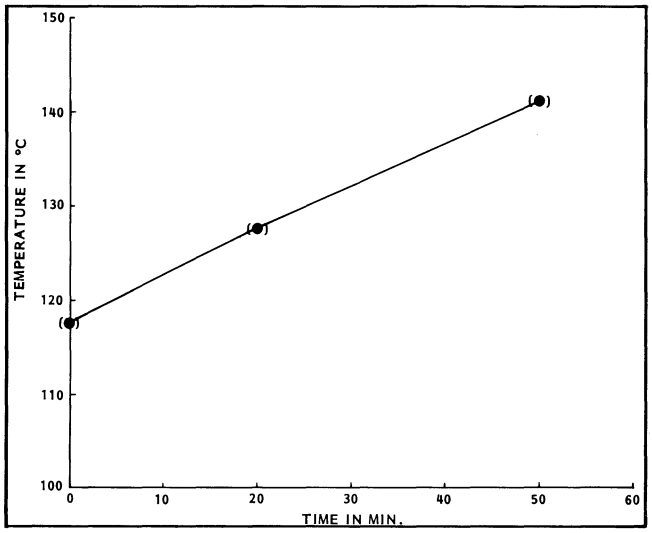

Figure 6. Pruett Kuster tool readings at 2,546.6 m in Sunedco well 58-28 starting 48 hours after circulation (data from Waibel, in preparation).

*(Continued on page 69, **Geothermal exploration**)*

Surface mined land reclamation in Oregon, 1984

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

GENERAL

Since its inception in 1971, Oregon's Mined Land Reclamation Program (MLR), administered by the Oregon Department of Geology and Mineral Industries (DOGAMI), has overseen the reclamation of slightly over 2-1/3 mi² of Oregon land. Of the more than 97,000 mi² of land within Oregon, less than 10 mi² are actually affected by mining operations at a given time. (These figures do not include mining within the beds and banks of streams, which is covered under a different law, and mining in numerous pits located within tree farms and forests for material to be used only for access roads, which is exempted by the legislature.)

Post-mining uses of land are as varied as the commodities mined, their geographic and environmental locations, and the lengths of the various operations.

Some land has been returned to the arid grazing land it was before mining, some is being cropped, and some has been reforested. At least one site is now a cranberry bog, another a fish farm. Several are recreational fisheries and housing and industrial developments. Some sites are dedicated primarily to wildlife management, from wetlands to deep water, from waterfowl to raptors, and from furbearers to fish. A few have been used for more than one purpose after mining, such as dry land fills with subsequent commercial development, and the value of such properties has almost invariably increased considerably over their pre-mining value.

The nature and size of operations varies from promotions and write-offs to small family operations; to perennial sand-and-gravel, crushed-rock, or industrial-mineral producers; and to operations by interstate contractors, interstate mining companies, and public agencies.

The location and characteristics of mines vary greatly. Sand and gravel; crushed alluvial rock; and quarry rock from basalt, andesite, rhyolite, and metamorphic rock are mined in every area of the State. Gold placers operate in all the traditional gold mining areas, such as Josephine, Douglas, Grant, Baker, and Malheur Counties. Silica sand is taken from dunes in Coos County, and the top of a mountain in Douglas County is being cut off as it is mined for silica-rich rock for use in smelting. Clays have been or are mined from hilltops and lower rolling terrains in western, central, and eastern Oregon. Cinders and pumice are mined from volcanic cones and beds in central and eastern Oregon. Diatomite is mined in central and eastern Oregon. Massive deposits of limestone are worked in the east, and marble is quarried periodically in the southwest. Gemstone operations are conducted in southwestern, central, south-central, and southeastern areas. A peat mine operates in northwest Oregon. Coal, mercury, uranium, and some other commodities could conceivably be produced in the future.

Another variable is the length of operations. There is a category of operations in which a maximum of publicity is generated, permits are obtained, equipment is procured and set up with considerable ostentation, supporting facilities are installed, and labor is hired — but significant production is never attained. The life expectancy of such an operation is one to two years, with another year or so to clean it up. Another type is the one-shot contract operation that usually fulfills its schedule and is completed in one to two seasons. At the other end of the scale is a mine that usually represents a considerable investment, probably by an established mining company, and has been professionally prospected, drilled, and investigated for a number of years. This operation may last 50 years or longer. Typically, in the mining industry, there is quite a large group of sites whose active life is intermittent. Such sites sit idle until a contract is offered for which the mine operator can compete successfully. Finally, some mine operations are based on intuition, in that a mine operator may not have determined accurately the extent of the deposit (quantity of reserves), the quality of the rock, or the amount of overburden. The life expectancy of such sites is quite indeterminable.

Commercial development on former part of Washington County basalt quarry. Area was backfilled with dry demolition waste, left to settle, sold, and developed. (MLR photo)

Of all mining sites under bond (which means that reclamation is mandatory) at the end of 1984, 58 percent represented sites where five or less acres of land was disturbed; in 76 percent of all sites the disturbed acreage was in parcels of 10 acres or less. However, the 10 largest operators are responsible for almost 40 percent of all acreage disturbed by mining and subject to reclamation. Such sites are physically inspected by DOGAMI at least once a year to insure that the reclamation plan, the conditions to the permit, and the bonding safeguard the purpose of the reclamation law.

AWARD

The 1984 award for the Outstanding Mined Land Reclamation Project was shared by Portland General Electric Company and the Oregon State Highway Division, Department of Transportation. The selection committee, composed of representatives from environmental organizations, industry, and MLR, agreed that each of these projects was so important in its accomplishment that both projects and their operators should be recognized. Washington County was a deserving runner-up. Of particular merit were (1) Washington County's management of the mined area through successive uses and (2) the cumulative value of the county's efforts to its citizens. These projects were described in the February 1985 issue of *Oregon Geology*.

DEPARTMENTAL RECLAMATION

The Oregon Department of Geology and Mineral Industries called in three bonds in 1984 and expended those funds in the reclamation of three sites. Two were completed by October: By

waiting until earth moving equipment was in the area for other purposes, it was possible to complete the reclamation of one remote and abandoned gemstone site. Another site, larger and more complex, was adequately reclaimed in cooperation with the U.S. Bureau of Land Management (BLM), which donated seed and provided supervision without charge.

MLR wishes to acknowledge the outstanding cooperation and assistance from other agencies and organizations. We often solicit advice. We do not ask for financial assistance, but from time to time we do receive tangible support. It may be the donation of seed; it may be the assistance by individuals who show up and help with seeding or supervise the job because they are in the area anyway. In any case, it is appreciated, and we all benefit.

The third site whose bond was called is an outstanding example of voluntary cooperation and contributions. The bond was set in the mid-1970's, and the site was abandoned in 1978. Under these circumstances, the bond could not be increased as costs increased and paid for about two-thirds of the required earth-moving cost. The Oregon Soil and Water Conservation Commission allocated grant money to the Fort Rock-Silver Lake Soil and Water Conservation District for revegetating the mine spoils. This provided funds for seed-bed preparation, planting, fertilizer, and seed. The Oregon State University Soils Testing Lab provided some information concerning the unique diatomaceous soil of the site. Members of the Soil and Water Conservation District drilled most of the seeds. The District Conservationist broadcast seed on the steeper areas. MLR personnel established test plots to evaluate the effectiveness of various rates of fertilizer and mulch. It is anticipated that BLM will fence the area to protect it. It has been posted by MLR. Aside from the accomplishment of reclaiming an abandoned site, there is the additional benefit that the information derived from this project and its best test plots will be valuable in the future.

In March 1984, several additional sites were considered probable prospects for DOGAMI reclamation. Upon initiation of action leading to reclamation by the Department, operators of five sites obtained current permits, one site was reclaimed by the operator, and one site is being reclaimed by the owner. One site was closed, based on legal sufficiency of an agreement between owner and operator, and one site was sold to a fire district for a training-facility site. The fire district has all necessary approvals and has committed itself to reclamation through development of the training facility.

On three sites, bids are expected to be offered this spring for reclamation under DOGAMI direction, one each in Baker, Douglas, and Grant Counties. Approximately 36 acres must be reclaimed, and a total of $30,500 is available in securities on these sites.

LEGISLATION

Over a year ago, a task force was appointed by the DOGAMI Board of Governors. The mission of the Mined Land Reclamation Advisory Committee, as the task force was known, was to study all possible alternatives for guaranteeing recovery of costs of mined land reclamation pertaining to aggregate mining in Oregon. Emphasis was on the availability of funds in the event DOGAMI must reclaim mined lands. The committee, which was created in response to a mandate by the 62nd Oregon Legislative Assembly, was composed of representatives from the mining industry, government agencies, environmental groups, and bonding companies.

Seven monthly meetings were held. A mass of information was considered, including the responses received from queries to over 120 agencies in other states. Data from governmental and professional publications and testimony from industry, environmental, and governmental representatives and lobbyists were considered. The committee visited sites and viewed photographs of more sites.

By September 12, 1984, all members of the Advisory Committee had signed a unanimous report and recommendations. The recommendations were incorporated into and filed as House Bill (HB) 2048. The bill provides there should be no change in the $500 maximum security per acre affected for existing sites, but there should be an increase from $2,000 to $2,500 in the per-site security maximum wherever referenced in the law. It stipulates that the Governing Board shall identify by rule the procedures for determination of the amount of the security required, provide an opportunity for participation by the applicant as part of the procedures, and specify by rule the procedures for appeal of such determinations to the Board or Department. It states further that for a two-year period beginning July 1, 1985, each applicant for a new aggregate site shall provide security equal to the cost of reclamation, should the Department perform the reclamation. The bill also provides the following criteria for the goal or standards of reclamation performed by DOGAMI: (1) Remove hazards, (2) protect from drainage problems and pollution, (3) meet local land use requirements for reclamation, and (4) comply with all Federal and State laws. Finally, it revises the procedures for recovery of bond, provides for continuation of the present or a newly appointed advisory committee through July 1, 1987, and includes an emergency declaration making all changes effective July 1, 1985.

This bill passed the House on February 6, 1985, by 51-7 vote and was referred to the Senate Energy and Natural Resources Committee.

HB 2048 pertains only to "aggregate" operators. In professional terms this includes producers of aggregate, gemstones, and industrial minerals and those producers of metallic minerals who held permits on August 16, 1981. Other producers of coal and metal-bearing ore are already subject to a bonding or security maximum of $10,000 per acre.

Also submitted was another bill, HB 2050, which provides a penalty of up to $1,000, upon conviction, for aggregate-mine operators who violate the reclamation law, related administrative rules, or permit conditions. A similar penalty for such offenses, up to $10,000, exists for nonaggregate operators. HB 2050 also passed the House on February 6, 1985, by a vote of 56-1 and was referred to the Senate Energy and Natural Resources Committee.

TECHNICAL EVOLUTION

Increased interest on the part of gold miners in cyanide processing has created new problems for regulatory agencies, particularly for the Department of Environmental Quality (DEQ) and MLR. Cyaniding of gold and silver ores is not new; it was invented in 1892. But processes have been vastly improved since the 1940's and are still evolving, so that, with the renewed interest in gold mining in recent years, a number of operations now use cyanide extractions of gold. In somewhat oversimplified terms, there are two major types of extraction. Both employ the excellent solubility of gold in cyanide solutions. One type includes those outdoor heap-leaching operations in which ore is stacked on a prepared base, a weak solution of (usually) sodium cyanide is run through the ore by spray or trickle, and the pregnant liquid is collected and stripped. The other major practice has many variants, but all of them are essentially enclosed cyanidation plants. The concerns of DEQ and MLR are that no unused cyanide is abandoned on site, that no solution seepage occurs from heap-leach pads or cyanidation-plant tailings, that leach-pad contents and all solutions are adequately neutralized before abandonment, and that no

cyanide gas is released into the atmosphere.

RESEARCH AND DEVELOPMENT

In the near term, MLR research efforts will be concentrated on the following subjects: (1) Continuing collection of information and samples pertaining to ground stabilization, erosion control, and sediment control. Flocculants, means of dewatering areas with minimum erosion or sediment transport, mulches, netting, and tackifiers are of prime interest. (2) Continuing emphasis on collection of data concerning revegetation (species, fertilizers, mulches, and techniques) of bentonite, diatomaceous, lateritic, and serpentinite soils. (3) Evaluation of the results, effectiveness, and lessons learned in post-reclamation reviews of selected revegetated sites. These will be conducted as time allows in the three- to five-year period following the planting and release of the sites.

Status of the Mined Land Reclamation Program

Total acreage reclaimed

1972 through Dec. 1980:	443
1972 through Dec. 1981:	805.75
1972 through Dec. 1982:	961.65
1972 through Dec. 1983:	1,344.15
1972 through Dec. 1984:	1,516.15
(1984:	172)

Total acreage under security to guarantee reclamation

December 31, 1980:	2,173
December 31, 1981:	2,606
December 31, 1982:	3,105
December 31, 1983:	3,189
December 31, 1984:	3,289

Uses to which acreage was reclaimed

	Agriculture	Forestry	Housing	Other*
1972 through 1980	251	6.5	37	148
1981	168	7	21	167.5
1982	105	14.5	0	36
1983	52.65	264	0	66
1984	109	18	0	45
Cumulative totals	685.65	310	58	462.5

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

Changes: New and closed sites, 1980-1984
(permits issued for new sites, records closed, sites reclaimed, or activity legally terminated)

	Surfacing mining permit[1]		Limited exemption[2]		Total exemption[3]	
Year	New	Closed	New	Closed	New	Closed
1980	46	19	34	4	46	3
1981	84	32	50	7	51	26
1982	35	34	24	14	106	28
1983	36	37	21	9	54	34
1984[4]	56	25	24	9	73	94

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

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

[3] Sites legally exempt from fee, reclamation, and bonding for various specific reasons, most commonly "access roads," size, and inactivity. (Surface mining permit category sites *cannot* go to total exemption status unless the surface mining permit has not been utilized or unless the site is to revert to an exempt use such as BLM or USFS community pit, operated under Federal rules, or a tree farm or State Forestry access roads source.)

[4] During 1984, there were 63 other changes in status from one category to another.

Field inspections per year

1980 - 681
1981 - 912
1982 - 682
1983 - 785
1984 - 740 □

***(Geothermal exploration,** continued from page 66)*

depths of about 1.8 mi (3 km) throughout much of the High Cascade heat-flow anomaly in central and possibly southern Oregon, regardless of the presence or absence of local young volcanoes or shallow intrusives. Upward hydrothermal convection and additional heat from shallow intrusives is additive to this background heat flow. Considering that the geothermal industry generally targets hydrothermal fluids at depths of 1.8 mi (3 km) or less and at temperatures of 150° C or more, this could mean that there is an enormous resource under the Cascade Range.

ACKNOWLEDGMENTS

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New USGS study measures amounts of snow and ice on Cascade volcanoes

The U.S. Geological Survey (USGS) has released Open-File Report 84-581, *Ice Volumes on Cascade Volcanoes: Mount Rainier, Mount Hood, Three Sisters, and Mount Shasta*, by Carolyn Driedger and Paul Kennard. This survey of the ice and snow volume on these Cascade volcanoes in the Pacific Northwest is part of a continuing assessment of long-term geologic and hydrologic hazards presented by the Cascades. The study of these particular volcanoes was undertaken in part because the catastrophic eruption of Mount St. Helens in 1980 melted an estimated 4.6 billion ft^3 of that volcano's snow and glacier ice, which helped form large mudflows and floods that caused havoc and devastation in valleys for many miles downstream.

USGS scientists emphasized that, except for Mount St. Helens, no specific forecasts of eruptions have been issued for any of the 14 Cascade volcanoes in the United States, although none of them are extinct. Several of the mountains, including Lassen Peak, Mount Baker, Mount Rainier, and Mount Hood, have erupted during the past 200 years, however. Since 1975, as a result of increased gas emissions from its summit, Mount Baker has produced steam or meltwater — a reminder of possible deep-seated but still present volcanic heat sources.

The new USGS study showed that Rainier, Hood, Shasta, and the Three Sisters have potential snow and ice hazards similar to those that existed on Mt. St. Helens. Most of the other Cascade volcanoes also have ice and snow covers.

Carolyn L. Driedger, a hydrologist at the USGS glacier-studies office in Tacoma, Washington, and Paul Kennard, formerly a geophysicist in the same office and now in private industry, said the slopes and craters of the four volcanoes that were studied hold more than 40 major glaciers, plus extensive snow fields.

"Floods and mudflows are common during eruptions of Cascade volcanoes because the snow and ice melt and often mix with soil and volcanic eruption debris," said Driedger, the principal author of the USGS report.

"During the May 18, 1980, eruption of Mount St. Helens, the floods and mudflows that carried debris down the Toutle and Cowlitz Rivers and into the Columbia River demonstrated the need for predicting similar water-hazard events during possible future eruptions of other Cascade volcanoes," she added. "A basic requirement for such predictive analysis is information about the volumes and distribution of snow and ice on these volcanoes."

During the USGS study that began in 1981, aerial photographs were taken to map the areas covered by each volcano's snow and glacier ice. A backpack radar unit was used on the ground to measure the thickness of ice at representative locations, thus permitting ice volumes to be estimated.

Here are summaries from the USGS report for each of the four volcanoes:

- **Mount Rainier**, located southeast of Tacoma and Seattle, Washington, rises to 14,410 ft and has 23 major glaciers that are among the nation's most accessible to the public. The volcano has an estimated 156 billion ft^3 of ice and snow covering more than 35 mi^2 of land surface. The thickest ice is 705 ft thick on Carbon Glacier, which has the largest volume of ice of any Rainier glacier, with 25.1 billion ft^3. The Emmons Glacier has the largest surface, covering about 4.3 mi^2.

Lahars (mudflows and volcanic debris flows) would be the major threat to people and property if a volcanic eruption of Mount Rainier should occur. In recent geologic times, melting of snow and ice has in part been responsible for mudflows that have moved as far as 70 mi downvalley beyond Auburn (about 6,000 years ago) and 30 mi to Orting (about 500 years ago). In historic times, mudflows have occurred most often in the valleys of the White, Nisqually, and Mowich Rivers and Tahoma and Kautz Creeks.

The area on Mount Rainier above the 12,000-ft altitude is approximately the region of the old summit depression that contains two craters and has an ice volume of 8.7 billion ft^3. If an eruption occurred on any side of the summit, this ice could be melted and released as water to drainages below.

- **Mount Hood**, near Portland, Oregon, with its summit at 11,245 ft, has an estimated 12.2 billion ft^3 of ice and snow covering an area of about 5.2 mi^2. The volcano has nine major glaciers. Eliot Glacier has the largest volume of ice at 3.2 billion ft^3 and is thickest at 361 ft. The Coe-Ladd glacier system covers the largest area, with about eight-tenths of a square mile.

Much of the topography on the lower slopes of Mount Hood is the result of mudflows and pyroclastic flows during an eruptive period 12,000 to 15,000 years ago.

Earlier USGS studies indicated that a dome-building viscous lava eruption in the Crater Rock region might deposit debris on the White River, Palmer, Zig Zag, and Reid Glaciers and affect about 2 billion ft^3 of ice and snow. An eruption outside the debris-fan region but near the summit might cause eruptive deposits on the remainder of the Mount Hood glaciers, which have an ice and snow volume of 10.5 billion ft^3.

- **Three Sisters** (which includes North Sister, Middle Sister, and South Sister volcanic cones) west of Bend, Oregon, rising to a maximum of 10,358 ft, has five major glaciers. The volcanic complex has an estimated 5.6 billion ft^3 of ice and snow covering about 3.2 mi^2.

Collier Glacier is the largest, with a surface area of more than four-tenths of a mi^2, a volume of 700,000 ft^3 of ice, and the greatest ice thickness at 300 ft.

There is no direct geologic evidence to indicate large-scale glacier melting during past eruptions, but there is evidence that some flank eruptions during the past 5,000 years were accompanied by small lahars, which probably were aided by rapid snowmelt. Regional eruptive patterns during that period indicate that future eruptions could occur on the south flank of South Sister. In this drainage basin are the Prouty and Lewis Glaciers, with a total volume of 800 million ft^3 of ice and snow. Eruptions north and south of the Three Sisters could pose an additional hazard if erupted onto thick snowpack.

- **Mount Shasta**, located in Northern California 40 mi south of the Oregon border, rises to 14,162 ft, has five major glaciers, and has an ice and snow volume of 4.7 billion ft^3 covering an area of about 2.7 mi^2. The main lobe of Hotlum Glacier has the largest area with seven-tenths of a square mile and the largest volume with 1.3 billion ft^3, but Whitney Glacier has the thickest ice at 126 ft.

Past eruptions have included mudflows, and similar eruptions could occur in the future near the present summit or could form new vents as has happened in the past (such as the satellite cone Shastina). But, unlike the valleys on Mount Rainier, those on Mount Shasta are not of great length, allowing mudflows, lava flows, and pyroclastic flows to form deposits around the flanks of the mountain rather than many miles distant.

Mudflows, many of them unrelated to eruptions, have traveled more than 16 mi in the valleys of Mud, Ash, Whitney, and Bolam Creeks and the McCloud and Sacramento Rivers. About 80 percent of Mount Shasta's ice is at the tops of these drainages on the northern and eastern parts of the mountain.

Copies of this USGS report, Open-File Report 84-581, may be purchased from the Open-File Services Section, Western Distribution Branch, USGS, Box 25425, Federal Center, Denver, Colorado 80225. Prices are $33.75 for each paper copy and $8.50 for microfiche. □

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