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OREGON'S MINERAL AND METALLURGICAL INDUSTRY IN 1977

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Oregon Department of Geology and Mineral Industries

Oregon's mining during 1977 was mainly for the production of construction materials and one metal, nickel. Sand and gravel and stone accounted for 65 percent of total production; in 1976, they had accounted for 68 percent. Preliminary figures for mineral production for 1977 show an increase of 4 percent to $116.6 million.

Table 1 summarizes the State's production for 1976 and 1977. Commodities are arranged in descending order by value, except for the group of 11 commodities combined to protect individual companies' confidential data.

Industrial Minerals

For Oregon's two major mineral commodities, sand and gravel and stone, 1977 was the year of the sellout. Several large sand and gravel and stone producers have changed hands in Oregon during the last year or so, apparently because of the phasing down of large highway and dam construction projects and also for environmental and regulatory reasons. The phase-down may be the reason Kaiser Industries sold its Pacific Building Material's Portland plant (Figure 1, Point 1) to Willamette Hi-Grade and sold the Santosh pit and plant (Point 2) near Scappoose to Cascade Aggregates. Ross Island Sand and Gravel's conflict with the Army Corps of Engineers over dredging permits for its Portland operation (Point 1) may be the reason the firm was sold to a private individual. The equipment at both the Rivergate Rock Products quarry at Portland (Point 1) and at Columbia West Construction's quarry at Rainier (Point 3) was sold at auction. The Rainier pit is in conflict with the Mine Enforcement and Safety Administration over the height of the quarry walls.

The Oregon Department of Geology and Mineral Industries continued its program of sand and gravel and stone inventory studies, including an on-the-ground survey of each pit and quarry, mined land reclamation advice, and economic analysis and forecasting. These studies are needed to provide a data base for many of the

Table 1. Some of Oregon's minerals at a glance

Mineral commodity	1976 Value (thousands)	1976 Percent	1977* Value (thousands)	1977* Percent
Stone	$ 42,686	38	$ 42,555	36
Sand and gravel	33,473	30	34,000	29
Cement, copper, diatomite, gold, industrial sands, lead, lime, nickel, silver, talc, and tungsten	33,252	29	37,031	32
Pumice	2,311	2	2,262	2
Gemstones	525	0.5	525	0.5
Clays	315	0.3	227	0.2
Gold	4	-	Combined	-
TOTAL	$ 112,566	100	$ 116,600	100

* Preliminary data provided by U.S. Bureau of Mines

current and future actions taken under the State's land use planning laws.

Limestone, production statistics for which are included with the figures for stone, was the source rock for the following projects: (1) The Oregon Portland Cement Company announced that a new cement plant will be built near Durkee (Point 4), Baker County, to replace the one at Lime, 13 miles to the southeast. The new $38 million plant will have a rated capacity of 500,000 tons per year, 2.5 times that of the old plant. The cement will be shipped to the Spokane area, eastern Oregon, and western Idaho. (2) Ash Grove Cement Company (Point 1) announced the enlargement of its plant, thereby doubling its lime output. Construction, to be completed by late 1978, will raise daily output from 200 tons to 400 tons. Limestone for the plant will continue to be imported from Texada Island, B.C. (3) A farm cooperative is studying the feasibility of mining the Marble Mountain limestone deposit near Grants Pass (Point 5), Josephine County. After being mined, the limestone would be ground and shipped to the Willamette Valley for agricultural use.

The American Fossil Company continued to mine diatomaceous earth, used mainly for cat litter, in Christmas Valley (Point 6), Lake County. Production of the new crushing, screening, and bagging plant, completed in early 1977, has been reported at about 20 tons per day, with plans to increase output to 50 tons per day by the end of 1977.

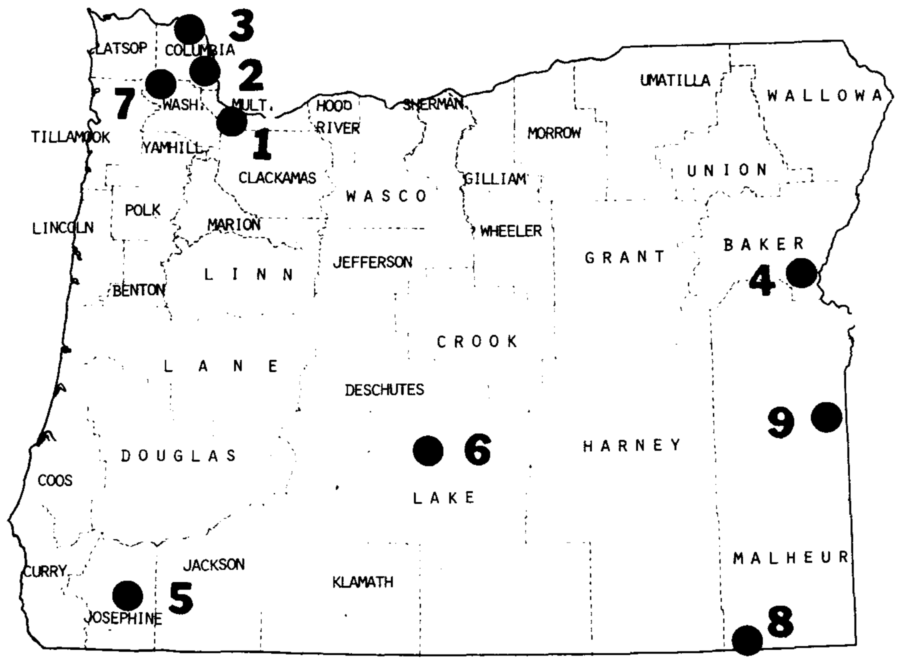

Figure 1. Oregon 1977 industrial mineral highlights. 1. Sand and gravel, stone, and lime. 2. Sand and gravel. 3. Stone. 4. Cement. 5. Agricultural lime. 6. Diatomite. 7. Shale. 8, 9. Gemstones.

The construction slowdown may have caused the closing of Oregon's only bloating shale operation (Point 7). Since 1945, Empire Building Materials had produced a lightweight concrete aggregate, using a kiln to fuse crushed shale from western Washington County into small pellets. Fines produced during processing were sold as pozzolan. During 1976, however, the plant and pit were sold to GATX Leasing; and in November 1977, the plant and mining equipment were sold at auction.

The output of picture-rock jasper from Malheur County (Point 8, McDermitt area; Point 9, Lake Owyhee area) continues to remain high. Part of the output is processed into finished gems by the mine owners. The rest is sold and shipped rough to other states. Several of the mines are large enough to require permits under the Mined Land Reclamation Law.

Metals

Oregon's dominant metal mining operation, the Hanna Mining Company nickel mine at Riddle (Figure 2, Point 1), Douglas County, operated at about the same rate as that of 1976. The Riddle operation produces the only primary nickel in the United States.

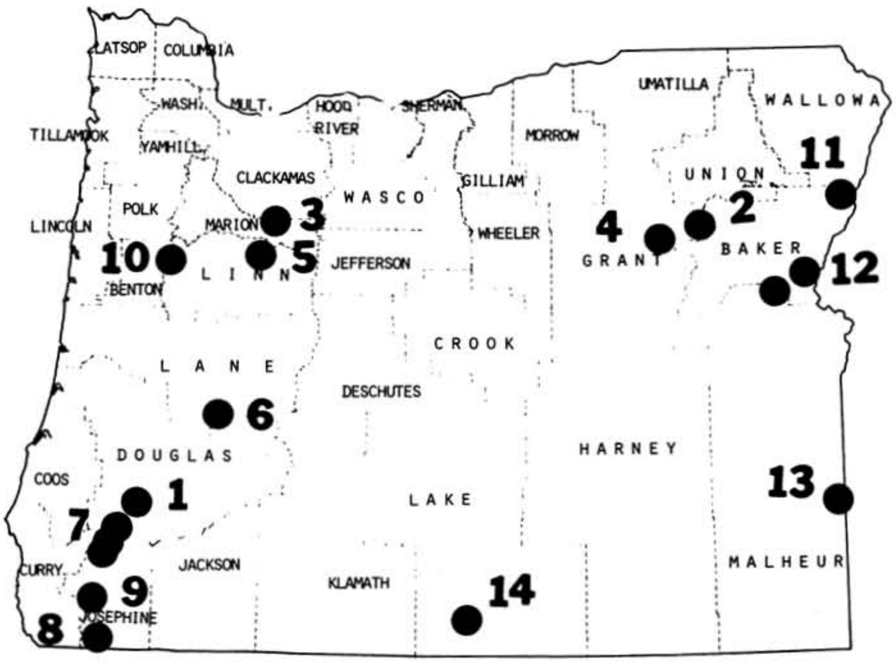

Figure 2. Oregon 1977 metallic minerals and exploration highlights. 1, 9, 10. Nickel. 2, 4, 12, 13. Gold and silver. 3, 5, 6, 7. Copper, lead, and zinc.

Small tonnages of gold ore from the Bald Mountain mine (Point 2), Baker County, were shipped to a smelter in Tacoma, Washington, by Tony Brandenthaler. Shiny Rock Corporation placed a 25-ton-per-day pilot lead-zinc floatation mill into operation (Point 3). Ore for the mill, located in North Santiam mining district, Marion County, comes from the nearby retimbered Ruth mine. Mill concentrates were stockpiled until an industry-wide smelter strike ended. Dixie Meadows Gold Mines, Ltd., conducted a successful gold-ore heap-leach cyanidation test at Dixie Meadows mine (Point 4), Grant County. Application was made to the Department for a surface-mining permit in preparation for full-scale mining operation. Placer-gold production was hindered because of low stream flows. Production losses cannot be determined because most placer-gold output is unreported.

Exploration Programs

In northwestern Oregon, exploration for copper, lead, and zinc massive sulfide and copper-molybdenum porphyry deposits was conducted within both the North Santiam (Point 3) and Quartzville (Point 5) mining districts, Linn County, and Bohemia (Point 6) mining district, Lane County.

The areas in southwest Oregon that have received the most attention from mining companies during the past year include the Silver Peak-Almeda mine zone (Big Yank lode) (Point 7), Douglas and Josephine Counties. Five or six mining companies have conducted geochemical sampling, geophysical surveying, claim staking, geologic mapping, and some drilling along this zone. Three of the companies entered and completed a joint venture to drill 3,000 ft of core hole. This is the third year of extensive exploration activity on this zone, which contains volcanogenic sulfide mineralization with some massive barite gangue.

The old underground workings of the Queen of Bronze copper-gold mine (Point 8), Josephine County, were reopened and mapped geologically by Canadian Superior. The mine, which was worked from 1903 to 1930, was still in fair condition when reopened.

Nickel laterite exploration activities were mainly those of the Inspiration Development Company at the Eight Dollar Mountain deposit (Point 9), Josephine County. Their work involved seismic surveying, mapping, back-hoe sampling, and trommel processing of large bulk samples to test preliminary up-grading techniques. The U.S. Bureau of Mines did some reconnaissance sampling and some bulk sampling of this and other southwestern Oregon laterites, preliminary to setting up a pilot plant at the Metallurgical Research Center, Albany (Point 10), to study methods of nickel recovery.

In northeastern Oregon, W.A. Bowes and Associates continue to explore and develop the New York and Cougar-Independence gold mines (Point 2), Grant County. Johns-Manville at Meadow Lake (Point 2), Baker County, is continuing to explore for a copper-molybdenum porphyry. Texas Gulf continued working at the old Iron Dyke copper-gold mine (Point 11), Baker County; and Ibex Minerals, Inc., explored the Bay Horse silver mine (Point 12), Baker County.

The State of Oregon Department of Geology and Mineral Industries continued to evaluate the nickel resources of Oregon, under a grant from the U.S. Bureau of Mines. Reconnaissance mapping and sampling of a few occurrences of nickel in northeastern Oregon disclosed that most prospects were zones of silica-carbonate replacement of serpentinite, with no enrichment of the serpentinite's original nickel content. All of these occurrences appear to be too low-grade to be of interest. A report on all of Oregon's nickel deposits, presently being prepared by the Department of Geology and Mineral Industries, will be published in 1978 as a bulletin.

In southeastern Oregon, the opening of a gold-silver mine in DeLamar, Idaho, affected the small town of Jordan Valley (Point 13), Malheur County, 2 mi from the Idaho line. Jordan Valley originally had a population of about 200; it now has 600. Idaho is getting the tax dollars from the mine, and Oregon is getting the school children. The life style and values of the original 200 residents will be modified by that of the newcomers, and the original population, needless to say, is divided as to whether the mine is a good thing.

In the Lakeview area (Point 14), Lake County, several companies have been active in looking for uranium. Lucky Mc Uranium explored on claims from Utah International. Polaris Resources, a consulting firm from Golden, Colorado, is doing an evaluation for Urania, Inc. Western Nuclear continues to hold the White King and Lucky Lass and has been somewhat actively exploring with some drilling. Exxon had staked a large group of claims in 1976 but has now relinquished most of them.

* * * * *

MINED LAND RECLAMATION, 1977

Standley L. Ausmus, Administrator
Mined Land Reclamation
Oregon Department of Geology and Mineral Industries

During 1977, the reclamation of Oregon's surface mined lands continued at the rate of approximately 4.2 new projects per month. A total of 50 new reclamation projects were approved during 1976. Seven previously approved projects were completed, and the reclamation work was approved by the Department as being in conformance with the reclamation plan.

At the end of December 1977, active surface mining sites with limited exempt status (grandfather sites) totalled 322, a net increase of 16 during the past year. A total of 37 new "grandfather" sites were registered during 1977, however, and 21 were either closed or converted to operating-permit status.

The number of new "fee paying" sites averaged 7.28 sites per month, a net increase of 53 as of the end of December 1977. This slight decrease in the rate of expansion over that projected in January 1977 may reflect decreased State highway construction and maintenance activities during the past year.

During 1977, the Mined Land Reclamation Division of the Department of Geology and Mineral Industries has been cooperating with the Pacific Northwest Regional Commission in a land resource inventory project funded by the Federal government to determine the feasibility of using remote sensing data from satellites and high altitude photography for mineral-resource inventory and surveillance. Although this project has not been completed, considerable evidence indicates that, at least in certain areas of the State, this new technology may prove to be a very valuable tool for mineral-resource survey.

The 1977 Oregon State Legislative Session effected certain changes in the Mined Land Reclamation Statute, resulting in improvements in the Department's ability to fund the Mined Land Reclamation program. In addition, the Department now has greater flexibility in determining when and where field inspections are to be conducted.

The current Mined Land Reclamation Division staff remains the same as in 1976, with two clerical positions (one funded by CETA), one administrative position, and one full-time field representative. With this minimal staff, the ability of the Department to respond to the needs of the program in the field is limited. To accomplish the extent of field coverage the program demands, the administrator must spend up to 50 percent of his time in field activities. In spite of this limitation, the Mined Land Reclamation program is proving its effectiveness in accomplishing a State-wide reclamation ethic.

The Mined Land Reclamation Division staff would like to take this opportunity to express its appreciation for the support and cooperation of the mining industry in the development of the Mined Land Reclamation program around the State. For the most part, industry leaders and individual operators are cooperating with the Department, and as a result, the impact of the surface mining reclamation ethic is becoming obvious around the State, even to the casual observer.

In this regard, the Mined Land Reclamation Division extends to the mining industry and to all others concerned with the orderly development of the State's mineral resources, the conservation of our natural resources, and the preservation of our environmental integrity an open invitation to continue and expand this spirit of cooperation during 1978. The Department will continue its assistance to the surface mining industry, State and local natural resource agencies, and the general public in dealing with the myriad and complex environmental problems associated with surface mining activity and site reclamation. This assistance will be restricted only by the physical limits of our staff and program resources.

Questions or comments concerning the Mined Land Reclamation program should be directed to:

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1129 S.E. Santiam Road
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GEOTHERMAL ENERGY IN 1977

V.C. Newton, Jr.,* and Donald A. Hull**

In 1977, government and university researchers conducted a variety of geological, geochemical, and geophysical studies directed toward evaluation of Oregon's geothermal energy resources. Several private companies continued detailed exploration of promising geothermal prospects in Oregon (Figure 1), with most activity consisting of drilling temperature gradient holes in the Cascade Range and in southeastern Oregon.

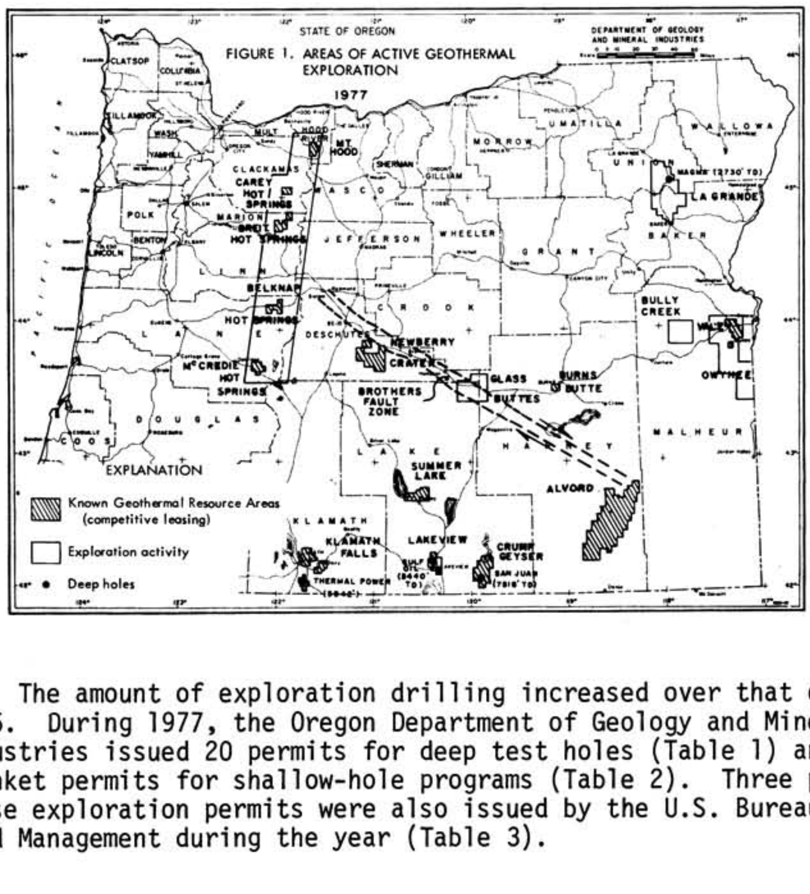

FIGURE 1. AREAS OF ACTIVE GEOTHERMAL EXPLORATION 1977

The amount of exploration drilling increased over that of 1976. During 1977, the Oregon Department of Geology and Mineral Industries issued 20 permits for deep test holes (Table 1) and 9 blanket permits for shallow-hole programs (Table 2). Three prelease exploration permits were also issued by the U.S. Bureau of Land Management during the year (Table 3).

* Petroleum Engineer, Oregon Department of Geology and Mineral Industries

** State Geologist, Oregon Department of Geology and Mineral Industries

Table 1. 1977 State geothermal well permits (deep holes)

Permit no.	Company	Area or lease	Location	Projected or drilled depth
8	Weyerhaeuser Pacific Power and Light	Klamath Lake	NW¼ sec. 15 T37S, R7E Klamath Co.	2,006 ft T.D.*
10	Northwest Natural Gas	Old Maid Flat	SW¼ sec. 15 T2S, R8E Clackamas Co.	1,850 ft (suspended)
12	DOGAMI	Black Mountain	SE¼ sec. 21 T4S, R28E Morrow Co.	815 ft T.D.*
15	DOGAMI	Cloud Cap	SE¼ sec. 10 T2S, R9E Hood River Co.	1,500 ft (not drilled)
16	DOGAMI	Timberline	SE¼ sec. 6 T3S, R9E Clackamas Co.	1,500 ft (suspended)
17	USGS	Newberry Crater	NE¼ sec. 5 T22S, R12E Deschutes Co.	1,500 ft (not drilled)
18	USGS	Newberry Crater	SE¼ sec. 15 T21S, R13E Deschutes Co.	1,260 ft T.D.*
19	Sunoco Energy	Breitenbush	NE¼ sec. 14 T9S, R7E Marion Co.	1,500 ft T.D.*
20	Sunoco Energy	Breitenbush	SW¼ sec. 29 T9S, R7E Marion Co.	1,500 ft
21	Sunoco Energy	High Rock	SW¼ sec. 14 T6S, R7E Clackamas Co.	1,500 ft
22	Sunoco Energy	High Rock	NE¼ sec. 29 T6S, R7E Clackamas Co.	1,500 ft
23	Sunoco Energy	High Rock	SW¼ sec. 17 T6S, R7E Clackamas Co.	1,500 ft
24	Sunoco Energy	Fish Creek Mountain	Center sec. 13 T6S, R6E Clackamas Co.	1,500 ft
25	Chevron	Bully Creek	NE¼ sec. 8 T43E, R18S Malheur Co.	1,500 ft
26	Chevron	Crump Lake	SE¼ sec. 6 T41S, R24E Lake Co.	1,440 ft T.D.*

*Total depth

Table 1. 1977 State geothermal well permits (deep holes) (continued)

Permit no.	Company	Area or lease	Location	Projected or drilled depth
27	Phillips Petroleum	Glass Buttes	NE¼ sec. 33 T23S, R23E Lake Co.	2,000 ft
28	Phillips Petroleum	Alvord Valley	SE¼ sec. 12 T33S, R35E Harney Co.	2,000 ft
29	Amax Exploration	Vale area	SW¼ sec. 24 T17S, R42E Malheur Co.	2,000 ft
30	Amax Exploration	Vale area	SE¼ sec. 13 T17S, R42E Malheur Co.	2,000 ft
31	Amax Exploration	Vale area	Center sec. 26 T17S, R42E Malheur Co.	2,000 ft

Exploration work in the State has increased since passage of the Oregon geothermal law in 1971. The studies appear to have progressed in stages: geological and geophysical work and the drilling of gradient holes to depths of 10 m (30 ft) was done during the period 1971-1973; programs in 1974-1976 utilized gradient holes drilled to depths of 10 to 150 m (30 to 500 ft); last year, gradient holes were drilled to depths of 450 to 600 m (1,500 to 2,000 ft). Drilling in 1978 should focus on deep production tests in areas where high geothermal gradients have been found.

Table 2. 1977 State prospect well permits (shallow holes)

Permit no.	Company	Area	Proposed programs
27	DOGAMI	Vale Malheur County	Used existing Two States oil and gas hole
28	DOGAMI	Ontario Malheur County	500-ft gradient hole
29	Chevron	Harney County	500-ft gradient holes
30	Chevron	Lake County	500-ft gradient holes
31	DOGAMI	(changed to a deep well permit)	
32	Chevron	Malheur County	500-ft gradient holes
33	Chevron	Lake County	500-ft gradient holes
34	Sunoco	Clackamas County	500-ft gradient holes
35	Sunoco	Lane County	500-ft gradient holes

Table 3. Federal geophysical permits

Company	Area	Type survey
Geonomics	Alvord Valley	Dipole and magneto-telluric
Anadarko	Alvord Valley	Electrical resistivity
Supron Energy	Klamath Falls	Electrical resistivity and gravity

Leasing

To date, there are an estimated 600,000 acres of existing geothermal leases in the State. Lessors include 20 large companies and numerous independents. The Federal government's slowness in issuing leases is still an important factor delaying deep drilling to find commercial geothermal resources. The only lease sale held in Oregon last year was on a 640-acre Known Geothermal Resource Area (KGRA) created by an overlap of applications. No bids were received in this sale, conducted at Burns Butte, Harney County.

Court action by environmental groups has postponed drilling at Alvord Valley, southeastern Oregon, and the case is still pending. Legal action has probably delayed the drilling of two deep production tests at this high-ranked geothermal prospect.

Geothermal leasing continued in the State during 1977, but not at the same level as that of the 1974-1975 peak years. Leases in force on public and private lands last year are totalled in Table 4.

Table 4. Geothermal leases

Federal:	
30 KGRA leases issued	60,685 acres
82 noncompetitive leases issued	109,162 acres
KGRA lands not yet offered for lease	398,936 acres
State:	
Leases in force	6,080 acres
Applications	4,080 acres
Private:	
Total estimated acreage	400,000 acres

Industry Activity

Minimal surface geophysical work was done in geothermal areas during 1977, and no commercial discoveries were announced. Deep drilling consisted of temperature gradient holes varying in depth from 450 to 600 m (1,500 to 2,000 ft). In addition to the deeper holes, shallow gradient holes were drilled to depths of 150 m (500 ft) or less in several areas (Tables 1 and 2).

Northwest Natural Gas Company, with technical assistance from the Department of Geology and Mineral Industries, drilled a 560-m (1,850-ft) temperature gradient hole at Old Maid Flat, 5 mi west of Mt. Hood (Figure 2). Sun Energy Development Company drilled a 380-m (1,260-ft) gradient hole 3 mi east of Breitenbush Hot Springs, eastern Marion County. Other exploration drilling projects were located in the Basin and Range province, southeastern Oregon.

On Bully Creek, northwest of Vale, Chevron U.S.A. completed drilling a deep gradient hole; and Amax Exploration, Inc., drilled several gradient holes to depths ranging from 65 to 100 m (220 to 320 ft). In December, Phillips Petroleum Company began drilling a gradient hole at Glass Buttes, northeastern Lake County, with a target depth of 600 m (2,000 ft).

In the Alvord Valley, Chevron U.S.A. drilled gradient holes near Borax Lake and Mickey Hot Springs and conducted several electrical surveys in other areas. Chevron also drilled gradient holes near Summer Lake and in southern Warner Valley, both in Lake County.

The city of Klamath Falls was scheduled to begin drilling a 600-m (2,000-ft) geothermal production well near the campus of the Oregon Institute of Technology in December 1977.

In 1977, Wy'East Exploration Company was issued geothermal leases adjacent to Timberline Lodge at Mt. Hood. The firm is planning to develop hot water for heating at the resort facilities. Additional exploratory drilling is planned for the spring of 1978. Financing for the project is being applied for through the Energy Resources Development Administration (ERDA) Geothermal Loan Guarantee Program.

Alexander Beamer began drilling last fall on a shallow well in the Breitenbush Hot Springs area. He plans to develop hot water for heating buildings and a swimming pool. Beamer had reached a depth of 110 m (350 ft) by December 1977. Results of the drilling thus far are very encouraging.

Research

Geological, geochemical, and geophysical studies were conducted by various individuals associated with the U.S. Geological Survey, Oregon Department of Geology and Mineral Industries, University of Oregon, Oregon State University, Portland State University, and Eastern Oregon State College (see list of publications at end of article).

In northeastern Oregon, a study of geothermal resources in Baker and Union Counties is nearing completion. This project,

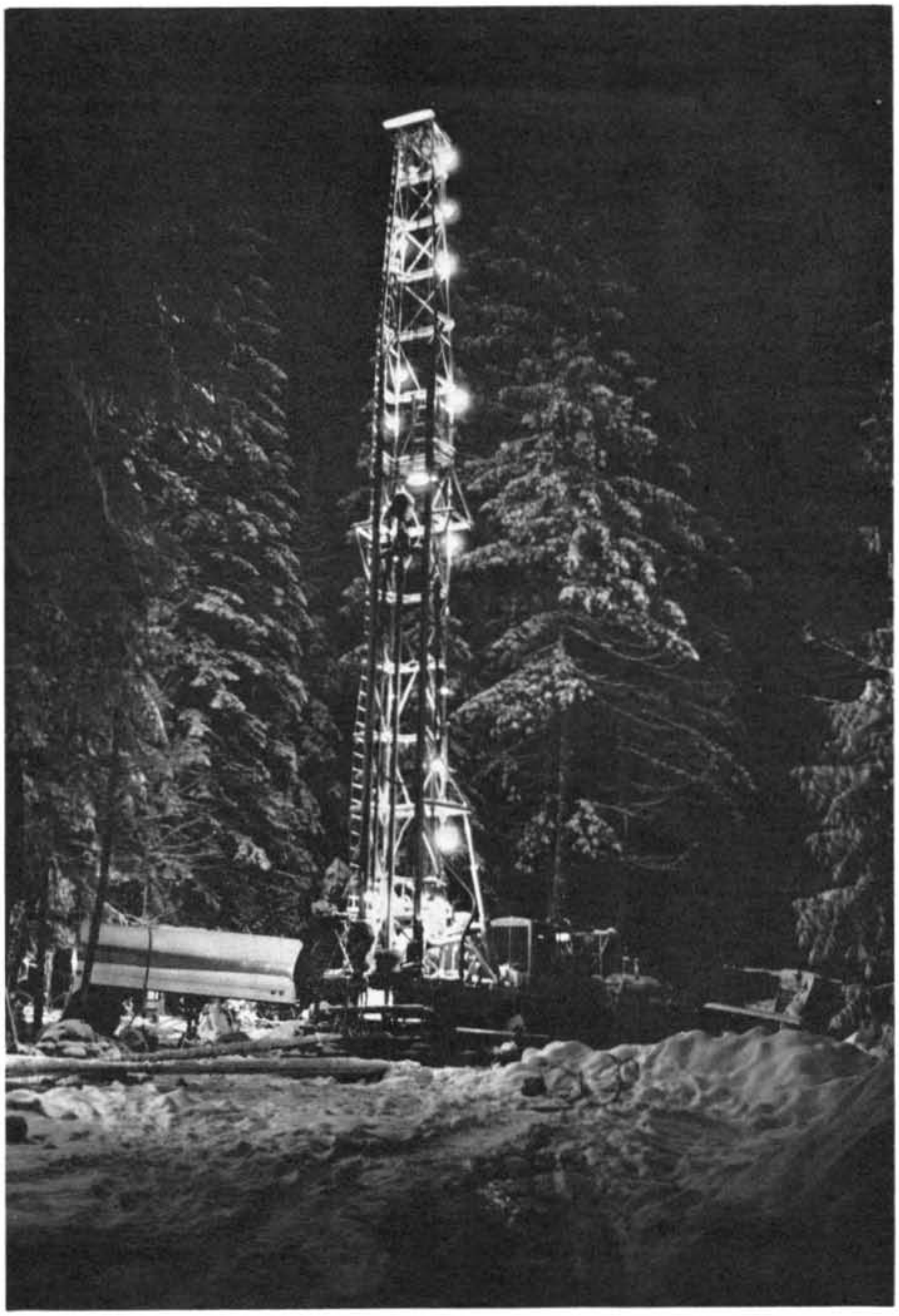

Figure 2. Night drilling at Old Maid Flat (Photo courtesy Northwest Natural Gas).

headed by Rich Huggins of the Eastern Oregon Community Development Council and faculty from Eastern Oregon State College, has included systematic sampling of hot-spring waters for chemical analysis.

The Geo-Heat Utilization Center at Oregon Institute of Technology (OIT) and the Oregon Department of Geology and Mineral Industries (DOGAMI) are completing an investigation into direct geothermal energy applications in the food-processing industry, with emphasis on two areas of prime agricultural importance: the Snake River basin near Vale, Ontario, and Nyssa, northern Malheur County; and the Klamath basin, southwestern Oregon. In the former area, the study has focused on sugar and potato processing; in the latter area, a wide range of prospective applications has been identified. The U.S. Department of Energy (formerly ERDA) has provided funds for the OIT-DOGAMI work.

Richard W. Couch, Oregon State University, and Brian Baker, University of Oregon, have supervised an aeromagnetic survey in the central Cascade Range. Couch has also recently completed an aeromagnetic survey of the Vale area, where previous gravity surveys have been useful in delineating the structural control of hot springs.

A statewide inventory of Oregon's low-temperature geothermal resources (those less than 90°C) is being conducted by DOGAMI with funds from the U.S. Department of Energy. A long-term statewide heat-flow study being conducted jointly by DOGAMI and David D. Blackwell, Southern Methodist University, is nearing completion.

A 3-year geothermal energy resource assessment of Mt. Hood volcano was begun in 1977. The project was undertaken jointly by the U.S. Department of Energy (DOE), U.S. Geological Survey (USGS), U.S. Forest Service, and DOGAMI. In 1977, a variety of geophysical surveys were made by USGS personnel, including aeromagnetics (David L. Williams), self-potential (Don B. Hoover), microseismic (H.M. Iyer and Craig S. Weaver), and infrared (Ken Watson, Jules D. Friedman, and David L. Williams).

A magnetotelluric and telluric electrical resistivity survey was supervised by Norman E. Goldstein and associates, Lawrence Berkeley Laboratory (LBL), University of California. Thermal modeling is being done by David D. Blackwell. Studies of Columbia River Group basalt in the vicinity of Mt. Hood are underway under the direction of Marvin Beeson, Portland State University.

Geological and geochemical studies of young volcanic rocks at Mt. Hood were conducted by Craig M. White, University of Oregon; and areas of hydrothermal alteration were examined by Donald A. Hull, DOGAMI. Water chemistry at Mt. Hood was studied by Harold A. Wollenberg, LBL, James H. Robison, USGS, and Richard G. Bowen.

Elsewhere in Oregon, geochemical samples of various hot

Figure 3. Thermal gradient drilling by USGS near Newberry Crater, July 1977.

springs were collected by DOGAMI personnel and Robert H. Mariner and associates, USGS.

At Newberry Crater, the USGS is engaged in a study of geothermal energy under the direction of E.A. Sammel (Figure 3). Included in the project are drilling and geochemical sampling of hot springs. The Oregon Energy Department and the Department of Geography at Oregon State University completed a study of structural lineations and geothermal phenomena in portions of Lake County and adjoining areas in California.

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OIL AND GAS EXPLORATION IN 1977

V.C. Newton, Jr., Petroleum Engineer
Oregon Department of Geology and Mineral Industries

Onshore

The Department issued five new oil and gas drilling permits in 1977: one to Mobil Oil Company; three to Reichold Energy Corporation, Tacoma, Washington; one to John M. Rex, Terrebonne, Oregon (Table 1). In December, Mobil applied for a permit to drill a 14,000-ft explor-

Table 1. Drilling permits

Company	Permit number	Well name	Location	Total depth	Status
Reichhold (API No. 009-20007)	69	Columbia County No. 1	NW¼ sec. 11 T6N, R5W Columbia County	3,111 ft	Suspended 9/29/77
M.T. Halbouty (API No. 025-20023)	70	Federal No. 1-10	NE¼ sec. 10 T23S, R29E Harney County	7,684 ft	Abandoned 9/11/77
Reichhold (API No. 009-20008)	71	Dia-Shamrock Columbia County No. 2	NE¼ sec. 14 T6N, R5W Columbia County	3,088 ft	Suspended 10/15/77
Reichhold	72	Dia-Shamrock Columbia County No. 3	SE¼ sec. 10 T6N, R5W Columbia County	-	Permit issued 10/3/77
Reichhold	73	Dia-Shamrock Longview Fibre No. 1	SW¼ sec. 11 T6N, R5W Columbia County	-	Permit issued 10/3/77
John M. Rex (API No. 031-20001)	74	Grizzly No. 1	SE¼ sec. 33 T12S, R15E Jefferson County	-	Spud 12/2/77 Drilling 500± ft
Mobil Oil	75	Sutherlin No. 1	SW¼ sec. 36 T24S, R5W Douglas County	-	Application for permit 12/9/77

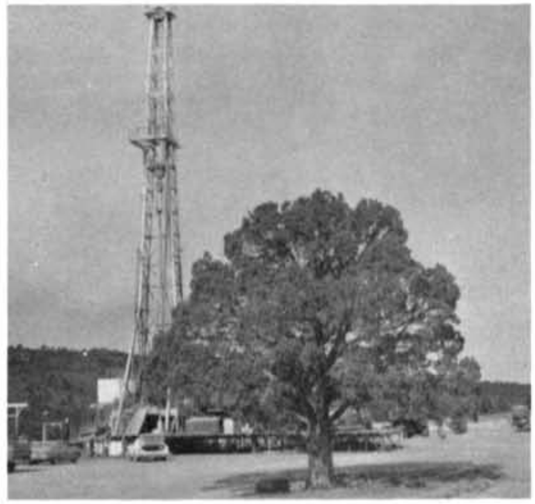

Figure 1. Michel Halbouty's deep oil and gas test hole drilled near Burns, Harney County, 1977.

atory hole north of Roseburg in southwestern Oregon. Reichhold engaged in follow-up test drilling with its new partner, Diamond Shamrock Corporation, Houston, Texas. John Rex began drilling a 4,500-ft wildcat on the Morrow Brothers ranch near Madras in central Oregon. Interest in Oregon's oil and gas prospects last year was greater than in prior years, as shown by the increase in requests to the Department for regulatory and geological information.

The moratorium on Federal oil and gas leases in Oregon was lifted in December 1974 by the U.S. Department of the Interior. Lease applications pending since 1971 were processed, allowing three major exploration programs to proceed: one by Texaco in eastern Oregon; one by Michel Halbouty near Burns (Figure 1); and a third by Mobil Oil Company in southwestern Oregon.

Mobil Oil Company continued extensive geophysical studies in 1977 on its 900,000-acre lease block in southwestern Oregon. This end of the Tertiary marine basin has never been explored below a depth of 5,000 ft (Union Oil drilled a 7,000-ft hole in the area in 1951, but steeply dipping beds shortened stratigraphic penetration).

Last spring, a large oil seep in Clatsop County was called to the attention of the Department by an Oregon State University geological field party. The seepage was found on the Alfred Watson property near the town of Olney, approximately 10 mi southeast of Astoria (Figure 2). Three oil companies have confirmed the fact that the seepage is crude oil.

Offshore

Gulf Energy and Minerals Company conducted limited geophysical surveys off the Pacific Northwest coast in 1977. Less ac-

Figure 2. Oregon Department of Geology and Mineral Industries test drilling at Watson oil seep in Clatsop County.

tivity took place along the Oregon shelf in 1977 than in the previous 7 years, when five oil companies made geophysical surveys along the Oregon coast. The decrease in activity may be a result of Secretary of the Interior Cecil Andrus' postponement indefinitely of OCS (outer continental shelf) leasing off the Oregon and Washington coasts.

The reason cited for the cancellation was that the northwest Pacific shelf region was rated low in oil potential, compared to other offshore prospects in the United States. Three major oil firms, however, stated publicly this past summer that they were definitely interested in Oregon-Washington shelf prospects. In private conversation with representatives of this Department, geologists from three or four other international oil companies have indicated they would very likely participate in future OCS lease sales involving Oregon and Washington shelf lands.

The U.S. Bureau of Land Management has stated that the Pacific Northwest ranks low as a prospect, as indicated by replies from the oil industry. This rating is of questionable value, since oil companies place different priorities on future prospects. Oregon and Washington OCS development should not be comparable with the Atlantic, because there has already been leasing and drilling here. Knowledge of geologic conditions has been obtained from the 12 deep holes drilled on the Oregon-Washington shelf. Results were discouraging in that no reservoir rocks were encountered; but shows of petroleum were found in three of the holes drilled, and 60 MCF/D (1,000 cu ft/day) of natural gas were obtained on a formation test in the Pan American well drilled off the southwest coast of Oregon. Recent interpretations of seismic data suggest that two of the holes were drilled on shale piercement structures and thus did not penetrate a typical section of rocks.

In the recent past, exploration, though greatly diminished, had been continuing off the Oregon coast until 1969, when Secretary of the Interior Hickel declared a moratorium on all OCS drilling. Furthermore, only portions of the coast were open for leasing in 1964, when the only OSC sale in this area was held; and recent studies indicate that portions of the coast not opened to leasing during that sale may contain coarse-grained sediments (reservoir rocks).

There are still prime targets on the Oregon-Washington OCS lands for future drilling. If the current OCS leasing schedule remains intact, Oregon-Washington shelf land will not be offered for lease until some time after 1981; and if production is eventually found, it cannot be utilized until 1986 or 1988 because of the delay in making environmental studies and completing exploration drilling.

Leasing

The past year was the most active on record for oil and gas leasing in Oregon. Oil and gas leases, either in force or under application, were estimated to amount to 1.3 million acres at the close of 1977. At least eight exploration firms and a dozen or more individuals hold leases at the present time (Figure 3). Some leasing can be credited to speculators who have been attracted to

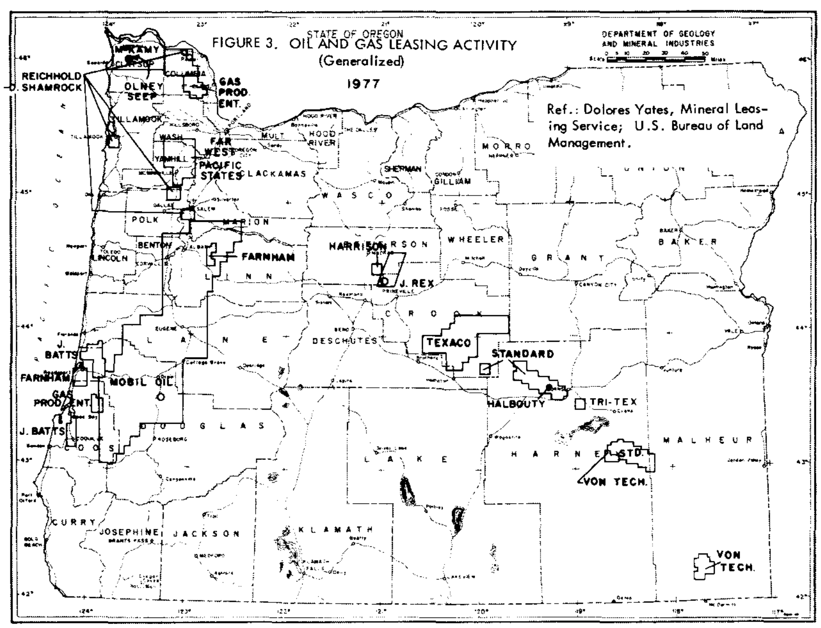

FIGURE 3. OIL AND GAS LEASING ACTIVITY (Generalized) 1977

the State by announcements of increased oil and gas activity. The figures for oil and gas leases are as follows:

Ownership	Total acres
Federal lands (237 leases)	439,802
State lands (leases)	38,182
County lands (estimated)	80,000
Private lands (estimated)	800,000

The following major lessors have assembled the oil and gas leases in the State:

Mobil Oil Corporation	Denver, Colorado
Texaco, Inc.	Los Angeles, California
Standard Oil	San Francisco, California
Reichhold Energy	Tacoma, Washington
John Rex and Associates	Terrebonne, Oregon
John Batts	Billings, Montana
Inter American Petroleum	Denver, Colorado
Erick Von Tech	North Bend, Oregon
Farnham Chemical	Portland, Oregon
R.F. Harrison	Seattle, Washington
Tenneco Oil Company	Bakersfield, California
Northwest Exploration	Denver, Colorado
Far West Oil	Portland, Oregon

In 1975, Shell Oil Company began a large leasing program in the Columbia basin of eastern Washington, and Texaco and Gulf Oil have since joined the leasing effort. An estimated 300,000 acres are believed to be under lease in this region at the present time, but leasing has not yet extended into the Oregon portion of the basin.

Objectives in the Columbia Plateau leasing appear to be Tertiary nonmarine and pre-Tertiary marine beds underlying Miocene lavas. Discovery of oil in Tertiary nonmarine rocks at Trapp Springs, southeastern Nevada, has focused attention on a whole new area, including similar deposits in the Northwest.

Table 2. Oil and gas records released

Operator	Well name	Location	Total depth (ft)	Released
Reichhold Energy Corp.	Crown Zellerbach No.1 Northwest Natural Gas	Sec. 22 T2S, R10W	5,557	8/21/77
Reichhold Energy Corp.	Finn No. 1 Northwest Natural Gas	Sec. 17 T6S, R4W	7,252	9/23/77
Reichhold Energy Corp.	Merrill No. 1 Northwest Natural Gas	Sec. 24 T8S, R4W	5,282	10/14/77
Reichhold Energy Corp.	Crown Zellerbach No.1 Northwest Natural Gas	Sec. 8 T4N, R3W	5,805	11/ 1/77

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* * * * *

NEW STATE GEOLOGIST

Donald A. Hull
(Photo courtesy Oregon Journal)

December 16, 1977 marked the beginning of Donald A. Hull's tenure as State Geologist for the Oregon Department of Geology and Mineral Industries, a post he assumed after having served as the Department's geothermal specialist since October 1974.

Prior experience includes four years with Homestake Mineral Development Company as district exploration manager, in charge of exploration in the northwestern United States and Canada; a year as geologist-in-charge for Homestake Mining Company, Carlin, Nevada, where he directed a conceptual exploration program for Carlin-type gold deposits; and a year with Port Costa Clay Products Company, Port Costa, California, as geologist and assistant manager, directing the search for, acquisition of, and mining of clay and shale deposits.

Hull earned his Ph.D. degree at the University of Nevada, Reno, in 1970. His dissertation was entitled "Geology of the Puzzle Vein, Creede Mining District, Colorado." His master of science degree came from McGill University, Montreal, Canada, in 1962, after undergraduate studies at the University of Idaho.

Hull is a member of the Canadian Institute of Mining and Metallurgical Engineers, the Northwest Mining Association, the Geothermal Resources Council, and the Engineers Club of San Francisco. He is author or coauthor of several publications, primarily geothermal studies.

* * * * *

THE OREGON AGATE AND MINERAL SOCIETY will present its annual Gem and Mineral Show from January 28 through February 5 at the Oregon Museum of Science and Industry.

Admission is free beyond the OMSI gate. A prize drawing will be held.

Hours: 9 - 5 weekdays; 9 - 9 Friday; 9 - 6 Saturdays and Sundays.

RALPH MASON RETIRES

Ralph S. Mason, who retired from his position as State Geologist September 30, 1977 remained with the Department as Acting State Geologist until December 15. He left behind him a record of service and achievement of which he can be proud and for which we of the State Department of Geology and Mineral Industries are deeply grateful.

A native Oregonian, Ralph was born in Hood River and lived in Hood River County until 1930. He received a B.S. in geology from Oregon State University in 1937 and was a Registered Mining Engineer for the State Department of Geology and Mineral Industries from 1943 to 1971. He served as Deputy State Geologist from 1971 through 1976. In 1977 he became State Geologist, a position for which he was extremely well qualified.

Ralph's 34 years of service to the people of Oregon have produced approximately 75 articles and publications on the mineral industry of Oregon; hundreds, if not thousands, of talks to interested groups and organizations; numerous radio and television appearances; assistance to Department staff members; and countless answers to questions from the public, industry, press, and fellow geologists about Oregon's geology and the State's role in the development and protection of Oregon's mineral resources.

Mason has been associated with many societies including the American Institute of Mining, Metallurgical and Petroleum Engineers; Geological Society of the Oregon Country; Oregon Museum of Science and Industry; Oregon Association of Engineering Employees; Oregon Inventors Council; and Columbia Inter-Agency Task Force on Lands and Minerals. He was an instructor in geology in the Portland State College Evening Program from 1950 to 1972 and a guest lecturer at the Oregon State Junior Engineers Science Summer Institute from 1958 to 1972. His interests extend beyond geology and mining to specialty woodworking and design, practical around-the-home inventions, and civic service.

Ralph S. Mason

At the core of Ralph's contribution is a quality available only through long-term experience and commitment. The Department has been very privileged to have had Ralph on its staff. We will miss his knowledge, high standards of excellence, unfailing courtesy, and unexpected witticisms. To Ralph Mason, resource in rough times and leader in good times, wit cracker and occasional whip cracker, and friend, we extend our deepest appreciation and wishes for a healthy and happy retirement.

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THE ANNUAL CYCLE OF PROFILE CHANGES OF TWO OREGON BEACHES

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Introduction

Two Oregon coast beaches with significant differences in grain size, and thus in beach profile morphology and response to wave conditions, were studied. Gleneden Beach, just south of Siletz spit and Lincoln City, has a median grain size of 0.35 mm (0.014 in) (medium sand) and a steep beach face slope; Devil's Punchbowl beach has a median grain size of 0.23 mm (0.009 in) (fine sand) and a low concave-up beach face slope. Between August 1976 and July 1977, fourteen sets of beach profiles were obtained both at Gleneden Beach and Devil's Punchbowl beach.

Beach profile and wave conditions

The beach profile configuration, in nature and laboratory wave tanks, is a function of the intensity of energy dissipation by waves breaking on the beach. Beach profile changes are caused by storms, longshore sand transport, tides, and coastal winds (Komar, 1976). Monitoring all of these variables at the same time in order to understand the variations in the beach profile is difficult.

The principal observed variation commonly found in beach profiles is annual, resulting from overall changes in the energy level of waves between summer and winter. Some of the first measurements of this annual shift were made on California beaches by Shepard (1950), and overall shift in profile type is illustrated in Figure 1. Shepard (1950) found that during the summer, when small waves prevail in California, beach profiles are characterized by wide berms and relatively smooth offshore profiles. Storms during the winter shift sand from the berms to offshore bars (Figure 1). Because profile types are generally seasonal, Shepard used the terms "summer profile" and "winter profile." As such shifts, however, are not always seasonal, the terms "swell profile" and "storm profile," after Komar (1976), are used in this paper. Figure 1 emphasizes the relationship of the profile types to swell waves and storm waves. Generally, however, Oregon beach profiles, like those of California beaches, are approximately seasonal.

The two types of beach profiles are most commonly related to steepness of waves, H_∞/L_∞, where H_∞ is the deep-water wave height and L_∞ the deep-water wave length. The deep-water wave length is related to the wave period, T, by

$$L_\infty = \frac{g}{2\pi} T^2$$

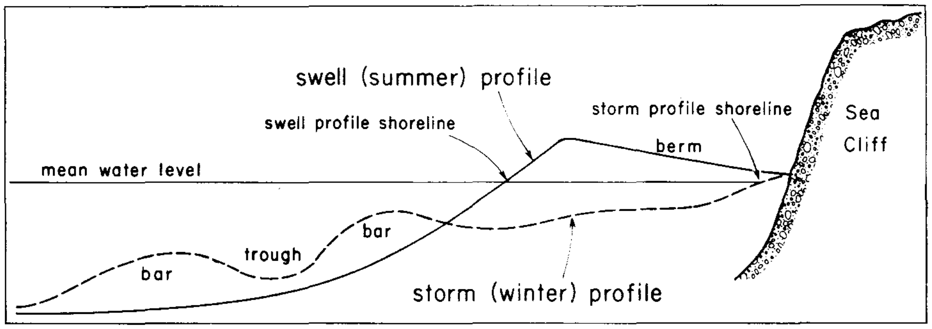

Figure 1. Swell (summer) profile with its wide berm v. storm (winter) profile with larger offshore bars. These differences result from changing wave conditions (from Komar, 1976).

where g is the acceleration of gravity. Thus wave steepness includes wave period as well as wave height. In wave tank experiments, Johnson (1949) found that the beach profile changed from a swell profile to a storm profile when wave steepness, H_∞/L_∞, reached a value of 0.025 to 0.03. Rector (1954) and Watts (1954) found the critical wave steepness to be 0.012, lower than values given by Johnson (1949). Using a wave tank which generated waves as large as those occurring on actual beaches, Saville (1957) found a critical wave steepness of 0.0064, much lower than that found in other studies.

Iwagaki and Noda (1963) and Nayak (1971) have shown that the value of the critical wave steepness for the change from a swell profile to a storm profile depends on the ratio, H_∞/D, where D is the mean grain size of beach sediment; their two studies, however, did not particularly agree. Dean (1973) presents a model for the shift in profile type based on a consideration of the trajectory of a suspended sand particle as it falls to the bottom, acted upon at the same time by horizontal water motions of waves. He finds that critical wave steepness depends on the ratio of the settling velocity of beach sediment to the period of waves.

All considerations of a critical wave steepness that causes the shift in profile type agree that the deep-water wave height, H_∞, and the wave period, T, are the major parameters important in the process, since they govern the value of the wave steepness. Previous studies clearly demonstrate that deep-water wave height, or breaker height, or wave energy (which depends on the wave height), is important in the shift in profile type. Komar (1976, p. 293) suggests, however, it is not clear that the wave period, T, is an important parameter. On North Carolina beaches, for example, Dolan (1966) found a significant correlation between both onshore-offshore shifts of sand and profile types with wave height or energy but almost no correlation with the wave period.

Purpose of study

The purposes of this study are (1) to examine annual changes in beach profiles on the Oregon coast and (2) to relate these changes to wave conditions. Of particular interest is winter erosion of the beach because when most of the beach berm has been removed, waves wash directly against the coastal sea cliffs or dunes (Komar and others, 1976), resulting in erosion of coastal properties such as has occurred on Siletz spit (Rea, 1975; Komar and Rea, 1976) and Bayocean spit (Terich and Komar, 1974; Komar and Terich, 1977). The ultimate purpose of the investigation is to allow the prediction of the amount of beach erosion or deposition (the onshore-offshore shifts of beach sand) from a knowledge of the wave conditions. Waves measured daily at the Marine Science Center in Newport on the mid-Oregon coast could thus be used to predict beach erosion along the coast.

Previous Oregon studies

Only two previous investigations of beach profile changes have been conducted on the Oregon coast. The first involved an extensive University of California, Berkeley, study of West Coast beaches for the Navy during and immediately following World War II. The findings of those studies are summarized by Komar (1977). The investigations summarized in this article can be viewed as a continuation of the studies of Oregon beach profiles undertaken by Fox and Davis (1974) from June 1973 to May 1974 when they examined the response of the beach to changing waves, winds, and tides, finding that during the winter, wave swash and nearshore currents remove large volumes of sand from the beach. They learned that the beach partially recovers during stormless periods, even during winter, because the sand removed from the berm and stored in offshore bars returns to the beach in the form of small intertidal bars that migrate onshore.

Beach Profile Locations

The two Oregon beaches from which profiles were obtained differ significantly in grain size. The coarser sand occurs along a stretch of beach at Gleneden Beach immediately south of Siletz spit and 9.2 km (5.7 mi) south of Lincoln City; the profiles were obtained at the northern edge of Gleneden Beach State Park and the private property to the immediate north of the park. More details of the location and arrangement of profiles are given by Aguilar-Tunon (1977).

Figure 2 shows a typical Gleneden Beach profile with the grain-size parameters along its length. The sand is generally approximately 0.36 mm (0.014 in) in median size (medium sand, according to Wentworth's (1922) classification). Gravel concentrations commonly appear on the beach face, especially within pronounced longshore troughs that develop during the spring.

Because of its relatively coarse sediment, the beach has a steep profile and beach face slope, demonstrating the relationship of increasing beach slope with increasing grain size (Bascom, 1951; Wiegel, 1964; and Komar, 1976, p. 303-308). Because coarse sand beaches change their profiles in response to varying wave conditions much faster than do beaches composed of finer sized grains, Gleneden Beach may also be expected to be in closer equilibrium with prevailing wave conditions.

The second beach examined in this study is located from 410 to 510 m (1,350 to 1,700 ft) south of Devil's Punchbowl at Otter Rock, 11.6 km (7.2 mi) north of Newport. Profiles were obtained far enough away from Devil's Punchbowl itself so that the rocky headland would not interfere with the waves at the profile locations and should therefore not significantly affect the beach response. Figure 3 shows a typical beach profile with the grain-size parameters along its length. The beach there is composed principally of fine-grained material (Wentworth, 1922), with a median diameter of approximately 0.23 mm (0.009 in),

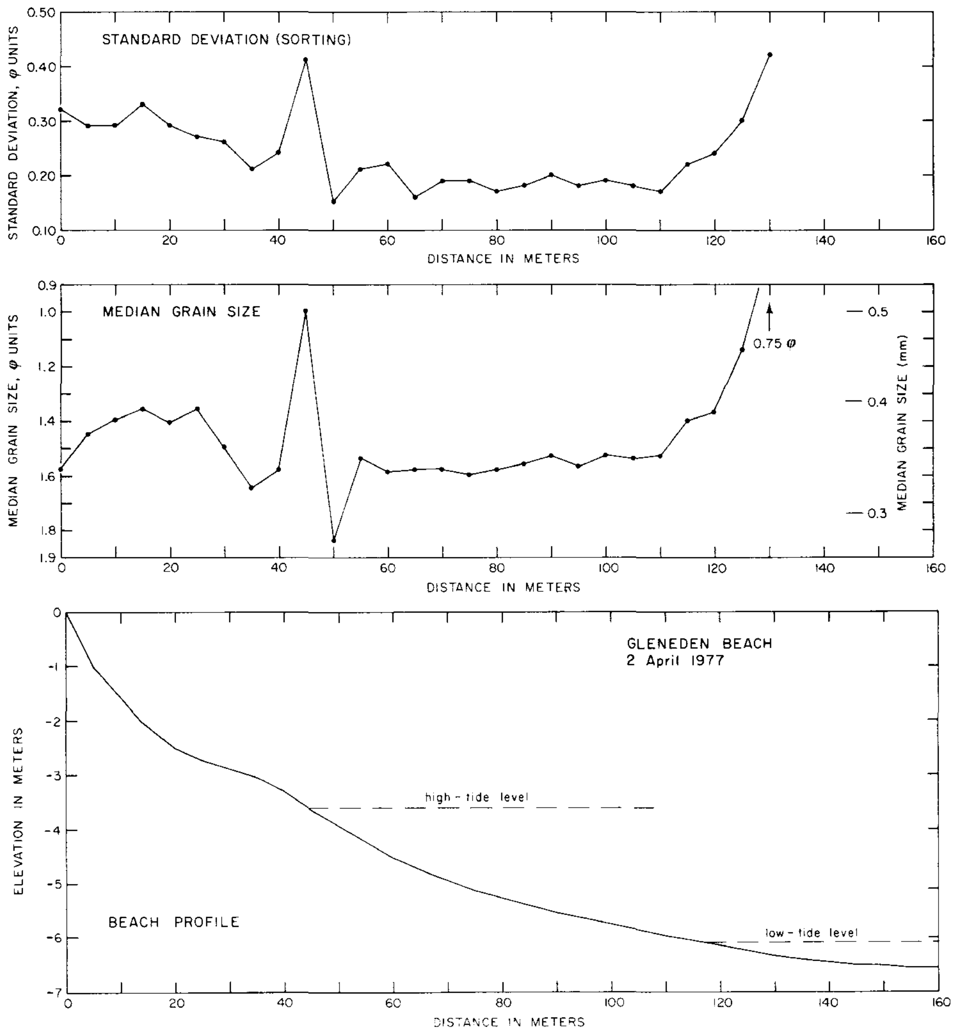

Figure 2. Median grain size and standard deviation (sorting) of grain-size distributions across typical beach profile at Gleneden Beach. Analyses were performed on sedimentation balance.

much finer than the sand at Gleneden Beach. The beach slope is also much lower.

There are other differences in the beaches, as well. The overall mineralogy of the beach at Devil's Punchbowl changes during the year. In summer, when the berm is widest, the beach is light in color because it consists mainly of clear to cream-colored quartz and feldspar. During winter, sand is shifted offshore from the upper beach, exposing a concentration of heavy minerals, mainly hornblende, epidote, and garnet, leaving the beach almost black, with a distinct green tinge due to the epidote. Gleneden Beach does not show similar concentrations of heavy minerals and resulting changes in color, consisting instead of quartz-feldspar sand throughout the entire year.

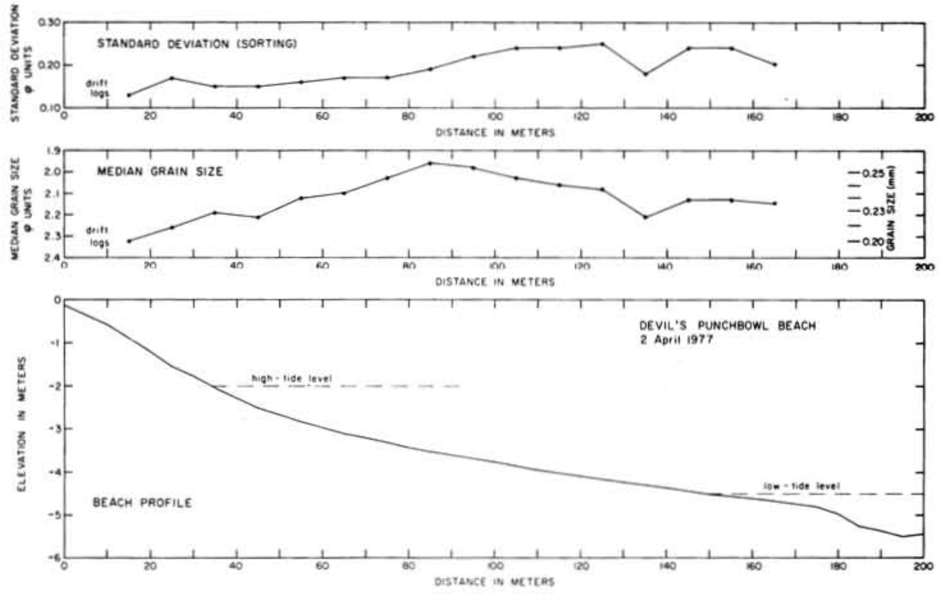

Figure 3. Median grain size and standard deviation (sorting) of grain size distributions across typical beach profile at Devil's Punchbowl beach. Sand on this beach is much more uniform and finer grained than that at Gleneden Beach (Figure 2).

Beach Profiling Techniques

The profiling techniques used in this investigation are the same as those described by Emery (1961), Hoyt (1971), Fox and Davis (1974), and, in greater detail, Aguilar-Tunon (1977). The approach is the line-and-stakes method, which utilizes the horizon to determine the horizontal to which vertical changes in the profile are referred. Emery (1961), Davis (1976), and Aguilar-Tunon (1977) discuss the accuracy of the approach.

The 14 sets of surveys conducted at both Devil's Punchbowl beach and at Gleneden Beach were generally carried out during spring tides, when the most beach is exposed. For this reason, the successive profile sets are separated in time by either two weeks or one month. Aguilar-Tunon (1977) lists profile dates. Four wooden stakes and one iron stake were located at the top of the beach along the base of the sea cliff at Gleneden Beach; the distance between the stakes was 60 m (200 ft) (Aguilar-Tunon, 1977, Figure 9). The stakes served as base marks for the survey lines; the tops of the stakes provided a base level to which the repeated profiles could be compared. Similarly, three wooden stakes located at the base of the cliff along Devil's Punchbowl beach were reference points for the three survey lines there (Aguilar-Tunon, 1977, Figure 10). Distance between these stakes was 50 m (165 ft).

The purpose of having multiple survey lines, five at Gleneden Beach and three at Devil's Punchbowl, was to allow longshore variations in beach erosion and deposition patterns to be assessed and averaged. The chief cause of these variations was expected to be rip currents, which hollow out more of the beach, producing embayments. If a single survey line were used and it happened to be at the location of a rip current, the resulting erosion would not correspond well to the wave conditions. Rip current embayments or other beach irregularities actually presented few problems until April to June 1977, toward the end of the study. This was a matter of chance, especially at Gleneden Beach, where rip current embayments could be seen both to the north and south of the survey area throughout the winter. Similarly, no longshore irregularities appeared on Devil's Punchbowl beach throughout the winter. Rip current embayments and irregular longshore throughs developed at both beaches in late April through June, as sand began to shift onshore, returning to the exposed beach berm. These irregularities will be discussed later.

Multiple survey lines served another purpose in that stakes were sometimes lost and had to be replaced. Fortunately, one stake at each location survived for the entire study peri d. Most determinations of beach erosion and deposition were obtained from those two survey lines, with confirmation checks from other survey lines to insure that longshore variations were not appreciable.

Wave Measurements

Sea wave conditions were recorded daily for 10-minute intervals every 6 hours at the Marine Science Center in Newport. The microseism system for wave measurements and the wave analysis procedures are described by Enfield (1973), Quinn and others (1974), Zopf and others (1976), and Komar and others (1976). The system empirically yields measurements of the significant wave height and period at a water depth of 12 m (40 ft) off Newport; as discussed by Komar and others (1976), these measurements can be considered as deep-water waves with little introduction of error. Corresponding breaker heights of waves were calculated from offshore wave data provided by the Newport seismic system, utilizing the equation developed by Komar and Gaughan (1973).

Resulting Beach Profiles

Gleneden Beach

Figures 4 and 5 show the 14 profiles obtained at Gleneden Beach along the profile range for which the stake was not lost, and all profile elevations and horizontal distances are relative to the top of that stake. Profile 1 (27 August 1976), Figure 4, shows a berm 70 m (230 ft) wide, sloping in a landward direction, meeting the seaward-sloping beach face in a pronounced berm crest. Such a profile, with a low in the mid-berm and a sharp berm crest, is a typical swell (summer) profile for this location. The landward-sloping berm is produced by waves washing over the berm crest, depositing sand, and then ponding in the low of the mid-berm. Bascom (1954) shows similar profiles at Carmel, California.

Profile 2 (7 October 1976), Figure 4, shows that the berm has been partially eroded. Profile 3 and subsequent profiles in Figure 4 show no berm, the beach instead consisting of an offshore-sloping beach face, a typical concave-upward storm (winter) profile. Thus, between Profiles 1 and 3, a shift similar to that shown in Figure 1 has occurred. The summer type of profile has been transformed into the winter type. Sand has presumably moved offshore into bars which could not be reached by these profiles but which can be seen in profiles obtained with an amphibious DUKW (Komar, 1977).

Figure 5 includes Gleneden Beach profiles that demonstrate the growth of the exposed beach berm as wave co iitions change and the profile shifts

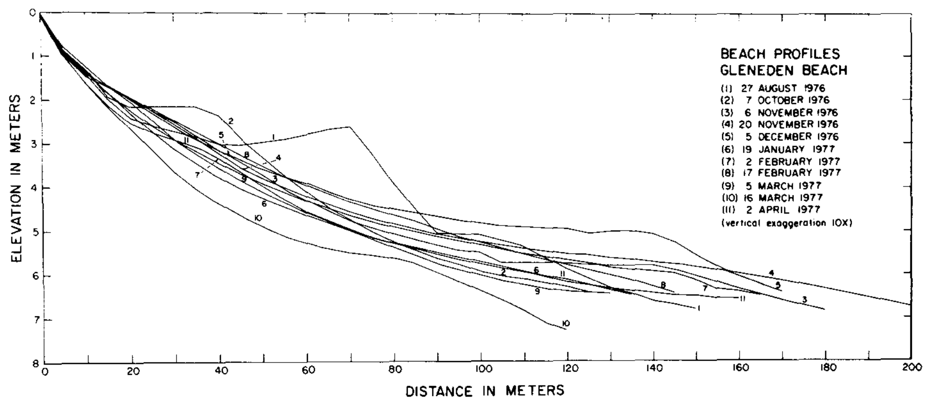

Figure 4. The first 11 beach profiles obtained along Profile Range 4 at Gleneden Beach on indicated dates, showing progressive beach erosion.

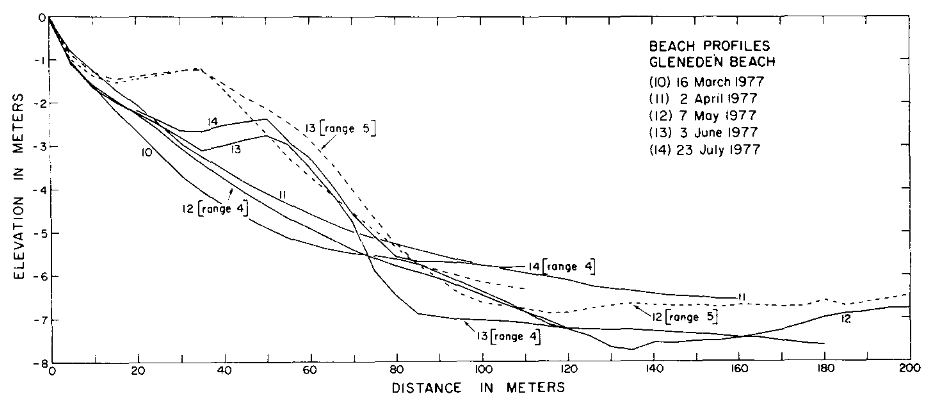

Figure 5. Profiles 10 through 14 at Gleneden Beach, showing recovery of beach berm under lowered wave conditions of spring and early summer. Dashed lines show Range 5; solid lines indicate Range 4; longshore separation of the two ranges is 50 m (165 ft). Note considerable longshore variability in berm recovery shown by these two ranges.

back to the swell-type profile that prevails during the summer. Profiles 10 and 11 are repeated from Figure 4, showing the maximum amount of erosion (Profile 10) and the beginning of recovery (Profile 11). Beginning with Profile 12 (7 May 1977), longshore variations in the profiles are appreciable, especially in the degree of berm recovery and in irregularities of the offshore portions. From this time through July, rip currents were very apparent, with longshore troughs cut by longshore currents feeding the rip currents. This was the main cause of the longshore variations in the beach profiles. It also governed local recovery of the berm.

Two beach profiles are given in Figure 5 for surveys 12 and 13 to depict this longshore change; all profiles shown in Figure 4 are located on Range 4, the location of the one stake not lost during the study.

Range 5 is 60 m (200 ft) to the south. Figure 5 shows the berm recovered much sooner at Range 5 than at Range 4 because a rip current was centered off Range 4 during this period. It was not until 23 July 1977 (Profile 14) that the berm at Ranges 4 and 5 appeared about equal in extent (elevations of Ranges 4 and 5 in Figure 5 are not comparable, since they are related to different stakes having different levels). Even during July, the beach profiles seaward of the steep beach face differed considerably due to the presence of nearshore circulation of longshore currents and rip currents.

Devil's Punchbowl

Representative profiles of the total 14 sets obtained at Devil's Punchbowl beach are shown in Figure 6; all the profiles can be found in Aguilar-Tunon (1977). At this beach, which is composed of fine sand, changes are much less pronounced than at the coarser grained Gleneden Beach. Devil's Punchbowl has little, if any, true berm, even in Profile 1 (27 August 1976). At the back of the beach a portion 10 m (30 ft) wide covered with drift logs could be called a beach berm. Otherwise, the exposed beach profile, even in midsummer, consists of a concave-upward beach face. Total vertical changes in the beach level from August 1976 to June 1977 were only on the order of 1 m (3 ft).

No ordered sequence of erosion occurs as the winter months of high waves begin followed by deposition as low waves return (Figure 6). While the coarser grained Gleneden Beach is undergoing erosion, Devil's Punchbowl beach might be undergoing deposition, and vice versa. The correspondence to the changing wave conditions was also rather poor; for example, erosion did not always occur when wave heights increased. The nonsystematic changes of Devil's Punchbowl beach cannot be attributed to errors in the profiling techniques because the changes are sufficiently large to be resolved by the approach, and, in most cases, all three profiles show the same changes. Perhaps the presence of Devil's Punchbowl headland some 400 to 500 m (1,300 to 1,650 ft) to the north has an indirect effect, even though it does not alter wave conditions at the profiling site. For example, the effects of the change in direction of waves from southwest to northwest and the resulting change in direction of the littoral drift, which would be blocked by Devil's Punchbowl, may have been felt as far south as the profiling location. This effect cannot be understood without further field studies.

A common feature of the beach at Devil's Punchbowl is a pronounced

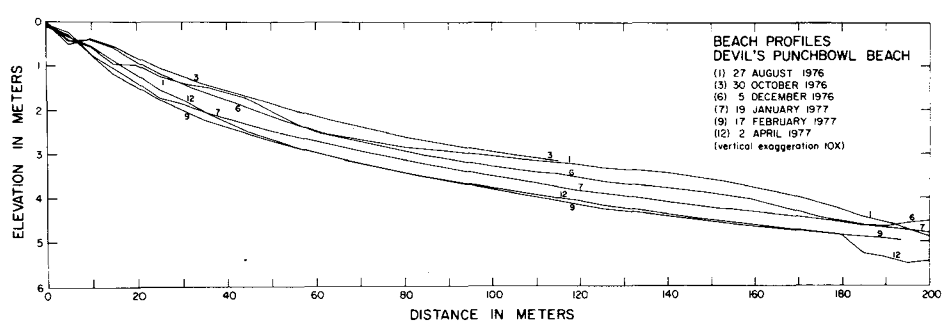

Figure 6. Selected beach profiles from Devil's Punchbowl beach, showing winter erosion of exposed beach.

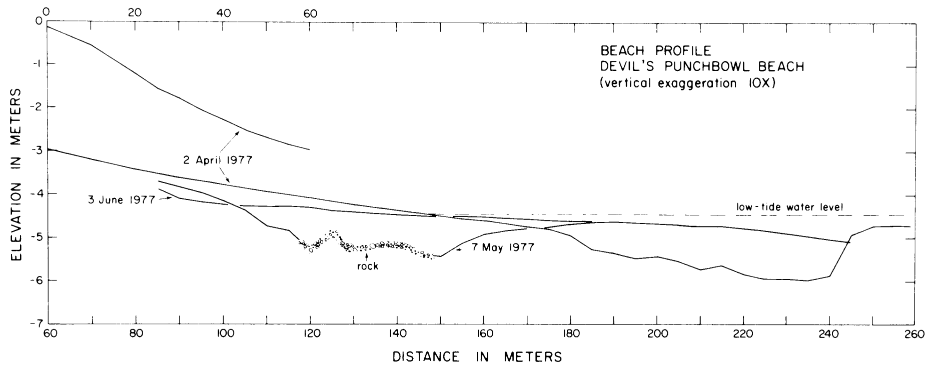

Figure 7. Development of an onshore-migrating bar as sand returned to beach berm during spring and early summer. A pronounced longshore trough developed between bar and exposed beach face, finally cutting completely through beach sand down to bed rock.

longshore trough and offshore bar. From August 1976 to March 1977, the trough was deep and the bar well offshore, and the profiles could not generally reach the bar. In spite of pronounced troughs, longshore currents were not strong. Rip currents were also weak; during the winter months they did not significantly hollow out embayments into the beach to produce longshore variations in the exposed beach. The 2 April 1977 profile (Figure 7) shows the offshore bar beginning to migrate shoreward while the confined longshore trough cuts deeper into the beach. On 2 April 1977, the bar top-to-trough-bottom relief was 1.3 m (4.3 ft); at low tide, the water depth in the trough was 1.5 m (4.9 ft). By 7 May 1977, the date of the next series of profiles, the bar had migrated shoreward by some 80 m (260 ft) (Figure 7). The more confined shoreward trough dug completely through the beach sand and flowed, in part, over exposed rock. During this stage, longshore currents were much stronger than during the winter, even though the waves were smaller. As individual waves dumped into the trough, water flowed over the bar into and along the trough until it reached a rip current. At the same time, the trough and rip current system produced significant longshore changes in the beach profiles. Figure 7 shows that by 3 June 1977, the date of the last profile, the trough had been completely refilled with sand and the onshore-migrating bar had welded itself onto the beach face. Such shoreward-migrating bars are better documented by Fox and Davis (1974) on Oregon beaches and in studies by Davis and others (1972), Hayes and Boothroyd (1969), and others on different coasts.

Beach Erosion and Deposition

Beach profiles obtained in this study have been used to compute the volumes of beach erosion or accumulation. Volumes of material moved by erosion or deposition during the time interval between two successive beach profiles are obtained by subtracting one profile from the other, assigning positive values (+) to areas where the second profile in time is higher than the first (deposition) and negative (-) to areas where the second profile is lower than the first (erosion). The procedure for approximating areas uses the trapezoid rule given in most calculus texts and yields a cross-sectional area between two successive profiles.

The resulting area can be thought of as the volume of erosion or accretion per unit length of beach in the longshore direction. This volume is, of course, also a function of the profile lengths. If the profiles had been somewhat longer, the volumes of calculated erosion or deposition would in most cases be greater. To help eliminate profile length effects on calculated volume, computed volumes were normalized by dividing by profile lengths. The result was the volume of erosion or deposition per unit profile length (cubic meters/meter) per meter of longshore beach distance.

The results of this analysis are presented in Figure 8, together with the measured wave steepness, H_∞/L_∞, and breaker height, H_b, obtained from the microseismometer system at Newport. The wave conditions show the usual general increase in breaker heights and wave steepness as the winter begins (Komar and others, 1976). Wave conditions fluctuate considerably because periods of large waves caused by North Pacific storm systems are separated by intervals of lower waves, when there are no storms. The largest waves measured during the study occurred on 9 March 1977, when breaker heights reached a significant wave height of 6.0 m (20 ft). Larger waves have been measured by the Newport wave recorder, installed in 1971. The largest breakers, 7.0 m (23 ft) high, occurred on 24-25 December 1972, causing considerable erosion on Siletz spit to the north of Geneden Beach (Komar and Rea, 1976). The storm on 9 March 1977 caused some erosion of property on Siletz spit, but not as much as that caused by the earlier erosion episodes of 1972-73 and of spring 1976.

The values of the wave steepness, H_∞/L_∞, in Figure 8 tend to be more erratic than the breaker height because the steepness includes both the measured wave height and period, each with inherent measurement errors. For this reason, Figure 8 includes a plot of the average, maximum, and minimum values of the wave steepness for the time intervals between profiles.

The resulting computations of beach erosion and deposition shown in Figure 8 further demonstrate that the volumes involved are much greater at the coarser grained Gleneden Beach than at the finer grained Devil's Punchbowl beach. Maximum erosion at Geneden Beach was 0.71m^3/m (7.6 cu ft/ft) of profile length; maximum erosion at Devil's Punchbowl beach was 0.25 m^3/m (2.7 cu ft/ft) of profile length. Simple progressive erosion of the exposed beach does not take place at either location as the winter months are entered because periods of net deposition occur between subsequent profiles, even in midwinter. It appears that the finer grained Devil's Punchbowl beach shows lesser volumes of change than the coarser grained Gleneden Beach, and erosional or depositional response may be entirely different.

Figure 9 shows the relationship between the amount of erosion or deposition between two successive profiles and the average breaker height that prevailed during the time. Also given are the total ranges of breaker heights observed during each period, the data bars extending from the maximum to the minimum observed breaker heights. As in Figure 8, computations are limited to months before April 1977, at which time longshore variations in the beaches became appreciable.

Figure 9 shows only a vague relationship between the amount of erosion/deposition and average breaker height. The slight trend that does exist indicates that with increasing breaker height comes an expected shift from deposition to erosion and an increase in the amount of erosion. More important to the erosion/deposition might be the maximum and minimum wave conditions that occur during the time period. The one

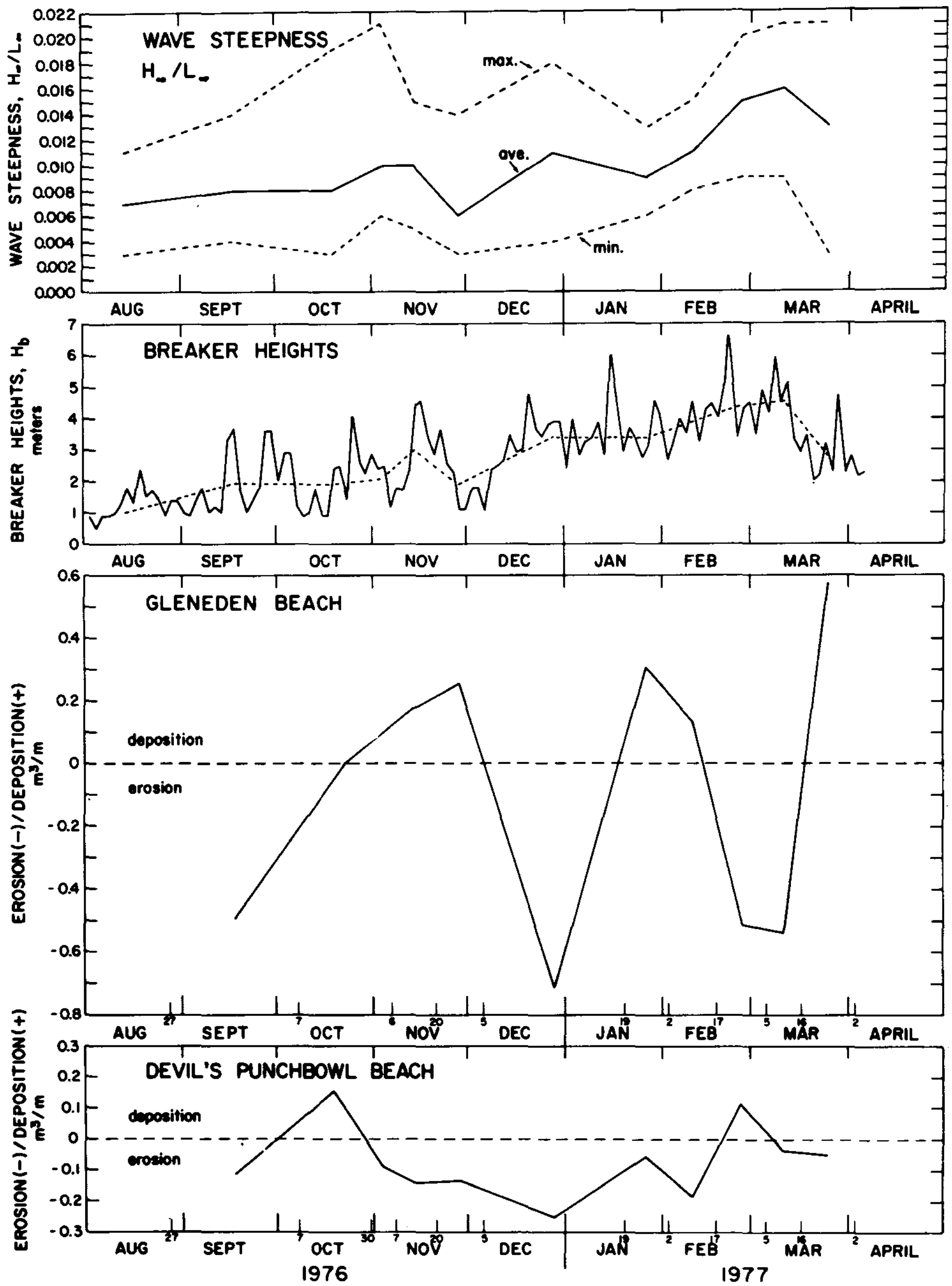

Figure 8. Beach erosion/deposition throughout study period before appreciable longshore variations v. wave steepness and breaker heights determined from wave data. Dates of surveys upon which erosion/deposition evaluations are based are shown. Wave steepness values are averages for intervals between surveys. Daily breaker heights and average values between surveys are indicated.

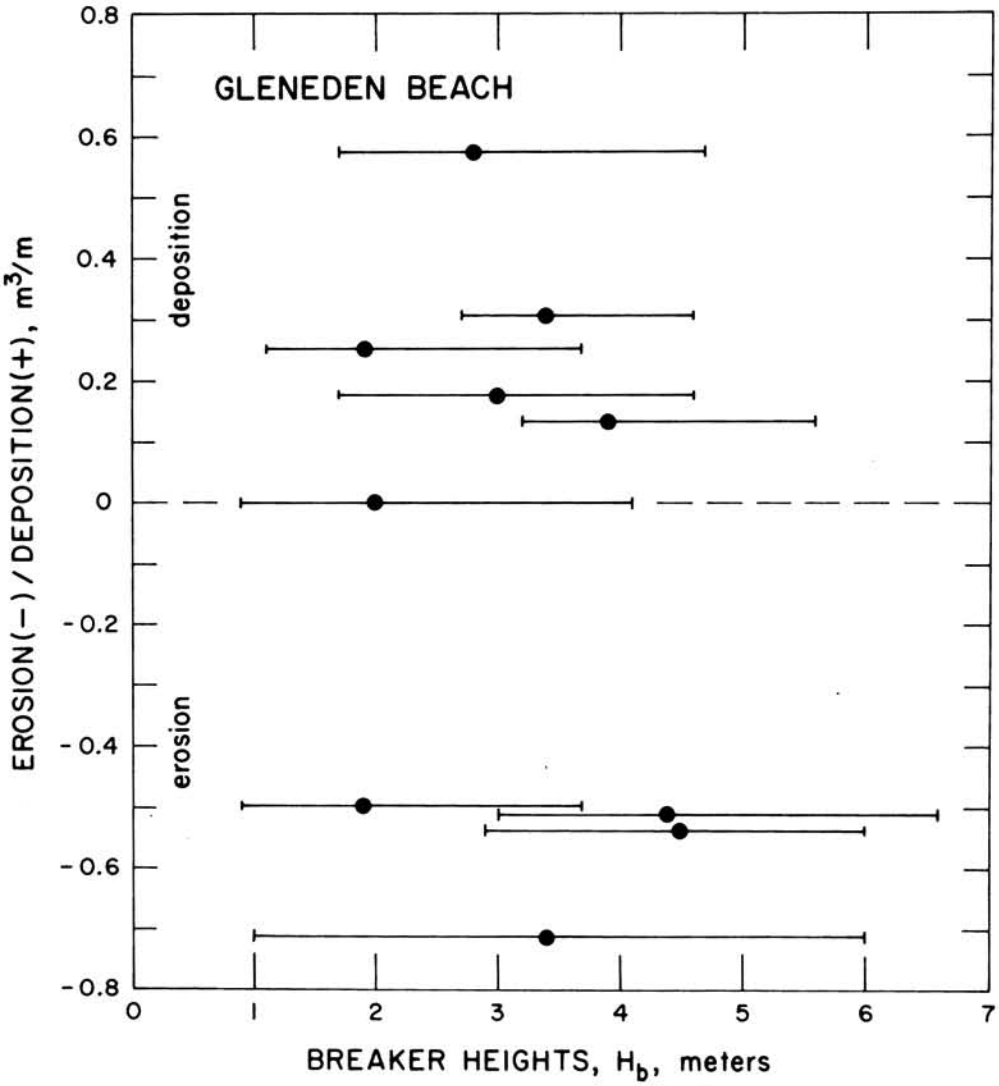

Figure 9. Volumes of erosion or deposition between successive beach profiles v. breaking wave heights prevailing during time intervals. Average breaker heights are plotted as well as total ranges of values measured.

large storm that took place during the period, represented by the maximum breaker height, might be responsible for the beach erosion, whereas the average or minimum breaker heights do little to change the volumes of sand on the exposed beach. This certainly appears to be the case; one single large storm with breakers higher than 6 m (20 ft) usually initiates erosion on Siletz spit (Rea, 1975; Komar and Rea, 1976). Deposition apparently occurs when there is no major storm during the period and the breaking waves average around 4 m (13 ft) or less. The minimum wave breaker heights that occur during the period do not appear to be significant, not differing between the periods of erosion and deposition (Figure 9), possibly because the minimum waves have such little energy and power that they are unable to appreciably change the volume of sand on the exposed beach. They may cause some beach deposition, but its importance is small compared with the volume changes associated with the average or maximum waves during that time period.

A further complication is the time element. This is especially apparent in Figure 9, which shows that erosion was produced by waves averaging only 2 m (7 ft) in breaker height with the maximum waves of the time period reaching only 3.7 m (12 ft). This occurred at the initial transition between the swell profile that prevails during summer and the storm profile that occurs during winter. As wave conditions are initially changing, the beach profile in its full summer condition is most out of equilibrium with the increasing wave heights. For this reason, during the transition period, an increase in wave height to even 2.0 to 3.8 m (7 to 13 ft) produces a large volume of erosion. Once the beach profile has shifted more toward the winter storm profile, those same wave heights would cause little, if any, erosion and might at that time even cause some beach deposition. Thus wave heights that at one time of year cause erosion may cause accretion on the exposed beach at another time of year. Of importance is the condition of the beach profile at the time the waves occur, whether it is shifted well into the swell (summer) configuration or into the opposite extreme, the storm (winter) profile.

Results of similar analyses undertaken to relate the volume of erosion/deposition to prevailing deep-water wave steepness, H_∞/L_∞, can be found in Aguilar-Tunon (1977). In this analysis, wave steepness shows an even poorer relationship than does breaker height (Figure 9) to erosion/deposition. There is only a slight indication that increasing wave steepness is accompanied by increasing tendency toward erosion and an increase in the volume of erosion. This led to the conclusion that including the wave period in the analysis to yield wave steepness, rather than using the wave height or energy alone, does not appear to be warranted, which agrees with the findings of Dolan (1966).

Summary of Conclusions

Oregon beaches undergo the usual profile changes resulting from seasonal variations in the wave conditions. During the year of this study, the beaches under investigation transformed from swell (summer) profiles to storm (winter) profiles from September through November, the period of generally increasing wave heights. The transition was accompanied by general erosion of the exposed portions of the beach. The swell (summer) profiles returned the following spring, making the transition in April through June, during which months the wave heights again decreased. The return to the swell (summer) profiles was marked by the shoreward migration of bars, producing for a time deeply incised longshore troughs and an increased nearshore water circulation.

Seasonal changes in profile types and accompanying erosion or deposition are not entirely systematic. For example, deposition on the exposed portion of the beach occurred even in midwinter during periods of prolonged low wave activity.

Of the two beaches under investigation, the coarser grained Gleneden Beach showed larger volume changes of sand on the exposed beach due to erosion and deposition. Vertical changes in the level of the beach face were also greater. The coarser grained and finer grained beaches did not always respond to the changing wave conditions in the same way; one could be eroding while the other showed a net accretion. Of the two, the coarser grained beach changes appeared to be more systematic and to correspond more closely to varying wave conditions.

Attempts were made to relate erosion or deposition volumes to changing wave breaker heights and deep-water wave steepness, H_∞/L_∞. This analysis met with only limited success, partly due to the time factor because waves of a given height could cause erosion during one season and deposition during another season. The governing factor in the response was the degree to which the beach profile was out of equilibrium with the waves. In general, for the Oregon beaches studied, the principal beach erosion occurred during storm conditions when wave breaker heights exceeded 5 to 6 m (16 to 20 ft). Deposition occurred when there was no major storm and breaking waves averaged 4 m (13 ft) or less. Wave steepness, H_∞/L_∞, showed a poorer relationship to the erosion/deposition than did breaker heights, indicating that the wave period was not a significant factor in the onshore-offshore shift of sand and the resulting changes in the beach profile type.

Acknowledgments

We would like to acknowledge those individuals who aided us in obtaining the beach profiles, especially Rafael Herrera, an undergraduate student who was always ready to enter the surf. Thanks go also to Clayton Creech for his help in obtaining the wave data.

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GEOLOGISTS REGISTRATION FEES ANNOUNCED

The State Department of Commerce Board of Geologist Examiners has announced fees for registering under the Geologist's Registration Act, Sec. 14, Chap. 612, Oregon Laws, 1977, passed by the 1977 session of the Oregon Legislature. The fee for examinations will be $50; initial or annual renewal licenses, $50; initial or annual renewal of certification in a specialty, $25; restoration of a past-due license or certificate, $10; replacement of lost certificate, $3.00.

Geologists 70 years old or older will pay a reduced fee of $10. All licenses must be renewed each year on or before November 1. Qualified practicing geologists may obtain licenses without examination by applying before September 30, 1978.

Address applications to the Department of Commerce, Board of Geologist Examiners, 428 Labor and Industries Building, Salem, Oregon 97310.

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BIBLIOGRAPHY OF OREGON CAVES PUBLISHED

The Oregon Speleological Survey has recently published "Bibliography of Oregon Speleology," an annotated and comprehensive bibliography of caves in Oregon. Data for the 101-page bulletin were painstakingly gathered by Charles V. Larson, who dedicated the work to Phil Brogan, longtime Bend newspaperman.

Although this book is technically a bibliography, the copious annotations have almost converted it into a basic text on Oregon speleology. In addition to the 1,155 entries, a list of caves is cross-referenced to pertinent literature. Also included are a map of caves that have been found in the state, a list of cave leads, and a table giving duplicate cave names.

The bibliography is available, at $6.00 postpaid, from the Oregon Speleological Society, 13402 N.E. Clark Road, Vancouver, Washington 98665.

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FORMER BOARD MEMBER DIES

Herbert Lyle (Van) Van Gordon, member of the Department's Governing Board from April 1973 through March 1976, died January 21, 1978, in Grants Pass. Van Gordon was born June 26, 1913, in Cove, Oregon. He spent his boyhood in Nevada and later took mining courses at the University of Nevada. During the war years, Van Gordon served on the War Manpower Commission, involved in magnesium research and process control. In 1944 he moved with his family to Grants Pass, where he was self-employed until 1950, when he began work for Pacific Power and Light Company.

Upon his appointment by then-Governor Tom McCall to the Governing Board, Van stated: "This is the finest and will be the most interesting and rewarding opportunity to serve that has come my way."

State Geologist Donald A. Hull, on receiving the news of Van Gordon's death, observed: "Lyle Van Gordon's interest in mining and the outdoors gave him unique insights into the activities of the Department. A personal knowledge of Oregon's mining areas contributed to his outstanding service as a member of the Department's Board of Governors."

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SURFICIAL GEOLOGIC HAZARD CONCEPTS FOR OREGON

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Introduction

Geologic hazards are those geologic processes which adversely affect the activities of man and therefore pose threats to his safety, health, and welfare. Included are earthquakes, mass movement or landslides, floods, slope erosion, and stream erosion and deposition. The increased need for information on geologic hazards in Oregon is addressed by the Environmental Geology Program of the Oregon Department of Geology and Mineral Industries.

Purposes of the program are:

(1) To provide pertinent information on geologic hazards in Oregon for land use planning.
(2) To integrate information on surficial geologic processes into land management activities and policy formulation for the purpose of more effective land management.
(3) To develop new concepts and techniques in the study and portrayal of geologic processes so that data may be more effectively conveyed to the practical user.

In keeping with the third objective of the program stated above, this paper is designed to explain geologic hazard concepts that have evolved in the completion of investigations conducted by the Department to date. The selected concepts are basic to the discipline and are not products unique to this agency. Rather they are a selection and refinement of countless geologic hazard concepts developing in many disciplines and institutions throughout the State and the nation. They are adopted here owing to their unique applicability to Oregon.

Because of its varied relief, youthful topography, and highly variable bed rock, Oregon has a considerably wider array of geologic hazards than many other states have. The geologic hazards and factors producing them can be properly addressed only with a systematic and knowledgeable study of the bed rock. Accordingly, a review of the geology of an area with the emphasis on engineering properties of geologic units is an integral part of all geologic hazards investigations conducted by the Department.

Geologic Units

General

In Department reports summarizing geologic hazards investigations, discussion of geologic units is provided to (1) document and explain information on geologic maps, (2) aid in geologic hazard interpretation, and (3) systematically relate geologic units to other sections of the report.

Geologic units are distinguished primarily on the basis of rock type and, to a lesser extent, by other physical properties, distribution, topographic setting, and age. Generally, each geologic unit possesses a unique association of engineering properties that can be summarized in table form (Table 1).

Interpretation of the regional distribution of specific geologic hazards is based in part on (1) identification of the causes of the hazard, (2) relation of causes to engineering properties of rock units, and (3) delineation of the distribution of pertinent engineering properties through an understanding of the geology. Extrapolation of information from a given area to other areas follows a similar procedure.

Bedrock structure is briefly discussed in Department environmental reports to (1) document interpreted distribution of rock units, and (2) allow more accurate interpretation of hazard distribution and potential. Generally speaking, most traditional geologic mapping is aimed at interpretation of rock genesis. The manner of origin of the rock, in turn, is accurately reflected in its composition and texture and therefore in its engineering properties. Because of this coincidence, it is possible to adopt the major rock categories recognized by traditional geologic efforts as also the major engineering categories for preliminary assessments in a region.

Surficial geologic units

Surficial geologic units are unconsolidated, relatively thin stream deposits overlying bed rock. Major landforms are flood plains, terraces, and alluvial fans.

Volcanic and sedimentary geologic units

Volcanic and sedimentary geologic units include a variety of consolidated rock units that (1) underlie surficial units where they are present, (2) are to some extent folded and faulted, and (3) do not display metamorphic features. In addition, they do not include intrusive igneous rocks. These highly varied volcanic and sedimentary rocks have a wide range of engineering properties and associated hazards.

Metamorphic geologic units

Metamorphic rocks are rocks derived from preexisting rocks by temperature or pressure extremes beneath the zone of weathering. Metamorphic rocks display different mineralogic and structural characteristics than do their parent rocks and are generally very hard and jointed to give angular chips and slabs. Some metamorphic rocks are strongly foliate; that is, they possess closely spaced parallel planes of structural weakness resulting from metamorphism.

Intrusive geologic rock units

Intrusive rocks are rocks emplaced as a unit into preexisting rocks. Subsequent erosion exposes them at the earth's surface. Most intrusive rocks are igneous and are characterized by massive textures. Intrusive

General rating

- ● Relatively high or great
- ◓ Moderate
- ○ Relatively low or small
- • Not applicable

	Physical properties										Regolith					Drainage			Local hazards									
	Hardness	Joint development	Bedding distinctness	Foundation strength	Excavation difficulty	Cut slope stability	Slope intensity	Infiltration rates	Landfill potential	Septic tank capacity of soils	Thickness on steep slopes	Thickness on gentle slopes	Clay content	Silt content	Expansion-contraction	Overland flow	Shallow subsurface flow	Deep subsurface flow	Deep bedrock slides	Earthflow and slump topography	Steep slope mass movement	Potential future mass movement	Flood prone	Slope erosion potential	Historic channel change	Stream bank erosion	Torrential flood terrain	High ground-water hazard
Surficial units																												
Volcanic units																												
Sedimentary units																												
Intrusive units																												
Metamorphic units																												

Table 1. Typical matrix of engineering properties and geologic units

rocks of nonigneous origin (e.g. serpentinite) generally possess planar fabric. The specific manner of emplacement of intrusive rocks strongly influences their engineering properties.

Bedrock structure

A final consideration in the grouping of rock types is the influence of structure (folds and faults) in the land management behavior of rock units. Thus, normally competent rocks may behave incompetently in sheared zones. Commonly an additional category of rocks (sheared rocks) must be addressed on the matrix (Table 1). Development of a grouping scheme which addresses all types of rock behavior is a useful tool in extrapolation techniques.

Geologic Hazards

General

Accomodation of orderly development while insuring public health, safety, and welfare is difficult and complex. The complexity, however, is greatly reduced where an understanding of the natural characteristics of the land, the processes that shape it, and the geologic hazards that threaten it is rationally applied in guiding growth. Surficial geologic hazards of concern to the planner include mass movement, slope erosion, stream flooding, stream erosion, and stream deposition. Each hazard is characterized by unique distribution, causes, and ranges of impacts. Recommentations for treatment or mitigation of geologic hazards should be flexible to allow for variations in physical, social, political, and economic settings.

Mass movement

General: Mass movement is the movement of rock or soil material downslope in response to gravity. Table 2 summarizes several kinds of mass movement occurring in Oregon.

Causes: Mass movement occurs on slopes where the downslope component of gravity exceeds shear resistance. In areas of sliding, potential sliding, low cutbank stability, or hazardous slopes, the activities of man should be controlled to assure that the downslope component of gravity is minimized and that shear resistance is maximized.

Downslope gravity components: Weight of the regolith (weathered rock and soil above bed rock) column is increased by the placement of fill for road construction or other purposes, saturation during winter rains, and artificial obstruction of surface and shallow subsurface runoff with improperly designed roads, poorly located dwellings, and other developments.

Models of slope failure presuppose that the weight of the regolith column is perpendicular to the earth's surface. Where nearby blasting or seismicity is a factor, a horizontal component of acceleration is introduced along with the vertical gravity component. The resulting inclined direction of acceleration has the same effect from an engineering standpoint as does steepening of the slope. Also to be considered are disaggregations and consequent loss of strength of regolith by blasting.

Shear resistance: Under saturated conditions, soil particles are buoyed, thereby reducing internal friction and shear resistance. Where soil water is increased to the point of saturation by rainfall, drainage interference, or blocking of springs, shear resistance decreases and potential for sliding increases. Under conditions of heavy rain, infiltration may exceed the rate of shallow subsurface drainage so that the liquid limit of the soil is actually exceeded (Campbell, 1975). Debris flows in colluvial (earth material transported by mass movement rather than by running water) pockets over impermeable bed rock may result.

Cohesion, the bonding attraction of soil particles, varies with soil type and water content. Silts have low cohesion when dry, moderate cohesion when wet, and no cohesion when saturated. Clay-rich soils generally accomodate large quantities of water before reaching their liquid limit. Slow moving landslides or expanding soils result.

Root support by trees is now recognized as a primary agent of stability in colluvial areas on steeply sloping terrain. Root support declines rapidly after logging, and many slides in logged areas are attributed to the loss of root support through root decay. In wooded areas it is doubtful, however, that increased soil moisture associated with logging has a measurable impact on slope stability.

Distribution: Interpretation of mass movement on geologic hazards

Type		Description	Distribution
Deep bedrock slide		Downward movement of rock along a curved basal shear plane accompanied by backward rotation of the slide block. Characterized by pronounced headscarp overlooking irregular, more gently sloping terrain.	Moderately steep to steep slopes in youthful valleys of moderately large to large streams. Common in faulted terrain, jointed terrain, and areas of interbedding of distinctly differing rock types. Favored by deep percolation of ground water and undercutting.
Earthflow and slump topography		Downslope movement of regolith along numerous shear planes in manner analogous to highly viscous flow; generally accompanied by rotational failure upslope. Characterized by irregular topography, sag ponds, and irregularities of soil distribution and drainage. Commonly too small to be detected with aerial photography where bed rock is not involved.	Moderately steep to steep slopes in areas of low surface runoff and significant chemical weathering. Most common also along faults, joints, and bedrock contacts; also common in heads of gullies or in areas of natural or artificial undercutting of regolith.
Steep slope failure	Debris flow and debris avalanche	Rapid flow or sliding of regolith down steep slopes along bedrock surfaces approximately parallel to the slope. Characterized by linear deposits of unvegetated colluvium in steep drainageways.	Steep to very steep slopes where regolith overlies impermeable bed rock and where shallow subsurface flow is significant, as in steep linear drainageways. Favored by silty soils prone to liquefaction when saturated and by removal of vegetation and consequent loss of root support.
	Rockfall and rockslide	Falling and rolling rock at the base of cliffs. Characterized by unvegetated talus or scattered boulders on slopes beneath cliffs of jointed or faulted hard bed rock.	Very steep slopes with exposures of jointed or faulted bed rock, particularly breccia, agglomerate and flow interbeds; also parts of metamorphic units.

Table 2. Types of mass movement

maps produced during Department studies is based upon field reconnaissance, topographic analysis, consideration of slide mechanics, and aerial photographic analysis. More refined delineation is costlier and requires more detailed field work, larger scale photographs, and larger map scale. Locally, remote sensing, geophysics, and monitoring are sometimes appropriate in highly critical areas.

Planners are concerned with existing landslides and, in addition, with the prevention of future slides. These may be viewed in two categories. Cutbank failures result from improperly engineered cuts and generally can be avoided by adhering to the provisions of the Uniform Building Code. Critical features such as jointing, bedding, clay content, and subsurface flow, however, present special problems. The second category of future slides encompasses slides that will be initiated by natural or artificial means other than cuts including overloading, changes of drainage, and removal of vegetation. Interpretation of slide potential is based primarily on the discussion of slide causes.

The distribution of present mass movement features is easily presented on geologic hazards maps. Further mapping of areas of future mass movement can be accomplished on a regional basis using overlays of slope, critical topographic features, and rock type. More detailed maps of local extent can be generated using detailed plotting of engineering features contributing to sliding in each of the geologic rock units.

Impacts: Impacts of mass movement are variable with the type of mass movement being considered (Figures 1 and 2). Deep bedrock failures (Figure 3) are either active or inactive and have associated with them irregular ground-water and drainage conditions, highly variable foundation strengths and cutbank stabilities, and secondary slides in eroding areas.

Earthflow and slump topography are associated with poor drainage, shallow subsurface flow of ground water, and the possibility of ongoing movement which can destroy man-made structures including roads, homes, and other buildings. In addition, active earthflows leading into streams adversely impact water quality.

Debris flows (Figures 4 and 5) and debris avalanches (Figure 6) generally occur in uninhabited areas and therefore pose their greatest threats to water quality and the forestry resource. Logging roads are particularly subject to damage. Other impacts include loss of topsoil, which in extreme instances also reduces water retention capabilities of regolith. This may contribute to increased storm runoff in places.

Rockfall and rockslide are minor hazards in most areas, but they pose threats to hikers and motorists in more steeply sloping terrain. Rolling rocks in areas of high relief occasionally travel considerable distances beyond the bases of slopes from which they were derived.

Slope erosion

General: Slope erosion is the removal of soil or weathered bed rock by sheet wash (no conspicuous channels), rill erosion (numerous small rivulets), or gully erosion (larger, more permanent channels). It does not include erosion through larger channels between slopes, stream bank erosion, or mass movement, although these are sometimes grouped together in regional analyses of soil loss. Dominant factors controlling slope erosion are land use, land cover, slope, soil type, and rainfall intensity (Figure 7).

Figure 1. Coastal erosion and associated landslides such as these at Cape Blanco threaten several coastal communities (Beaulieu and Hughes, 1976). (Photo courtesy Oregon Highway Division)

Figure 2. Slide at Catching Slough inlet in Coos County during 1974 flood is typical of damage inflicted on Oregon roads by geologic hazards (Beaulieu and Hughes, 1975). (Photo courtesy The World)

Figure 3. Deep bedrock failure near Lolo Pass is similar to Canyonville slide which claimed nine lives in 1974 (Beaulieu, 1974).

Figure 4. Debris flows emanating from steep terrain destroyed part of Union Pacific railway near Mapleton in winter of 1964-1965 (Schlicker and Deacon, 1974). (Photo courtesy Siuslaw News)

Figure 5. Debris flows in Portland are typically small but historically numerous and troublesome (Oregon Department of Geology and Mineral Industries, 1970).

Figure 6. Debris avalanches such as this one in steep terrain along the South Fork of the Coquille River commonly expose bed rock (Beaulieu and Hughes, 1975).

Figure 7. Areas such as this in western Curry County when exposed by mass movement are commonly sites of severe slope erosion (Beaulieu and Hughes, 1976).

Soil erosion is extremely sensitive to slope gradient and moderately sensitive to slope length. The slope intensity factor is greatest in mountainous areas and along steep valley sides. It is least in flat bottomlands.

Soil erodibility varies greatly with land use and soil cover. Where sediment yield rates have been measured, they provide a good general guide to slope erosion but should not be confused with actual soil loss (Wischmeier, 1976). Sediment yield studies do not measure footslope deposition and other local forms of deposition which capture much of the eroded material before it ever reaches the streams being monitored. Actual soil loss is always greater than measured sediment yield.

In California, Knott (1973) demonstrates that the conversion of woodland to intensive agriculture and construction increases sediment yields by 65 to 85 times. Yorke and Davis (1971) record a 90-fold increase in sedimentation during conversion of pastureland to townhouses in a small watershed in Maryland. In the H.J. Andrews Experimental Forest, uncontrolled clear cut logging increased rates of sedimentation 67 times; and Anderson (1971) reports similar results in a similar study in California. Langbein and Schumm (1958) determine that for areas of greater than 40 inches annual effective precipitation, the sediment yield rate under natural vegetation is approximately 200 cubic meters per kilometer per year (about 1,500 tons per square mile). For areas having lower rainfall, the sediment yield is greater because of the decrease in protective cover offered by natural vegetation. These figures apply to land in the natural state; erosion in agricultural or construction areas is much higher.

Soil erosion is also a function of permeability, structure, grain size, and organic content of the soil. For example, soils composed primarily of silt and fine-grained sand are easily eroded. On steeper slopes, very shallow depths to bed rock increase soil erosion because of decreased infiltration and increased runoff.

Methods of study: Many of the diverse factors controlling soil erosion are brought together in the Universal Soil Loss Equation developed by the U.S. Department of Agriculture (1972):

$$A = RKLSCP$$

A refers to annual soil loss in tons per acre, R is the rainfall intensity factor, K is a measure of soil erodibility, LS is a slope intensity factor which considers slope gradient and slope length, C is the land cover and land use factor, and P is a factor of conservation practices. Until very recently, empirical data used in deriving the equation were based entirely on studies of flat to gently sloping agricultural land. Land use figures are now extended to consider nonagricultural uses.

Figures for steeper slopes are extrapolated beyond the range of empirical data and are used only for speculative estimates. In practice, mass movement processes are a greater concern on more steeply sloping terrain. The Universal Soil Loss Equation, however, is appropriate for estimating soil losses for particular parcels of land and gives good results within broad limits for gently sloping terrain (Williams and Berndt, 1972).

Additional techniques for estimating slope erosion potential on a more regional basis are also available. In a manner similar to the analysis of mass movement in Table 2, a series of pertinent overlays can be developed for a region and a series of erosion potential provinces can be defined. These can then be related to existing erosion data and monitor information to produce relative measures of erosion or actual semiquantitative estimates of erosion. Identification of erosion potential provinces also allows the projection of erosion data from one locality to other areas of similar nature. The erosion province method of analysis is appropriate for regional assessments of erosion potential and sedimentation potential in gently to moderately sloping terrain.

Impacts: Severe slope erosion removes valuable topsoil and may form gullies, damage landscapes, and hinder revegetation. Where allowed to continue to extreme conditions, it may also result in more rapid storm runoff.

Soil material carried to streams may adversely impact stream biology and cause greater flooding by raising the stream beds. Although increased turbidity is also an adverse impact of slope erosion, it is largely the result of mass movement and stream bank erosion.

Flooding

Causes: Flooding is caused by large increases in discharge or by natural or man-caused modifications of the channel. The Manning Equation of stream discharge provides a systematic basis for reviewing the causes of stream flooding and for qualitatively predicting impacts of various possible channel modifications:

$$Q = \frac{1.486}{n} AR^{2/3}S^{1/2}$$

Q is discharge (cfs), n is channel roughness, A is cross-sectional area of the channel, R is hydraulic radius (A divided by the wetted perimeter), and S is slope (gradient) of the stream. Flooding is caused by increasing Q or by holding Q constant and modifying factors on the right side of the equation to generate compensating increases in depth.

Natural flooding is caused by heavy orographic rainfall, rapid snowmelt, low infiltration rates, steep slopes, and steep gradients. Most floods on local streams crest shortly after peak precipitation; floods on larger streams show greater delay. An additional potential cause of flooding is the impoundment and sudden release of waters behind landslide dams.

Land use can influence local flooding by altering surface water residence times and infiltration rates. Urbanization greatly increases peak flow and total runoff (Seaburn, 1969; Knott, 1973). In logging areas, road construction decreases regional infiltration and intercepts shallow subsurface flow to produce increases in peak flow (Harr and others, 1975). A variety of modeling procedures are available for predicting runoff in areas of changing land use and should be incorporated into storm sewer design.

The impact of logging on stream flooding varies with type of tree, soil, and climate but appears to be minimal in most instances. In the Alsea drainage (Harris, 1977) and the H.J. Andrews Experimental Forest (Rothacher, 1970), no increase in peak flows with logging is noted. Changes in channel geometry and the manner of flood water conveyance through lowlands outside logged watersheds has been little investigated.

A beneficial impact of logging in many areas is increased summer streamflow when the need is greatest. Removal of conifers under ideal conditions of soil thickness and climate reduced summer evapotranspiration by approximately 18 inches in the H.J. Andrews Experimental Forest (Rothacher, 1970). As a result, summer streamflow after logging increased 30 percent (Moore, 1966). In regions of drier climate, thinner soils, and less uniform original conifer cover, the beneficial impact is less dramatic. In the Ochoco Mountains, for example, evapotranspiration was reduced by 2 inches and resulted in slightly increased stream flow (Berndt and Swank, 1970).

If discharge Q is held constant, flooding may be caused by modifications of the cross-sectional area A or slope S. Thus, artificial fill, other artificial obstructions (roads, bridges, structures), gravel and silt deposits, and natural channel obstructions such as log jams may contribute to flood potential. The Flood Insurance Act of 1968, administered by the U.S. Department of Housing and Urban Development, and Goal 7 of the Land Conservation and Development Commission regulate obstructions in the floodway. Placing of fill in channels is regulated by the U.S. Army Corps of Engineers and the Division of State Lands.

Slope S is influenced by aggradation and channel modifications. If slope is decreased, cross-sectional area (and therefore, depth) must be increased accordingly to accommodate a given discharge.

Impacts of channel modifications for the purposes of flood control, aggregate removal, or erosion control depend on the specific conditions at a given site. Thus, channel restrictions in some parts of a stream may aggravate flooding whereas constrictions elsewhere may have no significant impact on flooding. Likewise, channel modifications may be justified to minimize flooding or stream bank erosion elsewhere.

Stream erosion and deposition

General: Much planning and designing of channel modifications emphasize the water aspects of the total stream system. Equally important, but often neglected, are sediment load and a variety of transient stream parameters including width, depth, channel roughness, and channel layout. Changes in any one of these leads to changes in one or more of the others.

Larger particles in stream beds, including boulders, pebbles, and coarse sand grains that are moved by rolling, sliding, and bouncing, constitute the bed load. The capacity of a stream to transport bed load is determined by channel geometry, volume of discharge, and velocity. Smaller particles, including fine sand, silt, and clay, generally are transported in suspension. The volume of suspended load is controlled primarily by runoff and slope erosion. This aspect of sediment transport is particularly significant in terms of water quality management. Medium-grained sand can be carried in suspension under extreme conditions of velocity and turbulence.

Torrential flood channels: Torrential flood channels are most prevalent in mountainous terrain, where slopes are characteristically steep and infiltration rates are low. Areas of recent torrential flooding are easily recognized on the basis of scoured, unvegetated creek bottoms and coarse, poorly sorted stream bed deposits. Where vegetation has reclaimed the channel, recognition is based upon indirect features including steep side slopes, steep gradients, impermeable bed rock, narrow stream channels, and the absence of a flood plain. Torrential flood channels pass downstream into topographically more mature channels with flood plains.

Because torrential flood channels are generally cut in bed rock, they are unable to adjust to rapid changes in discharge by channel modification. Instead, depth and velocity increase sharply during times of high flow. Consequently, torrential floods are highly erosive and commonly destroy artificial obstructions in the channel such as bridge abutments and road fill. Where torrential flood channels spill into flat terrain, rubble and debris fans may quickly bury roads or clog culverts (Figure 8).

Concentrations of suspended sediment during torrential floods are commonly high. Under extreme conditions of slope erosion and rainfall, torrential stream channels may transport flowing mud and debris rather than water (Beverage and Culbertson, 1964).

Lowland flood channels: Gentler gradients, broader valleys, and the greater capacity to modify channel geometry in response to rapidly fluctuating discharge are characteristics which distinguish flood plain stream channels from torrential flood channels (Figure 9). Short-term variations in depth and velocity are less extreme in these channels, but long-term changes in width, depth, and layout are more variable in response to slope, discharge, and bed load. Stream meandering (flow along a curved sinuous channel) and stream braiding (flow along several channels) in flood plains are subjects of considerable research but still are incompletely understood.

Erosion in flood plains is restricted primarily to channels, outer bends of meanders, and cutoff channels that develop during times of flooding. Stream deposition includes not only the deposition of silt and clay from relatively slow moving overbank flood waters but also the formation of bars in channels, on the inner bends of meanders, and behind obstruc-

Figure 8. Torrential flood channels are characterized by channel scour in high gradient segments and rapid deposition at foot of mountainous areas in western Curry County (Beaulieu and Hughes, 1976).

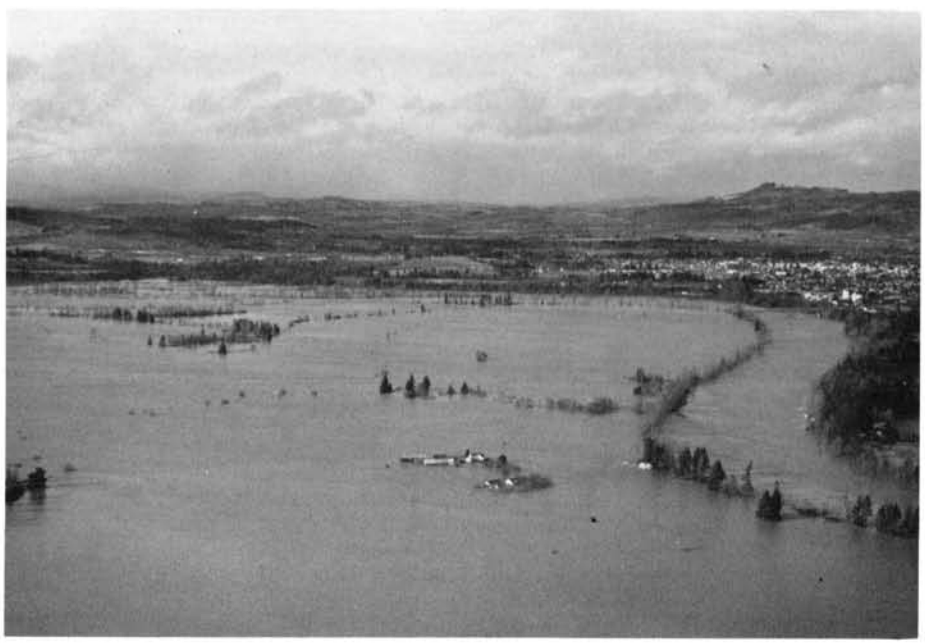

Figure 9. Lowland flooding of Willamette River is typical of floods that inflict $20 million losses annually in Oregon (Oregon Department of Geology and Mineral Industries, 1970).

tions such as snags. Stream erosion and deposition operate in harmony to modify the stream channel. Sediment supplied by stream bank erosion is deposited as bars farther downstream. Bars, in turn, redirect streamflow against river banks downstream to cause additional stream bank erosion.

Conclusion

Regional investigations of surficial geologic hazards have been conducted by the Department in Tillamook, Clatsop, Lincoln, Coos, Douglas, Curry, Jackson, Hood River, Wasco, Sherman, Linn, Marion, and Washington Counties. Selection of concepts used in the successive investigations has been a balanced consideration of (1) the need for technical accuracy, (2) the need of information useful for a wide variety of persons, and (3) the fundamental place of geology in the geologic hazards of Oregon. In future projects the Department will continue to draw upon the experience of others and produce documents useful to a wide spectrum of persons and agencies in need of geologic hazard information.

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(Bibliographies of publications related to environmental geology will be found in Department Bulletins 79, 81, 82, 84, 85, 87, 90, 91, 93, and 94. Complete titles of these bulletins are listed on the inside back cover of this Ore Bin, and the bulletins are available at the Department's Portland, Grants Pass, and Baker offices.)

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CORRECTION

In the article "Oil and Gas Exploration in 1977" (ORE BIN, January 1978) page 19, paragraph two, line 11, which reads "60 MCF/D (1,000 cu ft/day)", should instead read "60 MCF/D (60,000 cu ft/day)".

* * * * *

ENGINEERING GEOLOGY SYMPOSIUM TO BE HELD AT PSU

A symposium "The Practice of Engineering Geology in Oregon - Techniques and Legalities" will be held March 18, Earth Science Department, Cramer Hall, Portland State University, Portland. The symposium, sponsored by the Oregon section of the Association of Engineering Geologists and co-sponsored by the Oregon Department of Geology and Mineral Industries and Portland State University, will focus on current techniques and practices of engineering geology in Oregon, the position of engineering geology within the framework of land use planning requirements, and registration of geologists and engineering geologists.

Cost of registration is $26 and includes registration, luncheon, and symposium papers in published form. Student registration is $10 (not including luncheon). Preregistration prior to March 11, 1978, is $22. For more information or preregistration contact Rick Kent, AEG, 19443 Wilderness Drive, West Linn, Oregon 97068.

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THE GOLDEN YEARS OF EASTERN OREGON *

By Miles F. Potter and Harold McCall

*Reprinted by popular request from the June 1968 ORE BIN

This pictorial article is an abstract of the authors' book, "Oregon's Golden Years," published by Caxton Publishing Company, Caldwell, Idaho, in 1976. The book is already in its third printing.

The article and accompanying pictures remind us of a commonly forgotten fact: The discovery of gold in eastern Oregon had a tremendous impact on the economy and development of the entire region, and this impact is still being felt more than a century later.

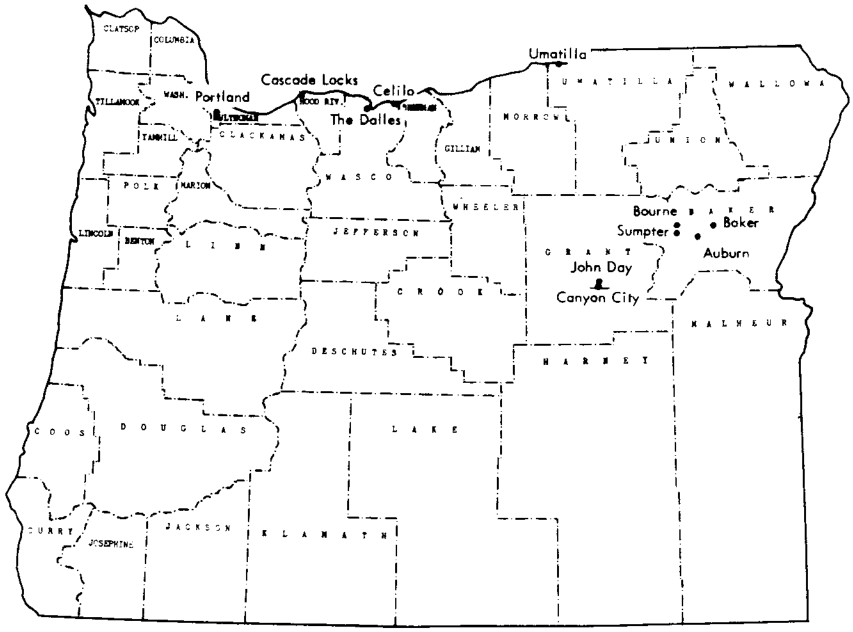
Gold mining was also the mainstay of southwestern Oregon's early economy and played an equally significant role in the development of that area.

Mr. Potter is a long-time resident of eastern Oregon and an amateur historian of some of the early gold camps in Grant and Baker Counties. Mr. McCall, a photographer in Oregon City, has a keen interest in the history of gold mining. The two worked together for a number of years to assemble photographs and data from many sources for their book.

Prior to the start of the Civil War in 1861, the early pioneer wagon trains which traversed the Oregon Country east of The Dalles did not tarry. Instead, they rolled ever westward through eastern Oregon's vast wilderness over the dusty ribbon of the Oregon Trail to the comparative safety and more alluring market area of the Willamette Valley. Contributing to this westward push was a military order by General Wool discouraging settlement in the eastern area by immigrants, or "whites," other than Hudson Bay men and miners [provided that the miners did not molest the Indians and their squaws].

The story of the early settlement of eastern Oregon owes its existence to a particular wagon train known today as the "lost wagon train of 1845" -- so named because its members took an ill-advised short cut through east-central Oregon and lost their way during the process. While they were hunting for the short cut they made a reported discovery of gold somewhere along their route -- a report that resulted quickly in the legend of the Blue Bucket mine.

This legend of the Blue Bucket mine is the reason a party of miners was



Index map of Oregon, showing transportation points along the Columbia River and gold-mining centers in Baker and Grant Counties

in eastern Oregon 16 years later when the Civil War was in progress. The miners had set out to look for the Blue Bucket, but ended up making a demonstrable discovery of gold in their own right. The place: Griffin Gulch, in what is now Baker County. The date: October 1861.

Display of the Griffin Gulch gold in Portland under a large banner saying "The First Gold Discovered in Eastern Oregon" gave rise to a cry that spread like fire in a strong wind. Another discovery of gold on Canyon Creek, in what is now Grant County, in 1862 and an almost simultaneous discovery of the yellow metal near Lewiston, Idaho, started a stampede of thousands of prospectors, miners, merchants, gamblers, and camp followers. Also in the same year, 1862, Congress passed the Homestead Act. Thus many farmers joined the rush, knowing that the mining industries would furnish a market for their products.

During the years immediately following the Griffin Gulch discovery, and indeed for a period of several decades thereafter, gold mining served to stimulate settlement and the establishment of a diversity of related business activities. For instance, even in 1862 steamers out of San Francisco heading north for Portland were sold out weeks ahead of time, and on one trip in that year the steamer "Brother Jonathan" landed more than a thousand people on the docks in Portland. Other shipping records show that 24,500 persons traveled up the Columbia River by boat in 1862. Another 22,000

About 800 people lived in Portland when this picture of Front Street was taken in 1852. Ten years later, when the gold stampede got under way, the population was around 2900, yet during the opening 3-year period of the gold rush it is estimated that 82,000 people passed through Portland en route to the gold fields in eastern Oregon and Idaho. (Oregon Historical Society photograph)

The portage at the Cascades in 1861 (now known as Cascade Locks) was 6 miles long. When steamers from Portland unloaded their up-river freight at the Cascades for transport over the portage during the gold rush, the mule-drawn flat cars were so slow that freight sometimes piled up for days before it could be loaded onto steamers above the rapids for transfer to The Dalles. (Oregon Historical Society photograph) made the passage in 1863 and 36,000 more did so in 1864 -- all following the rainbow to the pot of gold.

The river boats belonged to the Oregon Steam Navigation Co. and operated originally between Portland and The Dalles, with a portage around the Cascade Rapids. Horse-drawn drays in Portland at times waited for 24 hours with baggage and supplies to be loaded on the up-river steamers, and so great was the traffic at Cascade Rapids that the portage was frequently blocked for days. In fact, steamer records show that 46,000 head of cattle were shipped up river along with additional thousands of horses, mules, hogs, and sheep during the first eight months of 1862.

At the outset, and with no competition, transportation costs on the river to The Dalles varied between $40 and $50 per ton. The passenger fare was $20 with meals extra. The freight on a dozen brooms was a dollar and it was not until 1869, when a trail was opened through the Gorge for cattle and pack trains, that rates were greatly reduced.

The Dalles was the original jumping-off place and the outfitting headquarters for all of what became known as the eastern Oregon gold belt -- an area that is today recognized as extending in a northeasterly direction from the vicinity of Canyon City on the west to the Snake River on the east. The Dalles also served as the "last stop" for the mining camps in Idaho. Nearly every group of men had to outfit there; and $150 was the accepted price for a good mule during at least some of the period. Block-Miller & Co. became for a time the largest general merchandise store in the state and also the leading buyer of gold, averaging $50,000 a month in purchases between 1861 and 1863.

People and supplies heading out from The Dalles to the Oregon gold fields followed one of two routes: either the military road or the Oregon Trail. Those headed for Upper Town (now Canyon City) and for Lower Town (now John Day) moved over the old military trail. In 1862 this was merely a blazed line over much of the route. However, by 1864 it became a road of sorts with a regular stage schedule and relay stops along the way over a distance of 177 miles. The stage trip was made in the fast time of 39 hours. Freight charges averaged around 55 cents a pound. The charge for the first few shipments of gold carried by pack train was equal to 3 percent of the weight of the shipment; that is, 3 ounces of gold for every hundred shipped.

The Oregon Trail served as the route from The Dalles to the gold mines in the Auburn area. By 1863 Wells-Fargo was operating along this route as well as out of Canyon City. However, during 1863 a 15-mile portage road was built around Celilo Falls, after which another group of boats was put in service to ply the upper waters of the Columbia and Snake Rivers as far as Lewiston, Idaho. Thus, in 1863, Umatilla Landing became the port for shipments to the Auburn area, shortening the distance overland from The Dalles to around 150 miles. Gillette (1904) reported that on just one trip up river from Celilo to Lewiston the steamer "Tenino" took in $18,000 from passengers, freight, meals, and berths. By 1865 there were 14 steamers

This small engine, on display at the Union Station in Portland, was named "The Pony." It was built in San Francisco, then shipped to the Cascades in 1862 to help speed up the traffic over the portage. The rails were made of wood covered with strap iron. This was Oregon's first railroad. (Oregon Historical Society photograph)

The Dalles was the jumping-off place and last outfitting headquarters for the gold-seekers heading east, and the "Harvest Queen" pictured here was one of several boats plying the river between the Cascade portage and The Dalles. The famous Umatilla House is in the background. More money reportedly passed over its bar during this period than over any other bar in Oregon. Block Miller & Co., general hardware merchants, are said to have purchased an average of $50,000 in gold each month over a period of 3 years. (Oregon Historical Society photograph) operating up river from Celilo Falls and between there and Lewiston, Idaho, the traffic reportedly became so great that the boats paid for themselves in a few months.

Not all traffic flowed eastward during the 1860's. Instead, the surface and placer mining was funneling millions of dollars in gold westward over the trails to The Dalles and thence down river by boat to Portland and from there to San Francisco by either ocean steamer or overland express. Lindgren (1901, p. 717) estimated that Canyon Creek in Grant County produced between three to five million dollars a year up to 1865. Following this there was a gradual decline, as the richest of the easiest-to-mine placers became worked out. Even so, Raymond (1870, p. 224) estimated that production in 1865 averaged around $22,000 a week, or more than one million dollars per year.

The flow of gold from the Auburn area presumably moved at a similar rate as that from Canyon City. In any event, the river steamer "Julia" carried $100,000 worth of gold dust down river to Portland on April 28, 1862, and the "Carrie Ladd" followed with a $175,000 shipment on May 20 and another worth $200,000 on June 25.

As for ocean-going steamers, other records show the "Tenino," another vessel with the same name as the river boat mentioned earlier, carried a $200,000 gold shipment from Portland to San Francisco August 5, 1862. On October 27 of the same year the "Sierra Nevada" carried a half-million dollar shipment. During 1863, on three trips the "Sierra Nevada" transported an additional total of slightly more than $931,000 worth of dust. The "Brother Jonathan," also on three trips, conveyed in excess of one million and on one trip, December 4, the "Oregon" is credited with a shipment valued at $750,000. During 1864, these same steamers, plus the "John L. Stephens" and the "Pacific," carried gold cargoes totaling somewhat over $3,100,000 in value, and it is to be borne in mind that these records are without doubt quite incomplete. The reader should also remember that these values represent the old $20.67 price for gold which prevailed at the time, and not the present $35 per ounce price.

Some gold, of course, traveled by overland stages to San Francisco; available records for shipments of bullion from Portland by way of Wells Fargo Express are as follows:

For 1864	$6,200,000
For 1865	$5,800,000
For 1866	$5,400,000
For 1867	$4,001,000

All told, from 1861 to 1867 the Northwest produced $140,000,000 in gold, while during the same period California produced $210,000,000, according to figures cited in "The History of Oregon" by Harvey Scott. This production went a long way towards bolstering the economy of our government during the Civil War.

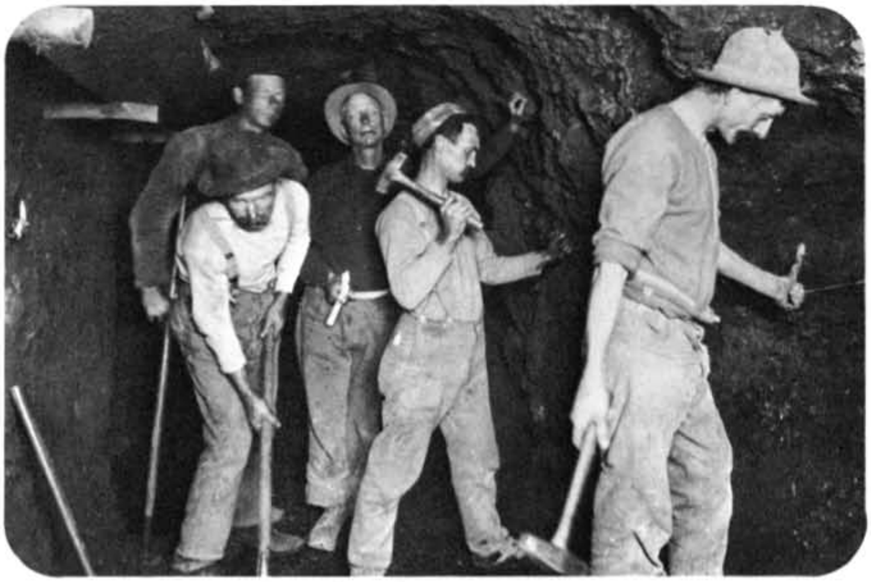
(Text continued on page 70)

The difficulties of the portage above The Dalles and past Celilo Falls were lessened by the construction in 1863 of the 15-mile narrow-gauge "portage" railroad. Built on the Oregon side of the Columbia River at a reported cost of $50,000 per mile and in service until the 1880's, this railroad constituted an important link between the river boats plying the Columbia between Cascade Locks and The Dalles and those plying the up-river run from Celilo to Umatilla Landing and Lewiston. (Oregon Historical Society photograph)

The river steamer "Tenino," on the upper Columbia. With stops at Umatilla Landing, Wallula, and Lewiston, this vessel is credited with having taken in $18,000 on one up-river trip in 1863. (Oregon Historical Society photograph)

Baker City as it appeared around 1867, or about one year after it became the county seat of Baker County. The large, unpainted building in the foreground served as the Court House and the repository of the county records removed from Auburn. With Auburn on the decline, Baker went on to become the Queen City in the eastern Oregon gold belt and the center for all heavy mining equipment. It even boasted a Chinatown population of more than 400 with its own stores and joss house before the end of the century. (Oregon Historical Society photograph No. 92)

Bourne, once known as Cracker City, is situated 6 miles north of Sumpter on Cracker Creek and is surrounded by some of the best mining property in the state -- the North Pole, E & E, Columbia, Golconda, and many other noted lode properties. Founded in 1890, Bourne soon had a population of 1500, with 2 hotels, 4 saloons, 7 general stores, 2 newspapers, 3 restaurants. Today there are only a few summer cabins and some buildings at the E & E mine. New exploration work has been under way in the area for several years; however, this, together with increasing world-wide pressure for a raise in the price of gold, may give the old town a new lease on life.

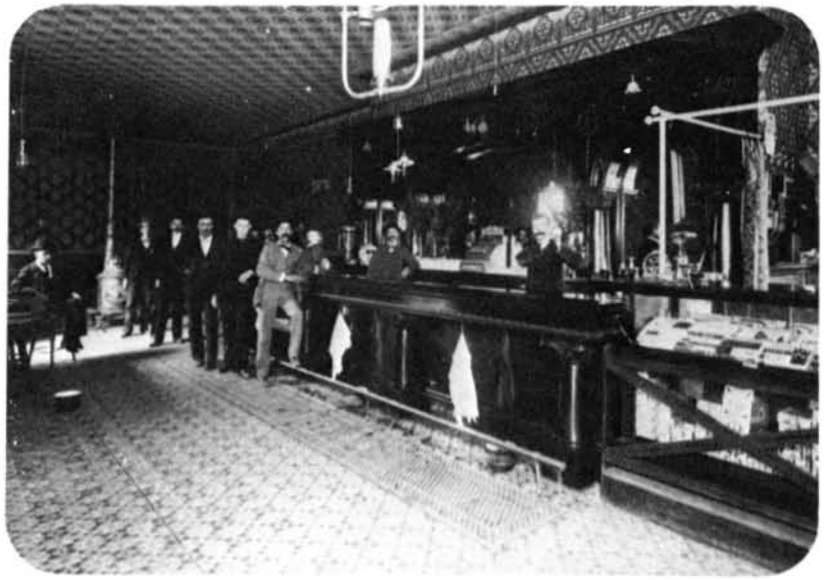


Miners and muckers at the Bonanza mine, 1894. Note use of wax candles and "single jacks" -- 4-pound hammers used with hand-held drill steel. Discovered in 1877 by Jack Haggard, the mine was sold for $350 in 1879 to the Bonanza Mining Co. In 1892 it was purchased by the Geiser Brothers, who took out about $400,000 before selling it to the Pittsburg Mining Co. for $500,000. The mine was eventually worked to a depth of 1200 feet with a production estimated at approximately 1-3/4 million dollars at the old $20.67 per ounce price of gold. Geiser, a town located at the mine, boasted a post office between July 15, 1898 and June 15, 1909.

The old Potosi cabin near Windy Gap in the Greenhorn Mountains, one of the oldest mines in the Greenhorns. Nearby mines included the Ben Harrison, Morris, and the Bi-metallic. Picture taken in July, 1917. Notice snow in background and snow-broken shakes along eaves. Cabin is at an elevation of 7000 feet above sea level.

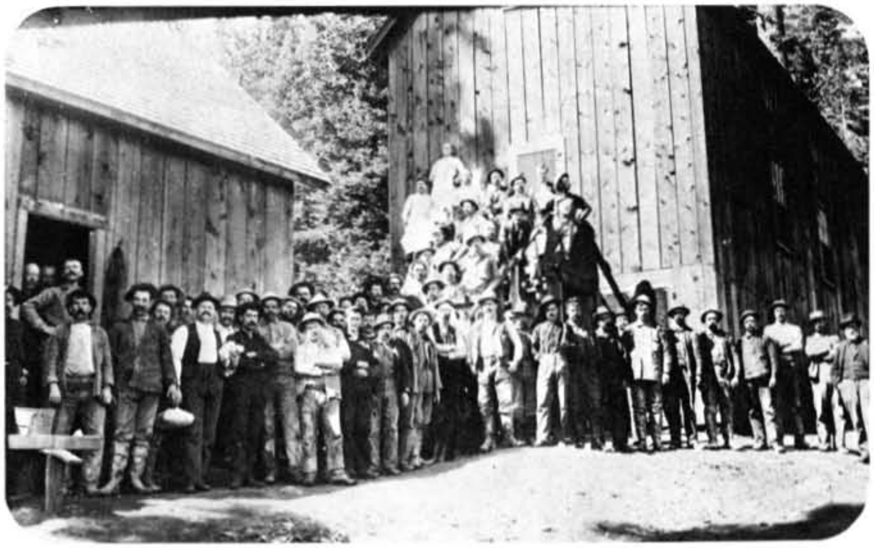
The small, but rich, Great Northern mine, "on the north side of Canyon Mountain" near Canyon City in Grant County, was discovered by Ike Guker, standing in the center. Man on right, standing on bank, is Frank McBean, old-time stage driver to Winnemucca. It is known that Guker let visitors pick nuggets and keep them. There was $65,000 taken from this little hole. The mine was discovered as late as 1897.

The narrow-gauge Sumpter Valley Railroad's Tipton station, located between Whitney and Austin, was an ore-shipping station for the mines around the town of Greenhorn during the fore part of the present century. The child in the picture is Dick Nokes, now assistant managing editor of the Oregonian.



The bar in the Gem Saloon in Sumpter -- a swanky establishment which featured a "lady orchestra" during the opening decade of the present century. When narrow-gauge rail service came in 1895, Sumpter was only a small mining camp. By 1904, however, the population reached 3500 with a payroll from the surrounding mines supporting two banks, 20 saloons, and the usual contingent of good managers, miners, and loggers along with the inevitable red-light district and its following of gamblers, shyster promoters and other fast-buck characters -- all looking for the "fickle goddess of fortune."

Saloons were not the only impressive establishments in the mining towns at the turn of the century. As the rich placer deposits became depleted, improved mining techniques made the source quartz lodes increasingly attractive targets for development; hence, wealthy investors and mining engineers came to the gold fields from all over the world. Their offices, often adorned with the latest of furnishings, were the headquarters for many planning sessions of far-reaching consequence.



The Cornucopia mine, located 10 miles northwest of Halfway in Baker County, was for a time one of the six largest gold mines in the United States. It also had the longest continuous run of any mine in Oregon. There were 36 miles of tunnels and a depth of 3000 feet. The estimated output is $18,000,000 in combined gold, silver, copper, and lead. About 300 men were employed during its heyday of operation in the late 1930's. This picture obviously was taken earlier, if mustaches and bowlers are any criterion.

The dining room at the Cornucopia mine, sometime after 1922, when the company installed its generating plant. This mine was in operation about 50 years, and before the 8-hour day went into effect the men worked 10 hours a day, 7 days a week. Just think of the food that was served over these tables!

↑Site of the old town of Auburn, located in Baker County south of Griffin Gulch. Nothing remains of Auburn today except fragments of old foundations. The June 1940 issue of "Oregon Mining Review" states that within 6 months after its creation the town had 700 cabins, many tents, and stores, hotels, and gambling houses. Between May and August of 1872, about 1700 mining claims were recorded in the vicinity. A post office was established Nov. 1, 1862. During that year Auburn became the seat of Baker County. If the report is true that Auburn had close to 6000 inhabitants in 1862-1863, it was for a time the largest town in Oregon.

↑Henry Griffin, the man who started it all by discovering gold in Griffin Gulch in 1861, ended up buried in a cemetery located near Auburn, with his name misspelled on his headstone. (Oregon Historical Society photograph)

That gold mining remained an exceedingly important factor in our local economy for many decades is well known. What seems to be too often overlooked, however, is the part this mining played in the settlement of all of the country east of the Cascades. For instance, it was not until the year 1865 that Portland's population reached 6000 persons -- about the reported size of Auburn in the winters of 1862 and 1863. Had it not been for the market the mines created, the settlement of eastern Oregon would undoubtedly have occurred at a far slower rate.

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U.S. DOUBLES EARTHQUAKE RESEARCH

Earthquake research by the USGS will more than double this year. Direct appropriations for research on the reduction of earthquake hazards total $30 million for Fiscal Year 1978, an increase of $18 million over Fiscal Year 1977.

The expanded program, aimed at mitigation of potential earthquake losses, is focused on the development of capability to predict earthquakes, evaluation of the potential of large reservoirs to trigger earthquake activity, and evaluation of earthquake hazards and risks in earthquake-prone regions.

Robert M. Hamilton, chief, Office of Earthquake Studies, USGS National Center, Reston, Va., says that the increase in the earthquake research budget reflects heightened concern over the potentially disastrous consequences of future major earthquakes in the United States. "Areas such as the Pacific Coast, Alaska, and the Mississippi and St. Lawrence river valleys that have experienced destructive earthquakes in the past will experience more in the future. Moreover, the increased development and growth in these areas have increased greatly the potential for future injury and destruction," Hamilton explains.

The Earthquake Hazards Reduction Act of 1977, which recognizes the major roles to be undertaken by the U.S. Geological Survey and the National Science Foundation, directs the establishment of a National Earthquake Hazards Reduction Program and authorizes direct appropriation to the two agencies. The Act also provides for the development of an implementation plan to provide for the optimum use of the research results through land use planning, design criteria, building specifications and standards, evaluations of scientific predictions, and warnings to residents.

The combination of research elements by the USGS and the National Science Foundation to provide for balance in the rapid expansion of the earthquake program is based, in large part, on a comprehensive study by an advisory group organized by the Science Advisor to the President.

Among highlights of the expanded earthquake program are:

- A major resurvey by spirit leveling of the southern California uplift area, the so-called "Palmdale Bulge," is being conducted by crews from federal, state, and local agencies, with leveling being coordinated by the National Geodetic Survey, National Oceanic and Atmospheric Administration.

- Hazards evaluation, including seismological studies of both regional and local earthquake activity, and geologic investigations of faults, recent deformations of the earth's crust, landslides, and other forms of ground failure caused by earthquakes, will be focused on eight major regions, each containing one or more urbanized areas and having an identified seismic risk.

- Major investigations to evaluate hazards in central and southern California are being expanded, and hazard evaluation efforts are being augmented in the Puget Sound, Ogden-Salt Lake City-Provo, and southern coastal Alaska regions.
- Somewhat over half the hazard evaluation effort is being concentrated in the western U.S.; but new or expanded earthquake studies are underway in major regions of the eastern U.S., where earthquakes of the 18th and 19th centuries could cause widespread destruction if they were to occur today.
- Topical studies aimed at developing the capability to make reliable predictions of the time, place, and magnitude of future earthquakes will continue to focus on the seismically active parts of central and southern California.

Copies of "Earthquake Prediction and Hazard Mitigation: Options for USGS and NSF Programs; September 15, 1976," are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for $1.90 each.

* * * * *

PET ROCK LOSES LIFE

The Pet Rock belonging to Charles H. Hunt, Medford, Oregon, was killed in an accident March 7. Hunt had mailed Pet Rock to the Department for a pedigree, but as no note was found with the rock, it was assumed that a routine mineral identification, which required crushing of the sample, was to be conducted. Pet Rock was crushed, thereby losing his life. Portland Police do not plan to file charges.

Pet Rock, a native of Alaska, was well rounded as a result of his extensive travels. Friends, viewing his body as it lay in state, said that his only real defect was a minor vein of calcite and that although his surface was tarnished he had a heart of (fool's) gold. Pet Rock left a large number of sons and daughters as he passed from life.

Hunt, informed of the tragedy by phone, took the news well. Burial took place immediately after the phone call.

* * * * *

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1978

PACIFIC NORTHWEST METALS & MINERALS CONFERENCE

New Horizons In Metals and Minerals

MAY 15-17, 1978
HILTON CONVENTION CENTER
921 S.W. Sixth Avenue
Portland, Oregon

SUNDAY — MAY 14

Registration — Broadway Lobby — 5:00 - 8:00 p.m.

MONDAY MORNING — MAY 15 9:00 a.m.

"BENEFICATION AND PROCESSING OF PHOSPHATES"

A. R. Rule, Chairman

"Dry Beneficiation of Western Phosphates." F. Hamill, Alumet Co., Soda Springs, ID

"Phosphoria Leaching Mechanisms, Useful for Planning By-Product Recovery." J. Clements, K. Prisbrey, O. Wick, and J. Hartley, Univ. of Idaho, Moscow, ID

"Flotation of Carbonate and Silicate Minerals From Partially Altered Rock." D. C. Dahlin, A. Rule, and A. J. Fergus, Bureau of Mines, Albany, OR

"Absorption of Depressants in the Collophane Calcite System." M. C. Fuerstenau, South Dakota School of Mines, Rapid City, SD

"RARE METALS"

G. J. Dooley and M. B. Siddall, Chairmen

"Substitution of Titanium for Other Materials in Corrosive Environments." J. M. York and G. J. Dooley, Oregon Metallurgical Corp., Albany, OR

"Perturbed Gamma-Ray Correlations — Applications to Hf-Zr Submicroscopic Structure." R. Rasera, Oregon State Univ., Physics Dept., Corvallis, OR

"Application of Surface Techniques to Anodizing in Ti and Al Alloys." J. T. Grant, Univ. Energy Sys., Inc., Medway, OH, and T. W. Haas, AFML, Wright-Patterson, OH

"METALS: RECENT DEVELOPMENTS"

R. Blickensderfer, Chairman

"Stainless Steel — A Multifaceted Material." D. C. Perry, Armco Steel Corp., Middletown, OH

"High Yield Steels." D. C. Little and P. M. Machmeier, General Dynamics, Fort Worth, TX

"Metals Substitution — A Review of the ASM-OTA Meeting." K. J. Sharma, SRI International, Menlo Park, CA

"Hydrogen Embrittlement." N. S. Stoloff, Rensselaer Polytechnic Institute, Troy, NY

WELCOMING LUNCH — 12:00 p.m.

Keynote Speaker — Dr. Tom Falkie, Vice President, Berwind Corp., Philadelphia, PA

MONDAY AFTERNOON — 2:00 p.m.

"NEW DEVELOPMENTS IN EXTRACTIVE METALLURGY"

R. E. Siemens, Chairman

"The Selective Reduction of Nickeliferous Ores In An Electric Furnace." D. Halter and M. A. Warnert, Hanna Nickel Smelting Co., Riddle, OR

"Solvent Extraction of Cobalt From Ammoniacal Laterite Leach Liquors." D. N. Nilsen, R. E. Siemens, S. C. Rhoads, Bureau of Mines, Albany, OR

"Coupled Transport Membranes for Metal Separation." R. W. Baker, W. C. Babcock, H. K. Lonsdale, and D. J. Kelly, Bend Research Inc., Bend, OR

"The Removal of Iron From Aluminum Chloride Leach Liquor by Solvent Extraction." R. T. Sorenson, Bureau of Mines, Boulder City, NV

"Application of Pressure Hydrometallurgy for Metal Production." M. Cantle, Sherritt Gordon Mines, Canada

"Problems Associated With Low-Level Naturally Occuring Radionuclides in Mineral Processing." D. Voit, Teledyne, Wah Chang, Albany, OR

"METALS: RECENT DEVELOPMENTS"

K. Mensah, Chairman

"Materials for High Energy Applications." R. M. Horn, Univ. of California, Berkeley, CA

"Materials Problems of Sulfidization." M. S. Bhat, Univ. of California, Berkeley, CA

"Coatings for High Energy Applications." G. Lea, Gulf Gen. Atomic, San Diego, CA

"GOLD TECHNICAL SESSION"

J. M. West, Chairman

"Enhancing Percolation Rates in Heap Leaching of Gold and Silver Ores." H. J. Heinen, R. E. Lindstrom, and G. McClelland, Bureau of Mines, Reno, NV

"Heap Leaching of Gold at Round Mountain, NV." R. Leone, Smoky Valley Mining Co.

"Gold Operations at the Atlanta Mine, Nevada." P. Hulse, Standard Slag Corp., Reno, NV

"Geology and Gold Operations at the New York Cougar, Independence Mines, Eastern Oregon." J. Young, W. Bowes & Assoc., Steamboat Springs, CO

MONDAY EVENING — 5:00 - 7:00 p.m.

A complimentary beer party with snacks will be held in the industrial exhibit area.

TUESDAY MORNING — MAY 16 — 8:30 a.m.

"GOLD AND MONEY"

V. C. Newton and W. Zwick, Chairmen

Russell Wallace (Session Moderator) Vice President, Homestake Mining Company, San Francisco, CA

"History's Greatest Flight From Paper Money to Gold." J. Exeter, Consultant on International and Domestic Money, Mountain Lakes, NJ

"Challenges Facing American Investors Interested in Gold Shares." J. McFalls, Value-Action Advisory Service, Gold Investment Consultant, Seattle, WA

"Predominance of Credit in the Present Monetary World." P. Simpson, Professor of Economics, University of Oregon, Eugene, OR

"Gold Investments, South Africa." F. J. Rahn, General Mining & Finance Corp., Ltd., Johannasburg, South Africa

(Title to be Announced) — Office of the Assistant Secretary for International Affairs, U. S. Treasury, Washington, D.C.

"NEW WELDING HORIZONS"

D. Wold, Chairman

"Weldability and Sound Welding Decisions." F. Gatto, Puget Sound Naval Shipyard, Bremerton, WA

"Design for Reliability in Welded Structures." G. Teeter, State of Oregon, Bridge Dept. Salem, OR

"Fabrication for Reliability in Welded Structures." L. Thompson, Northwest Scientific, Portland, OR

"Clean Steels for Construction." J. L. Fox, Lukens Steel Co., Burlingame, CA

"GEOTHERMAL"

E. Zais, Chairman

"Cost, Benefit and Risk of Geothermal Energy." A. Grant, Portland General Electric.

"The Mount Hood-Portland Geothermal Project." J. Hook, Consulting Geologist, Salem, OR

"Non-Electric Applications of Geothermal Energy in Klamath Falls, Oregon." J. Lund, Oregon Institute of Technology.

"Exploration for Geothermal Energy in the Pacific Northwest." W. Dolan, Chief Geophysicist and Manager of Geothermal, AMAX Eploration, Denver, CO

"Raft River Geothermal Project and Geothermal Project and Geothermal Applications in Boise, ID" (Speaker to be announced) Idaho National Engineering Laboratory

TUESDAY NOON — 12:00 p.m.

GOLD AND MONEY LUNCH

(Speaker to be announced)

TUESDAY AFTERNOON — 2:00 p.m.

"GEOLOGY OF THE NORTHWEST"

Mr. & Mrs. R. C. Kent, Chairpersons

"Quartsville Mining District." S. Muntz, COMINCO, Inc., Spokane, WA

"Basalt Geology of Eastern Oregon." S. Farooqui, Shannon and Wilson, Inc., Portland, OR

"Geology of Southern Washington Cascades." P. Hammond, Portland State Univ., Portland, OR

Also included:—

A PANEL ON COAL GEOLOGY OF THE NORTHWEST

TUESDAY AFTERNOON — 2:00 p.m.

POSTER SESSION

C. B. Daellenbach, Chairman

"Minerals Needed to Fuel Alternative Energy Resources." R. Tallman, Bonneville Power Admin. Portland, OR

"Investigation in the Chloride Metallurgy of Copper." S. El-Rahaiby, W. Taylor, and Y. Rao, Univ. of Washington, Seattle, WA

"Synthetic Fluorspar from Fluosilicic Acid." S. Bullard, R. Olsen, and W. Gruzensky, Bureau of Mines, Albany, OR

"Advancement in Die Forming for Saw Chain Cutters." A. Hille and J. DeHaven, Omark Industries, Portland, OR

"Cadmium Behavior During Oxidation of Zinc Sulfide Concentrate." H. Leavenworth and D. Yee, Bureau of Mines, Albany, OR

"Fixation of Arsenic-Bearing Flue Dusts." A. Mehta and L. Twidwell, Montana College of Mineral Science and Technology, Butte, MT

"Zeta Potential Studies of Idaho Phosphoria Phosphate." P. Wikoff and K. Prisbrey, Univ. of Idaho, Moscow, ID

"Volatilization of Arsenic During Roasting of Copper Ores." A. Landsberg and J. Mauser, Bureau of Mines, Albany, OR

"Rubber Tired Equipment in Underground Mining." S. Countryman, Wagner Mining Equipment Co., Portland, OR

"NEW WELDING HORIZONS"

W. E. Wood, Chairman

"Investigations of Welding Problems." R. L. Ray, Consulting Metallurgical Engr., Oakland, CA

"Let's Help Each Other." (Discussion on Filler Metal Testing & Purchasing Specifications), Harry Reid, Teledyne McKay Co., York, PA

"Applied Advantages, Bulk Welding Process." T. Jordan, TAPCO Corp., Houston, TX

TUESDAY EVENING — BANQUET, 6:30 p.m.

"Alyeska Pipeline." John Moeller, Past National President AWS, Los Angeles, CA

WEDNESDAY — MAY 17 — 8:30 a.m.

"CHALLENGE OF CHANGE"

A. J. Fergus, Chairman

"Farming Mined Farm Land." J. Gray, State of Oregon, Dept. of Geology and Minerals Ind., Albany, OR

"Overview of the Resources Planning Act: Legislative Intent and the 1980 Plan." J. Butruille, Region 6, Forest Service, Portland, OR

"Economic and Environmental Implications of Recent and Proposed Federal Legislation." W. Cate, Speculative Ventures, Pacifica, CA

"Planning on Open Pit Mine Today: Engineering Geology and Hydrology." R. Howard and D. Ralston, Univ. of Idaho, Moscow, ID

"PYROMETALLURGY"

R. Nafziger and D. Taylor, Chairmen

"Present Smelting Practice at Anaconda, Mont." J. McCoy and C. Partin, Anaconda Company, Anaconda, MT

"Recovery of Iron and Copper from Slags by Carbon Injection." J. Paige, D. Paulson, and W. Hunter, Bureau of Mines, Albany, OR

"Electrical Characteristics of Smelting Slags." J. Persson, Lectromelt Corp., Pittsburgh, PA

"The Application of Real-Time Computer Control to Vacuum Arc Melting of Titanium." D. Mathews and F. Pendleton, Titanium Metals Corp. of America, Henderson, NV

"Magnesium Purification by Use of Iron and Zirconium to Remove Aluminum." M. Siddall, Teledyne Wah Chang, Albany, OR

"PANEL ON ENERGY" — 9:00 a.m.

O. D. Osborne, Moderator

"The Future of Electrical Energy in the Northwest — What It Means for the Metals Industry."

Richard Timm, Oregon Dept. of Energy
Harry Helton, Reynolds Metals
Larry Williams, Oregon Environ. Council
Robert Murray, Energy Consultant
Hugh Hansen, Oregon State University

NOTE: Montana Tech. Alumni Breakfast, Tuesday, May 16, 1978, 7:00 a.m. For reservations, call Al Ekeberg, (206) 573-7440.

PNMMC — PRE-REGISTRATION FORM — MAY 15-17, 1978

Mail to: Dwayne Lewis, c/o Omark Industries, 9701 S. E. McLoughlin Blvd., Portland, OR 97222
(Must be paid by April 15 to get preregistration discount)

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Spouse Registration	1.00	Gold and Money Lunch	7.50	TOTAL	$ ______

(NO REFUNDS AFTER MAY 14)

* * * * *

USGS ISSUES NEW OREGON "TOPO" INDEX

A new index showing 1,003 topographic maps covering most of Oregon is now available. About 45 percent of the State has been covered by 7.5-minute quadrangle maps at a scale of 1:24,000 (one inch to 2,000 ft). An additional 45 percent of the State is mapped in 15-minute quadrangles at a scale of 1:62,500 (one inch to about one mile).

For free copies of the Index to Topographic Maps of Oregon, write to the Branch of Distribution, U.S. Geological Survey, Box 25286 Federal Center, Denver, Co. 80225.

* * * * *

OREGON GEOLOGISTS CAN NOW REGISTER

To request application forms to register under the new Oregon Geologist Registration Act and a copy of the Code of Professional Conduct, write to the State Department of Commerce, 403 Labor and Industries Building, Salem, Oregon 97310 (phone 503-378-4294).

Fee for initial registration is $50; annual renewal is $50; initial registration and annual renewal in the engineering geologist specialty is an additional $25. Qualified practicing geologists may obtain licenses without examination before September 30, 1978.

* * * * *

DOGAMI WILL FILL IN THE BLANKS

A few January and February ORE BINS containing some blank pages were inadvertently mailed. If you received a defective copy, write to the Department for a free replacement.

AVAILABLE PUBLICATIONS

(Please include remittance with order; postage free. All sales are final - no returns. A complete list of Department publications, including out-of-print, mailed on request.)

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36. Papers on Tertiary foraminifera: Cushman, Stewart and Stewart, 1949: v.2 . .	1.25
39. Geol. and mineralization of Morning mine region, 1948: Allen and Thayer . .	1.00
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49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch . . .	1.00
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62. Andesite Conference guidebook, 1968: Dole	3.50
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81. Environmental geology of Lincoln County, 1973: Schlicker and others . . .	9.00
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84. Environmental geology of western Linn County, 1974: Beaulieu and others . .	9.00
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GEOLOGIC MAPS	
Geologic map of Galice quadrangle, Oregon, 1953	1.50
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OVERVIEW OF THE BOHEMIA MINING DISTRICT

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This is the third in a series of four articles on mineralization in the Western Cascades. The first, a field trip guide to the Quartzville mining district, appeared in June 1977. The second, printed in December, discussed the history, geology, stratigraphy, and mineralization of 14 Western Cascade mining areas. This article focuses on the major area, the Bohemia mining district; and a field trip guide to Bohemia will be published in next month's (June) Ore Bin.

The Bohemia district was selected for detailed study in the series because it is the largest and most productive mining area in the Western Cascades. All facets of Western Cascades mineralization are represented in the district.

Checkpoints mentioned in both this and next month's articles refer to locations on the centerfold map.

Location and Geography

The Bohemia mining district (see map, centerfold) lies about 35 mi southeast of Cottage Grove in Lane County (Tps. 22 and 23S; Rs. 1 and 2E). The roughly circular mineralized area is about 5 mi in diameter. From Cottage Grove, access to the district is by Row River Road and Forest Service roads which follow Sharps and Brice Creeks. The district lies at the southern limits of the Willamette Valley, where the east-west-trending Calapooya Mountains separate drainages of the Willamette and Umpqua Rivers. The Bohemia district is on the eastern part of the divide, in an area characterized by high, rugged summits and steep, heavily timbered slopes (Figure 1).

Narrow ridges and valleys radiate from the central part of the district. Elevations range from just under 2,000 ft on Champion Creek on the edge of the district to 5,933 ft on Fairview Peak located near the center. The area is drained by tributaries of Brice and Sharps Creeks on the Willamette side of the divide and by Steamboat Creek tributaries on the Umpqua side. Glaciation helped shape the upper mountain heights; glaciers moved down the valleys, leaving debris and forming cirques (deep, steep-walled, bowl-shaped valleys). Some of the cirques now contain lakes or bogs. Champion Creek begins in a cirque (checkpoint 55).

Geology

The Bohemia area is underlain by Oligocene and early Miocene volcanic rocks of the Little Butte Volcanic Series which have been intruded by

Figure 1. Panoramic view taken through arc of 165° in a northerly direction from summit of North Grouse Mountain, in Bohemia district. Note many of the characteristic surface features of the Western Cascades. A rough accordance of ridge tops may be noted. Noonday Ridge is typical of the long ridges sloping toward the valleys of major streams. In the center, short ridges slope gently, then break off abruptly into the very narrow valley of Champion Creek. Glacial cirques are visible in the area between Bohemia Mountain and Fairview Peak and on the east slope of Fairview Peak (Callaghan and Buddington, 1938).

late Miocene and early Pliocene rocks. All rock types have been subjected to alteration, mineralization, and faulting. For a more detailed discussion of geology and mineralization, see the December 1977 Ore Bin.

Volcanic, sedimentary, and intrusive rocks

Layered rock units exposed in the district consist of about 4,000 ft of lapilli tuff; tuff breccia; flows and domes of basalt, andesite, dacite, and rhyolite; and minor amounts of tuff, tuffaceous shale and sandstone (Figure 2), and conglomerate.

A 1,000-ft section of lapilli tuff and tuff breccia is exposed from halfway between checkpoints 25 and 26 to checkpoint 27. Another section of these rocks occurs between checkpoints 61 and 62. Tuffaceous shale and sandstone is exposed between checkpoints 27 and 31. A conglomerate with subrounded boulders of various types of volcanic rock up to 10 ft in diameter occurs at checkpoint 62 (Figure 3). Other volcanic features exposed in the district include part of a dome at checkpoint 33, prophyritic basalt flow between checkpoints 39 and 40, and another lava flow on the south side of the fault at checkpoint 61.

The youngest intrusive rocks are porphyritic dacites; the next older are andesitic and basaltic dikes and sills; and the oldest intrusions are granitoid, ranging in composition from diorite to granite. Granodiorite, the most common type of granitoid rock, occurs at checkpoints 43, 52, and 53. Porphyritic dacite is exposed at checkpoint 58, an andesite sill at checkpoint 28, and an andesite dike at checkpoint 29.

Alteration

All types of rock alteration discussed in the December 1977 Ore Bin can be seen along the route to and through the Bohemia mining district. Low-grade zeolite alteration occurs outside the district at checkpoints 12 and 15. All rocks within the district show a moderate degree of propylitic alteration as an alteration "background."

The boundary between propylitic alteration and contact metamorphism within the Bohemia district is not easily identified. Near the edges of the district, rocks have been propylitically altered, as shown by the presence of chlorite and epidote in rocks at checkpoints 29, 60, and 61. The

Figure 2. Thin-bedded tuffaceous shale and sandstone (checkpoint 28).

Figure 3. Conglomerate of volcanic pebbles, cobbles, and boulders up to 10 ft in diameter, found in stream bed at checkpoint 62.

alteration also hardened these rocks, so that they now form resistant outcrops (checkpoints 51 and 60). Near the intrusive contact, albite-epidote and tourmaline hornfels occur (checkpoint 38).

Alteration caused by hydrothermal action is discussed in the next section.

Veining

The 100 known veins within the district have open-space fillings of quartz, complex sulfides, and other minerals. Associated with the veining is hydrothermal alteration of the country rock.

Veins crop out at checkpoints 32, 36, and 42. The vein mineralization is zoned. Copper, lead, and zinc sulfide minerals with quartz and specular hematite occur in the center of the district. Minerals found at the Musick mine dump (checkpoint 40) and the Champion mine dump (checkpoint 55) are typical of this zone; they include comb quartz, pyrite, chalcopyrite, specularite, sphalerite, and galena (Figure 4).

Veins in the zone surrounding the center also contain the same minerals except the specularite. Stibnite-bearing veins (checkpoint 32) on the south side of the district characterize the outer zone.

Along with vein mineralization, large areas such as that along Hard-

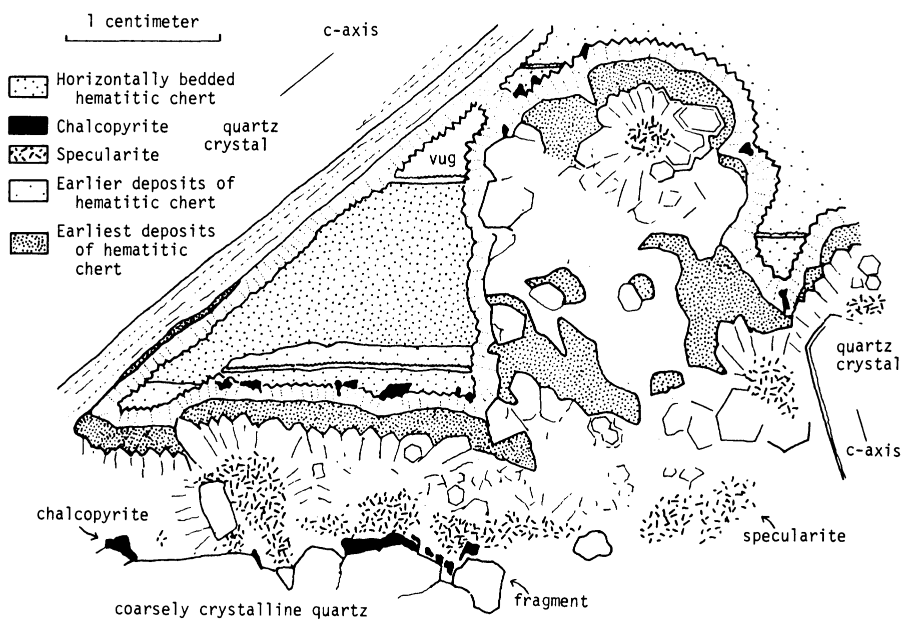


Figure 4. Sketch of photomicrograph of specimen containing horizontally (?) bedded hematitic chert (dotted) with contemporaneous chalcopyrite filling vugs in coarsely crystalline quartz. Earliest deposits are medium-grained quartz and specularite, followed by a layer of hematitic chert. Later deposits include alternating layers of hematitic chert and fine comb quartz. About 5 percent chlorite accompanies hematite and chert in the upper layer (after Lutton, 1962).

scrabble Road between checkpoints 24 and 27 have been silicified and pyritized. Rocks in these areas are bleached and iron stained.

Structure

Structure in the Bohemia area includes faults, breccia zones, a broad warp, and a few minor folds. The warping and the folds are not apparent without much study; checkpoint 47, however, does show a breccia zone; and faults can be found at checkpoints 15 and 61. Veining follows the faulting-fracturing system, but most of the vein-faults do not indicate much displacement.

Mineral and Fossil Localities

Minerals listed in Table 1 are typical of the district and, with the exception of gold, are relatively easy to find at the indicated locations.

Table 1. Mineral compositions and localities in the Bohemia district

Mineral	Composition	Checkpoint numbers*
Calcite	$CaCO_3$	12, 15
Chalcopyrite	$CuFeS_2$	40, 55
Epidote (Figure 5)	$Ca_2(Al,Fe)_3Si_3O_{12}(OH)$	39, 40, 58, 61, 62
Galena	PbS	40, 55
Gold	Au	40, 55
Hematite	Fe_2O_3	36, 40, 55
Magnetite	Fe_3O_4	61, 62
Pyrite	FeS_2	18 through 63
Quartz (Figures 6, 7)	SiO_2	15, 30, 36, 40, 44, 55
Sphalerite	ZnS	40, 55
Stibiconite (Figure 6)	$H_2Sb_2O_5$	32
Stibnite (Figures 6, 8)	Sb_2S_3	32
Tourmaline (Figure 9)	$Na(Mg,Fe)_3Al_6(BO_3)_3(Si_6O_{18})(OH)_4$	38, 40, 58

*See map, centerfold

The fossil suite found at the Rujada locality (checkpoint 73) contains 40 different types of plant life. The Oligocene fossils, mainly leaves and cones (Figure 10), are described in detail by Lakhanpal (1958).

History

The Bohemia district surpasses all mining districts of the Western Cascades in area, number of producing properties, amount of development work, and total production. In 1858, placer gold was discovered on Sharps Creek (checkpoint 11) by W.W. Oglesby and Frank Brass. The following year, values were found and recovered from Sailor's (or Saylor's) Gulch (checkpoint 22). In 1863, lode gold was found by George Ramsey and James (?) Johnson within three-quarters of a mile of Bohemia Mountain. Soon prospectors began arriving in the area, and because Johnson, from the country of Bohemia, was nicknamed "Bohemia" Johnson, the district was named Bo-

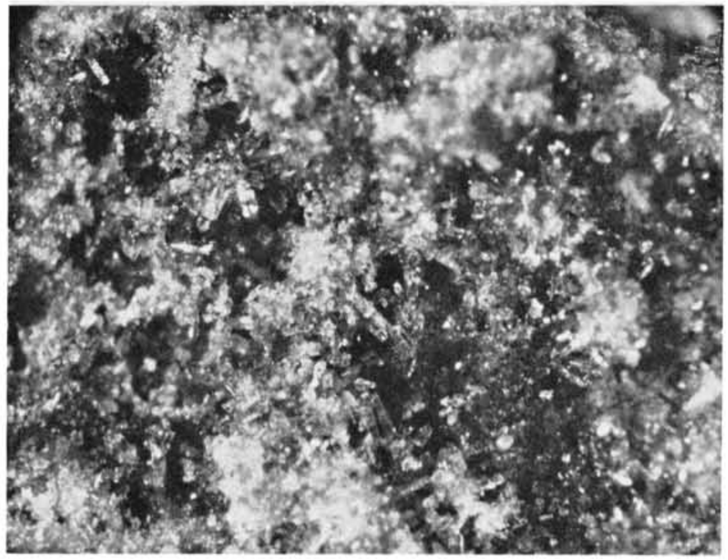


Figure 5. Photomicrograph of epidote knots found at checkpoint 61. Crystals are epidote; black material is fine-grained magnetite. (X30) (Photo courtesy Larry Brown)

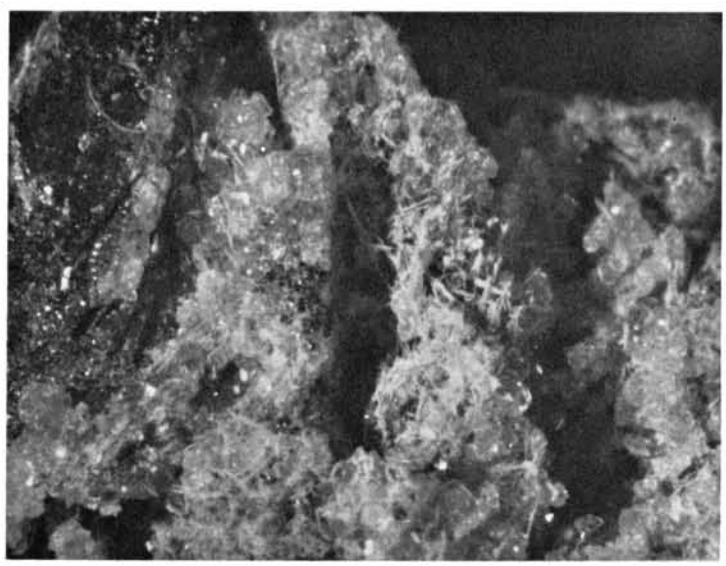


Figure 6. Photomicrograph of stibnite ore found at checkpoint 32. Clear material is quartz; metallic black is stibnite; straw-shaped crystals are stibiconite. (X10) (Photo courtesy Larry Brown)

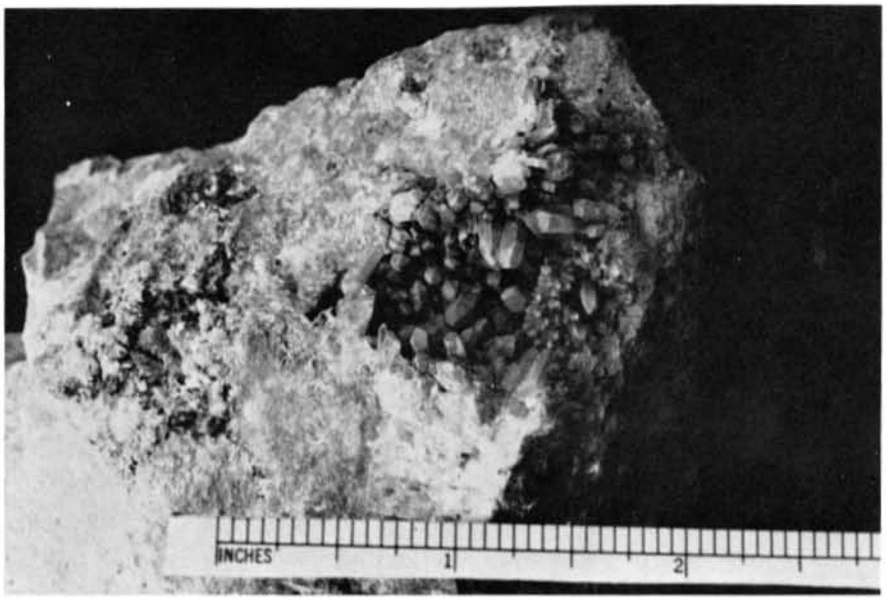
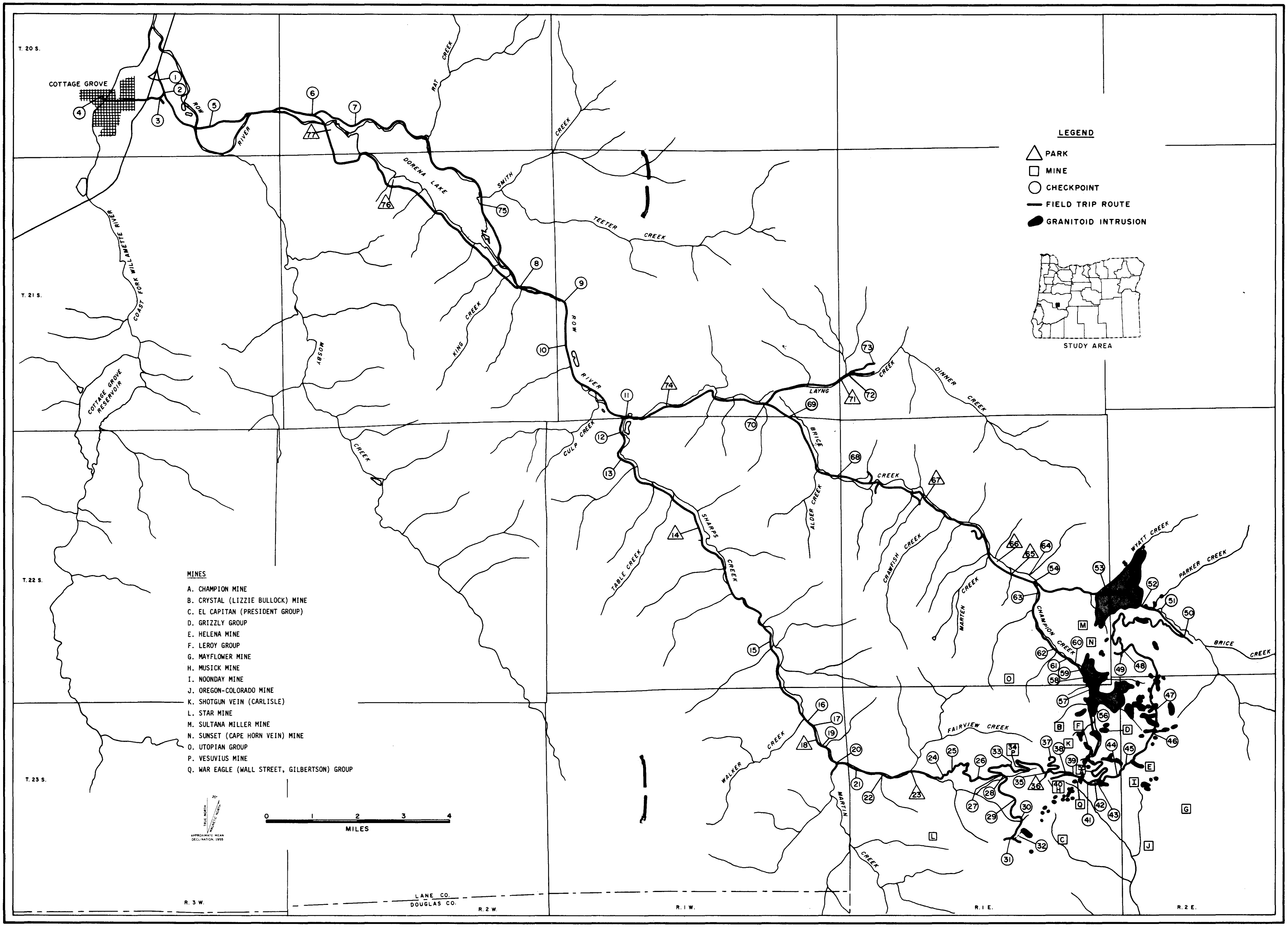


Figure 7. Quartz crystals like these are found filling veins, lining vugs, and surrounding breccia fragments in many locations in the Bohemia district.

Figure 8. Radiating masses of stibnite found in veins at checkpoint 32.



MAP OF THE BOHEMIA MINING DISTRICT

Cartography by Kath Eisele

Numbers on this map refer to field trip guide that will be printed in next month's Ore Bin

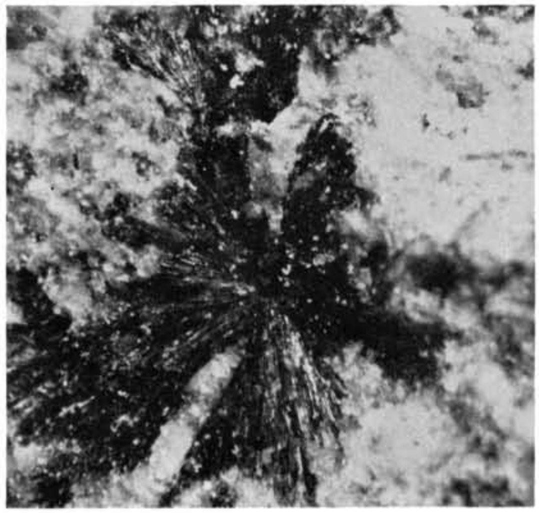


Figure 9. Photomicrograph of tourmaline (var. schorlite), which can be found at checkpoints 38, 40, and 58. (X10) (Photo courtesy Larry Brown)

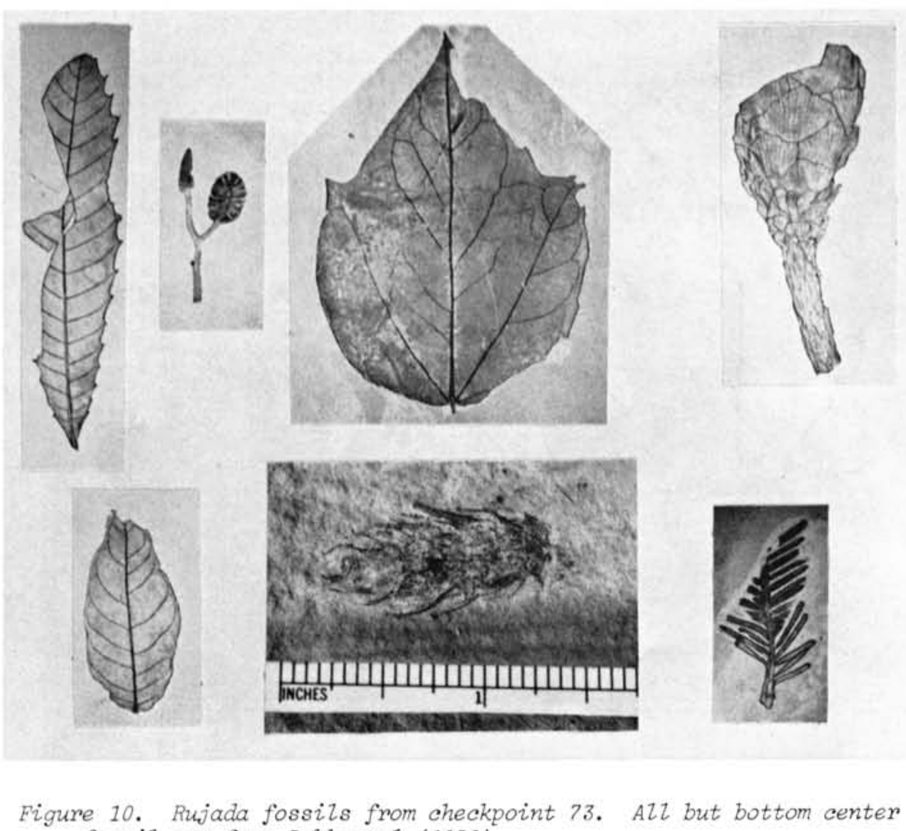


Figure 10. Rujada fossils from checkpoint 73. All but bottom center fossil are from Lakhanpal (1958).

hemia. In 1870 (?), the Knott trail (between checkpoints 35 and 37 and at checkpoint 41) was built by hand labor to the Knott claim, now part of the Champion group (checkpoint 55). In 1872 (?), the district's first stamp mill, powered by a steam engine and boiler, was installed on the Knott claim, where it ran for about 2 years. Recoveries were poor, however, and because the mill was located near the summit, water was scarce. Eventually the mill was closed because of litigation.

The Musick vein, the first really important discovery, was located in 1891, and a stamp mill was brought to the property by way of the Noonday trail (checkpoints 46, 49, and 63). Figure 11 shows the Ridge Hotel, at checkpoint 49, on the Noonday trail.

The Noonday mine was opened in 1892. A 10-stamp mill was installed at the Champion mine in 1895 and a 20-stamp mill at the Noonday in 1896. By 1902, not less than 2,000 claims (some undoubtedly duplicate recordings) had been filed in the district. Between 1902 and 1912, West Coast Mines Company consolidated the Champion, Helena, and Musick mines and erected a 30-stamp mill at the Champion. The Noonday was a producer between 1896 and 1908. The Vesuvius and Evening Star mines produced during the 1900's.

Between 1932 and 1938, Mahala Mines, Bartels Mining, and Minerals Exploration Companies produced ore with a total value of more than $400,000 at the old gold price of $33/oz. Between 1939 and 1942, Higgins and Hinsdale (H. and H. Mines, Inc.) completed some development work and erected a flotation mill and power plant at the Champion mine (Figure 12, checkpoint 55). In 1942, before major production was attained, the mill and plant were closed; however, considerable development ore had been milled. In 1944, F.J. Bartels acquired the mill and property from H. and H. Mines. Between 1945 and 1949, Bartels produced a small amount of gold from the Champion and Evening Star mines and milled ore from the Helena mine, operated by K.O. Watkins. In 1950, Watkins obtained the Champion lease and operated the Champion mill, producing about $35,000 at 1950 metal prices.

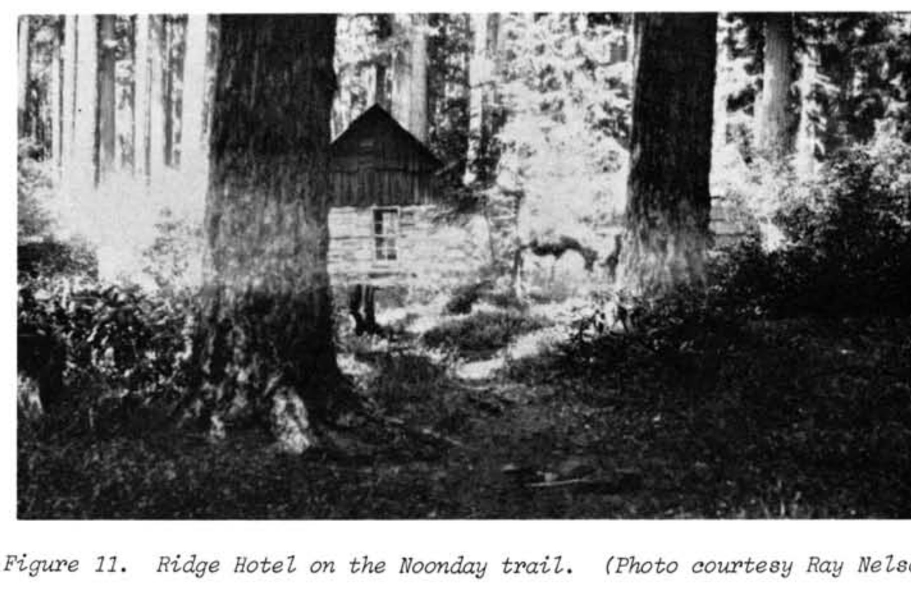


Figure 11. Ridge Hotel on the Noonday trail. (Photo courtesy Ray Nelson)

Figure 12. Champion flotation mill (checkpoint 55) as it appeared in the early 1960's. (Photo courtesy Fred Miller) Insert: Mill as it appears today.

In 1961 and 1962, the Office of Minerals Exploration contracted to help finance a long drift to expose the Musick vein 335 ft below the old No. 6 level. The Emerald Empire Mining Company did the work. In 1964, a diamond-drilling program to explore the Champion, Evening Star, Musick, and other nearby properties was announced by Federal Resources Corporation of Salt Lake City. The program was modified to include drilling on extensions of the Helena vein and a production drift known as the 1,000 level (Figure 13) on the California-Defiance veins of the Musick. Work was completed at 1,196 ft in May 1965.

The history of Bohemia is being kept alive by four community groups: the Cottage Grove Historical Museum (checkpoint 3); the Cottage Grove Prospectors; the Bohemia Mine Owners Association; and the Bohemia Mining Days, sponsored by the Cottage Grove Chamber of Commerce. The museum contains displays of mining tools from Bohemia, a working model of a stamp mill, and a full-scale 5-stamp mill. The Cottage Grove Prospectors are restoring the buildings at Bohemia City (Figure 14, checkpoint 40). The Bohemia Mine Owners Association has worked to keep surface resources of the mines open for public use. The Cottage Grove Bohemia Mining Days, scheduled annually on the third weekend in July, features a parade, art show, stage show, beer garden, and tour through the Bohemia district.

Ray Nelson, Cottage Grove, has been instrumental in keeping Bohemia history alive. Several photographs used in this series are from his collection. His book, "Facts and Yarns of the Bohemia, Oregon, Gold Mines,"

Figure 13. Three-car, compressed-air driven tram that ran from 1,000 level of Musick mine during diamond-drilling exploration program that included the Champion, Evening Star, Musick, and other mines in the Bohemia district.

Figure 14. Lundberg Stage House, one of buildings reconstructed at Bohemia City (checkpoint 40) by Cottage Grove Prospectors.

which can be purchased at the Cottage Grove Historical Museum, was the source of much of the history in this article.

Production

At today's prices, about $4.2 million in metallic minerals have been produced from the district (see Table 1, December 1977 Ore Bin). This is a little less than one-half of the total production from the north-central Western Cascades. Of the total Western Cascades' mineral output, the Bohemia district has produced: lead, 75 percent; gold, 63 percent; silver, 31 percent; copper, 26 percent; zinc, 5 percent; mercury, 0 percent. Hal Barton (oral communication, 1977) estimates that two-thirds of all production was obtained without modern equipment. Most mining, instead, was done with hand steel.

Present Status and Future Outlook

Currently, no mines in the Western Cascades are producing; but this condition will change if the economic and technological climates become more favorable for mining. The outlook depends largely on better definition of orebodies.

In Bohemia, assessment work is being done to keep unpatented mining claims current. Several patented mines have changed hands. Almost all old miners' cabins, mine buildings, and mill buildings have been destroyed. However, a large national mining firm is currently gaining a land base in the district.

Mining was started in the district with hand steel and the free milling gold found in the oxidized zones of veins. After the oxide zones bottomed out, sulfides of lead, zinc, and copper were found. A bulk concentrate of all of these sulfides can be produced very easily, but it cannot be sold. A copper smelter charges a penalty for lead and zinc, a lead smelter for copper and zinc, and a zinc smelter for lead and copper. The three sulfides, therefore, must be separated before being sold. The separating can be done with a flotation mill. The district had one flotation mill, at the Champion mine (checkpoint 55), but operation was suspended before major production was attained. One or two of the mines alone could not support a modern-day mill, but all of the mines together in the district could. Unfortunately, because the mines are all owned by different people, capital for a mill will be hard to find.

Two factors may change the outlook for mining in this and other districts. The U.S. Bureau of Mines has been studying the processing of bulk concentrates by electric smelting and electrowinning. If one of these processes were to be successful, a small gravity mill could be built at each mine. Another factor that could improve the mining situation would be an economic discovery by one of several national mining firms currently conducting exploration for copper-molybdenum porphyries. If one of the firms succeeds in this search, mining in the district will be conducted on a different scale than in the past. Bulk mining, through open pit, underground, or solution mining could be considered. Capital in the millions of dollars would be needed, and the district would have to be worked as a unit. Conceivably, one day's production could be greater than all of the district's past production.

Next month: A field trip guide to the Bohemia mining district.

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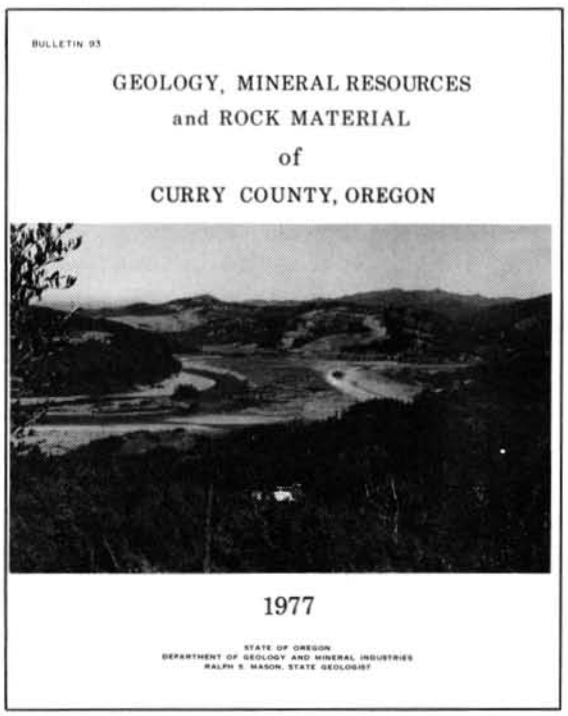
DEPARTMENT ISSUES THREE NEW BULLETINS

All of the bulletins described below were published by the Department and are on sale at the Department's Portland, Grants Pass, and Baker offices (see inside front cover for various addresses).

CURRY COUNTY STUDY RELEASED

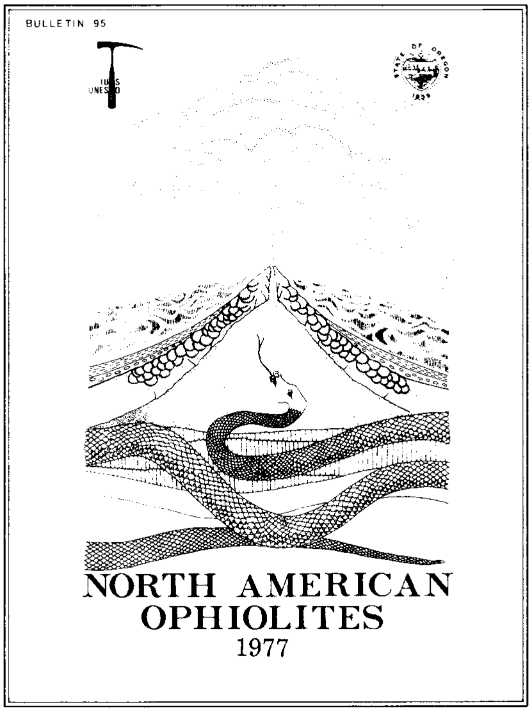
First of the publications recently completed by the Department is Bulletin 93, "Geology, Mineral Resources, and Rock Material of Curry County, Oregon," by Len Ramp, Herbert G. Schlicker, and Jerry J. Gray, all of the Department staff. The 79-page bulletin is intended to be a companion report to "Land Use Geology of Western Curry County, Oregon," by John Beaulieu and Paul Hughes, which was released as Bulletin 90 in 1976.



The new bulletin is a study embracing geography, geology, rock-material resources, metallic-mineral resources, nonmetallic-mineral resources, mineral fuels, and reclamation. Twelve figures, nine tables, and three maps accompany the text. The several appendices include a mined land reclamation application form, a reclamation plan guideline, and a glossary.

The authors wrote the bulletin to provide Curry County with mineral-resource information for use in planning and to add to the Department's data base.

The price is $7.00.



NORTH AMERICAN OPHIOLITES ATTRACT WORLDWIDE INTEREST

Participants from around the world attended the 1977 field excursions and seminars conducted by the International Geological Correlation Program to study ophiolites.

The North American excursions began in Newfoundland and ended in the Klamath Mountains province.

R.G. Coleman and W.P. Irwin, USGS, edited 13 papers from the conference, now on sale as Bulletin 95, "North American Ophiolites." The 183-page book contains many photographs and drawings, an index map of North America showing areas of ophiolites described, and five geologic maps in a pocket.

Bulletin 95 sells for $7.00.

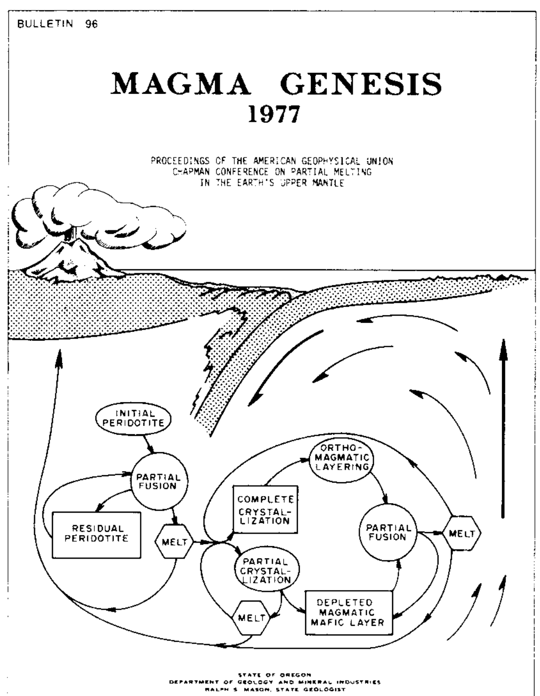
ORIGIN OF MAGMA IS STUDIED

"Magma Genesis" is the title of the Department's new Bulletin 96, a compilation of 19 papers from the Proceedings of the American Geophysical Union Chapman Conference on Partial Melting of the Earth's Upper Mantle.

Concepts of magma genesis developed in the text will be an aid to geologic mapping and to assessment of mineral wealth in magmatic terrain. Several of the articles deal directly with rock in Oregon.

Henry B. Dick, Woods Hole Oceanographic Institution, edited this comprehensive document, which includes numerous illustrations.

The 311-page book costs $12.50.



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A GEOLOGICAL FIELD TRIP GUIDE FROM COTTAGE GROVE, OREGON TO THE BOHEMIA MINING DISTRICT

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This article, a companion to the "Overview of the Bohemia Mining District" (Ore Bin, May 1978), is the last in the four-part series on mineralization in the Western Cascades. The route of the self-guided trip and locations of checkpoints mentioned in the article are indicated on the centerfold map. Titles of the other articles in this series and sources of additional information on individual mines and the geology of Lane County are given on page 116.

Anyone taking this field trip is warned of the dangers of entering abandoned mines, caves, open pits, and quarries. Remember, you enter any mine at your own risk, and the greatest dangers are those that you cannot see until it is too late. Mines that look safe to you may instead be extremely dangerous.

Road Log

(Circles indicate checkpoints; triangles are parks; squares are mines.)

(1)	(2)	(3)*	
①	0.0	0.0	Starting point is the junction of Interstate Highway 5 on-off ramp east of the Interstate and Row River Road. Take Row River Road south, passing the Village Green Motel, to Thornton Road South.
②	0.4	0.4	Turn right on Thornton Road South and go to Mosby Creek Road junction.
③	0.1	0.5	Turn right. You are now traveling west on Mosby, which, after a few city blocks, becomes Main Street. Follow Main until it crosses the bridge over the Coast Fork of the Willamette River. Turn right onto North River Road; then, within half a block, turn left onto "H" Street. The Cottage Grove Historical Museum is two blocks ahead on the left, at the corner of Birch Street.
④	1.4	1.9	Cottage Grove Historical Museum. The museum (Figure 1), housed in an octagonal-shaped former Roman Catholic church that was built in 1897, is a joint

*(1) Checkpoints; (2) Mileage intervals; (3) Cumulative mileage.

project of the city of Cottage Grove and the Cottage Grove Historical Museum Committee.

On display are some of the crude mining tools from the Bohemia mining district, including a working model of an ore stamp mill that shows how gold was extracted from ore taken from mines located east of Cottage Grove.

In July and August, museum hours are Wednesday through Sunday, 1-5 p.m.; the rest of the year, the museum is open 1-4 p.m. Saturday and Sunday on the second weekend of each month.

Return to checkpoint 2.

(2) 1.6 3.5 Row River Road and Thornton Road South junction. Turn right onto Row River Road.

(5) 1.4 4.9 U.S. Forest Service Ranger Station, on Cedar Park Road, which intersects on the left. Here you may obtain a copy of the Forest Service's "Tour of the Golden Past," containing more information about Bohemia.

(6) 2.5 7.4 Row River Road-Government Road junction. Turn left onto Government Road, which soon crosses and then follows the old OP&E Railroad, built by and for the Bohemia miners in the early 1900's. Now the railroad serves mainly the lumber industry.

(7) 1.1 8.5 Cerro Gordo Mountain. Dorena Reservoir viewpoint and parking lot are to the right and past the roadcut. Park, walk back about 200 ft, and examine the roadcut. The rock high up in the cut is from a lava which flowed over an earlier, already cooled lava flow. Note the bright red color at the contact between flows. The color is caused by heat from the overlying flow baking the material below. Both flows are part of the Little Butte Volcanic Series as mapped by Peck and others (1964). In some parts of the roadcut, sedimentary material occurs between the lava flows (Figure 2).

(75) 4.2 12.7 At milepost 10, to the left about 50 ft above road level, is Pinnacle Rock (Figure 3), a needle-shaped erosional remnant left when soft, weathered, outer rock was worn away, leaving behind the harder, unweathered core. On the return part of the trip, at checkpoint 75, you will see Pinnacle Rock from across the reservoir.

(8) 2.2 14.9 Stop sign at junction with Row River Road. Across the road and to the right is an old covered bridge. Turn left onto Row River Road.

(9) 1.0 15.9 You are now traveling around a bend in the river. Because river currents are always stronger on the outside of a bend, this is the area where it is hardest to keep a highway from being washed away. Here, during the 1964 flood, the river took the highway completely out and washed away the steel railroad track on your left, wrapping it up along the mountainside.

(10) 1.1 17.0 Dorena Post Office and business district on the right.

(11) 2.3 19.3 Row River Road-Sharps Creek Road junction. Turn

Figure 1. Cottage Grove Historical Museum (checkpoint 4).

Figure 2. Little Butte Volcanic Series lava flow rock overlying sedimentary material (checkpoint 7).

Figure 3. Pinnacle Rock, about 50 ft above road, visible from across the reservoir at checkpoint 75 on return trip.

right onto Sharps Creek Road and cross the bridge. The "Red Bridge" sign is the Forest Service "Tour of the Golden Past" mile point 0.0.

(12) 0.3 19.6 Alteration zone. The rock face on the right shows zeolitic (green-colored) alteration. Such zones can be identified by the alteration of pyroxene, hornblende, and volcanic glass into green clay. Zeolites, carbonate minerals, and chalcedony have been introduced into the original rock.

(13) 0.9 20.5 Rock quarry on the right. Mining in Oregon today generally means sand and gravel and stone. During 1975 (latest year for statistics), stone production from mines such as this was 21 million tons, making stone the mineral commodity with the greatest output. Sand and gravel production during the same period was 17 million tons. No other mineral commodity in Oregon came close to these totals.

△14 2.2 22.7 Sharps Creek Recreational Area on the right. This Lane County park rests on a stream terrace underlain by a gravel deposit. In the past, the stream bed was at a higher level and the stream had a lower gradient. Then the stream eroded laterally, cutting a broad valley. Now, with a steeper gradient, the stream is instead downcutting a narrow channel.

Just before you reach checkpoint 15, you cross a bridge listed in the Forest Service Tour.

(15) 3.7 26.4 The rock face on the right (Figure 4) has a complex geological history. As you face the outcrop, the rock jutting out on the right is a volcanic breccia with angular fragments from 0.1 to 7 in long. On the left is black basaltic lava flow rock. The 2-ft-wide vertical band of rock in the center is a dike. Between the dike and breccia and between the dike and basalt are zones of zeolitic and hydrothermal alteration. The flat face on the breccia next to the alteration is a fault plane. Slickensides, polished and striated (scratched) surfaces resulting from rocks moving past one another along a fault, occur high on this fault plane against the alteration zone. The slickensides dip toward the road slightly, showing that movement along the fault was mostly horizontal. The dike is parallel to the fault plane. Massive and crystalline calcite occur within the alteration zone.

Examine the black basalt on the left. Just above the road level, you can see quartz and another type of volcanic breccia. Fragments of basalt, about 1 or 2 in across, are cemented together by white quartz (Figure 5). The geological events at this stop include the faulting of two different types of rock against each other. Then a dike intruded along the zone of weakness created by the faulting. The basalt was crushed during faulting, forming a small breccia zone within the basalt. Hot-water action produced zeolitic alteration. At this stop, yellow and brown clay minerals formed, in contrast to the green minerals found at checkpoint 12. The water here may have been hotter and more highly mineralized than the water at checkpoint 12.

(16) 2.1 28.5 Arrastra mine, located a short distance up Walker Creek and abandoned about 1900. An ore-grinding mill called an arrastra, powered by water from a falls in Sharps Creek, was set up on the flat area between Sharps and Walker Creeks. Here ore was crushed to powder and gold was separated from the crushed ore. Although no evidence of the old arrastra remains, you may be able to find where holding bolts were fastened to the rocks.

(17) 0.2 28.7 Yellow-brown alteration in roadcut to left. This 100-ft zone has been silicified and pyritized, making the rock so hard and resistent to erosion that it formed the falls used as a water source for the arrastra. These types of alteration zones or areas within them are often gold bearing.

(18) 0.3 29.0 Gold Bottom unimproved campsite on the right, part of an old mining site. At the creek below the parking area, a cut was driven into a pyritized and silicified white- to gray-colored fracture zone. Small pyrite crystals and secondary quartz veinlets can be seen on broken rock surfaces in this zone. Apparently values were nonexistent or too low to warrant mining.

(19) 0.2 29.2 Umpqua National Forest boundary sign. This forest of about 980,000 acres is managed by the U.S. Forest

Figure 4. Checkpoint 15. At left is basaltic lava flow rock; in center is alteration zone cut by dike; at right is volcanic breccia.

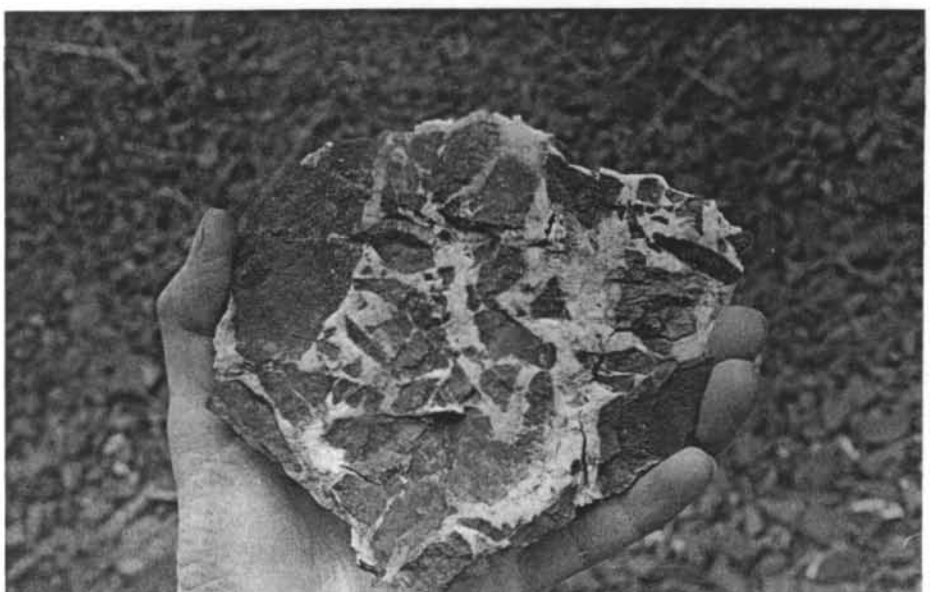


Figure 5. Breccia cemented by quartz (checkpoint 15).

Service under the Multiple Use Act of 1960.

(20) 0.6 29.8 Fork in road. Take the left road and continue on Sharps Creek Road (Road 230).

(21) 0.5 30.3 Stage Road sign on the right.

(22) 0.6 30.9 Sailors Gulch (also spelled Saylors Gulch). Placer gold was discovered on this small tributary of Sharps Creek in 1858. Water flowing over ore veins upstream picked up and carried gold particles in suspension until they were dropped as placer deposits farther downstream. Recovering this gold is called placer mining, in contrast to quartz or hardrock mining, whereby gold is extracted from bed rock.

(23) 0.8 31.7 Mineral campground. This now peaceful spot was, at the turn of the century, the last stop for miners and freighters before they began the long, hard trip to Bohemia Saddle. At one time, a two-story hotel (Figure 6) was located between Fairview and Sharps Creeks. A post office, general merchandise store, several mining claims, and an assay office were located here at Mineral.

The 6-mi road between Mineral and Bohemia Saddle is known as Hardscrabble Grade. According to early travelers, it took from 4 to 8 hours to cover this stretch of road. Freight wagons needing only four horses to go from Cottage Grove to Mineral required six to eight teams to get up Hardscrabble Grade. According to Nelson (1969), this section of the road was built in 1898; the County contributed $700, and mining companies and miners supplied the remainder of the cost. Because the grade, especially the first 3 mi, is extremely steep and the road between Mineral and Glenwood is narrow, drive very carefully. Once you start up Hardscrabble Grade, you have little opportunity to turn around.

Most of the rock along the Hardscrabble Grade from here to checkpoint 27 (Glenwood sign) has been silicified and pyritized. The rock is hard, so mine adits driven into it stand well.

(24) 0.8 32.5 On the left are three adits which, at the time of this writing, should be reasonably safe to enter. Do not enter any mine, adit, tunnel, open pit, or cut except those listed in this guide as being reasonably safe. Remember that conditions may deteriorate. Furthermore, any loose rocks near or within adits should be removed by a skilled miner before anyone tries to enter. You enter any underground opening at your own risk.

The first adit is about 15 ft long, the second about 50 ft long, and the third about 20 ft long. The adits have been drive in a silicified tuff breccia. The breccia fragments have been eroded and are soft, while the quartz that came in along the fractures between the fragments is very hard. Pyrite crystals can be seen on freshly broken surfaces. Where weathering could reach it, pyrite has been oxidized to limonite.

Figure 6. Old Mineral Hotel and post office located at foot of Hardscrabble Grade (checkpoint 23). (Photo courtesy Ray Nelson)

Figure 7. Giants similar to those described at checkpoint 28. These giants were operated in Josephine County, but similar ones were used in placer operations in the Bohemia district.

(25)	0.3	32.8	The 65-ft-long adit on the left is unsafe to enter because the back and hanging wall have loose rocks. The adit was driven on a 4-ft fracture zone bound by two parallel fault planes. The rocks have been silicified and pyritized.
(26)	1.5	34.3	An adit driven subparallel to the road is on the left. It follows a small fracture system for about 40 ft. The rock has been silicified and pyritized.
(27)	0.7	35.0	Road junction. Glenwood sign. Turn right for a side trip to Shane Saddle.
(28)	0.1	35.1	Glenwood cabin. In a switchback part way up Hardscrabble Grade was a way station, a small shelter in which mail and supplies were deposited for those who lived and worked near Shane Saddle, 2 mi to the south. A placer mine at the same site employed the hydraulic system, using powerful jets of water to loosen alluvial material containing gold deposits and wash it downhill. Water from the stream above traveled through a hose and was forced through a nozzle, called a giant (Figure 7). The dirt, sand, and gravel accumulated in the stream bed was channeled into sluice boxes, from which the gold was recovered. Even today the nearby stream can be panned for a few flakes of gold. In the roadcut in front of the cabin are thin-bedded, flat-lying shale and sandstone beds, evidence that a body of water such as a lake existed in this area at one time (Figure 2, May 1978 Ore Bin). By walking down the hill below the cabin toward the creek, you can see a thick sill of andesite which has intruded along the bedding of the sedimentary rocks. This sill is about 50 ft thick, and the top of it forms a flat plane on which the stream is flowing. This plane also formed a trap for placer gold.
(29)	0.9	36.0	Wet Canyon. These sedimentary rocks have been altered; those near the cabin were not. Note the small dike (Figure 8) intruding the country rock on the east side of the canyon. The dike has elongated vesicles, and some of these gas-formed holes are filled with white minerals called zeolites. Both the sedimentary rocks and dike have been silicified, making the rocks hard, and chloritized, making the rocks green.
(30)	0.7	36.7	Adit at the left just before you cross a small stream. This was the Bull Lead mine (Figure 9). The adit was driven along a silicified zone which has sparsely disseminated chalcopyrite, galena, and sphalerite and considerably more disseminated pyrite. Pyrite can also be found along fractures, as can cockscomb and drusy quartz. This adit is reasonably safe to enter. It was driven into hard, strong rock that should not cave in. The roof has a natural arch with no loose hanging rocks. No shafts have been dug below the tunnel, and no mine timber has been left to rot and form bad air. At 20 ft the adit forks; the right fork is 20 ft long and the left about 40 ft long.

Figure 8. Dike at Wet Canyon (checkpoint 29).

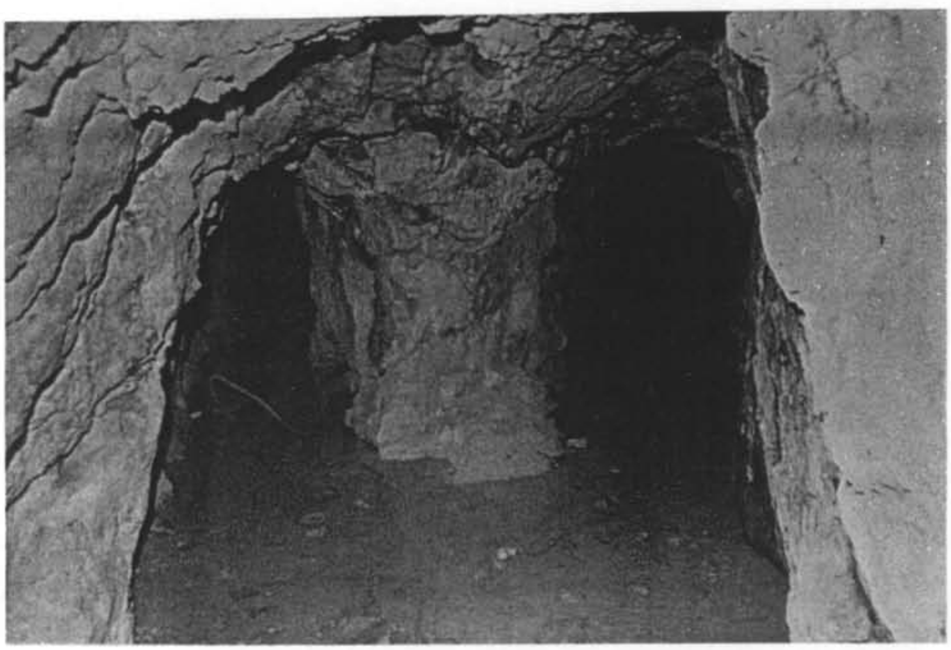


Figure 9. Fork in adit at Bull Lead mine (checkpoint 30).

Remember that most mines, tunnels, and shafts in the Bohemia and other mining districts are not safe to enter.

(31) 0.5 37.2 Shane Saddle junction. Stop and park your car. A poorly maintained jeep trail starts about 200 ft east around the curve and leads to the northwest. Follow this trail for 600 ft to where it forks, and take the right-hand fork, which leads uphill for 200 ft.

(32) 0.0 37.2 An open cut on the right of the trail contains a narrow band of stibnite-bearing ore.

This is the end of the side trip. Return to your car and then to the road junction at Glenwood (checkpoint 27).

(27) 2.2 39.4 Road junction at Glenwood. Turn right and continue up the Hardscrabble Grade (Road 230).

(33) 0.9 40.3 Road turns to the right. Note on left side of road a lava flow with 10 or more regularly spaced planes containing elongated vesicles (Figure 10). This lava is interbedded with tuff breccia and has been mapped by Lutton (1962) as part of a dome, a circular or oval accumulation of extremely viscous lava which, after having been squeezed from a volcano, congealed above and around the orifice instead of flowing away.

[34] 0.7 41.0 To the left is the old Vesuvius mine cabin. A boarding house was once above the road. The Vesuvius veins were discovered and staked about 1895; claims were bought a few years later by the Ziniker and Graber brothers, who sold them to Vesuvius Mines Company in 1902. By 1908 a ten-stamp mill was operating. The company also built a tramway and several buildings.

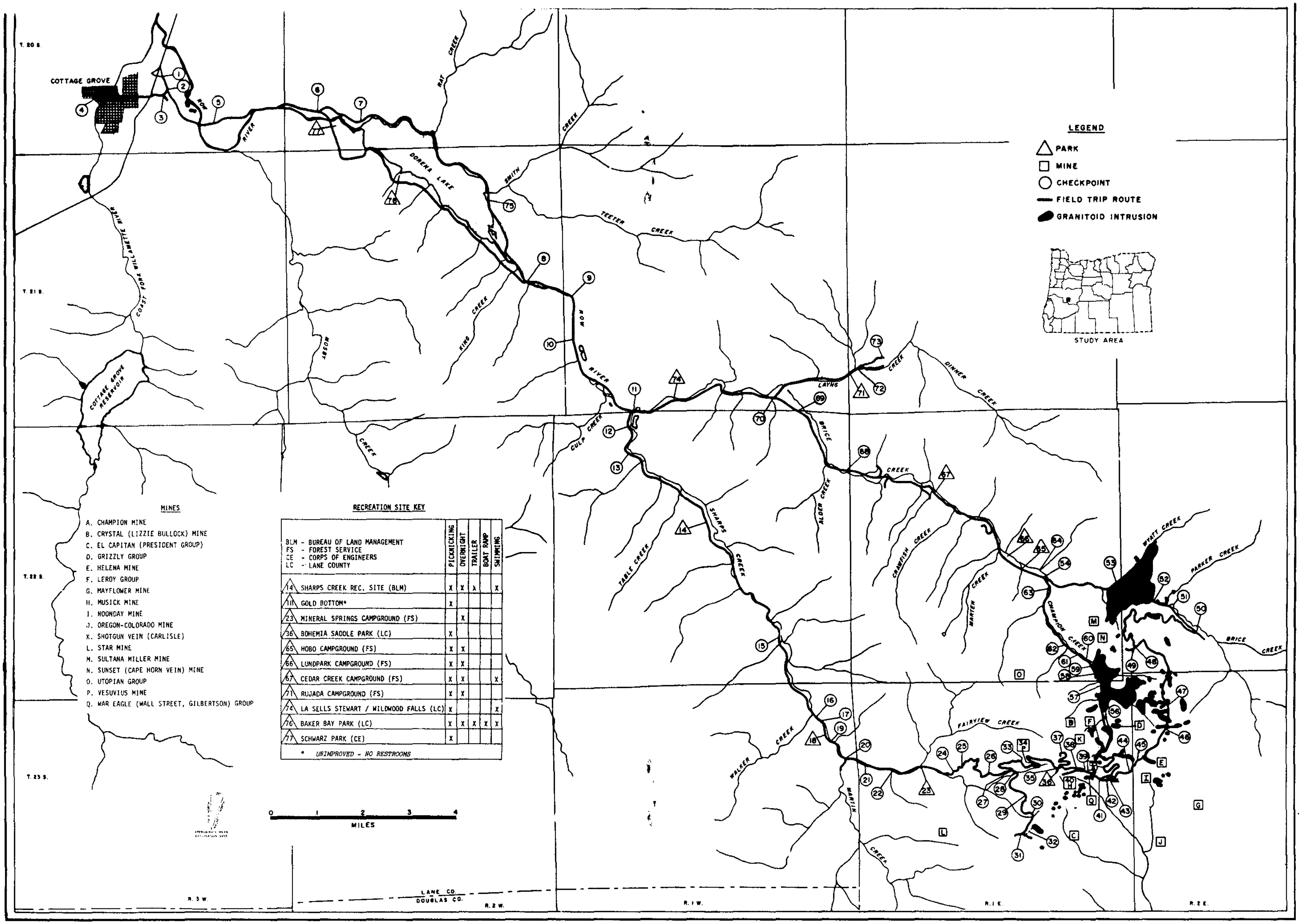
(35) 1.3 42.3 Bohemia Saddle. Turn right for side trip to Bohemia Saddle Park.

△36 0.1 42.4 Bohemia Saddle Park, maintained by Lane County. This park is situated on top of the Musick mine's old workings. The square-planked area near the picnic table is the top of a sealed-off ventilation shaft. Do not try to lift the timbers to look into it, because you could take a 40-ft vertical fall into one of the larger stopes (mine workings). Following the trail going down and along the mountain slope, you can see where the California vein crops out and where the mine workings have reached the surface (Figure 11). This dangerous hole is nearly vertical and is protected only by a smooth wire fence. Stay back from the edge.

This is the end of the side trip. Double back to Bohemia Saddle (checkpoint 35).

(35) 0.2 42.6 Bohemia Saddle. By turning to the left onto Road 230-F you may take a side trip to a lookout point.

(37) 1.3 43.9 Fairview Peak Lookout, elevation 5,933 ft. As you drive up to Fairview Peak, look for what appear



MAP OF THE BOHEMIA MINING DISTRICT
Cartography by Kath Eisele

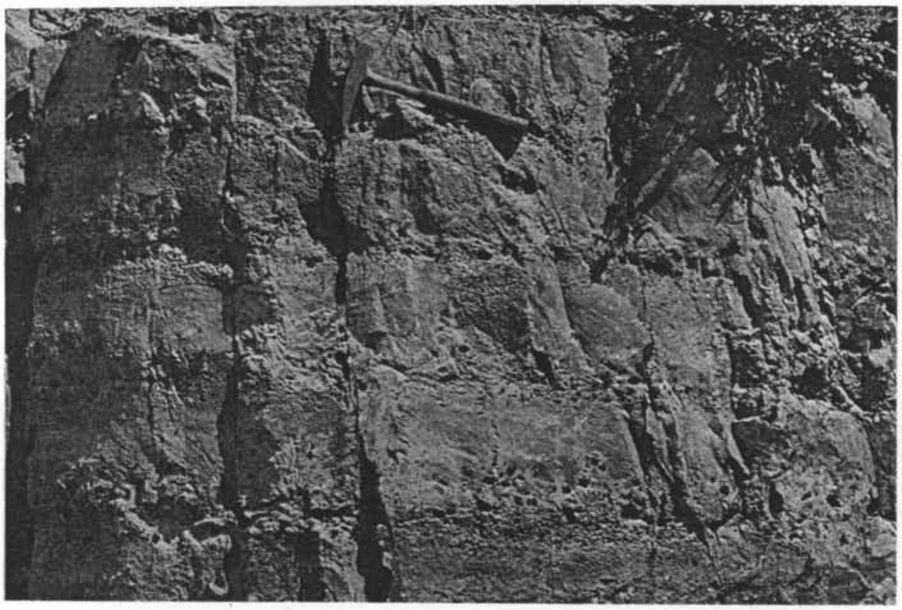


Figure 10. Planes of vesicles, called sheet vesicles, in volcanic rock (checkpoint 33).

Figure 11. Part of old Musick mine workings which have reached the surface (checkpoint 36). Shafts like these are very dangerous, so stay away from them.

to be old roadcuts. These were part of the old Knott Trail, built around 1870. The trail was wide enough only for a narrow wagon or sled, but it enabled mining and milling equipment to be brought into the district.

On a clear day, from the lookout you can see the Coast Range to the west and the Three Sisters and other Cascade volcanic peaks to the east. On a very clear day the Pacific Ocean can be seen to the west; Mt. Shasta, California, to the south; and Mt. St. Helens, Washington, to the north.

This is the end of the side trip. Double back to Bohemia Saddle (checkpoint 35).

(35) 1.2 45.1 Bohemia Saddle. Turn left back onto Road 230 and go east toward Champion Saddle.

(38) 0.6 45.7 The rock in a small open cut (6 by 10 ft) on the left side of the road and about 4 ft above the road bed (Figure 12) contains tourmaline of the schorlite variety. This site is hard to find, so drive slowly. On the way to checkpoint 39, the unimproved road to the left can be taken for a side trip to the old Forest Service Musick Guard Station, only 0.1 mi off Road 230. There you will see the old mule barn and guard station.

(39) 0.2 45.9 Musick mine road. Turn onto the road on the right for a side trip to the Musick mine and Bohemia City town site. Beward of high-centering your vehicle. Porphyritic basalt crops out on the right side of the road. The closer you get to the mine, the more epidotized the basalt becomes. Epidote gives the rock a greenish cast and forms a green coating along fractures.

[40] 0.6 46.5 Musick mine and Bohemia City. One of the most productive veins in the district, the Musick vein, was discovered in 1891 by James Musick, who organized the Bohemia Gold Mining and Milling Company. The mine was later purchased by the Oregon Securities Corporation, which also acquired the Champion and Helena mines. Consolidating operations at the Champion site, they built an electric railroad (Figure 13) to haul Musick ore over to the Champion stamp mill.

When you return to Road 230, just past the junction you will notice an extremely level stretch, which was the grade of the narrow-gauge electric railroad that ran between the Musick mine and the stamp mills at the head of Champion Creek. After 1908, the mine was owned by various companies and ran periodically. By the 1950's, however, snow had collapsed most of the buildings. All that remained of the once-prosperous camp were some crushed snowsheds, the old Lundberg stage house (now being restored by the Cottage Grove Prospectors Club), post office, store, hotel, a few cabins, and the ruins of the stamp mill (Figure 14).

Among hazards in the area are rotting boards and timbers with nails, and the mine adit is not safe to enter.

In the mine dumps and along the road to the upper dump you may find specimens of galena, epidote, pyrite,

Figure 12. Tourmaline occurs in open cut above road (checkpoint 38). This stop is hard to find, so watch mileage carefully.

Figure 13. Electric tram that once ran between Musick mine and Champion mill. (Photo courtesy Ray Nelson)

chalcopyrite, sphalerite, cockscomb quartz, and, rarely, a flake of gold.

End of the side trip. Double back to Road 230 (checkpoint 39).

(39) 0.7 47.2 Road junction. Turn right (east) onto Road 230.

(41) 0.3 47.5 Champion Saddle. The old Knott Trail can be seen nearby. Here you may choose to stay on Road 230, going around the bend to the right, or you may instead take Road 2259, the Champion Creek road, to the left. The roads join at the junction of Champion and Brice Creeks.

This road log first follows Road 230 to the junction; then it jumps back to this point again and describes Road 2259 from here to the junction.

(42) 0.2 47.7 The road has crossed the saddle, and the roadcut is now on the right. The light-colored outcrop on the right is the Champion vein. From within 500 ft of this spot, $300,000 in gold values have been taken. The Champion vein also crops out along Road 2259, so checkpoint number 42 is used for both outcrops.

(43) 0.1 47.8 The close relationship between granitic (granodiorite) intrusions and veins is shown here and at checkpoint 42. The vein cuts across the granodiorite. Hot water circulating during late stages of cooling of these intrusions was probably the source of metals found in the veins. The granodiorite looks unaltered; however, the green mineral epidote, an indicator of alteration, can be found along rock fractures called joints and in small veinlets.

(44) 0.4 48.2 The rock on the right side of the road shows some propylitic alteration, which means it has a greenish cast because of the development of fine-grained chlorite and epidote, both green-colored minerals. The rock contains a vein-fracture system along which up to 4-in quartz veins, containing euhedral, thumbnail-sized quartz crystals, have formed.

(45) 0.3 48.5 Notice the grove of trees to the left and upslope. Their trunks are curved near the ground but become straight higher up. This curvature is caused by the weight of the annual 10- to 15-ft-deep winter snow pack as it creeps slowly downhill, deforming the bases of the saplings in the process. As you drive through the grove, also look to the right for trees with yellow metal plates. These trees are survey bearing-trees. By reading the plates, you can tell how close you are to a section marker.

(46) 1.3 49.8 Road fork. Road 230 continues to the right, but you should take the left fork, Road 2243, which parallels the Noonday Ridge and its trail. The old Noonday (or Annie) Trail, built in 1892, was the main route for freight and supplies before Hardscrabble Grade and Champion Creek Trails were built.

(47) 0.6 50.4 A roadcut showing an alteration zone to the right. The yellow-brown color is from the oxidation of the introduced pyrite. Near the center of the cut, you can

see a gray clay fault gouge zone. The fault may have acted as a channel for hydrothermal solutions carrying sulfur, which combined with iron in the wall rock to produce pyrite. This site, part of the San Francisco vein system, has been mapped by Luttor (1962) as a breccia zone or pipe. Breccia zones are often rich in ore.

(48)	2.3	52.7	Turn left for a short side trip on the unnumbered road which joins Road 2243 at the switchback.
(49)	0.2	52.9	Take the fork to the left for a short distance and park in the grove of tall trees at the site of the old Ridge Hotel, which was located on the Noonday Trail (Figure 11, May 1978 Ore Bin). The hotel had lodging for both miners and animals. Double back to Road 2243 (checkpoint 48).
(48)	0.1	53.0	Road junction. Turn left back onto Road 2243.
(50)	3.8	56.8	Junction with Brice Creek and Road 2149. Turn left onto Road 2149 and follow the creek downstream.
(51)	0.8	57.6	Here the road is about to pass through a small ridge of very hard rock which causes Brice Creek to make a horseshoe bend. The rock is hard because it is near a large granodiorite intrusion and has been subjected to propylitic or contact alteration. Near the creek, small, light-colored dikes are exposed in the bed rock.
(52)	0.5	58.1	This is the east edge of a large granodiorite intrusion, molten igneous rock which cooled slowly underground before reaching the surface of the earth. Not only was local ground water heated by this intrusion, but it was also changed in chemical composition. Heat from the slowly cooling granodiorite body affected the surrounding country rock, both by direct contact and also by these hot aqueous solutions which circulated throughout the area. These solutions probably produced the major changes in the country rock. The granodiorite was later exposed after cooling by uplift and erosion and can be seen in the roadcut on the left.
(53)	0.9	59.0	On the left, high up on the slope, a granodiorite dike stands up like a wall.
(54)	1.7	60.7	As you cross the Brice Creek bridge, look downstream to the right. When the Oregon Securities Company took over the major mines, it did a great deal of development, including provisions for generating electrical power. A dam was constructed between two rock walls beneath the bridge on which Road 2149 crosses Brice Creek. A flume ran along the north bank of Brice Creek, and you can still see traces of the ditch that carried the water. The dam was removed several years ago by State officials to allow migrating fish to pass. You are at the junction of Champion Creek Road 2259. At this point, the road log returns to Champion Saddle (checkpoint 41). Those wishing to go directly to Cottage Grove from here should instead continue with checkpoint 54 on page 113.

(41) 0.0 47.5 You are back at Champion Saddle. Now take the left fork, Road 2259.

(42) 0.2 47.7 The little open cut to the right is the Champion vein outcrop. Look up and see where the vein crops out on Road 230. The checkpoint number 42 was used for both outcroppings of this vein. As you look down the valley you see a glacial cirque, a steep-walled, half-bowl-shaped recess caused by glacial erosion.

[55] 1.0 48.7 Champion mine and mill. The building (Figure 15) back against the mountain slope is the 1,200-level adit portal house. Do not try to enter; the portal building is in bad shape and the adit is caved in. Take care as you look around.

This mine was discovered in 1892, and a ten-stamp mill was built here in 1895. A thirty-stamp mill operated from 1902 to 1917 under the Oregon Securities Company and the West Coast Mines Company. The mine was idle until the period between 1932 and 1938, when various operators, including the Mahala Mines and the Bartels Mining Companies, produced nearly $100,000 from the Champion. A flotation mill (Figure 12, May 1978 Ore Bin) built in 1939 recovered other minerals in addition to gold, values which would otherwise have been lost.

Some concentrates and ores were shipped intermittently from 1939 until the early 1960's, but since then the mine has been inactive. In 1960 the Champion site still contained many buildings, including a machine shop, blacksmith shop, assay office, portal house, mine office, diesel electric plant, cookhouse, bunkhouse for 75 men, flotation mill, and several smaller buildings. Now only the portal house and mill foundations remain.

Minerals found on the Champion dump include quartz crystals, galena, sphalerite, and hematite. Because ore was transported over a narrow-gage railroad from the Musick mine to be processed at this mill, the ore samples may have come from either mine. From where you stand, the railroad grade looks like a line; the end of the grade has a rock dump downslope. The Musick ore came down to the mill level by tram.

(56) 2.4 51.1 Golden Curry mine. The authors did not find and check this adit; therefore we warn you to stay out of it if you come upon it.

(57) 0.3 51.4 Trixie mine. Stop and look at the two portals on the left, but do not enter. These adits are unsafe: the timber is rotted; and the bank and rock above the portal are ready to cave down. Look and drive on.

(58) 0.4 51.8 The two adits on the left are not safe to enter. The first, about 65 ft deep, was driven along a fault zone. Material from this fault is falling into the portal. At the second, 10 ft deep, large rocks on the floor have fallen from the back (roof). One large rock in the back is ready to join the others on the floor.

The rock along the road is granodiorite containing

Figure 14. Musick mine and Bohemia City, with restored stage house and post office (checkpoint 40). In foreground is covered portal and mine track. Stay out of mine.

Figure 15. Old Champion mine portal house (checkpoint 55).

tourmaline (black) and epidote (green) along fractures.

(59) 0.2 52.0 Downing Point. Two greenhorn miners died here during a snowstorm in the early 1890's.

(60) 0.2 52.2 Bohemia Smith Falls on the right. Here a drunk early-day miner named Bohemia Smith wandered off the trail between Lundpark and the Champion mine, stepped off the edge of a cliff, and fell, landing in a small tree. When searchers found him, he was completely unharmed, holding his jug, and singing merrily. The spot where he fell has been known as Bohemia Smith Falls ever since. This waterfall and several of the others are caused by basalts that have been altered by nearby intruding granodiorite. The contact alteration has resulted in dense, blocky fractured rock which forms erosion-resistant outcrops.

(61) 0.3 52.5 Epidote-rich knots can be found in the volcanic breccia on the left. These knots contain plagioclase, quartz, chlorite, pyrite, and magnetite, and some contain very small, well-formed crystals (Figure 5, May 1978 Ore Bin). Walk back up the road and around the curve to see a vertical fault which has lava flow rock on one side and volcanic breccia on the other.

(62) 0.4 52.9 The rock face on the left at the first curve past Weaver Creek also has epidote knots which contain the same minerals as those at the previous stop, but here the country rock is a volcanic conglomerate rather than a breccia. Breccias have angular fragments, while conglomerates have rounded components. This conglomerate (Figure 3, May 1978 Ore Bin), with subrounded boulders of various types of volcanic rock up to 10 ft in diameter, crops out in Champion Creek below the road curve. To go down to the creek to see this conglomerate, walk past the curve for about 150 ft, and then go down the road outslope.

(63) 1.6 54.5 The start of the old Noonday (Annie) Trail is marked by a sign board. The trail, on the right, goes up the ridge. This was the main route for freight and supplies before Hardscrabble Grade and the Champion Creek Trail were built.

(54) 0.2 54.7 / 60.7 Junction with Road 2149. This stop has been described. The two legs of the tour have joined. We now show two cumulative mileages: the first is for the southwest leg, which followed the Champion Creek; and the second is for the northeast leg, which followed Noonday Ridge. Now turn left onto Road 2149.

(64) 0.3 55.0 / 61.0 Trestle Creek sign on the right. Trestle Creek enters the other side of Brice Creek from the northeast. The name came from the trestle built to carry water from the dam to the powerhouse at Lundpark. A lost gold mine is reported to be somewhere along this creek. By checking the map, you will note that Trestle Creek parallels the granodiorite-country rock contact. Along this creek is a good place to look for mineralization.

65 0.4 55.4 61.4

Hobo campground on the right.

66 0.6 56.0 62.0

Lundpark campground on the right. Lundpark, named after Alex Lundberg and Harry Parker, was an overnight stop on the way to Bohemia. Although nothing remains of the old buildings, Lundpark was once a bustling place. Parker ran the hotel, where nearly all of the men going up the mountain spent the night; Lundberg took care of the barn and warehouse. Freight from the Lundpark warehouse went up to the Champion mine two or three times each week during the summer.

Water from the dam at checkpoint 54 ran a powerhouse (Figure 16) on the north side of Brice Creek. Some of the concrete foundation remains.

67 2.4 58.4 64.4

Cedar Creek campground on the right.

68 2.2 60.6 66.6

Umpqua National Forest boundary sign on the left.

69 2.0 62.6 68.6

Disston store to the right. The town of Disston was the easternmost end of the railroad started in 1902 and completed by the Oregon Securities Company, which controlled the Champion, Musick, Helena, and Noonday mines. A post office was established here in 1906. With the railroad operating, supplies reached the mines in two days instead of three.

You are now back on Row River Road.

70 0.7 63.3 69.3

Junction with Layng Creek road. Turn right onto Layng Creek road for a side trip to a fossil plant location.

71 1.9 65.2 71.2

Forest Service Rujada campground on the right.

72 0.2 65.4 71.4

Forest Service Road 2142 joins Layng Creek road on the left. On the right is the Forest Service Layng Creek Work Center. Turn left onto Road 2142.

73 0.7 66.1 72.1

The Rujada fossil locality (Figure 10, May 1978 Ore Bin). The thin-bedded shale and sandstones exposed on both sides of the roadcut (Figure 17) contain up to 40 recognized types of plant fossils. Lakhanpal (1958) describes the fossil flora in detail.

R. Upton and J. Anderson once established a logging camp nearby. The name "Rujada" is derived from their initials plus "da" for the Department of Agriculture.

This is the end of the side trip. Return to checkpoint 70.

70 2.9 69.0 75.0

Row River road junction. Turn right.

74 2.6 71.6 77.6

La Sells Stewart Park on the right. The sign is almost hidden by trees. The gravel road leading to the park crosses a private logging road that parallels the main road.

The park affords a good view of Wildwood Falls, caused by Brice Creek's effort to erode a basalt flow.

Figure 16. Hydroelectric powerhouse built at Lundpark (checkpoint 66). Only foundation remains today. (Photo courtesy Ray Nelson)

Figure 17. Rujada fossil locality (checkpoint 73).

A dike has intruded the flow, adding to its resistance to erosion. The flat valley floor above the falls is the top of the flow. Look at the stream channel wall downstream from the falls to see how much erosion has occurred. Wildwood Falls Park is on the other side of the creek.

(11)	1.0	72.6 78.6	Sharps Creek Road junction, the starting point of the loop through the Bohemia mining district, on the left.
(8)	4.4	77.0 83.0	Government Road joins Row River Road. Take the left fork and stay on Row River Road. You will now go around the southwest side of Dorena Lake.
(75)	0.5	77.5 83.5	After about half a mile, look northeast across the lake and valley to see Pinnacle Rock (Figure 3) rising above the trees.
(76)	3.3	80.8 86.8	Baker Bay Park on the right.
(77)	2.6	83.4 89.4	Schwartz Park on the right
(1)	4.7	88.1 94.1	Interstate 5, east on-off ramp, the starting and the ending point for the road log.

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LEVYNE IN THE WALLOWAS

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Introduction

The zeolite mineral levyne has been collected in a number of localities in Oregon. The purpose of this article is to report a new occurrence of this and other minerals in the vicinity of Aneroid Lake, Wallowa County, Oregon (Figure 1).

Aneroid Lake lies 6 mi by trail (#1804) from the south end of Wallowa Lake State Park (Figure 2a). Details about the trail are given in "100 Oregon Hiking Trails" (Lowe and Lowe, 1969). Good campsites around the lake are available. The store and cabins are now on private property and should not be used without permission. Current owners of the camp are the Halton Tractor Company, Portland, Oregon. The camp is made available to the Portland YMCA, and several week-long trips to the area are usually organized during the summer. For further information, contact the Metro Office of the Portland YMCA.

Geologic units exposed in the Aneroid Lake area (Figure 2b), from oldest to youngest, are (1) Martin Bridge Limestone (TRmb) - coarsely crystalline, locally metamorphosed Triassic limestone that forms many of the steep walls in the Wallowas; (2) Hurwal Formation (TRh) - Triassic siltstone and mudstone that makes up many of the crests of the Wallowa Mountains; (3) Late Jurassic-Early Cretaceous granitic intrusive rock (JKgd) - light-colored granitic rock ranging in composition from quartz diorite to granodiorite; (4) Columbia River Basalt Group (Tcr) - fine-grained, dark-colored Miocene flood basalt that once cov-

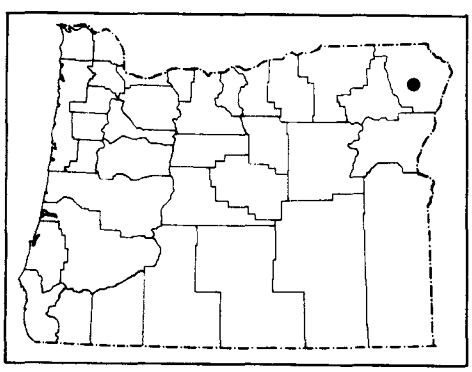


Figure 1. Index map showing location of Wallowa Mountains.

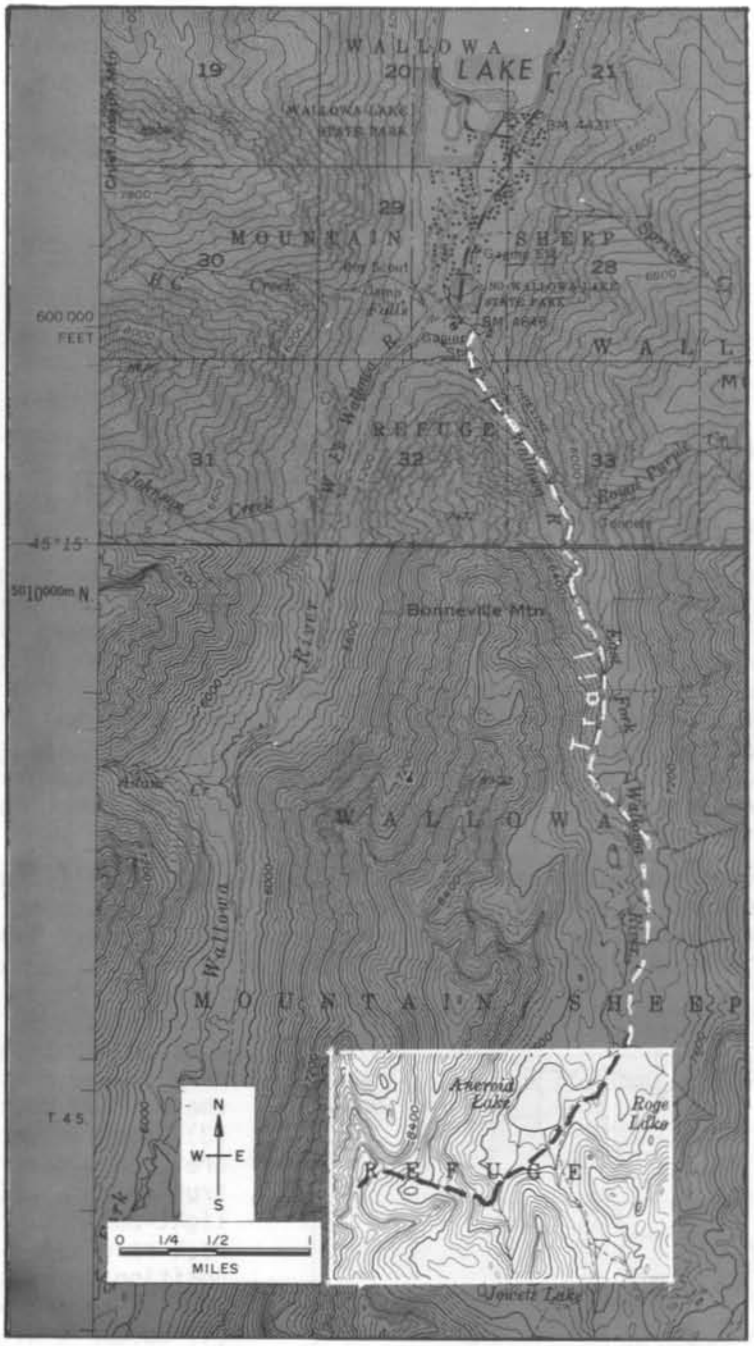
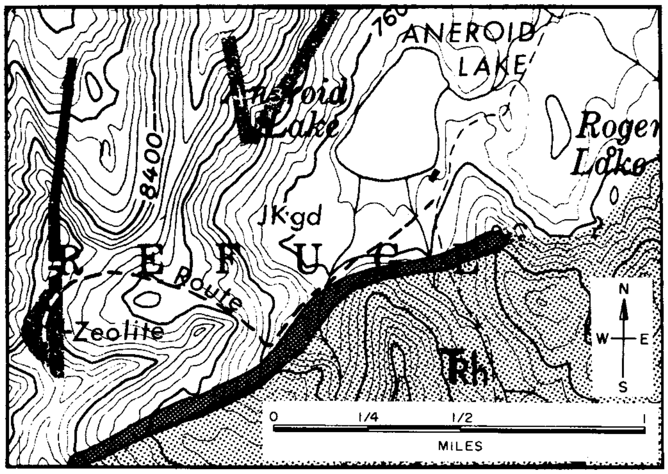


Figure 2a. Trail from Wallowa Lake to Aneroid Lake. See Figure 2b for larger scale map showing geology of Aneroid Lake area.



LEGEND

Tcr - Columbia River Basalt Group

JKgd - Quartz diorite or granodiorite

TRh - Hurwal Formation

TRmb - Martin Bridge Limestone

--- Route to levyne locality

Figure 2b. Geology of Aneroid Lake area. Geology from Smith and Allen (1941). Levyne is found in Columbia River Basalt outcrop southwest of Aneroid Lake; garnets occur in Martin Bridge Limestone south of Aneroid Lake. Note that it is necessary to leave trail on southeast side of Aneroid Lake and go cross-country via recommended route to reach zeolite locality.

ered the entire region and now remains as cover for some Wallowa peaks. Columbia River Basalt feeder dikes occur in the mountain west of Aneroid Lake and elsewhere in the Wallowas.

The ridge to the west of Aneroid Lake is composed of granitic rock that has been intruded by dikes and at one time was covered by basalt of the Columbia River Group. Several of the surrounding peaks, such as Aneroid Mountain to the east, are composed of Columbia River Basalt. South of Aneroid Lake and extending up to Tenderfoot Pass are rocks of the Martin Bridge and overlying Hurwal Formations.

Locations of Minerals

Garnet and other minerals

Garnet-rich Martin Bridge Limestone is exposed on the slopes at the top of the meadow at the southern end of the lake and can be traced westward up toward the ridgetop above Jewett Lake and eastward across the ridge behind the cabins to a point near the south end of Roger Lake. The unit is several feet thick and dips steeply. The coarsely crystalline limestone is liberally sprinkled with crystals of grossularite garnet (Figure 3). Most of the garnets are opaque and irregular in form, but in some places sharp dodecahedral crystals can be found. Some of the garnets are an inch or more in diameter. In addition, diopside and blue

Figure 3. Dodecahedral grossularite garnet crystals found south of Aneroid Lake in Martin Bridge Limestone. Bar = 0.25 in.

calcite with clear, honey-brown garnet crystals have been found above Jewett Lake.

Several old mine tunnels are located near the Martin Bridge Limestone in the meadow and along the ridge to the east. The tailings show stains of malachite, which has apparently altered from disseminated grains of chalcopyrite and chalcocite. The Martin Bridge Limestone also contains considerable vesuvianite near the tunnels above the trail going south from Aneroid Lake to Tenderfoot Pass.

Levyne

Levyne is found in vesicles in Columbia River Basalt occurring on the very crest of the ridge to the west of the small, unnamed lake southwest of Aneroid Lake. This area lies about 1,200 ft above the camp area, at an elevation of almost 9,000 ft above sea level (see Figures 2a and 2b). From this ridge, the view of the Aneroid and Roger Lakes basin, the West Fork lake basin, and all the surrounding peaks is truly spectacular. There is no trail to the ridgetop, so the easiest route to it is to leave the main trail, go through the private cabin area and across the meadow at the south end of Aneroid Lake, following the central stream south and taking the canyon to the west. From there, go up along the face of the portion of the ridge to the left of the waterfall, across the unnamed lake basin, and up a short scree slope to the top. The zeolite area is some distance south from the saddle along the top of the ridge, in rock at the base of a 12-ft-high "tower" (Figure 4).

Various zeolites, including thompsonite, chabazite, apophyllite, cowlesite, stilbite, and levyne, are found in vesicles in the basalt. Some occur as amygdules; most of the cavities are filled or lined with fibrous thompsonite, on top of which may be crystals of chabazite. There is no thompsonite lining, however, in the cavities in which levyne occurs. Chabazite crystals associated with stilbite and calcite crystals covered with thompsonite line cracks and cavities in the nearby rocks.

Levyne

Levyne (or levynite) is a calcium aluminum silicate of the chabazite group with the formula $Ca[Al_2Si_4O_{12}]\cdot 6H_2O$ (Deer and others, 1963). Members of the chabazite group all have a similar atomic structure in the form of a framework of silicon aluminum oxide arranged in two types of structures: (1) 6-fold rings that form hexagonal prisms and (2) larger, cagelike 8- or 12-fold rings. The various types of zeolites differ in the order of stacking of these units. The chabazite group, including chabazite, gmelinite, and levyne, all crystallize in the rhombohedral system, but because of the subtle differences in internal structure, their crystal habits are quite different. Chabazite typically forms rather simple rhombohedrons; these "pseudo-cubes" make identification rather easy (Figure 5). Gmelinite also forms equant crystals, but with considerably more faces present. Levyne crystals are almost always tabular, with well-developed basal faces, which often give the crystals a bladelike appearance.

Levyne was first collected from the Faroe Islands in 1825. It has also been found in northern Ireland; Table Mountain, Colorado; Kamloops, British Columbia; and several places in Oregon, especially Ritter Hot Springs and a site along Beech Creek, north of Mt. Vernon (Figure 6). Crystals from these last two locations typically form thin blades occurring in basalt vesicles. They are white because of a surface coating of a thin, fibrous layer of another zeolite, offretite (White, 1975).

When levyne from the Aneroid Lake area occurs within a cavity, it is the only mineral present within that cavity, with no evidence of the thompsonite coating that fills neighboring vesicles and forms a base layer in those vesicles containing chabazite. The levyne crystals are clear and uncoated; their habit, while tabular, is not bladelike, but considerably more equant (Figure 7). The crystals are up to 1 mm thick and are clustered so that only a few faces of each crystal show. The habit resembles that of the crystals from the Faroe Islands, reported by Goldschmidt (1918), rather than those of the Ritter and Beech Creek locations.

Figure 4. View looking west across meadow south of Aneroid Lake to zeolite locality. Best way to ridge is marked by dashed line. Levyne and other zeolites occur in basalt "tower" in center, directly above waterfall.

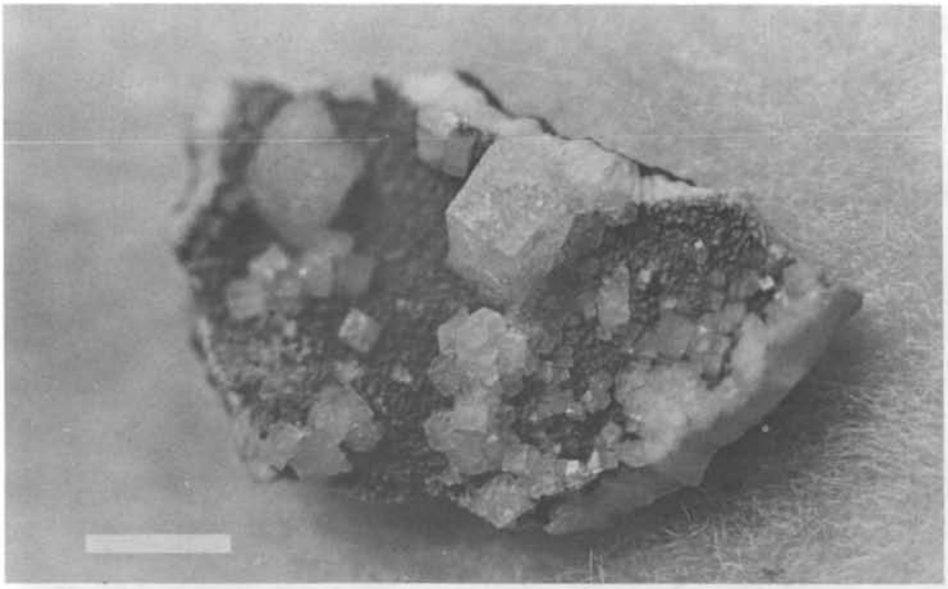


Figure 5. Rhombohedral chabazite from Aneroid Lake area, Wallowa Mountains, Oregon. Bar = 0.25 in.

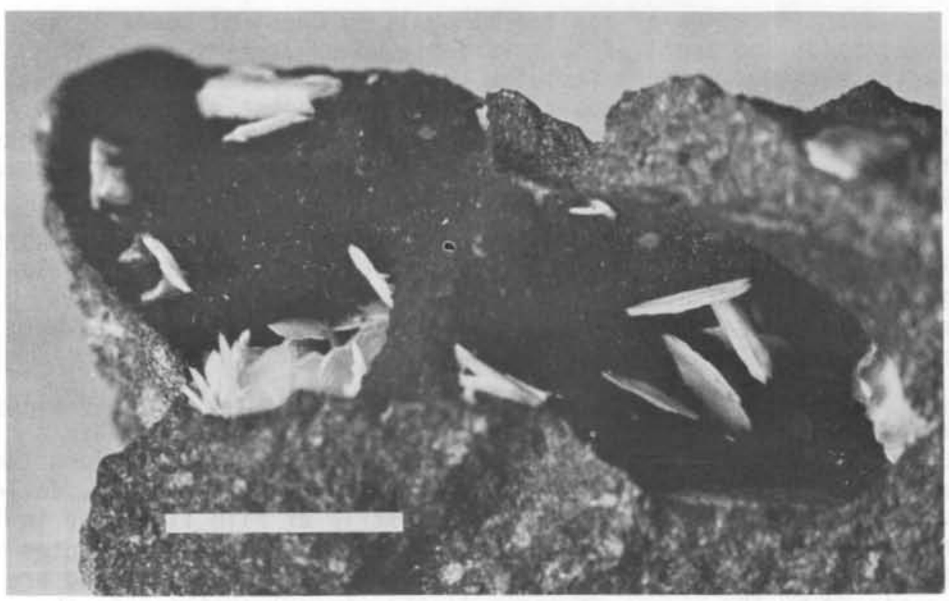


Figure 6. Levyne with covering of offretite. These crystals were found at Beech Creek, Oregon. Bar = 0.25 in.

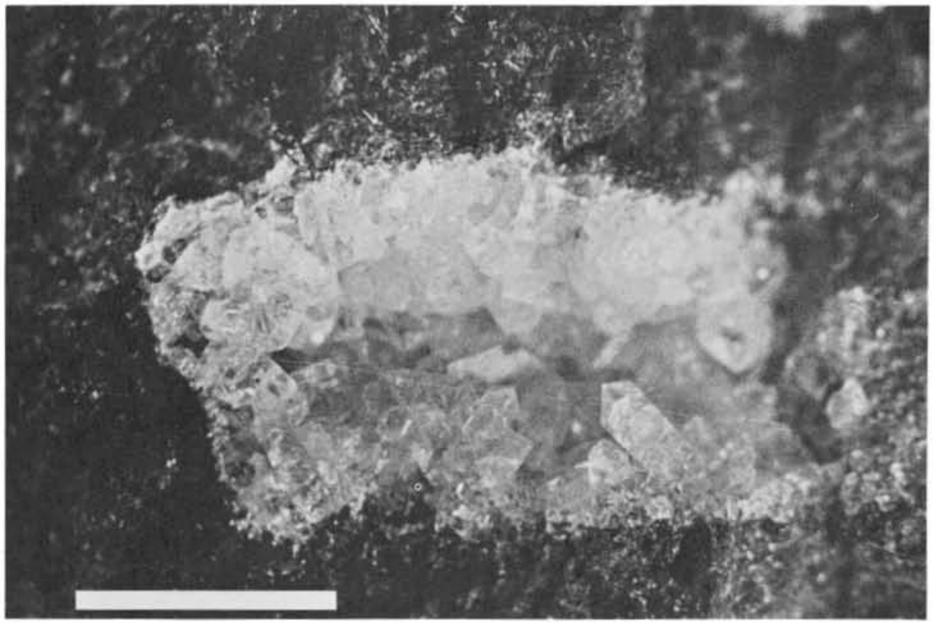


Figure 7. Levyne crystals from Aneroid Lake area, Wallowa Mountains, Oregon. Bar = 0.25 in.

Method of Identification

Identification of zeolite minerals by chemical means is not practical. The zeolites have variable water content and can easily exchange cations (calcium replaced by sodium, for example). Moreover, the ideal composition of most zeolites is very nearly the same, in both quantity and quality. Since differences between these minerals are basically structural, it is by crystallographic means that they can be distinguished.

The zeolite minerals from this location were identified using X-ray techniques. The method, often referred to as powder analysis (Hurlbut, 1971), has the double advantage that only a few milligrams of sample are required and the sample need not be a single crystal.

The sample is ground very fine and made into a tiny rod using a non-crystalline binder such as model cement. A glass fiber coated with grease can also be used. The rod is mounted along the axis of a cylindrical metal housing, 36 cm in circumference, called a Debye-Sherrer camera (Figure 8). A strip of film lines the interior of the cylinder. X-rays of a particular wavelength enter from one side (in Figure 8, the left), strike the sample, and are scattered by the planes of atoms in the mineral grains onto the film. The sample is slowly rotated so that the reflecting planes of atoms will all be brought into position to scatter X-rays.

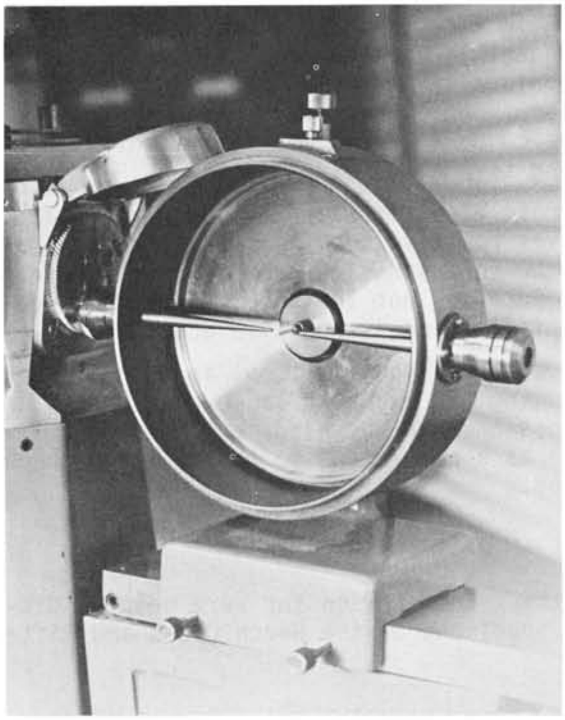


Figure 8. Debye-Scherrer camera in position on X-ray machine. Sample is mounted on rod in center of camera; strip of film lines interior of cylinder; X-rays enter camera from left via collimator, strike sample, and are scattered by planes of atoms in sample to various portions of film. See Figure 9 for pattern produced on film by levyne sample.

The film, when developed, shows a set of circular bands (Figure 9). From the known dimensions of the camera, the scattering angle corresponding to each band can be calculated; and these, together with X-ray wavelength, are used to calculate the separation between planes of atoms in the sample.

The set of interatomic plane separations, together with their relative ability to scatter X-rays, as estimated from the degree of darkening on the film, serves as a kind of "fingerprint" for any particular mineral. A card file of these patterns has been published by the American Society for Testing Materials (ASTM).

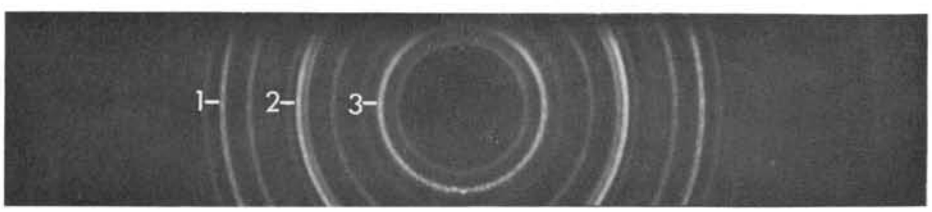


Figure 9. X-ray scatter pattern from levyne. This positive print was made from negative of film placed inside camera housing. Mineral identification is normally made directly from negative. Rings labeled "1," "2," and "3" were used in primary identification.

To aid in comparison, the ASTM file is indexed according to the spacings of the three strongest lines, and these have been collected especially for the naturally occurring chemical compounds. Once a possible fit to these three lines has been located, the full set of spacings can be compared for a complete identification or to distinguish among several candidates.

The powder method is most effective for noncubic materials. However, while it often gives positive identification from a small amount of material, it can be confusing if more than one mineral is present in the sample. Such was not the case with the levyne from Aneroid Lake; the identification is positive and unique.

Though X-ray analysis can be a powerful tool in identification, it is also time-consuming (an exposure of several hours, followed by reading and cross-checking by hand) and therefore expensive. It often serves as a complement to physical and chemical means of identification.

Acknowledgment

The author wishes to thank Paul Lawson for very helpful discussions and for providing specimens of the Beech Creek and Ritter levyne.

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* * * * *

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QUARTZ IS SYMPOSIUM TOPIC

The Pacific Northwest Chapter of the Friends of Mineralogy has scheduled its 4th Annual Northwest Mineral Symposium for Saturday, September 30 and Sunday, October 1 at the Ramada Inn South, Portland.

Among the speakers will be Paul Seel, Si Frazier, and Lanny Ream. The conference theme will be quartz and associated minerals.

Those attending will enjoy excellent displays of minerals and will have the opportunity to meet and enjoy conversation with such recognized dealers as Si Frazier, Dwight Weber, and John Metteer.

For details and registration forms, write to:

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* * * * *

NUCLEAR PLANT SITES SUBJECTS OF OPEN-FILE REPORTS

In January 1978 the State of Oregon Department of Energy requested the Department's assistance in evaluating geologic information relating to the Trojan nuclear power plant site to determine whether any recently recognized facts relate to the safety of temporary spent fuel storage or plant operations.

The Department prepared the 42-page Open-file Report 0-78-1, "Geologic Hazards Review, Trojan Nuclear Power Site, Columbia County, Oregon."

The procedure embraced data collection, identification of plausible hazards, interpretation of data and geologic analysis, and summarization of findings with development of conclusions and recommendations. The final report includes a lengthy reference list.

To receive a copy of 0-78-1, write to the Department's Portland Office. The price is $4.00.

The U.S. Geological Survey and Portland General Electric Company have conducted further studies since the 1974 Pebble Springs nuclear plant site was reviewed. 0-78-2, "Supplement to the February 11, 1974, Pebble Springs Review," discusses items raised since the 1974 report was made.

The 1872 earthquake; additional information regarding the effect of explosive volcanic activity in the Cascade Mountains; the April 12, 1976, Deschutes Valley earthquake; and recent studies by Shannon and Wilson, consultants for Portland General Electric Company, are subjects considered in this open-file report.

Department geologists conclude that design standards for the Pebble Springs plant are adequate; but the Department reserves the right to reassess geologic hazards as new data become available.

V.C. Newton, Jr., and N.V. Peterson wrote the "Supplement to the February 11, 1974, Pebble Springs Review"; J.D. Beaulieu was the editor.

O-78-2 is priced at $3.00 and is available at the Department's Portland Office.

* * * * *

MATSON NEW GENERAL MANAGER OF HANNA NICKEL MINE AND SMELTER

Early this year, Robert P. Matson, General Manager of the Hanna Domestic Iron Ore Division at Hibbing, Minnesota, since 1971, became General Manager of the Nickel Division Headquarters in Riddle, Oregon. E.J. Maney, Nickel Division General Manager since 1967, was transferred to Hibbing as Domestic Iron Ore Division General Manager.

The Hanna Domestic Iron Division is responsible for the operation of four U.S. iron ore pellet projects and a pellet project at Capreol, Ontario, Canada.

The Nickel Division operates the Hanna Nickel Mine and Smelter near Riddle and the Silicon Division at Rock Island, Washington. The Nickel Mountain Mine and Smelter, in Douglas County about 5 mi west of Riddle, employs about 600 people. The only nickel mine in the United States, Nickel Mountain Mine produces about 9 percent of the national nickel consumption and is the most important metal mine in Oregon. The smelter produces ferronickel alloy averaging about 50 percent nickel.

* * * * *

1977 MINERAL OPERATIONS INCOME SET RECORD

U.S. Geological Survey estimates indicate that royalties collected in 1977 from production of oil, gas, coal, potash, phosphate, and other minerals on Federal and Indian lands exceeded $1,250 million, topping the previous record set in 1976 by $227 million.

Of the total royalties collected during 1977, more than 69 percent, or $859 million, accrued from oil and gas production on the Outer Continental Shelf; $848.9 million came from production in the Gulf of Mexico; and $10.1 million was from offshore California production. The increase in royalties is due primarily to the increase in oil and gas prices.

At the year's end, 128,000 oil and gas leases covered more than 104.5 million acres of public, acquired, Indian, military, and Outer Continental Shelf lands.

From more than 14,800 producible leases, 1977 production is estimated to have been 551 million barrels of crude oil and gas liquids plus 4.8 trillion cubic feet of marketed gas, together valued at more than $7.7 billion. This represents about 24 percent of the marketed gas and 18 percent of the total crude oil and gas liquids produced in the United States during the calendar year. Compared to 1976 production, this is a decrease of 18.0 million barrels of crude oil and gas liquids and an increase of 17.8 billion cubic feet of gas.

The Outer Continental Shelf portions of these totals are 2,089 leases, covering more than 9.8 million acres. OCS production from about 860 producible leases is estimated to be 351 million barrels of crude oil and gas liquids and 3.6 trillion cubic feet of marketed gas, valued at more than $5.4 billion. This represents about 18 percent of the marketed gas and 12 percent of the total crude oil and gas liquids produced in the United States during the calendar year.

Estimate of the total value of coal, potash, sodium, phosphate, and other minerals mined from leased Federal and Indian lands during the year is $1,140 million. More than $56 million royalty was collected on this production.

Royalties accruing from mineral leases supervised by the U.S. Geological Survey are ultimately credited to the States, Indians, the Reclamation Fund, the Land and Water Conservation Fund, and the U.S. Treasury.

* * * * *

REGISTRATION REMINDER

Qualified practicing geologists may be licensed without examination by applying to the Department of Commerce, Board of Geologist Examiners, 403 Labor and Industries Building, Salem, Oregon 97310. Applications must be received before September 30, 1978.

* * * * *

CORRECTION

In the article, "A Geological Field Trip Guide from Cottage Grove, Oregon, to the Bohemia Mining District" (ORE BIN, June 1978), the following corrections should be made:

1. Page 94, checkpoint 6, line 2. "Government Road" should be changed to "Row River Road."
2. Page 94, checkpoint 8, line 1. "Row River Road" should be changed to "Government Road."
3. Page 103, checkpoint 36, line 9. "California" should be changed to "Defiance."

CLASTIC DIKES IN SOUTHEASTERN OREGON

Norman V. Peterson, District Geologist
Grants Pass Field Office
Oregon Department of Geology and Mineral Industries

A group of clastic dikes are present in a cinder-scoria deposit about 2 mi south of U.S. Highway 20 southwest of Hines, Oregon (NW 1/4 sec. 2, T. 24 S., R. 30 E.). The clastic dikes exposed in the quarry vary from a few inches to 18 in. in width and have crude vertical as well as horizontal layering. The material is pumiceous, tan to almost white, and ranges in size from fine ash to pumice lumps as large as 1 in. in diameter.

At least five dikes trend in a northwest-southeast direction and can be traced for several hundred yards. Clastic dikes of similar material cut through layered pumice on the north side of Highway 20 at the same general northwest-southeast trend.

The dike material appears to be of the same composition as the overlying layered pumice described as <u>Tsv</u> by R.C. Greene and others (1972). ". . . pumice and pumiceous sedimentary rocks, light brown to white, slightly to moderately well consolidated;

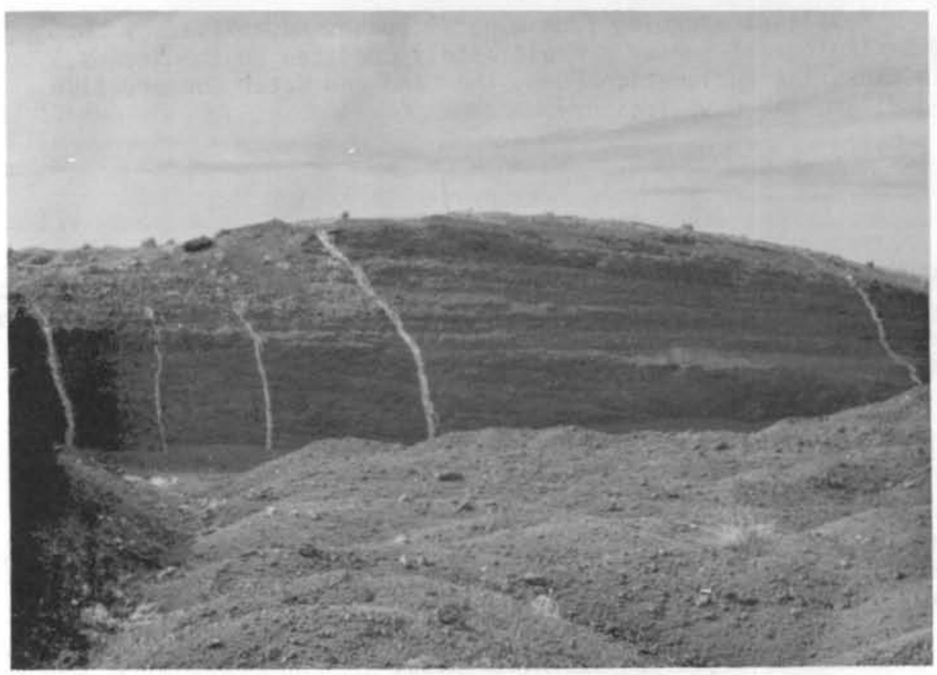

Figure 1. Clastic dikes found in cinder-scoria quarry southwest of Hines, Oregon. Dikes trend northwest-southeast and can be traced for several hundred yards.

Figure 2. Clastic dikes range in thickness from a few inches to 18 in. and contain pumiceous material.

ash flow tuff with abundant lump pumice, in part densely welded. Present on south side of Burns Butte, T. 23 S., R. 30 E."

The dikes must have been emplaced very soon after the layered pumice was deposited, as the pumice lumps and the glass shard ash are angular and fresh looking.

The length, width, and continuity of the fractures which these dikes filled certainly suggest tectonic origin. Tensional forces from doming may have opened the fractures. Mechanism for dike emplacement is not apparent, although it appears that the clastic material came in from above.

The elevation of about 4,160 ft is about 200 ft lower than Pleistocene sedimentary deposits of the Harney Basin, so it is possible that the dikes could have developed in a hydrous environment. The dikes are younger than the Pliocene sediments they cut, but no more about their age is known.

Reference:

Greene, R.C., Walker, G.W., and Corcoran, R.E., 1972, Geologic map of the Burns Quadrangle, Oregon: U.S. Geological Survey Misc. Geol. Inv. Map I-680.

GEOTHERMAL SPECIALIST JOINS STAFF

Joseph F. Riccio

Joseph F. Riccio assumed the position of Geothermal Specialist on the Department's Portland staff in May 1978.

Riccio is a graduate of the University of Southern California, where he earned his Ph.D. degree in 1965.

From 1955 to 1970 Riccio was President and Chief Engineering Geologist of Pacific Soils Engineering, Inc., Harbor City, California. He has had prior geological experience with Rothchild Oil Company, Santa Fe Springs, California, and International Petroleum, Bogata, Colombia. Between 1970 and 1976 he was a consulting geologist in Alabama and California.

In 1976 Riccio became Geothermal Development Manager of the Public Service Department for Burbank, California, with responsibility for the city's geothermal program. "Site-Specific Analysis of Hybrid Geothermal/Fossil Power Plants," a study dealing with evaluation of hybrid power plants which combine geothermal and coal energy, is an Energy Research and Development Administration (ERDA) publication to which Riccio contributed research.

Currently, he is involved in the geothermal resource assessment of Mt. Hood volcano and the statewide low temperature geothermal resource evaluation for the Department.

* * * * *

OIL AND GAS SURETY BONDS FOR DRILLING INCREASED

July 1, 1978, the Department issued a temporary rule to amend Chapter 632, Oregon Administrative Rule 10-010. The amendment raises the surety bond for drilling oil and gas wells from $4,000 to $10,000.

This increase is necessary to make coverage commensurate with current drilling costs. The bond requirement for geothermal wells was set by statute at $10,000 in 1973.

Anyone desiring a copy of the amended rule may write to the Department's Portland Office.

* * * * *

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MOUNT BAKER'S CHANGING FUMAROLES

Eugene P. Kiver
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Introduction

On March 10, 1975, a dark fume cloud rising a few hundred meters above the subsummit crater (Sherman Crater) of 3,286-m-high (10,781-ft-high) Mount Baker (Figures 1 and 2) in the North Cascade Mountains of Washington generated considerable concern among scientists, government officials, and local residents (Frank and others, 1977; Kiver, 1975; Malone and Frank, 1975; and Rosenfeld and Schlicker, 1976). The substantial increase in gas volume, temperature, and certain gaseous components makes Sherman Crater one of the more interesting fumarolic areas in the conterminous United States.

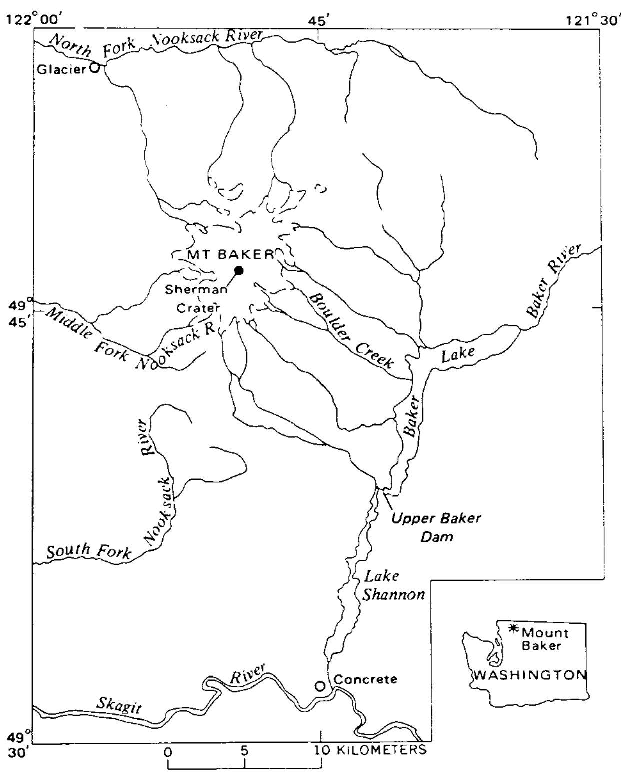

Figure 1. Index map of Mount Baker, Wash. (Reprinted from Frank and others, 1977)

Because no significant additional volcanic manifestations have occurred since 1975, the intense concern over the mountain's immediate future has subsided. Nearby reservoirs have been raised to normal levels and most restrictions on public use of the area have been removed.

The present

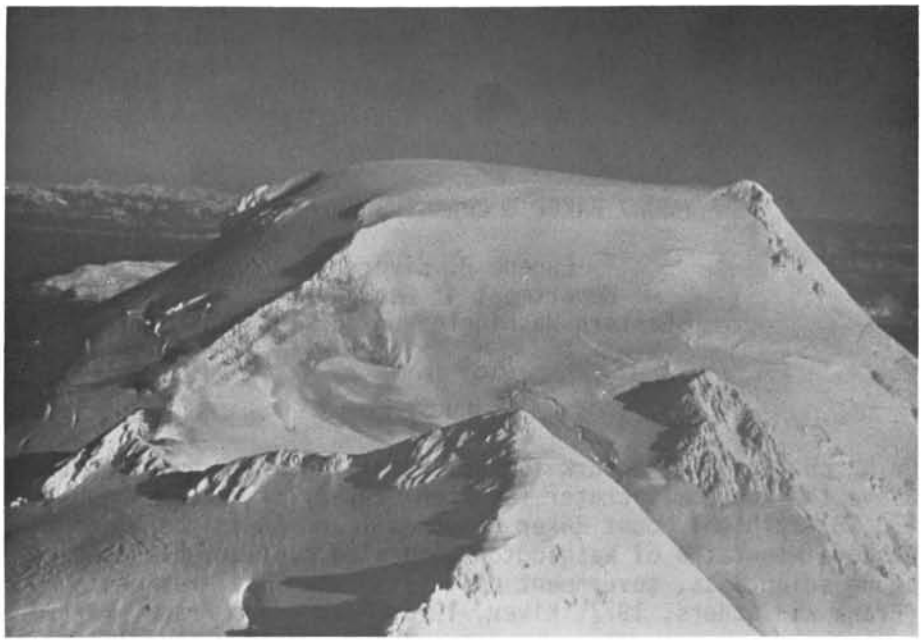

Figure 2. Sherman Crater viewed from south in March 1975. Note vapor plumes from west rim (left) and East Gap areas. Summit crater is ice filled and thermally inactive.

activity, however, could yet prove to be a pre-eruptive phenomenon. Even if the volcano does not erupt, continuing shifts in fumarole location and the elevated level of thermal activity have greatly increased the probability of large, destructive mudslides and avalanches.

A geothermal ice cave and fumarole study initiated in 1974 in Sherman Crater and continued to the present enables documentation of some of the physical and chemical conditions before and after the March 1975 event. The knowledge and experience gained at Mount Baker should prove useful in evaluating future thermal manifestations from Mount Baker and other dormant volcanoes in the Cascade Mountains of both Washington and Oregon.

Fumarolic Activity, Pre-1975

No doubt Mount Baker's fumaroles have been active since at least the 1840's, when relatively reliable accounts indicated minor eruptive activity. Gibbs (1874) noted that since the 1843 eruption, ". . . smoke is frequently seen issuing from the mountain." Whether the reference to "smoke" indicates fumarolic vapor or the more violent but minor eruptive activities of 1846 (Plummer, 1893), 1854, 1858, 1859, and 1870 (Davidson, 1885) is not clear. E.T. Coleman's party, during the first successful ascent of Mount Baker in 1868, and subsequent climbing groups reported sulfurous fumes and fumarolic activity in Sherman Crater (Coleman, 1869).

By 1940, when the first vertical air photos of Mount Baker were taken, fumarole activity had increased over the late 1800-early 1900 level (Frank and others, 1977). In the 1940 photographs, fumarole vents and ice cave entrances were apparent on the west and northwest rim, and sub-ice fumaroles had melted an estimated 1,220 m (4,000 ft) of ice cave passages at the base of the crater ice fill. The largest fumarole was at the base of an ice pit 20 to 30 m (65 to 100 ft) deep near a crater rim breach called the East Gap.

Air photos taken during the period from 1940 to 1974 show additional snow melt areas, indicating an increased heat flux. The largest change occurred in the southwest part of the crater, where an ice pit 46 m (150 ft) deep and 32 m (110 ft) wide appeared some time between the 1960-63 airphoto flights (Figure 3).

In August 1974, maximum fumarole temperatures were at the boiling point of water (89-90°C) for this elevation of 2,950 m (9,650 ft). Volcanic gases were measured with commercially available detector tubes in which a known quantity of gas is pumped through a glass tube filled with chemical reagents. The length of the colormetric reaction of the reagents is proportional to the amount of a specific gas in the sample after pressure and temperature corrections are made. The results are reproducible to within ± 10 percent. In 1974, the CO_2 content of gases taken from the west rim fumaroles measured 19 percent; H_2S content was 0.0074 percent.

Recent Fumarolic Activity

An estimated tenfold increase in heat flux in March 1975 was accompanied by the appearance of new, superheated fumaroles (maximum measured temperature 131°C), numerous cooler fumaroles, a fallout layer of dust from a new vent in the East Gap, a doubling of CO_2, a thousandfold increase in H_2S, and considerable melting of the crater ice fill (Figures 4 and 5). Any one of these changes could be a precursor to a true magmatic eruption. The grey dust cloud in early 1975 was associated with an enlarging steam vent in the East Gap. The ash and pumice fragments ejected are now regarded not as new magmatic material but as older debris torn from the enlarging vent wall (Frank and others, 1977).

The enlargement of the sub-ice cave system (Figure 6) and the crevassing and collapse of the crater ice fill proceeded rapidly during 1975 (Figures 7 and 8) but subsequently slowed as ice came into equilibrium with the new thermal conditions. Occasional major shifts in fumarole location are still occurring and can cause some new adjustments in the ice fill. The present trend seems to involve increasing fumarole activity on the west rim (Figure 9) at

Figure 3. Southwest ice pit that appeared between 1960 and 1963. Large fumarole at base increased in intensity in 1975 but had moderated greatly by summer of 1977. (Photo courtesy Fred Munich)

Figure 4. East Gap superheated fumaroles building sulfur cones. Small puddle of molten sulfur was found just inside vent in foreground. (Photo courtesy Fred Munich)

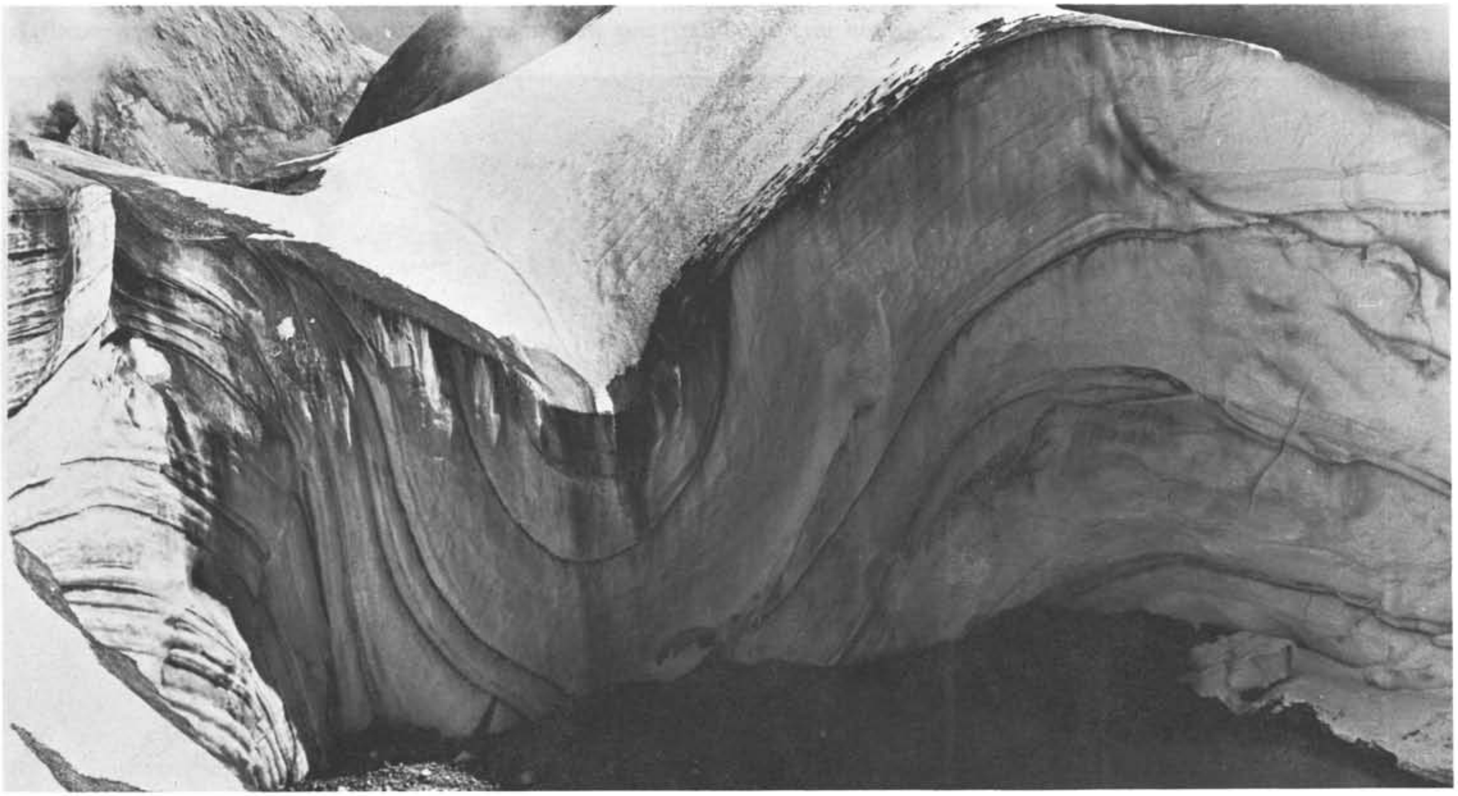

Figure 5. Crater lake and large ice pit generated by increased fumarole activity in 1975. Lake is 40 x 60 m (130 x 200 ft) long, 1 m (3 ft) deep, and has water temperature of 20°C. Water flows through syphon at base of ice wall into East Gap beyond. Increased melting produced rapid subsidence and synclinal form in dark, annual accumulation layers on 27-m-high (89-ft-high) ice wall. (Photo courtesy Fred Munich)

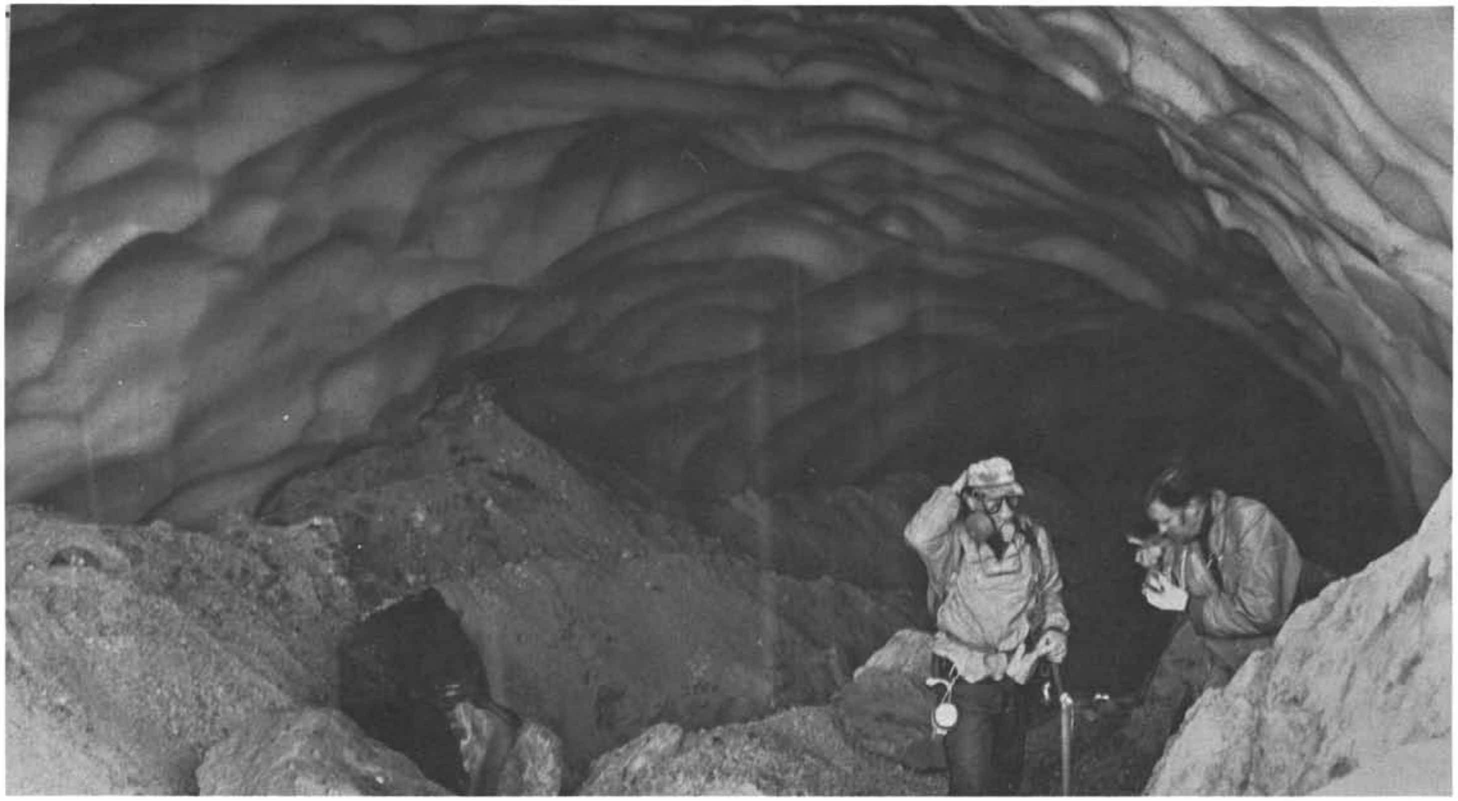

Figure 6. Geothermal ice cave entrance along west rim of Sherman Crater. Fluted ice walls and ceilings and bedrock or rubble floors are typical. Gas masks are necessary for prolonged exposure to sulfur and CO_2 atmosphere. Increased heat flux enlarged cross-sectional area of cave passages approximately 20 percent. (Photo courtesy Fred Munich)

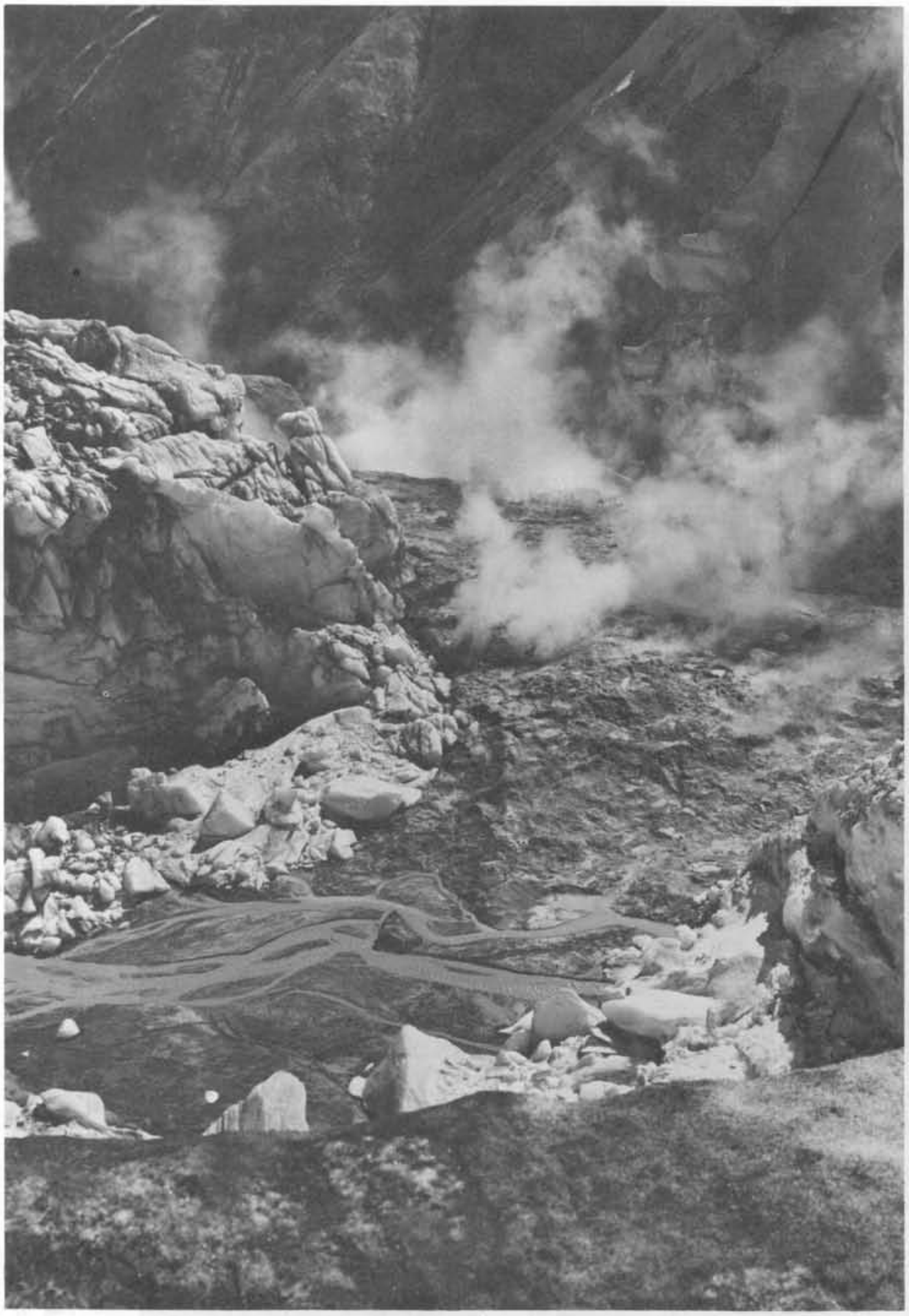

Figure 7. East Gap area in 1975 as large new fumaroles melt away east edge of crater ice fill. (Photo courtesy Fred Munich)

Figure 8. Large, superheated fumarole (T. > 110°C) developed in 1975 under glacier on northwest side of crater, creating large ice pit that enlarged in 1976. Overhanging ice collapsed in 1977, and ice blocks buried east side of crater. (Photo courtesy Fred Munich)

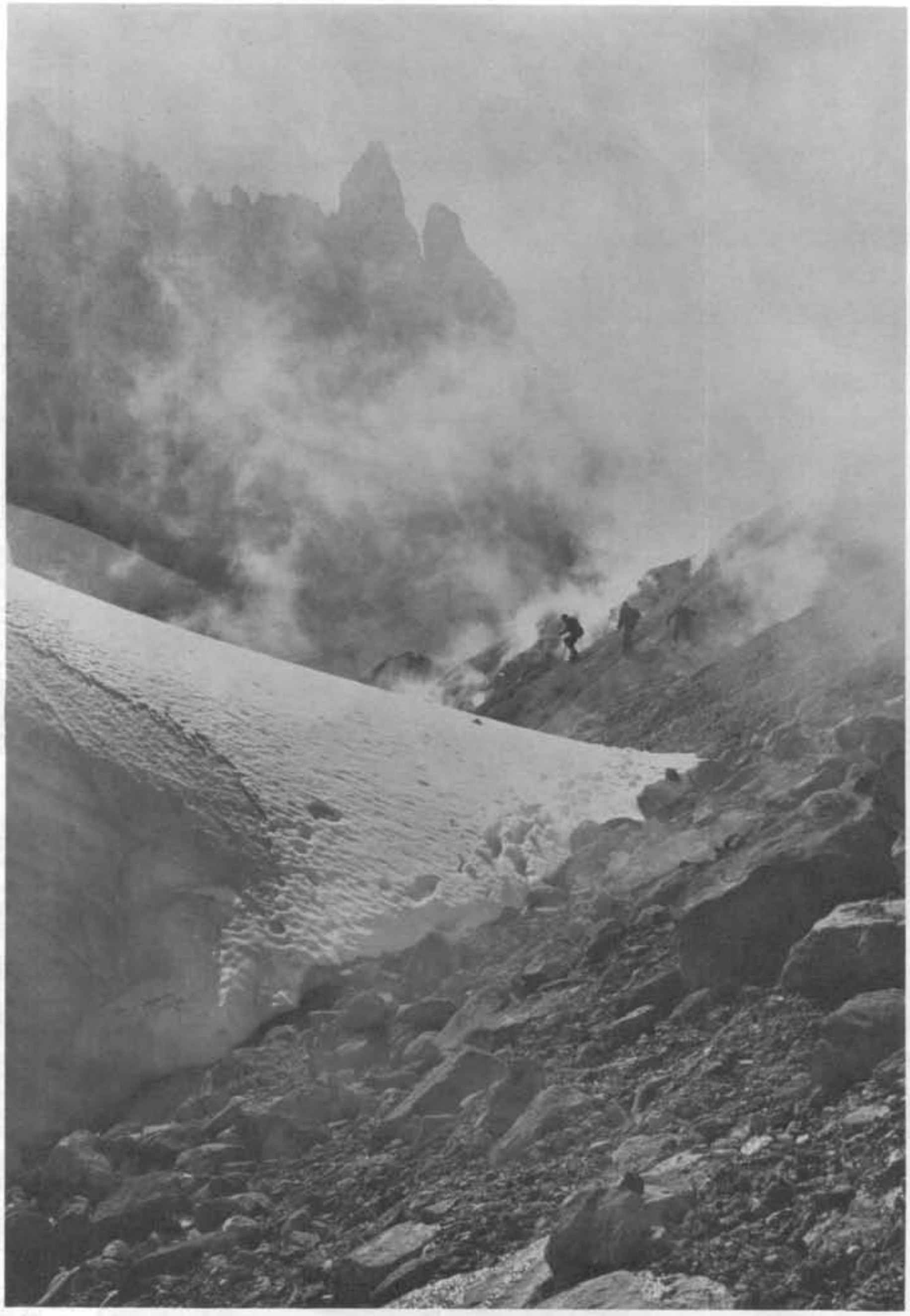

Figure 9. View south along part of west rim of Sherman Crater. Some shifting of thermal energy from other fumarole areas to west rim occurred in 1977. (Photo courtesy Fred Munich)

the expense of fumaroles in the central vent (crater lake) and perhaps the East Gap areas. Total gas volume from Sherman Crater since March 1975 appears to be unchanged.

The most recent change was first noted during a March 1978 overflight. At the time of this printing, steam is discharging violently from a new vent system along the northwest rim of the crater where only small fumaroles formerly existed. Although discharge has fluctuated during the past few years, the total gas has remained well above 1974 levels and shows no signs of decreasing.

Volcanic Gas Composition

Increases in concentration of sulfur and other gases can be ominous signs preceding major eruptions (Tonani, 1971). Dramatic increases in concentration occurred from August 1974 through early September 1975 in at least the west rim fumarole field. The concentration of CO_2 by volume nearly doubled, and H_2S increased over 1,000 times (Figure 10). Using airplane-mounted instruments, Radke and others (1976) measured a 3.7-fold increase of gaseous sulfur in the steam plume between March 27 and June 30, 1975. With an emission of 4,680 kg (10,300 lb) per hour, Mount Baker became one of the largest sulfur polluters in the Pacific Northwest.

The 1976 and 1977 analyses show a reduction and leveling off of CO_2 and H_2S (Figure 10), suggesting that the volcano is now less likely to erupt than seemed possible earlier. However, gas concentrations remain substantially above the 1974 level and should continue to be monitored.

Some Conclusions and Observations

(1) Small increases in thermal activity preceded by many years the 1975 steam eruption at Mount Baker. Similar types of changes on other Cascade volcanoes, if recognized, might give considerable warning of an impending volcanic event.

(2) Eruptions from at least some of the Cascade volcanoes in Washington and Oregon are inevitable. Long-term detailed geochemical and geophysical studies of all dormant Cascade volcanoes should be initiated so that repose conditions can be better understood and changes that may later prove to have predictive value can be recognized.

(3) The meaning of the increased thermal activity that began in March 1975 on Mount Baker is still unclear. It may have been a pre-eruptive signal, but its true significance may not be realized for many years.

(4) Considerable shifting of vent locations in the crater has occurred since 1975. These dramatic changes are apparently

MOUNT BAKER, WEST RIM
MAXIMUM CO_2 AND H_2S CONCENTRATION

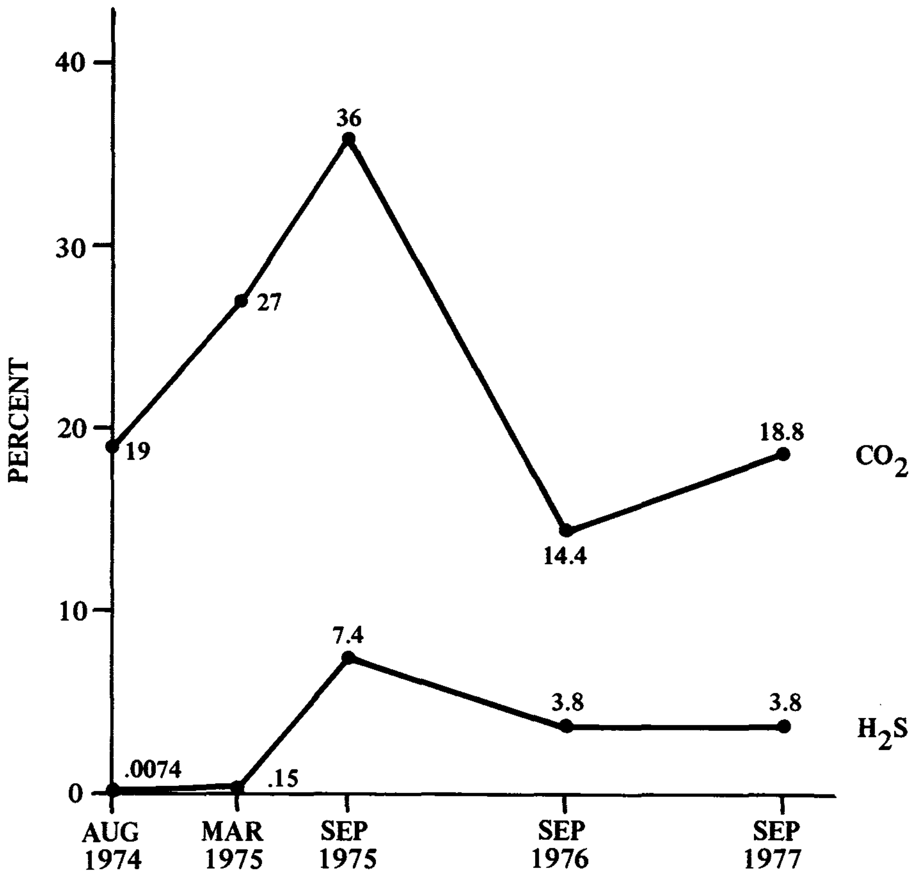

Figure 10. Hydrogen sulfide and carbon dioxide concentrations, 1974-1977.

related to gases finding new pathways through the highly fractured, altered rock in the crater area. This type of change, as well as apparent changes in visible steam emission that accompany cold weather conditions, have no relation to the volcano's eruptive potential.

(5) Floods and mudflows are the most common geologic hazards associated with volcanoes of the Cascade Mountain type, both in Washington and in Oregon. Mudflows are mixtures of water and debris that can move at more than 80 km (50 mi) per hour on steep slopes and cover the valleys below in a matter of minutes. Mudflows are sure to occur in a true eruption but can also be triggered during noneruptive phases by earthquakes, landslides, and steam activity.

The highly altered rock, oversteepened slopes, and abundance of meltwater in the crater area create an ideal situation for generating destructive mudflows. The shifting fumarole activity suggests structurally weak rock and sediment that could be water-saturated and capable of rapid, catastrophic movement.

(6) As man makes increasing use of land surrounding Mount Baker and the other Cascade volcanoes, it becomes imperative to recognize the potential hazards associated with these giant volcanoes and use the surrounding lands in such a way that losses in life and property will be minimized.

Acknowledgments

Sincere thanks to the Explorers Club, Mazamas, and National Speleological Society for their financial assistance and to Rod Barcklay, Gerard and Trudie Bloem, Ernest Gilmour, Steve Harris, Roger Hughes, Steve Malone, Fred Munich, Felix and John Mutschler, Jack and Donna Snavely, William Steele, and Don Swanson for their efforts in making this research possible.

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DOMESTIC EXPLORATION FOR MATERIALS

Philip H. Abelson, *Science* Editor

[Excerpts reprinted by verbal permission from *Science*, July 7, 1978, v. 201, no. 4350, p. 7.]

A civilization with a high standard of living is dependent on adequate supplies of many kinds of materials. Some elements are of critical importance. For example, chromium is an essential component of low-corroding stainless steels. Cobalt is needed to bond diamonds in cutting tools. The United States is dependent on outside sources for supplies of these and more than a score of other elements.

This country began the 20th century with more than its share of easily exploitable domestic resources. American prosperity and assurance of raw materials were reinforced by the results of geologic exploration elsewhere. Therefore, in the 1950's and early 1960's large parts of the world's oil and mineral reserves were owned by American companies. Most of the remaining reserves were under the control of friendly, stable governments. But great changes have occurred. The future of much of Africa is uncertain. American domination of foreign resources has ended. A long-term decline in the grade of domestic ore reserves has continued.

With an economy increasingly vulnerable to disruptions of supplies, with security of supplies uncertain, and with a diminished ability to pay for imports, intensified efforts to lessen U.S. dependence on foreign sources are needed.

Thus far there has been little action by the federal government; on balance, the government has hindered efforts to increase mineral supplies. During the past decade large areas of the most promising public lands have been closed to exploration. . . .

The quest for ore deposits is handicapped by lack of knowledge of how elements are mobilized in the earth. Many of them are present in an average abundance of a few parts per million or less. But when found in ores they may have been concentrated by a factor of 10^4 or more.

Processes relevant to the genesis of ore deposits probably go back to the beginning of the solar system. Apparently this planet was assembled from heterogeneous materials and some of the heterogeneity persists on a large scale. The earth has been a laboratory in which many chemical separations have occurred. . . .

Most of the ore that has been found in this country was discovered by primitive techniques— you might say, by stumbling over it. Recently, the discovery process has been aided by results from Landsat satellites and by the concept of colliding tectonic plates, but much of the physical chemistry of the mobilization of elements remains a mystery. For example, many ores occur as insoluble sulfides. How were the cations concentrated and brought to their final position? Where did the sulfur come from? If we understood this process and others we could predict much better where and how to explore for ores.

A decade or more elapses from the time of discovery of an ore body to exploitation. If this country is not to become a pawn in an international game of materials, it must begin to develop a more vigorous materials policy.

* * * * *

MOUNT HOOD GEOTHERMAL RESOURCE ASSESSMENT PROGRAM ANNOUNCED

The Oregon Department of Geology and Mineral Industries plans to drill 10 to 15 holes between 500 to 1,500 ft deep on the surrounding Mount Hood to test temperature gradients. The drilling program, scheduled to begin August 15, 1978, will last for two to three months.

Drilling on the 2,000-ft temperature gradient hole began July 20, 1978, at Timberline Lodge on the south side of Mount Hood. The hole is being drilled by Northwest Natural Gas for Wy'East Exploration and Development Company to test the possibility of the existence of hot water in the Pliocene-Pleistocene flows forming Mount Hood. Craig White, University of Oregon, will age date some of the flows with cuttings from drilling.

Drilling by Northwest Natural Gas is scheduled to commence August 1, 1978, to deepen the Old Maid Flat hole on the west side of Mount Hood from an existing depth of 1,850 ft to 4,000 ft. This hole, which will provide temperature gradient data and chip samples that can be used to determine stratigraphic sequence, is presently in late Miocene-early Pliocene Rhododendron Formation but is expected to reach and test the possibility of hot water in the underlying Miocene Columbia River Basalt. If fluids are encountered, geochemical fluid analyses will be conducted. Basalt chip samples will be analyzed by Marvin Beeson, Portland State University, as part of his study of the stratigraphy of the Columbia River Basalt surrounding Mount Hood.

* * * * *

GEOLOGISTS APPLY FOR REGISTRATION

As of July 21, 1978, 460 geologist applications and 262 engineering geologist applications have been received by the Geologist Licensing Board. Applications have come from South America, South Africa, Singapore, and Europe. After September 30, 1978, qualified geologists will be required to pass a written examination before being registered.

NEW BIBLIOGRAPHY SUPPLEMENT RELEASED

Latest publication released by the Department is Bulletin 97, Bibliography of the Geology and Mineral Resources of Oregon [Sixth Supplement].

The list was prepared by GeoRef, the American Geological Institute's computer data base service. The Department's librarian cooperated in the effort by obtaining information not already in GeoRef. The result is a most comprehensive compilation.

Bulletin 97 contains some 1,400 items published during the period from January 1, 1970, through December 31, 1975. Contents include a list of some 150 serials, the bibliography itself, subject index, county index, and rock-unit index.

Sale price is $3.00. See inside front cover for addresses of Department offices where Bulletin 97 may be purchased.

* * * * *

DRILLING HALTED ON COLUMBIA COUNTY GAS TEST

Reichhold Energy Corporation, Tacoma, Washington, suspended drilling on its fourth shallow gas test hole in Columbia County on July 18, 1978, at a depth of 2,780 ft. The "DSC - Columbia County No. 2" was located in the NE 1/4 sec. 14, T. 6 N., R. 5 W., approximately three-fourths of a mile northwest from the town of Mist. Reichhold also has put down gas test holes in Tillamook, Polk, and Marion Counties. The company has not announced any commercial discoveries for the seven wildcats drilled thus far in northwestern Oregon.

Diamond Shamrock Corporation, Houston independent, was a partner on the last three holes in Columbia County.

* * * * *

MOBIL OIL SPUDS OAKLAND GAS TEST

Mobil began drilling July 10, 1978, on what will very likely be the deepest well yet drilled in Oregon. The company plans to drill to a depth of 14,000 ft at a location 4 mi east of the town of Oakland. The site is located in the SW 1/4 sec. 36, T. 24 S., R. 5 W., Douglas County. Drilling began in the Roseburg Formation (lower part of what was formerly called the Umpqua Formation, lower Eocene age). Mobil hopes to explore pre-Tertiary rocks at this location with natural gas production as the objective.

* * * * *

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SOAPSTONE INDUSTRY IN SOUTHWEST OREGON

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and
Len Ramp, District Geologist

Grants Pass Field Office
Oregon Department of Geology and Mineral Industries

"Soapstone" is a general term used to describe a metamorphic rock composed essentially of the mineral talc, a soft hydrous magnesium silicate mineral. The term is sometimes applied to all massive gray to bluish or greenish talcose rocks which are slippery and easily carved with hand tools. Steatite is a variety of talc-bearing rock which has fewer impurities than soapstone.

The mineral talc, $Mg_6(Si_8O_{20})(OH)_4$, and the rock soapstone are extremely versatile materials and have a great number of uses as industrial products. Talc's extreme softness (1 on Mohs' scale of hardness); the ease with which it can be ground into an ultra-fine, white powder; its chemical inertness, high fusion point, low water absorption, low shrinkage when fired, low electrical and thermal conductivity, and high reflectivity make it useful as a ceramic tile base; paint extender; filler in rubber, paper, roofing, and plastics; and a diluent or carrier for pesticides. It is also used in rice and peanut polishing and salami dusting. Cosmetic-grade talcum powder is produced from steatite-grade talc. In the massive form, sawed soapstone slabs are used for laboratory table tops and sinks, cut pieces for crayons to mark steel, and irregular blocks for art carving.

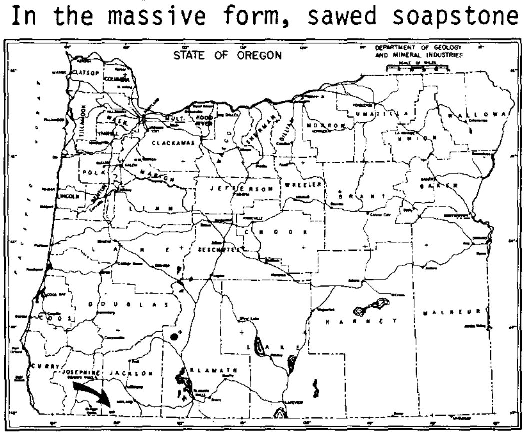

Figure 1. Map showing location of soapstone deposits.

Carving of soapstone was probably the earliest use; art objects and cooking utensils carved by prehistoric Indians have been found in California (Wells, 1975). In the mid-1800's, early-day California settlers used soapstone for ornamental and building stone, chimneys, furnace linings, and foundations.

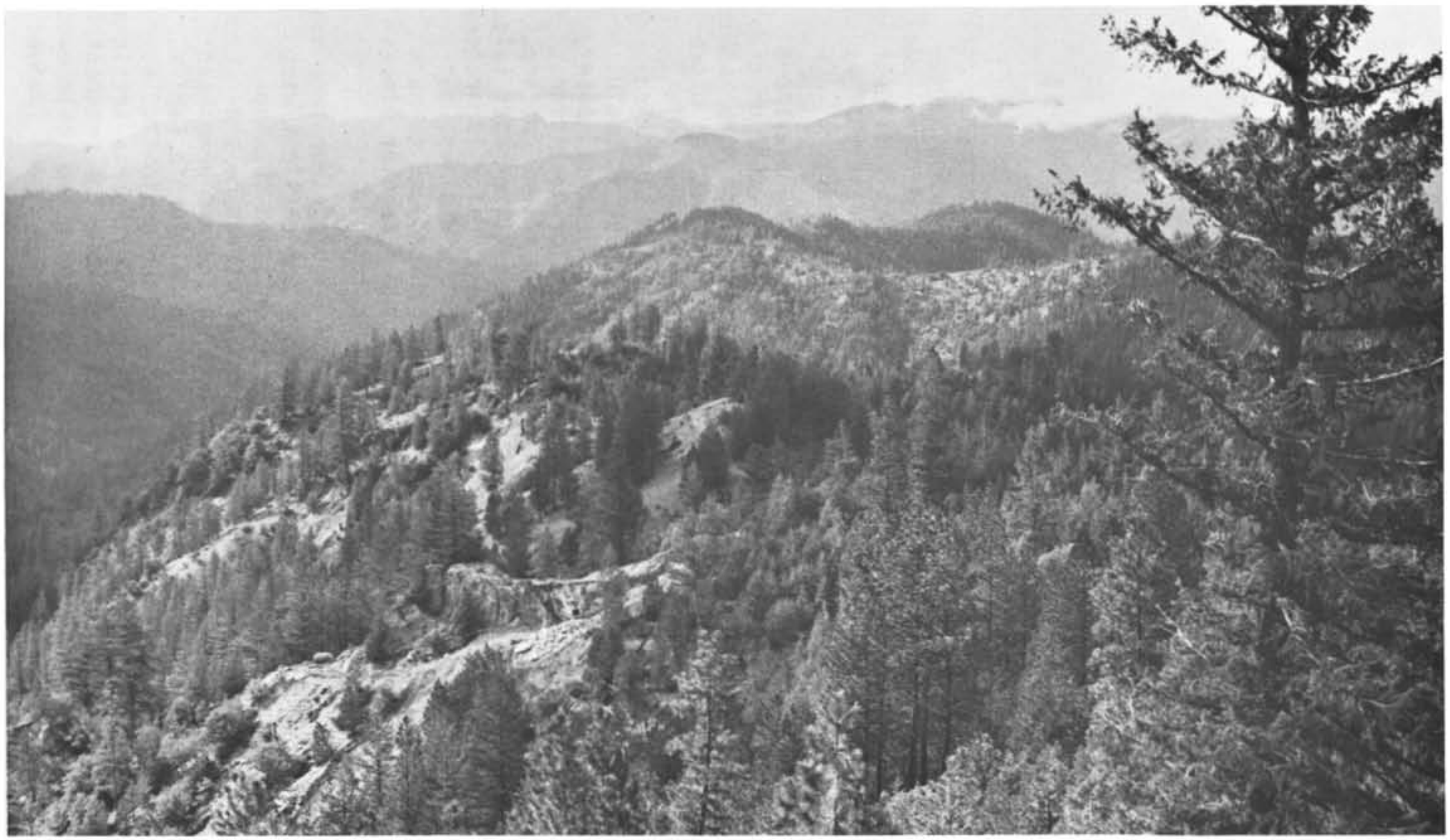

Figure 2. Looking west along Elliot Creek Ridge. Soapstone is being quarried from cut on lower left.

In talc and soapstone production statistics, art carving is listed as a minor use. It is, however, the basis for a small but steadily growing Oregon industry based in Grants Pass. Steatite of Southern Oregon, Inc., a family-owned and -operated company, mines and markets varicolored soapstone pieces and blocks for art carving throughout the western United States, Canada, and Alaska. In 1967, the company, founded by John H. Pugh of Grants Pass, began selectively mining pieces of soapstone from a landslide deposit on Powell Creek near Williams, Oregon. Their main source now is a group of relatively small occurrences in the upper Applegate-Squaw Creek-Elliot Creek Ridge area (secs. 9, 10, and 11, T. 41 S., R. 3 W.) in southern Jackson County (Figures 1 and 2).

Geology

Talc and soapstone deposits occur mainly with altered ultramafic igneous rocks or in metamorphosed dolomite. The known southwestern Oregon occurrences are all associated with serpentinized ultramafic rocks and are typical of this type of deposit. They occur as sheared lenses within or selvages on serpentinites. The talc alteration varies from thin selvages (Figure 3) to complete replacement of the serpentinite mass.

The talc and associated magnesium-bearing minerals are formed by the reaction of serpentinite with carbon dioxide or with siliceous country rocks in a suitable temperature and pressure environment. The deposits along Elliot Creek Ridge are in lenses and irregular pod-shaped masses of altered serpentinite within rocks mapped as older schists and schists of pre-Mesozoic age by Wells (1940, 1956). Hotz (1967, 1971) mapped and named similar rocks south of the border in California as the schists of Condrey Mountain and suggested possible correlations with similar California rock units from Mississippian, Triassic, and possibly Upper Jurassic rocks of the Galice Formation. Metamorphic age of these rocks, determined by potassium-argon analysis of muscovite, is 141 m.y., or Late Jurassic.

The schists, tightly folded and moderately metamorphosed, occur as a window beneath thrust plates of Triassic metamorphic rocks of the Applegate Group. The metamorphism which has changed fine-grained clayey sedimentary rocks to quartz mica and graphite schists and volcanic rocks to actinolite-chlorite schist (Figure 4) is believed to have been localized along the sole of a major thrust fault. Tectonically injected serpentinites appear to have been partly or completely altered during this period of tectonic metamorphism to talc, tremolite, chlorite, and silica-carbonate rocks.

Because the outcrops of altered serpentinite which contain the soapstone deposits are slightly more resistant to erosion than the surrounding schist, they form rough, craggy knobs and ridges at or near the crest of Elliot Creek Ridge. Soapstone

Figure 3. Surface boulder composed partly of soapstone and partly of serpentinite. This incomplete alteration makes selective mining necessary.

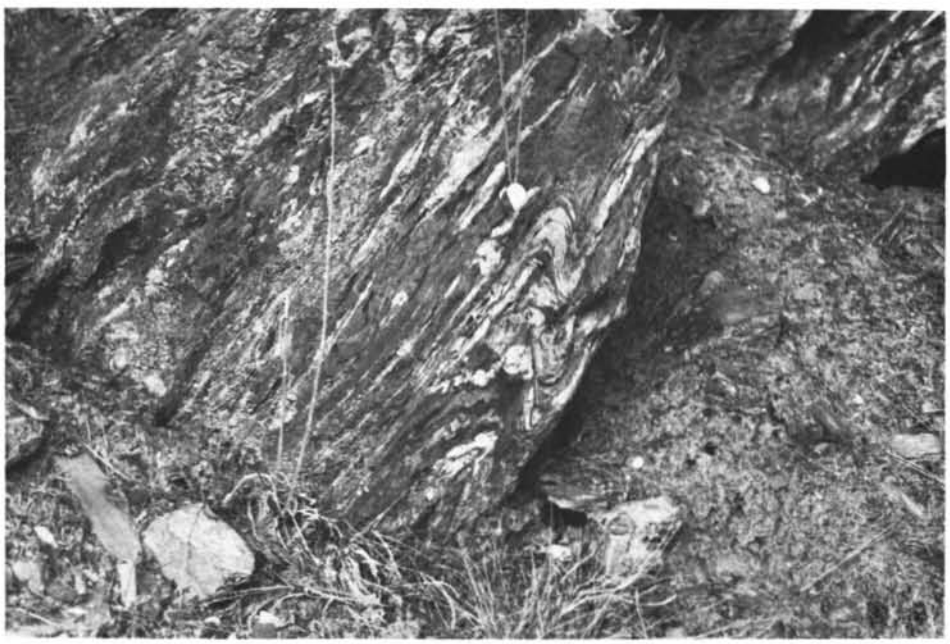

Figure 4. Tightly folded and crenulated quartz-mica-graphite schists, country rocks along Elliot Creek Ridge where soapstone deposits occur. Note hand lens for scale.

exposed at the surface is found as thin to thick selvages on the edges and as pods within the medium-grained, greenish metaserpentinite. Pyrite and limonite pseudomorphs of pyrite are present in the soapstone and in the enclosing schists. The pyrite occurs mainly in cubic form and is so abundant in some of the soapstone that it makes the rock unsuitable for carving. Green to brown chlorite, green to pale gray actinolite and tremolite, crystalline talc, and chrysotile are other minerals present in the soapstone outcrops. Magnetite, chromite, and black dendritic manganese minerals are also occasional accessory minerals found in the soapstone. The color of the massive soapstone is highly variable but is generally greenish gray. Sinuous patterns and color mottling that show original rock textures are visible on sawed or cut surfaces. In some places, former chrysotile veinlets have been completely replaced by talc without loss of the chrysotile structure (Figure 5).

Some of the Elliot Creek Ridge soapstone has small oval holes up to 4 cm in diameter extending downward from the surface, sometimes branching or intersecting (Figure 6). The inner surface of the holes has a striated pattern. At first, it appeared that soluble minerals had been removed from the rock by near-surface weathering. Cross sections, however, indicate that holes begin and end in massive talc and that material was more likely physically removed. Therefore, the most plausible explanation for these holes in the rocks is that at the base of the soil zone, small rodents such as moles, mice, or shrews encounter the soft rock and continue their burrows for a short distance into it.

Soapstone is mined selectively, using a large backhoe and small front-end loader (Figure 7). Blocks of good-quality soapstone weighing up to several tons (Figure 8) are removed and trucked to a staging area at Dividend Bar on Squaw Creek, about 2.5 mi from the mine, where they are sorted, sized, and cut into blocks for shipping (Figure 9). Basic equipment at the staging area is a front-end loader for moving large blocks, gang saw, band saw, and table trim saw. Marketing, packaging, and shipping are done from a small shop at the Pugh residence in Grants Pass.

Developing a market for an industrial mineral deposit usually takes many years of persistent and dedicated work, and the Grants Pass soapstone operation is no exception. After 10 years, orders for ton lots are being received, whereas formerly they were for samples or a few pieces. Acceptance of the good-quality soapstone by carvers from all over the country, including Alaska, and Canada now keeps the Pughs busy filling orders (Figure 10). This mineral industry still has to be considered small, but it contributes important employment and new wealth for Oregon.

The company is looking into the possibility of producing pulverized talc as a byproduct of the block operation.

Figure 5. Closeup of soapstone surface which clearly shows talc pseudomorphs after chrysotile. Area shown in photo has been completely altered to talc.

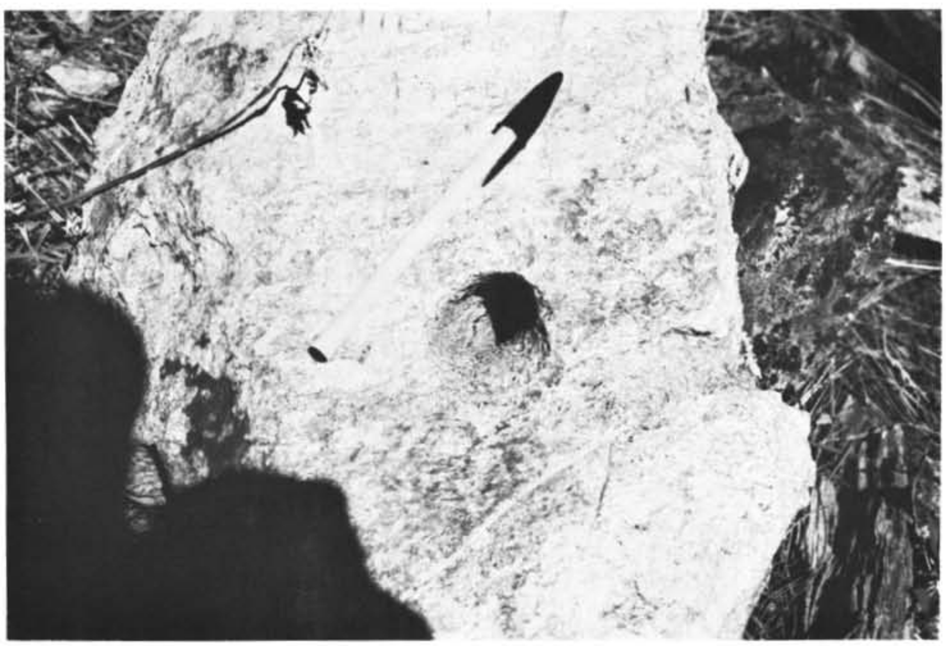

Figure 6. Oval-shaped holes on surfaces of soapstone blocks are believed to be rodent burrows.

Figure 7. Soapstone blocks are removed and loaded with large backhoe and smaller front-end loaders for haulage to Dividend Bar, where they are stockpiled.

Figure 8. Large block of nearly pure soapstone on Elliot Creek Ridge.

Figure 9. Soapstone is soft enough to be trimmed by chain saw, band saw, or other saw with specially hardened teeth. Here it is being cut with a special gang saw into specific sizes for marketing.

Figure 10. Carvings produced from southern Oregon soapstone. (Photo courtesy John Pugh)

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* * * * *

U.S. SCIENTISTS MAP POTENTIAL HAZARDS FROM VOLCANO IN ECUADOR

A map showing potential hazards from future eruptions of Cotopaxi Volcano, Ecuador, has been compiled by scientists of the U.S. Geological Survey, Department of the Interior, with the assistance of an Ecuadorian scientist.

Cotopaxi, a 19,347-ft (5,897-m) volcano located about 35 mi (56 km) south-southeast of the capital city of Quito, has erupted more than 50 times since 1738; at least five of the eruptions resulted in significant loss of life and property. Future eruptions are likely to endanger people, property, and agricultural land, especially in the broad valleys which lead away from the flanks of the volcano.

In November 1975, Cotopaxi showed signs of geological "restlessness" and began emitting heat and steam, with resultant melting of ice and snow near the crater rim. This activity -- notably above the town of Mulalo near the western base of the volcano -- suggested the possibility of an explosive eruption with resulting large mudflows.

With the possibility of an eruption and mudflow in mind, Ecuadorian officials requested U.S. assistance in monitoring the activity of Cotopaxi and assessing the nature of the potential hazards posed by the volcano. Responding to the request, which was made through the Office of Foreign Disaster Assistance, Agency of International Development (AID), three USGS scientists -- C. Dan Miller, Donal Mullineaux, and David Harlow -- were sent to Ecuador to assist Ecuadorian scientists in evaluating the situation.

The USGS map and accompanying text, prepared by Miller, Mullineaux, and Minard Hall of the Escuela Politecnica Nacional at Quito, summarize the results of their investigations. The map shows the hazard zones around Cotopaxi related to eruptive phenomena (mudflows, ashfalls, etc.) likely to occur in the future; the text describes the hazards associated with such eruptions.

The cone of Cotopaxi itself constitutes a zone of maximum hazard from future avalanches of hot rock debris, lava flows, mudflows, and floods. Main valleys leading away from Cotopaxi are divided into zones of severe hazard and lesser hazard from future mudflows and floods. Ashfall-hazard zones delineate a large sector southwest, west, and northwest of Cotopaxi into which prevailing winds will carry volcanic ash from most future eruptions, and a smaller area west of Cotopaxi where the hazard from ashfall is greatest.

The text accompanying the map also outlines measures which can be taken to reduce loss of life and property in the vicinity of Cotopaxi before, during, and after future eruptions. Some general measures include:

1) Identification of areas of potentially high hazard from the map, along with kinds of events that can be

expected to affect them so as to provide for contingency planning.

2) Development of seismic and other instrumented monitoring systems to detect earliest signs of volcanic activity.
3) Development of effective plans to improve communication and public awareness before an emergency situation develops.

Some specific recommendations of actions to reduce losses in zones of severe hazard when an eruption appears imminent are also given in the text of the map.

Cotopaxi, one of numerous volcanoes that rise above the Andes Mountains of South America, has a long history of historic and prehistoric eruptions. Beginning with 1742, at least five major eruptions of Cotopaxi have caused death, injury, or widespread property and crop damage. An eruption in 1877 triggered a large-scale melting of snow and the formation of devastating mudflows, which extended more than 60 mi (100 km) from the base of the volcano. Major activity also took place during the period 1532-1534, but no reports of the effects of that eruption are available.

Since 1742, eruptions at Cotopaxi have occurred at an average rate of about one per 10 years. These eruptions, however, did not occur at regular time intervals, but were clustered in episodes that were separated by quiet intervals of variable length. The duration of such quiet intervals cannot be predicted. At the present time, Cotopaxi has been inactive for at least 36 years, and perhaps as long as 74 years.

Robert I. Tilling, chief of the Office of Geochemistry and Geophysics at the U.S. Geological Survey's National Center, Reston, Virginia, said that the investigations at Cotopaxi should prove the value of hazards assessment in advance of a potentially dangerous situation.

"Such assessment," Tilling said, "is similar to that being carried out on the potentially active volcanoes of the Cascade Range in the northwestern United States. If Cotopaxi does erupt and does produce destructive mudflows, we may have an immediate test of our hazards evaluations, and the knowledge learned should materially improve the Survey's volcano hazards studies in the western United States."

Copies of the map showing potential hazards from Cotopaxi Volcano, published as USGS Miscellaneous Geologic Investigations Map I-1072, may be purchased from the USGS Branch of Distribution, 1200 South Eads Street, Arlington, VA 22202, at $1.50 per copy (checks or money orders payable to the U.S. Geological Survey).

* * * * *

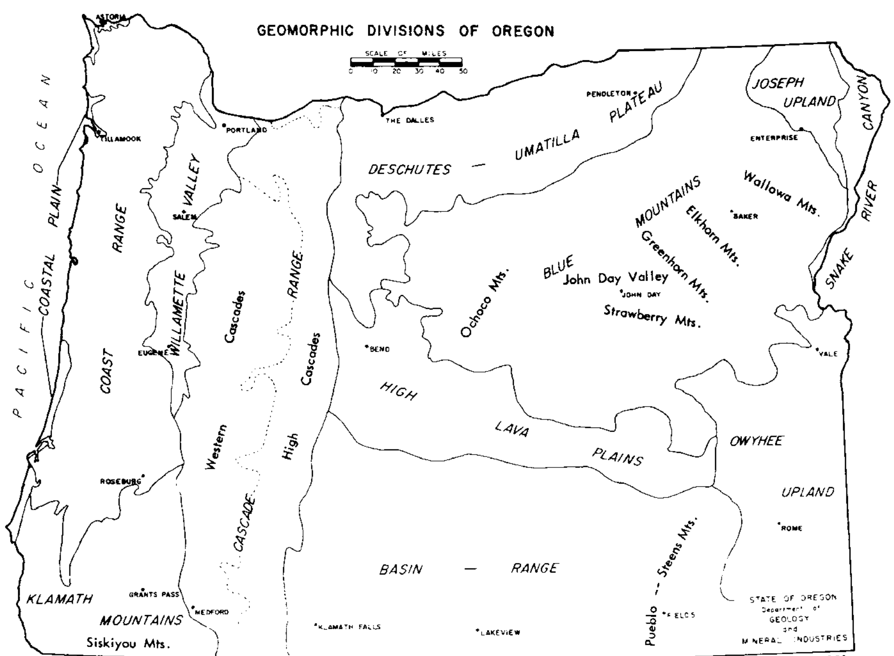
MINERAL EXPLORATION EXPENDITURES SUMMARIZED

Donald A. Hull, State Geologist
Oregon Department of Geology and Mineral Industries

Oregon's varied geologic environments contain a diverse group of mineral and energy-mineral resources and potential resources. The spectrum of mineral products produced historically in Oregon ranges from common varieties, such as sand, gravel, and crushed stone, to rarer metallic commodities, such as nickel, mercury, gold, silver, copper, and chromium.

Included in past production are mineral commodities such as uranium that are basic sources of energy. In recent years, the State has witnessed a relatively high level of exploration for a variety of minerals, including petroleum and natural gas, which have never been produced in commercial quantities here.

A recent survey of exploration activity reveals that expenditures for metallic mineral exploration in 1976 and 1977 exceeded \$2.3 million and \$3.6 million respectively. Most of this money was spent in searching for copper and gold, with lesser amounts



Modified from Dicken, Oregon Geography, 1950.

for uranium, nickel, and zinc. Metallic mineral exploration has been concentrated in the Blue Mountains; the second most active area has been the western part of the Cascade Range. The Klamath Mountains in the southwestern part of the State and the Basin and Range area of south-central Oregon have also received important attention from prospecting groups.

Detailed petroleum and natural gas exploration totals are not yet available, but statewide expenditures for both 1976 and 1977 are estimated to be in excess of $2 million and may have exceeded the totals for metallic mineral searches in these years. The areas of prime interest for oil and gas in recent years have been the Coast Range, southern Willamette Valley, and northern Harney County, in the central part of the State.

In 1976 and 1977, the search for geothermal energy by private companies resulted in expenditures exceeding $1.4 million and $600,000 respectively. The lower 1977 total is due to the lack of deep production drilling by industry in that year. In 1977, the geothermal resource assessment expenditures by various public groups, including Federal, State, and university organizations, were approximately the same as the industry costs, whereas in earlier years, the private sector conducted most of the geothermal resource assessment work.

Although most of the geothermal energy exploration and much of the metallic minerals prospecting are conducted on Federal lands, recent petroleum and natural gas drilling has been principally on private acreage. The future level of exploration for mineral and energy resources in the State is difficult to forecast; it is dependent upon economic conditions as well as public policies regarding taxation and land use.

* * * * *

IRVING RAND DIES

Irving Rand, a well-known mining attorney and son of a pioneer family, died July 20th in Baker, the city in which he was born October 27, 1896. During his 81 years, Rand led an active life both professionally and in many civic undertakings. After being educated at Dartmouth and Harvard, he was admitted to the Oregon State Bar in 1922. He practiced law in Portland for many years before returning to Baker to retire and devote his energies to various charitable activities. He was widely known as one of the few attorneys in the area having a comprehensive knowledge of mining law.

* * * * *

NMA SCHEDULES EXPLORATION GEOPHYSICS COURSE

The Northwest Mining Association preconvention short course scheduled November 27, 28, and 29 at the Davenport Hotel in Spokane, Washington, has been approved for graduate credit by Eastern Washington University.

The course, titled "Practical Geophysics for the Exploration Geologist," has been developed by R. "Dutch" Van Blaricom, supervisory geophysicist for the exploration office of Cominco American, Inc. It will present the practical application of six basic geophysical methods to mineral industry problems.

The course is divided into two major parts: the first will briefly explain the theory of each geophysical method but concentrate on application of the method to include case histories and model results; the second will be a comprehensive study of the particular geophysical techniques to use for each class or type of metallic and nonmetallic deposit.

The six basic methods to be covered in the course are (1) induced polarization and resistivity, (2) gravity, (3) magnetics, (4) seismics, (5) radiometrics, and (6) electromagnetics.

Authorities to present each unit include Philip G. Hallof and William H. Pelton, Phoenix Geophysics Limited; Don A. Hansen, ScienTerra, Inc.; Douglas J. Guion, EDCON (Exploration Data Consultants, Inc.); Sheldon Breiner, GeoMetrics, Inc.; Douglas B. Crice, GeoMetrics, Nimbus Division; Jan Klein and Jules Lajoie, Cominco Limited.

A text will be provided for the course and will be published as a formal volume for sale to the public after the course.

Complete information regarding course content and advance registration requirements is available from the Northwest Mining Association, West 1020 Riverside Ave., Spokane, WA 99201.

* * * * *

NEW GEOTHERMAL GRADIENT DATA IS COMPILED

Geothermal gradient measurements from water wells, mineral exploration holes, and oil wells have been presented in tabular and graphic form in the Department's latest open-file report, O-78-4, entitled "Geothermal Gradient Data."

The data were collected between December 1976 and December 1977 by Donald A. Hull, David D. Blackwell, and Gerald L. Black. Their measurements were made primarily in the Deschutes-Umatilla Plateau (Columbia Plateau), Cascade Range, and northern Willamette Valley physiographic provinces.

The Department sells the report at its Portland office. The price is $5.00.

APPLICATIONS FOR PERMITS TO DRILL GEOTHERMAL WELLS

Permit number	Company	Location	Proposed depth (ft)
32	Chevron Resources	NW1/4 sec. 9, T. 18 S., R. 43 E. Malheur County	2,000
33	Chevron Resources	SW1/4 sec. 5, T. 18 S., R. 43 E. Malheur County	2,000
34	Wy'East Exploration	NE1/4 sec. 7, T. 3 S., R. 9 E. Timberline Lodge Clackamas County	2,000
35	Anadarko Oil	SE1/4, sec. 6, T. 33 S., R. 36 E. Harney County	2,000
36	Anadarko Oil	SW1/4 sec. 7, T. 33 S., R. 36 E. Harney County	2,000
37	Anadarko Oil	SW1/4 sec. 18, T 33 S., R. 36 E. Harney County	2,000
38	Anadarko Oil	SE1/4 sec. 14, T. 33 S., R. 35 E. Harney County	2,000
39	Anadarko Oil	NE1/4 sec. 14, T. 33 S., R. 35 E. Harney County	2,000
40	Anadarko Oil	SW1/4 sec. 34, T. 34 S., R. 34 E. Harney County	2,000
41	Anadarko Oil	NE1/4 sec. 8, T. 35 S., R. 34 E. Harney County	2,000
42	Anadarko Oil	SE1/4 sec. 10, T. 37 S., R. 33 E. Harney County	2,000
43	Anadarko Oil	SW1/4 sec. 13, T. 37 S., R. 33 E. Harney County	2,000
44	Anadarko Oil	NW1/4 sec. 22, T. 37 S., R. 33 E. Harney County	2,000

* * * * *

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* * * * *

APPLICATIONS FOR OIL AND GAS DRILLING PERMITS

Permit number	Company	Well name	Location	Proposed depth (ft)
76	Agoil of Oregon	Hay Creek Ranch #1	NE1/4 sec. 23, T. 11 S., R. 15 E. Jefferson County	5,500
77	Agoil of Oregon	Hay Creek Ranch #2	NW1/4 sec. 6, T. 11 S., R. 15 E. Jefferson County	5,500
78	Farnham Chemical	W. Smith #1	NW1/4 sec. 32, T. 11 S., R. 1 W. Linn County	4,500

* * * * *

NOTICE OF HEARING TO REVIEW CHANGES IN OIL AND GAS REGULATIONS

Oregon oil and gas regulations have not been revised since 1956. Since then, some changes have been made in the statutes. The only significant change proposed at this time is to raise the amount of surety bond from $4,000 to $10,000.

1. On September 12, 1978, at 9:30 a.m., a public hearing will be held in Room 773 of the State Office Building, 1400 S.W. Fifth Avenue, Portland, Oregon, to consider adoption by the State Geologist of revised rules governing oil and gas drilling.

2. The Oregon Oil and Gas Rules are being revised to reflect modifications in the statute made since the rules were last amended in 1956. These proposed changes in the rules include amendments and the additions of new rules.

3. The amendments relate to the right of the State Geologist to revoke permits, drilling practices, construction of sumps, hole deviation, and flaring of gas. New rules cover wording for the bond form, disposal of wastes, underground storage wells, measurement of oil, and transportation reports.

4. Interested parties may submit comments by mail or appear in person to present their views to the State Department of Geology and Mineral Industries, 1069 State Office Building, 1400 S.W. Fifth Avenue, Portland, Oregon 97201.

5. Copies of the proposed rules may be obtained by writing the Department of Geology and Mineral Industries at the above address and enclosing 50 cents for postage and handling.

6. The State Geologist or his representative will conduct the hearing.

Donald A. Hull
State Geologist

Dated: August 25, 1978

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36. Papers on Tertiary foraminifera: Cushman, Stewart and Stewart, 1949: v.2 . .	1.25
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PRELIMINARY NOTE ON THE LATE PLEISTOCENE GEOMORPHOLOGY AND ARCHAEOLOGY OF THE HARNEY BASIN, OREGON

Keith D. Gehr and Thomas M. Newman
Department of Anthropology, Portland State University
Portland, Oregon

The geology and water resources of the Harney Basin (Figure 1) in southeastern Oregon have been studied by Russell (1903, 1905), Waring (1909), Piper and others (1939), Walker and Swanson (1968), and others. The most detailed and definitive work is that of Piper and his team of investigators from the U.S. Geological Survey, who worked in the Basin from 1930 to 1932. They recognized a prominent abandoned beach ridge along Harney Lake at an elevation of 1,249.7 m (4,100 ft) and commented: "No higher shore features are known to exist in the central area of the Harney Basin, although most other desert basins in eastern Oregon have prominent shore features at least 100 ft higher than their playas" (Piper and others, 1939, p. 14).

These writers left unresolved the question as to whether pluvial Lake Malheur had ever reached and overflowed the basalt dam, estimated to be 1,254 m (4,114 ft) high, across Malheur Gap. On the basis of the native fish fauna in the Harney Basin, Hubbs and Miller (1948) concluded that there had been a direct connection with the Columbia via the South Fork of the Malheur River and the Snake River.

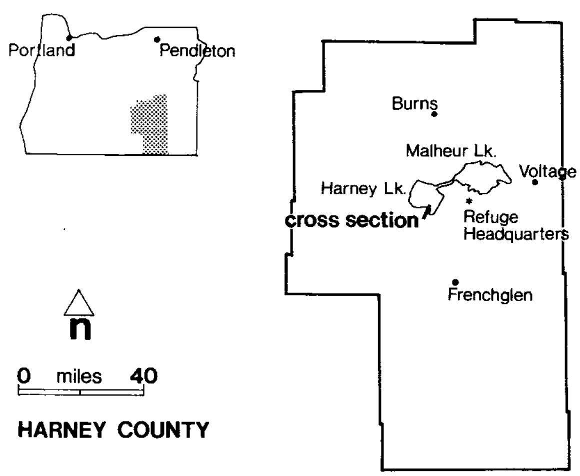

Figure 1. Map showing location of Harney Lake. See cross section, page 168.

Probably because their primary concern was with other matters, all of the previous investigators apparently failed to notice two clear wave-cut terraces,

Figure 2. Wave-cut terrace on northwest side of butte adjacent to Malheur National Wildlife Refuge Headquarters. Elevation of terrace is 1,255 m (4,118 ft).

each at an elevation of about 1,255 m (4,118 ft), which corresponds acceptably well with the elevation of the spillway across the Voltage lava flow, which blocked Malheur Gap. One terrace is on the northwest side of the low butte adjacent to the Malheur National Wildlife Refuge headquarters (Figure 2); the other, located mainly in sec. 24, T. 27 S., R. 29-1/2 E., contains a deposit of fossil shoreline molluscs that, by augering, were found up to an elevation of 1,255.1 m (4,111.7 ft). Ninety-eight percent or more of this population is comprised of a snail tentatively identified as *Lymnea utahensis*. Minority species include another snail tentatively identified as *Parapapolyx effusa*.

In 1975, two artifacts were found in the wall of a drainage ditch running roughly parallel to the terrace in sec. 34. The ditch is nearly 1,600 m (5,250 ft) long and averages 2 to 3 m (7 to 10 ft) in depth. The provenance of the artifacts was questionable, but for several reasons it seemed worthwhile to search for a possible early site. Later finds, both on and below pluvial lake gravels, have proved the presence of man in the Basin before the end of the pluvial period.

Along with the artifacts, the gravels in the ditch wall have preserved an excellent record of three pluvial lake stillstands. Two of these have been dated, as has the terrace, from carbon-14 determinations on fossil snails. Because measurements on outer fractions of samples indicated significant contamination with younger carbon in even the younger samples, ages were determined from the inner fractions of samples.

Figure 3 shows locations of the wave-cut terrace and various beach ridges at the southern part of Harney Lake. The oldest beach ridge (1), at 1,251.1 m (4,107.7 ft), has a preliminary date of about 32,000 B.P. (USGS-459). The mollusc population there is essentially reversed from that on the terrace, being 98 percent or greater *Parapapolyx effusa*, with the Lymnaeids being a minority species. This ridge is covered with younger gravels culminating in a shoreline (2) at 1,252.1 m (4,107.9 ft), now dated at approximately 9,600 B.P. (USGS-460). The lake bottom associated with this shoreline is covered with a prominent deposit of fossil Lymnaeid snails similar to those on the terrace. This line of tiny molluscs can be traced for almost 700 m (2,300 ft) in the side of the ditch. Two new species, tentatively identified as *Lymnea palustris* and *Helisoma anceps*, are plentiful in the last 100 m (300 ft) before the beach ridge. Their presence suggests a marshy ecozone that may have been seasonally dry.

A younger, undated shoreline (3) overlies the preceding one at an elevation of 1,253.4 m (4,112.2 ft). Artifacts have been found in almost unquestionable primary context both on the gravel surface of this deposit and immediately underlying it. The stratigraphically lower artifact appears to be a punch-struck obsidian blade, a tool little known in Oregon but fairly common in a surface site which overlies part of this beach ridge by about 1 m (3 ft) (Dumond, 1962).

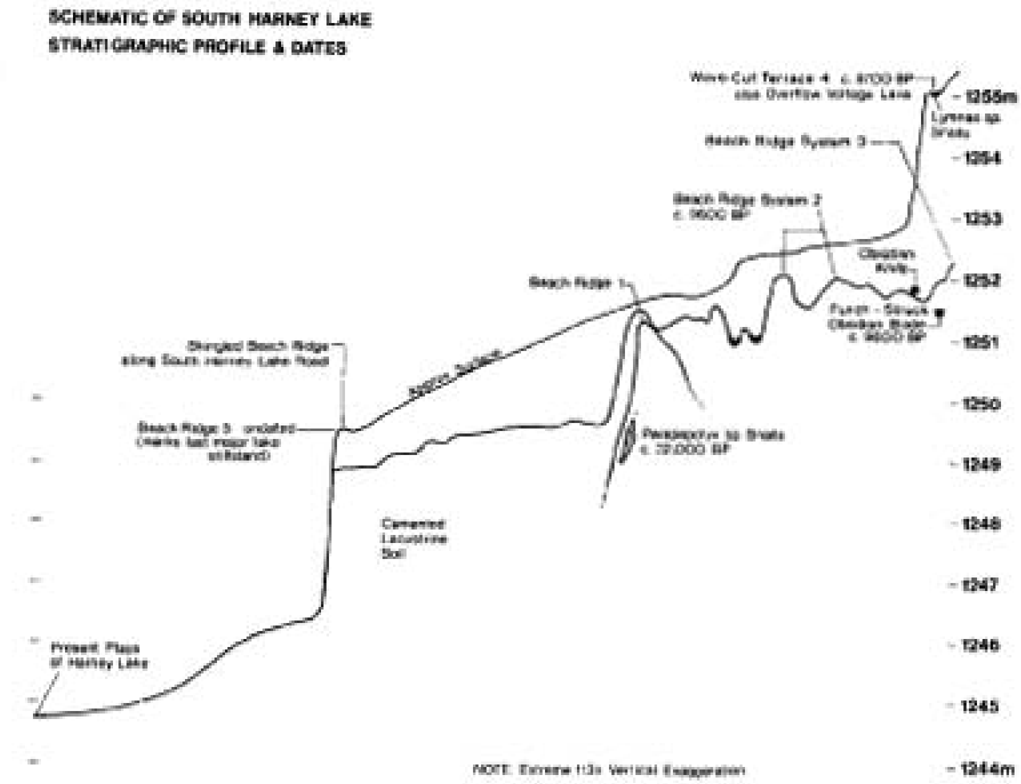

Figure 3. Cross section of southern part of Harney Lake showing elevations and ages of wave-cut terrace and beach ridges.

The previously discussed terrace (4) at 1,255 m (4,118 ft) is the youngest dated feature, with a shell radiocarbon age of 8,700 B.P. (USGS-461). It is unusual, if not unique in the Great Basin, for the highest shore feature to be among the youngest in the sequence.

Finally, the presently undated beach ridge (5), at 1,249.7 m (4,100 ft) seems to represent the final stillstand of pluvial Lake Malheur before drier conditions apparently rapidly reduced the huge Pleistocene lake to the present series of playas and marshes.

Two surface sites in the area, one on the terrace by the ditch and the other over the highest beach ridge, were clearly occupied when the lake level was at or just below the overflow point of the Basin. Dates approaching 8,700 B.P. can be inferred for these sites. Both sites have been heavily potted, but enough artifacts have been found to suggest a Cascade point-crescent-blade tool complex. Many of the Cascade points show basal grinding.

It is now apparent that the Voltage lava flow, which dammed the Basin, is not of the "very recent" age suggested by all earlier Basin investigators. Based on the shell dates, it must have occurred more than 32,000 years ago.

These observations should all be considered to be preliminary in nature and subject to later reinterpretation or change. They are presented now for any possible value they might have to other Great Basin investigators.

Particular thanks are given to Stephen Robinson and the U.S. Geological Survey for generous and speedy help on radiocarbon dating of the mollusc shells. Robert Herrmann of the Weyerhaeuser Company is also thanked for the tentative mollusc identification.

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Waring, G.A., 1909, Geology and water resources of the Harney Basin Region, Oregon: U.S. Geological Survey Water-Supply Paper 231, 93 p.

* * * * *

BLM TO OFFER GEOTHERMAL LEASES

The U.S. Bureau of Land Management is planning to offer geothermal leases in four parts of Oregon this fall. The lands fall within locations classified as Known Geothermal Resource Areas (KGRA's), so leases must be bid for. Sites and tentative sale dates are:

Alvord KGRA - Tps. 32-37 S., Rs. 33-36 E., W.B. and M., Harney County; October 19, 1978
Breitenbush KGRA - Tps. 8,9 S., R. 7 E, W.B. and M., Clackamas and Marion Counties; October 19, 1978
Belknap-Foley Springs - T. 16 S., R. 6 E., W.B. and M., Lane County; September 27, 1978 (new date to be set)
Carey Hot Springs - T. 16 S., Rs. 6,7 E., W.B. and M., Clackamas County; February 13, 1978 (new date to be set)

For more specific information write to the Oregon State Office of the U.S. Bureau of Land Management, 729 N.E. Oregon Street, P.O. Box 2965, Portland, Oregon 97208.

* * * * *

USGS TO REPRINT MINERAL RESTRICTIONS MAP

The U.S. Geological Survey is planning on reprinting a map, "Federal Lands Subject to Mineral Restrictions," which essentially shows that all public lands in the West currently have mineral entry restrictions. Because the map shows the Department of the Interior's recognition that all public lands do have mineral restrictions, it is important that legislators see the map before making decisions on public land minerals issues.

* * * * *

SURFACE MINE REGS PUBLISHED

A draft of surface mining regulations required by Public Law 95-87, the Surface Mining Control and Reclamation Act of 1977, has been published by the Office of Surface Mining, U.S. Department of the Interior. The proposed regulations are considered to be controversial by the mining industry.

ORDER FORM

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Bulletins		Price
57.	LUNAR GEOLOGICAL FIELD CONFERENCE GUIDE BOOK, 1965, Peterson and Groh, eds. [Used by International Lunar Geological Field Conference for official field trips in Bend and Crater Lake areas, August 1965. 51 p., 34 photos, and maps.]	$ 3.50____
77.	GEOLOGIC FIELD TRIPS IN NORTHERN OREGON AND SOUTHERN WASHINGTON, 1973. (GSA guide book.) [Descriptions, with many illus. and maps, of seven field trips covering central Oreg., western Oreg., the Columbia River, Columbia River Gorge, the Portland area, and the lava caves of Mt. St. Helens. 206 p., 3 figs. in pocket.]	$ 5.00____
87.	ENVIRONMENTAL GEOLOGY OF WESTERN COOS AND DOUGLAS COUNTIES, OREGON, 1975, Beaulieu and Hughes. [Discusses geography, engineering geology, mineral resources, geologic hazards, and geology of estuaries. 148 p., 16 separate geology and geologic hazards maps in color.]	$ 9.00____
88.	GEOLOGY AND MINERAL RESOURCES OF THE UPPER CHETCO DRAINAGE AREA, OREGON (INCLUDING THE KALMIOPSIS WILDERNESS AND BIG CRAGGIES BOTANICAL AREAS), 1975, Ramp. [Covers topography, climate, and vegetation; geology; hist. of mining activity; metallic mineral resources; and industrial minerals. 47 p., plus geology and mineral deposits maps.]	$ 4.50____
89.	GEOLOGY AND MINERAL RESOURCES OF DESCHUTES COUNTY, OREGON, 1976, Peterson, Groh, Taylor, and Stensland. [Descriptions of geologic units, geologic structure, geothermal resources, and nonmetallic minerals. 66 p., 60 figs., 4 geologic and mineral location maps.]	$ 6.50____
90.	LAND USE GEOLOGY OF WESTERN CURRY COUNTY, OREGON, 1977, Beaulieu. [Covers geography, engineering geology, tectonic setting, mineral resources, geologic hazards, and geology of cities. 148 p., 45 illus., 12 geology and geologic hazards maps.]	$ 9.00____

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Bulletins (continued)

91. GEOLOGIC HAZARDS OF PARTS OF NORTHERN HOOD RIVER, WASCO, AND SHERMAN COUNTIES, OREGON, 1977, Beaulieu. $ 8.00____
[Discusses geography, geologic units, and geologic hazards. 95 p., 51 figs., 11 separate geology and geologic hazards maps.]

92. FOSSILS IN OREGON, 1977, Margaret L. Steere, ed. $ 4.00____
[Collection of 22 articles reprinted from The ORE BIN. Categories comprise fossil plants, fossil animals, and fossil localities. Paleontological time chart included. 227 p., many figs.]

93. GEOLOGY, MINERAL RESOURCES, AND ROCK MATERIAL OF CURRY COUNTY, OREGON, 1977, Ramp, Schlicker, and Gray. $ 7.00____
[Subtopics include geography, geology, rock material resources, metallic mineral resources, nonmetallic mineral resources, and mineral fuels. 79 p., 12 figs., 9 tables, 3 maps.] (Companion to Bull. 90.)

94. LAND USE GEOLOGY OF CENTRAL JACKSON COUNTY, OREGON, 1977, Beaulieu and Hughes. $ 9.00____
[Covers geography, geologic units, engineering properties of geologic units, mineral resources, and geologic hazards. Glossary included. 87 p., 29 figs., 15 tables, 5 geologic maps, and 5 geologic hazards maps.]

95. NORTH AMERICAN OPHIOLITES, 1977, Coleman and Irwin, eds. $ 7.00____
[13 papers from field excursions and seminars of 1977 sponsored by the International Geological Correlation Program. 183 p., index map of North America, and 5 geologic maps.]

96. MAGMA GENESIS, 1977, H.J.B. Dick, ed. $12.50____
[Proceedings of the American Geophysical Union Chapman Conference on Partial Melting of the Earth's Upper Mantle. Aid to geologic mapping and to assessment of mineral wealth in magmatic terrain. 13 papers. 311 p., many illus.]

97. BIBLIOGRAPHY OF THE GEOLOGY AND MINERAL RESOURCES OF OREGON, SIXTH SUPPLEMENT, 1978, C.P. Hulick, ed. $ 3.00____
[Compiled by GeoRef, American Geological Institute computer data base service. Comprises 1,400 entries including titles from 150 serials and has subject, county, and rock-unit indexes. 74 p.]

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Open-File Reports

O-76-4 STREAM SEDIMENT GEOCHEMISTRY, NORTHEASTERN OREGON, 1976. $25.00____
[Analyses of stream sediments in 33 quadrangles for copper, lead, zinc, nickel, and mercury. 48 p., 33 topog. maps.]

O-78-4 GEOTHERMAL GRADIENT DATA, 1978, Hull, Blackwell, and Black. $ 5.00____
[Data collected between December 1976 and December 1977. Tables and graphs with measurements in metric and English units. 187 p., map of well locations.]

Other Publications

Misc. Paper No. 4 RULES, REGULATIONS AND LAWS RELATING TO EXPLORATION AND DEVELOPMENT OF OIL AND NATURAL GAS IN OREGON, 1977.
[Pt. 1. Oil and gas. Text p. 1-18 plus copy of ORS Chap. 520.] $ 1.00____
[Pt. 2. Geothermal. Text p. 19-34 plus copy of ORS Chap. 522.] $ 1.00____

Misc. Paper No. 19 GEOTHERMAL EXPLORATION STUDIES IN OREGON, 1977, Bowen, Blackwell, and Hull. $ 3.00____
[Identifies seven areas of anomalously high heat flow. 50 p., 17 figs., 10 tables, and well location map.]

Oil and Gas Invest. 5 PROSPECTS FOR NATURAL GAS PRODUCTION AND UNDERGROUND STORAGE OF PIPELINE GAS IN THE UPPER NEHALEM RIVER BASIN, COLUMBIA-CLATSOP COUNTIES, OREGON, 1976, Newton and Van Atta. $ 5.00____
[56 p. with geologic map in pocket.]

Short Paper 27 ROCK MATERIAL RESOURCES OF BENTON COUNTY, OREGON, 1978, Schlicker, Gray, and Bela. $ 4.00____
[Concise data to aid planners and contractors. 45 p., 16 figs., 10 tables, and rock material location and geology map.]

GMS-7 GEOLOGIC MAP OF THE OREGON PART OF THE BAKER 1° BY 2° QUADRANGLE, 1976, Brooks, McIntyre, and Walker: cartography by S.R. Renoud. $ 3.00____
[Color map with geologic time chart and stratigraphic cross sections. Scale 1:250,000.]

USGS Map I-902 GEOLOGIC MAP OF OREGON EAST OF THE 121ST MERIDIAN, 1977, G.W. Walker. $ 3.75____
[2 sheets, each 42 by 44 in; scale 1:500,000 (1 in = about 8 mi).]

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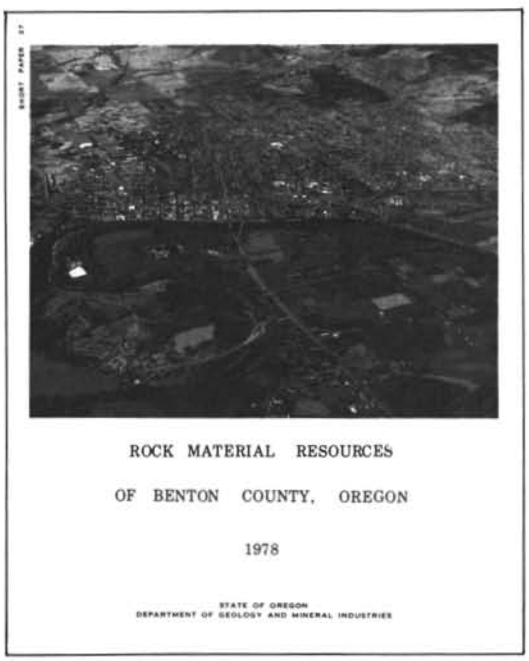
BENTON COUNTY ROCK MATERIAL RESOURCES STUDY PUBLISHED

The Department has just released Short Paper 27, entitled "Rock Material Resources of Benton County, Oregon." The 47-page study discusses future demand, planning, mining, reclamation, and geology of the rock material resources of Benton County. Included are 16 figures, 10 tables, and a geology and quarry site map for the County. By linking rock resources with a geologic map, the report becomes a useful predictive tool for planning purposes, enabling the planner to address the complex issues surrounding the rock resources industry.

This publication, which is available at Department offices, sells for $4.00.

Purpose of This Study

Benton County's population is expected to continue to expand in the future as a result of increased light industrial development brought about by available manpower; availability of land and electric power; and favorable aesthetic, cultural, and climatic conditions. While creating an increasing need for construction aggregate, this growth may simultaneously restrict the use of existing sources of aggregate by zoning, encroachment of incompatible development, and loss of rock material deposits when structures are built over them. With proper planning, however, a continued supply of these important rock material resources will be available in a manner most compatible with the environment and long-range land use plans.



The purpose of the study was to develop concise data on the rock material of Benton County in a form which could be submitted to potential users or developers of these resources and which could be used as a data base for land use ordinances in compliance with ORS 215.055. Oregon law ORS 215.055 and Land Conservation and Development Commission (LCDC) Goal 5, Topic B, formally direct the County to take the processing of mineral aggregates into consideration in the adoption of any land use ordinance. Data on the locations of sand and gravel pits, clay pits, and rock quarries; past production; the quantity and quality of material available; and the future requirements for these products are needed before land use ordinances are passed. This study, financed by the Oregon Department of Geology and Mineral Industries and Benton County through a grant from the Land Conservation and Development Commission, provides the above data along with broad parameters for secondary and tertiary land uses after mining. The data presented in this report will be used by planners and public officials for making land use plans and decisions and also by contractors looking for rock materials for construction projects.

Recommendations from Short Paper 27

The study provides a strong mineral resource data base and a geologic map for use of the County Planning and Public Works Departments, County and State road and highway departments, private contractors, and private citizens.

Included in the text are an inventory of current mineral resource availability and a forecast of future demands, which will help to focus the County's needs. The report also stresses the necessity of planning for secondary usage and reclamation of surface mining sites in order to eliminate adverse environmental effects often associated with surface mining.

The study recommends that the land status of all active and potential mining sites, particularly those near urban areas, should be determined in terms of present use and zoning classification and that all future changes in status should consider the mineral resource potential of each parcel. County zoning of land which excludes mineral resource development has the effect of preventing any future production and reduces the available natural resource, thus affecting resource availability projections.

It is also recommended that the County encourage mined land reclamation on all surface mining sites within its boundaries. By working closely with State agencies and by reviewing all reclamation plans, the County also may have significant input into the State program.

* * * * *

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The Department receives with grateful appreciation the letters and telephone calls from ORE BIN readers who remark about articles they found especially interesting or enjoyable.

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MOBIL OIL DRILLING AT OAKLAND

Mobil Oil Corporation began drilling on a deep test hole near the town of Oakland in Douglas County on July 10, 1978. If drilled to the proposed depth of 14,000 ft, the exploration hole, called "Sutherlin Unit No. 1," will be the deepest hole put down in the State.

Not only is Mobil's wildcat the deepest in Oregon, its collection of oil and gas leases is the largest ever assembled in the State. The firm reportedly has under lease or option approximately 1 million acres. Superlatives extend also to the equipment being used to drill the hole; Brinkerhoff's (the drilling contractor) Rig No. 53 is the largest to drill in Oregon and has a capability of 20,000 ft.

The Sutherlin Unit No. 1 will explore lower Eocene sedimentary and volcanic rock units as well as older rocks underlying the Eocene units. The nature of the rocks at 14,000 ft is a subject of controversy among geologists. Will they consist of Mesozoic marine sediments or will they be oceanic basalts? Mobil geologists hope that their Sutherlin Unit No. 1 will find natural gas in large quantities at depth on the Oakland anticline.

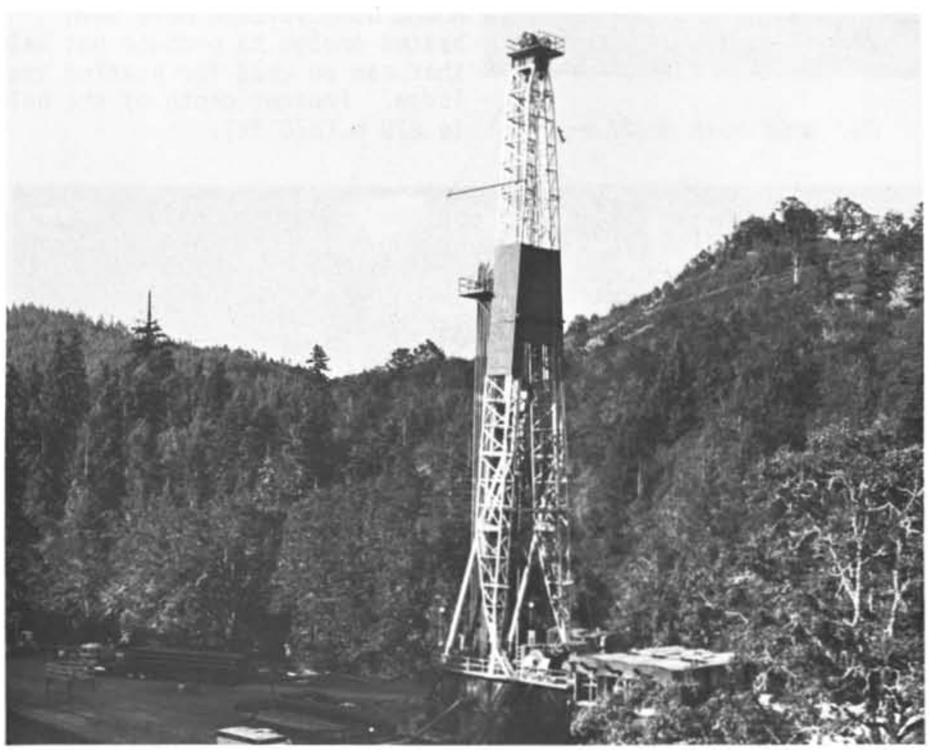
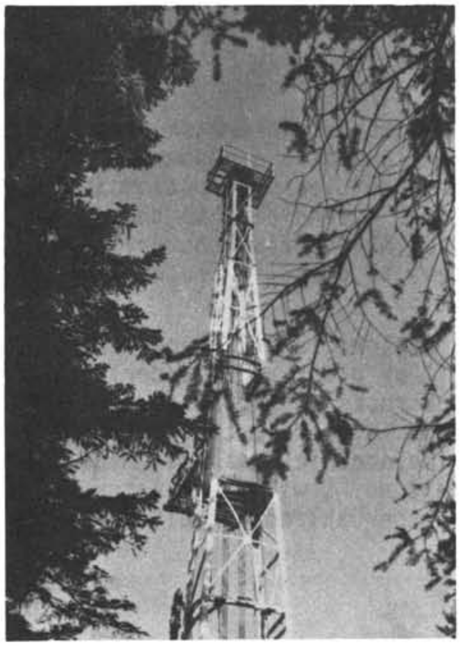


Photo courtesy Black Star, Doug Wilson, photographer

MOUNT HOOD GEOTHERMAL DRILLING PROGRAM CONTINUES



Old Maid Flat drill rig.

The Old Maid Flat geothermal test hole was deepened from 564 m (1,850 ft) to 1,220 m (4,003 ft) during July and August 1978. The preliminary bottom hole temperature of about 175°F may be high enough to make Northwest Natural Gas Company's proposed heating project feasible if a large enough supply of ground water of that temperature can be found. Results of the Old Maid Flat drilling are still being evaluated to guide future exploration.

A second geothermal test hole was started near Timberline Lodge in August. Plans are to drill to a depth of 600 m (2,000 ft) to see if rocks on the flanks of Mount Hood Volcano have been heated enough to produce hot water that can be used for heating the lodge. Present depth of the hole is 270 m (870 ft).

John Hook (left), Northwest Natural Gas, and Joe Riccio, Oregon Department of Geology and Mineral Industries, discussing results at Old Maid Flat.

Bill Covert (left), Northwest Natural Gas, and Joe Riccio, Oregon Department of Geology and Mineral Industries, conferring about drilling at Timberline Lodge.

Drilling below parking lot at Timberline Lodge.

OREGON 1977 MINERAL DATA SUMMARIZED

"Minerals in the Economy of Oregon," prepared under a cooperative agreement between the Bureau of Mines and the Oregon Department of Geology and Mineral Industries and published as SMP-21, may be obtained free upon request from the Publications Distribution Branch, Bureau of Mines, 4800 Forbes Avenue, Pittsburgh, Pennsylvania 15213.

The 14-page report contains tables summarizing Oregon's 1977 mineral production statistics; role in U.S. mineral supply; income from mineral bonuses, royalties, and rentals; and land ownership and mineral production. The report discusses the general mineral situation in Oregon, noting the construction of a new cement plant at Durkee, planned expansion of chlorine production in the Portland Rivergate district, and the reopening of small gold mines near Granite and Prairie City in eastern Oregon. The effects of regional energy problems and the implications of large withdrawals of land from mineral exploration and development are also considered in this report.

SMP-21 also contains a bibliography and 2-page map showing general locations of mineral deposits, geothermal wells, and mineral processing plants.

* * * * *

$IGN OF THE TIME$

Some 45 years ago a popular song advised, "Potatoes are cheaper; tomatoes are cheaper; now's the time to fall in love." Today's ditty, less lilting, has many variations. The DOGAMI version is, "Well, paper costs more now; and postage costs more now; ORE BIN prices must go up."

Beginning January 1, 1979, we will charge $4.00 for annual subscriptions and $10.00 for 3-year subscriptions. Each year the Department has had to spend more for supplies and printing to produce the ORE BIN without sacrificing quality. And that's not all. Changes in second-class rates are not timed or patterned to correspond with the raises in first-class postage. Between May and August 1978 alone, the cost of mailing the ORE BIN rose 29.9 percent!

Looking on the bright side, those who order before January 1 will enjoy the current rates. Use the coupons in the centerfold of this ORE BIN. Your order may be new, a renewal, or an extension of a current subscription, as long as DOGAMI has received it by January 1.

Another bright thought: On the drawing boards right now are plans for renovating the ORE BIN format. Readers may look forward to refreshing and welcome changes in '79. Be sure you and your friends will receive the hallmark January 1979 issue.

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The ORE BIN
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LATE PLEISTOCENE SEDIMENTS AND FLOODS IN THE WILLAMETTE VALLEY

Ira S. Allison
Professor Emeritus of Geology, Oregon State University

Quaternary geologic units are assuming increasing significance in helping us understand the history of the land on which we live and the constraints we must consider in earthquake engineering, resource management, and land use planning.

Many Quaternary deposits of northern Oregon are associated with late Pleistocene catastrophic floods, events which further challenge our thinking. The following article represents Ira Allison's interpretations of some of the deposits.

This contribution will be, we hope, one of many from within the geologic community which will collectively lead to a more refined comprehension of the Quaternary of northern Oregon.

Because of its length, this article is being published in two parts. The bibliography for the entire article will appear in next month's ORE BIN. Readers will find the index map (Figure 1) on page 178 useful for determining locations of individual larger scale maps presented in both the November and December issues of the ORE BIN.

Editor

Diverse Interpretations

The origin of certain unconsolidated sediments in the northern part of the Willamette Valley was attributed by Condon (1871) to a Willamette Sound. Sediments in the Portland-Vancouver area were called a delta in such a sound by Bretz (1919, p. 506), who later (1925, p. 252-257; 1928, p. 697-700) attributed them instead to river-bottom deposition by a huge Spokane Flood in a ponded drainage system. Allison (1932, 1935) assigned the Portland Gravels to a pre-Spokane Flood stage of alluviation by the Columbia River and named certain silts in the Willamette Valley the Willamette Silt (1953). Treasher (1924b, p. 13-15) noted that somehow ice-rafted erratics got into the Willamette Valley but said that there was little or no evidence for either the Spokane Flood or a Portland delta.

Lowry and Baldwin (1952, p. 17-21) recognized the Portland Gravels as dissected stream terrace deposits, considered the main bodies of silt in the Tualatin and Willamette Valleys to be a still-water facies of the Portland Gravels, accepted Allison's report of flooding via the Lake Oswego gap, and held that silt and erratics on the valley walls up to an elevation of 400 ft above sea level were deposited by a late flood long after the Portland Gravels stage of alluviation.

Bretz and others (1956) concluded that not just one flood but rather a whole series of floods came across the Columbia Plateau and on down the

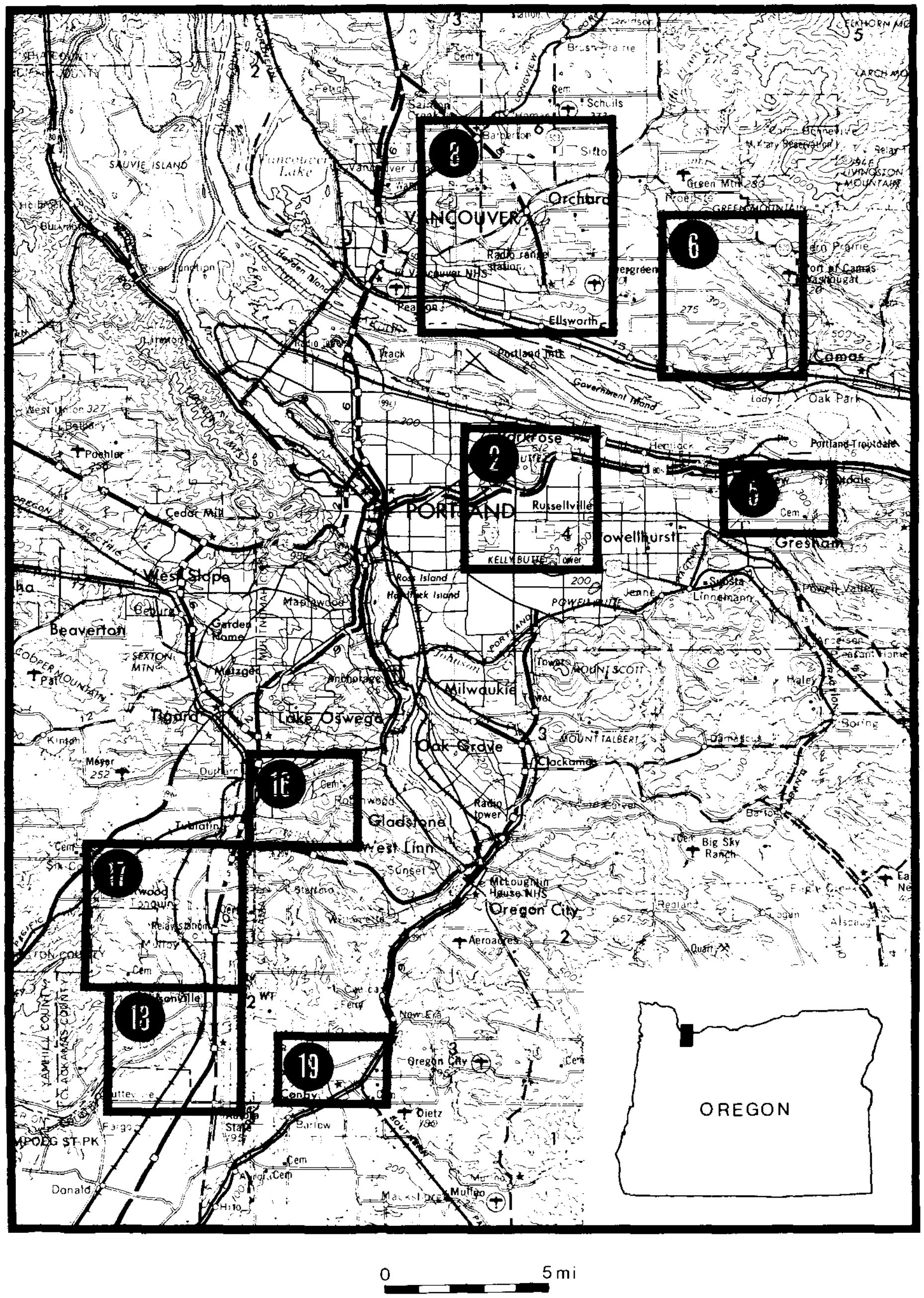

Figure 1. Index map showing areas of Washington and Oregon discussed in this article. Boxes show areas covered by larger sale maps appearing in this and next month's segments. Numbers in boxes are figure numbers.

Columbia River. Trimble (1957; 1963, p. 58-71) classified the sediments in the Portland area, largely on a textural basis, as lacustrine deposits in a ponded stream system, considering them to be products of Bretz-type flood waters of great volume and tremendous energy that were restricted by hydraulic damming of the Columbia River down-valley from Portland. Glenn (1965) concluded that the Willamette Silt was brought in by more than 40 surges of the Columbia River.

Schlicker and Deacon (1967, p. 29-35) described the Willamette Silt in or near Tualatin Valley and showed photographs of torrential bedding in sand and gravel deposited near Onion Flat and Durham, west of the Lake Oswego gap, by late flood currents. Ponding of the Willamette Valley was accepted by Price (1967, p. 27-32), who stated that alluvial deposits of the Columbia River impounded the Willamette Valley drainage in several inundations.

Bretz (1969) reviewed flood phenomena from northwestern Montana to Portland and determined that there were a total of seven or eight floods, five of which were caused by repeated failures of a glacier dam which once held back as much as 500 cu mi of water in a succession of Glacial Lake Missoulas. He gave special attention to scabland features, flood routes, divide crossings, flood gravels bearing gigantic current ripples, Grand Coulee, back-flooding of tributaries of the Columbia River, the Portland delta, the Rocky Butte fosse (long, narrow waterway) in Portland, and related matters.

Twofold Deposits

This author considers the unconsolidated deposits in the Portland-Vancouver area and most of the Willamette Valley to be of two different ages: (1) early phase sediments deposited by the Columbia River in a ponded Willamette River drainage system over an extended period of time, and (2) a late phase resulting from short-lived catastrophic drainage of a proglacial lake. Two widely separated occasions of flooding are involved: The first is multiple and mainly depositional in northwestern Oregon; the second is single and strongly erosional. The early phase is attributed mainly to repeated failures of the glacier dam at Pend Oreille, Idaho, and many evacuations of Glacial Lake Missoula, although other proglacial lakes may have been involved by experiencing similar outbreaks. Stream entrenchment had converted the early phase deposits into alluvial terraces before the violent debacle of the Spokane Flood, resulting from the failure of the ice dam at Glacial Lake Missoula.

Early Phase Deposits

Portland area

The terrace surface over a broad area east of Rocky Butte and Mount Tabor and northeast of Kelly Butte has an elevation of about 300 ft or more above sea level (Figure 2). It rises to the east and was greatly channeled and modified by the Spokane Flood.

The early phase deposits, reaching from the vicinity of Troutdale into Portland, are still conveniently called the Portland Gravels, following earlier usage (Bretz, 1928a, p. 697-700; Lowry and Baldwin, 1952, p. 17-19). They consist mainly of well-rounded pebbles (mostly basalt) less than 3 in. in diameter and a generous fraction of sand. The beds generally are nearly parallel layers a few inches to a foot or two thick (Figure 3), with only minor fluvial cross-bedding or river-bar structure.

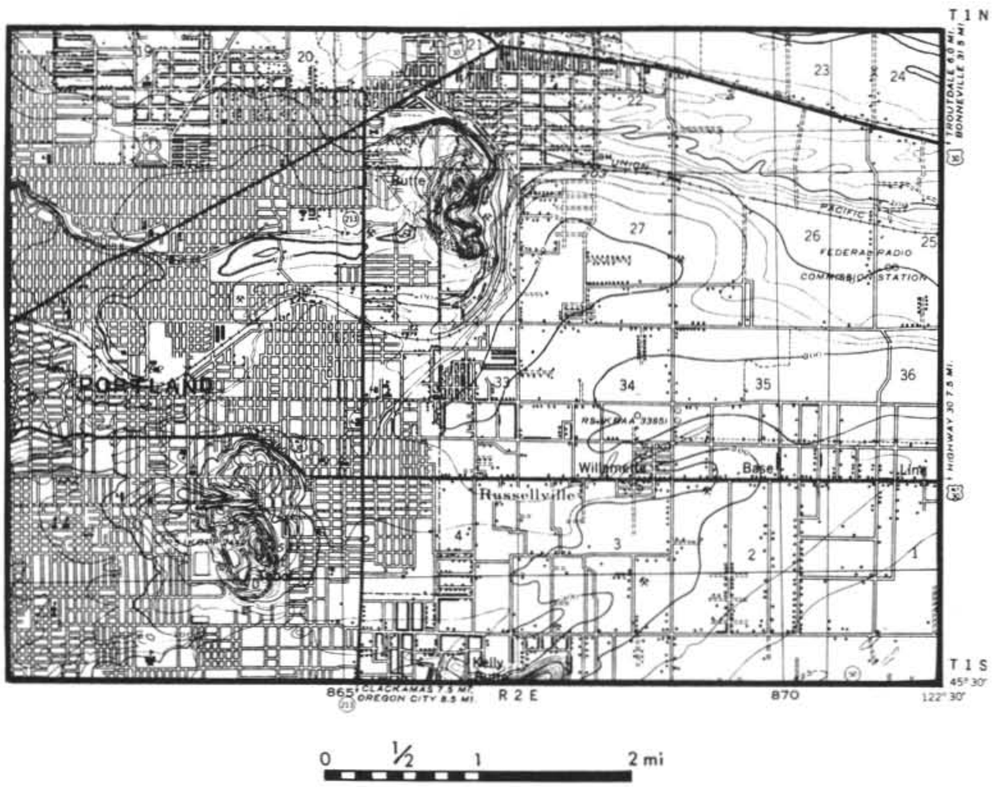

Figure 2. Southeast part of Portland Quadrangle (contour interval 25 ft). Note channel depressions near Rocky and Kelly Buttes, modified 300-ft terrace, and northeast-to-southwest channel east of Kelly Butte.

Figure 3. Parallel-bedded, somewhat sandy Portland Gravels in pit beside S.E. Division Street just east of 106th Avenue in Portland.

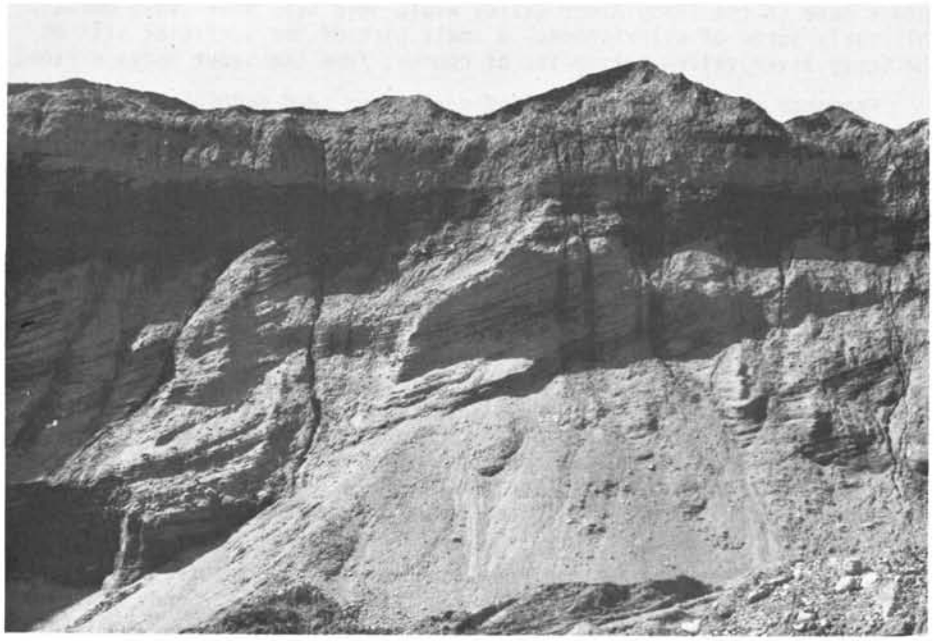

Figure 4. Sandy phase of Portland Gravels in pit 1.5 mi south of Troutdale, showing extensive deltaic foreset bedding inclined toward Sandy River valley.

They lack deltaic foresets except where Columbia River waters entered the mouths of tributaries which it had previously blockaded by alluviation.

One such exceptional deltaic structure occurs in a large exposure about a mile and a half south of Troutdale along the west side of the Sandy River valley, where a great deal of constructional material has been removed. Here long deltaic foresets slant east, southeast, and south (Figure 4). This site is at the eastern edge of a broad sand and gravel terrace remnant 3 mi long and 2 mi wide, at an elevation of more than 360 ft, between Troutdale and Gresham. A dry stony channel runs southwesterly along its southern edge. The northern and northwestern side of this terrace is an erosional scarp exhibiting basalt boulders and outcrops of basalt.

This gravel deposit grades into a silt-covered plain beside the Sandy River at an elevation of a little less than 200 ft (Figure 5). The easterly foresets apparently determine the eastward slope of the Troutdale-Gresham sand and gravel terrace. Similar foresets exposed at one time in a roadcut on Stark Street, half a mile to the south, were part of the reason Bretz called the deposit between Troutdale and Gresham a Spokane Flood eddy bar, supposedly favored by its position in the lee of a high rock shoulder east of the Sandy River.

In this author's opinion, the present terrace is part of a Portland Gravels fluvial deposit that once must have filled the adjacent Columbia River valley floor to an elevation of more than 360 ft at the mouth of the Columbia River Gorge. That deposit would have blocked the Sandy River drainage so that deltaic foresets directed by the Columbia River into a lake in the Sandy River valley would have been inevitable during this early stage of alluviation. A small part of the surficial silt on the Sandy River valley bottom is, of course, from the later Spokane Flood.

Remnants of similar early flood gravel and sand deposits showing foreset structures slanting up-valley also occur in the Willamette Valley and in the lower reaches of several tributaries of the Columbia River, such as Willow Creek, Old Lady Canyon, and Fifteenmile Creek, all east of the Cascade Mountains. Many gravels at the mouths of tributaries were later modified by the Spokane Flood into eddy bars. Silts antedating the climactic flood occupy the valley floors upstream in many of these tributaries as well as in the Willamette Valley. Bretz (1969, p. 514-515, 532-533) attributed them to back-flooding from a borelike flood front, but their origin remained unclear to him in 1969, notwithstanding his earlier statement (1956, p. 1034) that "perhaps two kinds of backwater episodes are recorded in these deposits, both with up-valley currents. The well-sorted, well-stratified valley bottom deposits may be the consequences of melt-water incursions from normal valley train building along the main scabland routes. Because, however, floods have all but destroyed any record of valley trains, survival of such bottom sediments seems anomalous." Floods did indeed scour the master channels but not the tributaries.

The present surface of the Portland Gravels descends from an elevation of more than 300 ft east of Rocky Butte to 260 ft at Sandy Boulevard, 1.5 mi west of the Butte, to 200 ft or less at Union Avenue, 2.5 mi farther west, and to still lower levels in the peninsula, or St. Johns area, some 4 mi farther on. This surface, however, has not only channels, such as those at the Rose City Golf Course and Sullivan Gulch (now the route of I-80N), but also has remnant ridges, such as those in the Alameda district of northeast Portland and in the St. Johns area, and a gradual slope toward the Columbia River. Apparently a considerable quantity of material

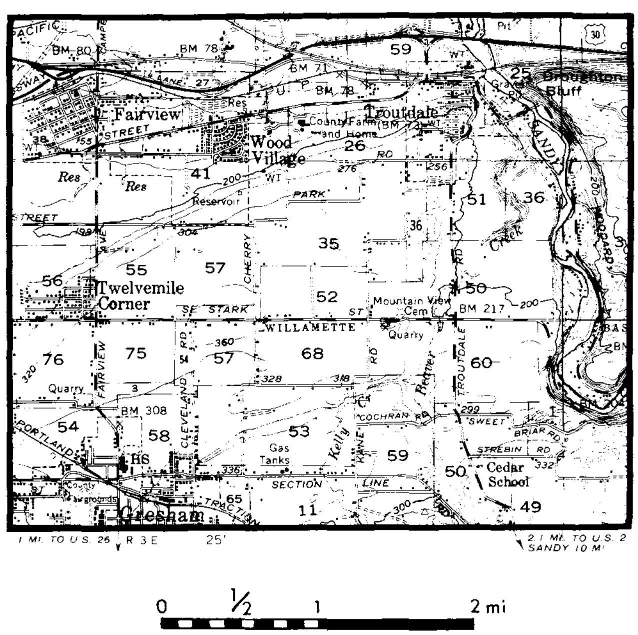

Figure 5. Southwest part of Camas (Washington-Oregon) Quadrangle (contour interval 40 ft), showing Portland Gravels terrace between Troutdale and Gresham.

has been eroded from this surface, presumably in large part by the Spokane Flood, whereas the corresponding surface of Mill Plain east of Vancouver, Washington, retains an approximate 300-ft level for many miles (Figure 6). So the present level of the Portland Gravels or equivalent sand and silt near the Willamette River in Portland cannot be used to find the precise level of the fill which diverted Columbia River water during flood seasons into the Willamette and Tualatin Valleys for the deposition of Willamette Silt.

Fluvial silt and fine sand (Figure 7) that now border the Willamette River in north Portland may be the downstream continuation of the Portland Gravels fill or perhaps, in part, products of the slow final outflow of previously ponded water of the last flood.

A terrace remnant, a correlative part of the Portland Gravels on the Washington side of the Columbia River, bears the local name of Mill Plain (Figure 8, middle right). It extends westward about 11 mi from the western part of T. 2 N., R. 3 E. to the eastern part of Vancouver, sec. 24, T. 2 N., R. 1 E. Its surface, nearly flat between elevations of 280 and 310 ft, may be at or near its original depositional level. A few shallow channels cross it. Its internal structure, well exposed in the English Pit (sec. 30, T. 2 N., R. 3 E.), reveals its fluvial, not deltaic nor catastrophic flood, origin (Figure 9). This internal structure is matched in several gravel pits on the Oregon side of the Columbia River (Figure 3) and is best ex-

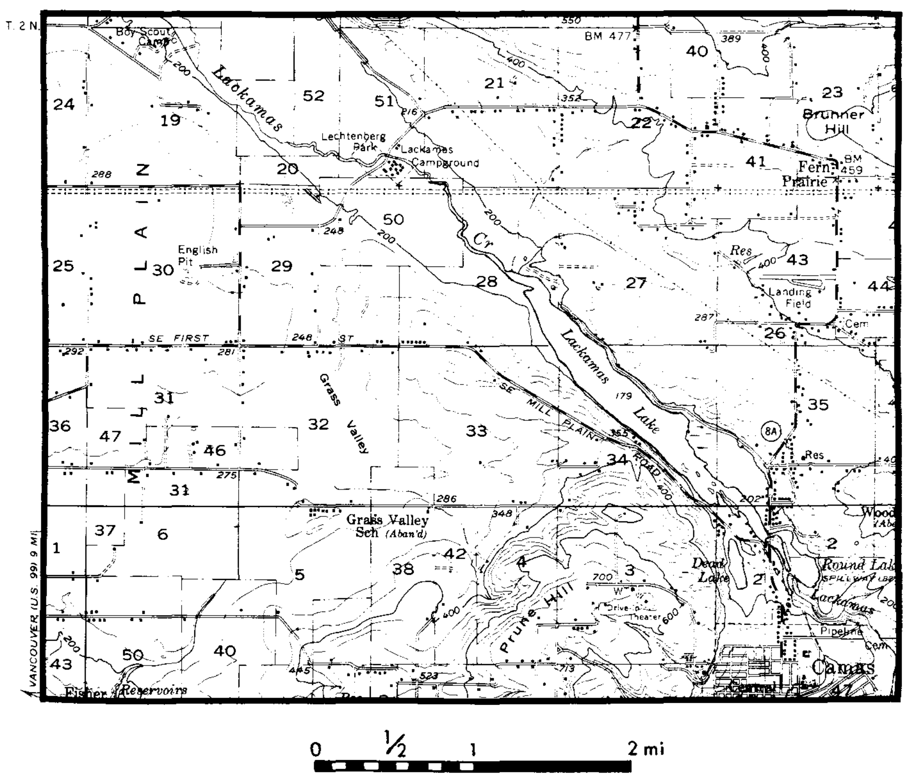

Figure 6. Western part of Camas Quadrangle (contour interval 40 ft), showing Mill Plain terrace of Portland Gravels west of Prune Hill and northwest-oriented Lackamas Lake channel eroded by Spokane Flood.

posed at present in pits: (1) 1.5 mi south of Troutdale, (2) at S.E. 195th Avenue and Division Street (Figure 10), (3) near S.E. 106th Avenue and Division Street, and (4) at N.E. 122nd Avenue and San Rafael Street. Figure 11 shows a former pit in which Portland Gravels are overlain by Spokane Flood deposits.

Tualatin Valley

A sandy extension of the Portland Gravels continues westward beyond the Tualatin River gap and the Lake Oswego lowland into the proximal part of the Tualatin River valley at a summit elevation of about 240 ft (Schlicker and Deacon, 1967, p. 30-32). These sands, which form uneven terraces on both the north and south sides of Tualatin Valley, at most places show channeling by the later Spokane Flood. Among the largest patches in the eastern part of Tualatin Valley are those: (1) at Six Corners (top greater than 210 ft), (2) northeast of Onion Flat (top greater than 190 ft), and (3) in secs. 19 and 20, T. 2 S., R. 1 E. (top greater than 210 ft).

These early sands in the Tualatin Valley afford an approximate measure of the maximum former height of the Portland Gravels (and sands) fill at the toe of the deposit along the present position of the Willamette River in Portland, now generally 50 to 150 ft above sea level. The original level clearly exceeded 210 ft, matching the graded level in the Tualatin Valley.

The reduction of level of the fill in Portland from approximately 250 ft or more and the abundance of later flood channels across the Portland Gravels testify to large-scale erosion of the fill, partly by the huge Spokane Flood and partly by ordinary stream activity both earlier and later.

The early sands in the Tualatin Valley give way up-valley to Willamette Silt deposits from a few feet to about 50 ft thick (Schlicker and Deacon, 1967, p. 30-32).

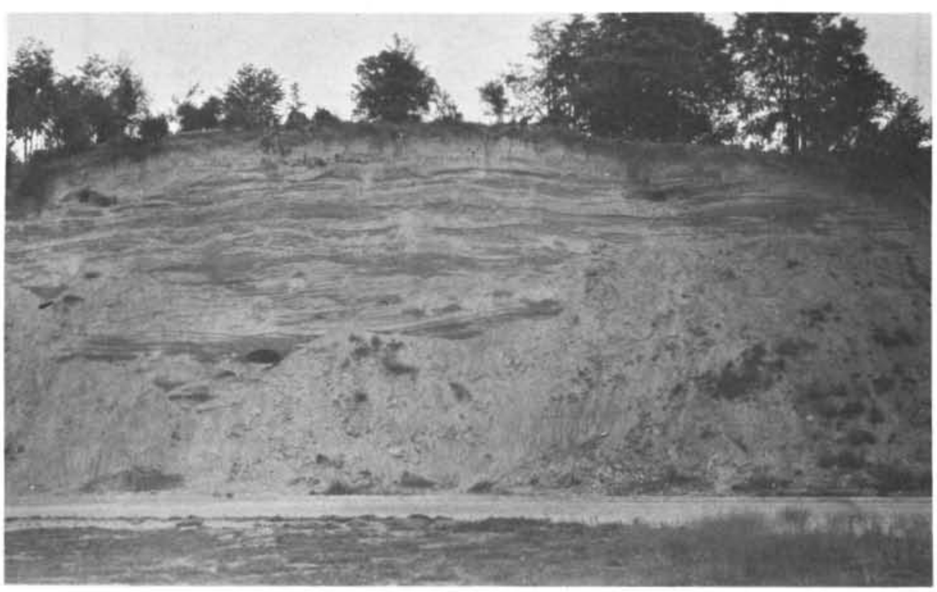

Figure 7. Fine-grained fluvial deposits at N. Greeley Avenue and N. Going Street, Portland.

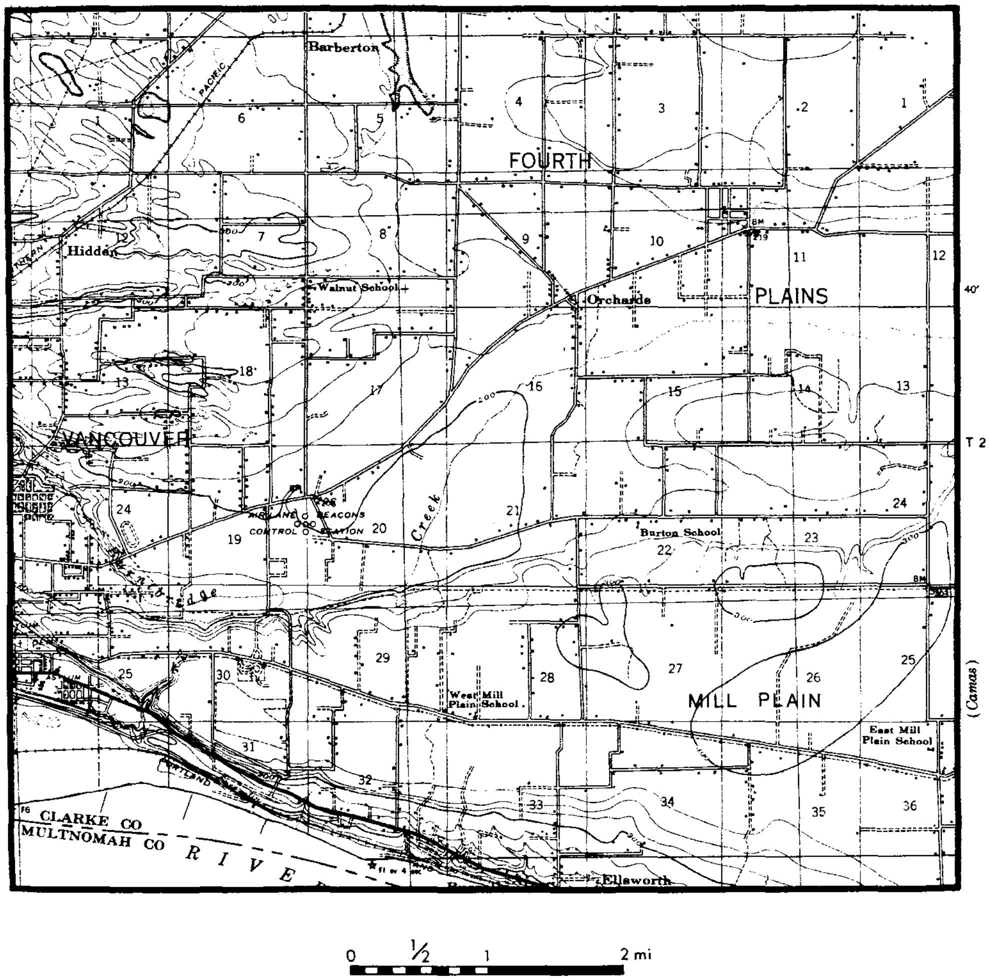

Figure 8. East-central part of Portland Quadrangle (contour interval 25 ft), showing western part of Mill Plain 300-ft terrace of Portland Gravels, flood-swept Fourth Plains channel, and eroded sand hills (terrace remnants) north-northeast of Vancouver.

Figure 9. Texture and fluvial, not deltaic, structure of Portland Gravels in English Pit, 5 mi northwest of Camas, Washington. Deposit here includes considerable sand.

Figure 10. Bouldery Spokane Flood deposits in western part of gravel pit 1.5 mi west of Gresham, showing poor sorting and wide range of textures.

Figure 11. Portland Gravels in former pit at southwest edge of terrace near northern Clackamas County line, with foresets toward southwest. Few-feet-thick sheet of Spokane Flood deposits, including erratics of various sizes, overlies older gravel. Range pole is 8 ft long.

Figure 12. Roadcut on U.S. Highway 99E, just across Pudding River from Aurora. Material at base is sand of early phase of Willamette Valley filling, overlain by Spokane Flood mixture of gravel, sand, silt, and erratics (light-colored stones). Note small cut-out at right side of roadcut at contact.

Willamette Valley

Similar sands and silts were washed southward in large volume through the Oregon City watergap into the open part of the Willamette Valley. Near Canby and Aurora (Figure 12), sand predominates. These sands are overlain by or give way laterally to tens of feet of Willamette Silt, which continues up-valley southward as far as Harrisburg, Oregon, about 90 mi from Portland. South of Harrisburg, the valley fill of equivalent or greater age consists of gravel and sand from the headwaters of the Willamette and McKenzie Rivers.

In the northern part of French Prairie (Figure 13), portions of the partly dissected Willamette Valley fill south of the bend of the Willamette River have nearly flat surfaces with maximum elevations of a little more than 190 ft above sea level; and 170- to 190-ft levels extend for many miles into other nearby areas.

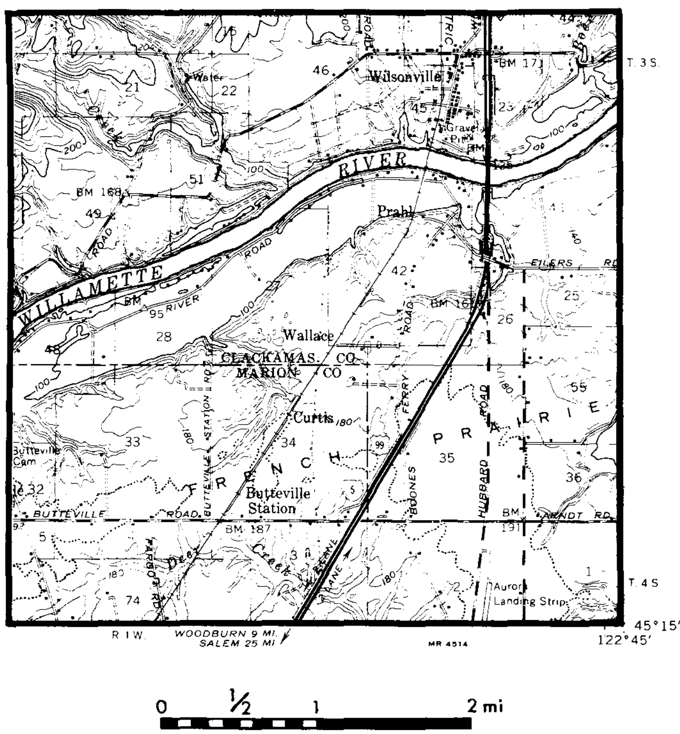

Figure 13. Southeastern part of Sherwood Quadrangle (contour interval 20 ft), showing part of Spokane Flood-modified French Prairie; a 190-ft Willamette Silt terrace (dotted contour lines, lower part of map), correlative and consanguineous with Portland Gravels; and site of Portland Flood rubble deposit over edge of Willamette River trench at Wilsonville.

Willamette Lake

The lake in the Willamette Valley in which Willamette Silt and correlative deposits were laid down is here named the Willamette Lake. It was caused by upbuilding of the Portland Gravels fill at Portland above the grade of the Willamette River, presumably as part of a glacial Columbia River valley train. Its highest level, as recorded by silts near Harrisburg, was about 300 ft above sea level. Whatever may have been the elevation of the toe of the Portland Gravels deposit in Portland, the original summit of the valley fill south of the Oregon City narrows may not have been much more than 200 ft. In that case, the depth of Willamette Lake in the northern Willamette Valley above the present top of the fill at times may have approached 100 ft and was probably much greater when the filling began. The level of the lake must have fluctuated through a wide range because of repeated surging and ebbing of water from the Columbia River.

As laboratory tests of Willamette Silt show almost complete sedimentation within a few minutes, one may wonder how the nearly clay-free silt was kept in suspension long enough to reach the 300-ft level, 90 mi upvalley. After passing through the Oregon City gap, the heavily loaded, roily, inrushing Columbia River water evidently deposited its basaltic sand in the Canby-Aurora area, leaving the silt and fine sand to flow along the lake bottom as turbidity currents. A steep front on the incoming surge of water would have helped keep material in suspension, but the main requirement was a rapid rise of a large volume of turbid water.

Unlike the later Spokane Flood, the Willamette Lake may have been intermittent over a considerable span of time. The repetitively banded structure and graded bedding of the Willamette Silt indicate the occur-

Figure 14. Roadcut at edge of Willamette River trench, about 5 mi south-southeast of St. Paul, Oregon, showing stratification of Willamette Silt (and fine sand) deposited in Lake Willamette. Note characteristically uneven sands (dark when moist) at base of each bed. Structure, including graded bedding, is attributed to turbidity or density currents flowing along bottom of Lake Willamette.

rence of many surges of silt-laden Columbia River water into the valley. Faint laminations appear within many of the beds, but evaluation of the time significance of these layers is difficult.

Each layer of Willamette Silt in the northern and central parts of the valley typically has an uneven sandy base under a thicker band of silt (Figure 14). Some beds show reverse grading or compound grading. The prevailing structure is somewhat like that of varves in glacial lakes, as though each layer were the result of an annual Columbia River freshet. A year-by-year origin may be questioned, however, because each layer seems to be too voluminous for an annual increment from a single flood season, even from one lasting several spring and early summer months as experienced by the Columbia River at present. If the layers were annual and repeated in successive years, the whole record would require only decades of time. On the other hand, if there are time gaps in the sequence, the time scale may run to centuries--still a very short fraction of geologic time.

At Irish Bend, its type locality in the Willamette River bank about 7 mi north of Harrisburg (Figure 15), the Willamette Silt contains little fine sand, so beds are somewhat indistinct, and each one is only a few inches thick. Perhaps the River Bend section (Glenn, 1965) should be considered a co-type, as it is representative of the northern facies. The silt consists mainly of quartz, feldspar, and mica, but a great variety of other minerals are present in small quantities.

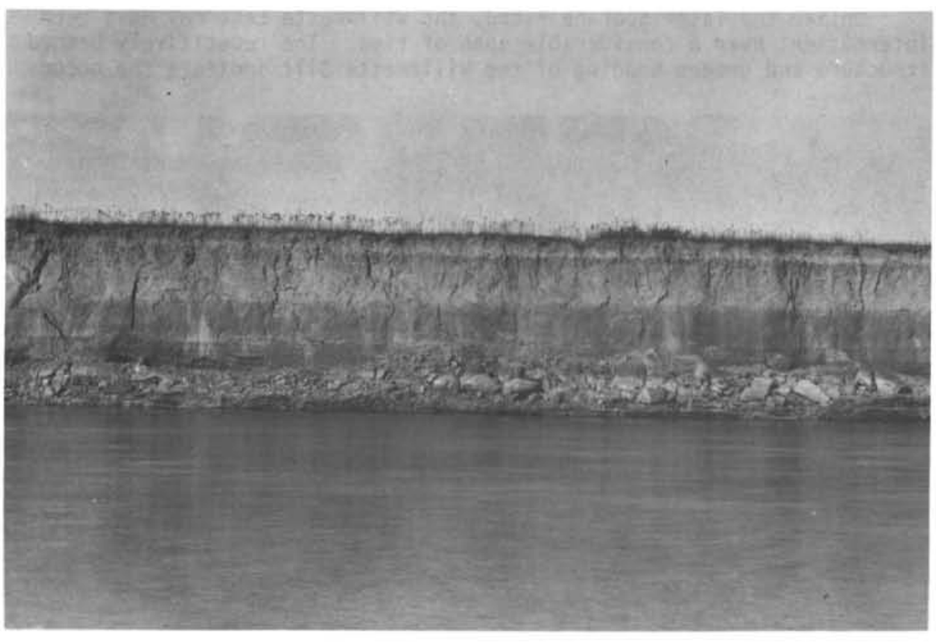

Figure 15. Willamette Silt (wide upper gray band) in bank of Willamette River at Irish Bend, southeastern Linn County, Oregon, overlying deeply weathered, semiconsolidated river deposits and underlying thin sheet of silt from Spokane Flood. Somewhat weathered top of Willamette Silt ranges in color from pale yellowish gray when wet to dark reddish brown.

The Willamette Valley fill is thought to have been formed by multiple extraordinary Columbia River floods caused by the repeated deterioration of the Pend Oreille glacier that dammed Glacial Lake Missoula. In a setting where glacial ice and proglacial lake water are in a contest, we may visualize each of them having mastery of the lake outlet from time to time, first one and then the other. Any weakening of the glacier would allow the lake to burst out. Judged by the number of sediment beds in the valley fill in northern Willamette Valley, several tens of floods must have occurred during the early phase of alluviation. Bretz (1969) deduced a total of seven or eight floods from the scabland record in eastern Washington.

Next month: A discussion of late phase erosion and deposits of the Spokane Flood will complete this two-part article.

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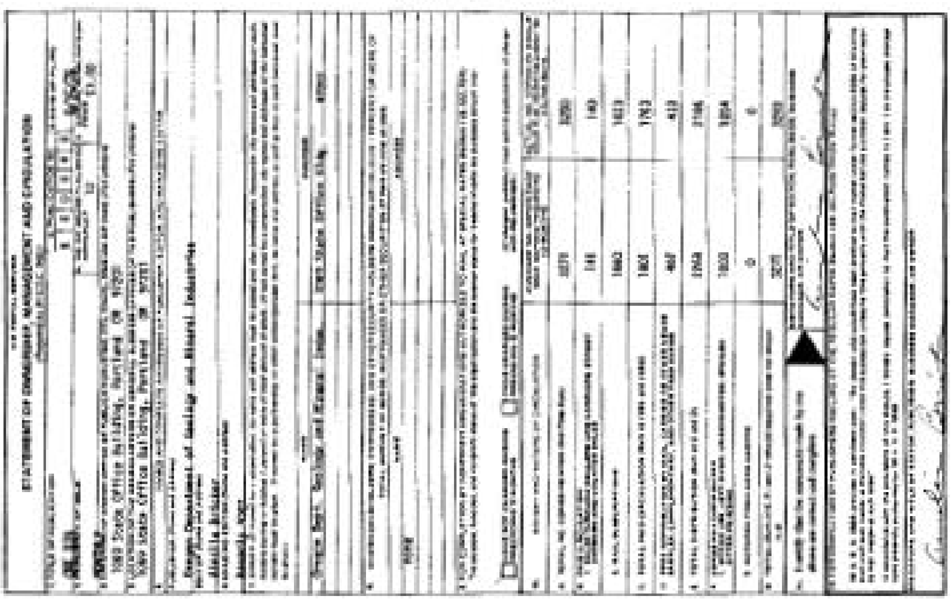

SUNOCO OBTAINS FOUR GEOTHERMAL TRACTS

Sunoco Energy Development Company of Dallas, Texas, was the only bidder on four tracts of land near Breitenbush Hot Springs offered for geothermal development.

The successful bidding allows Sunoco to proceed with geothermal development plans, pending approval of the bids by the U.S. Geological Survey and the Bureau of Land Management's issuance of leases.

The lands are located about 12 mi northeast of Detroit, Oregon, and are managed by the U.S. Forest Service. A fifth tract received no bids. The Bureau of Land Management conducted the sale.

Acreage and bids are as follows:

Tract	Acres	Bid
1.	2,133.4	$27,734.20
2.	1,280	$22,592.00
3.	1,365	$32,459.70
4.	1,040	$ 3,796.00
5.	1,029	No bids received

* * * * *

NORTHWEST MINERS TO HOST

The Northwest Mining Association's 84th Annual Convention is expected to draw more than 1,600 miners from around the world. The meetings will be held at the Davenport Hotel, Spokane, from November 30 through December 2.

John B. Hite, General Chairman, said the convention theme, "The Great Northwest - Resources for Tomorrow," was chosen to emphasize the known and potential mineral and energy sources in the Northwest. "In these days of energy and mineral shortage and increasing uncertainty of foreign supplies, every effort must be made in the energy-rich Northwest United States to discover and produce the enormous reserves that nature has provided," Hite said.

Details and registration materials are available at the association offices at 1020 Riverside Avenue, Spokane, Washington.

* * * * *

WESTERN STATES RECOVER FROM DROUGHT

Streamflow measurements made by USGS hydrologists indicate that heavy snow and rains brought to years of drought in most western states to an end. The scientists have been compiling records of the 1978 water year, which was from October 30 through September 30.

Throughout the water year, Oregon's streamflow fluctuated, but amounts were generally normal or above average. The Columbia River streamflow was above average in December for the first time since September 1976. The drought experienced in the season preceding the 1978 water year was the most severe on record for the State of Oregon.

In neighboring California, Idaho, and Washington it may be years before ground-water supplies are recovered, although the drought appears to be over.

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LATE PLEISTOCENE SEDIMENTS AND FLOODS IN THE WILLAMETTE VALLEY

Ira S. Allison
Professor Emeritus of Geology, Oregon State University

Continuation

The first portion of this article was printed in the November ORE BIN, v. 40, no. 11. In it, Dr. Allison outlined diverse interpretations, including his own of multiple late Pleistocene catastrophic floods, of the origins of sediments found in the Portland area, Tualatin Valley, Willamette Valley, and Willamette Lake.

Figure numbers in this issue resume from the November segment, beginning with Figure 16. The complete list of references for both articles appears at the end of this final installment.

Late Phase Erosion and Associated Deposits

The Spokane Flood produced many effects in the Willamette Valley. The erosional channels near Rocky Butte (Figure 2) are especially noteworthy. One, 20 to 50 ft deep, leaves the Columbia River trench near Fairview, Oregon, and separates the 360-ft Troutdale-Gresham terrace remnant from the 300-ft part of the terrace east of Rocky Butte. This channel continues southwestward nearly 10 mi across the Portland Gravels to the southwestern edge of the terrace. The Spokane Flood picked up gravel and sand en route and presumably deposited it in the Willamette and Clackamas River channelways, from which it was later largely removed, probably by ordinary stream erosion.

Below an erosional scarp along the northern edge of Mill Plain east of Vancouver is a long tract, called Fourth Plains, eroded by flood waters that poured from the Columbia River through the channel now occupied by Lackamas Lake (Figures 6 and 8). The flood removed at least 100 ft of gravel and sand from much of the Fourth Plains area. Lag boulders lie on the channel bottom.

In a belt 3 to 6 mi north-northeast from downtown Vancouver (Figure 8), where the terrace consisted mostly of sand, flood erosion produced a complex of multiple channels and elongate residual ridges (Allison, 1933, p. 717-718; Trimble, 1963, p. 62). The ridges are not bars, as Bretz once thought (1925, p. 254). This large Fourth Plains channel, however, may have been eroded by a flood later and lower than the Spokane Flood.

The Spokane Flood surged westward through the Tualatin River and Lake Oswego channels and, upon reaching the wide-open portion of the Tualatin Valley, deposited loose, poorly sorted, rubbly and bouldery gravel and sand (Figure 16). Direction of flow is indicated by westward-slanting foreset bedding in the rubbly gravel (Schlicker and Deacon, 1967, p. 32-35) and by channels in previous sand and silt deposits farther west (Lowry and Baldwin, 1952, p. 19-20).

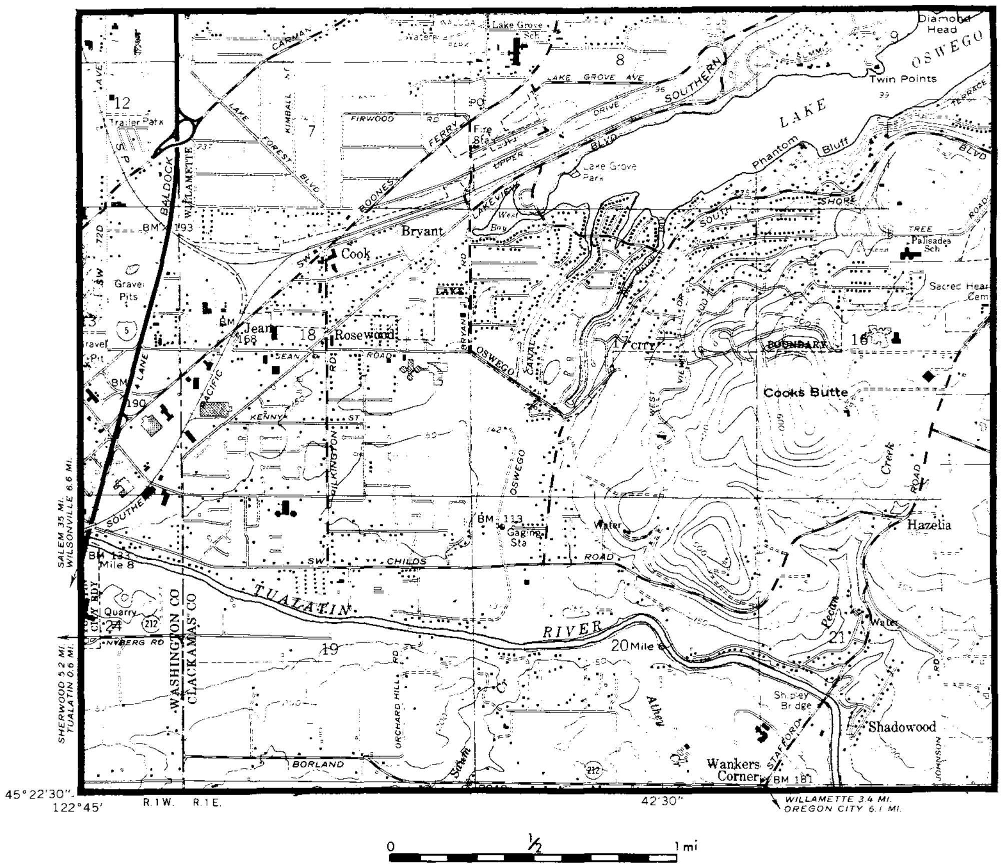

Figure 16. Southwest corner of Lake Oswego Quadrangle (contour interval 10 ft), showing Lake Oswego and Tualatin River routes used by Spokane Flood pouring into Tualatin Valley. Gravel pits along west edge of map are in ill-sorted, rubbly deposits which have west-slanting foresets.

The flood level in the Tualatin Valley rose high enough to spill with great force across the divide separating the Tualatin and Willamette drainage basins. This vigorous overflow southward across the divide scoured multiple channels in the basaltic bed rock, dug small rock-bound basins, and left rock knobs barren of soil (Allison, 1932; Glenn, 1965, p. 155), forming a topography in the Rock Creek-Tonquin area (Figure 17) that is a miniature replica of the well-known scabland in eastern Washington. The divide, of unknown preflood elevation, was lowered locally to a little less than 150 ft above sea level. The coarse products of erosion were dumped over the north side of the Willamette River channel at Wilsonville as poorly sorted, bouldery rubble with south-slanting foresets. Much of this material was removed and used locally in the construction of the I-5 freeway. The onrushing flood also eroded the northern edge of the early-phase terrace south of the Willamette River. Part of the sands and silts settled along the valley bottoms of the Willamette River and its tributaries.

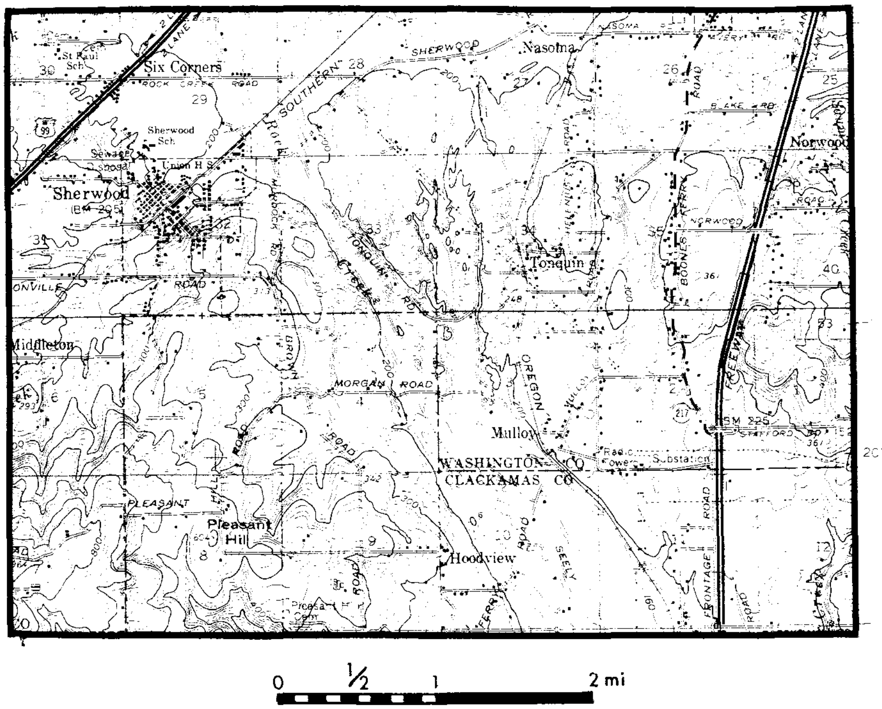

Figure 17. Scabland tract eroded by Spokane Flood across Tualatin-Willamette drainage divide in northern part of Sherwood Quadrangle (contour interval 10 ft). Channels end at Wilsonville (Figure 13).

A large flow of Spokane Flood water poured southward through the Oregon City water gap (Figures 18 and 19); at the north edge of the Mollala River trench near Canby it left southwest-slanting coarse, ill-sorted gravel beds that are no longer exposed. The flood also removed tens of feet of sand and silt from the terrace near Canby and from the northern part of French Prairie (Figures 13 and 19). Some of the sediments removed from the terraced valley fill were left in the then-entrenched channelways of the Pudding, Mollala, Yamhill, and Willamette Rivers and were later partly removed by these streams.

Portions of this late fill remain within the Willamette River trench and in its tributaries in the northern part of the Willamette Valley, occupying a second bottom terrace above the present flood plains. This fill of well-bedded silts and fine sands, whose mineral composition is similar to that of the Willamette Silt, forms a flat or gently rolling surface unlike the curving meander scars and point bars of the modern flood plains. The best examples are found along the Willamette, Yamhill, and Pudding Rivers and in the valleys of Champoeg, Mill, and Butte Creeks.

The inflow of flood water from the Columbia River temporarily raised the water level in the Willamette Valley to an elevation of 400 ft, forming a body of water named Lake Allison (Allen, in press). This 400-ft water level contrasts with the 1,100-ft level of the Spokane Flood east of the Columbia River Gorge, which cuts through the Cascades. Pebbly silts, a

Figure 18. Spokane Flood boulders from basement excavation in Canby.

few inches to a foot or two thick, containing iceberg-rafted erratics ranging in size from tiny particles to blocks several feet in diameter (Allison, 1935), were spread over the terraced Willamette lowland and its entrenched valleys and onto the lower slopes of adjacent hills. The erratics include granitic and metamorphic rocks foreign to the Willamette drainage basin, and some retain glacial striations.

Glenn (1965) found that these ubiquitous gray pebbly silts locally overlie oxidized Willamette Silt along the Willamette River bend exposure near Feasters Rocks, about 3 mi south-southwest of St. Paul, and at the Needy clay pit, approximately 4 mi east of Hubbard. A 50-ft bank of Willamette Silt and associated sand is exposed at the Needy site. The exposure at the bend of the Willamette River is somewhat thicker. Entrenchment of the streams and the surficial oxidation of the Willamette Silt indicate a time gap between its deposition and that of the disconformable gray pebbly silts deposited by the Spokane Flood. Lowry and Baldwin (1952, p. 20-21) also noted that a flood "long after the Portland Gravels" did some local scouring and left thin deposits of silt, gravel, and erratics elsewhere.

Trimble (1957, 1963) found deposits of fine sand and silt, both stratified and unstratified, disconformably overlying Portland Gravels at several places in Portland, notably, west of Mount Tabor and between Rocky Butte and Kelly Butte. At first he classified these fine-grained sediments as Pleistocene alluvium; later he called them "upper (?) Pleistocene sand and silt deposits." In places they occupy channels eroded into the earlier fill and may be slack-water deposits of the climactic flood waters that rose to their maximum level, held a short stillstand, and then continued down the Columbia River. This water was joined by Allison Lake water that reversed directions and flowed back out of the Tualatin and Willamette Valleys into the Columbia River.

The presence of late silts and fine sands in the Portland area and the thin sheet of Lake Allison pebbly silt over the Willamette Valley lowland means that the Spokane Flood waters were obstructed downstream from Portland, either by hydraulic damming of a tremendous volume of water (Trimble, 1963) or, in this author's view, by a combination of a huge volume of water and an ice jam. Some of the numerous icebergs were big enough to carry large tonnages of erratics. For example, a block of ice more than 75 ft on a side would have been required to carry one boulder found near Sheridan (Allen, in press). Groups of erratic boulders found elsewhere in the region affected by the flood would have also required icebergs of considerable size as carriers (Figure 20). The general prevalence of other smaller foreign particles in the pebbly silts is evidence of an abundance of ice in the flood water (Figures 11, 12, and 21). So the concept of ice in the Columbia River at that time is not farfetched.

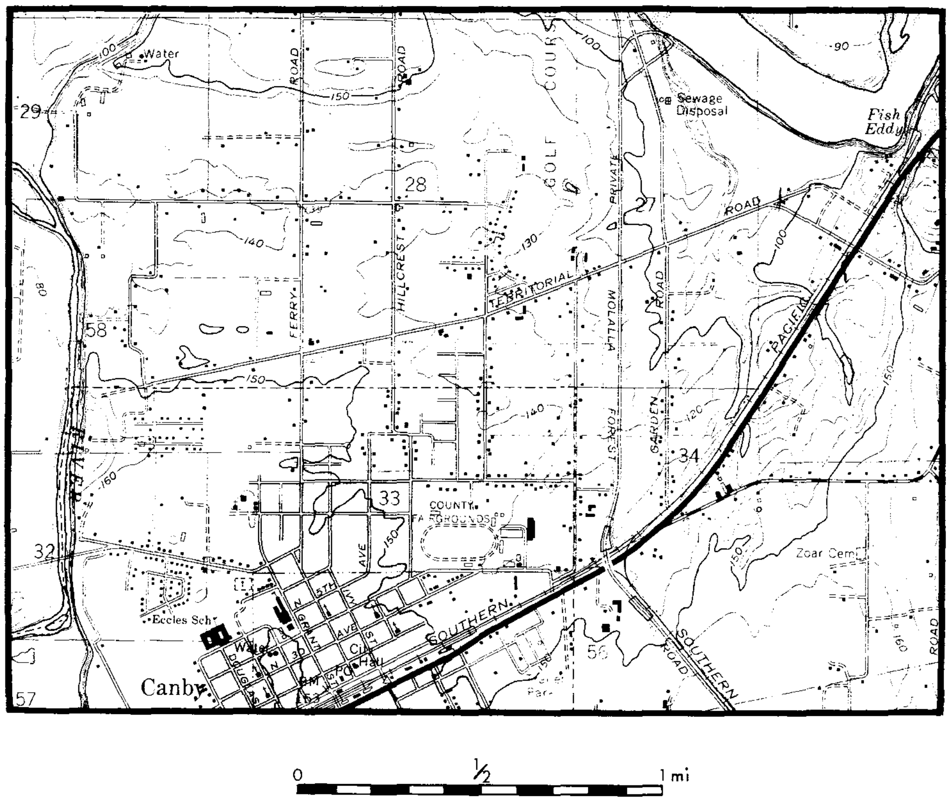

Figure 19. Spokane Flood-washed sandy terrace, correlative with Willamette Silt and Portland Gravels, near Canby (contour interval 10 ft). Flood currents coming out of Oregon City watergap (top right) crossed terrace from northeast and dumped their deposits southwesterly over side of already entrenched Mollala River and on valley bottoms generally. Large river in northeast corner of map is the Willamette. Flood topped ridge east of sharp turn of river at Fish Eddy.

Figure 20. Granitic erratics found at elevation of 310 ft near middle of sec. 32, T. 12 S., R. 2 W., south of Peterson Butte, Linn County. Other erratics are nearby.

The effect of ice is also seen in an analogous situation elsewhere. Waters (1933, p. 815-820) agreed with Bretz that the Okanogen ice lobe dammed the Columbia River west of the upper end of Grand Coulee, but he notes that as the ice melted, "This dam holding the lake became more and more unstable until eventually it collapsed, giving rise to a spectacular flood. The impounded water, charged with large blocks of ice from the broken dam, rushed through the Columbia Valley, jamming the bergs in great numbers behind every spur and projection." These grounded river-rafted icebergs melted and left a large number of kettle holes in the lowest outwash terrace in the Columbia River canyon. Waters stated, "Many of the kettles on the 'Great Terrace' are of such size that it would require a raging flood of water over 100 ft deep to carry the bergs that formed them."

A similar or even greater abundance of rafted ice should be expected from outbreaks of Glacial Lake Missoula. Evidence of large icebergs on the northeastern slopes of the Rattlesnake Hills between the Columbia River and lower Yakima Valley was recorded by Bretz (1930, p. 409-412) and Allison (1933, p. 678-681).

Geologic Ages

The Pleistocene was characterized by multiple stages of continental and montane glaciation, separated by long, warm, interglacial stages (Black

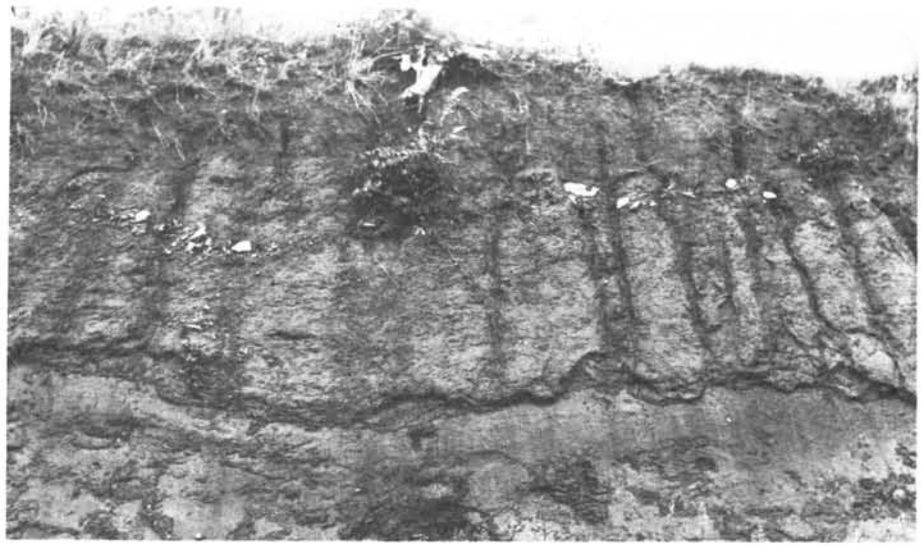

Figure 21. Roadcut at McNary, few miles southwest of Salem, showing streak of early-settling, ice-rafted erratics in valley fill.

and others, 1973). The last glacial stage was the Wisconsinan and its substages in the Great Lakes area (Frye and Willman, 1973); corresponding events in the northern Rocky Mountains area include two (locally three) stades of Bull Lake Glaciation and three stades of Pinedale Glaciation (Richmond, 1965). During the Bull Lake-Pinedale Interglacial Period, the Bull Lake deposits weathered to mature soil or, in dry areas, received considerable caliche.

Glenn (1965) believed that the main body of Willamette Silt is older than 19,000 years and younger than 34,000 years B.P. (before present). Glenn's 34,410 ± 3,450-year figure is based on the carbon-14 content of a log found at a depth of 20 ft in sec. 35, T. 2 S., R. 1 W., near Salem. The 19,000-year figure comes from an extrapolation beyond a radiocarbon date of 12,240 ± 330 years B.P. for peat 16 ft below the surface in Onion Flat, 3 mi west of Tualatin, assuming that the basal peat accumulated at a rate of 1 m/1,000 years.

Hansen's (1947) pollen diagrams for Onion Flat show a normal postglacial forest succession, starting principally with lodgepole pine (a pioneer invader), Sitka spruce, and fir, giving way later to Douglas fir and Oregon oak, and still later to more Douglas fir and less Oregon oak. This sequence implies (1) prolonged, gradual warming and drying of a cool moist climate, (2) a pronounced warm stage about 4,000 to 6,000 years ago, and (3) return to a moister and cooler climate. There is no sign of intervention of a cold, wet, glacial climate; so the record appears to be entirely postglacial. Since no severe flood capable of excavating holes in solid rock, as did the Spokane Flood in the Tonquin area, could have passed the Onion Flat site without completely removing the peat, the Spokane Flood was unquestionably the last flood to pass through the area. Because of the common and contemporaneous origin of the Portland Gravels and the Willamette Silt, the Willamette Silt age determination applies to the Portland Gravels also.

The only Cordilleran glaciation occurring within the 19,000- to 34,000-year time span was the early and middle Pinedale Glaciation. Bull Lake Glaciation is estimated to have taken place more than 32,000 years B.P. The Portland Gravels and Willamette Silt are much less weathered than are the typical Bull Lake till and outwash deposits in Wyoming and elsewhere, despite a more favorable climate for chemical weathering in Oregon. A Pinedale and not a Bull Lake age assignment of the Portland Gravels-Willamette Silt seems therefore appropriate.

The last catastrophic outburst of Glacial Lake Missoula, the Spokane Flood, occurred near the end of early Pinedale Glaciation, according to Richmond and others (1965). In their words, "The youngest catastrophic flood, first recognized and described by Bretz (1923), scoured moraines and other deposits of early Pinedale age. Its deposits overlie early Pinedale glacial and lake deposits and are themselves overlain by moraines and other deposits of middle Pinedale age. Transported wood in the deposits at Vantage [Washington], but probably derived from older deposits, yields a radiocarbon date of 32,700 years."

Baker (1973, p. 65) says, "The last major scabland flood probably occurred during the early Pinedale Glaciation, about 22,000 years ago." The U.S. Geological Survey pamphlet, "The Channeled Scabland of Eastern Washington -- the Geologic Story of the Spokane Flood," uses a date of 18,000 to 20,000 years ago.

New radiocarbon dates and correlation of tephra in flood sediments with the Mount St. Helens "set S" tephra suggest a date as recent as 13,000 years B.P. for the Spokane Flood (Waitt, 1978).

Whether these age assignments or more recent age assignments allow enough time for the Columbia River and its tributaries to have entrenched themselves in early Pinedale outwash and valley-train deposits before the Spokane Flood is uncertain. Conceivably the overflow of several proglacial lakes in valleys dammed by the lobate front of the Cordilleran ice sheet may have shifted the regimen of certain streams, including the Columbia River, from deposition of valley trains to erosion and hence entrenchment.

One may speculate that the Spokane Flood deposits in the lower reaches of Pudding River valley may have caused the diversion of the Willamette River from its former northeastward course through the site of Lake Labish, now a peat bog, into its present northerly route and thence through the Pudding River valley. Peat near the base of the bog fill in Lake Labish, 20 ft below the surface, yielded a radiocarbon age of 11,000 ± 230 years B.P. (Glenn, 1965). This age date conforms with an age of 13,500 years B.P. for the last flood. Minor valley filling occurred in a time range of approximately 11,000 to 12,000 years ago. Or the Willamette River may merely have entered a more direct route northward from Salem via a former tributary of the Yamhill River as a result of stream piracy, regardless of any such intravalley deposits.

Although floods could have come from an Okanogan glacier-dammed Lake Columbia upriver from upper Grand Coulee (Richard and others, 1965, p. 237) or from other proglacial lakes, because of its great size, Glacial Lake Missoula seems to be the most likely source of the Spokane Flood. Presumably such a final flood from Glacial Lake Missoula used both the scabland routes on the Columbia Plateau and the Grand Coulee slot (Bretz, 1969; Richmond and others, 1965). No flood has crossed the plateau in the last 12,000 years.

Two later floods, smaller than the last great Spokane Flood, are thought to have used the route around the big bend of the Columbia River northwest of the plateau (Bretz, 1969, p. 506). These are attributed to successive failures of the dam created by the Okanogan glacier as it advanced into or across the Columbia River trench in middle Pinedale time downstream from Grand Coulee.

No evidence of a lesser flood later than the Spokane Flood has been recognized in the Portland environs, unless the eroded Fourth Plains channel east and northeast of Vancouver be attributed to such a subordinate flood or unless the "upper (?) Pleistocene sand and silt deposits" described by Trimble (1963, p. 58-71) can be assigned to it.

Of all the flood possibilities, the catastrophic Spokane Flood remains to many observers the best explanation for the very impressive Fourth Plains flood channel, the channeling of the Portland Gravels, and the array of flood-related features in the Tualatin and Willamette River Valleys.

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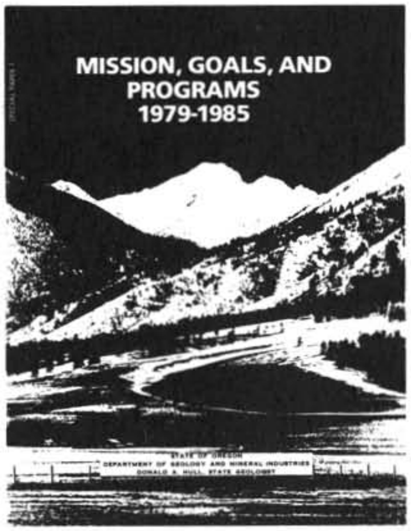
NOTICE OF PUBLIC HEARING

Notice is hereby given that Coos County intends to lease mineral rights for gas and oil in approximately 13,000 acres of land in Coos County. Descriptions will be sent on request to below address. Oral bids will be received on December 21, 1978, at 1:30 p.m. in the Commissioners' Courtroom, Courthouse, Coquille, Oregon 97423. Minimum acceptable bids shall be one dollar per net mineral acre.

Bidders will be required to negotiate a lease and agree to abide by all conditions and regulations set forth by the Coos County Board of Commissioners in the document entitled "Mineral Rights Lease Agreement and Requirements for Bidders," copies of which are available in the Commissioners' Office, Courthouse, Coquille, Oregon 97423. Telephone number is (503) 396-3121.

DEPARTMENT ANNOUNCES NEW SPECIAL PAPERS SERIES

The Oregon Department of Geology and Mineral Industries issues a number of publications in order to disseminate geologic information among interested persons and agencies.



Over the years, the Department has maintained a variety of publication series, including Bulletins, Oil and Gas Investigations, Short Papers, Miscellaneous Papers, Open-File Reports, and Geological Map Series. Now, to improve efficiency in project planning and in editing procedures, we are discontinuing the old Short Papers and Miscellaneous Papers series and starting a new Special Papers series.

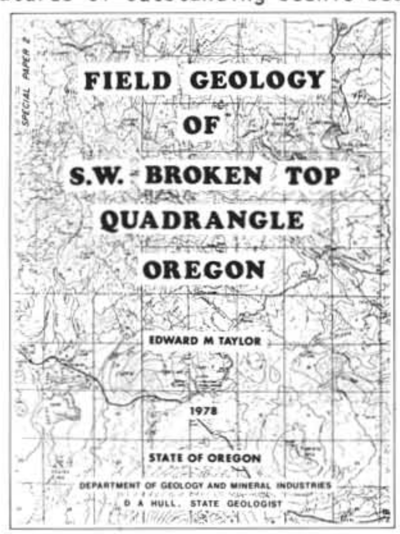
Special Papers will have 75 or fewer pages and relatively few maps. They will be of interest to a diffuse readership and are expected to remain in demand over a period of years.

This month, we are pleased to announce publication of the first two papers in this new series.

"Mission, Goals, and Programs--1979-1985" is the initial offering. The 39-page discussion of the purpose, organization, goals, and programs of the Oregon Department of Geology and Mineral Industries features an easy-to-read two-column format. Several maps show the locations of completed, current, and planned Department projects. Also included are several full-page photographs.

Special Paper 2 is "Field Geology of S.W. Broken Top Quadrangle, Oregon," by Edward M. Taylor. Among the 22 figures in this book of 50 pages are photographs showing geologic features of outstanding scenic beauty and nine full-page geologic maps.

The text presents a summary of the geologic relationships at Broken Top volcano in the central High Cascades and detailed descriptions of lithologic units shown on the geologic maps. Included in the appendix are chemical analyses and descriptions of locations of 247 rock samples from Broken Top.



In the foreword, State Geologist Donald A. Hull notes, "This paper provides basic data that will serve the scientific community for decades to come."

Both reports are available at all offices of the Department of Geology and Mineral Industries. Special Paper 1 sells for $2.00; Special Paper 2 costs $3.50.

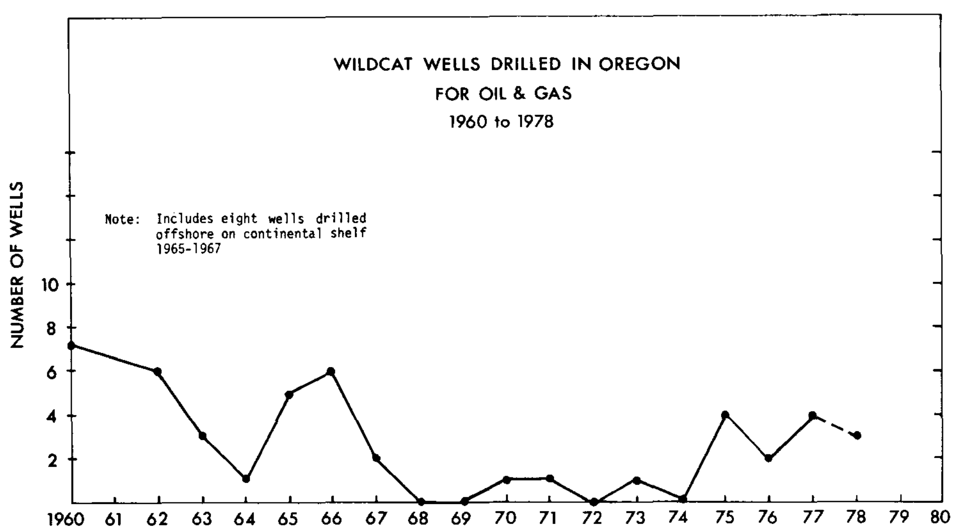
INCREASE OF OIL, GAS, AND GEOTHERMAL
EXPLORATION IN OREGON

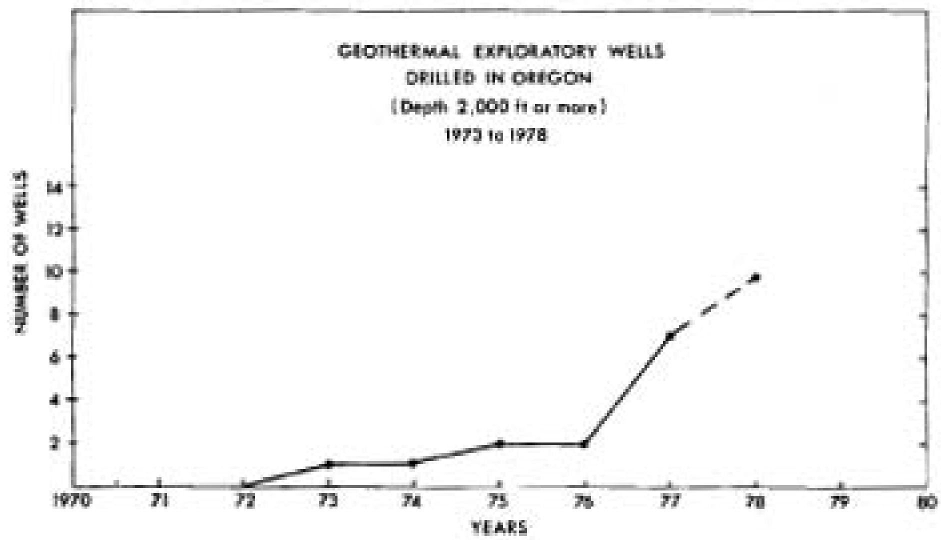
The level of exploration for energy resources is a simple measure of a complex set of energy factors impacting the economy and influencing society. Among these factors are individual choices in consumption patterns; policy decisions on all levels, public and private, as they respond to changing costs; foreign influences such as embargoes; perceptions of national security; and, of course, geologic factors influencing the natural fuel supply.

In recent years, this mix of factors has combined to accelerate the exploration for oil, natural gas, and geothermal resources in the United States. Of the 50,000 oil and gas wells drilled in the world last year, for example, about 90 per cent were drilled in the United States or short distances offshore. Areas such as Oregon, previously passed over for a variety of reasons, are now attracting considerable attention and can be expected to receive even greater attention in the future.

The total number of oil and gas wells drilled in Oregon to date is approximately 220, or one for every 400 sq mi of surface area. Plainly, this is a minimal level of effort for a state known to have hydrocarbon source rocks, potential reservoir rocks, and numerous types of stratigraphic and structural traps. Increasing attention to oil and gas potential in Oregon is aimed at locating the appropriate mix of organic shale, sandstone reservoir, and structural trap capable of yielding commercial production.

Exploration for geothermal power is also difficult. Technical assessments of heat flow patterns, geologic structures, heat sources, and geophysical properties of large areas of the State are needed to guide the more localized and the more expensive drilling efforts needed to ultimately locate the resource. With geothermal energy, as with oil and gas, the level of historic exploration in Oregon has been low. This low level of geothermal exploration is attributed to the recency with which society has recognized the desirability of this resource and to





delays in leasing of federal lands, rather than to a history of being passed over in search for more favorable regions.

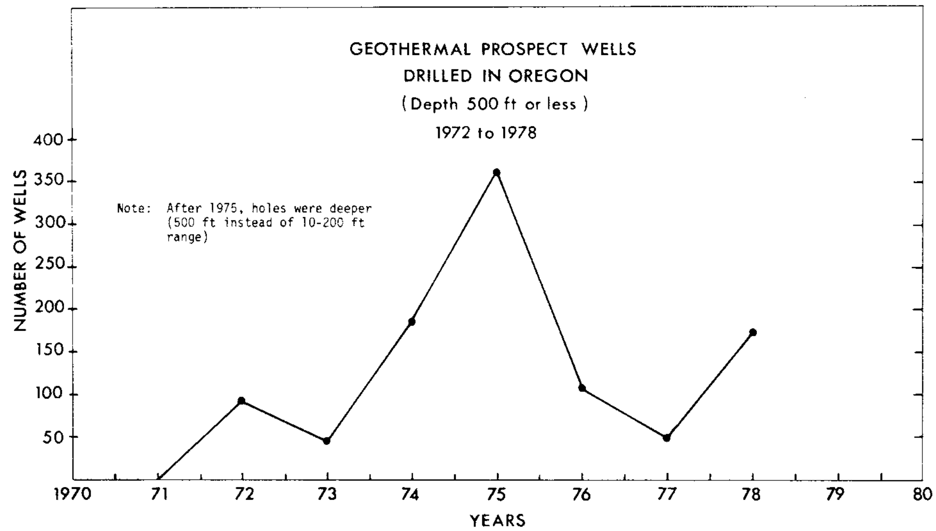
In either case, the rate of oil and gas and geothermal exploration in Oregon is accelerating. In 1972, for example, the Oregon Department of Geology and Mineral Industries oversaw one oil well permit, one well plugging, and one well deepening as part of its regulatory duties associated with the oil and gas resource. In 1977, however, the Department oversaw 9 geothermal prospect well permits, 14 geothermal well permits, and 3 oil and gas permits. Temperature gradient holes less than 500 ft deep are defined under Oregon law as "prospect wells," whereas both deeper gradient holes and deep production drilling are categorized as "geothermal wells."

For the period July 1, 1978, to October 1, 1978, the Department issued 3 oil and gas permits, 6 geothermal permits for prospect wells, and 13 geothermal well permits. Coincident with the increased number of permits, of course, is an increase in field inspections by Department personnel. Inspections are required during the early stages of well drilling to test blowout prevention equipment, periodically during drilling, and finally to insure safe plugging and site restoration at unsuccessful wells.

Oil and Gas Leasing

The past year was the most active on record for oil and gas leasing in Oregon. At the close of 1977, oil and gas leases, either in force or under application, were estimated to amount to 1.3 million acres. At least eight exploration firms and a dozen or more individuals now hold leases. Some leasing can be credited to speculators who have been attracted to the State by announcements of increased oil and gas activity by major companies. The figures for oil and gas leases are as follows:

Ownership	Total acres
Federal lands (237 leases)	439,802
State lands (leases)	38,182
County lands (estimated)	80,000
Private lands (estimated)	800,000



The following major lessors have assembled the oil and gas leases in the State:

Mobil Oil Corporation	Denver, Colorado
Texaco, Inc.	Los Angeles, California
Standard Oil	San Francisco, California
Reichhold Energy	Tacoma, Washington
John Rex and Associates	Terrebonne, Oregon
John Batts	Billings, Montana
Inter American Petroleum	Denver, Colorado
Erick Von Tech	North Bend, Oregon
Farnham Chemical	Portland, Oregon
R.F. Harrison	Seattle, Washington
Tenneco Oil Company	Bakersfield, California
Northwest Exploration	Denver, Colorado
Far West Oil	Portland, Oregon
Floyd Cardinal and Assoc.	Billings, Montana
Gas Producing Enterprises	Denver, Colorado

The U.S. Department of the Interior lifted the moratorium on federal oil and gas leases in Oregon in December 1974. Lease applications pending since 1971 were processed, allowing three major exploration programs to proceed: one by Texaco in eastern Oregon; one by Michel Halbouty near Burns in central Oregon; and a third by Mobil Oil Company in southwestern Oregon.

In 1977 Mobil Oil Company continued its extensive geophysical studies on a 900,000-acre lease block in southwestern Oregon. This end of the Tertiary marine basin has never been explored below a depth of 5,000 ft. (In 1951 Union Oil drilled a 7,000-ft hole in the area, but steeply dipping beds shortened stratigraphic penetration.) A 14,000-ft hole is now being drilled in Douglas County east of Oakland.

In the spring of 1977, an Oregon State University geological field party found an oil seep on the Alfred Watson property near Olney, about 10 mi southeast of Astoria. Three oil companies have confirmed the fact that the seepage is crude oil.

In 1975, Shell Oil Company began a large leasing program in the Columbia Basin of eastern Washington; and Texaco and Gulf have since joined the leasing effort. An estimated 300,000 acres are believed to be under lease in this region at present, but leasing has not yet extended into the Oregon portion of the basin.

Objectives in the Columbia Plateau leasing appear to be Tertiary nonmarine and pre-Tertiary marine beds underlying Miocene lavas. Discovery of oil in Tertiary nonmarine rocks at Trapp Springs, southeastern Nevada, has focused attention on a whole new area, including similar deposits in the Pacific Northwest.

* * * * *

OREGON'S NICKEL DEPOSITS INVENTORIED

Miscellaneous Paper 20, "Investigations of Nickel in Oregon," is a report of the statewide assessment of nickel deposits in Oregon conducted by the Department of Geology and Mineral Industries in cooperation with the U.S. Bureau of Mines.

Designed to supply basic resource data to various groups, policy formulators, agencies, and land use planners needing information on the State's nickel potential, the 67-page paper contains numerous figures and maps.

During the period 1966-77, the entire United States primary mine production of nickel was from the Hanna Mine near Riddle, in Douglas County. These investigations cover the Hanna Mine plus 24 deposits that lie in the southwest corner of the State in Curry and Josephine Counties. Future development of one or more of these nickel areas could make a major economic impact in this part of Oregon.

Two other main areas of future nickel production potential lie in Oregon. One is in the Illinois Valley, in which a centrally located plant could draw from the larger, better grade, and more accessible deposits in the Josephine peridotite sheet; the other is in the Red Flat area southeast of Gold Beach in Curry County. Several factors will affect possible expansion of Oregon's nickel industry--future supply of and demand for nickel, chromium, and cobalt; national and local political policy regarding domestic production of these stratigic minerals; the ability to develop energy-efficient, inexpensive, and nonpolluting metallurgical processes; and the ability to develop satisfactory and inexpensive reclamation procedures for mined lands.

"Investigations of Nickel in Oregon" is the last report to be issued by the Department as a miscellaneous paper. Similar studies will be included in the new Special Papers series.

Department offices in Portland, Grants Pass, and Baker have supplies of Miscellaneous Paper 20 on sale at $5.00 per copy.

NEW APPLICATIONS FOR GEOTHERMAL PROSPECT WELLS

State file number	Company	Area	Proposed number of 500' temperature gradient holes
36	Aminoil, USA, Inc.	Alvord Valley	6
37	Aminoil, USA, Inc.	Breitenbush Hot Springs	2
38	Phillips Petroleum	Brothers Fault Zone	80
39	Union Oil Company	Alvord Valley	12
40	Hunt Energy Corporation	South Warner Valley	20
41	Hunt Energy Corporation	Owyhee Reservoir	25
42	Hunt Energy Corporation	Klamath Falls	30
43	Chevron Resources	Bully Creek	13
44	Anadarko Production	Alvord Valley	75
45	Oregon Department of Geology and Mineral Industries	Mount Hood (around base)	11
46	John Hook	Upper Clackamas River	6

* * * * *

NEW APPLICATIONS FOR OIL AND GAS DRILLING

State file number	Company	Well name	Location	Proposed depth (feet)
79	Farmham Chemical	K-Barr #1	NE1/4 sec. 31, T. 11 S., R. 1 W. Linn County	4,500
80	Farnham Chemical	Normarc #1	NE1/4 sec. 31, T. 11 S., R. 1 W. Linn County	4,500
81	Mobil Oil Corp.	Ira Baker #1	NE1/4 sec. 28, T. 15 S., R. 3 W. Linn County	10,500
82	Mobil Oil Corp.	E. Glaser #1	SW1/4 sec. 14, T. 13 S., R. 3 W. Linn County	10,500
83	Farnham Chemical	Normarc #2	NW1/4 sec. 31, T. 11 S., R. 1 W. Linn County	4,500
84	Farnham Chemical	Normarc #3	NW1/4 sec. 31, T. 11 S., R. 1 W. Linn County	4,500
85	Farnham Chemical	Normarc #4	NE1/4 sec. 36, T. 11 S., R. 2 W. Linn County	4,500

OFFSHORE OIL BOOKLETS AVAILABLE

"Oregon and Offshore Oil" is being sold at the Portland office of the Oregon Department of Geology and Mineral Industries. The 54-page booklet was prepared by the Oregon State University Sea Grant College Program for the Governor's Task Force on Outer Continental Shelf Oil and Gas Development and was released in September 1978.

Jeffrey M. Stander and Bronwyn H. Echols did both the research and the writing for "Oregon and Offshore Oil." Their purpose was to provide Oregonians with useful background on the process of exploiting continental shelf petroleum and on the possible economic, social, and environmental effects of such energy development. Use of such information is essential to those who must make decisions on the best areas for leasing, siting of offshore facilities for exploiting this energy, and management of social and economic changes resulting from the development of such an industry.

Connie Morehouse designed the attractive book, which contains many photographs and illustrations as well as a glossary and lists of references and of agencies involved in offshore oil exploration and development.

To assure comprehensiveness and accuracy in their work, Stander and Echols called upon many specialists from Oregon state agencies for information and critical reviews. Among those represented were the Departments of Land Conservation and Development, Environmental Quality, Energy, Fish and Wildlife, and the Division of State Lands.

"Oregon and Offshore Oil" costs only $1.00 per copy. The supply is limited, so come to the Portland office to get your copy, or send $1.00 promptly. See inside front cover for the address.

* * * * *

STAY OUT OF OLD MINES!
(and operating ones, too)

The recent near-tragedy involving two youngsters at an operating mine in central Oregon prompts the Department to once again issue a warning about the hazards involved with poking around in mines. Mines, particularly old mines, can be most dangerous to life and limb at any time. Rotting timbers, foul air, and weathered rock about to collapse are only a few of the deadly hazards that are encountered by those who decide to explore.

Operating mines pose additional dangers. Noisy equipment can mask cries for help when something goes wrong. Active mines, even during periods when operations are shut down temporarily, can trap the unwary. This is what happened to the children who decided to investigate a bunker filled with lightweight aggregate. The stockpile collapsed and totally engulfed one child, trapped the other, and even started to bury one of the rescuers.

Remember, mines are a necessary adjunct to our way of life, but to the idly curious they can be deadly.

* * * * *

WATCH FOR "OREGON GEOLOGY"

This is the last issue of the ORE BIN. Starting next month, the Oregon Department of Geology and Mineral Industries will publish its successor, OREGON GEOLOGY, each month.

OREGON GEOLOGY will have a larger page size (8-1/2 by 11 in.); a less expensive self-cover with large photographs, drawings, or maps; and a two-column format that will give us greater flexibility in layout, providing you, in turn, with a more attractive, interesting, and readable magazine. The new name, we believe, reflects more accurately the current content of the magazine and the nature of the readership.

The first ORE BIN was mimeographed in January 1939, replacing the PRESS BULLETIN, and had eight 8-1/2 by 11 in. pages. Articles in the first issue included "Oregon Mineral Production," "Fissure Eruptions Near Bend," and "Rocks That Float: A New Metallurgical Process." The first ORE BINs were free; but in July 1940, a subscription rate of $0.25 per year was instituted.

By January 1962, when the ORE BIN with the now-familiar 6 by 9 in. format appeared, the subscription rate was $0.50 per year. Articles in the first 16-page issue included "Oregon's Mineral Industry in 1961," "Oil and Gas Exploration in 1961," "Geologic Map of Western Oregon Now Available," "Pacific Stoneware Production Expands," and "Nehalem Wax Gets Carbon-14 Date."

Over the years, the ORE BIN has contained articles on just about every aspect of Oregon's mining, mineral resources, mining history, and geology. ORE BIN field trips have introduced many readers to the beauty and geologic wonders of the State. And many ORE BIN articles have provided quick, complete answers to many questions asked of Department staff. The ORE BIN has been a successful publication that has attracted a loyal readership.

But readers' habits, needs, and tastes have changed; and over the years the content and nature of the ORE BIN has been changing, too. As time goes on, we plan to print general interest articles for the layman as well as technical articles for the professional geologist. We want OREGON GEOLOGY to be a clearing house for information about Oregon geology, and we want it to be responsive to your interests and needs.

So look forward to the first issue of OREGON GEOLOGY. Let us know how you like it.

* * * * *

WHY PAY MORE?

"Going rate" for the ORE BIN is $3.00 a year or $8.00 for three years. This subscription rate will apply until January 1, 1979, to subscriptions for OREGON GEOLOGY.

After the turn of the year, OREGON GEOLOGY will cost $4.00 a year or $10.00 for three years. This increase is because of rising printing and postal costs, not because of the change in magazine format.

Extend or renew your subscription now. And order gifts before the increased price is required. You and your friends can enjoy OREGON GEOLOGY for up to three years at the "old ORE BIN price."

INDEX TO THE ORE BIN
VOLUME 40, 1978

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There's nothing constant in the universe,
All ebb and flow, and every shape that's born
Bears in its womb the seeds of change.
Ovid, *Metamorphoses*, XV (A.D. 8)

AVAILABLE PUBLICATIONS

(Please include remittance with order; postage free. Minimum mail order, $0.50. All sales are final - no returns. A complete list of Department publications, including out-of-print, mailed on request.)

BULLETINS	Price
26. Soil: Its origin, destruction, and preservation, 1944: Twenhofel	$ .45
33. Bibliography (1st suppl.) geology and mineral resources of Oregon, 1947: Allen	1.00
36. Papers on Tertiary foraminifera: Cushman, Stewart and Stewart, 1949: v.2 . .	1.25
39. Geol. and mineralization of Morning mine region, 1948: Allen and Thayer . .	1.00
44. Bibliog. (2nd suppl.) geology and mineral resources of Oregon, 1953: Steere .	2.00
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49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch . . .	1.00
53. Bibliog. (3rd suppl.) geology and mineral sources of Oregon, 1962: Steere, Owen	3.00
57. Lunar Geological Field Conf. guidebook, 1965: Peterson and Groh, editors . .	3.50
62. Andesite Conference guidebook, 1968: Dole	3.50
63. Sixteenth biennial report of the Department, 1966-1968	1.00
64. Mineral and water resources of Oregon, 1969: USGS with Department	3.00
65. Proceedings of Andesite Conference, 1969: [copies]	10.00
67. Bibliog. (4th suppl.) geology and mineral resources of Oregon, 1970: Roberts .	3.00
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76. Eighteenth biennial report of the Department, 1970-1972	1.00
77. Geologic field trips in northern Oregon and southern Washington, 1973 . . .	5.00
78. Bibliog. (5th suppl.) geology and mineral resources of Oregon, 1973: Roberts .	3.00
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80. Geology and mineral resources of Coos County, 1973: Baldwin and others . .	6.00
81. Environmental geology of Lincoln County, 1973: Schlicker and others . . .	9.00
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GEOLOGIC MAPS	
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	Part 1. Oil and natural gas rules and regulations, 1977	1.00
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16.	Mosaic of Oregon from ERTS-1 imagery, 1973	2.50
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Oregon base map (22 x 30 inches)	.50
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Mining claims (State laws governing quartz and placer claims)	.50
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Fifth Gold and Money Session and Gold Technical Session Proceedings, 1975 (including papers on gold deposits, exploration, history, and production)	5.00

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