

The Ore Bin



Vol. 33, No. 1
January 1971

**STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES**

The Ore Bin

Published Monthly By

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
Head Office: 1069 State Office Bldg., Portland, Oregon - 97201
Telephone: 229 - 5580

FIELD OFFICES

2033 First Street	521 N. E. "E" Street
Baker 97814	Grants Pass 97526

X X X X X X X X X X X X X X X X X X X

Subscription rate \$1.00 per year. Available back issues 10 cents each.

Second class postage paid
at Portland, Oregon

X X X X X X X X X X X X X X X X X X X

GOVERNING BOARD

Fayette I. Bristol, Rogue River, Chairman
R. W. deWeese, Portland
Harold Banta, Baker

STATE GEOLOGIST

R. E. Corcoran

GEOLOGISTS IN CHARGE OF FIELD OFFICES

Norman S. Wagner, Baker	Len Ramp, Grants Pass
-------------------------	-----------------------

X X X X X X X X X X X X X X X X X X X

Permission is granted to reprint information contained herein.
Credit given the State of Oregon Department of Geology and Mineral Industries
for compiling this information will be appreciated.

OREGON'S MINERAL AND METALLURGICAL INDUSTRY IN 1970

By Ralph S. Mason*

In 1970 mineral production ranked third in dollar value among the natural resources produced in Oregon, outshadowed only by agriculture and forestry. The state also is rapidly becoming a major processor of metallurgical products, with most of the raw materials coming from points outside of Oregon. Another "natural resource" related to the mineral industry is the group of professional geologists and engineers living in the state who are not only knowledgeable about the state's mineral resources but find that they are being called upon more and more to help in the solution of a wide range of environmental problems.

Included in this issue is a summary of the Department's proposed activities for the next biennium, which starts in July. A rapidly changing world requires new approaches, presents new problems, and offers novel solutions. Some of the Department's programs are long range but some are brand new.

Oregon's mineral and metallurgical industries contributed more than \$700 million to the state's economy during 1970. Mineral production declined 3.3 percent below the 1969 level to \$58.2 million but metallurgical processing of ores originating in the state and imported from other states increased significantly. The construction of a third aluminum plant in the state, scheduled to start in early 1971, will boost production figures even higher.

In response to increased regulations for controlling pollution, the mining and metallurgical industries have been spending and will continue to spend millions of dollars in effluent treatment and stack-emission control equipment, plus new solid-waste disposal methods.

The slow-down in the over-all economy has been reflected in the slight decline in the state's mineral production, which is summarized in

*Mining Engineer, Oregon Department Geology and Mineral Industries.

the accompanying box. Unlike the general economy, however, unit prices of the principal mineral commodities, sand and gravel and crushed stone increased less than one percent over last year. The average price increase during the past 20 years for these critical "growth minerals" has been less than one and one-half percent per year, a remarkable testament to an industry which operates on a completely unsubsidized, tax-paying basis.

The Metals

Oregon's metallurgical industry extends from aluminum to zirconium, with nearly a dozen other metals in between. Mercury is the only metal that is presently mined and refined in the state. All of the other metals

Metallurgical products from Oregon plants

Aluminum
Brick and tile
Calcium carbide
Cement
Expanded shale
Ferromanganese
Ferronickel
Ferrosilicon
Lime
Mercury
Minor exotic metals
Perlite
Silicon
Steel
Titanium
Vermiculite
Zirconium

processed here originate beyond the state's borders, several of them coming from foreign countries. Two aluminum reduction plants, Reynolds Metals at Troutdale and Harvey Aluminum at The Dalles, and the American Metals Climax plant to be built this year at Warrenton in Clatsop County are located here because of cheap and abundant electricity and to a lesser extent deep water transportation. Oregon Steel Mills built its new plant near the mouth of the Willamette River to take advantage of deep water frontage and a new concept of transporting iron ore from Peru in the form of a slurry.

Reduction and fabrication facilities for processing titanium, zirconium, and a number of minor rare metals are also treated in the Albany area by Wah Chang Albany, Oregon Metallurgical, REM Metal, Zirtech, and TiLine. All of these operations are located near the U.S. Bureau of Mines Electrodevelopment Laboratory, which did pioneer work in the reduction and fabrication of the highly refractive metals. A

further, and more recent, related development in the Albany area has been the establishment of a Department of Metallurgical Engineering at nearby Oregon State University.

Hanna Mining Co. produced 1.2 million tons of nickel laterite ore at its open pit property located on top of Nickle Mountain in Douglas County. The ore contained 1.41 percent nickel and was treated in the Hanna Smelting Co. smelter at the foot of the mountain, where nearly 26,000 tons of ferronickel were smelted. Over 19,000 tons of ferrosilicon were produced in plant by the company for use in processing the ore.

In the face of a declining world price for mercury, Oregon production increased nearly seven times over the previous year. A total of 295

The Million-Dollar-a-Year Club, 1969 *

<u>County</u>	<u>Value</u>	<u>County</u>	<u>Value</u>
Baker	\$4,566,000	Klamath	2,139,000
Clackamas	9,432,000	Lane	3,953,000
Coos	1,083,000	Linn	1,149,000
Jackson	1,049,000	Multnomah	7,937,000
Josephine	1,247,000	Washington	2,678,000

* In addition to the values shown, there was a total of \$15,572,000 which could not be assigned to specific counties. Production from Columbia, Douglas, Harney, Hood River, Malheur, and Wasco Counties was concealed to avoid disclosing individual company confidential data. If the state's total mineral production had been divided equally among the 36 counties, each county would have produced an average of \$1,671,222 during the year.

flasks was produced with the bulk of the metal coming from the old Elk-head mine operated by Alcona Mining Inc. in Douglas County. A small amount of mercury was recovered at the Maury Mountain mine in Crook County, with some exploration and development reported at the Canyon Creek mine in Grant County, at a prospect on Connor Creek in eastern Baker County, and at the Doodle Bug mine in Jackson County.

Gulf Oil Corp. completed its investigation for uranium in eastern Oregon, and no activity was reported from either the Lucky Lass or White King properties, both former producers, in Lake County.

Reynolds Mining Co., a subsidiary of Reynolds Metals Co., conducted several small-scale mining experiments in Washington, Columbia, and Marion Counties. The company stockpiled the topsoil, removed the ore for test purposes, levelled the site, replaced the topsoil, and revegetated the disturbed area. All of these operations were carried out in the space of a few days. The tests were conducted to determine the best method for reducing the environmental impact during any subsequent mining activities.

Copper production was restricted to some secondary metal recovered from the production of hard-rock gold and silver at the Brass Ledge mine in Josephine County. Interest in copper mineralization in the state remained high with exploration programs by Nuclear Development Co. at the Standard and Copperopolis properties in Grant County, and by St. Joe Minerals Corporation in the copper belt of eastern Baker County.

Some of Oregon's Minerals at a Glance
Preliminary Figures for 1970
(in thousands of dollars)

	1969	1970
Clays	\$ 321	\$ 265
Diatomite	W	W
Gem stones	750	750
Gold (recoverable content of ores, etc.)	36	W
Lime	2337	2337
Mercury	22	121
Nickel (content of ore and concentrate)	W	W
Peat	---	---
Pumice and volcanic cinders	1139	1067
Sand and Gravel and stone	39,388	36,000
Silver (recoverable content of ores, etc.)	9	W
Talc and soapstone	---	---
Value of items that cannot be disclosed: Cement, copper (1969) and values indicated by symbol "W"	<u>16,162</u>	<u>17,659</u>
Total	60,164	58,199

The Enhanced Minerals

The transmutation of common sand and gravel into a wide variety of useful products exceeds even the wildest hopes of the medieval alchemists who hoped to change base metals into gold. The wealth generated by the producers of sand and gravel and crushed stone reaches into every section in the state and, in fact, provides the basic ingredient necessary for community growth and development. During 1970 each one of Oregon's citizens used an average of 12.5 tons of these "growth minerals," whether he realized it or not. On a dollars and cents basis, the value of the raw sand and gravel and stone came to an estimated \$36 million -- or exactly one million dollars for each of the state's 36 counties. Despite a nationwide trend to higher and higher unit costs, the sand and gravel industry in Oregon reported only a one-cent-per-ton rise.

Growing concern for future supplies of sand and gravel, particularly in Western Oregon was expressed during the year. The Department made several sand and gravel resource studies at the request of local government

bodies which desired information on the location and reserves of sand and gravel in their communities before making long-range plans. Unlike many other natural resources, mineral deposits cannot be transferred from place to place but remain fixed until mined out. This inflexibility places a premium on comprehensive planning by those agencies charged with the responsibility for preserving the environmental quality of a community while providing the necessary ingredients for its growth.

Production of clays, diatomite, pumice, and lime declined somewhat from last year's totals in response to the general slackening in demand.

* * * * *

PRINCIPAL OREGON MINERAL PRODUCERS - 1969*

Commodity and company	Address	Type of activity	County
NONMETALS			
Cement:			
Oregon Portland Cement Co.....	111 S.E. Madison St. Portland, Oregon 97214	Plant.....	Baker and Clackamas.
Clay:			
Central Oregon Bentonite Co.....	Bear Creek Route Prineville, Oregon 97754	Pit and plant.....	Crook.
Ceramco, Inc.....	P.O. Box 5 McMinnville, Oregon 97128	....do.....	Yamhill.
Columbia Brick Works.....	1320 S.E. Water St. Portland, Oregon 97214	....do.....	Multnomah.
Corvallis Brick & Tile Works, Inc.	P.O. Box 327 Corvallis, Oregon 97330	....do.....	Benton.
Empire Lite-Rock, Inc.....	9255 N.E. Halsey St. Portland, Oregon 97220	....do.....	Washington.
Klamath Falls Brick & Tile Co..	P.O. Box 573 Klamath Falls, Oregon 97601	....do.....	Klamath.
Mandrone Mining Co., Inc.....	Rt. 1, Box 337 Molalla, Oregon 97038	Pit.....	Clackamas.
McMinnville Brick Co.....	451 College Ave. McMinnville, Oregon 97128	Pit and plant.....	Yamhill.
Monmouth Brick & Tile Co.....	Rt. 1, Box 22 Monmouth, Oregon 97361	....do.....	Polk.
Monroe Clay Products Co.....	P.O. Box A Monroe, Oregon 97456	....do.....	Benton.
Needy Brick & Tile Co.....	Rt. 1, Box 102 Hubbard, Oregon 97032	....do.....	Clackamas and Marion.
Oregon Portland Cement Co.....	111 S.E. Madison St. Portland, Oregon 97214	Pit.....	Baker.
Scholls Tile Co.....	Rt. 2, Box 208 Hillsboro, Oregon 97123	Pit and plant.....	Washington.
Tillamook Clay Works.....	6690 Brickyard Road Tillamook, Oregon 97141	....do.....	Tillamook.
Willamina Clay Products Co., Inc.	9780 S.W. Hunziker St. Tigard, Oregon 97223	....do.....	Yamhill.
Diatomite:			
Keating Diatomaceous Earth Co.	2019 Washington St. Baker, Oregon 97814	Mine and plant....	Baker.
A. M. Matlock.....	P.O. Box 3307 Eugene, Oregon 97402	....do.....	Lake.
Lime:			
Ash Grove Lime & Portland Ce- ment Co.	101 W. 11th St. Kansas City, Missouri 64105 (Portland, Oregon 97200)	Plant.....	Multnomah.
Chemical Lime Co.....	Baker, Oregon 97814.....	....do.....	Baker.
Pacific Carbide & Alloys Co.....	P.O. Box 17008 Portland, Oregon 97200	....do.....	Multnomah.
Perlite (expanded):			
Supreme Perlite Co.....	P.O. Box 66 North Portland, Oregon 97043	....do.....	Multnomah.

* From U.S. Bureau of Mines Minerals Yearbook, 1969 preprint.

Principal Oregon mineral producers - 1969, continued

Commodity and company	Address	Type of activity	County
NONMETALS—Continued			
Pumice:			
Central Oregon Pumice Co.....	5 Greenwood Ave. Bend, Oregon 97701	Mine and plant....	Deschutes.
Graystone Corp.....	Box 1087 Bend, Oregon 97701	....do.....	Do.
Chester Hiatt.....	147 N. 12th St. Redmond, Oregon 97756	....do.....	Do.
Oregon Portland Cement Co.....	111 S.E. Madison St. Portland, Oregon 97214	Mine	Baker.
Parks Pumice Mining.....	Box 54 Chemult, Oregon 97731	....do.....	Klamath.
Jed Wilson & Son.....	Box 125 La Pine, Oregon 97739	Mine and plant....	Lake.
Roofing Granules:			
Flintkote Co.....	P.O. Box 2744 Portland, Oregon 97208	Plant.....	Multnomah.
Sand and Gravel:			
Baker Rock Crushing.....	2030 E. Main St. Hillsboro, Oregon 97123	Pit and plant.....	Washington.
Bethel-Danebo Sand & Gravel....	150 Bertelsen Road S. Eugene, Oregon 97402	....do.....	Lane.
Copeland Sand & Gravel.....	695 S.E. J St. Grants Pass, Oregon 97526	....do.....	Josephine.
Delta Sand & Gravel.....	999 Division Ave. Eugene, Oregon 97402	....do.....	Lane.
Eugene Sand & Gravel.....	Box 1067 Eugene, Oregon 97401	....do.....	Do.
Glacier Sand & Gravel.....	5975 E. Marginal Way Seattle, Washington 98134	....do.....	Multnomah.
McKenzie Sand & Gravel.....	Box 347 Eugene, Oregon 97400	Pit and plant.....	Lane.
M.P. Materials.....	645 Seventh St. Salem, Oregon 97300	....do.....	Marion.
Milwaukie Sand & Gravel.....	1635 S.E. McLoughlin Blvd. Milwaukie, Oregon 97222	Dredge and plant...	Clackamas.
Morse Brothers.....	Lebanon, Oregon 97355...	Pit and plant.....	Benton and Linn.
Chas. T. Parker Construction....	6457 N.E. Columbia Blvd. Portland, Oregon 97203	....do.....	Multnomah.
Portland Sand & Gravel.....	10717 S.E. Division Ave. Portland, Oregon 97266	....do.....	Do.
Rich Valley Top Soil Co.....	Box 30 Oregon City, Oregon 97045	....do.....	Clackamas.
Rock Creek Sand & Gravel.....	Clackamas, Oregon 97015...	....do.....	Multnomah.
Roseburg Sand & Gravel.....	Box 1207 Roseburg, Oregon 97470	....do.....	Douglas.
Ross Island Sand & Gravel.....	4129 S.E. McLoughlin Blvd. Portland, Oregon 97200	Dredge and plant...	Multnomah.
Umpqua River Navigation Co....	Box 25 Reedsport, Oregon 97467	....do.....	Douglas.
Wildish Sand & Gravel.....	Box 1106 Eugene, Oregon 97401	Pit and plant.....	Lane.
Willamette Hi-Grade Concrete Co.	Foot N. Portsmouth Ave. Portland, Oregon 97203	Dredge and plant...	Multnomah.
Stone:			
L. V. Anderson.....	Box 757 Oakridge, Oregon 97463	Quarry and plant...	Lane.
Boise Cascade Corp.....	La Grande, Oregon 97850..	....do.....	Union, Uma- tilla, Wallowa.
L. H. Cobb.....	8275 S.W. 145th Ave. Beaverton, Oregon 97005	....do.....	Washington.
J. C. Compton.....	Box 86 McMinnville, Oregon 97128	....do.....	Baker, Des- chutes, Harney.
Eckman Creek Quarries.....	Box 15 Waldport, Oregon 97394	....do.....	Lincoln.
Georgia-Pacific Corp.....	Drawer AA Pilot Rock, Oregon 97868	....do.....	Grant, Lincoln, Umatilla.
L. W. Govro.....	Rt. 4, Box 253-W Albany, Oregon 97321	Quarry and plant	Linn.
Roy L. Houck Sons.....	1158 Chemeketa N.E. Salem, Oregon 97301	....do.....	Coos, various.
Hughes & Dodd.....	Box 246 Medford, Oregon 97501	....do.....	Coos, Curry, Jackson.
Peter Kiewit Sons Co.....	Box 1777 Vancouver, Washington 98663	....do.....	Various.
Materne Bros.....	Box O—Rosewood Station Spokane, Washington 99208	....do.....	Do.

Principal Oregon mineral producers - 1969, continued

Commodity and company	Address	Type of activity	County
NONMETALS—Continued			
Sand and Gravel—Continued			
Oregon Portland Cement Co.....	111 S.E. Madison St. Portland, Oregon 97214	do.....	Baker.
Pacific Crushing Co.....	610 Irving Drive Eugene, Oregon 97402	do.....	Klamath, Lane.
Pioneer Construction Co.....	7881 N.W. St. Helens Road Portland, Oregon 97229	do.....	Multnomah.
Quality Rock Co.....	Rt. 2, Box 608 Beaverton, Oregon 97005	do.....	Washington.
Rogue River Paving Co., Inc.....	1133 S. Riverside Medford, Oregon 97501	do.....	Coos, Douglas Jackson, Josephine.
Roseburg Sand & Gravel Co.....	Box 1207 Roseburg, Oregon 97470	do.....	Coos, Douglas, Lane.
Sunset Crushed Rock.....	Clatsop Airport Astoria, Oregon 97103	do.....	Clatsop.
Jed Wilson & Son.....	Box 125 La Pine, Oregon 97739	do.....	Lake.
Talc and Soapstone:			
John H. Pugh.....	2891 Elk Lane Grants Pass, Oregon 97526	Mine.....	Josephine.
Stauffer Chemical Co.....	P.O. Box 68 Portland, Oregon 97403	Plant.....	Multnomah.
Vermiculite (exfoliated):			
Supreme Perlite Co.....	P.O. Box 66 North Portland, Oregon 97043	do.....	Do.
Vermiculite-Northwest, Inc.....	P.O. Box A Auburn, Washington 98002	do.....	Do.
METALS			
Aluminum:			
Harvey Aluminum Co.....	The Dalles, Oregon 97058	Plant.....	Wasco.
Reynolds Metals Co.....	Troutdale, Oregon 97060	do.....	Multnomah.
Ferrous alloys:			
Hanna Nickel Smelting Co.....	Riddle, Oregon 97469	do.....	Douglas.
Union Carbide Corp., Mining and Metals Division ¹	Portland, Oregon 97200	do.....	Multnomah.
National Metallurgical Co.....	Springfield, Oregon 97477	do.....	Lane.
Gold and Silver:			
Baker Assets Co.....	Baker, Oregon 97814	Mine and mill.....	Baker.
Beaver Rock Products, Inc.....	Albany, Oregon 97321	Mine.....	Grant.
Cornucopia Placer Co.....	Halfway, Oregon 97834	Placer.....	Baker.
Ray Evans.....	Kerby, Oregon 97531	do.....	Josephine.
Frank Ramsey.....	Baker, Oregon 97814	Mine.....	Baker.
Mercury:			
Alcona Mining, Inc.....	366 S. 79th St. Springfield, Oregon 97477	do.....	Douglas.
C. F. Taylor.....	1128 Phelps Ave. San Jose, California 95117 (Prineville, Oregon)	do.....	Crook.
Nickel:			
Hanna Mining Co.....	Riddle, Oregon 97469	do.....	Douglas.
Steel:			
Cascade Steel Rolling Mills, Inc..	McMinnville, Oregon 97128	Plant.....	Yamhill.
Oregon Steel Mills.....	Portland, Oregon 97200	do.....	Multnomah.
Titanium:			
Oregon Metallurgical Corp.....	Albany, Oregon 97321	do.....	Linn.
Zirconium:			
Wah Chang Albany Corp.....	Albany, Oregon 97321	do.....	Do.

¹ Produces ferromanganese and silicomanganese.

METALS AND MINERALS CONFERENCE PROGRAM FILLED

A total of 65 papers will be presented at the Pacific Northwest Metals and Minerals Conference which will be held at the Sheraton Motor Inn, Portland, April 5, 6 and 7, 1971. Technical sessions include: Minerals; Metals; Mining and Exploration; Oceanic and Atmospheric; Gold and Money; Geology; Industrial Minerals; Iron and Steel; Non-ferrous Alloys; Non-Ferrous Extraction; Titanium; Super Alloys; and Refractory Metals. Field trips and social activities round out the three-day conference.

* * * * *

OIL AND GAS EXPLORATION IN 1970

By V. C. Newton, Jr.*

Exploration activity in Oregon during 1970 was the first of consequence since the offshore search in 1962-67. Two drilling permits were issued for shallow Willamette Valley wildcats, while another venture continued attempts to deepend an old hole in the central Oregon area. The most significant event in the state relative to petroleum during 1970 was the leasing in central Oregon by Texaco, Inc. Objectives appear to be Mesozoic-Paleozoic marine beds underlying Tertiary volcanics (see Fig. 1). No production has been found in Oregon to date but there is good reason to be optimistic when a major oil company decides on a drilling program. The wildcat scoreboard shows 32 deep dusters, 148 shallow dusters, and 0 discoveries. Average discovery odds in the United States are better than 50 to 1. Four holes drilled in Oregon during the past 15 years penetrated to depths below 12,000 feet before operations were halted. Production tests have been made on many of the holes drilled in the state but none of them showed more than a trace of oil.

Leasing

Texaco assembled more than 200,000 acres of leases in Crook and Grant Counties near the location of the Standard "Pexco State" and Sunray "Bear Creek" tests which were drilled in 1955 and 1958. The leases include federal, state, and private land but the major portion is under federal ownership. The location of the lease block is believed to be near the eastern margin of Cretaceous marine sediments, so the drilling objective is probably for a stratigraphic type enclosure. Three deep holes have penetrated Mesozoic marine rocks which underlie Tertiary volcanics in central Oregon (see Fig. 2). Some minor oil and gas shows were encountered while drilling the older sediments.

Mobil Oil Co. holds an estimated 25,000 acres of leases in northwestern Oregon and 10,000 acres in southwestern Oregon which were acquired in 1967. Standard Oil of California and Texaco have offset acreage to Mobil's leases in northwestern Oregon amounting to approximately 15,000 acres. Mobil's interest lies within the Tertiary marine basin of western Oregon. The firm drilled a 9,000-foot hole in Douglas County in 1957 under its former name of General Petroleum Corp. The G-P Douglas County hole

* Petroleum Engineer, State of Oregon Dept. Geology & Mineral Industries.

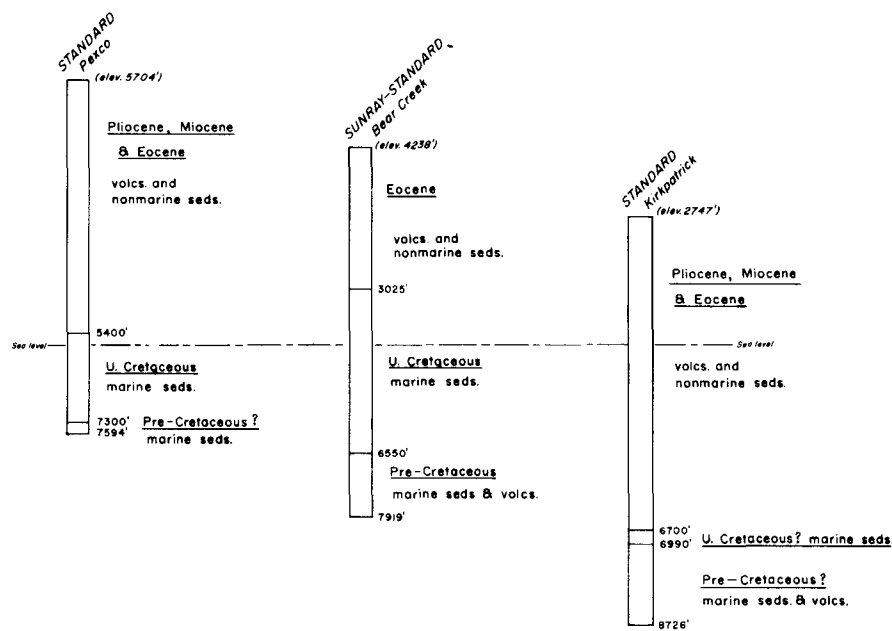


Figure 1. Mesozoic test holes in central Oregon.

tested middle Eocene marine sediments and bottomed in lower Eocene volcanics.

The Craig and Jackson-Dahl ventures have an estimated 8,000 acres under lease near Buena Vista in the Willamette Valley. Drilling and testing are continuing on two shallow wildcats near Buena Vista. R. F. Harrison and Associates of Seattle, Washington probably control more than 5,000 acres of leases in their venture near the town of Madras in central Oregon.

No lands are under lease off the Oregon coast at the present time. Standard of California and Union Oil Co. relinquished shelf lands in 1968 and 1969. Nine of the original bidders for Oregon shelf lands quitclaimed 400,000 acres of leases in 1966.

Expiration dates of offshore geophysical permits

<u>Company</u>	<u>Federal permit</u>	<u>State permit</u>
Humble Oil & Refining Co.	April 1971	- - -
Standard Oil of California	- - -	Sept. 1971
Texaco, Inc.	May 1971	May 1970

Drilling activity

Wildcatters were the only contributors to exploration drilling in 1970. Wm. Craig - Producers Oil & Gas and Jackson - Dahl Leasing drilled shallow holes near Buena Vista in the Willamette Valley. Work was still being planned on both projects at the end of the year. Shows of gas in two holes drilled near Buena Vista by Portland Gas & Coke Co. in 1935 encouraged the present search. Objectives of the drilling are upper Eocene Spencer sands.

R. F. Harrison and Associates was hampered by caving hole and stuck tools in the effort to deepen the Central Oils, Inc., "Morrow Ranch" wildcat southeast of Madras in north-central Oregon. Pre-Tertiary marine rocks crop out 3 miles northeast of the drilling site (Peck, 1964).

Active drilling permits - 1970

<u>Company</u>	<u>Permit no.</u>	<u>Unique well no.</u>	<u>Location</u>	<u>Depth</u>	<u>Status</u>
R.F.Harrison	60-D	031-00002	SW $\frac{1}{4}$ sec. 18, T12S., R15E. Jefferson Co.	3300' (old T.D.)	Idle
Wm. Craig- Producers Oil & Gas	61	047-20001	NW $\frac{1}{4}$ sec. 24, T9S, R4W Marion County	1565'	Testing
Jackson-Dahl	62	047-20002	NE $\frac{1}{4}$ sec. 24, T9S., R4W Marion County	1585'	Suspended temporarily

Rock outcrop map

The map (Figure 1) shows surface exposures of major rock types and locations of deep drillings. Three main drilling provinces are indicated: the western Tertiary marine, central Paleozoic-Mesozoic marine, and eastern Tertiary nonmarine intermountain basins. The western Tertiary marine rocks underlie the coast shelf, Coast Range, Willamette Valley, and an unknown portion of the Western Cascade Mountains. The central Paleozoic-Mesozoic marine basin west of the Blue Mountain uplift has been of interest for oil and gas exploration because rock exposures on this end of the Blue Mountains are unmetamorphosed. Farther east in the Blue Mountains, Paleozoic-Mesozoic marine sediments are metamorphosed. Thick sections of Tertiary nonmarine sediments and interbedded volcanic rocks in southeastern

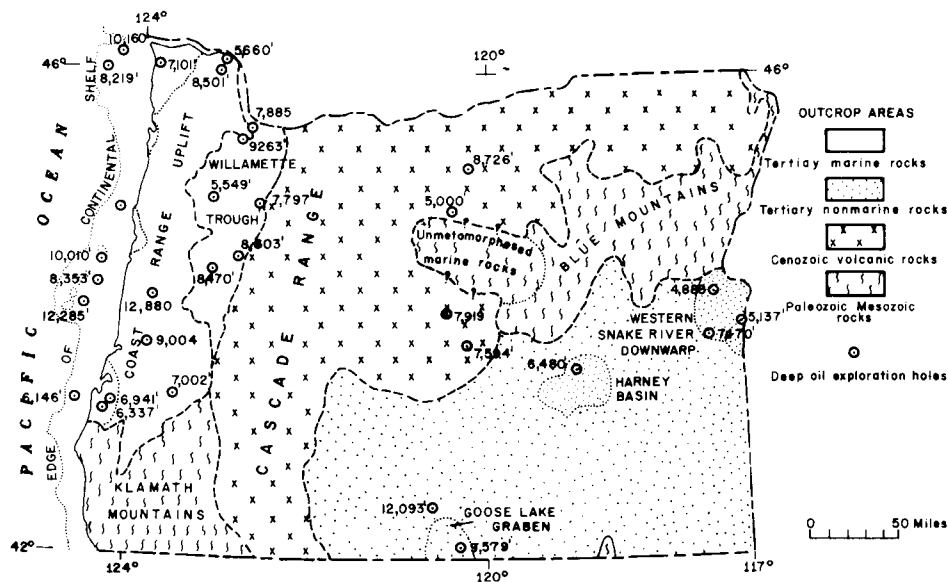


Figure 2. Major rock types and deep exploratory wells in Oregon (adapted from Wagner and Newton, 1969).

Oregon constitute the third drilling province.

Prospects

The onshore Tertiary marine basin has been fairly well drilled except for the eastern margin. Offshore, much work has been done, but seven holes are not enough to evaluate 7,000 or 8,000 square miles of basin area. The prospective eastern nonmarine areas have been fairly well evaluated by drilling, but more effort could be expended in the Western Snake River area. The two Humble wells in Lake County were designed to test pre-Tertiary marine sediments and do not reflect interest in the nonmarine rocks in the Goose Lake graben. Three deep exploratory holes have been put down in central Oregon to explore Paleozoic-Mesozoic marine rock below several thousand feet of volcanic rocks. Findings in these holes have been somewhat encouraging, but still very little is understood about the possibilities of the deeply buried older sediments. It is hoped that Texaco geologists will find encouragement enough in their studies to recommend deep drilling.

References

Buddenhagen, H. J., 1967, Structure and orogenic history of southwestern

part of the John Day Uplift: The ORE BIN, v. 29, no. 7, p. 129-138 (Geologic maps on open file at Oregon Department of Geology and Mineral Industries offices).

Dickinson, W. R., and Vigrass, L. W., 1965, Geology of the Suplee-Izee area: Oregon Dept. Geology and Mineral Industries Bull. 58.

Peck, D. L., 1964, Geologic reconnaissance of the Antelope-Ashwood area, north-central Oregon: U.S. Geol. Survey Bull. 1161-D.

Wagner, H. C., and Newton, V. C., 1969, Petroleum and natural gas: in Mineral and water resources of Oregon: Oregon Dept. Geology and Mineral Industries Bull. 64, p. 280-298.

* * * * *

FIELD WORK IN OREGON DURING 1970

During the 1970 field season at least 80 geologic field studies were conducted in the State of Oregon. Listed below are the studies about which this Department is aware. For convenience, the state is subdivided into six sections, and the studies are grouped according to location. Also, a section dealing with water-resource studies is included in the list.

The list is probably not complete, and the Department would appreciate receiving information about other studies in progress in this state. Reports received will be included in the Summary of Field Work to be issued on a limited and unpublished basis by the Department in the early spring. With regard to the following list, resumes received thus far have been of immeasurable help, and the Department expresses its gratitude for these contributions.

Regional Studies

Northwest Oregon

1. Sedimentary petrology of the upper Nehalem River basin, Oregon: R. O. Van Atta, doctoral candidate, OSU.
2. Geology of the Oregon Coast Range. P. D. Snavely and Norman MacLeod, U.S. Geological Survey, Menlo Park, Calif.
3. Engineering geology of the northern Willamette Valley. H. G. Schlicker, DOGAMI*, and R. J. Deacon, consulting geologist, Shannon & Wilson Co.
4. Miocene igneous rocks of the Western Cascades. A. R. McBirney, professor of geology, UO.
5. Intrusive and extrusive rocks in the northern Western Cascades. Andrew Duncan and Jaroslav Lexa, graduate students, UO.

* DOGAMI = Abbreviation for State of Oregon Department of Geology and Mineral Industries.

6. Coastal landforms. E. Lund, professor of geology, UO.
7. Cenozoic stratigraphy and paleontology. W. O. Addicott, U.S. Geological Survey, Menlo Park, Calif.
8. Land sea transect in the Newport area. P. D. Snavely, Jr., U.S. Geological Survey, Menlo Park, Calif.
9. Trace elements in the 'Columbia River Basalt.' G. Gales, professor of geology, UO.
10. Latitudinal gradients of Tertiary molluscan faunas of the Pacific Coast. W. O. Addicott, U.S. Geological Survey, Menlo Park, Calif.
11. Urban land instability problems of Portland. L. A. Palmer, professor, PSU.
12. Geology of lower Willamette Basin. P. Howell, professor, PSU.
13. Transportation of volcanic rock fragments in various climates. P. Kersey, graduate student, Harvard Univ.

Southwest Oregon

1. Oregon black sands project. H. E. Clifton, U.S. Geological Survey, Menlo Park, Calif.
2. Alpine-type ultramafic rocks. R. Loney, U.S. Geological Survey, Menlo Park, Calif.
3. Geology of the Camas Valley and Tyee quadrangles. E. M. Baldwin, professor of geology, UO.
4. Petrology and structure of the Preston Peak area. A. W. Snoke, doctoral candidate, Stanford Univ.
5. Paleomagnetism of some Cenozoic intrusives. H. C. Clark, professor of geology, Rice Univ.
6. Geology of the Kalmiopsis Wilderness Area. Len Ramp, DOGAMI.
7. Siliceous sediments near Bandon. W. Orr, professor of geology, UO.
8. Decapod fauna in the Umpqua Formation. W. Orr, professor of geology, UO.
9. Geology of the Powers quadrangle. E. M. Baldwin and P. Hess, UO.
10. Specimens of Buchia in the Riddle Formation. D. Jones, U.S. Geological Survey, Menlo Park, Calif.
11. Seismic profiling. P. D. Snavely, Jr., U.S. Geological Survey, Menlo Park, Calif.
12. Minor structures of the Colebrooke Schist. G. T. Benson, professor of geology, PSU.
13. Stratigraphy and sedimentary petrology of the Colestin Formation at the type locality, Jackson County, Oregon. R. Carlton, graduate student, OSU.
14. Geology and mineral deposits of Eden Valley-Saddle Peaks and vicinity, southeastern Coos County, Oregon. W. Utterback, OSU.
15. Limestone samples from Grants Pass area. A. Boucot, professor of geology, OSU.
16. Mapping of Ordovician through Devonian rocks in the eastern Klamath Mountains. Potter, A., Zdanowic, T., Rohr, D., graduate students, OSU.
17. Sand and gravel resources of the Applegate River valley. H. G. Schlicker, DOGAMI, and R. J. Deacon, consulting geologist, Shannon & Wilson Co.

North-central Oregon

1. Petrology of the Oregon Cascade Range. A. R. McBirney, professor of geology, UO.
2. Trace element geochemistry. G. Goles, professor of geology, UO.
3. Middle and Lower Jurassic faunas of eastern Oregon. R. Imlay, U.S. Geological Survey, Washington, D.C.
4. Seismicity. Morris Brown, UO.
5. Petrochemical comparison of various High Cascade volcanoes. T. L. Steinborn, graduate study, UO.
6. Geology of the Long Creek quadrangle. T. Thayer, U.S. Geological Survey, Menlo Park, Calif.
7. Cenozoic floras of the Pacific Northwest. J. A. Wolfe, U.S. Geological Survey, Menlo Park, Calif.
8. Mapping in the Parkdale area. P. H. Hammond, professor of geology, PSU.
9. Chemical analyses of rock units in the central High Cascades. E. M. Taylor, assistant professor of geology, OSU.
10. Petrography of the Clarno Formation. H. Enlows, professor of geology, OSU.
11. Stratigraphy and petrography of the Rattlesnake Formation at the type locality. H. Enlows, professor of geology, OSU.
12. Clay mineralogy of the Cretaceous rocks of the Mitchell area. C. Jarman, OSU.
13. Stratigraphy and sedimentology of the Madras sequence in the Deschutes drainage. D. Stensland, OSU.
14. Stratigraphy and geology of the Clarno Formation. K. Oles, professor of geology, OSU.
15. Chemical petrology of part of the Clarno Formation. J. Rogers (advisor to two unnamed master's candidates), Rice Univ.

South-central Oregon

1. Seismicity of Crater Lake National Park. J. K. Westhusing, on leave of absence from Lockheed Electronics, at UO.
2. Seismicity of the Klamath Falls-Lakeview area. M. Brown, graduate student, UO.
3. Geomorphology of the Warner Valley-Hart Mountain area. D. Weide, graduate student in geography, UCLA.
4. Geothermal steam investigations. R. Bowen and N. Peterson, DOGAMI.
5. Geology of proposed waste management areas, Lake and Klamath Counties, Oregon. V. C. Newton, DOGAMI.
6. Diatomite occurrences in Klamath County. N. Peterson, DOGAMI.
7. Uranium and quicksilver in Lake County. N. Peterson, DOGAMI.
8. Dating of volcanic events at Newberry Crater. N. Peterson, DOGAMI.
9. Mapping of the Lava Butte area. P. Hammond, professor of geology, PSU.
10. Culminating explosions of Mount Mazama. J. Lidstrom, graduate student, OSU.

Northeast Oregon

1. Geology of the Huntington quadrangle. H. Brooks, DOGAMI.

2. Geology of the Snake River Canyon. T. Vallier, professor of geology, Indiana State Univ.
3. Tertiary geology of the Baker AMS quadrangle. James McIntyre, DOGAMI.
4. State Geologic Map Project. G. W. Walker, U.S. Geological Survey, Menlo Park, Calif.
5. Middle and Lower Jurassic faunas of eastern Oregon. R. Imlay, U.S. Geological Survey, Washington, D.C.
6. Geology of the Wallowa Mountains. W. H. Taubeneck, professor of geology, OSU.
7. Landslide geology of the LaGrande area. H. Schlicker, DOGAMI, and R. J. Deacon, consulting geologist, Shannon & Wilson.
8. Stratigraphy of the Columbia River Basalt in the Wallowa Mountains. W. Taubeneck, professor of geology, OSU.
9. Structure, petrography, and petrology of granitic rocks in the Wallowa Mountains. W. Taubeneck, professor of geology, OSU.
10. Structure, petrography, and petrology of granitic rocks of the Bald Mountain batholith in the Anthony Butte and Limber Jim Creek quadrangles. W. Taubeneck, professor of geology, OSU.
11. Geologic investigation of the Eagle Cap Wilderness. P. Weis, U.S. Geological Survey, Spokane, Wash.
12. Structural geology of the Canyon Mountain complex. H. G. Avé Lallemant, graduate student, Rice Univ.
13. Zeolites of the Durkee Basin. R. A. Sheppard, U.S. Geological Survey, Federal Center Building, Denver, Colo.

Southeast Oregon

1. Geology of the Diamond Craters volcanic field. C. Rowan, U.S. Geological Survey, Denver, Colo.
2. Geology and mineralization of the Cordero quicksilver district, Oregon-Nevada. R. C. Greene, U.S. Geological Survey, Menlo Park, Calif.
3. Lacustrine environments. R. E. Miller, U.S. Geological Survey, Menlo Park Calif.
4. Geology of the Pueblo Mountains. H. Enlows, professor of geology, OSU.
5. Geology and ore deposits of the central Pueblo Range. D. Tower, graduate student, OSU.
6. Petrography, distribution, and origin of the Danforth Ignimbrites, Harney Basin. D. Parker, graduate student, OSU.

Water Resource Studies

1. Ground water of the Eugene-Springfield area. F. Frank, U.S. Geological Survey, Portland, Ore.
2. Ground water of the Corvallis-Albany area. F. Frank, U.S. Geological Survey, Portland, Ore.
3. Ground water in the dune-sand area north of Coos Bay. J. Robison, U.S. Geological Survey, Portland, Ore.
4. Ground water of the Grants Pass quadrangle. J. Robison, U.S. Geological Survey, Portland, Ore.

5. Ground water of part of the Klamath River basin. Al Leonard, U.S. Geological Survey, Portland, Ore.
6. Flood mapping reports for Rogue River and Elk River in Jackson County. D. Harris, U.S. Geological Survey, Portland, Ore.
7. Flood mapping report for the Applegate River in Jackson County. D. Harris, U.S. Geological Survey, Portland, Ore.
8. Movement of radionuclides in the Columbia River estuary. D. Hubbell and J. Glenn, U.S. Geological Survey, Portland, Ore.

* * * * *

GEOTHERMAL ACTIVITY IN 1970

By R. G. Bowen*

Interest and activity in geothermal power production accelerated noticeably in 1970. The Larderello field in Italy, with a capacity of 400,000 kw, continued to be the largest developed geothermal field in the world. Exploration activity has been directed to the south in the Naples area, and efforts are now under way to develop new resources in that region. In New Zealand, where the Wairakei field with an installed capacity of 200,000 kw is the second largest, a new field, Brodlands, is currently being drilled. The first units are expected to be in production during the early 1970's. The Geysers field in northern California continues to be the world's third largest production facility, with an installed capacity of 83,000 kw. This is being expanded with two new plants of 110,000 kw each, now under construction and expected to be on stream in 1971 and 1972. In Japan, where installed capacity is a little more than 30,000 kw from two areas, expansion programs are under way.

Exploration programs sponsored by the United Nations are going on in El Salvador, Turkey, Chile, Kenya, and Ethiopia. During the year significant discoveries of dry steam were made in widely scattered parts of the world: Guadeloupe, West Indies; Los Alamos, New Mexico; and Los Negritos, Mexico. In southern California a program is under way to evaluate the geothermal potential of the Imperial Valley, an area where preliminary drilling has found fluids with temperatures of nearly 700°F and geophysical studies indicate these may be widespread. Development there has stopped because of the high salinity of the geothermal fluid, but it is expected that lower salinity fluids amenable to development will be found in other parts of the valley. A few miles to the south in Cerro Prieto,

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

Mexico, low salinity fluids have been found, and development is under way on the first 75,000 kw unit of a planned 300,000 kw plant.

Probably the most important development in the United States during the year was President Nixon's signing of the Federal Geothermal Leasing Law on Christmas Eve. The passage of this act allows exploration and development on federal lands, withholding national parks, wildlife refuges, wilderness areas and Indian trust lands. This bill was of particular importance because it is believed that at least 75 per cent of the land with a potential for producing geothermal resources is owned by the Federal Government.

During the year numerous articles about geothermal power appeared in the newspapers and magazines, as the press and public became aware of the promise of geothermal energy and its capacity for producing electricity with minimal impact on the environment. The public's growing enthusiasm for this clean power source is well founded because the geothermal boiler is deep within the earth and requires no combustion with its attendant smoke, sulfur oxides, nitric oxides, and fly ash. Nor is there any radioactivity associated with either the generating plant or the supporting activities.

The public's attitude toward geothermal energy, along with its proven economic advantages, has caused the electric power utilities to show more interest in the possibilities of geothermal power generation. During the hearings in Washington, D. C. on the Federal Steam Leasing Law, other utility companies, besides Pacific Gas & Electric, testified that they supported the development of geothermal energy even though their funds for research activities are limited. Southern Edison is furnishing some of the funds for the Imperial Valley studies of Dr. Robert Rex and his group at the University of California, Riverside. Sierra Pacific Power is working with Magma Power Co. to develop a method for producing electrical power from hot water reservoirs. Both of these companies, along with the Northern California Power Agency, have expressed interest in purchasing natural steam.

World-wide interest in geothermal energy was demonstrated in 1970 by the Second International Symposium on Geothermal Resources, sponsored by Italy and the United Nations, held in Pisa, Italy, during September. (The first international meeting was in Rome in 1961.) Papers presented at Pisa summarized the developments of geothermal energy around the world since 1961, and presented new ideas for its exploration and utilization.

The exploration for geothermal resources is going through a transitional period as new ideas are being put forth, tested in the field, and in many cases rejected. Geologic thought is changing from: "Find a hot spring and drill it" to more basic theories developed from studies of volcanology, plate tectonics, and sea floor spreading. One of the tools being used most extensively is temperature gradient surveys. By this method areas of high heat flow can be located, the first requirement for a geothermal field, but

it does not necessarily indicate the presence of a reservoir containing geothermal fluids. The detection of characteristic seismic impulses radiating from the geothermal reservoir at depth is the principle of the geothermal ground noise and microseismic methods. These methods have apparently figured in the recent dry steam discoveries in Mexico and New Mexico.

Several factors combine to predict widespread utilization of geothermal resources in the western United States during the 1970's. First is the passage of the Federal Leasing Law thereby making large blocks of land available on which to explore. Next is the recognition that electricity can be produced by this method with a minimal effect on the environment. A third factor is new financing coming in from oil and mining companies that are beginning to explore for geothermal resources. This is occurring at a time when exploration philosophies are crystallizing and sophisticated geophysical tools are becoming available.

Within the Department of Geology and Mineral Industries, our main activity has been to act as a "clearing house" for information on geothermal resources. During the year we have been called on many times to provide information on this subject from groups as diverse as high school students and members of the Congress of the United States. One staff member, R. G. Bowen, attended the International Symposium for development and utilization of geothermal resources in Pisa, Italy. A map listing thermal springs and wells (Miscellaneous Paper 14) was published by the Department in December. Several geothermal gradients were measured in wells drilled for other purposes in eastern Oregon and "borrowed" for study by the Department. A published report will appear on these gradients later in 1972.

* * * * *

FUTURE DEPARTMENT PROGRAMS

In the past, the State of Oregon Department of Geology and Mineral Industries has engaged in a wide variety of activities and short- and long-range programs without benefit of any formally published pronouncement, other than that appearing in the biennial reports. Starting with the next biennium, which begins July 1, 1971, the Department will use a fully detailed set of activities as a guide. A summary of the more important and interesting portions of these activities appears below. Although there are no plans for publication of the complete document, interested persons may examine an open-file copy at the Department's Portland office at any time.

Activity 1 Geologic Studies for Protection and Enhancement of the Environment. Geology is the study of the earth and man is steadily damaging the earth by dumping his waste materials without regard to the environment. The Department plans to continue its studies of suitable sites for disposal of

solid, chemical, and nuclear wastes. Selection of the best sites for construction of homes, factories, and public improvements and the identification of economic reserves of sand and gravel and stone will occupy a considerable portion of the Department's activities.

Environmental concern caused by power-generation plants has spurred research by the Department into possible sources in the state for geothermal steam. Oregon has a wealth of volcanic areas of very recent origin. The hot rocks lying at depth under these areas offer possible sites for developing steam at high temperature and pressure. Geothermal power is "clean," in that there is no air or water pollution and there is a minimum of alteration of the environment.

Activity 2 Oil and Gas. The Department is charged with the responsibility for administering the Oil and Gas Conservation Act. The Department enforces safe drilling practices for test wells, prevents the transfer of subsurface waters, and ensures that all holes are permanently filled and capped. Records of all test wells eventually become available for inspection, and the Department publishes compilations and test results based on these and other data. The Federal Tax Court has ruled that geothermal steam is mineral in character, and since the problems encountered in drilling for high pressure steam are closely similar to those met in gas and oil wells, the Department plans to draw up rules and regulations designed to protect the public, the environment, and the resource itself from undue danger.

Activity 3 Economic Geology Studies. Geology is a many-faceted science. One of the most important facets is mineral economics. Our level of civilization has been largely achieved by our ability to extract mineral wealth at a minimum expense. Over the years[and with continued emphasis for the coming biennium] the Department has conducted basic studies designed to define target areas where better-than-average chances for discovering mineral reserves exist. Publication of the findings of these studies leads, hopefully, to their exploration by mining companies. A long-range geochemical program of stream-sediment sampling will be continued and approximately 2000 square miles of the state will be mapped geologically.

Activity 4 Interagency Assistance. The Department assists approximately 30 other state agencies in various ways. Assistance will be given in the drafting of some proposed legislation for the mining of offshore hard minerals in areas administered by the state.

Activity 5 Special Services. The Department serves as a clearing house for all types of geologic information. It is anticipated that about 750 requests for information will be received from industry, local governments and other agencies during the coming biennium. Basic geologic information

will be provided to several local governments to assist them in long-range planning.

Activity 6 Public Services. The Department has always provided the public with free assays of rocks and minerals found in the state. The Department also operates a spectrographic laboratory which makes a nominal charge for its services to both industry and the public generally. Hundreds of requests for rock, mineral, and fossil identification are also handled in addition to an expected 13,500 other requests for information on Oregon geology by the public. The Department issues The ORE BIN, the only state publication distributed on a subscription basis. Approximately 80,000 copies will be printed during the coming biennium.

Activity 7 Recreation Geology. Oregon's wide variety of interesting geologic phenomena ranges from the spectacular coastline to the glaciated mountains, surging rivers, barren deserts, and volcanic areas just barely cool. Excellent highways make most of these features readily accessible and the demand for geologic information increases yearly. The Department plans to publish a series of articles on some of the outstanding features and several road logs for scenic highway stretches. A history of Oregon mining will be printed as well as the geology of five more of the state's parks.

Activity 8 Information and Education. Geology used to be taught only in colleges. Now instruction is being given in high schools and grade schools and both teachers and pupils are calling on the Department for information. The Department is planning to prepare a series of basic course outlines in geology for classroom use, as well as some pamphlets of general interest. At the adult level the Department will continue to provide access to materials in its collections of publications, reports, minerals, fossils and industrial products, as well as present radio and television programs on geologic subjects.

Activity 9 Preparation for Geologic Catastrophies. The Department operates very much like a fire department. Immediately after a geologic catastrophe such as a landslide, an earthquake, a seismic sea wave, volcanism, flooding, or land subsidence, the Department receives calls from concerned citizens, local governments, and industry. On the other hand, the Department spends much of its time with studies and investigations designed to either eliminate these geologic hazards or lessen their effect. These studies begin with a geologic reconnaissance of the region, followed by more intensive studies of potentially hazardous areas, and finally recommendations for site use and suggested procedures to reduce likelihood of the hazard's occurrence.

* * * * *

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Groh, editors	3.50
58.	Geology of the Supplee-Izee area, Oregon, 1965: Dickinson and Vigrass	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dole, editor	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Mineral and water resources of Oregon, 1969	1.50
65.	Proceedings of the Andesite Conference, 1969: McBirney, editor	2.00
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970: Roberts	2.00

GEOLOGIC MAPS

Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others	0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37)	0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker	1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts	0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams	1.00
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka	1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon, 1962: Corcoran et al.	1.50
GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka	1.50
Geologic map of Oregon west of 121st meridian: (over the counter)	2.00
folded in envelope, \$2.15; rolled in map tube, \$2.50	
Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set]: flat	2.00
folded in envelope, \$2.25; rolled in map tube, \$2.50	

[Continued on back cover]

The ORE BIN
1069 State Office Bldg., Portland, Oregon 97201

The Ore Bin

POSTMASTER: Return postage guaranteed.



Available Publications, Continued:

SHORT PAPERS

2. Industrial aluminum, a brief survey, 1940: Motz \$ 0.10
18. Radioactive minerals the prospectors should know (2nd rev.), 1955:
White and Schafer 0.30
19. Brick and tile industry in Oregon, 1949: Allen and Mason 0.20
20. Glazes from Oregon volcanic glass, 1950: Jacobs 0.20
21. Lightweight aggregate industry in Oregon, 1951: Mason 0.25
23. Oregon King mine, Jefferson County, 1962: Libbey and Corcoran 1.00
24. The Alameda mine, Josephine County, Oregon, 1967: Libbey 2.00

MISCELLANEOUS PAPERS

1. Description of some Oregon rocks and minerals, 1950: Dole 0.40
2. Key to Oregon mineral deposits map, 1951: Mason 0.15
Oregon mineral deposits map (22" x 34"), rev. 1958 (see M.P. 2 for key) 0.30
3. Facts about fossils (reprints), 1953 0.35
4. Rules and regulations for conservation of oil and natural gas (rev. 1962) 1.00
5. Oregon's gold placers (reprints), 1954. 0.25
6. Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton 1.50
7. Bibliography of theses on Oregon geology, 1959: Schlicker 0.50
7. (Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts 0.50
8. Available well records of oil & gas exploration in Oregon, rev. '63: Newton 0.50
11. A collection of articles on meteorites, 1968: (reprints, The ORE BIN) 1.00
12. Index to published geologic mapping in Oregon, 1968: Corcoran Free
13. Index to The ORE BIN, 1950-1969, 1970: M. Lewis 0.30
14. Thermal springs and wells, 1970: R.G. Bowen and N.V. Peterson 1.00

MISCELLANEOUS PUBLICATIONS

- Oregon quicksilver localities map (22" x 34"), 1946 0.30
- Landforms of Oregon: a physiographic sketch (17" x 22"), 1941 0.25
- Index to topographic mapping in Oregon, 1968 Free
- Geologic time chart for Oregon, 1961 Free

OIL and GAS INVESTIGATIONS SERIES

1. Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:
Newton and Corcoran. 2.50
2. Subsurface geology of the lower Columbia and Willamette basins, Oregon,
1969: Newton 2.50

The Ore Bin



Vol. 33, No. 2
February 1971

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

The Ore Bin

Published Monthly By

STATE OF OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Head Office: 1069 State Office Bldg., Portland, Oregon - 97201

Telephone: 229 - 5580

FIELD OFFICES

2033 First Street

Baker 97814

521 N. E. "E" Street

Grants Pass 97526

X X X X X X X X X X X X X X X X X X X

Subscription rate \$1.00 per year. Available back issues 10 cents each.

Second class postage paid

at Portland, Oregon

X X X X X X X X X X X X X X X X X X X

GOVERNING BOARD

Fayette I. Bristol, Rogue River, Chairman

R. W. deWeese, Portland

Harold Banta, Baker

STATE GEOLOGIST

R. E. Corcoran

GEOLOGISTS IN CHARGE OF FIELD OFFICES

Norman S. Wagner, Baker

Len Ramp, Grants Pass

X X X X X X X X X X X X X X X X X X X

Permission is granted to reprint information contained herein.
Credit given the State of Oregon Department of Geology and Mineral Industries
for compiling this information will be appreciated.

COASTAL LANDFORMS BETWEEN FLORENCE AND YACHATS, OREGON

By Ernest H. Lund
Department of Geology, University of Oregon, Eugene, Oregon

The 26-mile stretch of shore extending from Florence to Yachats (Fig. 1) is one of the most rugged and scenic parts of the Oregon Coast. Along most of this part of the coast the shore is bounded by basalt bedrock of varied types. Through differential erosion of the basalt, the many landforms, such as headlands, rocky shores, reefs, and sea stacks, that impart the rugged character to the coast have been and are still in the process of being developed. In places where the basalt bedrock is least resistant to erosion, small embayments with bay-head beaches have been formed, and areas where the bedrock is sedimentary are characterized by coastal plains as much as 4 miles wide. The larger areas of coastal plain are also areas of sand dunes; here the surface configuration is attributed to dune development that has gone on from late Pleistocene to the present.

Bedrock

Basalt

The basalts between Florence and Yachats were extruded in the form of lava flows and pyroclastic fragments from numerous centers during late Eocene time. The textures and structures of the basalt are varied, depending on the mode of eruption and on whether the eruption was subaerial or submarine. In places, the lava flows are dense, hard, and uniform in texture. Elsewhere they are very much fragmented to yield breccias in which the particles commonly exceed a foot in their maximum dimension (Fig. 2). The large number of flows in sequence and their nearly horizontal position in places, as at Cape Perpetua, suggest that the flows accumulated as broad volcanic structures such as shield volcanoes.

The fragmental basalt makes up a large part of the total and is of several origins. Some of it is breccia that formed at the tops of lava flows, where a solidified crust formed on the surface of a still mobile lava and then broke into fragments as the underlying lava continued to flow. Where the lava erupted beneath the sea or where it poured into the sea, the sudden chilling of the solidified part caused fragmentation. In places these fragmental lavas have associated spheroidal masses, the pillow structure, which indicates a submarine origin. A third mode of origin of fragmental basalt was pyroclastic eruption, in which the particles were exploded from a volcano either in the solid state or as liquid particles that solidified while still airborne.

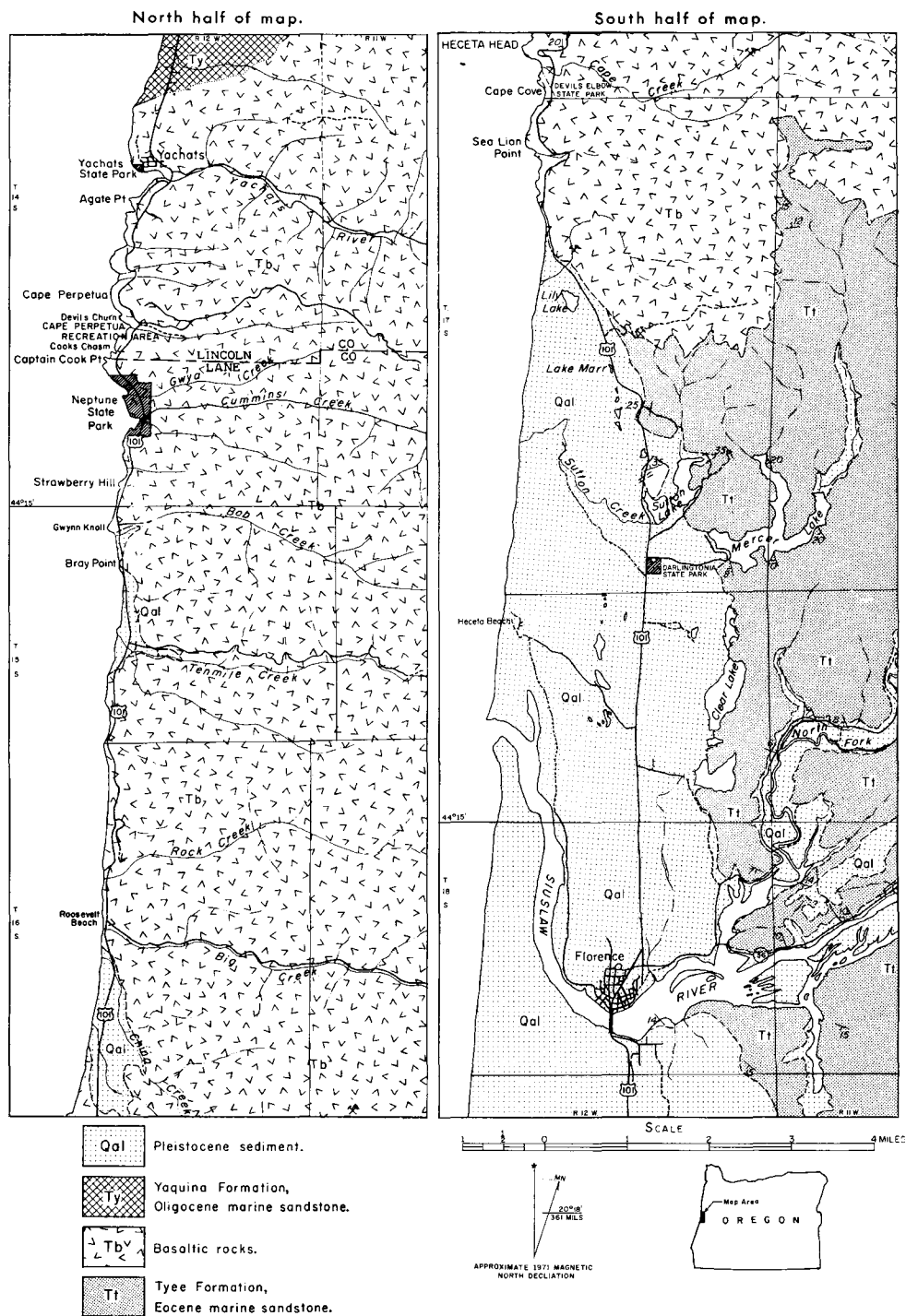


Figure 1. Index and geologic map of Oregon coast between Yachats and Florence.



Figure 2. Volcanic breccia in sea cliff at Devil's Elbow State Park.



Figure 3. Sorted and stratified volcanic material and rounded boulders in sea cliff at Devil's Elbow State Park.

Where fragmental rock was directly formed beneath the ocean or where the particles entered the ocean subsequent to solidification some size-sorting, rounding and stratifying of particles by wave action (Fig. 3,4) has occurred. In places the water-reworked volcanic materials are intermixed with sediment of other origins, including shell fragments of marine organisms. Several of the volcanic units in the sequence at Heceta Head are of stratified and sorted volcanic material, some of which contains shell fragments.

Numerous small dikes ranging from a few inches to several feet in width cut through the extrusive basalts and are particularly abundant in the fragmental varieties (Fig. 5). These dikes were probably formed where rifts developed on the flanks of volcanic cones. Lava welled up through the rifts and extruded out over the surface, and in the final stages the lava remaining in the rifts solidified to form the dikes.

Sedimentary rocks

South of Sea Lion Point and the associated headlands the bedrock belongs to the Tyee Formation, an Eocene sandstone older than the basalts. This sedimentary rock underlies the dune sand in the lowland of the "Florence embayment" (Fig. 6) and crops out along the margins of the dune belt where the dunes join the hilly terrain of the Coast Range. Along Oregon Highway 126 the North Fork of the Siuslaw River marks the boundary between the Eocene sandstone and the Pleistocene dune sand.

North and east of Heceta Head is a small area (not shown on map) where the bedrock is an unnamed series of interbedded sandstones, siltstones, and shales. These beds are believed to be of Eocene age, but their affinities are not well known. They crop out along Cape Creek and extend northward, underlying Pleistocene sediments in an "embayment" along China Creek north of Heceta Head.

Basalt extends for about a mile north of Yachats (Fig. 7), and beyond that is the Yaquina Formation, a sandstone of Oligocene age. Along the coast, erosion during the Pleistocene reduced the surface on the Yaquina Formation to a platform, over which were deposited terrace sediments; the area underlain by the formation is now a coastal plain.

Pleistocene Sediments

Bay filling

The "embayment" north of Heceta Head is an area of low elevation covered by sand dunes. During the Pleistocene it was a small bay of the ocean that received sand and silt from the streams flowing into it. These sediments are exposed along the shore at the southern end of Roosevelt Beach north of Heceta Head. For about a mile north of Heceta Head they form a low sea cliff (Fig. 8). Their upper surface is marked by tree stumps, logs, and other pieces of wood and organic matter. They are somewhat more compacted and consolidated than the overlying dune sand and are capable of maintaining vertical cliffs, whereas the dune sand is a slope former. The bay sediment is less permeable than the dune sand, and water that filters down through the dune sand moves laterally along its contact with the bay sediments and emerges along the sea cliff as springs and seeps at the contact and in the upper layers of the bay sediment.



Figure 4. Stratified and sorted volcanic material in sea stack at Devil's Elbow State Park.



Figure 5. Surface of Pleistocene wave-cut bench from which the overlying terrace sediments have been removed. A small dike extends from the lower left to the center of the photograph.



↑ Figure 6. Air view of Heceta Beach from near Sea Lion Point. Summer dunes are present on the dry-sand part of the beach. Several active dune areas are shown in the upper part of the photograph, and near the center are some stabilized dunes. (Oregon State Highway Department photograph)

↓ Figure 7. View to the north from Cape Perpetua. Yachats, in the upper right, is built mostly on a marine terrace. The basalt bench on which the terrace was formed is exposed along the edge of the shore. (Oregon State Highway Department photograph)



Terrace deposits

Numerous preserved segments of a marine terrace that was once extensive along the Oregon Coast are present in the more protected parts of the coastal area described in this article. The terrace was formed during late Pleistocene time when sea level was higher than it is at present. During this time a wave-cut bench was formed at an elevation higher than the bedrock surface presently under wave attack, and as sea level receded, a layer of sediment was left over the wave-cut surface (Fig. 5).

The terrace sediments range in thickness from a few feet to several tens of feet and have been weakly consolidated into sandstone and conglomerate capable of maintaining a vertical cliff on the seaward side (Fig. 9). The surface of the terrace, where not modified by dune development or stream erosion, is generally level or has a slight seaward slope. The terrace segments are desirable building sites along the coast, and most of the town of Yachats is on one of the larger segments. The conglomerate is the major source of agates found along the beaches.

Dune deposits

Sand dunes, the ages of which range from the Pleistocene to the present, extend from the headlands south of Sea Lion Point (Fig. 6.) southward to Coos Bay in a continuous belt that is as much as 4 miles wide in places. In the Florence vicinity the dune sand is believed to cover a wave-cut platform that was developed on the Tyee Formation during the Pleistocene, when sea level stood higher and the shore line was along the foothills of the Coast Range.

North of Heceta Head is a dune area, mentioned above, that extends to China Creek, a distance of about 2 miles, and attains a maximum width of about three-quarters of a mile (Fig. 10). Dune sand extends southward to the saddle on the back side of Heceta Head, where it is exposed in a roadcut; it overlies the bay sediments along the shore and perhaps older sedimentary rock along China Creek. Where dune sand comes to the edge of the beach, the sea cliff is poorly developed or absent.

In the vicinity of Neptune Beach and just south of Cape Perpetua (Fig. 11) are small dune areas where the dune sand rests on terrace deposits. The Cape Perpetua Visitor Center is built on dune sand, and dune sand forms a prominent knob at the north parking area of Neptune State Park. Numerous shell fragments at the top of this knob are from a kitchen midden, the "garbage dump" of the Indians that used the area.

Major Landforms

In an explanation of the origin of the landforms along the coast, consideration must be given to the characteristics of the bedrock along the shore and to the geologic history of the area through the Pleistocene to the present.

Coastal plains and dunes

The sedimentary rocks are generally less resistant to erosion than the basalts, and, as stated above, where the bedrock is one of the sandstone formations erosion has created a lowland area of coastal plain. The development of the plain was



Figure 8. Sea cliff developed on bay sediments along Roosevelt Beach near Washburne Park. Dune sand overlies the bay sediments. Note log near the contact.



Figure 9. Sea cliff against terrace conglomerate and sandstone at Neptune State Park.

at a time or times when sea level stood higher than it does now, for during the Pleistocene interglacial stages there was less ice on the land and a correspondingly greater amount of water in the sea. When sea level rose, the shore line shifted landward at a greater rate where the bedrock is sandstone than where it is basalt. A wave-cut platform was formed over the sedimentary rock, and a layer of sediment of mostly sand and gravel was deposited on the platform. As the sea receded with the onset of another period of glaciation, the layer of sediment was left behind, covering the wave-cut surface.

Once above sea level, the plain came under the influence of wind and sand dunes were formed over its surface. Most of the dunes have been stabilized with vegetation but many are still active. The surface of dune areas is characterized by ridges, knobs, and depressions. Many of the depressions are deep enough that they intersect the ground-water level, and these are the sites of interdune lakes, of which there are many in the major dune areas.

Headlands and rockbound shore

Within the basalts there is a wide variation in the resistance to erosion, the greatest resistance being offered by the dense flows and the least by some of the fragmental varieties. A further factor in the erosion of the basalts is the extent to which the rock has been broken along fractures. Fracture zones are places of weakness and erosion proceeds at a greater rate there than where the rock is intact.

Where the shore is bounded by basalt, two major types of terrain have developed. One is the promontory or headland (Figs. 12,13) developed where the rock offers the greatest resistance to erosion and where in certain places, as at Cape Perpetua and Sea Lion Point, the basalt flows accumulated to great thickness. The other type of terrain is the low, rockbound shore (Figs. 7,11), where a wave-cut bench, formed at a time of higher sea level and covered by Pleistocene terrace deposits, is now being uncovered and reshaped by wave action. Flows of dense, hard basalt and interbedded fragmental rocks are characteristic of the promontories, whereas the lower areas are characterized mainly by fragmental types and associated dikes. A narrow ledge (Fig. 12) present in many places near the base of the promontories in the Heceta Head-Sea Lion Point vicinity corresponds to the wave-cut bench developed on the less resistant fragmental basalt. At Cape Perpetua the bench is continuous along the shore around the headland.

Minor Landforms

In the two major types of terrain developed on the basaltic rock are numerous landforms of lower order of magnitude. The shaping of these landforms is governed mainly by differences in resistance to erosion, and this in turn is related to differences in hardness of the rock from place to place and the extent to which the rock has been weakened through fracturing.

Sea stacks

Sea stacks are prominent erosional remnants that have become isolated from the mainland and stand as small, steep-sided islands (Figs. 4,14). In some places the rock in the stack is harder than the rock around it and, therefore, becomes isolated when the less resistant surrounding rock erodes. In other places fractures



Figure 10. Beach along Ponsler Wayside (lower left and Washburne State Park (upper left). Beach terminates against Heceta Head. Stabilized dunes are visible between the wayside and the park. (Oregon State Highway Department photograph)



Figure 11. View south of Cape Perpetua. The Pleistocene basalt bench with its many erosional landforms is well displayed here. Cook's Chasm is at the bridge near the center of the photograph. The roadcut near the left side is in dune sand. (Oregon State Highway Department photograph)



Figure 12. Sea Lion Point and caves. Cave farthest to the left is the south entrance to the Sea Lion Cave. A small segment of the Pleistocene bench is shown at the bottom of the photograph. (Oregon State Highway Department photograph)

localize the erosion that ultimately separates the rock of the stack from the mainland.

Stacks in the area described here are associated mainly with the headlands and are best developed in the vicinity of Heceta Head, where fractures in the rock have guided erosion in such a way that several large rock masses stand isolated near the shore. Near Cook's Chasm, south of Cape Perpetua, a rock mass rises above the general level of the Pleistocene bench (Fig. 15). This was a sea stack during the Pleistocene.

Sea caves, trenches, and chasms

Sea caves, trenches, and chasms have formed in places where the bedrock has been weakened by fractures, and in many places the fractures are distributed over a zone from a few feet to many feet wide. Broken rock along the fracture zone is quarried by the forces of water under pressure and compressed air and either a cave or an open trench or chasm is formed. Trenches and chasms are essentially the same type of landform, and the only distinction made here is one of size. Trenches are only a few feet across (Fig. 16), and chasms are from a few feet to several tens of feet across (Figs. 17,18).

Some of the chasms and trenches may have been sea caves originally, but were "deroofed." Many have sea caves at their landward ends. The Devil's Churn, an excellent example of this landform, terminates in a sea cave suggesting



Figure 13. Heceta Head and the tunnel promontory. Cape Cove is in the foreground. (Oregon State Highway Department photograph)



Figure 14. Devil's Elbow State Park. Beach sand and gravel forms a thin veneer over the present-day wave-cut bench, visible to the right of the center of the photograph. (Oregon State Highway Department photograph)

that "deroofing" of a cave contributed in part to its origin. Trenches and chasms are numerous along the coast from Yachats southward to Neptune Beach where the Pleistocene bench is most prominently displayed.

Numerous small caves are present in the basalt on which the Pleistocene bench was cut, but the largest ones are at Sea Lion Point (Fig. 12), and the most magnificent of all is the Sea Lion Cave (Fig. 22). This cave was localized by intersecting fracture zones, one trending about north-south and the other in a nearly east-west direction. The largest opening is along the east-west fracture and is the one used by the animals as they move in and out of the cave. A tunnel that passes through the headland was developed along the north-south fracture zone, and the floor of the southern part is below sea level. The northern part is the site of the viewpoints for the cave and the shore to the north. The position of this segment of the tunnel above sea level indicates that it was formed during a time of higher sea level. The fractures along which the tunnel was formed are visible in the ceiling. Lateral erosion within the cave and dislodging of rock from the ceiling have shaped it into a large, high-vaulted, amphitheater-like cavern.

Another form related to the north-south fracture zone in the cave is a cleft that separates a small stack from a promontory south of Sea Lion Point. As with other stacks in the Heceta Head-Sea Lion Point locality, the separation of the stack from the mainland was by erosion localized along the fracture zone.

Spouting horns and hissing fissures

Some of the small caves in the Pleistocene bench have small openings along them, mainly at their landward ends, and when waves are driven with sufficient force into these caves, water erupts through the openings. These are called spouting horns (Fig. 19). A few of the caves have fissures in their ceilings that extend to the surface, and air expelled from the cave by an incoming wave makes a loud hissing sound. When the water recedes, the cave "breathes" in a fresh supply of air. If the water level in the cave is high enough, water is expelled along the fissure in a sputtering fashion.

Arches

The large arches along the Oregon Coast are sea stacks penetrated by tunnels that usually have a high arch. Smaller versions of the arch are common along the Pleistocene bench, most of them being remnants of what was once a sea cave or tunnel through a rock mass. There is a small one near the sea cliff just south of the sand-dune knob at the north parking area of Neptune State Park (Fig. 20).

Tidal Pools

Many tidal pools occupy irregular depressions over the Pleistocene bench, and these are the sites of a varied assemblage of marine animals and plants. Some have a change of water with each high tide and offer a favorable habitat for living things. Others receive a change of water only during storms and have a limited flora and fauna. During the summer months, when there is little or no change of water in these pools and the evaporation rate is high, salt may precipitate, and in some of the small ones a thin salt layer that looks like ice forms over the surface.



Figure 15. Irregular surface on the Pleistocene bench south of Cape Perpetua. Knob in the center of the photograph was a sea stack during the Pleistocene.



Figure 16. Trench formed along a fracture in the basalt at Neptune State Park.

References

- Baldwin, E. M., 1956, Geologic map of the lower Siuslaw River area, Oregon: U. S. Geol. Survey Oil and Gas Inv. Map OM-186.
- , 1964, Geology of Oregon, 2nd edition: Eugene, Oregon. Univ. Oregon Cooperative Bookstore, 165 p.
- Vokes, H. E., Norbistrath, H., and Snavely, P. D. Jr., 1949, Geology of the Newport-Waldport area, Lincoln and Lane Counties, Oregon: U. S. Geol. Survey Oil and Gas Inv. Prelim. Map 88.

ROAD LOG BETWEEN FLORENCE AND YACHATS

The following road log was prepared with the starting point at Florence, but north-to-south mileages are given so the southbound traveller can use the log by starting at the end and working towards the beginning. Certain difficulties are inherent in this arrangement because a road log is prepared from a shifting point of view, and the direction of motion is a factor, but an attempt has been made to minimize these difficulties.

The log not only lists landmarks along the route but also includes descriptions of select segments of the shore. Most of the landforms remain the same throughout the year, but others, where the substance of the form is mobile, change seasonally. A beach that is predominantly sand during the summer may be mostly cobbles and boulders after winter storms have swept the sand away. Summer dunes on the dry sand part of the beach are destroyed by winter storm waves sweeping across the full width of the beach. Spouting horns that are dormant during the summer come to life during winter. The patterns in the sand are more striking in the winter than in the summer because the colored grains become concentrated by selective removal of the lighter quartz sand. These colored components - the pink garnet, green olivine, epidote, pyroxene, amphibole, and black magnetite and ilmenite - are selectively transported and redeposited.

Appealing as the scenes along the coast may be, much of the charm of the shore comes from the sounds made by the waves as they break over the beach, plunge against a sea cliff or rush along a trench or chasm. One can hear the steady roar of the waves from a distance, but only at close range can the variety of sounds be totally appreciated. The rattle of rocks rolling back and forth can be heard only at the site, and the hissing of air through a fissure is audible only near the vent. Sounds, like some of the landforms, vary from season to season. Those made by the waves are subdued in summer but are increased in volume many times over by the violence of a winter storm. The roar of the surf in summer becomes thunderous in winter, and the feeble sputtering of a spouting horn changes to a forceful eruption. Those who are privileged to visit the coast after a winter storm, when the air is clear and calm and when the waves are still running high, will find the visit a rewarding experience.



Figure 17. Cook's Chasm near Cape Perpetua Visitor Center.



Figure 18. Devil's Churn on the south side of Cape Perpetua is a chasm that terminates in a sea cave.

Mileage S-N	Mileage increment	Mileage N-S	
0.0		25.6	Junction of Oregon Highway 126 and U. S. 101. The city of Florence is built on dune sand at a place where the dune belt is 3 miles wide. For a distance of $7\frac{1}{2}$ miles north of Florence, Highway 101 passes along a dune belt with gently rolling terrain marked by low dune ridges and knobs and intervening flat areas and depressions. In many of the low areas the land surface intersects the ground-water level, and these places are sites of lakes, marshes, and bogs. Most of the dunes are stabilized by a cover of trees and underbrush, but in places they are active.
3.0	3.0	22.6	Heceta Beach junction.
3.3	0.3	22.3	Active dunes west of highway.
5.0	1.7	20.6	Mercer Lake junction. Darlingtonia Botanical Wayside: a small bog with pitcher plants is the main feature.
5.4	0.4	20.2	Sutton Creek and Sutton Lake. Sutton Lake lies mostly within the dune belt and was formed by the impounding of Sutton Creek with dune sand. Mercer Lake, which lies east of Sutton Lake, is of similar origin, but it lies mostly in the lower parts of two small intersecting stream valleys cut into the Eocene sandstone.
5.8	0.4	19.8	Active dunes west of highway.
6.3	0.5	19.3	Buck Lake west of highway.
6.5	0.2	19.1	Alder Dune turnoff. Dune crossbedding in roadcut on east side of highway.
7.4	0.9	18.2	Lake Marr west of highway.
7.6	0.2	18.0	North edge of dune belt along highway. Dunes extend farther to the north along the shore.
8.4	0.8	17.2	Lily Lake west of highway (Fig. 6).
9.9	1.5	15.7	Viewpoint with excellent view of Sea Lion Point and caves (Fig. 12). Headlands and small beaches characterize the shore between Heceta Beach and Roosevelt Beach. The headlands, the most prominent of which are Heceta Head and Sea Lion Point, consist of basalt flows and inter-layered pyroclastic material. Numerous caves in the headlands were formed along fracture zones in the basalt. Narrow ledges around the base are segments of a wave-cut bench formed during a time of higher sea level.

10.9	1.0	14.7	Sea Lion Caves (Fig. 22).
11.1	0.2	14.5	Viewpoint with excellent view of Heceta Head and lighthouse (Fig. 13).
11.5	0.4	14.1	South end of tunnel.
11.7	0.2	13.9	North end of tunnel.
12.0	0.3	13.6	Entrance to Devil's Elbow State Park. Devil's Elbow Park (Fig. 14) is in a small cove between Heceta Head and the tunnel promontory. The parking and picnic area is on a

low terrace, the surface of which is continuous with the narrow alluvial plain along Cape Creek. The beach is typical of small beaches that lie between or are adjacent to headlands. The upper part is a zone of boulders and cobbles and driftwood, and seaward from that a layer of sand covers a wave-cut bench of basalt bedrock. The bench is exposed north of the sand beach during the lower stages of the tide.

The basalt in the cliffs and the sea stacks north of the park is mostly the fragmental variety (Fig. 2) cut by numerous small dikes. Stratification, sorting and rounding of boulders indicate that the fragments either were erupted into the sea or entered it shortly after eruption and were reworked by waves (Fig. 3). The inclination of the rock layers suggests that they were deposited on the western flank of a volcano (Fig. 4).

Several shallow caves were formed in the sea cliff along fracture zones; the fractures are visible in the rock above the caves. One of the most striking features formed along a fracture zone is a deep, narrow chasm at the base of Heceta Head. Another fracture zone intersects this one and passes behind the large sea stack nearest the shore. A chasm along this fracture separates the stack from the mainland. A tunnel passes through the projection of rock that separates the two chasms but is not accessible.

The residence building formerly used by the lighthouse keeper is on a terrace segment. A layer of terrace conglomerate overlies the wave-cut bench on the basalt and is well exposed in the sea cliff along the edge of the terrace. Above the conglomerate the terrace sediment is sandstone. Shells in the sand just below the surface indicate that this site was used by Indians.

12.5	0.5	13.1	Dune sand in roadcut.
14.0	1.5	11.6	Entrance to Carl G. Washburne Memorial State Park. Washburne Memorial Park (Fig. 10) is in a stabilized sand dune area

that was a small embayment during a higher stand of sea level in Pleistocene time. The dune sand overlies sediments deposited in the embayment; these older loosely consolidated sediments are exposed along the southern end of Roosevelt Beach, where they support a low sea cliff (Fig. 8). The upper surface of the bay sediments is marked by logs, stumps, and smaller pieces of wood, and because the bay sediment is less permeable than the dune sand, springs and seeps occur along or just below the contact between the two.



Figure 19. Spouting Horn
near Cook's Chasm.
Water erupts from an
opening in the ceiling
of a small sea cave.

14.4	0.4	11.2	China Creek and boundary between dune sand and terrace.
14.7	0.3	10.9	Entrance to Muriel O. Ponsler Memorial Wayside. Ponsler Wayside (Fig. 10) is on a marine terrace that extends to Rock Creek.

A low sea cliff exposing terrace conglomerate at the base and sandstone above borders the beach. Basalt crops out at numerous places along the beach between the Wayside and Rock Creek. Just north of Big Creek weathered basalt bearing white agate amygdules is exposed in the sea cliff. The amygdaloidal basalt overlies a clay bed at this locality; it is also exposed at the base of the cliff just south of Rock Creek and near the base of the small headland north of Rock Creek.

15.0	0.3	10.6	Big Creek.
15.2	0.2	10.4	Roadcut in basalt.
15.5	0.3	10.1	Roadcut in basalt.
15.6	0.1	10.0	Rock Creek and north end of terrace.



Figure 20. Small arch at Neptune State Park.



Figure 21. Rock knobs along the beach at Neptune State Park are remnants of the Pleistocene bench.

15.7	0.1	9.9	Roadcut in basalt behind small headland.
16.1	0.4	9.5	Entrance to Ocean Beach picnic area. The Ocean Beach picnic area is on a small segment of terrace, and terrace conglomerate is exposed at the base of the sea cliff between the small headland to the south and a point a short distance north of the trail to the beach. Northward for a distance of about 2 miles the cliff is on basalt overlain by soil and rock particles that have moved down from adjacent slopes. The sand beach is about half a mile long, and north of it basalt crops out along the shore for about $1\frac{1}{2}$ miles.
17.1	1.0	8.5	Viewpoint
17.2	0.1	8.4	Viewpoint
17.9	0.7	7.7	South edge of terrace. Terrace conglomerate and sandstone are in the sea cliff here, and basalt is exposed at the beach level northward to Rockwood Beach.
18.5	0.6	7.1	Tenmile Creek and Rockwood Beach (Fig. 23). Rockwood Beach is at a place where Tenmile Creek has breached the terrace. The terrace deposits have been eroded away over a short distance, and instead of a sea cliff, a steeply sloping, rocky beach marks the shore line. The terrace resumes north of Tenmile Creek and continues to Bray Point. Basalt is exposed along the beach at numerous places between Tenmile Creek and Bray Point. Rough rock masses around Bray Point are remnants of the Pleistocene bench.
19.3	0.8	6.3	North edge of terrace.
19.6	0.3	6.0	Bray Point and viewpoint.
20.0	0.4	5.6	Bob Creek; small segment of terrace.
20.2	0.2	5.4	Dune sand in roadcut.
20.4	0.2	5.2	Terrace.
20.6	0.2	5.0	Strawberry Hill; viewpoint. The Pleistocene bench is well displayed at Strawberry Hill and continues northward to a point beyond Yachats, interrupted here and there where it is crossed by streams or where it has been removed by wave erosion.
21.0	0.4	4.6	Dune sand in roadcut.
21.2	0.2	4.4	Roadcut in basalt.



Figure 22. Interior of Sea Lion Cave. (Oregon State Highway photograph)



Figure 23. Tenmile Creek crosses a segment of marine terrace. Rockwood Bench is in the foreground. A low sea cliff is developed on the terrace sediments north of the creek, and basalt is exposed along the beach that ends at Bray Point in the upper left corner of the photograph. (Oregon State Highway photograph)

21.3	0.1	4.3	Entrance to Neptune State Park camping area.
21.4	0.1	4.2	Entrance to south picnic area of Neptune Park.
21.5	0.1	4.1	Cummins Creek.
21.6	0.1	4.0	Dune sand in roadcut.
21.8	0.2	3.8	Entrance to north picnic area of Neptune State Park. Most of Neptune State Park is on a terrace segment; the two picnic areas

are on flat parts of the terrace, and between them the terrace deposits are covered by dune sand. The sea cliff between and adjacent to the picnic areas is against terrace sediments, with the usual sequence of conglomerate at the base and sandstone above (Fig. 9). The cliff gives way to a steep slope on the dune sand above the terrace sediments. The conglomerate rests on the surface of the Pleistocene bench, which here is as much as 15 feet above the surface that is presently being eroded on the basalt. The Pleistocene bench is in various stages of erosion. Where it has been recently exposed through the removal of the terrace deposits, it is fairly level (Fig. 5). Where it has been subjected to erosion for a long time, it has been sculptured into the fascinating landforms that give this segment of the coast between Strawberry Hill and Yachats its distinctive charm. The numerous isolated rock masses (Fig. 21) between the picnic areas are erosional remnants of the bench, and the more nearly intact part of the bench adjacent to the sea cliff is penetrated by numerous trenches formed along fractures.

At the north picnic area the bench projects seaward and is bounded on the north by a chasm through which Gwynn Creek enters the sea. The projection of the basalt bench is cut by numerous trenches (Fig. 16) trending in various directions, and small caves penetrate it at several places. Openings in ceilings of caves are the sites of spouting horns and hissing fissures. Numerous tidal pools supporting many forms of marine life occupy depressions on the bench, and at its southern edge is a small arch. The knob at the west edge of the north parking area is a sand dune.

22.2	0.4	3.4	Viewpoint on Captain Cook Point at north edge of Neptune State Park.
22.3	0.1	3.3	Lane-Lincoln County boundary.
22.4	0.1	3.2	Cook's Chasm and viewpoint. Some of the best examples of trenches, caves, arches, spouting horns (Fig. 19), and other forms developed on the Pleistocene bench are in the

vicinity of Cook's Chasm. A knob (Fig. 15) projecting above the general level of the bench south of the Chasm was a sea stack during the Pleistocene. A tunnel penetrates the rock on its north side.

22.6	0.2	3.0	Cape Perpetua Visitor Center entrance. Displays, slides, and a movie tell the story of this locality. Forest Service personnel are available for further information. Easy trails lead to selected areas of biologic and geologic interest. A 22-mile self-conducted auto tour through the forest begins just north of the Center and ends at Yachats.
22.7	0.1	2.9	Dune sand in roadcut below Visitor Center.
22.9	0.2	2.7	Side road to Cape Perpetua viewpoint and beginning of self-conducted auto tour.
23.0	0.1	2.6	Devil's Churn parking lot. The Devil's Churn (Fig. 18) is an outstanding example of a chasm and, like other chasms and trenches along this part of the coast, was formed along a fracture in the basalt. It terminates in a cave, which suggests that it owes its origin, at least in part, to the "deroofting" of a sea cave.
23.4	0.4	2.2	Viewpoint on face of Cape Perpetua with excellent view of the shore to the north and Yachats (Fig. 7).
24.3	0.9	1.3	Yachats city limits; highway on terrace.
24.5	0.2	1.1	Yachats Beach access road.
25.2	0.7	0.4	Yachats River and Yachats Beach access road. The road is a scenic drive along the south edge of the river and the seashore.
25.6	0.4	0.0	Yachats Post Office. Yachats, like many towns along the Oregon Coast, is built on a marine terrace. The basalt beneath the veneer of sedimentary rock underlying the terrace is exposed along the shore and imparts to it the ruggedness that characterizes this part of the coast.

* * * * *

NOTICE: IMPORTANT MINERALS ACT PASSED

An Act to establish a national mining and minerals policy was passed by the House and Senate and signed by the President on December 31, 1970. It is titled "Mining and Minerals Policy Act of 1970." For the purpose of the Act, "minerals" includes all minerals and mineral fuels. More information about this important legislative matter will be presented in the March 1971 ORE BIN.

* * * * *

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Groh, editors	3.50
58.	Geology of the Supplee-Izee area, Oregon, 1965: Dickinson and Vigross	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dole, editor	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Mineral and water resources of Oregon, 1969	1.50
65.	Proceedings of the Andesite Conference, 1969: McBirney, editor	2.00
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970: Roberts	2.00

GEOLOGIC MAPS

Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others	0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37)	0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker	1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts	0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams	1.00
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka	1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon, 1962: Corcoran et al.	1.50
GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka	1.50
Geologic map of Oregon west of 121st meridian: (over the counter)	2.00
folded in envelope, \$2.15; rolled in map tube, \$2.50	
Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set]: flat	2.00
folded in envelope, \$2.25; rolled in map tube, \$2.50	

[Continued on back cover]

The ORE BIN
1069 State Office Bldg., Portland, Oregon 97201

The Ore Bin

POSTMASTER: Return postage guaranteed.



Available Publications, Continued:

SHORT PAPERS

2. Industrial aluminum, a brief survey, 1940: Motz \$ 0.10
18. Radioactive minerals the prospectors should know (2nd rev.), 1955:
White and Schafer 0.30
19. Brick and tile industry in Oregon, 1949: Allen and Mason 0.20
20. Glazes from Oregon volcanic glass, 1950: Jacobs 0.20
21. Lightweight aggregate industry in Oregon, 1951: Mason 0.25
23. Oregon King mine, Jefferson County, 1962: Libbey and Corcoran. 1.00
24. The Alameda mine, Josephine County, Oregon, 1967: Libbey 2.00

MISCELLANEOUS PAPERS

1. Description of some Oregon rocks and minerals, 1950: Dole 0.40
2. Key to Oregon mineral deposits map, 1951: Mason 0.15
3. Oregon mineral deposits map (22" x 34"), rev. 1958 (see M.P.2 for key). 0.30
4. Facts about fossils (reprints), 1953 0.35
5. Rules and regulations for conservation of oil and natural gas (rev. 1962) 1.00
6. Oregon's gold placers (reprints), 1954. 0.25
7. Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton 1.50
8. Bibliography of theses on Oregon geology, 1959: Schlicker 0.50
9. (Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts 0.50
10. Available well records of oil & gas exploration in Oregon, rev. '63: Newton 0.50
11. A collection of articles on meteorites, 1968: (reprints, The ORE BIN) 1.00
12. Index to published geologic mapping in Oregon, 1968: Corcoran Free
13. Index to The ORE BIN, 1950-1969, 1970: M. Lewis 0.30
14. Thermal springs and wells, 1970: R.G. Bowen and N.V. Peterson 1.00

MISCELLANEOUS PUBLICATIONS

- Oregon quicksilver localities map (22" x 34"), 1946 0.30
- Landforms of Oregon: a physiographic sketch (17" x 22"), 1941 0.25
- Index to topographic mapping in Oregon, 1968 Free
- Geologic time chart for Oregon, 1961 Free

OIL and GAS INVESTIGATIONS SERIES

1. Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:
Newton and Corcoran. 2.50
2. Subsurface geology of the lower Columbia and Willamette basins, Oregon,
1969: Newton 2.50

The Ore Bin



Vol. 33, No. 3
March 1971

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

The Ore Bin

Published Monthly By

STATE OF OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Head Office: 1069 State Office Bldg., Portland, Oregon - 97201

Telephone: 229 - 5580

FIELD OFFICES

2033 First Street

Baker 97814

521 N. E. "E" Street

Grants Pass 97526

X X X X X X X X X X X X X X X X X X X

Subscription rate \$1.00 per year. Available back issues 10 cents each.

Second class postage paid

at Portland, Oregon

X X X X X X X X X X X X X X X X X X X

GOVERNING BOARD

Fayette I. Bristol, Rogue River, Chairman

R. W. deWeese, Portland

Harold Banta, Baker

STATE GEOLOGIST

R. E. Corcoran

GEOLOGISTS IN CHARGE OF FIELD OFFICES

Norman S. Wagner, Baker

Len Ramp, Grants Pass

X X X X X X X X X X X X X X X X X X X

Permission is granted to reprint information contained herein.
Credit given the State of Oregon Department of Geology and Mineral Industries
for compiling this information will be appreciated.

WASTE -- A MINERAL RESOURCE AND A GEOLOGIC PROBLEM

by

V. C. Newton, R. S. Mason, N. V. Peterson, and H. G. Schlicker
Oregon Department of Geology and Mineral Industries

Problems involving solid wastes have centered mainly on how to dispose of them in some handy "sanitary landfill." The Department feels that an equally pressing problem is the sheer waste of irreplaceable metals and minerals that are used once and then dumped. Environmental enhancement cannot subsist on short-term emotionally charged programs. A long-term program based on economic incentive is suggested as a better way to insure that old cars, bottles, refrigerators, and all other items manufactured out of minerals get back into a closed cycle of repeated use rather than ending up in some dump. In our economy of abundance and obsolescence, we will always be plagued with problems of waste disposal. Until technology figures out the answers, waste disposal sites will have to exist, but their locations must meet geologic requirements for public health and safety.

Each year our local governments spend about \$4.5 billion to collect and dispose of solid wastes. A national survey by the U. S. Public Health Service in 1968 (APWA, 1970) estimated that 360 million tons of household, commercial, and industrial wastes are produced annually in the United States. Approximately 200 million tons of this is collected and disposed of in dumps.

Much effort, and even more talk, is being spent on how to dispose of solid wastes in a safe and efficient manner. It is true that waste disposal is a very real and rapidly growing problem, but an equally serious matter looms for the future. As we continually throw away most of the trappings of our way of life, after using them only once,

Contents of a Typical City Dump (APWA, 1970)	
<u>Category</u>	<u>Percent</u>
Food wastes	25.9
Cloth & synthetics	1.3
Paper products	45.5
Plastics	1.7
Leather & rubber	1.0
Yard wastes	1.6
Wood	0.3
Glass products	10.9
Metals	10.8
Brick, rock, dirt, etc.	1.0
	<u>100.0</u>

will cost at least \$1 billion. The loss of metal such as aluminum represents a value of \$200 a ton, but to replace this ton of wasted metal, industry must process 4 tons of bauxite ore. This process results in 2 tons of red mud residue to be disposed of and 2 tons of alumina requiring 16,000 kilowatt hours of electricity to reduce it to 1 ton of metal.

A typical soft drink bottle is made out of high-purity silica plus several other minerals. All too often that bottle is used only once and and tossed out along the highway to become a minor environmental disaster. Not only is the wasted bottle unsightly and highly resistant to

Amount and Value of Principal Scrap Metals in the Average Car (Dean and Stern, 1969)		
<u>Metal</u>	<u>Pounds</u>	<u>Value</u>
Iron	3040	\$33.50
Copper	32	11.30
Zinc	54	3.30
Aluminum	50	6.20
Lead	<u>20</u>	<u>1.40</u>
Totals	3200	\$55.70

in just a few years we'll run out of many of the materials we take for granted. Of particular concern to the Department are the mineral materials. According to the Public Health survey, they represent about 23 percent of what goes into a typical waste dump.

Metals and Minerals Lost

We throw away an estimated 10 million tons of iron, 1 million tons of nonferrous metals, and 15 million tons of glass in a year. To replace the metals and minerals lost in any one year requires valuable resources from ever diminishing deposits that

decomposition, but it represents a loss of scarce, nonrenewable minerals. The accumulation of coke bottles alone, at the present consumption will total 55 billion by the year 1975. Neatly stacked, these bottles would make a pile one mile square by 82 feet high, certainly a large amount of material, but only a fraction of the total glass involved in a one-way ride.

The modern automobile consists of more than a ton of various metals, chiefly iron, copper, zinc, aluminum, and lead. Other metals in lesser amounts include tin, tungsten, chromium, manganese and nickel. Fortunately there is a lot of

iron ore in the world, but much of the easily mined, low-cost iron in the United States is gone and we will have to depend more heavily on foreign sources. Most of the other metals that go into the manufacture of an automobile will have to be imported at an accelerating rate because our high-grade deposits are being used up.

U. S. Consumption of Selected Metals in 1969 and Percent Imported (USBM Commodity Data Summaries, January 1971)			
<u>Metal</u>	<u>Total U. S. Consumption</u>	<u>Imports</u>	<u>Percent of Consumption</u>
Aluminum (tons)	4,661,000	558,000	12%
Nickel (tons)	141,737	129,332	91
Manganese (tons)	2,181,000	1,962,000	90
Lead (tons)	1,389,000	389,000	28
Zinc (tons)	1,368,000	931,000	68
Iron ore (tons)	140,235,000	40,758,000	29
Copper (tons)	2,142,000	710,000	33
Mercury (flasks)	79,104	30,848	39

Salvage Attempts

There is a lot of metal in the 17 million unreclaimed junked cars strewn throughout the country, and some of it is beginning to be salvaged. Shredding plants are reducing car bodies to small particles so that steel can be recovered by magnetic separation. Researchers at Vanderbilt University, Nashville, Tennessee, are working on profitable ways to salvage the nonferrous metals from automobile scrap. Others have suggested including salvage cost in the purchase price of automobiles. Such a plan is outlined by the accompanying flow chart.

Besides the 26 million tons of metal in junk automobiles (Dean and Stern, 1969) there is an estimated additional 8 million tons of assorted metal wastes in the refuse heaps of the United States. These include beverage cans, appliances, containers, and industrial scrap. The iron can be gathered from the waste by magnetic separation but mixtures of other metals are more difficult to separate. Initial design of metal products could facilitate their recovery from refuse.

Glass collected by community groups is currently being salvaged in many cities, including Portland, but it must be sorted into green, amber, and clear varieties before reclaimers will accept it. The Coca Cola bottling Co. of Madison, Wisconsin, has established a bottle and can recycling center at which 90,000 lbs. of glass and 24,000 lbs. of metal were

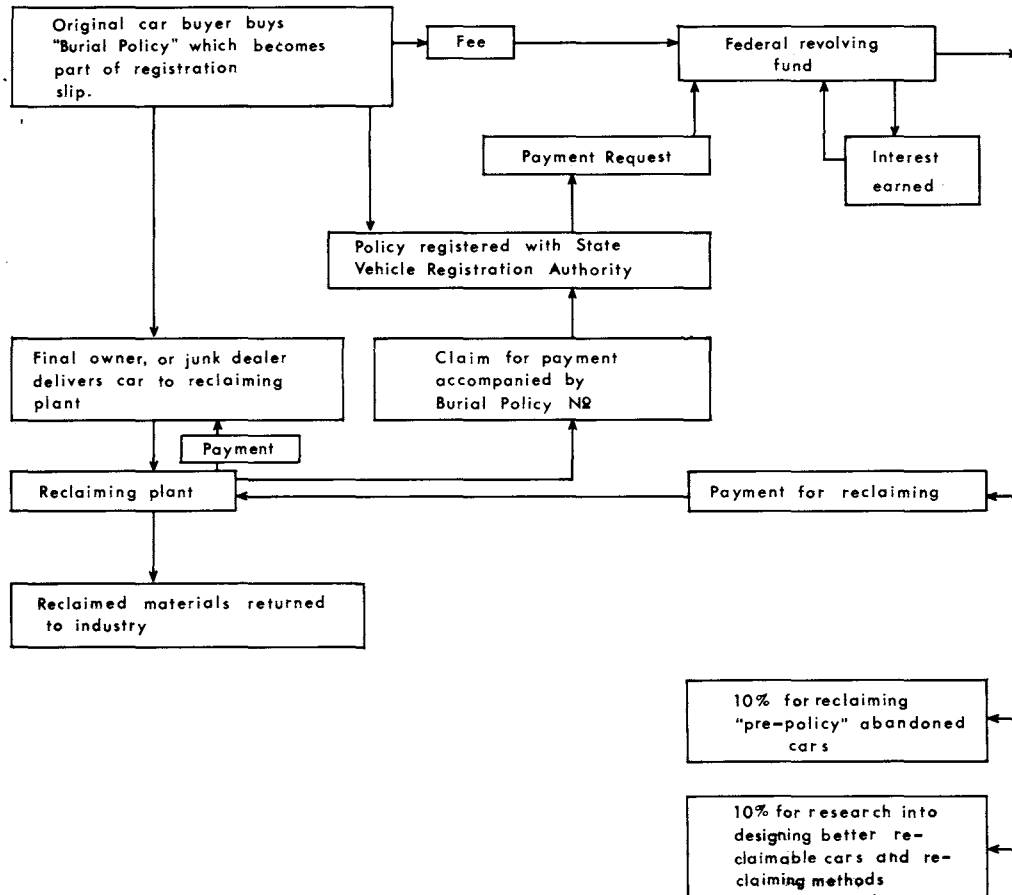


Crushed car bodies ready for feeding the metal shredding machine at Schnitzer Steel Products Co., Portland. (Photo courtesy of Sherman Washburn, Oregon State Board of Health)

processed for reclamation in the month of January 1971. Thus far in the operation, costs have been \$2 for every \$1 gained in sale of the glass and metal (Coca Cola Newsletter, Jan. 1971).

The Blitz-Weinhard Co. of Portland recently announced plans to replace its steel-aluminum containers with an all-aluminum can so that the used cans will be reclaimable. The firm will pay 10 cents a pound for returned containers. All of Blitz-Weinhard warehouses in the state will become collection points for recycling aluminum cans. Using certain communities as test plots for a one-cent return on bottles, Blitz-Weinhard obtained 90 percent cooperation. The community group SOLV (Save Oregon from Litter and Vandalism) is cooperating with packaging companies like American Can Co. and Continental Can Co. in supplying used containers to the company's collection centers in Portland, Salem, Eugene, and Astoria.

A Burial Policy for Cars



Economics of Recycling

The most economic salvage operations are usually those that are selective and that function independently of the municipal dump. City officials hesitate to recommend recycling and reclamation because fluctuations in the market and lack of demand for the product can leave the city with a great pile of junk. Past experience has shown that prices for salvaged materials have not kept pace with labor costs and this trend is likely to persist (APWA, 1970).

Until recently, very few municipal salvage projects were designed. But lately it has become apparent that the mounting volume of discarded substances requires some recycling. Federal grants have assisted in initiating several pilot recycle plants in the United States. An example is a



The use of porous material such as this as cover in sanitary fills in western Oregon leads to active leaching of the refuse and almost certain contamination of the groundwater.



When refuse in a landfill remains saturated or is buried beneath the level of the water table, methane gas is generated. At the Day Island landfill in Eugene, gas is bubbling to the surface through the leachate that seeps into the Willamette River.

shredding operation in New Castle County, Delaware, where glass granules, steel, aluminum, and shredded paper will be separated and re-used. A new plant planned for Washington, D. C., will convert by incineration 130,000 tons of refuse into 52,000 tons of salable materials worth \$840,000; steam generated during the process will be used by a local utility company (Time, Feb. 1, 1971). Houston, Texas installed a recycle plant in the late 1960's for separation of metals, cardboard, and paper and has been testing on-line separation techniques. In-put quantity can be controlled to allow for market and other fluctuations since only part of the city's refuse is recycled (APWA, 1970).

In most instances, recycling at municipal sites will probably require some kind of subsidy or tax to cover cost of operating the plant.

Waste Disposal Methods

The most popular method of waste disposal today is the landfill, or so-called sanitary landfill, a name coined for cut-and-cover operations which began in the 1930's (APWA, 1970). Following World War II, wide use was made of sanitary landfills in the United States, and by the late 1960's, more than 1400 cities in the nation were using this type of disposal for solid waste. During the past few years, a number of large cities have found it necessary to curtail landfill projects because of lack of suitable sites. Large eastern cities are now reserving their fills for noncombustibles.

The U. S. Public Health Service made a national survey of solid-waste disposal sites in 1968 and set up the landfill classification outlined below. Results of the survey showed that 94 percent of the landfill operations in the United States fell into category "C."

- A. Operated without public nuisance or public health hazard; covered daily and adequately; no deliberate burning practiced.
- B. Operated without public nuisance or public health hazard, but location permits modification of "A" type operations, such as burning of certain types of waste at site, covering only three times weekly.
- C. Operating techniques permit development of public nuisance and potential public health hazards, such as fly breeding, rodent sustenance and giving off odors and gases.

The 1968 survey discloses the urgent need for planning of municipal disposal projects by professional staff members or by consultants. The volume of waste can be reduced 40 to 50 percent by introducing high-temperature incineration and recycling processes. Use of these more sophisticated disposal systems can prevent waste of essential minerals and can provide heat energy as a by-product.



City of Portland Swift Boulevard landfill. Looking north across Bybee Lake and North Slough. Final soil cover will complete the fill.



The Swift Blvd. fill has two working faces; one for commercial users and the other for private use. An average of 1000 tons of refuse is dumped each day at this site.



Compacter working on fill at the Swift Blvd. site. After 10 or 12 inches of refuse is spread it is compressed with the compacter. Ten-foot layers of compressed fill are alternated with 2-foot layers of soil.



Soil layer being spread on refuse at the Swift Boulevard fill. Cover material is contracted from a nearby firm. A clay-silt is used in dry weather and a sandy loam for wet weather to improve workability.

Now that community planners are issuing bans on burning of all refuse, the greatest part of the waste collection has to be buried in landfills. Even though located at the outer margins of populated areas, most of these operations are considered a nuisance or a potential public health hazard. Burning of refuse in the United States in 1966 provided only 3.6 percent of the total waste emissions present in the atmosphere; internal combustion engines and industrial facilities contributed 80 percent of the air pollution (Cummins Engine Co., 1970). For a small benefit to cleaner air, hundreds of tons of burnable wastes are buried in landfills, shortening the operating lives of these disposal sites by half.

Landfill Site Requirements

There are few, if any, landfill sites in Oregon, particularly in the western part of the state, that are aesthetically tolerable or meet the geologic requirements for public health safety. In finding suitable disposal areas, several controlling factors must be considered. The prime requisite is that the project obtain public acceptance. The land should be isolated as far as possible from population centers, land-use potential should be low, and hauling distance should be within reason. The remaining factors in selecting a site are related to climate and geology.

In humid climates where annual rainfall is more than 30 inches, a growing problem from landfill operations is water pollution. Investigations in northeastern Illinois showed that a considerable amount of leachate was produced in a fill where annual precipitation was 33 inches (Landon and Farvolden, no date). Leachates which result from the dissolving of chemicals by water percolating through a landfill, can move into surface and groundwaters and contaminate water supplies for years after the landfill site is abandoned (Deutsch, 1963). In western Oregon, where annual rainfall ranges from 40 to more than 100 inches, contamination of water supplies from poorly located landfills can be expected.

Low-rainfall regions appear to offer a wide selection of sites; however, these areas are often subject to torrential floods. Generally there should be less chance of polluting water sources in dry regions because of high evaporation rates and small surface run-off.

Rock type, topography, and geologic structure can greatly influence pollution of groundwater, and special care must be used in selecting sites for disposal of refuse. Listed below are the geologic factors that should be considered:

1. Landfill foundations should be composed of fine-grained material having a minimum thickness of 30 feet to prevent seepage from reaching usable water. Satisfactory materials could be:
 - a. Fine-grained alluvium and soil containing very little organic matter.



Lane County administers a clean appearing sanitary landfill at Cottage Grove. The Row River is within 100 yards of the left edge of the photograph and the refuse is buried at the level of the water table on the floodplain. No salvage is allowed.



Proposed landfill site in an abandoned rock quarry near Scholls southwest of Portland. Standing water suggests that drainage must be diverted before filling begins.

- b. Shale and siltstone bedrock. Coarse materials such as sandstone and gravel, and fissured bedrock are unsatisfactory because they allow escape of leachate.
- 2. Base of the fill should be at least 20 feet above the water table and above the maximum seasonal flood level. Locations near rivers or on floodplains are unfavorable.
- 3. An adequate supply of medium-textured cover material with good compaction characteristics should be available near the site. Coarse material such as gravel makes an unsatisfactory cover because it is easily penetrated by rainwater and it does not seal against odors.
- 4. Flat upland areas, heads of gulleys and ravines are favorable locations for fills as they drain a smaller land surface than downstream locations. Steep slopes, slide areas, and sites subject to erosion should be avoided.
- 5. Fills in swamps, tidelands, and partially submerged areas are potential water-pollution hazards.

Research Programs Encouraging

The passage of the Federal Solid Waste Disposal Act of 1965 saw the beginning of an ever-increasing program of research and pilot plant work by government agencies and industry to carry out the purpose of the Act:

- 1. To initiate and accelerate a National research and development program for new and improved methods of proper and economic solid waste disposal including studies directed toward the conservation of natural resources.
- 2. To provide technical and financial assistance to State and local governments and interstate agencies in planning, developing and the conduct of waste disposal programs.

The U. S. Bureau of Mines' responsibility under the Act of 1965 was greatly expanded and its research has been accelerated, mainly in the field of municipal waste.

The Bureau has reported favorably on many promising new methods including:

- 1. A low cost, smokeless automobile incinerator.
- 2. A continuous processing plant for separating metal and glass from incinerator residue.
- 3. A vertical vortex-type incinerator which offers promise for burning high moisture sludges and industrial wastes to urban refuse.

4. A process for carbonization (destructive distillation) of urban refuse giving char, oil, and gas.
5. A novel process for converting the putrescible material in urban refuse to hydrocarbons.

Several cities, including Houston, Texas and Brooklyn, New York, are building new waste-disposal systems including a final composting step so that a hygienically safe end-product is the result. The process involves four steps: 1) handling, sorting, and shredding the material; 2) salvaging metal wastes; 3) incinerating at high temperature and utilizing heat for secondary purpose; and 4) stockpiling.

Summary

Several changes appear to be needed in present disposal practices. Usable materials are discarded in our society in large volume and many of these substances are nonreplaceable minerals. Not only are the minerals themselves lost to society but the energy which produced them is lost as well. Also, the current disposal system depends to a large extent on unsuitable burial procedures. Here are some suggestions for planning future disposal methods:

1. Begin as soon as possible recycling usable materials, especially nonreplaceable minerals and metals. Consider separation of metals, glass, etc., at the home.
2. Use greater care in locating and designing landfills in relation to geologic conditions. Require proper drainage and reduce leachate production. Long-range planning, at least in western Oregon, should recognize the poor climatic and geologic conditions for sanitary landfills.
3. Continue limited burning to reduce the volume of waste to be buried.
4. Use high-temperature incineration where large collection stations can be justified.
5. Improve initial design of products in order to cut down waste and facilitate recycling.

A very basic recommendation for improvement in waste management practice is quoted from the concluding remarks in the study of solid waste disposal in Oregon, 1969, by the State Board of Health, "The greatest need is for people to recognize that waste management has a cost and a method of financing this cost must be developed."

Selected Bibliography

- American Public Works Association, 1970, Institute for Solid Waste, Municipal refuse disposal: Public Administration Service, Chicago, Illinois, Third Edition.
- Bleuer, N. K., 1970, Geologic considerations in planning solid-waste disposal sites in Indiana: Indiana Dept. of Natural Resources Geological Survey Special Report No. 5.
- Cartwright, K., and Sherman, F. B., 1969, Evaluating sanitary landfill sites in Illinois: Illinois State Geological Survey Environmental Geology Notes No. 27.
- Coca Cola Bottling Co., 1971, Monthly Newsletter, Issue No. 3, January 28, 1971.
- Cservenyak, F. J., and Kenahan, C. B., 1970, Bureau of Mines research and accomplishments in utilization of solid wastes: U. S. Bur. Mines IC 8460.
- Cummins Engine Co., Inc., 1970, Clean air and the diesel: Bull. No. 952725, Columbus, Indiana.
- Dean, K. C., and Sterner, J. W., 1969, Dismantling a typical junk automobile to produce quality scrap, U. S. Bur. Mines RI 7350.
- Deutsch, Morris, 1963, Ground-water contamination and legal controls in Michigan: U. S. Geol. Survey Water-supply Paper 1691.
- Landon, R. A., and Farvolden, R. N., (no date:) Hydrology of solid waste disposal sites in northeastern Illinois: HEW Demonstration Grant No. 5-001-00006-02.
- Multnomah County, 1957, Rules and regulations for operation and maintenance of garbage and refuse dumps.
- Olmos, Robert, 1971, Recycling paper, metal cans, glass, even oyster shells, curbs pollution: The Oregonian, February 21, 1971.
- Pennsylvania Dept. of Health, 1970, Rules and regulations for the administration of solid waste.
- Rold, J. W., 1969, Governor's conference on environmental geology: Colorado Geol. Survey Special Publication No. 1, April-May, 1969.
- Sanner, W. S., Ortuglio, C., Walters, J. G., and Wolfson, D. E., 1970, Conversion of municipal and industrial refuse into useful materials by pyrolysis: U. S. Bur. Mines RI 7428.
- State Government Administration Magazine, 1971, Project studies on how to make auto salvage possible: v. VI, no. 1, p. 15, Jan.-Feb. 1971.
- The Oregonian, 1971, Steel cans discontinued: March 10, 1971.
- Time Magazine, 1971, Gold in garbage: p. 61, February 1, 1971.
- Wolfson, D. E., Beckman, J. A., Walters, J. G., and Bennett, D. J., 1969, Destructive distillation of scrap tires: U. S. Bur. Mines RI 7302.

* * * * *

ACT ESTABLISHES NATIONAL MINING AND MINERALS POLICY

The national mining and minerals policy bill, which had the backing of all segments of the mining industry, as represented by the American Mining Congress, passed both the House and Senate last fall and was signed by the President December 31, 1970 (see announcement in Feb. 1971 ORE BIN). The text of the act is quoted as follows:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Mining and Minerals Policy Act of 1970."

Sec. 2. The Congress declares that it is the continuing policy of the Federal Government in the national interest to foster and encourage private enterprise in (1) the development of economically sound and stable domestic mining, minerals, metal and mineral reclamation industries, (2) the orderly and economic development of domestic mineral resources, reserves, and reclamation of metals and minerals to help assure satisfaction of industrial, security and environmental needs, (3) mining, mineral, and metallurgical research, including the use and recycling of scrap to promote the wise and efficient use of our natural and reclaimable mineral resources, and (4) the study and development of methods for the disposal, control, and reclamation of mineral waste products, and the reclamation of mined land, so as to lessen any adverse impact of mineral extraction and processing upon the physical environment that may result from mining or mineral activities.

For the purpose of this Act "minerals" shall include all minerals and mineral fuels including oil, gas, coal, oil shale and uranium.

It shall be the responsibility of the Secretary of the Interior to carry out this policy when exercising his authority under such programs as may be authorized by law other than this act. For this purpose the Secretary of the Interior shall include in his annual report to the Congress a report on the state of the domestic mining, minerals, and mineral reclamation industries, including a statement of the trend in utilization and depletion of these resources, together with such recommendations for legislative programs as may be necessary to implement the policy of this act.

* * * * *

OAS PROCEEDINGS PUBLISHED

Proceedings of the Oregon Academy of Science, vol. 6, for 1970 has been published and can be obtained from Dr. Courtland L. Smith, Department of Anthropology, Oregon State University, Corvallis, Oregon 97331.

* * * * *

MINING CLAIM OCCUPANCY ACT EXPIRES JUNE 30, 1971

Only eight applicants qualified to purchase homesites in Oregon and Washington under the mining claim occupancy act, reports the Bureau of Land Management. Scheduled to expire on June 30, 1971, the law is also known as the Johnson-Church Act.

The 1962 act was designed to make it possible under certain circumstances for persons living on unpatented mining claims to acquire an interest in the lands from the federal government. It applies to unpatented mining claims which were used as a principal place of residence on October 23, 1962, and the land must have been used for residence purposes at least from July 23, 1955. In the state of Oregon since passage of the 1962 law, 37 applications have been filed. Six applicants qualified to purchase residential sites, and thirteen were granted leases. Fifteen applications were rejected, and three are pending. In the state of Washington, eight applications have been filed. Five were rejected, two patents were offered, and one lease was granted. People living on claims not being used for mining purposes are subject to trespass action, unless they apply and qualify under the Johnson-Church Act.

Any person holding a mining claim which has not been invalidated and who wishes to determine if the act applies to him has until June 30, 1971 to do so. Inquiries should be directed to the Bureau of Land Management, P. O. Box 2965, Portland, Oregon 97208. (BLM News, March 17, 1971)

* * * * *

GEOLOGY OF SOUTHERN OREGON COAST PUBLISHED

The Department has issued "Geology of the Southwestern Oregon Coast West of the 124th Meridian," as Bulletin 69. The author is R. H. Dott, Jr., professor of geology at the University of Wisconsin. Dr. Dott and his students mapped the geology of this extremely complex region between 1958 and 1968. The report is a compilation of their work with re-interpretations of some of their earlier conclusions in the light of new concepts of sea-floor spreading.

The 63-page bulletin is illustrated by numerous photographs, diagrams, and two multicolored geologic maps. Bulletin 69 is available from the Department's offices in Portland, Baker, and Grants Pass. The price is \$3.75.

* * * * *

MORNING MINE BULLETIN AGAIN AVAILABLE

The Department's Bulletin 39, "Geology and Mineralization of the Morning Mine, and Adjacent Region, Grant County, Oregon," by R. M. Allen, which was withdrawn pending revision soon after its publication in 1948, is now available for \$1.00. The geologic map by C. E. Brown and T. P. Thayer, U. S. Geological Survey, accompanies the text.

* * * * *

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Grah, editors	3.50
58.	Geology of the Supplee-Izee area, Oregon, 1965: Dickinson and Vigross	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dole, editor	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Mineral and water resources of Oregon, 1969	1.50
65.	Proceedings of the Andesite Conference, 1969: McBirney, editor	2.00
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970: Roberts	2.00

GEOLOGIC MAPS

	Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
	Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others	0.40
	Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37)	0.50
	Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker	1.00
	Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts	0.75
	Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams	1.00
	GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka	1.50
	GMS-2: Geologic map, Mitchell Butte quad., Oregon, 1962: Corcoran et al.	1.50
	GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka	1.50
	Geologic map of Oregon west of 121st meridian: (over the counter)	2.00
	folded in envelope, \$2.15; rolled in map tube, \$2.50	
	Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set]: flat	2.00
	folded in envelope, \$2.25; rolled in map tube, \$2.50	

[Continued on back cover]

The ORE BIN
1069 State Office Bldg., Portland, Oregon 97201

The Ore Bin

POSTMASTER: Return postage guaranteed.



Available Publications, Continued:

SHORT PAPERS

- | | | |
|-----|---|----------|
| 2. | Industrial aluminum, a brief survey, 1940: Motz | \$. 0.10 |
| 18. | Radioactive minerals the prospectors should know (2nd rev.), 1955:
White and Schafer | 0.30 |
| 19. | Brick and tile industry in Oregon, 1949: Allen and Mason | 0.20 |
| 20. | Glazes from Oregon volcanic glass, 1950: Jacobs | 0.20 |
| 21. | Lightweight aggregate industry in Oregon, 1951: Mason | 0.25 |
| 23. | Oregon King mine, Jefferson County, 1962: Libbey and Corcoran | 1.00 |
| 24. | The Almeda mine, Josephine County, Oregon, 1967: Libbey | 2.00 |

MISCELLANEOUS PAPERS

- | | | |
|-----|---|------|
| 1. | Description of some Oregon rocks and minerals, 1950: Dole | 0.40 |
| 2. | Key to Oregon mineral deposits map, 1951: Mason | 0.15 |
| | Oregon mineral deposits map (22" x 34"), rev. 1958 (see M.P. 2 for key) . . | 0.30 |
| 3. | Facts about fossils (reprints), 1953 | 0.35 |
| 4. | Rules and regulations for conservation of oil and natural gas (rev. 1962) . | 1.00 |
| 5. | Oregon's gold placers (reprints), 1954 | 0.25 |
| 6. | Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton . . . | 1.50 |
| 7. | Bibliography of theses on Oregon geology, 1959: Schlicker | 0.50 |
| 7. | (Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts . . | 0.50 |
| 8. | Available well records of oil & gas exploration in Oregon, rev. '63: Newton . | 0.50 |
| 11. | A collection of articles on meteorites, 1968: (reprints, The ORE BIN) . . | 1.00 |
| 12. | Index to published geologic mapping in Oregon, 1968: Corcoran | Free |
| 13. | Index to The ORE BIN, 1950-1969, 1970: M. Lewis | 0.30 |
| 14. | Thermal springs and wells, 1970: R.G. Bowen and N.V. Peterson | 1.00 |

MISCELLANEOUS PUBLICATIONS

- | | | |
|--|---|------|
| | Oregon quicksilver localities map (22" x 34"), 1946 | 0.30 |
| | Landforms of Oregon: a physiographic sketch (17" x 22"), 1941 | 0.25 |
| | Index to topographic mapping in Oregon, 1968 | Free |
| | Geologic time chart for Oregon, 1961 | Free |

OIL and GAS INVESTIGATIONS SERIES

- | | | |
|----|--|------|
| 1. | Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:
Newton and Corcoran | 2.50 |
| 2. | Subsurface geology of the lower Columbia and Willamette basins, Oregon,
1969: Newton | 2.50 |

The Ore Bin



Vol. 33, No. 4
April 1971

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

The Ore Bin

Published Monthly By

STATE OF OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Head Office: 1069 State Office Bldg., Portland, Oregon - 97201

Telephone: 229 - 5580

FIELD OFFICES

2033 First Street
Baker 97814

521 N. E. "E" Street
Grants Pass 97526

X X X X X X X X X X X X X X X X X X

Subscription rate \$1.00 per year. Available back issues 10 cents each.

Second class postage paid
at Portland, Oregon

X X X X X X X X X X X X X X X X X X

GOVERNING BOARD

Fayette I. Bristol, Rogue River, Chairman
R. W. deWeese, Portland
Harold Banta, Baker

STATE GEOLOGIST

R. E. Corcoran

GEOLOGISTS IN CHARGE OF FIELD OFFICES

Norman S. Wagner, Baker Len Ramp, Grants Pass

X X X X X X X X X X X X X X X X X X

Permission is granted to reprint information contained herein.
Credit given the State of Oregon Department of Geology and Mineral Industries
for compiling this information will be appreciated.

EARTHQUAKES AND SEISMIC ENERGY RELEASE IN OREGON

By Richard W. Couch* and Robert P. Lowell*

Introduction

The sector of the circumpacific earthquake belt which extends along the west coast of North America (Barazangi and Dorman, 1969) bifurcates in southern California; the western locus of earthquake activity passes out to sea in the vicinity of Northern California and is situated approximately 200 to 300 kilometers west of the coasts of Oregon and Washington. The eastern locus of activity extends northward through Nevada, Utah, Idaho, Wyoming and Montana. The eastern activity appears either to terminate near the border between the United States and Canada or to rejoin the earthquake activity in the vicinity of Puget Sound and Vancouver Island. Oregon appears as a relatively quiet island in this very active earthquake belt. Consequently, Oregon does not experience the level of activity of its neighboring states; however, Oregon is not aseismic--that is, it is not free from earthquakes.

A meaningful seismic history of Oregon extends back only to the late 1800's and is insufficient in length of observation to establish either the largest size earthquakes to be expected in Oregon or the frequency of occurrence of lesser shocks. The earliest reports extend from 1841 (Berg and Baker, 1963) but are clearly dependent on the size and distribution of the population. The population of Oregon approximately tripled between 1920 and 1970, and during those 50 years, approximately twice as many earthquakes were reported as during the preceding 50 years.

Over the past several years, the general populace has shown an increased awareness of the earthquake hazard and the general problem of earth stability, particularly when related to areas of rapid urbanization, or potential sites of large public construction projects. This awareness has greatly increased the demand for information concerning earthquakes.

It is the purpose of this paper to compile and review the available information concerning earthquake activity in Oregon. Although the available information is severely limited, it is hoped that it will allow those concerned to make more meaningful projections of anticipated earthquake activity in Oregon.

*Department of Oceanography, Oregon State University, Corvallis, Oregon

Seismograph Stations in Oregon

Immediately after World War II, Dr. Harold R. Vinyard of the Physics Department of Oregon State College, Corvallis, Oregon began construction of two Wood-Anderson seismographs. These instruments produced the first seismograms at Oregon State College in 1946. In 1949, Dr. Vinyard in cooperation with Dr. Perry Byerly of the University of California emplaced three Schlichter seismographs in a hillside vault approximately three miles northwest of the OSC campus. In August 1962, the U. S. Coast and Geodetic Survey, on the request of Dr. Joseph W. Berg, Jr., of the Department of Oceanography of Oregon State University installed a World-Wide Standard Seismograph Station at Corvallis. This station consists of three short-period Benioff seismographs, three long-period Sprengnether seismographs, and a short-period vertical Geotech Corporation visual seismograph.

The Blue Mountains Seismological Observatory, a complex of 21 seismometers, is located at a seismically quiet site approximately 38 miles east of Baker, Oregon. The Air Force Cambridge Research Laboratories, operating under the Advanced Research Projects Agency's Vela Uniform Project, dedicated the Blue Mountains Observatory in September 1962. In January 1966, operation of the station was transferred to the U. S. Coast and Geodetic Survey. The station's seismometers consist of 13 short-period Johnson-Mathison instruments arranged as an array, one short-period Electro-Tech instrument, three intermediate-period Geotech instruments, and three long-period instruments. The seismic information is recorded on heat-sensitive paper, film, and magnetic tape and is transmitted to a central file in Rockville, Maryland. The station, under the direction of Mr. Lawrence Jacsha, Chief of the Observatory, Mr. Donald Newsome, Geophysicist, and Mr. James Myer, Electronics Technician of the National Ocean Survey, National Ocean and Atmosphere Administration, operates at a magnification of 750,000 and is Oregon's most sensitive station.

In 1963, Dr. Peter Dehlinger of the Department of Oceanography, Oregon State University, in cooperation with the Oregon Technical Institute, installed a short-period vertical Benioff seismograph at Oregon Technical Institute. Concurrently, Mr. Fred Brecken of the Oregon Museum of Science and Industry, installed a short-period Wilson-Lamison instrument at OMSI. All seismograph records obtained at Corvallis (OSU), Klamath Falls (OTI), and Portland (OMSI) since 1963 are catalogued and stored in the Department of Oceanography, Oregon State University.

During the summer of 1969, The Manned Spacecraft Center of the National Aeronautics and Space Administration under the direction of Dr. Richard Blank of the University of Oregon Center for Volcanology, installed a seismograph station at Pine Mountain, Oregon. This station, located approximately thirty miles south-east of Bend, Oregon is operated jointly by NASA and the University of Oregon. At present, the station's instrumentation consists of four short-period Geotech seismometers and associated 35 mm film recorders.

These five stations, Corvallis (OSU), Portland (OMSI), Klamath Falls (OTI), Blue Mountain (NOS), and Pine Mountain (UO-NASA), comprise the seismographic facilities of Oregon.

Earthquake Location

A shallow earthquake, in general, is the effect of a sudden release of elastic strain energy accumulated within the earth. The point within the earth from which the first energy is released is termed the focus or hypocenter, in reference to

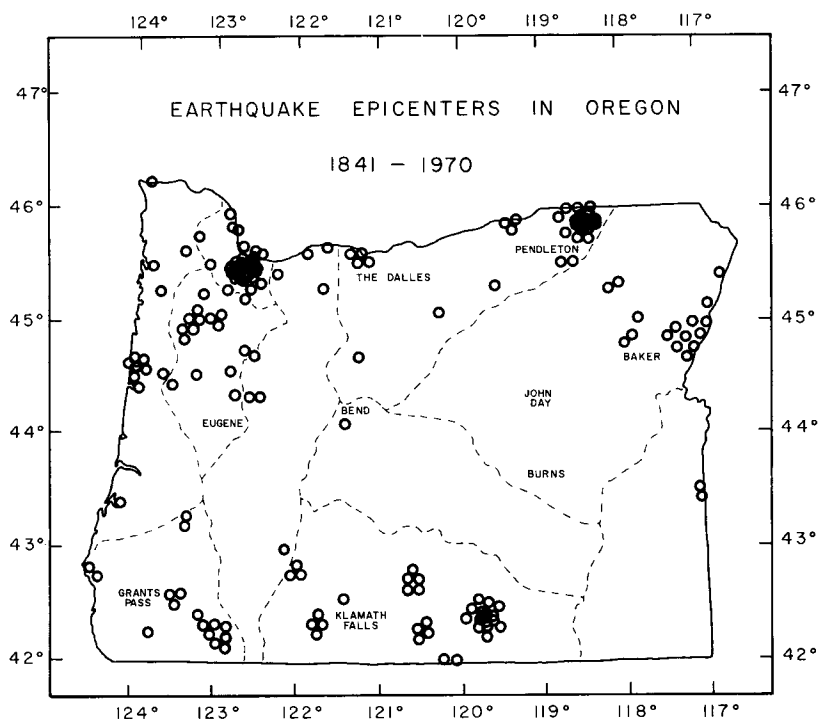


Figure 1. Earthquake epicenters in Oregon: 1841 through 1970. The dashed lines delineate physiographic areas as shown in Figure 3.

the radiated seismic waves the point is often termed the origin or source. The point on the earth's surface vertically above the focus is termed the epicenter.

Figure 1 shows the epicenters of earthquakes which occurred in Oregon from 1841 through 1970. Table 1 lists the date, time, location, intensity and magnitude of 44 earthquakes which occurred in Oregon from 1959 through 1970. Berg and Baker (1963) published a compilation of earthquakes which occurred in Oregon from 1841 through 1958.

In this paper, epicentral uncertainties are given as the radius of a circle of uncertainty whose center is the plotted epicenter and within which the true epicenter is expected to occur. Between 1841 and 1962 most earthquakes which occurred in Oregon were located by the felt effects reported by the people near the epicenter. The estimated uncertainty in epicenters located by felt effects is 8 km for the area west of the Cascade Range and 12 km east of and including the Cascade Range. These estimates are based on differences between epicenters located by instruments and by mapped intensities. The larger uncertainty east of the Cascade Range is due to the deeper focal depths and lower population density of the region.

From the late 1920's until 1962 some of the larger earthquakes in Oregon were located with seismographs of the University of California which at that time

TABLE 1. OREGON EARTHQUAKES: 1959 THROUGH 1970

Year	Month-Day	Origin Time(GMT)**	Location	Intensity +	Magnitude*
1959	Jan 21	07:15	Milton-Freewater	V	
	Nov 09	21:10	Heppner	IV	
1961	Aug 19	04:56:24.1	44°42'N 122°30'W	VI	4.5
	Nov 07	01:29:10	45°40'N 122°52'W	VI	
	Nov 07	21:30	Portland	V	
	Dec 15	11:35	Scappoose	III	
1962	Sep 05	05:37:06	Lebanon	IV	3.5
	Oct 17	08:33	West Linn	II	
	Nov 05	19:36:43.5	45°36.5'N 122°35.9'W	VII	5.0
1963	Mar 02	16:30	Portland	IV	
	Mar 07	22:53:25.0	44°54'N 123°30'W	V	4.6
	Dec 27	02:36:21.6	45°42'N 123°24'W	VI	4.5
1964	Oct 01	12:31:24.6	45°42'N 122°48'W	V	
1968	Jan 27	08:28:23.7	45°36.6'N 122°36.3'W	IV	3.7
	May 13	18:52:17.3	45°35.7'N 122°36.4'W	IV	3.8
	May 27	05:53:34	42°12'N 119°42'W		3.8
	May 28	00:08:48.0	42°15.0'N 119°40.1'W		4.4
	May 28	00:51:03	42°18'N 119°48'W		4.1
	May 28	12:55:42.8	42°15.0'N 119°48.6'W		4.4
	May 30	00:35:58.8	42°19.8'N 119°51.0'W	IV	5.1
	May 31	03:06:38	42°06'N 119°48'W		4.1
	Jun 03	13:27:39.7	42°15.0'N 119°48.0'W	V	5.0
	Jun 04	02:33:00	42°12'N 119°48'W		3.7
	Jun 04	02:34:14.5	42°14.4'N 119°52.2'W	VII	4.7
	Jun 04	02:38:29	42°18'N 119°48'W		4.0
	Jun 04	03:39:50	42°18'N 119°48'W		4.1
	Jun 04	05:52:22	42°18'N 119°48'W		4.0
	Jun 04	06:22:17.0	42°12.0'N 119°49.8'W		4.3
	Jun 04	10:58:22.4	42°15.6'N 119°46.2'W		4.2
	Jun 05	04:51:56.3	42°13.8'N 119°59.4'W		4.7
	Jun 05	05:12:35.4	42°18.0'N 119°46.2'W		4.4
	Jun 05	07:37:45	42°18'N 119°54'W		4.0
	Jun 05	08:04:40	42°18'N 119°48'W		3.3
	Jun 05	08:20:38	42°18'N 119°48'W		4.0
	Jun 05	14:08:40	42°18'N 119°54'W		3.8
	Jun 12	01:20:56	42°06'N 120°00'N		3.4
	Jun 12	01:46:21.9	42°07.8'N 119°47.4'W		4.3
	Jun 21	20:33:27.5	42°12.6'N 119°39.0'W		4.3
	Jun 22	09:39:52.9	42°10.8'N 119°43.2'W		4.3
	Jun 24	11:03:17.3	42°17.4'N 119°50.4'W		4.2
1969	Mar 05	11:43:07.3	45°37.8'N 122°49.0'W	III	3.5
	Aug 14	14:37:39.5	44°59'N 117°45'W	VI	3.6
1970	Feb 12	07:52:25.0	44°38.0'N 122°43.6'W	I	2.5
	Jun 25	07:48:20	W. Portland	IV	3.6

* Unified Magnitude Scale

+ Modified Mercalli Scale (1956 Edition)

** GMT=Greenwich Mean Time (Pacific Standard + 8 hours)

Data compiled from the following sources:

U. S. Coast and Geodetic Survey (U. S. Earthquakes, 1959-1967 and Preliminary Determination of Epicenters, 1968-1970); Heinrichs and Pietrafesa (1968); Couch, Johnson, and Gallagher (1968); Couch and Johnson (1968); Couch and Whitsett (1969); Unpublished records of the Corvallis Seismograph Station and the Geophysics Group, Department of Oceanography, Oregon State University.

included those at Corvallis. However, because of the epicentral distances, station limitations, and uncertainties in travel-times, the instrumentally located epicenters of that period are probably as inaccurate as those estimated from felt effects. The available instrumental results during that period do suggest, however, that no earthquakes greater than magnitude 5 passed unnoticed in Oregon. After 1963, earthquakes in Oregon were located with seismograph stations located principally in the Pacific Northwest.

The accuracy of epicenters located by triangulation depends on the uncertainties in arrival times of the seismic waves and in the knowledge of the wave velocities between the source and observing station. The larger earthquakes are observed at more stations and show the first waves more distinctly; hence, they are generally located with greater precision. Wave velocities or transit times between the source and observing station are obtained from travel-time curves. Jeffreys and Bullen (1940), and Gutenberg and Richter (Richter, 1958), have published global travel-time curves and Dehlinger and others, (1965) have published local travel-time curves applicable to the Pacific Northwest.

An epicenter in Oregon can be located with equal precision using the global travel-time curves and the local travel-time curves; however, the accuracy will be different. For example, if an earthquake located in the Portland area, using the J - B travel-time curves and arrival times at Blue Mountain, Oregon, Tumwater, Washington, and Corvallis, Oregon, is relocated using the local travel-time curves, the computed epicenter will be repositioned approximately 5 to 6 km toward the west-northwest. This occurs because the local travel-time curves show an approximate 0.3 km/sec difference in wave velocity between eastern and western Oregon whereas, the global travel-time curves indicate a common velocity.

The difference in epicenter locations, computed with the global and local travel-time curves, depends on the locations of the observing stations and on the location of the earthquake. A difference in epicenter location usually implies also a difference in computed focal depth.

The systematic difference in velocities in Oregon as determined from the global and local travel-time curves also suggests the possibility of a systematic difference in located epicenters. Northrup (1970) has reported systematic differences in epicenters of earthquakes located near the Gorda Ridge and Blanco Fracture Zone off southern Oregon. He suggests the differences are caused by a restricted azimuthal distribution of seismograph stations and uncertainties in the assumed wave velocities. This is analogous to the situation within Oregon. The National Ocean Survey uses the Jeffreys-Bullen (1940) travel-time curves to locate earthquakes in Oregon and the Geophysics Group of the Department of Oceanography, Oregon State University, uses the local travel-time curves of Dehlinger and others, (1965).

The seismographic facilities in Oregon available since 1963 and the development of travel-time curves applicable to the Pacific Northwest (Dehlinger and others, 1965) have greatly reduced the uncertainty in the epicenter locations. Figure 2 shows the epicenters of 35 earthquakes which occurred in Oregon from 1963 through 1970. The filled circles indicate the superposition of three or more epicenters.

The uncertainty in epicenter location depends on the number and distribution of the seismograph stations recording the earthquake and the travel-time information used. An average uncertainty of 4 km is estimated for earthquakes larger than magnitude 3.5 located using the local travel-time curves applicable to the Pacific Northwest. This estimate is based on the precision or goodness-of-fit of individual epicentral arcs at well-determined epicenters.

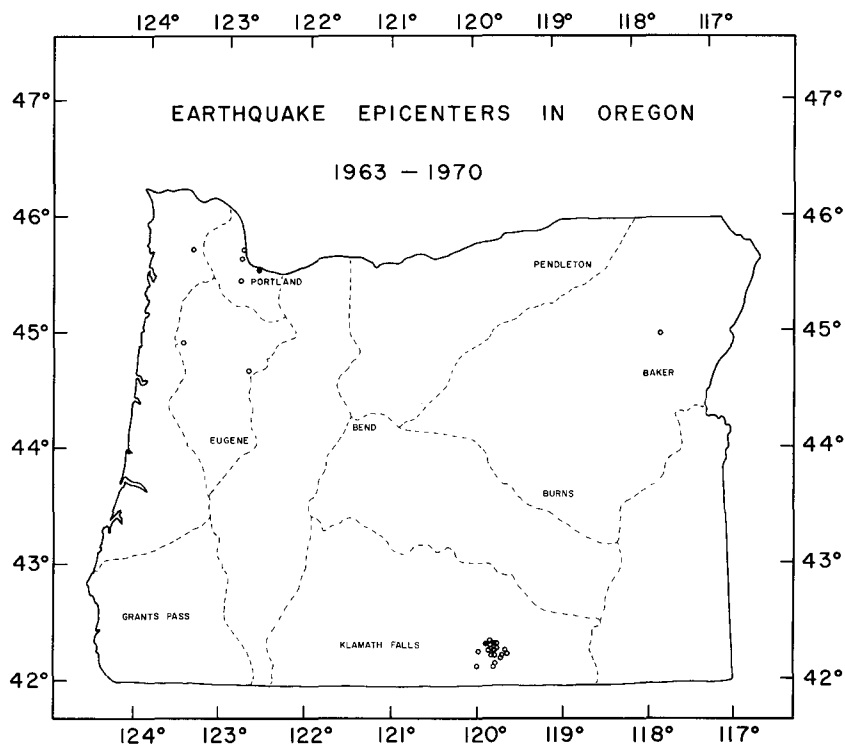


Figure 2. Earthquake epicenters in Oregon: 1963 through 1970. The earthquake data are listed in Table 1. The dashed lines delineate physiographic areas as shown in Figure 3.

The available facilities also suggest it is unlikely that any earthquakes greater than magnitude 3.5 have occurred in Oregon, post-1963, and passed unnoticed.

Focal Depths

The distance between the epicenter and the hypocenter is the depth of focus. Earthquake focal depths are termed "shallow" when they are less than 70 km deep, "intermediate" when they are between 70 km and 300 km deep, and "deep" when they are over 300 km deep. All reported depths of earthquakes in Oregon indicate shallow foci.

Earthquake focal depths in Oregon are currently determined by observing systematic shifts in projected origin times as a function of epicentral distance, by using a velocity profile and arrival times at a seismograph station located near the epicenter, or by the analysis of the arrival times of post- P_n phases. Earthquakes which occur in Oregon tend to be observed at a limited number of seismograph stations; hence, the uncertainty in focal depths determined by the analysis of shifts in the projected origin

times can be large. When computed by this method the uncertainty in the depth of focus may be as great as ± 15 km for earthquakes in Oregon. The method of estimating the depth of focus using a velocity profile and the arrival time at a near station is dependent on both the availability and accuracy of the velocity profile and the availability of a seismic station near the epicenter. A ± 5 km uncertainty in focal depth is estimated for this method based on expected variations in crustal velocities. Recently, French (1970) developed a method of determining focal depths from the analysis of post- P_n phase arrivals. This method requires the ability to resolve the phases which closely follow the P_n phase. This is usually not possible with the common photographic seismograph because of slow recording speeds. A ± 3 km uncertainty is estimated for focal depths determined with French's method.

The U. S. Coast and Geodetic Survey (1963-1970), Dehlinger and others, (1963), Heinrichs and Pietrafesa (1968), Couch and others (1968), Couch and Johnson (1968), French (1970) and Couch and Whitsett (1969) reported the focal depths of sixteen Oregon earthquakes. Their reported focal depths indicate an average focal depth between 20 km and 25 km east of the Cascade Range and between 5 km and 15 km west of the Cascade Range.

The work of Dehlinger and others (1968), Thiruvathukal and others (1970) and Dehlinger and others (1971) suggests the earth's crust in Oregon is approximately 20 km thick west of the Cascade Range and between 35 km and 40 km thick east of the Cascade Range. This suggests further that the earthquakes in Oregon are predominantly crustal shocks.

Faults

Crustal earthquakes are generally attributable to the sudden fracturing or faulting of rocks, predominantly in shear. Faults associated with earthquakes do not always intersect the surface and, hence, are not always visible. Maps delineating faults show the visible surface traces of faults but do not indicate whether they are active or inactive. To the authors' knowledge, there are no confirmed observations of movement on a mapped fault in Oregon associated with an earthquake.

Focal mechanism studies by Couch and MacFarlane (1970) and Dehlinger and others (1971) characterize a regional stress field which produces the earthquakes of Oregon. The minimum compressive stress is aligned approximately east-west. The maximum compressive stress varies from an approximate north-south alignment to a vertical alignment. Faults, hence earthquakes, occur when the stress differential exceeds the strength of the crustal rocks. Three fault types are expected under a stress field aligned as above: 1) right-lateral strike-slip, oriented northwest-southeast, 2) left-lateral strike-slip oriented northeast-southwest and 3) normal, oriented north-south. Geologic heterogeneities and old lines of weakness may modify the anticipated fault directions and/or cause mixed faulting to occur. The stress field and consequent faults and associated earthquakes in Oregon suggest a gradual dilation or stretching of Oregon in general east-west direction.

Wells and Peck (1961) and Walker and King (1969) have mapped the surface traces of faults in Oregon; none are confirmed to be active. The orientation and offsets of the faults are, however, consistent with the postulated stress field.

Intensity and Magnitude

Intensity describes the amount of shaking or damage at a specific location; it is highest in the epicentral region and decreases away from the region. Intensities

are based on observed or felt effects of the earthquake. Intensities range on the Modified Mercalli Scale (1956 Edition) (Richter, 1958), abbreviated M. M., from intensity I, which is not felt, to intensity XII in which damage is nearly total.

Magnitude is a rating that is essentially independent of the place of observation and that characterizes the amount of energy radiated from the source of an earthquake. Magnitudes are based on instrumental observations and range on a logarithmic scale from less than 1 for small shocks to over 8-3/4 for the largest earthquakes.

Richter (1958) has obtained an empirical relation between earthquake intensities and magnitudes based on observations of crustal shocks in California. An average depth of focus between 15 km and 20 km is estimated for California earthquakes. The average focal depths in Oregon as described above suggest that for a given intensity earthquake the empirical relation will yield a magnitude slightly high west of the Cascade Range where the hypocenters are shallower than in California and slightly low east of the Cascade Range where the hypocenters are deeper.

Table 1 lists the intensities and magnitudes of 44 earthquakes which occurred in Oregon from 1959 through 1970. The listed magnitudes were computed from seismograph measurements, and the intensities were estimated from reported or observed effects.

Observations indicate that intensities in Oregon are slightly greater than expected for a given magnitude earthquake. Enhanced ground motion in Oregon is due to relatively shallow foci, efficient energy transmission in the crustal layers, and the response of the surface layers. In most active areas of Oregon, the surface layers are composed of alluvial or fluvial deposits. This type of material generally exhibits the greatest movement of any earth material during the passage of seismic waves.

Energy

Intensity, magnitude, and energy are used to characterize the severity of an earthquake. Of these quantities, seismic energy, the wave energy that is radiated from the source, is the most significant, but it is difficult to determine. Empirical equations have been established (Richter, 1958) to approximately relate intensity with magnitude and magnitude with energy.

In the United States, three definitions of magnitude are commonly used: Richter's magnitude (M_L) applicable to local earthquakes, Gutenberg and Richter's magnitude (M) based on teleseisms and applicable to distant earthquakes, and the unified magnitude scale (m) developed by Gutenberg and particularly suited to earthquakes at epicentral distances between 200 and 1000 km (Richter, 1958). Most seismograph stations report unified magnitudes.

The energy, E , of an earthquake may be calculated from Richter's magnitude M_L with the empirical equation $\log_{10} E = 9.9 + 1.9M_L - 0.024M_L^2$ or from the unified magnitude m with the equation, $\log_{10} E = 5.8 + 2.4m$. The unit of energy E is ergs. Energy may also be calculated from intensity by obtaining a magnitude M_L for the earthquake from the MM intensity using the empirical relation of Richter (1958).

Only a few magnitudes are available for earthquakes which occurred prior to 1963; hence, most of the energy computations are based on intensities. The intensities and magnitudes of the earthquakes used in the computations are those reported by Berg and Baker (1963) and those listed in Table 1. As noted above, the intensities reported for Oregon earthquakes are slightly greater than expected for a given magnitude earthquake. Consequently, the computations of energy may be as much as several orders of magnitude too high.

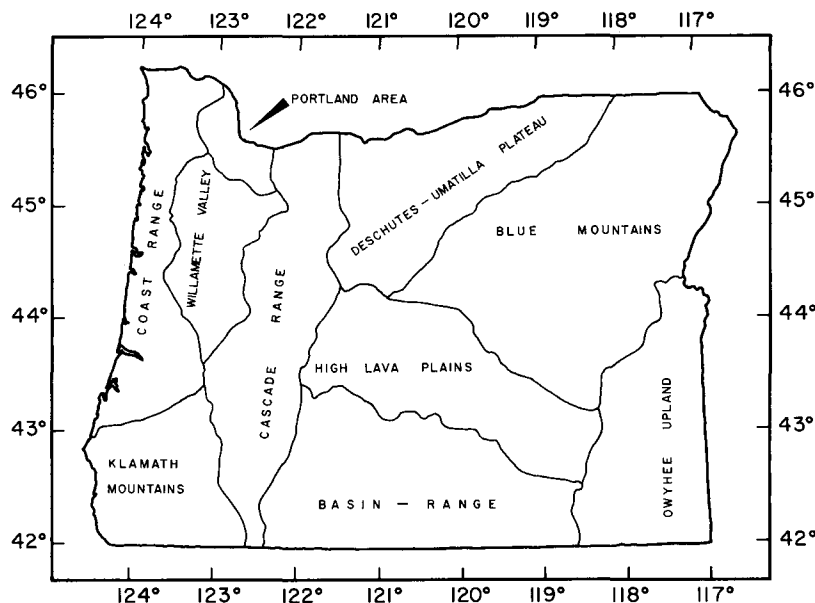


Figure 3. Physiographic divisions of Oregon (after Dicken, 1965).

Earthquakes and seismic energy release are discussed regionally following the physiographic divisions outlined by Dicken (1965) who divided Oregon into the following areas: Coast Range, Willamette Valley, Cascade Range, Klamath Mountains, Deschutes-Umatilla Plateau, Blue Mountains, High Lava Plains, Basin Range, and Owyhee Uplands. Because of the localized seismicity about Portland, the Willamette Valley division has been subdivided into the Willamette Valley area and the Portland area. Figure 3 delineates the nine areas. The low population density of historic Oregon may have caused some earthquakes to be missed or their intensity to be estimated too low. These omissions and inaccuracies would tend to reduce the error in the computed seismic energy release. Although significant uncertainties are associated with the available intensities, magnitudes and computed energies, a characteristic seismic level of each area of Oregon may be estimated and a comparison of areas may be made.

Using the relations between magnitude and intensity and magnitude and energy, a seismic energy release for every earthquake in Oregon from 1841 through 1970 has been computed. Benioff (1951) indicates that the square root of the energy (\sqrt{E}) is proportional to the elastic strain rebound, hence, the energies are plotted in Figures 4 through 11 as the cumulative square root of the energy. Each vertical bar represents the square root of the total seismic energy released for a given year; the year is indicated at the bottom of the graph.

Seismic Energy Release in the Portland Area

Of the areas of Oregon, the Portland area has the longest and most complete earthquake history. Figure 4 shows the cumulative seismic energy release in the Portland area for the period 1877 through 1970. The average seismic energy release

PORTLAND

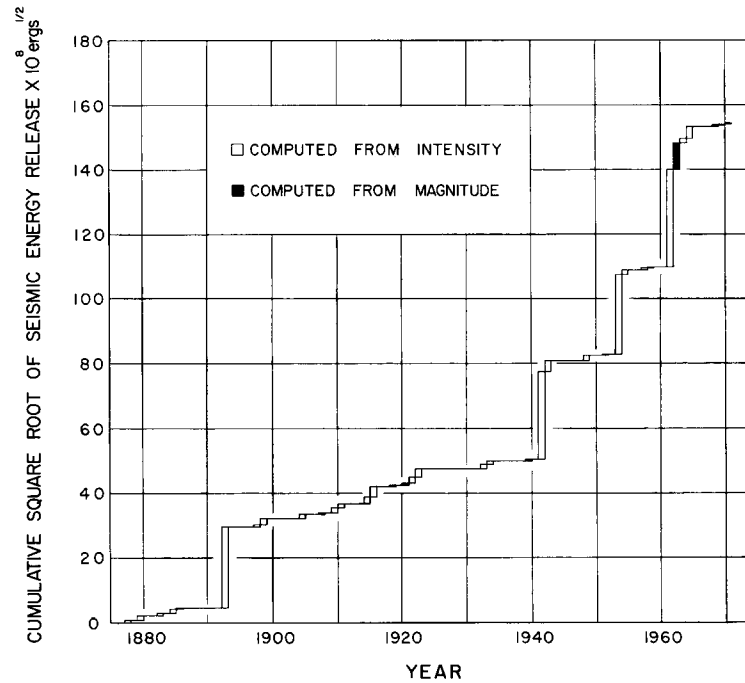


Figure 4. Cumulative seismic energy release in the Portland area.

rate during the 100 year period from 1870 through 1970 was 2.6×10^{17} ergs per year. This is approximately equivalent to one magnitude 4.8 (unified magnitude scale) (intensity MM V) earthquake each year. Couch and others (1968) noted that beginning about 1950 the rate of seismic energy release in the Portland area appeared to increase approximately ten times. The higher rate suggests a seismic level equivalent to one magnitude 5.2 earthquake (MM V-VI) approximately each decade. Historical records span too short a time period to indicate whether the change is a singular event or a cyclic change. Figure 4 does suggest, however, that seismic energy release in Portland is a continuing process and that the historical levels are quite likely indicative of future levels.

Figure 1 shows that (at least from the available records) the Portland area experiences more earthquakes than any other area of the state. The November 5, 1962, Portland earthquake was the largest of the recent earthquakes in that area. Dehlinger and others (1963) reported an average magnitude of 5 for this earthquake and indicated the observed maximum intensity in north Portland was VII. The U. S. Coast and Geodetic Survey strong motion seismographs recorded a maximum ground acceleration of 0.16 g (vertical component of 0.076 g and two horizontal components of 0.103 g and 0.096 g) (Dehlinger and others, 1968).

The epicenter was located between Vancouver, Washington, and Portland

COAST RANGE

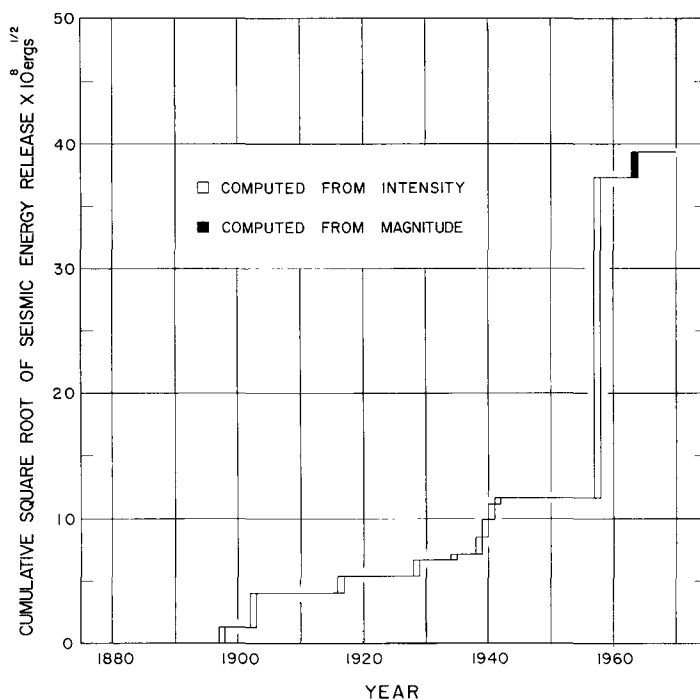


Figure 5. Cumulative seismic energy release in the Coast Range.

in the vicinity of the Columbia River (Dehlinger and others, 1963, Couch and others, 1968). No surface displacements or cracks were reported in the epicentral area (Westphal, 1962, Dehlinger and Berg, 1962, Dehlinger and others 1963). Westphal (1962) recorded 50 aftershocks associated with the Portland earthquake and suggested the seismic activity was related to motion on the Portland Hills fault. The epicentral locations of the principle shock and the subsequent aftershocks neither confirm nor deny this hypothesis. Figure 3 suggests the earthquake activity of the Portland area may occur in a broad fault zone with motion occurring on subsurface faults both in the vicinity of the Tualatin Mountains and the alluvium filled river valleys. Both right lateral motion along northwest-southeast trending faults and left lateral motion along northeast-southwest trending faults have been suggested as the cause of earthquakes in the Portland area (Dehlinger and others, 1963, Couch and others, 1968, Tobin and Sykes, 1968, Gallagher, 1969).

Seismic Energy Release in the Coast Range

Figure 5 shows the cumulative seismic energy release curve for the Coast Range area for the period 1897 through 1970. The average seismic energy release in

WILLAMETTE VALLEY

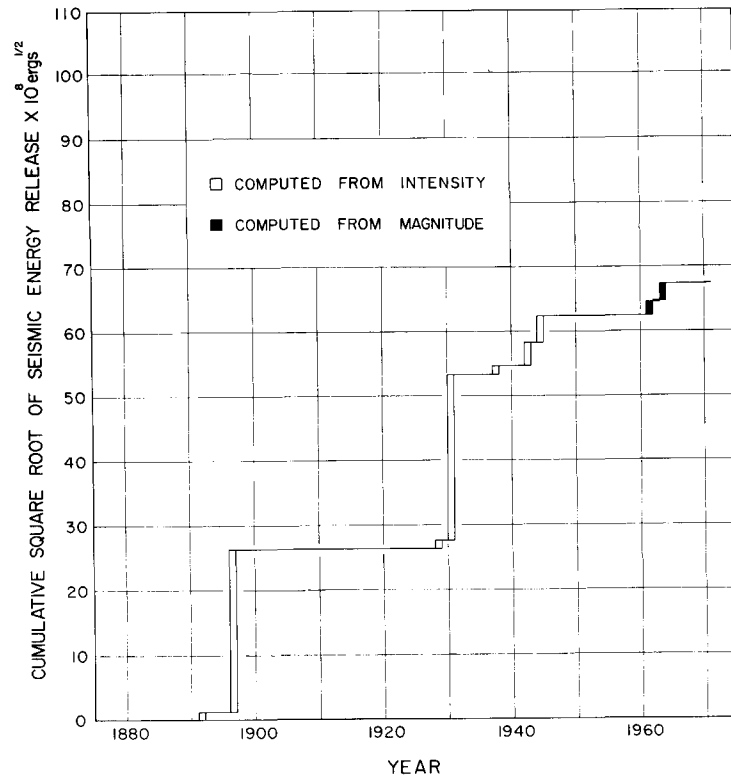


Figure 6. Cumulative seismic energy release in the Willamette Valley.

the Coast Range for the 100 year period (1870 through 1970) is 6.4×10^{16} ergs per year. This level of activity is approximately equivalent to one magnitude 5.0 earthquake (intensity V) each decade. In 1957 and 1963 earthquakes of intensity VI occurred in the region of the Coast Range between Tillamook and Salem and Tillamook and Portland, respectively. These recent earthquakes are the largest documented for the Coast Range area. The largest number of documented earthquakes for the area has occurred between Waldport and Newport and near Newport.

Mapped surface faults in the Coast Range (Wells and Peck, 1961, Walker and King, 1969) trend predominantly northeast-southwest; none are confirmed active faults. Observations at the Corvallis seismograph station indicate continuing minor activity in the area between Drain and Reedsport. It is not known at this time whether the activity is of tectonic origin, associated with downhill land movement, or due to quarrying.

Seismic Energy Release in the Willamette Valley

The earthquake activity in the Willamette Valley is distributed over the area with concentrations of epicenters occurring west of Salem and in the vicinity of the middle Santiam River. Figure 6 shows the cumulative seismic energy release for the Willamette Valley for the period 1891 through 1970. The average seismic energy release for the 100 year period from 1870 through 1970 is 1.3×10^{17} ergs per year. This level of activity is approximately equivalent to one magnitude 5.3 (intensity VI) quake each 30 years.

In 1963 a magnitude 4.6 earthquake occurred northwest of Corvallis, Oregon. Gallagher (1969) obtained a focal mechanism solution for this earthquake which suggests either motion on a northeast-southwest trending strike-slip fault or vertical motion on a northwest trending normal fault. The first solution is consistent with the mapped faults (Wells and Peck, 1961) in the vicinity of the epicenter. Analysis of the records of the Corvallis seismograph station indicates sporadic minor seismic activity occurring within short distances of the station.

Seismic Energy Release in the Klamath Mountains

The earthquake history of the Klamath Mountains extends from 1873 through 1970. Figure 7 shows the cumulative seismic energy release for this period. The average energy release rate for the 100 year period from 1870 through 1970 was 2.8×10^{18} ergs per year. As Figure 7 indicates, the total energy released during the 100 year period is clearly dependent on the intensity VIII earthquake which reportedly occurred near Port Orford in 1873. The intensity and location of this earthquake are questionable; consequently, the computed energy release rate may be much too high. No earthquakes have been reported in the Klamath Mountain area in the past twenty years. The mapped faults in this area trend predominantly northeast-southwest; none are considered tectonically active. Because of the high relief of the area, down-hill ground movement may occur with consequent minor earthquakes.

Seismic Energy Release in the Cascade Range

Figure 8 shows the cumulative seismic energy release in the Cascade Range area for the period 1877 to 1970. The average seismic energy release rate during the 100 year period from 1870 through 1970 was 2.7×10^{18} ergs per year. The computed energy release rate is largely dependent on the occurrence of an intensity VIII earthquake near Cascade Locks in 1877. The intensity and location of this earthquake are questionable; consequently, the computed energy release rate may be much too high. The Cascade Range, seismically, is a relatively quiet area in Oregon.

Decker and Harlow (1970) performed a reconnaissance survey of the micro-earthquake activity of the volcanic cones of the High Cascades during the summer of 1969. Microearthquake occurrence rates of 2 to 10 events per day were obtained in the vicinity of the larger cones. The surveys were of very short duration and consequently may not be indicative of the average seismic activity associated with the High Cascades. During the fall and winter of 1969 and summer of 1970, Dr. Tosimatu Matumoto, then affiliated with the University of Oregon Center for Volcanology, recorded microearthquakes in the vicinity of Crater Lake. Occurrence rates of 3 to 5 events per day were noted (Dr. Tosimatu Matumoto, personal communication).

KLAMATH MOUNTAINS

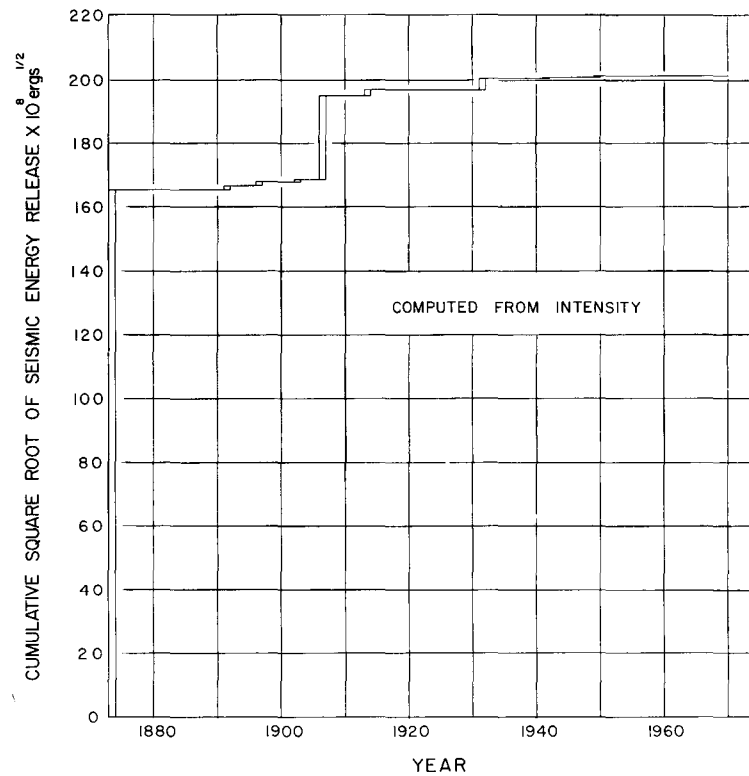


Figure 7. Cumulative seismic energy release in the Klamath Mountains.

Mr. Keith Westhusing, affiliated with the University of Oregon Center for Volcanology, emplaced a seismometer array on Mt. Hood during the summer of 1969 and Mr. Morris Brown under the direction of Dr. Richard Blank of the University of Oregon Center for Volcanology completed a microearthquake reconnaissance survey of the Cascade Range during the summer of 1970 (Dr. Richard Blank, personal communication). The analysis of their observations is continuing.

Seismic Energy Release in the Deschutes-Umatilla Plateau

Figure 9 shows the cumulative seismic energy released in the Deschutes-Umatilla Plateau area from 1892 through 1970. The average seismic energy release rate during the interval 1870 through 1970 was 8.4×10^{17} ergs per year. This is approximately equivalent to one magnitude 5.7 (intensity VI-VII) each 40 years.

CASCADE RANGE

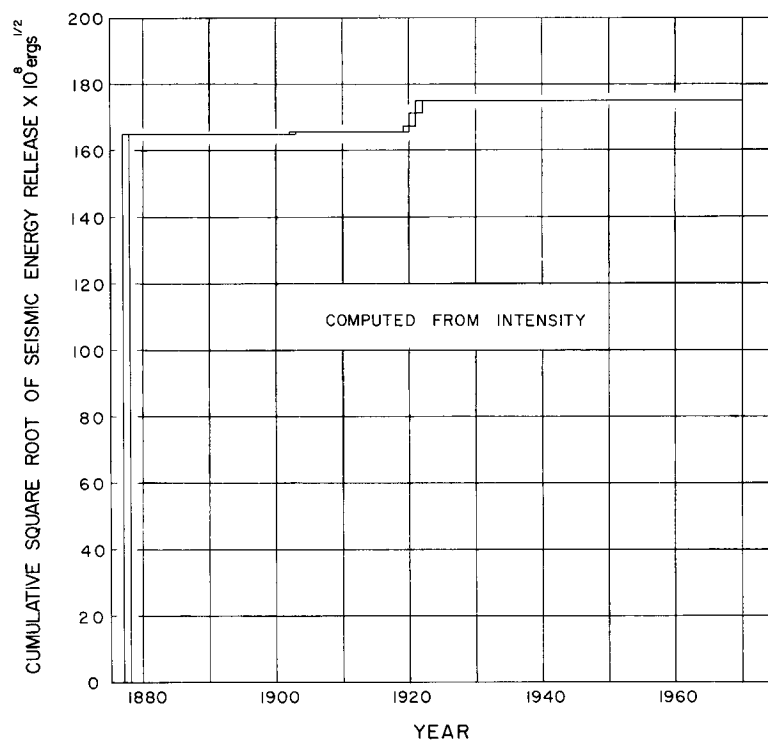


Figure 8. Cumulative seismic energy release in the Cascade Range.

The energy release in this area appears to occur in episodes spaced approximately 45 years apart. In 1936, an earthquake of intensity VII occurred near Milton-Freewater (Berg and Baker, 1963). This earthquake, the largest reported for the area was followed by twelve aftershocks with intensities from II to V. The aftershocks were located in the vicinities of Milton-Freewater, Athena, and Helix. Earthquakes have also been located near The Dalles and Hermiston. No earthquakes have been reported in the Deschutes-Umatilla Plateau area for the past ten years. Faults in this area are poorly mapped and no fault motions determined from earthquake analysis are available.

Seismic Energy Release in the Basin and Range

Figure 10 shows the cumulative seismic energy release in the Basin and Range area for the period 1906 through 1970. The average seismic energy release rate for the 100 year period from 1870 through 1970 was 8.8×10^{16} ergs per year. It is not known whether the absence of recorded earthquakes prior to 1906 is due to no seismic activity or because they were unnoticed. If earthquakes occurred in the area between 1870 and 1906 a slightly higher average seismic energy release rate is

DESCHUTES-UMATILLA PLATEAU

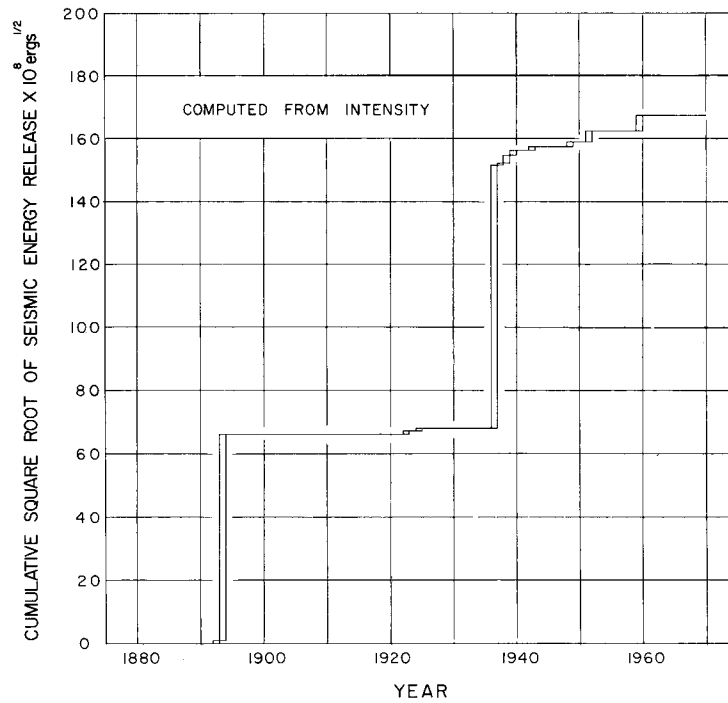


Figure 9. Cumulative seismic energy release in the Deschutes-Umatilla Plateau.

expected. The average seismic energy release as computed is equivalent to one magnitude 5.2 (intensity V-VI) earthquake per 20 years.

In 1968, a series of earthquakes occurred in the Warner Valley (Couch and others, 1968). Twenty-four earthquakes had magnitudes greater than 3.5. The largest magnitude was 5.1. These earthquakes occurred in a section of Oregon which had no previous history of earthquakes.

In the Warner Valley, normal faults which trend north-south are evident as are many northwest-southeast trending faults. Analysis of the first motions on seismograms of the earthquake series suggests fault motions which are consistent with both normal faulting along north-south trending faults and right-lateral strike-slip motion along northwest-southeast trending faults or left-lateral motion along northeast-southwest trending faults.

Seismic Energy Release in the Blue Mountains

Figure 11 shows the cumulative seismic energy release for the Blue Mountain area for the period 1906 through 1970. The average seismic energy release for

BASIN — RANGE PROVINCE

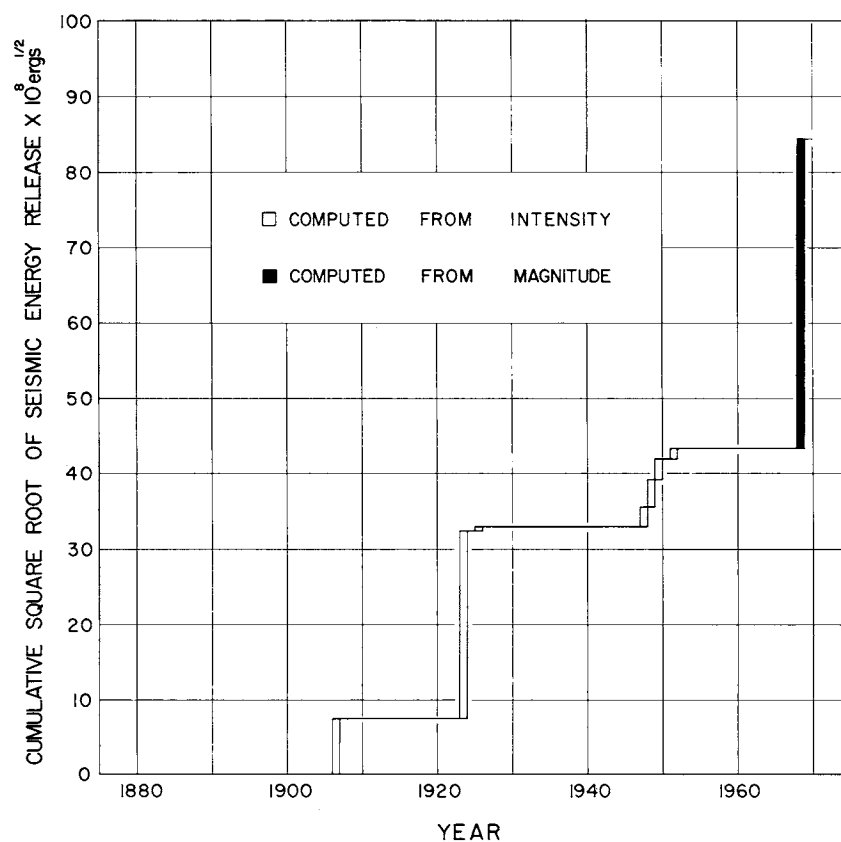


Figure 10. Cumulative seismic energy release in the Basin and Range.

the Blue Mountain area is 6.6×10^{16} ergs per year. This is approximately equivalent to one magnitude 5.1 (intensity V-VI) earthquake per 15 years. It is possible the slightly low energy release rate may be due to absence of reported earthquakes between 1870 and 1906.

The seismic activity of the Blue Mountains area is largely concentrated along the Snake River. A series of four earthquakes of intensity IV to V occurred in 1927 near Richland. Several earthquakes have also occurred in the vicinity of the Powder River north of Baker. Mapped faults in this area (Walker and King, 1969) trend predominantly northwest-southeast. The one earthquake motion study available for this area (Couch and Whitsett, 1969) is consistent with the mapped faults.

Seismic Energy Release in the High Lava Plains and the Owyhee Upland

The historical earthquake activity in the High Lava Plains and the Owyhee Upland areas is too low to compute an average cumulative seismic energy release. One intensity III earthquake occurred near Bend in 1943. Two earthquakes of intensity III

BLUE MOUNTAINS

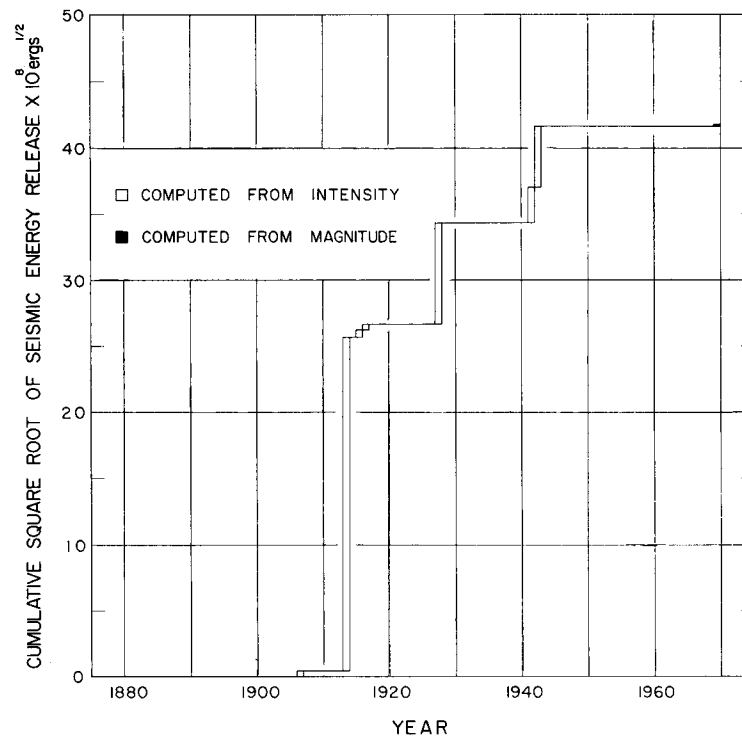


Figure 11. Cumulative seismic energy release in the Blue Mountains.

and IV occurred near Rockville, Oregon in 1943 and 1944 respectively. The Rockville earthquakes may be related to geothermal processes rather than to tectonic movements of the earth's crust (Berg and Baker, 1963). Because of the low population density and absence of a seismograph station in southeastern Oregon, it is possible that additional minor events may occur in these two areas without being detected. Mapped faults (Walker and King, 1969) trend predominantly northwest-southeast in the High Lava Plains and northwest-southeast and northeast-southwest in the Owyhee Upland. None of the mapped faults are known to be active. Decker and Harlow (1970) reported detecting no microearthquakes in the central Oregon lava fields during a 2-day recording period in 1969.

Earthquakes about Oregon

Earthquakes occur in the vicinity of Vancouver, Washington (Rasmussen, 1967, 1969) which are felt in Portland. It is quite likely the earthquakes in Vancouver are occurring along the same fault zone as those in Portland. The magnitude 7.1 earthquake which occurred between Olympia and Tacoma in 1949 exhibited an intensity of VII over the entire Portland area.

TABLE 2. EARTHQUAKE CHARACTERISTICS OF OREGON

Physiographic Area	Maximum Intensity ⁺	Maximum Acceleration (cm/sec ²)	Years of Maximum Intensity	Average E/yr(E=ERG) 1870-1970	Average E/yr/km ² 1870-1970	Estimated Seismic Activity Level
Portland Area	VII	68.1	1962	2.6×10^{17}	8.7×10^{13}	One magnitude 4.8*(intensity V) quake per year; or One magnitude 5.3*(intensity VI) quake per ten years
Coast Range	VI	31.6	1957 1963	6.4×10^{16}	3.4×10^{12}	One magnitude 5.0*(intensity V) quake per ten years
Willamette Valley	VI	31.6	1896 1930 1961	1.3×10^{17}	9.6×10^{12}	One magnitude 5.3*(intensity VI) quake per thirty years
Klamath Mountains	VIII	147.0	1873	2.8×10^{18}	1.8×10^{14}	Insufficient Data
Cascade Range	VIII	147.0	1877	2.7×10^{17}	9.6×10^{12}	Insufficient Data
Deschutes-Umatilla Plateau	VII	68.1	1893 1936	8.4×10^{17}	4.4×10^{13}	One magnitude 5.7*(intensity VI-VII) quake per forty years
Basin and Range Province	VII	68.1	1968	8.8×10^{16}	3.3×10^{12}	One magnitude 5.2*(intensity V-VI) quake per twenty years
Blue Mountains	VI	31.6	1913 1969	6.6×10^{16}	1.1×10^{12}	One magnitude 5.1*(intensity V-VI) quake per fifteen years
High Lava Plains	III	3.2	1943	2.4×10^{13}	1.1×10^9	Insufficient Data
Owyhee Upland	IV	6.8	1944	2.0×10^{14}	6.9×10^9	Insufficient Data

+ Modified Mercalli Scale (1956 Edition)

* Unified Magnitude Scale

Earthquakes occur in the vicinity of Walla Walla, Washington which affect the area about Milton-Freewater, and earthquakes occur in Idaho which are felt in the vicinity of Richland. Earthquakes also occur offshore, along the very active Blanco Fracture Zone (Bolt and others, 1968, Couch and Pietrafesa, 1968) which are felt by the coastal inhabitants between Gold Beach and Reedsport. It is possible in some areas that earthquakes occurring outside Oregon may show larger intensities in Oregon than earthquakes which occur in Oregon. Well water level changes were noted in eastern Oregon after the great Alaskan earthquake in March 1964; an effect not previously noted with earthquakes occurring in Oregon.

Estimated Seismic Activity in Oregon

Table 2 summarizes the results of the preceding sections. Column 1 lists the physiographic areas and column 2 lists the maximum intensity reported for an earthquake for the area. Column 3 lists the maximum accelerations expected for the reported intensity. The empirical relation between intensity and acceleration obtained by Richter (1958) was used to compute the acceleration. Accordingly, the acceleration, a , in cm/sec^2 , is calculated from $\log_{10} a = \frac{I}{3} - 1/2$ where I is the intensity in units of the Modified Mercalli Scale (1956 edition). Column 4 lists the years of reported occurrence of the maximum intensity. Column 5 lists average energy release per year for each area. The Klamath Mountains and the Cascade Range are indicated as the two highest energy release areas but both are dependent on early questionable intensities. Recent observations suggest that the Portland area, the Deschutes-Umatilla Plateau, and the Basin and Range area are the most active areas within the state. Column 6 lists the average energy release per year divided by the total area of the physiographic area. Column 7 lists an estimated seismic activity level for each area. This is an anticipated typical maximum level of seismic activity based on the magnitude and characteristics of the energy release curve for each area. These results are based only on the limited data available and are accurate only in so far as the past earthquake activity is a good predictor of future activity.

Figure 12 shows the seismic risk map of Oregon adapted from a seismic risk map of the United States (Committee on Seismology, 1969) prepared by the National Ocean Survey (formerly ESSA/USC and GS). The 1969 edition is currently included in the Uniform Building Code (International Conference of Building Officials, 1970). The seismic risk indicated by the map is in agreement with the results summarized in Table 2. The differences between the 1948-52 and 1969 versions of the seismic risk map of Oregon are indicative of the improved seismographic facilities in the Pacific Northwest.

Microseisms

The earth's surface is in constant vibratory motion. These motions, the continuous seismic background noise of the earth, are called microseisms or earth noise. Microseisms of 2 to 10 second period are termed storm microseisms (Iyer, 1964) and are generally attributable to storms over the ocean, ocean waves, and extended fields acting on coastal regions, passage of cold fronts, and other meteorological disturbances. The typical spectrum of microseisms observed at the Corvallis seismograph station during a stormy period show microseism periods between 2 and 10 seconds with a peak near 7 seconds and amplitudes near 12 microns. During quiet periods the predominant period is approximately 6 seconds and amplitudes are less than 1 to 2 microns. The

SEISMIC RISK MAP OF OREGON

ZONE 1 MINOR DAMAGE (MM V-VI)
ZONE 2 MODERATE DAMAGE (MM VII)

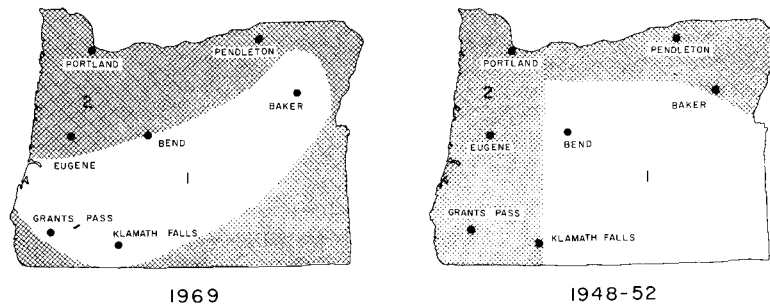


Figure 12. Seismic risk map of Oregon (after Committee on Seismology, 1969).

microseism amplitudes decrease from west to east but are detectable at the Blue Mountain Observatory near Baker, Oregon.

It is possible that microseisms may enhance movement of water-saturated potentially unstable earth particularly in coastal regions where amplitudes are several times larger than those observed in Corvallis, but in general, few effects are attributable to microseisms.

Surface Waves

Large earthquakes with shallow foci produce large surface waves which propagate great distances. Surface waves are of two types: 1) Rayleigh waves which in their passage cause the earth's surface to move in retrograde ellipses and 2) Love waves which cause the earth's surface to oscillate horizontally, normal to the direction of wave propagation. The ground displacements which occur during the passage of surface waves are relatively large but because the periods are long they are seldom noticed.

Surface waves, produced during the Alaska earthquake on March 28, 1964, exhibited amplitudes of approximately 0.5 cm with periods near 20 seconds during their passage across Oregon. The duration of these oscillations was approximately one hour. It is possible for waves of this type to set up a standing wave or seiche on the surface of an enclosed body of water (Richter, 1958) such as lakes, dams, or reservoirs, or on partially closed bodies such as harbors, channels, or estuaries. A seiche in an estuary may also be started by the arrival of a Tsunami.

Tsunamis

Tsunamis or seismic sea waves are usually generated by a vertical displacement of a large area of the sea floor. They are associated with earthquakes and usually occur as a consequence of surface or near surface normal or thrust faulting. Fault motions associated with the earthquakes of California, southwestern Oregon and the

Gorda Basin, and Mendocino Fracture Zone off the coasts of southern Oregon and northern California are predominantly horizontal. It is unlikely that such motions will generate a tsunami. It may be possible that normal faulting along the seismically active Gorda Ridge 200 km west of the southern Oregon coast could generate a minor tsunami but none attributable to this cause has been reported.

Tsunamis generated along other parts of the circumpacific earthquake belt, particularly those originating near Alaska, are of concern along the Oregon Coast. Shatz and others (1964) documented wave heights of 3 to 5 meters above high-tide along the Oregon coast following the great Alaskan earthquake of March 28, 1964. They have indicated that although the rugged open coast rapidly dissipated the waves, the estuaries and their environs were particularly susceptible to damage. Wilson and Tørum (1968) estimate the damage and loss in Oregon, due to the 1964 tsunami, was over \$500,000.

Pattullo and others (1968) detected a series of seismic sea-waves at Newport, Oregon, 15 centimeters in height, generated by earthquake activity near Japan. The successful operation of the Seismic Sea-Wave Warning System, at that time, provided approximately 10 hours advance warning of wave arrivals along the Oregon Coast. The Seismic Sea-Wave Warning System provides, via the Oregon State Department of Emergency Services and state, county, and city police radio and teletype facilities, approximately 4 to over 15 hours advance warning of the arrival of a tsunami to residents of coastal Oregon.

Summary and Comments

Seismically active areas exist within Oregon. The seismic history of Oregon is too short to be used as an accurate predictor of earthquake size, number, and distribution. Continual monitoring of earthquakes by seismograph stations during the next several decades should provide a more accurate estimate of the seismicity of Oregon. To provide adequate and accurate coverage additional seismograph stations are needed, particularly in southeastern Oregon.

Rapid urbanization of the Willamette Valley and extensive public works planned for other areas of Oregon make it imperative that the stabilities of the areas be known. Specialized equipment such as portable microearthquake seismometer arrays, which have been developed to assist in local immediate problems, can accurately map active fault zones. In addition, they can locate active zones of continuing deformation which exist without producing the larger release of elastic strain energy of felt earthquakes. Studies of both historical and concurrent seismicity of an area should be of paramount importance when considering potential sites for nuclear generating stations or large construction projects such as dams, airports, large office buildings, and housing developments.

Acknowledgements

The authors wish to acknowledge all the people whose foresight, concern, and effort provided the historic and contemporary data for this compilation. Recognition goes to the staff and students who tend daily the seismographs in and about Oregon. The OSU Geophysics Group has greatly appreciated the excellent cooperation of Messrs. Lawrence Jacsha, Donald Newsome, and James Myer of the Blue Mountain Seismological Observatory; Messrs. Fred Brecken and Norm Smalie of the Oregon

Museum of Science and Industry; Mr. James Hitt and assistants of the Oregon Technical Institute; Dr. Richard Blank and Messrs. Morris Brown and Keith Westhusing of the University of Oregon; Professor Norman Rasmussen and Mr. Richard Millard of the University of Washington; Mr. Alan Travis of Newport, Washington; Mr. Mark Castner of Gonzaga University; Dr. Robert Christman of Western Washington State College; Dr. Alan Ryall and associates of the University of Nevada; Dr. Bruce Bolt and associates of the University of California; Dr. William G. Milne of the Dominion Astrophysical Observatory; Dr. Kenneth Cook and associates of the University of Utah. Dr. Donald F. Heinrichs and Mr. Stephen Johnson provided critical and constructive reviews of the manuscript. This work was supported by the Department of Oceanography, Oregon State University.

Bibliography

- Barazangi, M., and Dorman, J., 1969, World seismicity maps compiled from ESSA, Coast and Geodetic Survey, Epicenter Data, 1961-1967: *Seism. Soc. Am. Bull.*, v. 59, p. 369-380.
- Benioff, H., 1951, Earthquakes and rock creep, Part I: *Seism. Soc. Am. Bull.*, v. 41, p. 31-62.
- Berg, J. W., Jr., and Baker, C. D., 1963, Oregon earthquakes, 1841 through 1958: *Seism. Soc. Am. Bull.*, v. 53, p. 95-108.
- Bolt, B. A., Lomnitz, C., and McEvilly, T. V., 1968, Geological evidence on the tectonics of central and southern California and the Mendocino Escarpment: *Seism. Soc. Am. Bull.*, v. 58, p. 1725-1767.
- Committee on Seismology, 1969, Seismology: responsibilities and requirements of a growing science, Parts I and II: *Natl. Acad. Sci.*, Washington D.C.
- Couch, R., and Johnson, S., 1968, The Warner Valley earthquake sequence: May and June, 1968: *The Ore Bin*, v. 30, p. 191-204.
- Couch, R., Johnson, S. and Gallagher, J., 1968, The Portland earthquake of May 13, 1968 and earthquake energy release in the Portland area: *The Ore Bin*, v. 30, p. 185-190.
- Couch, R. W., and MacFarlane, W. T., ¹⁹⁷¹~~1970~~, A fault plane solution of the October, 1969 Mt. Rainier earthquake and tectonic movements in the Pacific Northwest from fault plane and first motion studies (Abstract): *Am. Geophys. Union Trans.*, v. 52, in press.
- Couch, R. W., and Pietrafesa, L. J., 1968, Earthquakes off the Oregon coast: January 1968 to September 1968: *The Ore Bin*, v. 30, p. 205-212.
- Couch, R. W., and Whitsett, R., 1969, The North Powder earthquake of August 14, 1969: *The Ore Bin*, v. 31, p. 239-244.
- Decker, R. W., and Harlow, D., 1970, Microearthquakes at Cascade Volcanoes, (Abstract): *Am. Geophys. Union Trans.*, v. 51, p. 351.
- Dehlinger, P., and Berg, J. W., Jr., 1962, The Portland earthquake of November 5, 1962: *The Ore Bin*, v. 24, p. 185-188.
- Dehlinger, P., Bowen, R. G., Chiburis, E. F., and Westphal, W. H., 1963, Investigations of the earthquake of November 5, 1962, north of Portland: *The Ore Bin*, v. 25, p. 53-68.
- Dehlinger, P., Chiburis, E. F., and Collver, M. M., 1965, Local travel-time curves and their geologic implications for the Pacific Northwest states: *Seism. Soc. Am. Bull.*, v. 55, no. 3, p. 587-607.

- Dehlinger, P., Couch, R. W., and Gemperle, M., 1968, Continental and oceanic structure from the Oregon coast westward across the Juan de Fuca Ridge: Canadian J. of Earth Sci., v. 5, p. 1079-1090.
- Dehlinger, P., Couch, R. W., McManus, D. A., and Gemperle, M., 1971, North-west Pacific structure: The Sea, v. IV, John Wiley & Sons, in press.
- Dicken, S. N., 1965, Oregon geography: University of Oregon Cooperative Bookstore, Eugene, 4th edition, 147 p.
- French, W. S., 1970, Earthquake waves following Pn and their indications of focal depth and crustal structures in the Pacific Northwest states: Oregon State Univ. doctoral diss., 175 p.
- Gallagher, J. N., 1969, Focal mechanisms for small earthquakes in the Pacific Northwest, An amplitude analysis: Oregon State Univ. doctoral diss., 187 p.
- Heinrichs, D. F., and Pietrafesa, L. J., 1968, The Portland earthquake of January 27, 1968: The Ore Bin, v. 30, p. 37-40.
- International Conference of Building Officials, 1970, Uniform Building Code, v. 1, Pasadena.
- Iyer, H. M., 1964, The history and science of microseisms: Institute of Science and technology, University of Michigan, Ann Arbor, 72 p.
- Jeffreys, H., and Bullen, K. E., 1940, Seismological tables, (Reprint issued 1958), London: British Association for the Advancement of Science.
- Northrup, John, 1970, Accuracy of earthquake epicenters on the Gorda Ridge: Seism. Soc. Am. Bull., v. 60, p. 265-267.
- Pattullo, J. G., Burt, W. V., and Burdwell, G. B., 1968, Tsunami on the Oregon coast from an earthquake near Japan: The Ore Bin, v. 30, p. 182-184.
- Rasmussen, N., 1967, Washington state earthquakes 1840 through 1965: Seism. Soc. Am. Bull., v. 57, p. 463-476.
- Rasmussen, N., 1969, Seismic trends in Washington state, the trend in engineering: v. 21, p. 21-23.
- Richter, C. F., 1958, Elementary seismology: San Francisco, W. H. Freeman & Co., 768 p.
- Schatz, C. E., Curl, H., Jr., and Burt, W. V., 1964, Tsunami on the Oregon coast: The Ore Bin, v. 26, p. 231-232.
- Thiruvathukal, J. V., Berg, J. W., Jr., and Heinrichs, D. F., 1970, Regional gravity of Oregon: Geol. Soc. Am. Bull., v. 81, p. 725-738.
- Tobin, D., and Sykes, L. R., 1968, Seismicity and tectonics of the northeast Pacific Ocean: J. Geophys. Res., v. 73, p. 3821-3845.
- United States Department of Commerce, 1959-1967, United States earthquakes: Coast and Geodetic Survey.
- United States Department of Commerce, 1968-1970, Preliminary determination of epicenters: Coast and Geodetic Survey.
- Walker, G. W., and King, P. B., 1969, Geologic map of Oregon: U. S. Geol. Survey, Map I-595.
- Wells, F. G., and Peck, D. L., 1961, Geologic map of Oregon west of the 121st meridian: U. S. Geol. Survey, Map I-325.
- Westphal, W. H., 1962, Seismic aftershock investigations--Project Vela, Portland, Oregon earthquake of November 6, 1962: Stanford Research Institute, Tech. Rept. 1, 11 p.
- Wilson, B. W., and Tørum, A., 1968, The tsunami of the Alaskan earthquake, 1964: engineering evaluation: U. S. Army Corps of Engineers, Tech. Memo. No. 25, Coastal Engineering Research Center, 401 p.

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
39.	Geology and mineralization of Morning mine region, Grant County, Oregon 1948: R. M. Allen & T. P. Thayer.	1.00
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch . .	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Grah, editors	3.50
58.	Geology of the Suplee-Izee area, Oregon, 1965: Dickinson and Vigrass	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dole,	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68.	Free
64.	Mineral and water resources of Oregon, 1969.	1.50
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre . .	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970: Roberts	2.00
68.	The Seventeenth Biennial Report of the State Geologist, 1968-1970 . .	Free
69.	Geology of the Southwestern Oregon Coast W. of 124th Meridian, 1971: R. H. Dott, Jr.	3.75

GEOLOGIC MAPS

	Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
	Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others . .	0.40
	Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37) .	0.50
	Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker . . .	1.00
	Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts . .	0.75
	Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams	1.00
	GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka . .	1.50
	GMS-2: Geologic map, Mitchell Butte quad., Oregon: 1962, Corcoran et. al.	1.50
	GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka . .	1.50
	Geologic map of Oregon west of 121st meridian: (over the counter	2.00
	folded in envelope, \$2.15; rolled in map tube, \$2.50	

[Continued on back cover]

The ORE BIN
1069 State Office Bldg., Portland, Oregon 97201

The Ore Bin

POSTMASTER: Return postage guaranteed.



Available Publications, Continued:

SHORT PAPERS

- | | | |
|-----|---|---------|
| 2. | Industrial aluminum, a brief survey, 1940: Motz | \$ 0.10 |
| 18. | Radioactive minerals the prospectors should know (2nd rev.), 1955:
White and Schafer | 0.30 |
| 19. | Brick and tile industry in Oregon, 1949: Allen and Mason | 0.20 |
| 21. | Lightweight aggregate industry in Oregon, 1951: Mason | 0.25 |

MISCELLANEOUS PAPERS

- | | | |
|-----|---|------|
| 1. | Description of some Oregon rocks and minerals, 1950: Dole | 0.40 |
| 2. | Key to Oregon mineral deposits map, 1951: Mason | 0.15 |
| | Oregon mineral deposits map (22" x 34"), rev. 1958 (see M. P. 2 for key) | 0.30 |
| 3. | Facts about fossils (reprints), 1953 | 0.35 |
| 4. | Rules and regulations for conservation of oil and natural gas (rev. 1962) | 1.00 |
| 5. | Oregon's gold placers (reprints), 1954 | 0.25 |
| 6. | Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton | 1.50 |
| 7. | Bibliography of theses on Oregon geology, 1959: Schlicker | 0.50 |
| 7. | (Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts | 0.50 |
| 8. | Available well records of oil & gas exploration in Oregon, rev. 1963:
Newton | 0.50 |
| 11. | A collection of articles on meteorites, 1968: (reprints, The ORE BIN). | 1.00 |
| 12. | Index to published geologic mapping in Oregon, 1968: Corcoran | Free |
| 13. | Index to The ORE BIN, 1950-1969, 1970: M. Lewis | 0.30 |
| 14. | Thermal springs and wells, 1970: R. G. Bowen and N. V. Peterson | 1.00 |

MISCELLANEOUS PUBLICATIONS

- | | |
|---|------|
| Oregon quicksilver localities map (22" x 34"), 1946 | 0.30 |
| Landforms of Oregon: a physiographic sketch (17" x 22"), 1941 | 0.25 |
| Index to topographic mapping in Oregon, 1968 | Free |
| Geologic time chart for Oregon, 1961 | Free |

OIL and GAS INVESTIGATIONS SERIES

- | | | |
|----|--|------|
| 1. | Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:
Newton and Corcoran | 2.50 |
| 2. | Subsurface geology of the lower Columbia and Willamette basins, Oregon,
1969: Newton | 2.50 |

The Ore Bin



Vol. 33, No. 5
May 1971

**STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES**

The Ore Bin

Published Monthly By

STATE OF OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Head Office: 1069 State Office Bldg., Portland, Oregon - 97201

Telephone: 229 - 5580

FIELD OFFICES

2033 First Street

Baker 97814

521 N. E. "E" Street

Grants Pass 97526

X X X X X X X X X X X X X X X X X X X

Subscription rate \$1.00 per year. Available back issues 10 cents each.

Second class postage paid
at Portland, Oregon

X X X X X X X X X X X X X X X X X X X

GOVERNING BOARD

Fayette I. Bristol, Rogue River, Chairman

R. W. deWeese, Portland

Harold Banta, Baker

STATE GEOLOGIST

R. E. Corcoran

GEOLOGISTS IN CHARGE OF FIELD OFFICES

Norman S. Wagner, Baker

Len Ramp, Grants Pass

X X X X X X X X X X X X X X X X X X X

Permission is granted to reprint information contained herein.
Credit given the State of Oregon Department of Geology and Mineral Industries
for compiling this information will be appreciated.

VISITOR'S GUIDE TO THE GEOLOGY OF THE COASTAL AREA NEAR BEVERLY BEACH STATE PARK, OREGON *

By Parke D. Snively, Jr. and Norman S. MacLeod **

Introduction

The Oregon coast between Yaquina Head and Government Point owes its scenic grandeur to a unique wedding of ancient and recent marine environments. Visitors to Beverly Beach State Park, located in the southern part of this coastal strip (see figs. 1 and 2, and plate 1), have a rare opportunity to wander along a shoreline that some 15 m. y. (million years) ago, in Miocene time, was also a coastal area. Unlike the present coast, however, it was then the site of active volcanoes that erupted lava, fragmental debris, and ash both on the land surface and on the adjacent ocean floor.

The Miocene geologic events are recorded in the rocks that are well exposed in present sea cliffs and surf-cut platforms near sea level (see fig. 1) and in roadcuts. The areal distribution of the major rock units (geologic formations) that crop out along this part of coastal Oregon is shown on plate 1. A diagram that shows the sequence and relative ages (stratigraphy) of rock units discussed in this guidebook article is shown in figure 3.

This guidebook was written for visitors to this part of the Oregon coast in order to acquaint them with some of the intriguing geologic features that are well displayed and readily accessible. Those who desire a more detailed description of the geology of the region are referred to reports listed in the bibliography, page 67.

Geologic sketch

The sedimentary and volcanic rocks exposed in the coastal strip between Yaquina Head and Government Point (plate 1) record an eventful geologic history -- a history of uplift and erosion, of fluctuating shorelines, eruption of lava from several volcanoes, and the dislocation of rock units

* Publication authorized by the Director, U. S. Geological Survey

** Geologists, U. S. Geological Survey, Menlo Park, California

by faults. Most of the sedimentary rocks are sandstone (composed of sand-size particles), siltstone (composed of silt-size particles), mudstone (composed of clay- and silt-size particles), or conglomerates (composed of pebbles, cobbles, or boulders). The volcanic rocks are principally basalt, a dark fine-grained rock formed by the congealing of lava.

The oldest rock unit exposed in this coastal strip (plate 1 and figure 3) is the Yaquina Formation. It was deposited between 25 and 22 million years ago during late Oligocene and early Miocene time. The low hills east of Beverly Beach State Park are composed of rocks of this formation that consist principally of sandstone and lesser amounts of conglomerate and siltstone. The conglomerate contains cobbles of volcanic rocks that are similar to volcanic rocks exposed now in the foothills of the Cascade Range. Coal beds are also found within the Yaquina Formation; these were mined near the turn of the century.

Certain characteristics of the Yaquina Formation suggest that it is an ancient delta. It has a lens-shaped outcrop, and the sandstone in it interfingers to the north and south with marine siltstone. It contains an abundance of coarse sediment, with foreset bedding and crossbedding. Besides coal, it includes shallow-water marine and brackish-water fossils which are indicative of a deltaic environment. The sediment was apparently transported by an ancestral Yaquina River from highland areas of older rocks east of the present Coast Range and was deposited to form this large delta where the river discharged into the sea.

The Yaquina Formation is not well exposed in areas of easy access along this coastal strip, and the visitor is directed to exposures on the east side of Yaquina Bay, 2 to 4 miles southeast of Newport.

About 22 million years ago, early in Miocene time, deep crustal forces caused the earth's surface to warp downward resulting in a progressive deepening of the sea that covered parts of western Oregon. Mud and silt rich in organic material were deposited in moderately deep water and buried the sand deposits of the Yaquina Formation. These fine-grained strata are called the Nye Mudstone. Although not well exposed in the area described in this report, the Nye Mudstone is well exposed along the north side of Yaquina Bay in the city limits of Newport. Here it consists predominantly of olive-gray massive mudstone and siltstone that weather to rusty-brown fragments. Brown fish scales and vertebrae are abundant in some beds. Limy concretions and calcareous beds 2 inches to more than 1 foot thick occur locally.

A period of uplift and erosion occurred in middle Miocene time, about 18 to 20 million years ago. It was followed by an invasion of the sea along the Oregon coast and the deposition of the Astoria Formation on top of the Nye Mudstone. The Astoria Formation consists of beds of yellowish-gray sandstone and dark-gray carbonaceous siltstone that were deposited in shallow water. Ledge-forming calcareous sandstone beds, some of which contain large fossils of pelecypods (clams) and gastropods (snails) are common in the sequence exposed along the sea cliffs between Yaquina Head and



THE MAGNIFICENT OREGON COAST

Figure 1. This view of the Oregon coast looking south toward arcuate Beverly Beach was taken from the viewpoint at Otter Crest on Cape Foulweather. Yaquina Head, the low projecting headland on the horizon, is a Miocene volcano, as is Iron Mountain. On a clear day Cape Perpetua, 30 miles to the south, can be seen. This distant rugged coast is held up by a sequence of lava flows that erupted about 36 to 40 million years ago. The two flat-topped headlands (this side of Beverly Beach) are held up by sandstone and siltstone beds of the Astoria Formation that dip gently westward. The flat-lying sands that cap the headlands are Pleistocene marine terrace deposits. These terrace sands were deposited near sea level, and the land has since risen relative to sea level. The south flat-topped headland is Otter Rock, where a large collapsed sea cave can be seen. (fig. 8). Marine Gardens, in the foreground between Otter Rock and Otter Crest, is a surf-cut platform near sea level. Marine organisms of many varieties are found in tidal pools that dot this platform. The small wave-washed islands off Beverly Beach are the highest points of a Miocene lava flow that now forms an offshore reef.

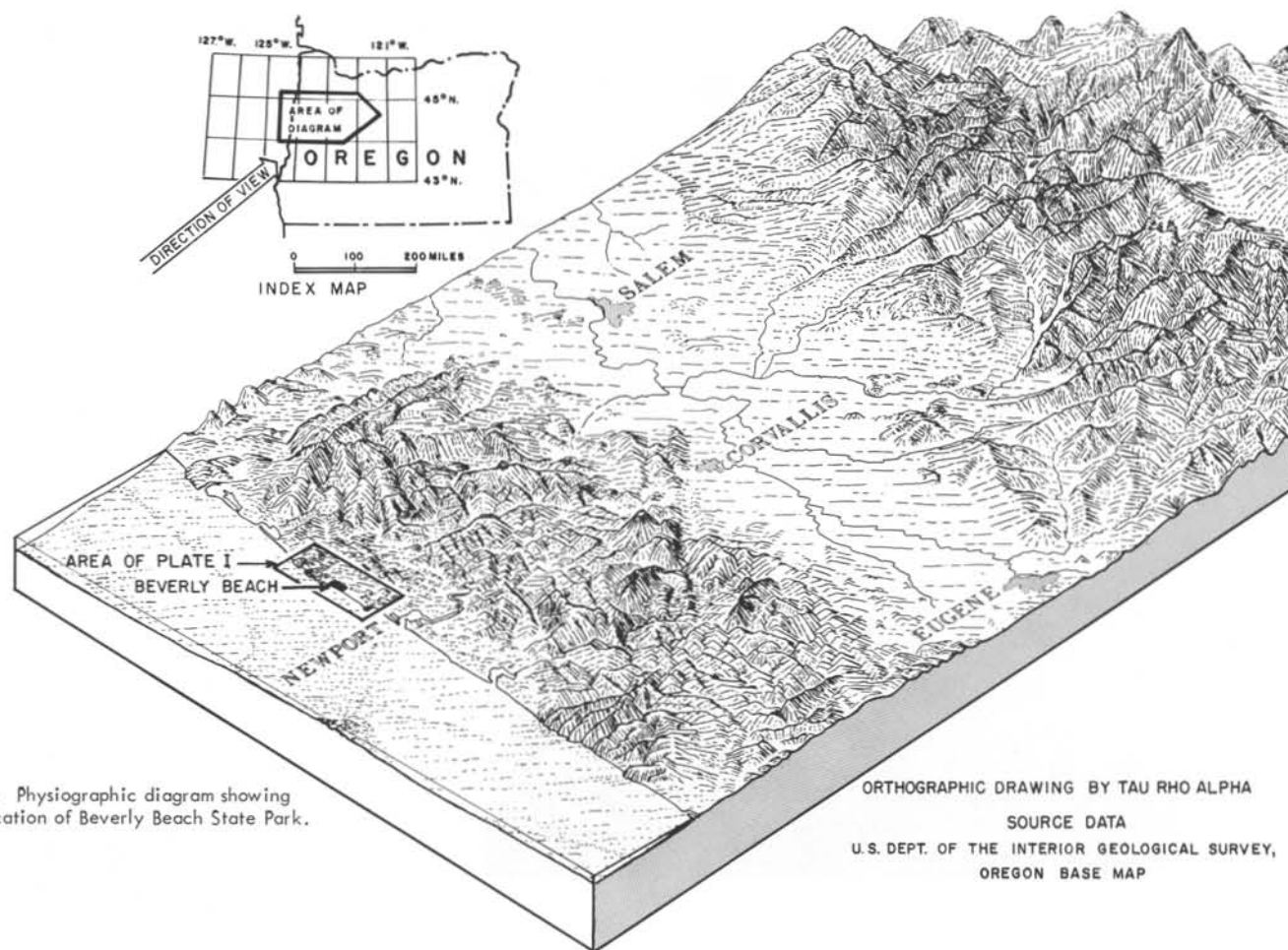


Figure 2. Physiographic diagram showing the location of Beverly Beach State Park.

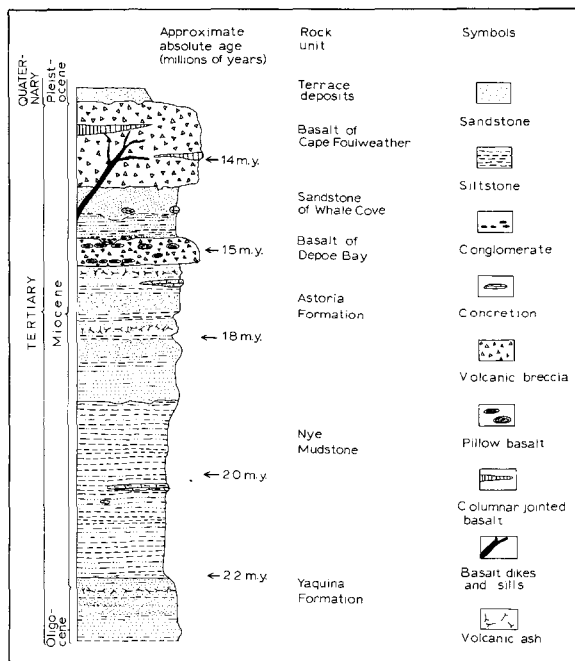


Figure 3

Diagram showing the types and ages of rocks exposed near Beverly Beach, Oregon.

Cape Foulweather. Thick beds of light yellowish-gray volcanic ash that were deposited in water also can be seen in many places along this section of the beach, as in the sea cliff on the south side of Devils Punchbowl State Park (at the base of the stairs leading down to the beach). This ash was probably derived from volcanic eruptions in an ancestral Cascade Range because it is similar in composition to ash of the same age exposed in the western Cascades and because volcanic vents of this age that might have produced this type of ash are absent in the Coast Range.

Deposition of Astoria marine sediments was brought to a close by uplift of the land, withdrawal of the sea, and outpourings of lava and fragmental volcanic debris from a number of volcanoes near the ancient coast. Volcanic eruptions occurred during two periods.

The older volcanic unit is exposed at Depoe Bay. It consists of dark basaltic lava that erupted about 15-16 million years ago from fissures in the hills 1/2 to 2 miles to the east and flowed into the ancient sea. Most of the hot lava fragmented explosively when quenched by the cold sea water and formed deposits of fragmental volcanic debris (breccia). Some of the lava congealed as ellipsoidal masses, called pillows, that occur within the breccia. Similar eruptions of dark volcanic rocks occurred along other parts of the Oregon coast and are now exposed in scenic headlands such as Cape Look-out, Cape Meares, Cape Falcon, and Tillamook Head.

Minor crustal adjustment accompanied this period of volcanism, and regional subsidence permitted a minor inundation by the sea. The massive concretionary yellowish-gray sandstone and thin-bedded medium-gray siltstone exposed at Whale Cove and on the north and south sides of Depoe Bay west of U. S. 101 were deposited during this marine transgression.

The younger volcanic unit is formed of basalt that erupted about 14 million years ago from vents at Yaquina Head south of Beverly Beach and at Cape Foulweather to the north. In the latter area a large variety of volcanic rocks is well exposed along both the old scenic route and the new route of U. S. Highway 101. Here vertical and horizontal tabular bodies (dikes and sills) of massive dark-gray basalt intrude fragmental basaltic debris (breccia). These dikes are former fissures along which molten lava rose from deep in the earth to feed the growing volcanic pile. Most of the lava that erupted from the Miocene volcano at Cape Foulweather was deposited on land; the well-bedded breccia that crops out between Whale Cove and Government Point, however, formed beneath the sea. The shoreline during this eruptive activity lay near Whale Cove. Basalt sills and dikes of this unit also form scenic Seal Rocks, 17 miles south of Beverly Beach on the coast.

The volcanic rocks exposed at Yaquina Head and Cape Foulweather are the youngest consolidated rocks visible along this part of coastal Oregon. Geophysical studies and sea floor samples, however, show that sedimentary rocks of late Miocene and Pliocene age (approximately 12 to 3 million years old) underlie the continental shelf several miles west of Beverly Beach. Marine sandstone and siltstone of this age are also exposed along the coast of southern Oregon and Washington.

Pleistocene terrace deposits consisting chiefly of sand with pebble beds and woody material are well exposed in sea cliffs between Yaquina Head and Otter Crest. These sediments were deposited near sea level, but now occur on an ascending flight of terraces ranging in altitude from 40 to some 500 feet above present sea level. These terraces indicate that several periods of uplift and erosion of the Coast Range have occurred during the past 2 million years. Relative changes in sea level were also caused by the removal of water from the oceans during growth of the continental glaciers in the Pleistocene ice ages and its return to the ocean as the ice melted.

Although the Miocene sedimentary rocks were deposited as essentially horizontal layers, most of them are now inclined 10° to 20° in a westward direction (plate 1). Some folds are locally developed, and faults displace the strata a few feet to more than 1,000 feet. This deformation is clear evidence of dynamic processes at work within the crust of the earth since Miocene time.

Pictorial Guide

We have selected 12 photographs (figures 4-15) of exposures that are readily accessible to the visitor and that illustrate significant geologic features along this section of the Oregon coast. These photographs and brief

descriptions appear on the following pages. The photography localities are indicated by circled numbers on the geologic map (plate 1). We suggest that visitors first stop at Otter Crest on Cape Foulweather, (see figure 1) which provides a spectacular overview of the coastal area in the vicinity of Beverly Beach State Park.

Selected Bibliography

- Baldwin, E. M., 1950, Pleistocene history of the Newport, Oregon region: Geological Society of the Oregon Country Geological News Letter, v. 16, no. 10, p. 77-81.
- _____, 1964, Geology of Oregon: Eugene, Oregon University Oregon Cooperative Bookstore, 2nd ed., 165 p.
- Fowler, G. A., 1966, Notes on late Tertiary foraminifera from off the central coast of Oregon: The ORE BIN, v. 28, no. 3, p. 53-60.
- Moore, E. J., 1963, Miocene marine mollusks from the Astoria Formation in Oregon: U. S. Geological Survey Professional Paper 419, 100 p.
- _____, in press, Fossil mollusks of coastal Oregon: Oregon State University studies in geology, Monograph No. 10.
- Snively, P. D., Jr., and Wagner, H. C., 1961, Differentiated gabbroic sills and associated alkalic rocks in the central part of the Oregon Coast Range, Oregon, in Geological Survey research, 1961: U. S. Geological Survey Professional Paper 424-D, p. D156-D161.
- _____, 1963, Tertiary geologic history of western Oregon and Washington: Washington Division Mines and Geology Report of Investigations 22, 25 p.
- Snively, P. D., Jr., and Wagner, H. C., 1964, Geologic sketch of northwestern Oregon: U. S. Geological Survey Bulletin 1181-M, p. M1-M17.
- Snively, P. D., Jr., Rau, W. W., and Wagner, H. C., 1964, Miocene stratigraphy of the Yaquina Bay area, Newport, Oregon: The ORE BIN, v. 26, no. 8, p. 133-151.
- Snively, P. D., Jr., Wagner, H. C., and MacLeod, N. S., 1965, Preliminary data on compositional variations of Tertiary volcanic rocks in the central part of the Oregon Coast Range: The ORE BIN, v. 27, no. 6, p. 101-117.
- Snively, P. D., Jr., MacLeod, N. S., and Rau, W. W., 1969, Geology of the Newport area, Part 1 and 2: The ORE BIN, v. 31, no. 2 and 3, p. 25-71.
- Wilkinson, W. D., ed., 1959, Field guidebook, college teachers conference in geology, Oregon State College, Corvallis, Oregon, June 15-27, 1959: Oregon Department of Geology and Mineral Industries Bulletin 50, 148 p.



ON THE BEACH

Figure 4. Beverly Beach State Park includes this broad sandy beach, which is exposed here at low tide. Cape Foulweather, a Miocene volcano, forms the high headland north of Beverly Beach. The light-colored strata south of this headland are sandstone and siltstone beds of the Miocene Astoria Formation. The rubble-covered sea cliff that borders the coast here consists of landslide blocks of the Astoria Formation; visitors should keep clear of the base of these unstable slopes. To the lower left "ribs" of sandstone and siltstone of the Astoria Formation crop out through the veneer of sand and ponded water on the beach. The low island in the upper left of the photograph is Otter Rock Island, which is composed of fragmental volcanic rocks similar to those exposed at Cape Foulweather. Black sands are commonly concentrated at the back beach, near the base of the sea cliff. These sands consist of heavy minerals such as magnetite, ilmenite, chromite, garnet, and epidote, as well as trace amounts (about 1 part per million) of gold. Light-colored beach sand in this area is made up of quartz, with lesser amounts of feldspar, muscovite (white mica), and biotite (black mica).



AN ANCIENT VOLCANO ASTRIDE THE BEACH

Figure 5. Yaquina Head, 4 miles south of Beverly Beach State Park, is an eroded Miocene volcano. In the sea cliffs and large quarries here one finds a variety of massive to poorly bedded fragmental basaltic debris (breccia), which is laced by numerous tabular intrusive bodies (dikes and sills) that fed molten lava (magma) to this volcano. Yellowish-white crystals of plagioclase up to 3/4 inch long are scattered through the basalt. These crystals formed in the magma deep within the earth before eruption. Quarries on the headland produce basalt that is crushed and used for road rock, a valuable natural resource in this region. Man-made modifications far exceed those of natural processes in the diminution of this headland. This volcanic unit overlies sedimentary rocks of the Astoria Formation, which form the light-colored sea cliffs north and south of the headland. As the photograph shows, these sedimentary deposits are much more prone to landsliding than the basalt that forms the headland. The low, partly logged hills on the horizon (under the wing tip) are underlain by sandstone of the Yaquina Formation.



THE FLOOR OF THE BEACH

Figure 6. This view from Yaquina Head north to Cape Foulweather shows north-striking beds of sandstone, siltstone, and water-laid volcanic ash of the Astoria Formation that form ribs partly buried by beach sand. This photograph was taken at low tide in late spring, when waves from winter storms had stripped the sands off the beaches to expose the bedrock on the surf-cut platform. During the summer months the beach sand is redeposited on the beaches and covers most of the bedrock. The Astoria Formation was deposited as essentially horizontal beds, but later deformation has tilted the beds about 15° towards the west. Small faults that offset beds a few inches to a few feet can be observed on these beach exposures. The small flat-topped cliff in the upper right contains fossiliferous sandstone beds of the Astoria Formation (see figure 7).



FOSSIL LAYERS, A FEW PAGES OF EARTH'S HISTORY

Figure 7. This sea-cliff exposure of the Astoria Formation is located between Schooner and Moloch Creeks (see plate 1). The sandstone and siltstone beds that dip gently to the west contain abundant large fossilized clams (*Pecten*, *Anadara*) and microscopic fossils (Foraminifera). The ledge-forming units are calcareous (limy) sandstone beds that are more resistant to erosion than adjacent beds. Fossil vertebrates, including *Desmostylus* (a hippopotamus-like creature that foraged for food in shallow coastal waters) and sea lions, have been collected along this stretch of beach by Mr. Douglas Emlong of Gleneden Beach, Oregon. Much of his collection is now on display at the Smithsonian Institution. These vertebrate fossils and the large clams indicate that these sandstones of the Astoria were deposited in shallow water adjacent to the coast in Miocene time. Visitors are warned not to visit here at high tide, as waves crash against this cliff.

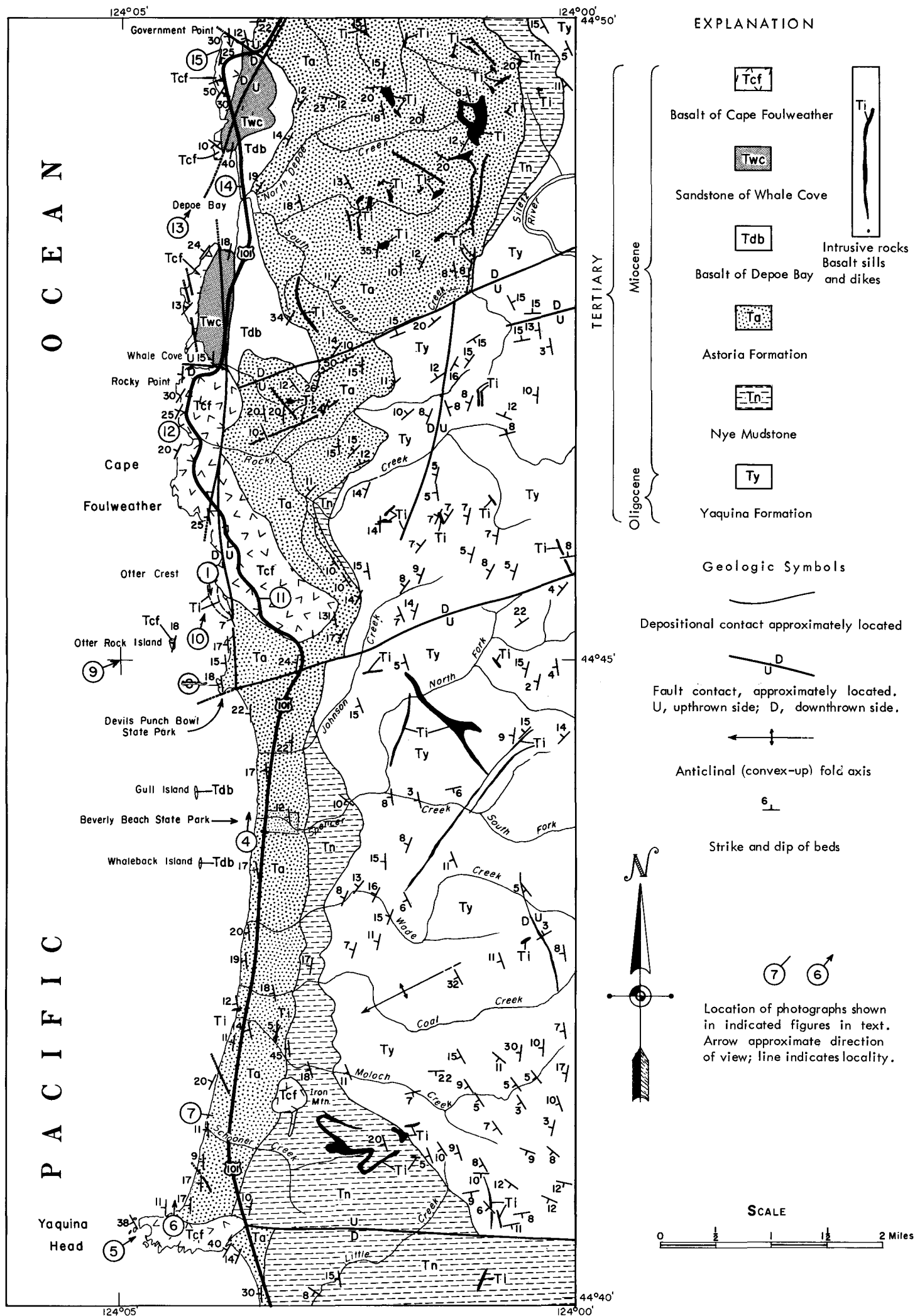


Plate 1. Generalized geologic map of coastal Oregon between Yaquina Head and Government Point. Pleistocene marine terrace deposits and Holocene beach sands and stream alluvium are not shown.



SATAN'S CAULDRON

Figure 8. Devil's Punchbowl at Otter Rock is a collapsed sea cave cut in thin-bedded sandstone and siltstone of the Astoria Formation. Two tunnel-like openings connect the Punchbowl with the sea, and during high tide the floor of the cauldron becomes a maelstrom of wild currents. The contact between the Pleistocene terrace sand (which contains fossil wood fragments) and the underlying Astoria Formation is shown in the upper right, below the vegetation. Most of the terrace deposits have been stripped off by the sea, exposing the upper surface of the Astoria Formation. This ancient surface contains a number of west-trending troughs, which are surge channels formed by marine erosion at an earlier time when sea level lay near the top of the Punchbowl. A number of borings, about 1 inch in diameter, are present along the sides of these channels and were made by rock-boring clams when the channels lay near sea level. Volcanic breccia cuts the Astoria sandstone on the floor of the Punchbowl. This breccia formed when hot lava was explosively injected into wet sediments. This explosive action probably shattered the overlying rocks and produced an easily eroded circular area. Photograph courtesy of the Oregon State Highway Department.



A VIEW FROM THE PACIFIC

Figure 9. Cape Foulweather, first sighted by Captain Cook in 1778, is one of the numerous rugged volcanic headlands along the northern Oregon coast. The black volcanic rocks (basalt breccia and associated feeder dikes and sills) of Miocene age that form this cape are more resistant to the ravages of the sea and erode more slowly than the softer light-colored sandstone and siltstone, which are visible in the right center along the sea cliff south of the cape. The flat-topped headland 450 feet above sea level near the center of the photograph is Otter Crest, (see figure 1) an excellent vantage point for viewing the coastline to the south. Otter Rock Island, the small island to the lower right, is also composed of fragmental volcanic rocks like those that form Cape Foulweather. This island is a refuge for a variety of sea birds as well as sea lions, and its light color is due to accumulation of guano. The broad, flat upland area on the horizon is held up by thick sills of gabbro of middle Oligocene age (30 m. y.). The lava that formed the sills never reached the surface but was intruded into bedded sedimentary rocks, much like forcing molasses between pages in a book. Although the gabbro is chemically similar to basalt at Depoe Bay, it cooled more slowly and the crystals that constitute the rock grew much larger.



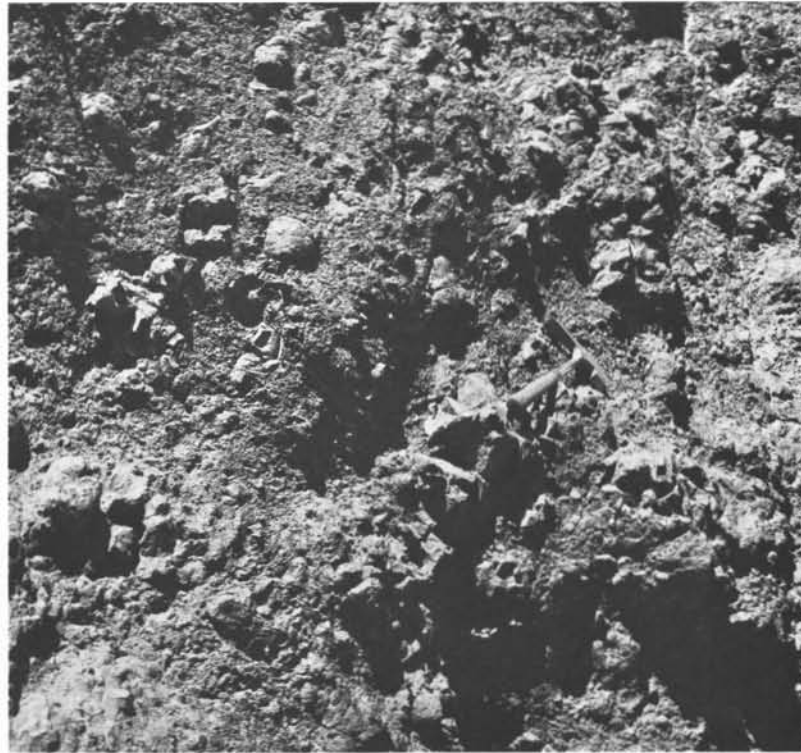
A RING OF BASALT

Figure 10. At the base of the 450-foot-high sea cliff on the south side of Otter Crest one can view two arcuate features that are portions of basalt ring dikes. The lava that formed these dikes was injected along circular fractures that probably developed above a magma chamber. Here at the base of Otter Crest these ring dikes intrude sandstone of the Astoria Formation. The large block-like mass near the center of the picture and the dark-colored band in the right center are dikes of basalt. They intruded radial fractures that formed at the same time as the circular fractures. Close examination of some of these dikes shows that they are made up of basalt breccia as well as massive basalt. The breccia formed as the molten lava was injected into water-saturated sediments. Explosive fragmentation propelled some small pieces of basalt several inches into the sandstone walls bordering the dikes.



A FAN OF BASALT

Figure 11. This small volcanic neck is exposed in a quarry along U. S. 101 on Cape Foulweather southeast of Otter Crest. Molten lava from deep within the earth was disgorged to the surface through this volcanic neck. After the last eruption, the lava that remained in the neck cooled and solidified to form basalt. Cooling cracks developed in the basalt approximately at right angles to the cooling surfaces at the margins of the neck, but are more steeply inclined in the interior of the neck. The fan-shaped columnar joints that were produced are typical of small circular-shaped intrusive bodies. Although the ring dikes shown in figure 10 are not quite concentric about this volcanic neck, both the ring dikes and neck may be related. Basalt intrusive bodies, including dikes, sills, and irregular-shaped bodies, are common on Cape Foulweather.



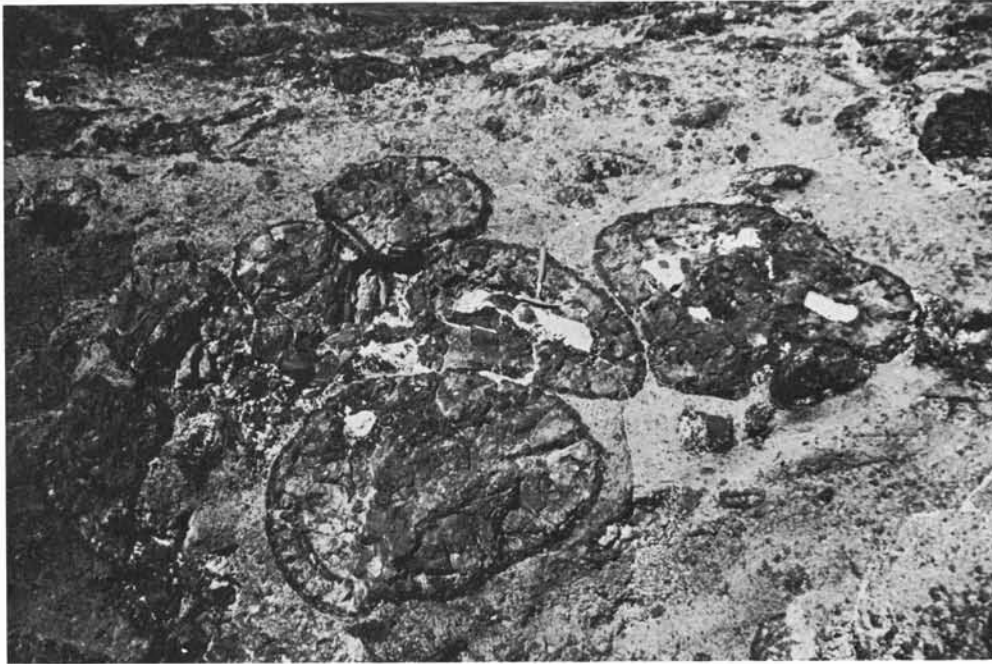
BROKEN BASALT

Figure 12. Much of Cape Foulweather and Yaquina Head is composed of basalt breccia like that shown in this photograph. This breccia is composed of angular pieces that are mostly less than 6 inches across; some large blocks are more than 5 feet across. Basalt breccia results from fragmentation of lava, and it can form either on land or in the sea. Breccia can form on land when lava contacts subsurface water immediately before eruption to the surface, or it can form during eruption or later during flow. Some breccia may also result when lava is ejected into the air and rains down around the vent. These deposits can usually be recognized by the occurrence of oxidized zones or relict soil zones or by the aerodynamic shapes imparted to lava that is ejected into the air. Breccia can form in the sea by the sudden cooling and fragmentation of lava that is extruded from the sea floor or that flows from land into the sea. Breccia commonly is associated with pillow lava (see fig. 14), which also forms under water or upon contact with water. The smaller fragments in marine breccia are commonly made up of clear basaltic glass (sideromelane) that forms during very rapid quenching of basaltic lava in contrast to subaerial breccias, in which the smaller basalt particles are finely crystalline or are composed of glass that contains abundant finely disseminated crystallites.



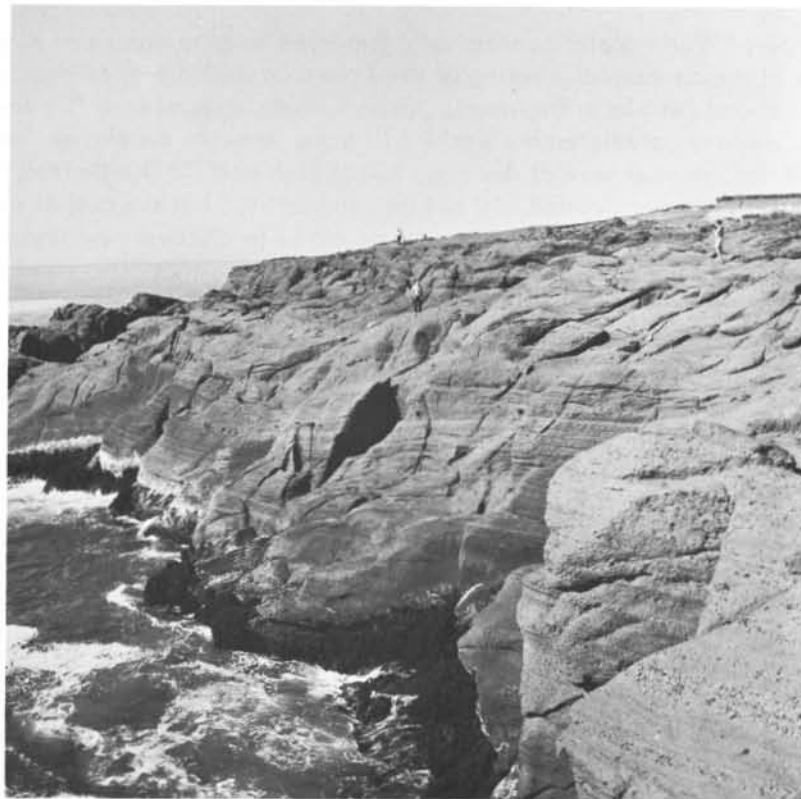
A SEA WALL OF LAVA

Figure 13. Three west-dipping rock sequences of Miocene age are well exposed in this view north across Depoe Bay. A sequence of pillow lava and breccia (see fig. 14) crops out along the east side of the bay (adjacent to U. S. 101). It is overlain by sandstone and siltstone (light-colored outcrops along the north side of bay) which in turn are overlain by a basalt breccia unit which forms the jagged coastline. The bridge crosses the narrow entrance to the inner bay. This entrance was eroded by Depoe Creek as it carved its way into the resistant basalt during Pleistocene uplift of this region. The boat harbor of the inner bay (east of the bridge) was carved out in the less resistant Astoria Formation by Depoe Creek. The narrowness of the entrance makes the return of boats to the inner harbor look perilous on days of heavy seas. A sea spout is located about one-tenth of a mile north of the bridge adjacent to the highway. A small slot in the pillow and breccia unit concentrates the force of large waves during high tide, and sea water is hurled several tens of feet into the air. The large headland on the horizon, Cascade Head, is composed of subaerial flows of basalt that were erupted about 36 to 40 million years ago.



A BED OF PILLOWS

Figure 14. Isolated pillow breccia in the basalt of Depoe Bay is exposed along the 100 to 150 foot wide belt of volcanic rocks west of (and adjacent to) U. S. 101 at Depoe Bay. Most of the lava which formed these rocks fragmented upon being quenched by sea water to form the breccia. Some of the lava, however, formed ellipsoidal pillows upon entering the sea, perhaps in much the same way as salad oil forms droplets when mixed with vinegar. The black margins of the pillows are basalt glass that formed by sudden cooling of the "globs" of lava. The interior of the pillows, insulated by the chilled rims, crystallized to fine-grained basalt. Tension cracks developed on the rims of some pillows and allowed steam to enter the interior of the pillows, where it produced a second chilled margin. Lava drained from some pillows before they completely solidified, leaving holes in the pillow cores. Some of these holes have been filled by sediment; other inclusions of sedimentary rocks were probably ripped from the walls of the fissures through which the lava ascended from the earth's mantle. Well-developed pillow lavas can also be seen at Cape Lookout and Cape Meares 40 miles to the north. Even on calm days infrequent very large waves occur on this coast, and the visitors are cautioned to remain far above water's edge.



A TUFF AND BRECCIA OUTCROP

Figure 15. Well-bedded deposits of water-laid fragmental volcanic debris (tuff and breccia) of Miocene age are exposed at Government Point State Park 1 mile north of Depoe Bay. These marine deposits formed a broad apron around the main volcanic vent area at Cape Foulweather. The finer grained material is called tuff and the coarser, breccia. The size of the fragments decreases between Whale Cove and Government Point in a direction away from Cape Foulweather. These deposits are capped with a thin veneer of late Pleistocene marine terrace (upper right) sands and re-worked volcanic material. Several notches in the Miocene rocks were cut by wave erosion when the land area was lower relative to sea level. It is hazardous to fish from the lower rock benches, as unexpected storm waves often sweep over them. On the north side of Government Point, erosion along a joint has created a slot along which wave energy is concentrated to form a water spout during high tide.

* * * * *

HIGH METAL COSTS PREDICTED

In a paper, "World Metal Economics", presented to an audience of minerals experts at the centennial meeting of the American Institute of Mining, Metallurgical and Petroleum Engineers, John G. Hall, president of The Anaconda Company, predicted the world will have enough metals to meet demand for the next several decades, but at high cost. "The limiting factor in meeting world demand will not be availability, but the cost of access and recovery. . . . Technology that will permit us to discover new underground ore bodies is being developed," he stated, predicting that "increased prices and improved technology will make lower grade ore bodies, not presently classified as reserves, commercially feasible." Mr. Hall discussed the future of 6 metals - aluminum, copper, iron ore, lead, nickel and zinc. He cited data forecasting steeply rising metal demands to the year 2000: iron ore consumption from 464 million short tons in 1968 to 840 million tons by 2000; aluminum - 11 million tons to 83 million tons; copper - 8.5 million tons to 38 million tons; zinc - 6 million tons to 14 million tons; lead - 3.5 million tons to 7 million tons; nickel - .5 million tons to 1.5 million tons. Mr. Hall cited several major factors that must receive increased consideration in assessing future mineral supply-demand: (1) The unpredictability of population growth: "If nothing is done to alter. . . trends, population will have more than doubled to $7\frac{1}{2}$ billion by the year 2000. . . but if efforts to control population growth are successful to a significant degree, there will have to be a whole new set of forecasts." (2) Concern for the environment: "Basically, three things are needed to achieve this objective--more ecological knowledge, new technology, and vast sums of money." (3) Availability of capital: ". . . expected to be a problem over a long period. . . capital costs are increasing all the time." (4) Political factors: "The foreign investor is finding it more and more difficult to please the host nation. . . contracts are broken, long-term goals are sacrificed for short-term gains. . ." (5) Substitution--competition or resource extended: "Even when traditional applications of metals have been taken over by other metals. . . the net effect has not been a lessened demand for the replaced metals, because of the increased demand in those areas where substitutes could not be made, either technically or economically." (6) New sources of metals: "Potential new sources will be the ocean bottoms. . . mineral-bearing formations at greater depths than ever mined before. . . discovery of blind orebodies with new ore horizons in older mines." (7) Expanded role for technology: "Technology is important to lower production costs while utilizing lower and lower grades of ore, to solve environmental problems, to increase productivity, to provide substitute materials, to enable recovery of the ocean's wealth, to provide better and more efficient recycling. . ."

(Nevada Mining Association News Letter, March 15, 1971)

* * * * *

MEGADIAMONDS PRODUCED

Synthetic industrial diamonds were first produced by Dr. H. Tracy Hall in 1954, 6 years after joining General Electric Research laboratory. In 1966, Dr. Hall founded Megadiamond Corporation (together with Dr. Bill J. Pope, former chairman of the department of chemical engineering at Brigham Young University, and Dr. M. Duane Horton, associate professor of chemical engineering at BYU) which recently produced a 20-carat diamond. In the Megadiamond process, the dust of used industrial diamonds or the minute synthesized diamonds are gathered in a graphite mold and put under hydraulic pressure of 2-million pounds per square inch in a tetrahedral press. The heat requirement is somewhat in excess of the 1400° C. at which steel melts. Megadiamonds can be produced in any number of shapes - cylindrical, square, hemispherical, disc, etc. which, in itself, is a major break-through as traditionally, the shaping of diamonds for a specific use required grinding by other diamonds at 3- to- 1 ratio. From a geologist's point of view, the formation of Megadiamonds is analogous to the formation of quartzite from enormous pressure and heat exerted on subterranean sandstone formations.

(Nevada Mining Assoc. News Letter, Oct. 15, 1970)

* * * * *

BIBLIOGRAPHY OF NORTH AMERICAN GEOLOGY

The Bibliography of North American Geology for 1966 has been issued as Bulletin 1266 by the U. S. Geological Survey. The 1069-page publication is for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. The price (paper cover) is \$4.75.

* * * * *

STRUCTURES IN COLUMBIA RIVER BASALT MAPPED

"Tectonic Structure of the Main Part of the Basalt of the Columbia River Group, Washington, Oregon, and Idaho," by R. C. Newcomb, has been issued by the U. S. Geological Survey as Miscellaneous Geologic Investigations Map I-587. The map is at a scale of 1:500,000 on a sheet 42 by 46 inches. Its main purpose is to show areas in which geologic structures favor the accumulation and storage of groundwater in the Columbia River Basalt. Map I-587 is for sale by the U. S. Geological Survey, Federal Center, Denver, Colo. 80225. The price is \$1.00.

* * * * *

JAMES P. JACKSON DIES

On April 9, a cerebral hemorrhage claimed the life of James P. Jackson, Jr., of Baker who will be widely remembered for his energetic and capable work in connection with exploratory development and operation of lode gold mines in eastern Oregon and neighboring states. The most outstanding of his activities, insofar as Oregonians are concerned, was his successful management of the Buffalo Mine in Grant County over nearly a twelve year span of year-around productive operation beginning in 1951.

Mr. Jackson's entire career was spent in mining. This began in the mid-1930's with exploratory development work on various properties in the Cornucopia, Baker and Susanville districts for Leverett Davis of the Cornucopia Gold Mining Company and thereafter, between 1939 and 1942, he was at the Bellevue Mine, in Oregon's Granite District when that mine was being productively operated by Rogers and McGinnis.

Although primarily identified with development work and operational management on lode gold mines, Mr. Jackson's mining activities did nevertheless include several drilling and sampling tests on placer deposits in Idaho for the Idaho-Canadian and the Natomas Dredging Companies in Idaho after World War II. During the past three years Mr. Jackson superintended exploratory operations at the Belshazzar mine near Placerville, Idaho, for H. J. Casey of Portland.

* * * * *

GROUNDWATER IN CLATSOP DUNES

Ground-water resources of the Clatsop Plains sand-dune area, Clatsop County, Oregon, by F. J. Frank, has been issued as Water-supply Paper 1899-A by the U. S. Geological Survey. The paper is for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington D. C. 20402. The price is \$1.00.

The 41-page report covers the coastal area between Tillamook Head and the mouth of the Columbia River. This area, known as the Clatsop Plains, is underlain by Tertiary shale and sandstone of nearly impermeable nature and yielding only small quantities of poor-quality water. The bed-rock is overlain by deposits of dune and beach sand locally more than 100 feet thick. It is estimated that 2,500 acre-feet of ground water per year per square mile of dune area may be available for withdrawal in the 10-square-mile area that is most favorable for development. The water is soft to moderately hard and of generally good quality. Geohydrologic maps and sections accompany the report.

* * * * *

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Volsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
39.	Geology and mineralization of Morning mine region, Grant County, Oregon 1948: R. M. Allen & T. P. Thayer	1.00
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Grah, editors	3.50
58.	Geology of the Suplee-Izee area, Oregon, 1965: Dickinson and Vigrass	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dole	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Mineral and water resources of Oregon, 1969	1.50
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970: Roberts	2.00
68.	The Seventeenth Biennial Report of the State Geologist, 1968-1970	Free
69.	Geology of the Southwestern Oregon Coast W. of 124th Meridian, 1971: R. H. Dott, Jr.	3.75

GEOLOGIC MAPS

	Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
	Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others	0.40
	Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37)	0.50
	Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker	1.00
	Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts	0.75
	Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams	1.00
	GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka	1.50
	GMS-2: Geologic map, Mitchell Butte quad., Oregon: 1962, Corcoran et. al.	1.50
	GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka	1.50
	Geologic map of Oregon west of 121st meridian: (over the counter folded in envelope, \$2.15; rolled in map tube, \$2.50)	2.00

[Continued on back cover]

The ORE BIN
1069 State Office Bldg., Portland, Oregon 97201

The Ore Bin

POSTMASTER: Return postage guaranteed.



Available Publications, Continued:

SHORT PAPERS

- | | | |
|-----|---|---------|
| 2. | Industrial aluminum, a brief survey, 1940: Motz | \$ 0.10 |
| 18. | Radioactive minerals the prospectors should know (2nd rev.), 1955:
White and Schafer | 0.30 |
| 19. | Brick and tile industry in Oregon, 1949: Allen and Mason | 0.20 |
| 21. | Lightweight aggregate industry in Oregon, 1951: Mason | 0.25 |

MISCELLANEOUS PAPERS

- | | | |
|-----|---|------|
| 1. | Description of some Oregon rocks and minerals, 1950: Dole | 0.40 |
| 2. | Key to Oregon mineral deposits map, 1951: Mason | 0.15 |
| | Oregon mineral deposits map (22" x 34"), rev. 1958 (see M. P. 2 for key) | 0.30 |
| 3. | Facts about fossils (reprints), 1953 | 0.35 |
| 4. | Rules and regulations for conservation of oil and natural gas (rev. 1962) . | 1.00 |
| 5. | Oregon's gold placers (reprints), 1954 | 0.25 |
| 6. | Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton . . | 1.50 |
| 7. | Bibliography of theses on Oregon geology, 1959: Schlicker | 0.50 |
| 7. | (Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts . | 0.50 |
| 8. | Available well records of oil & gas exploration in Oregon, rev. 1963:
Newton | 0.50 |
| 11. | A collection of articles on meteorites, 1968: (reprints, The ORE BIN). . | 1.00 |
| 12. | Index to published geologic mapping in Oregon, 1968: Corcoran | Free |
| 13. | Index to The ORE BIN, 1950-1969, 1970: M. Lewis | 0.30 |
| 14. | Thermal springs and wells, 1970: R. G. Bowen and N. V. Peterson . . . | 1.00 |

MISCELLANEOUS PUBLICATIONS

- | | |
|---|------|
| Oregon quicksilver localities map (22" x 34"), 1946 | 0.30 |
| Landforms of Oregon: a physiographic sketch (17" x 22"), 1941 | 0.25 |
| Index to topographic mapping in Oregon, 1968 | Free |
| Geologic time chart for Oregon, 1961 | Free |

OIL and GAS INVESTIGATIONS SERIES

- | | | |
|----|--|------|
| 1. | Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:
Newton and Corcoran | 2.50 |
| 2. | Subsurface geology of the lower Columbia and Willamette basins, Oregon,
1969: Newton | 2.50 |

The Ore Bin



Vol. 33, No. 6
June 1971

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

The Ore Bin

Published Monthly By

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
Head Office: 1069 State Office Bldg., Portland, Oregon - 97201
Telephone: 229 - 5580

FIELD OFFICES

2033 First Street	521 N. E. "E" Street
Baker 97814	Grants Pass 97526

X X X X X X X X X X X X X X X X X X X

Subscription rate \$1.00 per year. Available back issues 10 cents each.

Second class postage paid
at Portland, Oregon

X X X X X X X X X X X X X X X X X X X

GOVERNING BOARD

Fayette I. Bristol, Rogue River, Chairman
R. W. deWeese, Portland
Harold Banta, Baker

STATE GEOLOGIST

R. E. Corcoran

GEOLOGISTS IN CHARGE OF FIELD OFFICES

Norman S. Wagner, Baker Len Ramp, Grants Pass

X X X X X X X X X X X X X X X X X X X

Permission is granted to reprint information contained herein.
Credit given the State of Oregon Department of Geology and Mineral Industries
for compiling this information will be appreciated.

EVIDENCE FOR THE PORTLAND HILLS FAULT

By J. H. Balsillie and G. T. Benson
Department of Earth Sciences, Portland State University

Introduction

Downtown Portland is bounded on the west by a broad, partly dissected ridge named the Tualatin Mountains on topographic maps and locally called the Portland Hills. The linear character of the east front of the hills strongly suggests faulting (fig. 1). For obvious practical reasons, the evidence for such a fault (commonly called the Portland Hills fault) deserves careful investigation.

The Portland Hills, which stand about 1,000 feet higher than the Willamette Valley to the east, are the physiographic expression of an anticline. The west limb and crest of the structure are adequately defined, but the east flank poses the immediate problem: It may represent a normal fold limb within the area of the hills; it may represent a normal fold limb east of the present front of the hills, which has been eroded and covered by Quaternary sediments; or it may represent a fault. These alternative hypotheses may be evaluated on the bases of structural data, geomorphic features, and seismic records. This paper is primarily concerned with the area northwest of Portland -- Forest Park in the hills, and along the west bank of the Willamette River from the south end of Suavie Island to about Vaughn Street-- where the evidence for the Portland Hills fault seems least equivocal.

Diller (1916) described the uplift of Portland Heights, but did not analyze the structure; he did, however, postulate northwest-trending faults between southeast Portland and Oregon City. Treasher (1942) noted the escarpment of the east front of the Portland Hills and considered it possibly indicative of faulting, but he excluded faulting from his interpretation for lack of direct evidence. Trimble (1963) did not show a fault at the east front of the hills on his geologic map and cross section of Portland, and he did not mention faulting as a possibility in his report. On the other hand, various authors, such as Schlicker and others (1964), have noted seismic



Figure 1. Oblique aerial view looking northwest over downtown Portland and along the east side of the Portland Hills. Photo by L. A. Palmer, prepared by T. R. Bessler.

events which would support the presence of a fault with a projected trace along the eastern foot of the hills. Schlicker and Deacon (1967) showed a segment of the inferred fault and described it as a major structural feature of the region. Thus there is disagreement among geologists who have studied the area as to the existence of the Portland Hills fault.

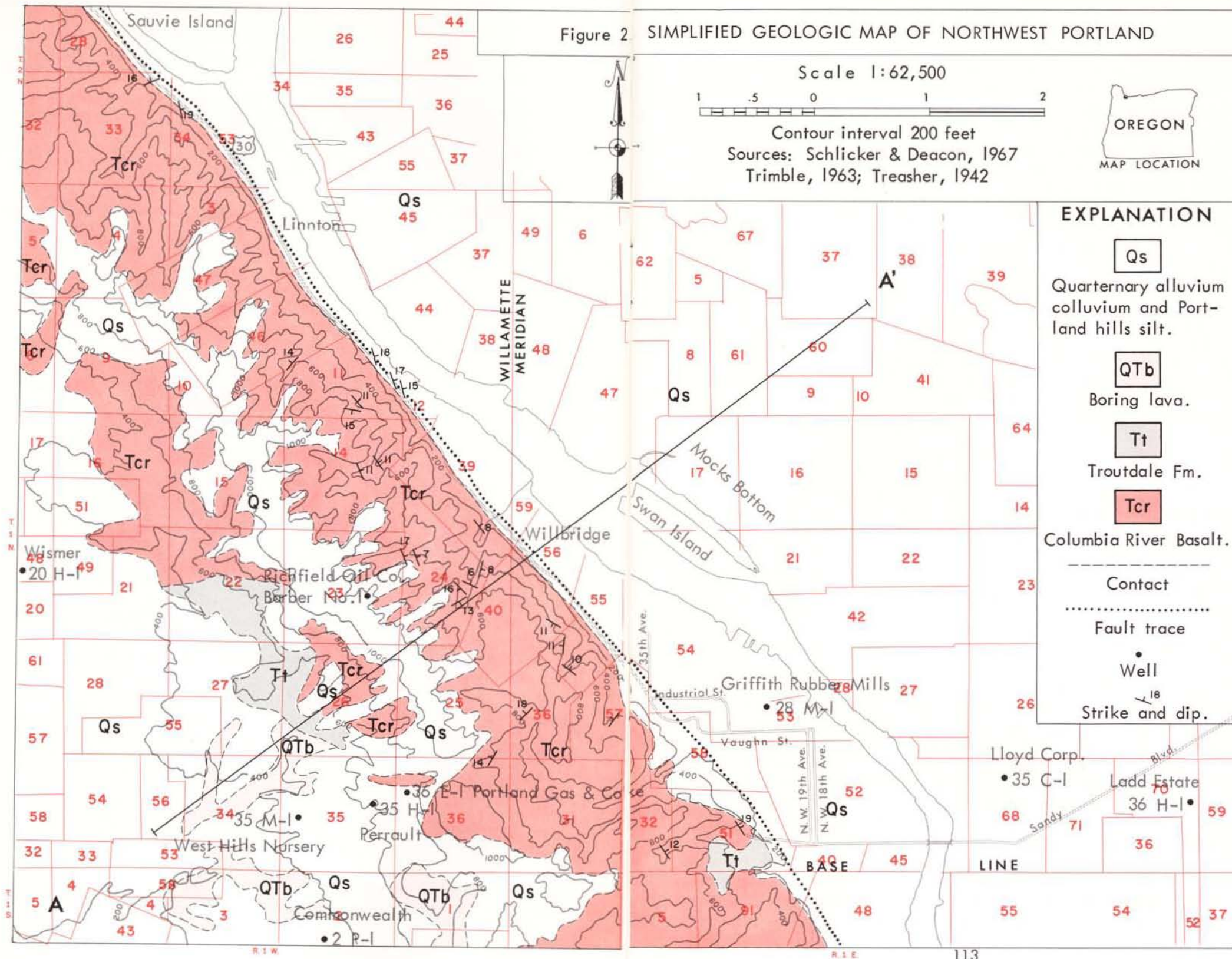
Rock Units

Stratigraphic units in the Portland area have been described by Treasher (1942) and Trimble (1963) among others. The following summary is based largely on published work and is simplified, omitting stratigraphic details which are not immediately pertinent. Units discussed are shown on the accompanying map (fig. 2) and cross sections (figs. 3A and 3B).

Columbia River Basalt (Tcr) underlies the whole area and is the oldest unit exposed, forming the core of the Portland Hills anticline (fig. 2). Fresh, dark gray to black, dense basalt, with well-developed columnar or close-cubic ("brick-bat") jointing, is exposed in roadcuts. Natural outcrops, however, are generally deeply weathered; the weathered zone (saprolite), up to 30 feet thick, consists of red to brown clay with fragments of decomposed basalt. Individual flows are 30 to 60 feet thick; weathered flow tops, and breccia and ash units have been recognized (Schlicker and Deacon, 1967). Although detailed petrographic studies were not made, the basalt is identified as Columbia River on the bases of stratigraphic position and gross lithologic similarity to the Columbia River Basalt in the Columbia Gorge.

In the Richfield Oil Co. "Barber no. 1" (sec. 23, T. 1, N., R. 1 W., near the top of the hills), Columbia River Basalt was encountered beneath mantle at 97 feet, and marine sedimentary rocks beneath the basalt at 803 feet (Hart and Newcomb, 1965). On the detailed cross section (fig. 3-B), the surface location of the well (elevation 1,047 feet) is shown approximately 200 feet below the projected top of the basalt. The pre-erosion top of the basalt may have been as little as 100 feet above the present surface at the well. This projection of the top of the basalt is important as it bears on the estimated throw of the fault.

In the subsurface beneath Portland, the Columbia River Basalt is overlain by the Sandy River Mudstone (Tsr on fig. 3-A). This unit is about 1,000 feet thick under east Portland (Trimble, 1963), but thins westward and is missing in wells immediately east of the front of the hills (Brown, 1963). The Troutdale Formation (Tt) of Pliocene age overlies the Sandy River Mudstone and the Columbia River Basalt (Hodge, 1938; Trimble, 1963). Isolated remnants of gravels of characteristic Troutdale lithology are mapped on the east side of the Portland Hills at elevations up to 600 feet. The Troutdale Formation has been recognized on the west slope of the hills and in the Tualatin basin to the west in finer-grained facies (Schlicker and Deacon, 1967). Distribution, thickness, and lithology of these units suggest that the Portland Hills structure has been developing, probably more or less



continuously, at least since Columbia River Basalt time.

Boring lava (QTb) of late Pliocene or early Pleistocene age is locally exposed on the crest and west slope of the Portland Hills. The Boring lavas are olivine basalt (or andesitic olivine basalt) distinguished by gray color, blocky or platy jointing, and diktytaxitic texture (Schlicker and Deacon, 1967). The thickness of the Boring is quite variable, depending on proximity to local vents. Various lines of Boring vents have been noted in the greater Portland area; one of these roughly follows the crest of the Portland Hills.

Quaternary sediments (Qs) deposited mainly in fluvial environments cover the Portland and Tualatin basins. Where Boring lavas are missing, discrimination between Quaternary deposits and underlying Troutdale Formation in well records is difficult. Absence of Troutdale exposures in the cliff at Mocks Bottom indicates a thickness of at least 90 feet of Quaternary deposits in the vicinity of the Willamette River. A relatively thin mantle of buff colored, cohesive silt covers much of the upper part of the Portland Hills. This unit has been identified as Portland Hills Silt (Lowry and Baldwin, 1952), loess of Quaternary age (Trimble, 1963), and Upland Silt (Schlicker and Deacon, 1967).

Structural Evidence

As noted above, the Portland Hills (Tualatin Mountains) are the expression of an anticline with Columbia River Basalt exposed in the core. The Tualatin and Portland basins, to the west and east respectively, are synclinal and largely filled with younger deposits covering the basalt (fig. 2). The axis of the anticline trends north-northwest, generally following the crest of the hills, but the top of the structure is broad and crenulated (fig. 3A).

Detailed study of the structure is hampered by lack of readily measurable bedding attitudes; exposures of flow surfaces and interbeds in the Columbia River Basalt are relatively scarce. Columnar joints, however, are commonly well displayed in roadcuts. As these joint columns are primary structures formed perpendicular to cooling surfaces, planes normal to column axes may be taken as geometric approximations (phantoms) of flow surfaces. The Columbia River Basalt flows spread widely over fairly gentle slopes, and flow surfaces were presumably nearly horizontal. Thus, present orientations of column axes and deduced phantom flow surfaces should record post-cooling deformation. The problem of column fans and irregular flow surfaces is avoided by considering only continuous exposures of reasonable length and uniform column orientations. (Independent measurements suggested that magnetite in the basalt had little effect on compass strike readings.)

Orientations of 75 column axes were used to determine average phantom flow surface attitudes in 21 localities in Forest Park northwest of Portland. Phantom flow surface attitudes shown on the map (fig. 2) were projected

into the detailed cross section (fig. 3-B) as apparent dips. These dips were used to extend the projected top of the Columbia River Basalt eastward from the Richfield Barber well. The geometrically constructed cross section (fig. 3-B) is compatible with faulting. The top of the Columbia River Basalt immediately west of the projected fault is located approximately 700 feet above sea level; east of the fault it is placed at about sea level. Thus the dip-slip component of displacement on the fault is about 750 feet. Easterly dips, which are obvious along the highway at the foot of the hills, are not found at higher elevations (fig. 3-B), and these dips have little effect on the projection of the top of the basalt. The easterly dips could be attributed to drag adjacent to the fault.

Geomorphic Evidence

Several physiographic features indicative of faulting along the east front of the Portland Hills are apparent on the Portland and Linnton 7 1/2' topographic quadrangle maps and on aerial photographs: 1) The eastern front of the hills is markedly linear. A straight edge can be placed along the break in slope on the map for as much as two miles; the break in slope lies within 250 feet of a line drawn from the intersection of NW. 35th and Industrial Streets in Portland to the highway at Linnton, five miles to the northwest. Segments of the line everywhere trend within 8° of N. 38° W. It seems hardly credible that the river could have cut such a straight valley side leaving no meander scars. 2) Spur ridges extending northeast from the crest of the hills terminate in aligned triangular facets. A straight edge can be used to follow the same contour from one facet to the next; breaks in slope at the tops of the facets are roughly aligned. The notable uniformity of facets may be accounted for in part by the uniform lithology and resistance to erosion of the Columbia River Basalt which forms them. 3) Cross profiles of canyons of northeast-flowing streams have wine-glass shapes, and long profiles of some of these streams show nick points; both features are indicative of local rejuvenation.

These physiographic features suggest not only that the eastern front of the Portland Hills is a fault-line escarpment, but also that movement on the fault has been relatively recent.

Anomalous benches low on facets in several localities are evident on aerial photographs (though not on topographic maps). At least one of these benches, just south of Willbridge, could not be a simple river terrace as it slopes gently southeast (upstream). Perhaps these benches are related to faulting, but this idea needs further investigation.

South of Vaughn Street, the physiographic front is less well defined, although it does continue and is generally linear. Contours on the top of the Columbia River Basalt beneath downtown Portland (based on data from Brown, 1963) suggest several steep zones in the subsurface east of the front of the hills. This raises the possibility of more than one fault in the area.

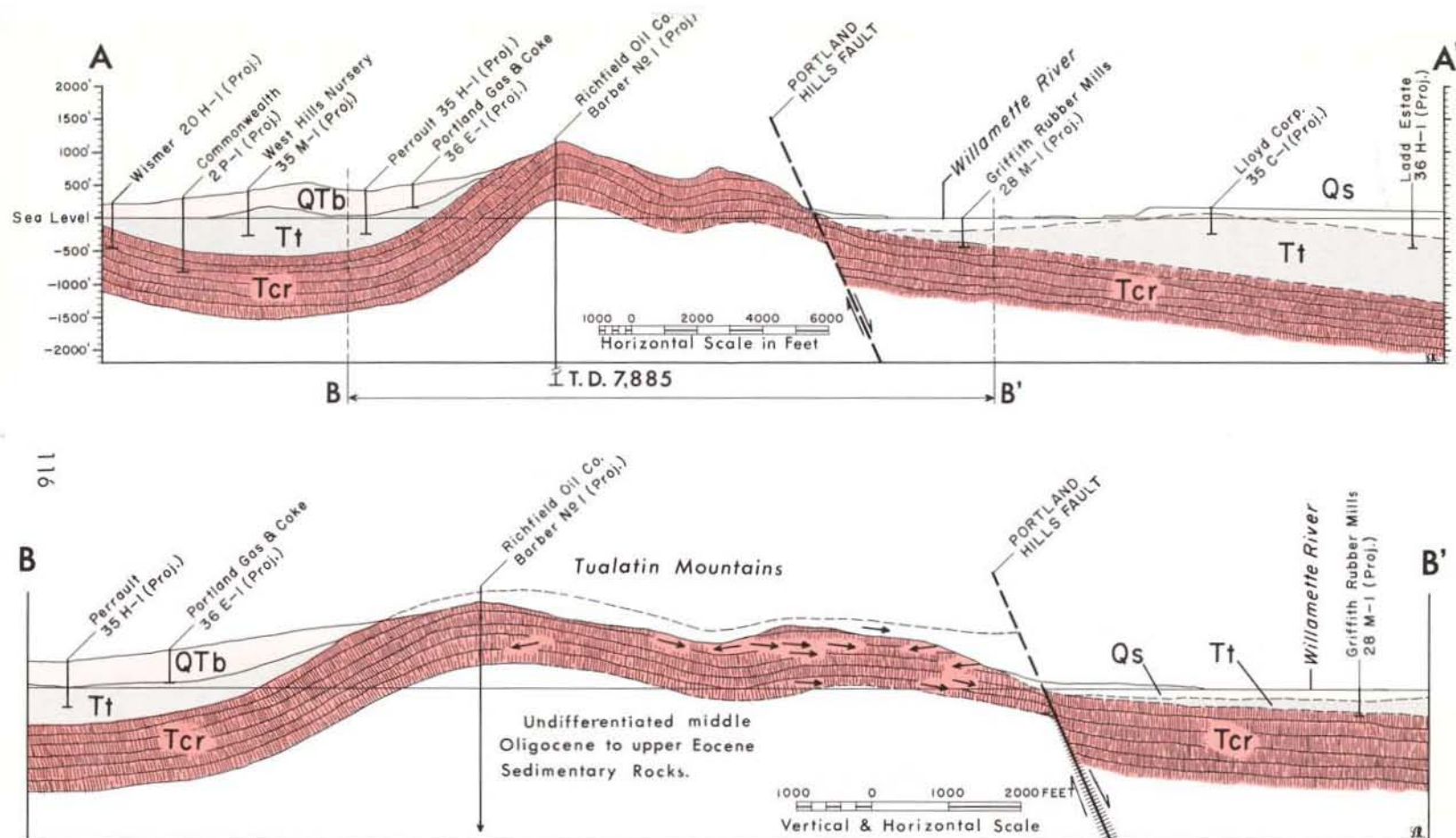


Figure 3 A & B. Geologic cross section. (Well data from Brown, 1963, Hart and Newcomb, 1965, and Hogenson and Foxworthy, 1965.)

Seismic Evidence

Of the 240 earthquakes felt in Oregon between 1841 and 1958, 51 were reported in the Portland area (Berg and Baker, 1963). Although this proportion may reflect population distribution in part, Portland is certainly among the more active seismic areas in the state. In the last few years about one shock has been felt in the Portland area per year. Some of these shocks have caused minor damage, but no ground breakage or other evidence of surface faulting has been reported.

The most useful seismic data obtained to date came from the earthquake of November 5, 1962 and its aftershocks (Dehlinger and Berg, 1962; Dehlinger and others, 1963). Based on revised travel-time curves, the epicenter of the principal event was placed at lat. $45^{\circ} 36' N$, long. $122^{\circ} 40' W$, between Portland and Vancouver, Washington. The depth of focus was estimated between 15 and 20 km (10 to 12 miles). This would be compatible with a normal fault having a surface trace at the eastern base of the Portland Hills and a northeasterly dip between 63° and 69° (shown as limits in fig. 3-B). Detailed studies related the aftershocks to the Portland Hills escarpment (Westphal, 1962).

Discussion

Of the alternative explanations of the eastern flank of the Portland Hills structure, a normal fold limb within the area of the hills is ruled out by structural data; there is simply not enough room to fit the fold limb. The possibility that the eastern limb of the fold has been eroded and buried cannot be eliminated owing to lack of attitudes in the Columbia River Basalt under the younger cover. Preference must be given to faulting as the explanation, however, on the basis of three separate lines of evidence--structural, geomorphic, and seismic.

The axiom of field geology, "when in doubt, don't map a fault," certainly has merit. But where several lines of indirect evidence suggest the presence of a fault, it should be mapped at least as inferred--particularly in a populated area. Here the fault should be carefully investigated and considered in urban planning and structural design. We must assume that the Portland Hills fault does exist and that it is active.

Acknowledgments

Kathleen Manning helped in all phases of this study. L. A. Palmer, R. J. Deacon, and P. E. Hammond read the manuscript and made valuable suggestions. Martha Appleman prepared the original drawings. Work was partly supported by Portland State University Research and Publications Fund Grant no. 493.

References Cited

- Berg J. W., Jr., and Baker, C. D., 1963, Oregon earthquakes, 1841 through 1958: *Seismol. Soc. Amer. Bull.*, vol. 53, p. 95-108.
- Brown, S. G., 1963, Problems of utilizing ground water in the west-side business district of Portland, Oregon: U. S. Geol. Survey water-supply Paper 1619-O, 42 p.
- Dehlinger, Peter, and Berg, J. W., Jr., 1962, The Portland earthquake of Nov. 5, 1962: Oregon Dept. Geology and Mineral Industries, The Ore Bin, vol. 24, no. 11, p. 185-188.
- Dehlinger, P., Bowen, R. G., Chiburis, E. F., and Westphal, W. H., 1963, Investigations of the earthquake of November 5, 1962 north of Portland: Oregon Dept. Geology and Mineral Industries, The Ore Bin, vol. 25, no. 4, p. 53-68.
- Diller, T. S., 1916, Guidebook of the western United States, Part D., The Shasta route and coast line: U. S. Geol. Survey Bull. 614, 146 p.
- Hart, D. H., and Newcomb, R. C., 1965, Geology and ground water of the Tualatin Valley, Oregon: U. S. Geological Survey Water-supply Paper 1967.
- Hodge, E. T., 1938, Geology of the lower Columbia River: *Geol. Soc. Amer. Bull.*, vol. 49, p. 836-929.
- Hogenson, G. M., and Foxworthy, B. L., 1965, Ground water in the east Portland area, Oregon: U. S. Geol. Survey Water-supply Paper 1793, 78 p.
- Lowry, W. D., and Baldwin, E. M., 1952, Late Cenozoic geology of the lower Columbia River Valley, Oregon and Washington: *Geol. Soc. Amer. Bull.*, vol. 63, p. 1-24.
- Schlicker, H. G., and Deacon, R. J., 1967, Engineering geology of the Tualatin Valley region, Oregon: Oregon Dept. Geology and Mineral Industries Bull. 60, 103 p.
- Schlicker, H. G., Deacon, R. J., and Twelker, N. H., 1964, Earthquake geology of the Portland area, Oregon: Oregon Dept. Geology and Mineral Industries, The Ore Bin, vol. 26, no. 12, p. 209-230.
- Treasher, R. C., 1942, Geologic history of the Portland area: Oregon Dept. Geology and Mineral Industries Short Paper 7, 17 p.
- Trimble, D. E., 1963, Geology of Portland, Oregon and adjacent areas: U. S. Geol. Survey Bull. 1119, 119 p.
- Westphal, W. H., 1962, Seismic aftershock investigations - Project Vela. Portland, Oregon, earthquake of 6 November 1962: Stanford Research Inst. Technical Report no. 1, 11 p.

* * * * *

OREGON EOCENE DECAPOD CRUSTACEA

By W. N. Orr and M. A. Kooser
Department of Geology, University of Oregon

Introduction

Although they are locally ubiquitous, fossilized crabs are seldom common in the Tertiary fossil record of the Pacific Northwest. Literature on this invertebrate group for the same area is limited to a few papers describing individual new species or faunal lists which include an occasional note on decapods. The most authoritative compendium at present on the fossil crabs of the west coast was produced by Mary J. Rathbun in 1926.

The present paper is to describe a particularly well-preserved assemblage of middle Eocene crabs found in association with a diverse invertebrate community in exposures of the Umpqua Formation in southwest Oregon.

Location

Collections described here were obtained from exposures of the Umpqua Formation in road cuts along road 3406 adjacent to Snout Creek in the N $\frac{1}{2}$, SW $\frac{1}{4}$ sec. 9, T. 35S., R. 11 W., between 2.5 and 3 miles east of Agness, Oregon (fig. 1). Most of the exposures along this road were found to be fossiliferous but the best single locality (U. of O. Locality no. 2594) is 3 miles east of Agness in the cut on the south side of the road. These sediments have been mapped and described by several authors but undoubtedly the most recent and continuing efforts in the area are by Baldwin (1961, 1963, 1964, 1965). According to that author [(1965) and oral communication], sediments in the area under study are from an interval in the upper half of the Umpqua Formation. Locally the sediments along Snout Creek dip gently to the west and are part of a syncline plunging to the northeast. The Umpqua Formation in the immediate vicinity consists of black to grey calcareous siltstones that weather yellow and tan upon oxidation of the iron content. Within the siltstone, calcareous concretions from 1 cm up to 10 cm are common and it is in these concretions that the best preserved invertebrate specimens are to be found. Calcite-filled fractures and small-scale slickensides within the siltstone suggest considerable movement and deformation of the sediments after consolidation.

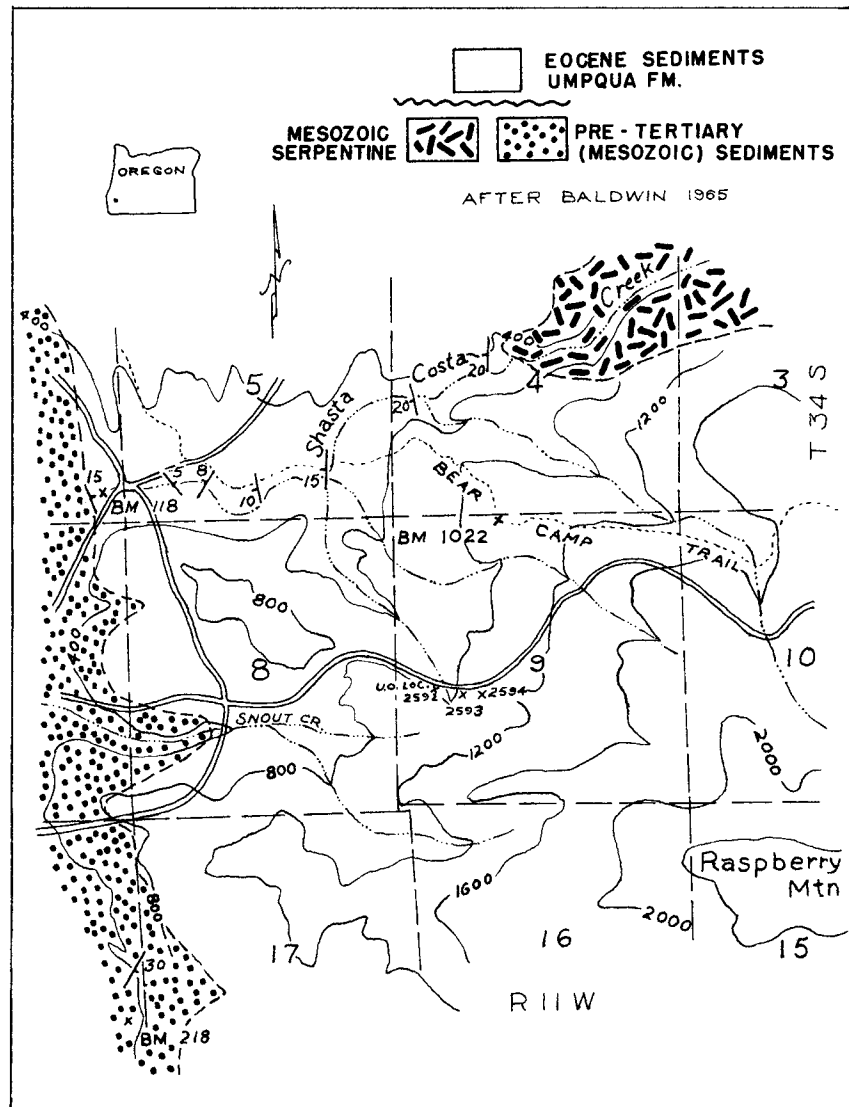


Figure 1. Geologic sketch map showing location of Univ. of Oreg. Mus. of Nat. Hist. Localities 2592, 2593, 2594. Geology from Baldwin [(1965) and oral communication].

Fossil Assemblage

Crabs

Fossilized crabs from these sediments are assigned to three genera and species including Raninoides washburnei Rathbun, Plagiolophus weaveri Rathbun and Cancer sp. The latter species is indeterminate and may be a new, as yet unnamed taxon.

By far the commonest species of crab recovered at any of the collecting sites was Plagiolophus weaveri. (figure 5A-I) This species is characterized by three prominent spines on the anterior periphery of the carapace and the large forward projecting orbits. Many of the living Pacific Coast crabs related to this species (family Goneplacidae) are burrowing types found in the mud flats of shallow bays and inlets. More than fifty complete carapaces of P. weaveri were recovered as well as several fragments sufficiently large for identification. This moderate number of whole specimens permits a simple analysis of growth in this species by plotting the width of the carapace against the length (fig. 2). With this type of graphic presentation, we are able to see that the ratio of width to length in the smallest individuals is very near one to one. Young adult specimens have a ratio of four to three whereas in mature adults the ratio is around three to two. A growth pattern of this type where the width increases at a more rapid rate than the length is not uncommon in decapods and is an expression of the rapid expansion of the branchial areas enclosing the gills within the lateral portions of the carapace. Males may be distinguished from females in this species by the slightly wider abdominal segments in females (fig. 5E & 5F). The observed ratio of males to females in the P. weaveri population was around four to one. Plagiolophus weaveri has been reported by Rathbun (1926) from several Eocene localities in California. Many of the specimens of P. weaveri represented in this study were complete articulated specimens. This was particularly true of specimens preserved in concretions. The frequency of whole specimens here suggests that these organisms were buried in a quiet or low-energy environment in the Eocene ocean. Another explanation for their outstanding preservation as fossils might lie in their habitat as borrowing organisms.

Somewhat less common at these localities was the species Raninoides washburnei Rathbun (fig. 4D, E, G). This species belongs to a family (Raninidae) of crabs that once lived along the north Pacific Coast. At present they are more representative of tropical to subtropical waters from Mexico to Panama (Rathbun 1926). Although no articulated specimens of R. washburnei were recovered, we were fortunate enough to extract a small specimen on which the sternum plates are displayed (fig. 3C, 4F). R. washburnei is characterized by the coarse punctations on the carapace, the outward projecting lateral spine off the ovate carapace and the broad bispinous outer orbital spine. Specimens of Raninoides washburnei have been reported (Rathbun 1926) from Oligocene sediments near Eugene, Oregon as well as

from middle Eocene sediments exposed in Douglas County, Oregon.

The final decapod species recovered from the southwest Oregon locality has been assigned to the genus Cancer because of subelliptical carapace outline, small orbits and the rows of five tooth-like spines on the anterior lateral margins (fig. 4H, I). Only a very few specimens assignable to this taxon were recovered and most were fragments. The difficulty of assigning even whole specimens to a recognized species, however, suggests that they may belong to a new species. The genus Cancer is commonly represented by several species in the Tertiary fossil record of the Pacific Northwest (Nations 1969) and is known from rocks dating from the Paleocene to the Holocene.

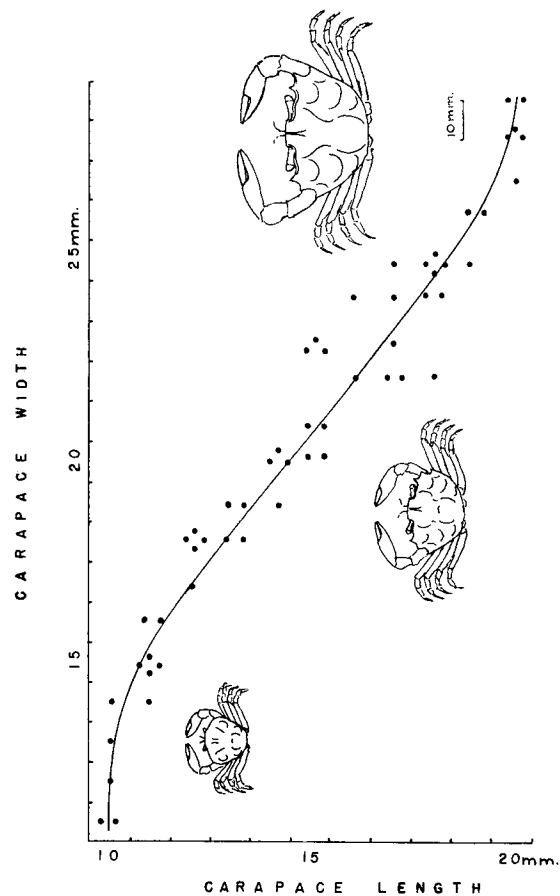


Figure 2. Length/ width distribution in the species Plagiolophus weaveri Rathbun.

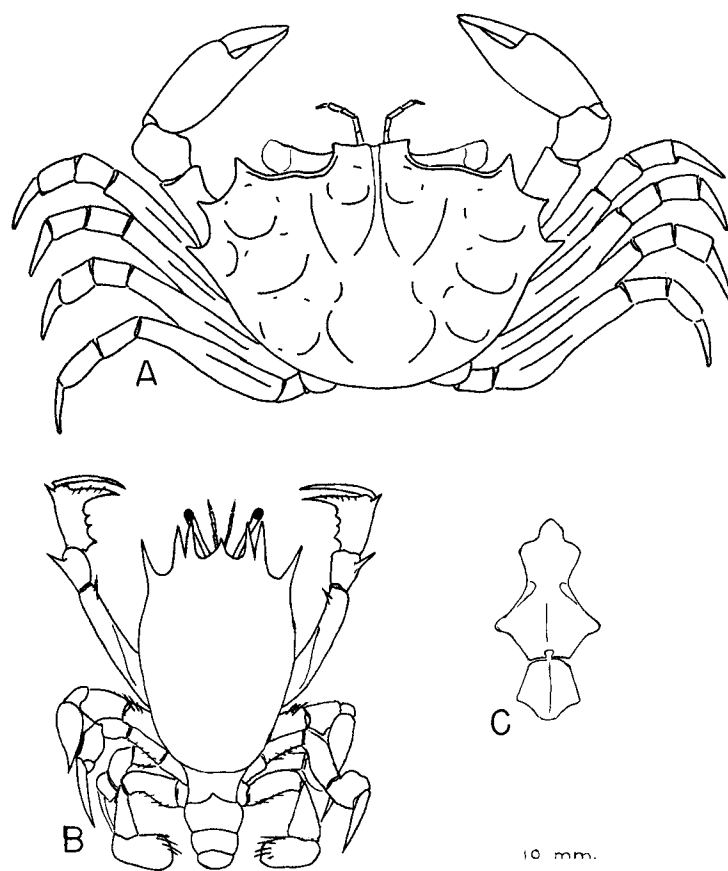


Figure 3. Reconstruction of *Plagiolophus weaveri* Rathbun (3A) and *Raninoides washburnei* Rathbun (3B), Sternum of *Raninoides washburnei* Rathbun (first and second segments and episternum) (3C). Details of reconstructed legs here as well as those on figure 2 are not precise (particularly those of *R. washburnei*) and are primarily to show the proportions of the carapace with respect to the entire body.

Echinoderms

Several specimens of irregular echinoids were recovered at the localities. Most of the specimens were small (2 cm dia. or less) and were considerably distorted. The specimens are characterized by well-defined, depressed

SPECIES LIST

MOLLUSCA

Pelecypods

Acila decisa (Conrad)

Anomia mcgoniglenensis Hanna

Crassatella cf. uvasana mathewsoni (Gabb)

Glycimeris fresnoensis Dickerson

Nuculana gabbi (Gabb)

Ostrea sp.

Solena (Eosolen) cf. coosensis Turner

Tellina soledadensis Hanna

Gastropods

Fusinus merriami Dickerson

Homalopoma wattsi (Dickerson)

Mitra cretacea Gabb

Olivella mathewsoni umpquaensis Turner

Siphonalia cf. bicarinata Dickerson

Turritella buwaldana coosensis Merriam

Volutocorbis oregonensis Turner

Scaphopods

Dentalina sp.

FORAMINIFERA

Bathysiphon eocenica Cushman & Hanna

Dentalina jacksonensis (Cushman & Applin)

Haplophragmoides cf. scitulum (Brady)

Haplophragmoides obliquicameratus Marks

Haplophragmoides sp.

Lenticulina sp.

Lenticulina theta Cole

Marginulina subbulata Hantken

Nodosaria pyrula D'Orbigny

Pseudoglandulina ovata Cushman & Applin

Rhabdammina eocenica Cushman & Hanna

Robulus alato-limbatus Gumbel

Spiroplectammina richardi Martin

Textularia sp.

Trochammina sp.

EXPLANATION FOR FIGURES 4 AND 5

Figure 4. A, B, C, Chela and leg segments of Plagiolophus weaveri Rathbun

A University of Oregon Museum of Natural History hypotype No. 28220
Length 25 mm Loc. No. 2594

B U.O.M.N.H. No. 28221 Length 23 mm Loc. No. 2594

C U.O.M.N.H. No. 28222 Length 25 mm Loc. No. 2594

D, E, G, Raninoides washburnei Rathbun, carapaces

D U.O.M.N.H. No. 28223 Length 33 mm Loc. No. 2594

E U.O.M.N.H. No. 29224 Length 36 mm Loc. No. 2594

G U.O.M.N.H. No. 29225 Length 22 mm Loc. No. 2594

F Raninoides washburnei Rathbun, sternum (first and second segments and episternum) U.O.M.N.H. No. 28226 Length 19 mm Loc. No. 2594

H, I Cancer sp. ventral (H) and dorsal (I) views of male carapace
U.O.M.N.H. No. 28227 Length 26 mm Loc. No. 2594

Figure 5. All specimens Plagiolophus weaveri Rathbun

A Juvenile, dorsal view of carapace U.O.M.N.H. No. 28228 Length 10 mm Loc. No. 2594

B Abdomen of small male U.O.M.N.H. No. 28229 Width 15 mm Loc. No. 2594

C Young adult, dorsal view of carapace U.O.M.N.H. No. 28230 Width 14 mm Loc. No. 2594

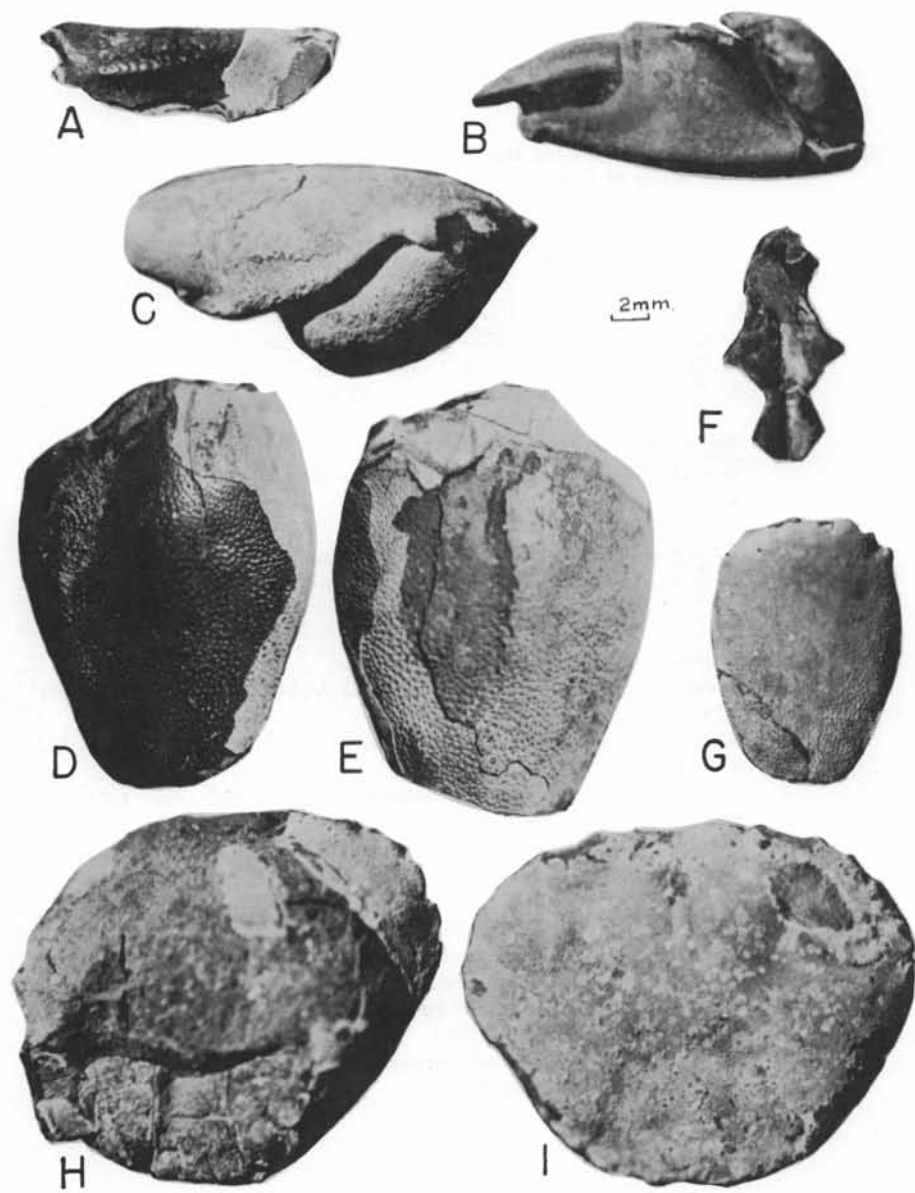
D Mature adult, dorsal view of carapace U.O.M.N.H. No. 28231 Width 24 mm Loc. No. 2594

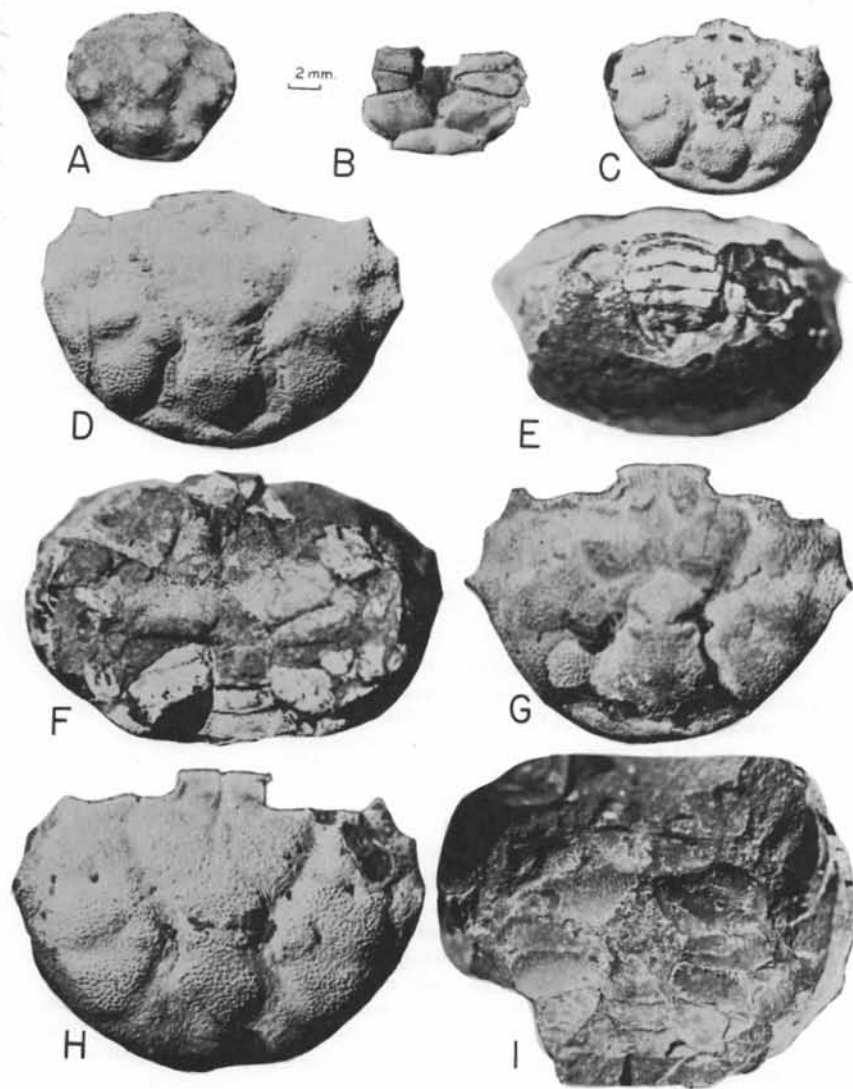
F Mature male, ventral view of carapace U.O.M.N.H. No. 28232 Width 28 mm Loc. No. 2594

E, G Posterior and dorsal views of carapace of a mature female U.O.M.N.H. No. 28233 Width 25 mm Loc. No. 2594

H Mature adult, dorsal view of carapace U.O.M.N.H. No. 28234 Width 28 mm Loc. No. 2594

I Adult male ventral view of carapace U.O.M.N.H. No. 28235 Width 20 mm Loc. No. 2594





ambulacral areas divided by sharp ridges. Because of the distortion it was not possible to immediately identify these organisms. Echinoid spines from both sand dollar and urchin types of echinoids were among the more common components of the biogeneous portion of the sediments.

Molluscs

Associated with the decapods at every locality was a diverse and well-preserved molluscan fauna. The fauna is made up of nearly equal numbers of gastropods and pelecypods and a very few, small scaphopod specimens (see species list). All of the molluscan species identified have been previously reported from Eocene rocks by Turner (1938) and Thoms (1964). Upon initial examination it was noticed that almost every molluscan specimen recovered was remarkably small. As a working hypothesis, the possibility that we were collecting a dwarf or depauperate fauna was considered. After some time was spent preparing the fauna, however, the large number of broken fragments of larger pelecypods and gastropods led us to the conclusion that the "dwarfism" phenomena was largely a post-consolidation deformation product. Larger specimens of molluscs may then have been more easily fragmented than the smaller, compact, geometrically competent specimens. It is possible that this phenomena may have had a similar effect on the decapods.

Protozoa

The protozoa are represented in the Umpqua sediments here by several species and most specimens are well preserved. In addition to the smaller calcareous and arenaceous foraminifera (list below), several perfect specimens of the larger foraminifera *Pseudophragmina psila* Woodring were recovered. This species has been reported by Thoms (1964) in both of his "Upper" and "Lower" Umpqua members. Despite the fact that several species of smaller foraminifera were identified it is difficult to assign a definitive correlation for the sediments other than middle Eocene. Most of the calcareous species are of the family Lagenidae whereas the remainder are characterized by an arenaceous test. The latter group is abundant even today in shallow bays and estuaries. The apparent lack of other families of foraminifera, particularly the planktonic Globigerinidae, further implies (but does not necessarily confirm) a shallow-water origin for the sediments and faunas under consideration here. Like many shallow-water forms, the foraminifera listed here tend to be stratigraphically long ranging. This may be due to a true longevity of the species involved or to the lack of sufficient distinguishable morphology on their relatively simple tests making them difficult to subdivide into evolutionary series. Most of these species range through several Eocene foraminiferal stages (Mallory 1959) and it is impossible to restrict the fauna to a shorter interval than the Ulatisian to Bulitian stages.

The presence of *Haplophragmoides obliquicameratus* Marks suggests the Narisian stage, as it is known only from that stage in California (Mallory 1959). Thoms (1964), however, has indicated that this species probably has a longer stratigraphic range in Oregon than in California on the basis of his study of Umpqua biostratigraphy. Thoms (1965) further correlates sediments from what is apparently the same stratigraphic interval with the late Ulatisian to late Penutian stages of Mallory (1959). Stratigraphic evidence presented by Baldwin [(1965) and oral communication] largely corroborates Thoms' (1964) correlation.

Bibliography

- Baldwin, E. M., 1961, Geologic map of the lower Umpqua River area, Oregon: U. S. Geol. Survey Map OM 204.
- _____, 1963, Lower and middle Eocene formations of southwestern Oregon: Geol. Soc. Amer. Spec. Paper 76, p. 188-189.
- _____, 1964a, Geology of Oregon: 2nd Edition, Eugene, Oregon, 165 p.
- _____, 1964b, Thrust faulting in the Roseburg area, Oregon: Oregon Dept. Geology and Mineral Industries, The Ore Bin, vol. 26, pp. 176-184.
- _____, 1965, Geology of the south end of the Oregon Coast Range Tertiary basin: Northwest Science, p. 93-103.
- Laiming, Boris, 1940, Some foraminiferal correlations in the Eocene of the San Joaquin Valley, California: Proc. 6th Pac. Sci. Cong., vol. 2, p. 535.
- Mallory, V. S., 1959, Lower Tertiary biostratigraphy of the California Coast Ranges: Am. Assoc. Petroleum Geol., Tulsa, Oklahoma, 416 p.
- Nations, J. Dale, 1969, The fossil record of *Cancer* on the West Coast of North America: Abstract G.S.A. Cordilleran Section 65th Ann. Mtg.
- Rathbun, Mary J., 1926, The fossil stalk-eyed Crustacea of the Pacific slope of North America: U. S. National Mus. Bull. 138, 155 p.
- Thoms, R. E., 1964, Biostratigraphy of the Umpqua Formation, southwest Oregon: Univ. California doctoral diss. (unpub.) 215 p.
- Turner, F. E., 1938, Stratigraphy and mollusca of the Eocene of western Oregon: Geol. Soc. Amer. Spec. Paper 10, 130 p.

Acknowledgements

The authors would like to express their appreciation to Dr. Ewart M. Baldwin for suggestions on the manuscript and to Michael E. Brownfield for help in photographing fossil specimens.

* * * * *

MINED LAND RECLAMATION BILL PASSES

House Bill 3013, popularly known as the "Mined Land Reclamation Bill," was approved by the state Senate on June 7, following earlier passage by the House. The measure becomes effective on July 1, 1972. All open pit mines and quarries which produce over 10,000 cubic yards per year will be subject to the provisions of the new law. Operations with excavations existing prior to the enactment of the law will not be required to reclaim worked-out areas, and operators having valid contracts with land owners as of January 1, 1971, are not subject during the life of the contract. This exemption does not apply after January 1, 1981, however.

Administration for the environmentally-oriented legislation rests with the State of Oregon Department of Geology and Mineral Industries. Funding will be derived solely from the \$100 permits and \$25 annual renewal fees. All operators, whether they have valid contracts or not, are subject to payment of the permit and annual renewal fees.

As stated in H.B. 3013, the purposes of the Act are:

- a. To provide that the usefulness, productivity and scenic values of all lands and water resources affected by surface mining operations within this state shall receive the greatest practical degree of protection and reclamation necessary for their intended subsequent use.
- b. To provide for cooperation between private and governmental entities in carrying out the purposes of this Act.

The Department of Geology intends to work closely with both industry and state and local government agencies in the preparation and administration of rules and regulations designed to permit the most economical extraction of mineral products while minimizing the adverse environmental effects both during the period of operation and afterwards.

* * * * *

DEPARTMENT ISSUES BULLETIN ON GEOLOGIC FORMATIONS

"Geologic Formations of Western Oregon," by John D. Beaulieu, has been published by the Department as Bulletin 70. The bulletin discusses all formations and units lying west of longitude 121°30', presenting pertinent data on distribution, lithology, contacts, structure, stratigraphy, and age. In compiling the information the author placed emphasis on the recent literature where possible. The publication includes correlation charts and an extensive bibliography. Bulletin 70 can be purchased from the Department's offices in Portland, Grants Pass, and Baker. The price is \$2.00.

* * * * *

CONFERENCE ON GEOTHERMAL POWER HELD IN OLYMPIA

On May 21 the Washington State Department of Natural Resources held the "First Northwest Conference on Geothermal Power" in Olympia. About 250 people from electrical utilities, governmental agencies, petroleum companies, mining firms, and the interested public heard several speakers discuss various factors concerning this developing industry.

The papers presented covered such subjects as the engineering and economic aspects of The Geysers steam field in California; electric energy demands of the Pacific Northwest; highlights of the United Nation's Geothermal Conference in Pisa, Italy; environmental effects of producing geothermal power; implementation of the Federal Geothermal Steam Act of 1970; a history of geothermal developments in the United States; exploration techniques for geothermal resources; and prospects for geothermal energy in Washington.

A discussion period held at the end of the meeting was highlighted by a proposal by Joseph W. Aidlin, General Council for Magma Power Company, for the establishment of a western geothermal council. The purpose of this council, to be composed of representatives of government, industry, and utilities, will be to advance the orderly development of geothermal resources. Bert Cole, Washington State Commissioner of Public Lands, volunteered the services of his Department to organize such a group.

* * * * *

LEGISLATURE ENACTS GEOTHERMAL DRILLING REGULATIONS

A law authorizing the State of Oregon Department of Geology and Mineral Industries to supervise and regulate the drilling, redrilling, operation, and abandonment of wells for the production of geothermal resources was enacted during this session of the legislature. The Department felt this law was necessary because, starting during the summer of 1971, a major effort will be expended within the state to appraise its geothermal potential.

Only two wells have been drilled in the state specifically for the purpose of finding steam for the production of electric power. The first, drilled north of Adel in the Warner Valley, was abandoned after it failed to produce fluid of sufficiently high temperature. Shortly after abandonment the well erupted as a continuous geyser until it was plugged several years later. The second well, drilled north of Lakeview by the same company, was abandoned at a shallow depth because of drilling difficulties.

Because uncontrolled blowouts are an ever present danger when working with the high pressure steam found in geothermal reservoirs, and because the drilling equipment and techniques are similar to those used in oil and gas exploration, the Department of Geology requested that authority to regulate this drilling be added to its already existing oil and gas drilling regulations.

* * * * *

DEPARTMENT TO CHARGE FOR ASSAY SERVICE

By legislative action in the passage of House Bill 2060 by the 1971 session of the Oregon State Legislature, and by authority of the Governing Board of the State Department of Geology and Mineral Industries, a fee is to be charged for all assays and chemical analyses made on rocks and minerals submitted to the Department for that purpose.

This is to go into effect on all samples received or postmarked on or after July 1, 1971. The following is a list of fees to be charged:

Gold	\$ 5.00	Iron	\$ 7.50
Silver	5.00	Magnesium	7.50
Gold and Silver	6.00	Manganese	7.50
Copper	7.50	Mercury	7.50
Lead	7.50	Molybdenum	10.00
Zinc	7.50	Nickel	7.50
Copper-Lead-Zinc	15.00	Phosphorus	7.50
Lead-Zinc	12.00	Platinum Group	12.00 each metal
Alumina	10.00	Rare Earths	30.00
Antimony	10.00	Silica	7.50
Barium	8.0	Tin	15.00
Calcium Oxide	8.00	Titanium	10.00
Chromium	10.00	Tungsten	15.00
Cobalt	10.00	Uranium	15.00
Loss on Ignition	3.00	Vanadium	7.50

Drying wet samples \$.75 per sample Prices for other analyses on request

There will be no limitation on the number of samples, and information concerning the legal description or ownership of the property will not be required. Fees for all analyses must accompany the samples. A convenient assay request blank will be provided upon request. Analytical results will be reported as promptly as possible after receipt of sample and fee.

* * * * *

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
39.	Geology and mineralization of Morning mine region, Grant County, Oregon 1948: R. M. Allen & T. P. Thayer.	1.00
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Groh, editors	3.50
58.	Geology of the Suplee-Izee area, Oregon, 1965: Dickinson and Vigrass	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dole,	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Mineral and water resources of Oregon, 1969	1.50
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970: Roberts	2.00
68.	The Seventeenth Biennial Report of the State Geologist, 1968-1970	Free
69.	Geology of the Southwestern Oregon Coast W. of 124th Meridian, 1971: R. H. Dott, Jr.	3.75

GEOLOGIC MAPS

Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others	0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37)	0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker	1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts	0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams	1.00
GMS-1: Geologic map of the Sparto quadrangle, Oregon, 1962: Prostka	1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon: 1962, Corcoran et. al.	1.50
GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka	1.50
Geologic map of Oregon west of 121st meridian: (over the counter	2.00
folded in envelope, \$2.15; rolled in map tube, \$2.50	

[Continued on back cover]

The ORE BIN
1069 State Office Bldg., Portland, Oregon 97201

The Ore Bin

POSTMASTER: Return postage guaranteed.



Available Publications, Continued:

SHORT PAPERS

- | | | |
|-----|---|---------|
| 2. | Industrial aluminum, a brief survey, 1940: Motz | \$ 0.10 |
| 18. | Radioactive minerals the prospectors should know (2nd rev.), 1955:
White and Schafer | 0.30 |
| 19. | Brick and tile industry in Oregon, 1949: Allen and Mason | 0.20 |
| 21. | Lightweight aggregate industry in Oregon, 1951: Mason | 0.25 |

MISCELLANEOUS PAPERS

- | | | |
|-----|---|------|
| 1. | Description of some Oregon rocks and minerals, 1950: Dole | 0.40 |
| 2. | Key to Oregon mineral deposits map, 1951: Mason | 0.15 |
| | Oregon mineral deposits map (22" x 34"), rev. 1958 (see M. P. 2 for key) | 0.30 |
| 3. | Facts about fossils (reprints), 1953 | 0.35 |
| 4. | Rules and regulations for conservation of oil and natural gas (rev. 1962) . | 1.00 |
| 5. | Oregon's gold placers (reprints), 1954 | 0.25 |
| 6. | Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton . . | 1.50 |
| 7. | Bibliography of theses on Oregon geology, 1959: Schlicker | 0.50 |
| 7. | (Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts . | 0.50 |
| 8. | Available well records of oil & gas exploration in Oregon, rev. 1963:
Newton | 0.50 |
| 11. | A collection of articles on meteorites, 1968: (reprints, The ORE BIN) . | 1.00 |
| 12. | Index to published geologic mapping in Oregon, 1968: Corcoran . . . | Free |
| 13. | Index to The ORE BIN, 1950-1969, 1970: M. Lewis | 0.30 |
| 14. | Thermal springs and wells, 1970: R. G. Bowen and N. V. Peterson . . | 1.00 |

MISCELLANEOUS PUBLICATIONS

- | | |
|---|------|
| Oregon quicksilver localities map (22" x 34"), 1946 | 0.30 |
| Landforms of Oregon: a physiographic sketch (17" x 22"), 1941 | 0.25 |
| Index to topographic mapping in Oregon, 1968 | Free |
| Geologic time chart for Oregon, 1961 | Free |

OIL and GAS INVESTIGATIONS SERIES

- | | | |
|----|--|------|
| 1. | Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:
Newton and Corcoran | 2.50 |
| 2. | Subsurface geology of the lower Columbia and Willamette basins, Oregon,
1969: Newton | 2.50 |

The Ore Bin



Vol. 33, No. 7
July 1971

**STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES**

The Ore Bin

Published Monthly By

STATE OF OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Head Office: 1069 State Office Bldg., Portland, Oregon - 97201

Telephone: 229 - 5580

FIELD OFFICES

2033 First Street	521 N. E. "E" Street
Baker 97814	Grants Pass 97526

X X X X X X X X X X X X X X X X X X X

Subscription rate \$1.00 per year. Available back issues 25 cents each.

Second class postage paid
at Portland, Oregon

X X X X X X X X X X X X X X X X X X X

GOVERNING BOARD

Fayette I. Bristol, Rogue River, Chairman
R. W. deWeese, Portland
Harold Banta, Baker

STATE GEOLOGIST

R. E. Corcoran

GEOLOGISTS IN CHARGE OF FIELD OFFICES

Norman S. Wagner, Baker Len Ramp, Grants Pass

X X X X X X X X X X X X X X X X X X X

Permission is granted to reprint information contained herein.
Credit given the State of Oregon Department of Geology and Mineral Industries
for compiling this information will be appreciated.

RELATION OF THE ELLENSBURG FORMATION TO EXTENSIONS OF
THE DALLES FORMATION IN THE AREA OF ARLINGTON
AND SHUTLER FLAT, NORTH CENTRAL OREGON

by R. C. Newcomb
Consulting Geologist, Portland, Oregon

The Columbia Plateaus physiographic province in the area of this report is characterized by the general basinal situation of the large east-west Dalles-Umatilla syncline. Within this broad downwarp, the local plateaus of about 1,000 feet altitude are bounded by the 200- to 700-foot declivities of the Columbia River Gorge and the canyons of the rivers and creeks that drain north to the Columbia River (see Fig. 1).

The bedrock belongs to the Columbia River Group, a 3,000-foot thick aggregation of accordantly layered basaltic lava flows. Only the top 1,000 feet or so of these lavas crop out in the study area. They have been designated as part of the Yakima Basalt. Interlayered below each of the upper two flows of the Yakima Basalt, and extending beyond the end of each, is a sedimentary member of the lower part of the Ellensburg Formation. Overlying both the basalt and the Ellensburg members are Pliocene gravels and tuffs, referred to as eastward extensions of the Dalles Formation (Newcomb, 1966). Pliocene and Quaternary loess, as well as Pleistocene and Holocene glaciofluvial deposits, colluvium, talus, and alluvium incompletely mantle the Tertiary rocks.

Except for some reconnaissance work, geologic studies have reached this area only from the north. Schmincke (1967) and Laval (1966) extended the members of the Yakima Basalt and the Ellensburg Formation to the north side of the Columbia River. As part of the investigations for the Chem-Nuclear Services, Inc.,* at their disposal site ten miles southwest of

*Thanks are due the Chem-Nuclear Services, Inc., for their contribution of the information obtained during the investigation of their site.

Arlington, the writer mapped the members of the Tertiary rocks and extended them northward to tie in with Schmincke's (1967) stratigraphic section. The mapping showed that the Ellensburg Formation plays a much more important part in the surface and near-surface geology of the area than had been reported previously (see Fig. 2).

Extension of the Ellensburg Members to Shutler Flat

The Rattlesnake Ridge member, the top member of the lower part of the Ellensburg Formation, crops out at intervals along the south wall of the Columbia River Gorge northeast of Arlington. The member is 40 to 60 feet thick and consists of lenticular beds of siltstone, sand, fine gravel, and several types of tuff and volcanic ash. It is overlain by the westward-thinning Elephant Mountain flow, the top flow of the Yakima Basalt. This basalt capping tapers to its western limit 3 miles northeast of Arlington. Both the Rattlesnake member and the Elephant Mountain basalt can be examined at intervals westward from the mouth of Willow Creek.

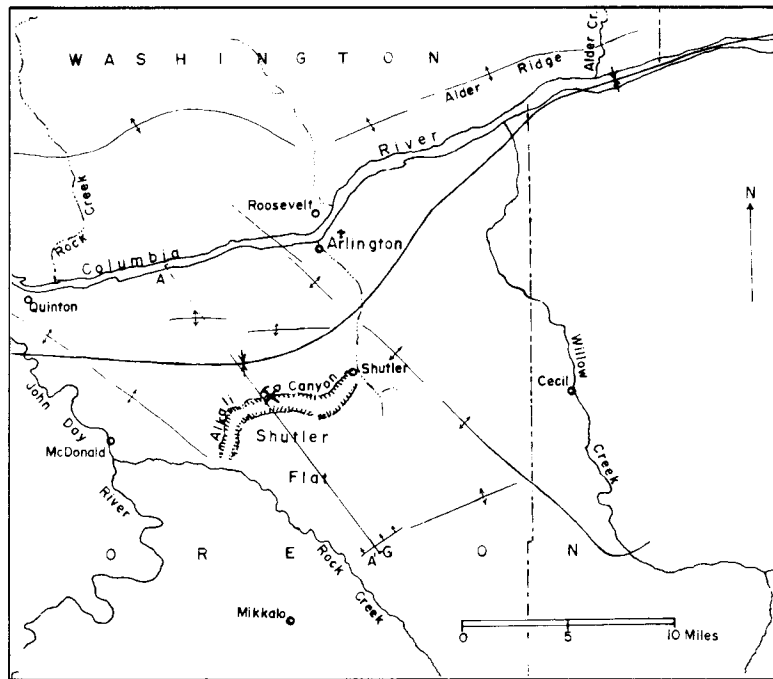


Figure 1. Map of the Arlington-Shutler area, Oregon.

Westward from the end of its basalt cap, the eroded remnants of the Rattlesnake Ridge member have few outcroppings and appear to be overlain, with erosional unconformity, by gravelly members of the Dalles Formation. In places, such as at the Gorge rim north of the Arlington Airport, the Rattlesnake Ridge member is entirely missing and Dalles conglomerate lies on the Pomona Basalt flow. It is believed that the Rattlesnake Ridge member occurs in places beneath the Dalles Formation southwest of Arlington. Its presence is indicated by the thickness of the Tertiary sedimentary section overlying the Pomona Basalt flow. This thickness exceeds the 70-foot maximum of the Dalles Formation observed elsewhere in the area.

In many places in south-central Washington, the Rattlesnake Ridge member contains much fluvial material, though at other places it is entirely fine-grained air-fall tuff. In the Yakima Valley it contains many, if not all, of the Columbia River-type of quartzitic gravels that occur in the Ellensburg Formation. No Columbia River-type gravels were seen within the member in this area. In general, the Rattlesnake Ridge member contains more fluvial materials than does the Selah member. This fluvial nature of the Rattlesnake Ridge member makes difficult its field distinction from the sedimentary facies of the Dalles Formation.

The Selah member of the Ellensburg Formation was traced by Schmincke (1967) from its type locality north of Yakima to its outcroppings in the Columbia River Gorge north of Arlington. Beneath the Pomona Basalt flow, the Selah member can be followed south from Arlington to Shutler where the Pomona flow tapers out along a general east-west line. South of the end of the Pomona flow, the slightly eroded top of the Selah member is overlain by the Dalles Formation in the few places where the Selah top can be observed (see Fig. 3).

Within this general north-south area through Arlington and Shutler Flat, the Selah member ranges from 130 to 300 feet in thickness, much greater than the 50 to 100-foot thickness common to other parts of its widespread occurrence in south central Washington. It is essentially all tuff composed of silt, clay- and sand-sized grains of volcanic glass, glass with crystallites, and crystalline fragments. A variable component of the mass has been altered to clay minerals. Most of the member is massive and coarsely bedded, but finely-bedded strata near its base have been logged in wells at Alkali Canyon. The tuff is compact but lacks cementation or welding of the grains. It has a high porosity, low permeability, and low specific gravity.

Basalt Below the Selah Member

Basalt flows below the Selah member include only a few thin sedimentary separations. A one-foot thick clay bed, beneath the first flow below the Selah at Arlington, may be an equivalent to the Mabton member of the

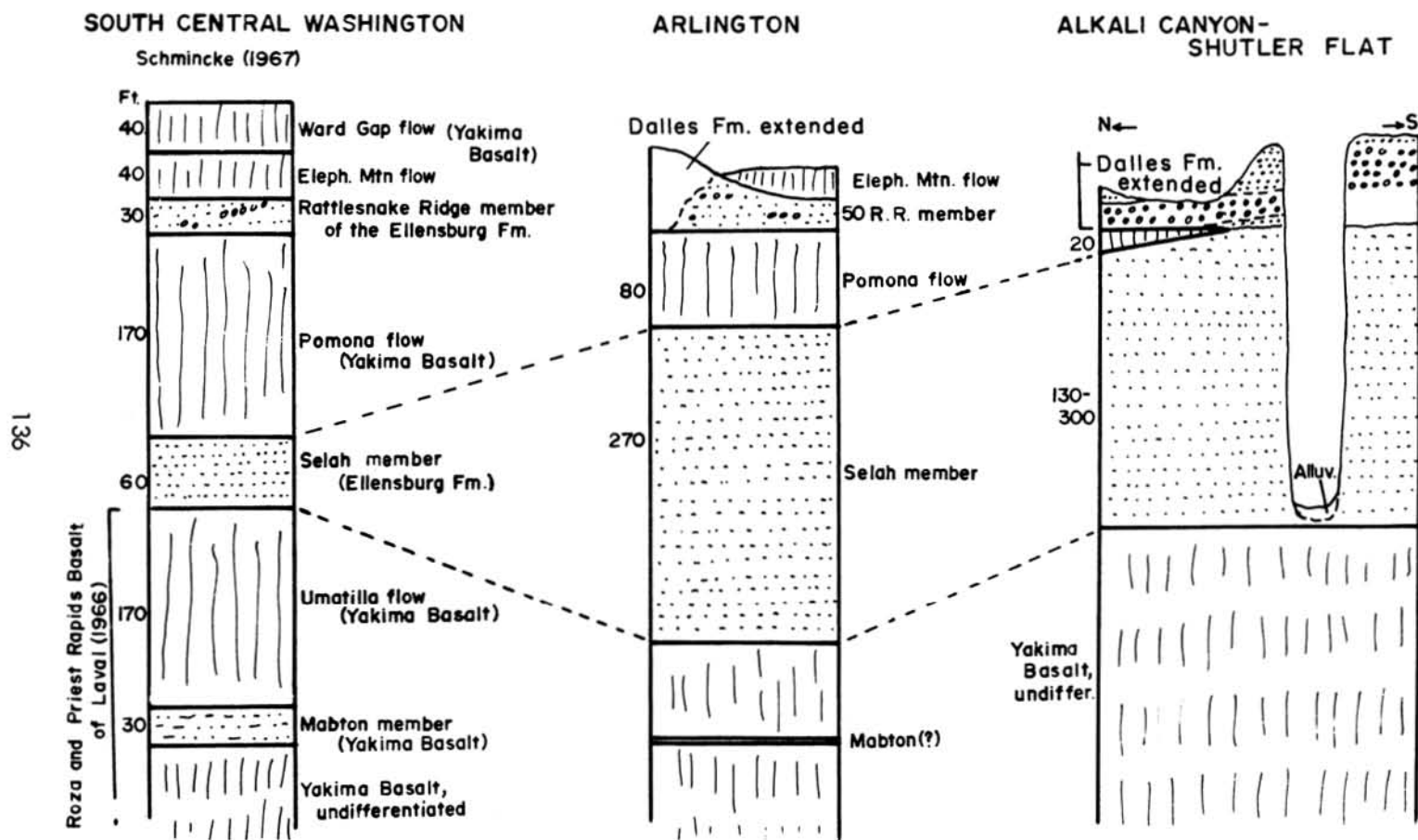


Figure 2. Type stratigraphic columns in south-central Washington and north-central Oregon.

Yakima Basalt that Schmincke (1967) observed farther north. This one-foot clay bed is not present either in surface exposures or in the drilling records of wells south of Arlington.

The first flows below the Selah member in the eastern end of Alder Ridge, 14 miles northeast of Roosevelt, were called the Priest Rapids Basalt by Laval (1966). A porphyritic basalt like that of the Roza flow, which underlies the Priest Rapids basalt of Laval (1966), was observed in railroad and highway cuts at 300 feet altitude $3\frac{1}{2}$ miles northeast of Roosevelt. Thus the exposed basalt below the Selah member in the Arlington area apparently includes equivalents of the Priest Rapids and Roza Flows.

Dalles Formation as Extended to This Area

In the face of the pozzuolana quarry, in the north bluff of Alkali Canyon, the Dalles Formation lies with erosional unconformity on the Selah member of the Ellensburg Formation. From the base upward the Dalles Formation consists of: 1) 10 to 20 feet of vitric rhyodacitic tuff, a lenticular and local occurrence; 2) 20 to 50 feet of pebble and cobble weakly-bonded conglomerate of Blue Mountains rock types; and 3) 30 feet of tan-brown silty tuff (see Fig. 4).

The local member of vitric tuff, the pozzuolana, lies between the Selah member and the conglomerate of the Dalles Formation; it is herein described with the Dalles Formation, though later work may prove that it belongs under another stratigraphic designation. A small outlying lens of the pozzuolana occurs on top of the Pomona flow at the head of Jones Canyon $1\frac{1}{2}$ miles northwest of the quarry exposure.

The basal part of the conglomerate in the quarry contains 4 to 8 feet of buff, silty, unbedded clay that is apparently a former loessal soil lying atop the pozzuolana.

The top (tuff) unit of the Dalles Formation has some indurated calcified zones, but on the whole it is poorly consolidated and has been extensively eroded by the wind.

In the south bluff of Alkali Canyon the conglomerate underlies the soils of Shutler Flat and lies upon the Selah tuff which continues downward 200 feet to the top of the basalt. Most of the soils of Shutler Flat are loessal; they are generally 10 to 15 feet thick beneath the upland parts of the area. If any significant amount of the light-brown tuff unit of the Dalles Formation remains upon the conglomerate beneath Shutler Flat, it has not been observed nor recorded in well logs.

In the sides of the shallow depressions of the plateau just north of the quarry the Dalles Formation lies on the Selah member, but half a mile north of the quarry the southern end of the Pomona flow separates the Selah member from the overlying Dalles Formation; in those outcrops there is no evidence of the Rattlesnake Ridge member. To the north of Alkali Canyon, the conglomerate member of the Dalles Formation, partly stripped of the

wind-vulnerable tan tuff member, underlies much of the upland surface that extends to the Columbia River Gorge.

The two principal units of the Dalles Formation in Alkali Canyon, the conglomerate and the overlying tan tuff, are lithologically and physiographically similar to units at the top of the Dalles Formation in Fifteen Mile Creek Valley 30 miles to the west. Likewise, they are similar to the sedimentary unit called Pliocene conglomerate, 28 miles to the east, by Hogenson (1964).

To the east of Arlington the relationships of the Dalles Formation to the Rattlesnake Ridge member of the Ellensburg Formation and to the Elephant Mountain basalt flow are not yet known. The following two conditions observed by the writer suggest, however, that these units may have been contemporaneous depositions: 1) No Dalles Formation lies upon that part of the Elephant Mountain basalt examined to date; and 2) the origins and lithologies (fluvial materials and air-fall tuff) of the Rattlesnake Ridge member and the "Dalles Formation extended" are, in general, similar.

The sedimentary units described above as belonging to the Ellensburg Formation and the Dalles Formation have been designated in reconnaissance work as Arlington Lake Beds (Hodge, 1932) and Shutler Formation (Hodge, 1942). These early designations included little specific petrologic or location data. Hodge correctly interpreted his Arlington Lake Beds as being older than the Columbia River Gorge (Hodge, 1932, p. 6).

Age of the Units

A collection of camel bones for which identification was secured by Foxworthy (1962, p. 19) determined the Selah member near its type locality to be probably early Pliocene. A small collection of vertebrate fossils from the sedimentary deposits (interpreted by the writer as Selah member) near the top of the Columbia River Gorge northeast of Roosevelt, was identified by the collecting group from California Institute of Technology as Barstovian (Arnold Shotwell, personal communication 1966). The radioisotope dates so far obtained for the Pomona flow place it in the range 12.3 to 13.3 million years, and an additional 68 per cent confidence interval expands the total range to 10.1 to 14.3 million years (Holmgren, 1969, p. 193). Thus the early Pliocene age of the Selah member as obtained by Foxworthy seems to be allowed by the subsequent determinations.

Discrepancies in the ages of sedimentary deposits assigned to the Dalles Formation were pointed out by Newcomb (1966). The early Pliocene age, generally accepted for paleobotanical and vertebrate fossils near the type area at The Dalles, was in conflict with a middle Pliocene (Hemphillian) age obtained on vertebrate fossils from what appear to be correlative deposits ("Dalles Formation extended") near Arlington and near McKay Reservoir 60 miles further east. Additional vertebrate specimens from the Dalles Formation near The Dalles reviewed since 1966, have been

interpreted as substantiating the early Pliocene age in the type area (Arnold Shotwell, personal communication 1967). Discrepancies still exist in the age (middle Pliocene) and in the stratigraphic assignment of the "Dalles Formation extended" in north central Oregon.

Conclusions

1. The top two flows of the Yakima Basalt taper out southward into the Ellensburg Formation near Arlington much as they do westward in the Yakima Valley.
2. The extension of the Selah member, and possibly of the Rattlesnake Ridge member, for many miles beyond the end of its capping basalt flows requires that large areas be mapped as Ellensburg Formation, a new experience for mappers in Oregon.
3. The relation of the lower part of the sedimentary facies of the "Dalles Formation extended" to the Rattlesnake Ridge member is not yet clear and the possibility that the two are in part contemporaneous has not been ruled out.
4. The Ellensburg Formation and the "Dalles Formation extended" comprise the materials that have been referred to in reconnaissance studies as "Arlington Lake Beds" and "Shutler Formation," terms that are no longer needed.
5. The discrepancies still exist between early Pliocene age in the type area of the Dalles Formation and middle Pliocene age for the supposed correlative strata ("Dalles Formation extended") in the Arlington area.

References

- Foxworthy, B. L., 1962, Geology and ground water resources of the Ahtanum Valley, Yakima County, Washington: U. S. Geological Survey Water Supply Paper 1598, 100 p., 11 illustrations.
- Hodge, E. T., 1932, Geological map of north central Oregon: Univ. Oregon Publ., Suppl. to Geology Series v. 1, no. 5, 7 p., scale 1:250,000.
- Hodge, E. T., 1942, Geology of north central Oregon: Oregon State College Mon., Studies in Geology, no. 3, 76 p.
- Hogenson, G. M., 1964, Geology and ground water of the Umatilla River Basin, Oregon: U. S. Geological Survey Water-Supply Paper 1620, 102 p., 16 illustrations.
- Holmgren, D. A., 1969, K/Ar dates and paleomagnetism of the type Yakima Basalt, Central Washington: Northwest Science Proceedings of the Second Columbia River Basalt Symposium, pp. 196-199.
- Laval, W. N., 1966, Miocene-Pliocene formations of south-central Washington (Abs.): Northwest Science., v. 40, pp. 38-39.

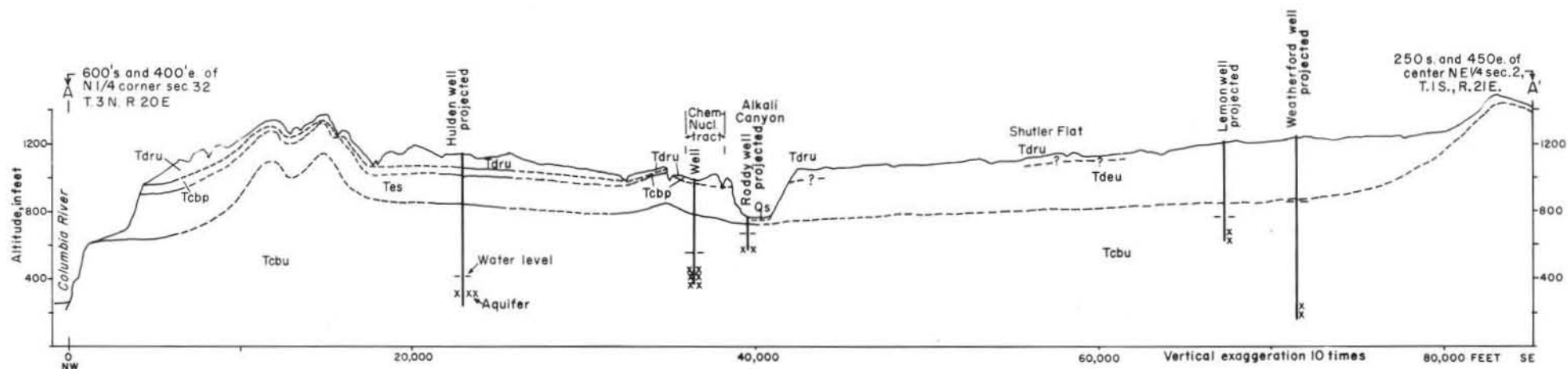


Figure 3. Section from the Columbia River to the south end of Shutler Flat. (Qa, Quaternary alluvium. Tdru, Dalles Formation and Rattlesnake Ridge member of the Ellensburg Formation, undifferentiated. Tdeu, Dalles Formation and Rattlesnake Ridge and Selah members of the Ellensburg Formation, undifferentiated. Tcbp, Pomona flow of the Yakima Basalt of the Columbia River Group. Tes, Selah member of the Ellensburg Formation. Tcbu, basalt of the Columbia River Group, undifferentiated.)

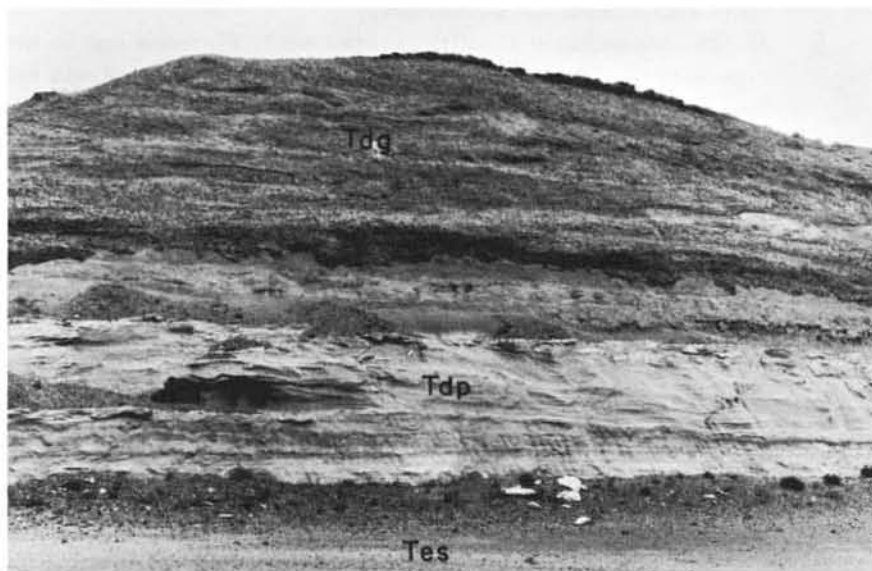


Figure 4a. Quarry face exposing 40-foot section of the Dalles Formation above the Selah member of the Ellensburg Formation, the top of which forms the quarry floor.



Figure 4b. View east across the quarry and along the north bluff of Alkali Canyon. (Tes, Selah member of the Ellensburg Formation. Tdp, pozzuolana lens; Tdg, conglomerate member; and Tdt, tan tuff member of the Dalles Formation.)

- Newcomb, R. C., 1966, Lithology and east ward extension of the Dalles Formation, Oregon and Washington: U. S. Geological Survey Prof. Paper 550-D pp. 59-63, illus.
- Newcomb, R. C., 1969, Effect of tectonic structure on the occurrence of ground water in the basalt of the Columbia River Group of The Dalles area, Oregon and Washington: U. S. Geological Survey Prof. Paper 383-C, 33 p., 19 illustrations.
- Schmincke, H. U., 1967, Stratigraphy and petrography of four upper Yakima Basalt flows in south-central Washington: Geological Society of America Bull. v. 78, pp. 1385-1422.

* * * * *

RALPH WORKS CHANEY

By Jane Gray

Paleoecology Laboratory
Museum of Natural History
University of Oregon, Eugene, Oregon

On March 3, 1971, at the age of 80, famed paleobotanist, Ralph Works Chaney died in Berkeley, California where he had made his home since 1931. Dr. Chaney, until the late 1950's Professor of Paleontology at the University of California, enjoyed a long career yielding a rich harvest in the fields of education, paleontological research and conservation.

Chaney spent his first field season in Oregon in 1916, and received his doctorate in 1919 from the University of Chicago with a dissertation based on studies of the Middle Tertiary Eagle Creek flora of the Columbia River Gorge. Thus began a long, intense association with Tertiary floras of the Pacific Northwest in which he used the State of Oregon as his most valuable laboratory to develop and test many of the innovative, analytical techniques that have contributed to an understanding of Tertiary floras throughout the world. His work established Oregon as a classic area in Tertiary paleobotany.

Among Chaney's significant contributions to the study of fossil floras are the following: the recognition that taxonomic considerations of a flora cannot be separated from its ecological considerations, thereby treating fossil plant assemblages as representatives of vegetation rather than as collections of isolated specimens; the handling of large numbers of specimens in the field to permit an accurate idea of morphological variations within fossil species that enabled detailed comparison with the leaf characters of designated living equivalent species; the use of leaf characters (such as

length, organization, nervation, margin, texture) and of morphological life form as an aid to determining the climatic conditions of a region or of a geological period; quantitative study of fossil floras in an attempt to arrive at some estimate of species dominance; the application, where appropriate, of corrective factors derived from studies of the comparative representation of plant remains in contemporary sediments, together with data on numerical representation of fossil species and the habitats of the equivalent living species to serve as guides in the reconstruction of the physical environment, including topography and climate, of fossil floras; the thesis that migrations of major vegetational units (termed geofloras) through Cenozoic time are the basis not only for the reconstruction of topographic and climatic changes, but since such migrations result from progressive physical changes, particularly in climate, which are a function of time, that the successive geographic positions of geofloras may serve to determine the age of sedimentary rocks with occurrences of plant fossils.

Although much of Chaney's professional work was concerned with the paleobotany of the Pacific Northwest, his scientific efforts ranged far afield from that area. He carried out field work intermittently in Central and South America and widely for many years in Asia; as a young man he was a member of the Central Asiatic Expedition of the American Museum of Natural History under the leadership of Roy Chapman Andrews. One of Chaney's most significant publications dealt with a revision of fossil *Sequoia* and *Taxodium* which was completed after his visit in 1948 to the only natural occurrence of *Metasequoia* in central China. Through his efforts in obtaining seeds and cuttings of *Metasequoia*, this conifer again thrives in many parts of the world where it once lived naturally.

In addition to his scholarly activities, Dr. Chaney was active in conservation as a long-time member and past President of the Save-the-Redwoods-League, and as a member of the Advisory Board of the National Park Service. During World War II, he served in an administrative capacity as Assistant Director of the University of California's Lawrence Radiation Laboratory.

During his lifetime, Dr. Chaney received many honors and awards; he was a member of the National Academy of Sciences, the American Philosophical Society, a Fellow and past Vice President of the Geological Society of America and a past President of the Paleontological Society of America. In recent years, he was an Honorary Vice President of the XI International Botanical Congress, where he was honored with a Congress Medal, he received the U. S. Department of the Interior Conservation Service Award and shortly before his death he was the recipient of the 5th Paleontological Society Medal, the first and only paleobotanist so honored.

* * * * *

METAL NEWS*

Silver

The price of silver continues "sluggish" and is presently quoted at \$1.633 per ounce. A number of silver investors have brought suit against Engelhard Industries, the Silver Users Association and certain of their officials for remarks made at the May 20 silver and gold forum sponsored by the American Metal Market. The suit was in response to comments made at the forum by Engelhard Industries president Richard C. Glogau, which discounted the importance of the deficit between silver production and consumption, and by Silver Users Association executive director Walter L. Frankland, who also spoke bearishly at the AMM forum. Although silver did go down on the day of the meeting and has performed sluggishly ever since, few traders are blaming Glogau or Frankland as silver has been sloppy of late anyway and the whole meeting was filled with depressing news.

Silver coin trading was started on the new West Coast Exchange on May 17, following the lead set by the New York Mercantile Exchange, which commenced coin futures on April 1. The Los Angeles-based exchange offers "half-size" contracts, with a \$5,000 face value, consisting of 5 bags of dimes, quarters, or half dollars minted before 1965.

Mexico, which has blamed the slumping silver market on speculators who dominate the commodity exchanges, has invited representatives from Canada, Peru, Australia, the U.S., and India to a meeting later this month to examine prospects for setting up a world producer silver price. It has been reported that U.S. participation will be limited to government observers. Mexico produces more than 40-million troy ounces of silver per year, most of which is as "prime" product. Canada is a larger producer, but there, as almost everywhere else, production is mostly byproduct output from base metal mining. While the upcoming meeting is preliminary and no attempt to set up a producer price in the future is expected, the possibility of a producer price somewhere down the line has stirred considerable conversation.

Gold

On June 9, London gold prices fell below \$40 a troy ounce for the first time since May 11 and gold is presently selling for \$39.49. Although trading and investing in gold per se has been denied to U.S. citizens since the Gold Reserve Act of 1934, they are stepping up the pressure to seek ways to buy gold, which include proposed legislation to revitalize the U.S. gold industry and to legalize bullion investment, as well as plans being formulated by major commodity exchanges to offer gold trading. California Congressmen H. T. Johnson and Don H. Clausen maintain that U.S. output of gold falls far short of the

* From News Letter, Nevada Mining Association, June 15, 1971.

nation's strategic needs, much less its normal industrial and consumer requirements. Domestic production totaled some 1.6-million troy ounces in 1969 while gold use hit about 7-million, of which nearly 40% or 2.7-million ounces went to space and defense. The U.S. Bureau of Mines estimated U.S. known reserves at about 400-million ounces, but startup costs for new mines can be prohibitive.

Earlier legislation to permit U.S. citizens to hold gold bullion was introduced by Illinois Representative Philipp M. Crane, who claims that interest among Americans has been substantial and that individuals should have the right to hold their wealth in tangible commodities as currency values continue to decline. Presently, Americans can hold gold only in the form of jewelry or coinage. The United Kingdom lifted restrictions on British citizens holding gold on April 1. Meanwhile, the West Coast Commodity Exchange is ready for any change in the federal rules as it has prepared complete contract specifications for trading in gold bullion as a futures contract if the current restrictions are lifted by Rep. Crane's legislation. Specifications of the contract, should it be permitted, call for trading units of 400 troy ounces in a bar of at least 99.95% pure gold. Delivery months would be in January, March, May, July, September, and December.

A strong demand for British gold sovereigns is reported by dealers. Frederick S. Bogart, manager of Republic National Bank's gold department, told a group at the recent American Metal Market silver and gold forum that these coins, which contain about $\frac{1}{4}$ ounce of gold and are worth $\pounds 1$ (\$2.40) face value, have risen sharply in price to about \$13 a piece.

Copper

Simon D. Strauss, executive vice president of American Smelting and Refining Company, told the Financial Analysts Federation at Cleveland, "If the geographical concentration of copper production becomes more diverse, the price should be less volatile." He said it is the dependence of Western European copper consumers on the CIPEC (Congo, Chile, Peru and Zambia) countries for supplies that has "accentuated the volatile fluctuations in the price of copper" in recent years. The flow of copper from CIPEC countries to Free World consumers has been well maintained, Strauss noted, "But this fails to quiet the fears of uneasy consumers who do not know what to expect next." The Asarco executive sees this situation changing, however. Strauss said, "There is no shortage of known copper reserves," but it is of "considerable significance that much of the new tonnage is being developed outside the CIPEC area. Capital is, in fact, showing considerable reluctance to invest in new CIPEC projects. Five or 10 years hence, the relative importance of the CIPEC countries seems likely to be less than it is today." He noted that the U.S. and Canada will maintain their production rank in the world while production from "other countries" may show proportionately the

greatest increase. Substantial new production is expected from the South Pacific basin (Indonesia, the Philippines, and Bougainville) while Australia is increasing its production by at least 50% within the next 2 years.

During a recent meeting of CIPEC mining ministers, it has been reported, other copper-exporting countries in the world were invited to join the group. Also, CIPEC issued its usual call for "price stabilization." Meanwhile, increased outputs were announced - Congo by 5%; Zambia by 4.5%, and both Chile and Peru talked about 12% increases. This would amount to 91,000 tons per year for Chile; 27,000 tons per year for Peru; and 36,000 tons per year for Zambia, and 18,000 tons per year for the Congo.

Mercury

Mercury is currently being quoted at \$265-270 per 76-pound flask. The U.S. Bureau of Mines states, "Domestic mine production in the first quarter of 1971 was 4480 flasks, down 20% from the preceding quarter. Eleven mines producing over 100 flasks each during the quarter accounted for 87% of the production. The three top producers were the New Idria and Mt. Jackson mines in California, and the Ruja mine in Nevada. Several mines became inactive, including the Buena Vista mine. Secondary mercury totaled 4058 flasks, which included 2700 flasks released from GSA, reducing their stock to about 10,800 flasks. GSA did not resume offerings for commercial sale during the quarter.

"Consumption was 12,720 flasks, about the same as the previous quarter, but down substantially from the 19,555 flasks recorded for the first quarter of 1970. Increases were noted in agriculture, catalysts, electrical apparatus, general laboratory use, industrial and control instruments, and mildew proofing for paint. Use in electrolytic preparation of chlorine and caustic soda declined to under 3000 flasks. No mercury was consumed for amalgamation of pulp and paper.

"The March 31 issue of the Federal Register contained a list, published pursuant to the Clean Air Act of 1970, in which mercury was designated one of the hazardous air pollutants."

* * * * *

BURTON W. SILCOCK APPOINTED BLM DIRECTOR

The appointment of Burton W. Silcock as Director of the Bureau of Land Management has been announced by Interior Secretary Rogers C. B. Morton. Mr. Silcock succeeds Boyd L. Rasmussen, who has been named an Assistant to the Secretary of the Interior. Silcock, a native of Burley, Idaho, and a graduate of Utah State University, joined the Bureau of Land Management in 1948 and has held successively responsible posts in public lands management in various areas of the West. Since 1965 he has been BLM Alaska Director.

* * * * *

GEOLOGY OF THE POWERS QUADRANGLE PUBLISHED

The Department has just issued, as the fifth in its Geological Map Series, "Geology of the Powers Quadrangle, Oregon," by Ewart M. Baldwin and Paul D. Hess, of the University of Oregon. The publication consists of a 21 by 26 inch sheet with a multicolored geologic map and cross sections on one side and text on the other. The map scale is 1:62,500.

The Powers quadrangle is situated along the northern edge of the Klamath Mountains in Coos and Curry Counties in a region underlain by pre-Tertiary and Tertiary rocks. The older pre-Tertiary units have a complex tectonic history involving development of schists, serpentinite, and melange facies.

GMS 5 is for sale by the Department of Geology and Mineral Industries at its Portland, Baker, and Grants Pass offices. The price is \$1.50.

* * * * *

STATE MINERALS RESEARCH CENTERS NEEDED

Senate Bill S.635 to amend the Mining and Minerals Policy Act of 1970 proposes to establish a minerals research and training center in each state. With reference to S.635 Dr. Vernon E. Scheid, Dean of the Mackay School of Mines, University of Nevada, writes:

"A moment's reflection is sufficient to convince a person that there are but two basic and fundamental industries and that all other human economic activity depends upon the satisfactory operation of: 1) the industry involved with living resources, that is, agriculture (including forestry, fishing, etc.); and 2) the industry involved with non-living resources, that is, the mineral industry. Without either of these industries, which compose the first level of human economic activity the world as we know it ceases to exist and man becomes a wandering animal. Thus it is folly to debate which is more important, agriculture or mineral industry. Other levels of human economic activity are important to the life of our nation but they cannot exist without the first level!

"Some hundred years ago, Congress recognized that a healthy agricultural industry was necessary to our nation's well-being and by means of the Morrill and other Acts created agricultural research and training institutes throughout America. The results are world famous. Regrettably, research and training institutes for the non-living (earth and mineral) resources were not established at that time. Thus, America, although well-supplied by nature with mineral materials, has paid a heavy price through lack of research and training. The nation that does not consider the economic condition of each of its two basic industries may soon lose its right of free choice in guiding its own future in the world!

"The time has come for America to think about its earth and mineral

(non-living) resources. The education and research necessary for these resources to be properly extracted and used must be supported and encouraged. Then, and only then, will America know that both of its basic and fundamental industries will be healthy and will contribute to our Nation's safety and well-being.

"As Dean of one of America's few remaining mineral industry colleges and as Director of one of our most active state bureaus of mines, I sincerely urge you to support the passage of S.635 which calls for the establishment of mineral resources research and training institutes throughout America." (News Letter, Nevada Mining Association, June 15, 1971)

* * * * *

PRESIDENT DELIVERS ENERGY MESSAGE

In a special energy message to Congress, President Nixon outlined a program which included: (1) additional funding of a program to develop and demonstrate, in partnership with industry, the technology for removing sulfur from the stack gases of power plants and industrial plants burning coal and oil; (2) a commitment to complete the successful demonstration of the liquid metal, fast-breeder reactor by 1980; (3) an expanded cooperative pilot plant program aimed at making coal gasification a commercial reality; (4) funding of a broad range of other energy research and development such as coal mine health and safety, fusion power, magnetohydrodynamics and underground electric transmissions; (5) the increasing of oil and gas lease offerings on the Outer Continental Shelf; (6) expediting development of an orderly oil shale leasing program with emphasis on environmental protection and recovery of a fair return to the government; and (7) expediting of the scheduling of a competitive geothermal lease program this fall under recently enacted legislation, provided environmental concerns can be satisfied.

* * * * *

NEW U. S. CHIEF GEOLOGIST NAMED

Dr. Vincent E. McKelvey has been appointed Chief Geologist to head the Geologic Division of the U. S. Geological Survey, Department of the Interior. Dr. McKelvey succeeds Dr. Harold L. James, who occupied the post since 1965, and who will return to his research on the geology and ore deposits of ancient rocks in the Northern Rocky Mountains.

McKelvey, who joined the Geological Survey in 1941, is internationally recognized for his studies of phosphate deposits, for his investigations into problems related to long-range energy and mineral resource needs, and particularly, in recent years, for his analyses and assessments of seabed resources of the world.

* * * * *

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
39.	Geology and mineralization of Morning mine region, Grant County, Oregon 1948: R. M. Allen & T. P. Thayer	1.00
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Grah, editors	3.50
58.	Geology of the Suplee-Izee area, Oregon, 1965: Dickinson and Vigrass	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dale	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Geology, mineral, and water resources of Oregon, 1969	1.50
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970: Roberts	2.00
68.	The Seventeenth Biennial Report of the State Geologist, 1968-1970	Free
69.	Geology of the Southwestern Oregon Coast W. of 124th Meridian, 1971: R. H. Dott, Jr.	3.75
70.	Geologic formations of Western Oregon, 1971: Beaulieu	2.00
71.	Geology of selected lava tubes in the Bend area, 1971: Greeley	in press

GEOLOGIC MAPS

	Geologic map of Oregon west of 121st meridian, 1961: (over the counter) . . .	2.00
	folded in envelope, \$2.15; rolled in map tube, \$2.50	
	Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
	Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others	0.40
	Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37)	0.50
	Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker	1.00
	Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts	0.75
	Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams	1.00
	GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka	1.50
	GMS-2: Geologic map, Mitchell Butte quad., Oregon: 1962, Corcoran et. al.	1.50
	GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka	1.50
	GMS-4: Gravity maps of Oregon, onshore & offshore, 1967: [Sold only in set] Flat, \$2.00; folded in envelope, \$2.25; rolled in map tube	2.50
	GMS-5: Geology of the Powers quadrangle, 1971: Baldwin and Hess	1.50

[Continued on back cover]

The ORE BIN
1069 State Office Bldg., Portland, Oregon 97201

The Ore Bin

POSTMASTER: Return postage guaranteed.



Available Publications, Continued:

SHORT PAPERS

- | | |
|---|---------|
| 2. Industrial aluminum, a brief survey, 1940: Motz | \$ 0.10 |
| 18. Radioactive minerals the prospectors should know (2nd rev.), 1955:
White and Schafer | 0.30 |
| 19. Brick and tile industry in Oregon, 1949: Allen and Mason | 0.20 |
| 21. Lightweight aggregate industry in Oregon, 1951: Mason | 0.25 |
| 24. The Almeda mine, Josephine County, Oregon, 1967: Libbey | 2.00 |

MISCELLANEOUS PAPERS

- | | |
|--|------|
| 1. Description of some Oregon rocks and minerals, 1950: Dole | 0.40 |
| 2. Key to Oregon mineral deposits map, 1951: Mason | 0.15 |
| Oregon mineral deposits map (22" x 34"), rev. 1958 (see M. P. 2 for key) | 0.30 |
| 3. Facts about fossils (reprints), 1953 | 0.35 |
| 4. Rules and regulations for conservation of oil and natural gas (rev. 1962) | 1.00 |
| 5. Oregon's gold placers (reprints), 1954 | 0.25 |
| 6. Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton | 1.50 |
| 7. Bibliography of theses on Oregon geology, 1959: Schlicker | 0.50 |
| 7. (Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts | 0.50 |
| 8. Available well records of oil & gas exploration in Oregon, rev. 1963:
Newton | 0.50 |
| 11. A collection of articles on meteorites, 1968: (reprints, The ORE BIN). | 1.00 |
| 12. Index to published geologic mapping in Oregon, 1968: Corcoran | Free |
| 13. Index to The ORE BIN, 1950-1969, 1970: M. Lewis | 0.30 |
| 14. Thermal springs and wells, 1970: R. G. Bowen and N. V. Peterson | 1.00 |

MISCELLANEOUS PUBLICATIONS

- | | |
|---|------|
| Oregon quicksilver localities map (22" x 34"), 1946 | 0.30 |
| Landforms of Oregon: a physiographic sketch (17" x 22"), 1941 | 0.25 |
| Index to topographic mapping in Oregon, 1969 | Free |
| Geologic time chart for Oregon, 1961 | Free |
| The ORE BIN - available back issues, each | 0.25 |

OIL and GAS INVESTIGATIONS SERIES

- | | |
|---|------|
| 1. Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:
Newton and Corcoran | 2.50 |
| 2. Subsurface geology of the lower Columbia and Willamette basins, Oregon,
1969: Newton | 2.50 |

The Ore Bin



Vol. 33, No. 8
August 1971

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

The Ore Bin

Published Monthly By

STATE OF OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Head Office: 1069 State Office Bldg., Portland, Oregon - 97201

Telephone: 229 - 5580

FIELD OFFICES

2033 First Street
Baker 97814

521 N. E. "E" Street
Grants Pass 97526

X X X X X X X X X X X X X X X X X X

Subscription rate \$1.00 per year. Available back issues 25 cents each.

Second class postage paid
at Portland, Oregon

X X X X X X X X X X X X X X X X X X

GOVERNING BOARD

Fayette I. Bristol, Rogue River, Chairman
R. W. deWeese, Portland
Harold Banta, Baker

STATE GEOLOGIST

R. E. Corcoran

GEOLOGISTS IN CHARGE OF FIELD OFFICES

Norman S. Wagner, Baker Len Ramp, Grants Pass

X X X X X X X X X X X X X X X X X X

Permission is granted to reprint information contained herein.
Credit given the State of Oregon Department of Geology and Mineral Industries
for compiling this information will be appreciated.

State of Oregon
Department of Geology
and Mineral Industries
1069 State Office Bldg.
Portland Oregon 97201

The ORE BIN
Volume 33, No. 8
August 1971

MINING COUNCIL ADVISES WESTERN GOVERNORS

At the Western Governors' Conference, held at Jackson Lake Lodge, Wyoming, July 14, 1971, the Western Governors' Mining Advisory Council presented its view on the mining industry's involvement in the nation's environmental and economic problems. Albert C. Harding, Chairman of the Council, prepared a report which expressed the deep concern of the mineral industry leaders for these issues. The following are paraphrased excerpts from his report.

TO: THE HONORABLE WESTERN GOVERNORS

Your Council welcomes this opportunity to try to put the mining industry into rational perspective. It seems especially pertinent this year to take a comprehensive look at the industry's involvement in environmental and economic problems -- twin problems which henceforth should be inseparable.

The environment is one of the most publicized issues of the seventies. Perhaps never before has there been such widespread public involvement in a national problem. Certainly never before has the mining industry faced such a multiplicity of proposals to legislate, regulate, and even to eliminate. Unfortunately, some of the loudest voices are shouting frenetic solutions that would create more problems than they would solve. Aggravating the situation are those who cry out against all industries, all construction, all environmental changes. Although we need to stop and take a rational look at the total picture, we should not do as some industry leaders do when confronted by belligerent audiences and pledge the impossible: an undisturbed environment. We know that change is inevitable. The environment is constantly affected by tremendous earth processes over which we have no control. We know also that each of us changes the environment by simply existing in it, by using and polluting some part of it.

The biggest problem affecting our natural environment stems from two concurrent, continuing factors: the tremendous population growth, and man's seemingly insatiable appetite for energy. These two factors have combined over the last 25 years to increase electrical energy consumption by six times and gasoline energy sixteen times. Most of the energy is

created, as is animal and human energy, by combustion, a process which always produces waste products. The resulting problems cannot be attributed directly to the mining industry. The industry acknowledges, however, an increased responsibility to avoid unnecessarily contributing to those problems.

The mining industry has factors peculiar to it. Because it is an extractive industry it is necessarily involved in creating unusable byproducts, sometimes of terrific proportions. A copper mine may recover only 8 pounds of copper from 2,000 pounds of ore, and move an equal volume of barren rock to reach ore. A gold mine, to recover a pound of gold, may treat 80,000 to 100,000 pounds of ore. Disposal of waste products is a continuing problem. However, some operations can result in actual improvement of the initial environment. In other operations some waste is put to beneficial use, or returned underground with the net effect of causing little degradation. The concern of the mining industry is, therefore, with avoiding unnecessary degradation and pollution while at the same time providing the mineral base necessary to our way of life.

A southwestern governor has called for continuing development of our mineral resources without deterioration of the environment. In a strict sense it may be that we cannot have the one without the other, but he has told mining companies in his state that the cost of removing pollutants must be part of their cost of doing business in that state. All miners now know that this and similar factors will be of increasing importance in making operating decisions. One state's new "Department of Economic Planning and Development" has already indicated that such factors will include fish and wildlife survival, urban development, and aesthetic, recreational, historic and agricultural values.

Therefore, although we are grateful to many of those people who are environmentally concerned, it seems certain that the mining industry must forever remain incompatible with those who profess concern only for a natural environment at the expense of man's economic, social, and cultural well-being. Protection of the environment cannot be absolute, but must be modified by man's need for production from the environment.

Our industry has not been blameless, by any means, during the years in which ecological problems have been developing. Now, however, from mining areas in every state come announcements of plans to correct and minimize damage, with special regard to water, land, and air.

Water

Problems created by acid mine waters at some eastern coal mines have tarnished the image of all mines. Such conditions are relatively rare in the west. In fact, some mine waters are harmless, while others are less harmful than permissible discharges of municipalities. Some mines even develop and provide water which otherwise would not be available.

The Bureau of Mines has reported that nationally the amount of water used by the mineral industry comprises only two percent of that used by all industries, and has noted that water used in mining is quite productive in an economic sense. In the eleven contiguous western states, average gross value of mineral production is \$3,250 per acre-foot of new water used, or 100 times as much as from the acre-foot used to produce a ton of alfalfa, perhaps valued at \$30. The water used by the miner is also more expensive. The average cost to Nevada's mineral industry is over \$32 per acre-foot, far above the agricultural economic range of \$3 to \$6.

For economic reasons the miner commonly re-circulates water, a process which has beneficial side effects in terms of the environment. Nevada's Carlin gold mine, for instance, discharges no water, and the only loss is to evaporation. Where water is discharged, it is now closely monitored and, when necessary, treated to avoid ecological damage. Plans to improve water discharges will cost several million at Anaconda, and \$5.6 million at Homestake.

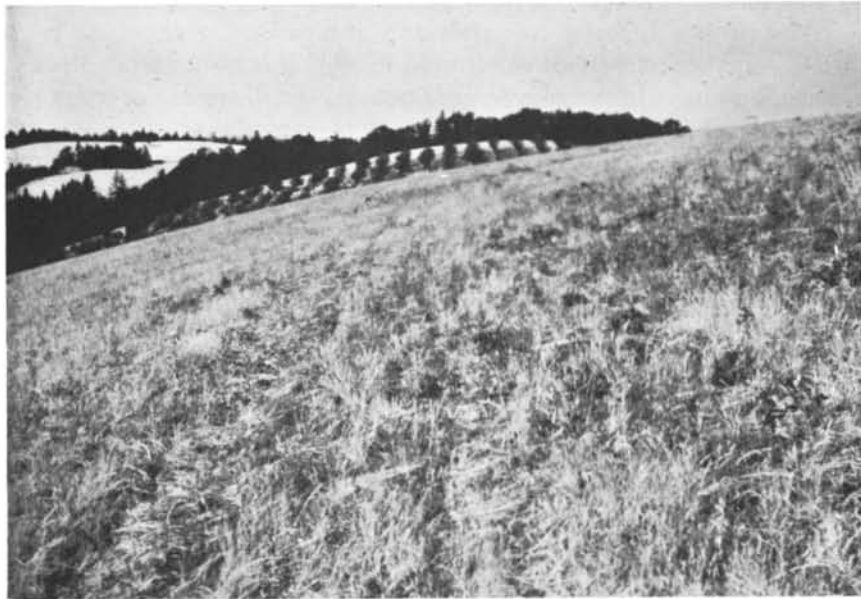
Land

Through the Mining and Minerals Policy Act of 1970, the Congress and the President recognized that mineral deposits of economic value are relatively rare, have to be mined where they are found, and require less surface area than most other land uses. The mining industry must damage some surface lands, but such damage is not extensive. Moreover, among causes of past land degradation have been the state laws encouraging some discovery work with bulldozers, which scarred the landscape and actually wasted work so far as mineral development was concerned. Some improvement has now been effected by substituting drill holes, through recommendations of the industry.

About half of the states have now adopted land reclamation laws that require that the land be returned to its natural state after mining. Considerable Federal legislation is being proposed in this regard, some of it unnecessarily restrictive and potentially disastrous. Public Land Law Review Commission recommendations, also, will result in many proposals for modification of general mining law. Some of those proposals already have mining industry endorsement, others will not be resisted, but some will require analysis when more definitely formulated. For instance, current strict legislation has curtailed our smelting capacity, compelling some companies to ship concentrates to foreign smelters, with obvious impact on domestic employment, tax revenue, and the balance of payments.

Air

Particulate matter is an obvious type of air pollution, and all industries are trying to reduce or eliminate visual emissions. Smelter operators



The photographs on these two pages illustrate good mining and reclamation methods employed in Oregon by the aluminum industry at a test site in the Salem Hills. Above: before bauxite was mined. Below: top soil set aside and ore being removed. Opposite (above): pit filled, soil replaced, and surface contoured. Opposite (below): young fir trees being planted.





and some coal burning power plants have special technological problems involving modifications for sulphur-dioxide emissions. For years methods have been sought to convert sulphur-dioxide to elemental solid sulphur. Present capabilities convert it to sulphuric acid, a process which is only partially satisfactory because of the limited demand for that product. One state alone could produce an annual excess of almost two million tons of sulphuric acid. Safe storage of this excess would be a continuing, staggering problem.

Hopeful for the future are many innovations, such as accelerated experiments in hydrometallurgy, a wet process in lieu of smelter combustion, and in development of geothermal sources and processes for power generation. Both governmental and private agencies are involved. The Bureau of Mines, for instance, is developing a wet process for recovery of mercury, and it seems likely that a wet process will be developed for copper. However, there will be an appreciable time lag for further engineering, pilot plant construction and testing. In the meantime, smelters are investing heavily toward reducing emissions at existing operations. For example, during the past six years Phelps Dodge has contracted, completed or programmed \$42 million for air pollution. Magma Copper is spending \$50 million for a new type of smelter. It is reported that all industries will expend between \$4 and \$10 billion a year for the next five years to help solve pollution problems.

There is no doubt in the mining industry that air standards are being imposed with little regard for economic and overall social consequences. Some standards have been confirmed by the Bureau of Mines as being improper conclusions based on unsubstantial data. It should be noted that air quality analysis and assessment is a science in its infancy. There are many questions to be answered involving not just the quantity of emissions but the actual effects on ecology. To help secure some answers one western state mining association last year made a grant of more than \$545,000 to establish an "Atmospheric Analysis Laboratory" at its state university.

Future Mineral Requirements

Making present problems more serious are predictions about the future. We are nationally concerned about population growth, but in the past 100 years our mineral consumption increased ten times faster than population. In approximately 30 years, when population is expected to double, energy and mineral requirements are expected to triple and quadruple. This country is far from being self-sufficient in minerals, particularly in metals, of which we supply our own needs in only one, molybdenum. Even gold, still a necessary component of reserves in international monetary structures, is in short supply. Our domestic production of gold, half of the amount needed by defense and space industries alone, equals only

one-fourth of our total consumption. We currently produce about \$25 billion worth of all primary minerals but consume \$32 billion worth each year. We are told that the 1971 international currency crisis, depreciating our dollar, was due to several factors, including a 1970 national deficit of \$10.7 billion in balance of payments. We know that foreign-aid programs and defense expenditures abroad, including Vietnam, contribute to the deficit in balance of payments, but \$7 billion, two-thirds of the total, can be accounted for by our deficiency in minerals. The need to discover and develop additional domestic mineral deposits is becoming more and more critical. Clearly, within our proposals to improve the environment we need to expand our mineral and energy technologies and to cultivate our mineral potential for greater production.

General Economics

We are inclined to forget the fundamental economic fact that the source of all wealth still originates from the earth as basic food, fiber, or minerals. Those raw materials provide the foundation for man's subsequent ingenuity and labor, the foundation for adding additional values, the foundation for a nation's total economy. If the mining industry did not exist we would have to use our collective efforts to try to create it. Only the production of food is more important than the production of minerals, and any farmer, without the products of the mineral industry, would have difficulty supplying even the needs of his own family.

Our national income has been likened to an annual stream which flows into and through the pool of national wealth, where some of it accumulates for the benefit of future generations. It is not just this year's mineral production which contributes to our present high standard of living, but all the mineral production compounded through the years of our history. This generation's homes, highways, hospitals, and schools are available today partly because of the capital generated by the past mining camps in the Mother Lode country, the Klondike, at the Comstock, Tombstone, Goldfield, Leadville, Cripple Creek, and a thousand others, most of them less glamorous and less productive than these but contributors also to today's standard of living.

The real source of any country's annual income and accumulated wealth truly lies in its productive resources. A country's mines are among its greatest resources. It has long been acknowledged that a nation which has no mines has no other recourse but to establish a favorable balance of trade to share in the wealth of those nations which do have mineral resources. As such, the have-not nation becomes dependent on others in terms of its destiny.

The Prospector's Future

Despite all threats to and problems of the industry, we can probably predict that large, well-established mining companies will survive simply because the nation needs them. We can further predict that any unnecessary controls will cause unnecessary expenditures with increased costs, which the public will pay either through higher taxes, higher prices, or both.

It is the small operator who is most vulnerable, the man who may lack either the money or talent to cope with innumerable problems. We need to consider him for we need him, too, as we also need the present non-producer, who may have only his dreams and little capital to contribute immediately to the nation's future. The prospector still exists. He looks through more knowledgeable eyes than did most of his predecessors and often uses more sophisticated tools, but his dream is still part of the American Dream. If our environmental fears result in banishing the prospector with his dream from our western mountains and deserts something good and necessary will vanish from our way of life.

Conclusions

This Council believes that an improved environment is both necessary and possible, but we also believe that where no substantial, immediate, or irreparable hazard or damage is involved, that improvement must come in an orderly fashion, that the rule of reason must prevail so that in solving one problem we do not create others of equal or greater magnitude, that consideration must be given to preventing local economic disasters. Hopefully then we can avoid the possibility of what one newswriter has termed "a national environmental recession."

Recommendation

The Council recommends the Secretary of the Interior be requested to authorize the U.S. Bureau of Mines and other resources of his department to do an economic survey of the western mining industry, including action taken by the western mining industry to prevent air, water, and land pollution and to correct past environmental damage. This report would fall under the provisions of the National Mining and Minerals Act of 1970.

The most value would be derived from this report if it could be made available to members prior to the 1972 Annual Meeting of the Conference.

The Conference Secretariat is instructed to transmit the resolution to the Honorable Rogers C. Morton, Secretary of the Interior, to the U. S. Bureau of Mines and to the Environmental Protection Agency.

* * * * *

GEOHERMAL RESOURCES COUNCIL HOLDS FIRST MEETING

The first meeting of the newly formed Geothermal Resources Council was held in Sacramento, California, on July 16, 1971. Creation of a council to advance the orderly development of geothermal resources had been proposed last spring by Joseph W. Aidlin, Los Angeles attorney, during the Northwest Conference on Geothermal Power in Olympia, Washington. The proposal was adopted and the staff of the State of Washington Department of Natural Resources then selected a steering committee comprising representatives of the geothermal development industry, equipment suppliers, public and private electric power companies, energy suppliers, universities, research organizations, concerned governmental agencies, environmental organizations, and the general public.

At its first meeting the steering committee selected as Chairman, R. G. Bowen, Economic Geologist with the Oregon Department of Geology and Mineral Industries; as Vice Chairman, R. G. Bates, Administrative Assistant to the Washington Commissioner of Public Lands; and as Secretary, David N. Anderson, Geothermal Officer of the State of California Division of Oil and Gas. An organizational policy statement was drafted as follows:

1. Encourage research, exploration, and development throughout the geothermal energy field.
2. Encourage and promote criteria for the development of geothermal resources compatible with the natural environment.
3. Encourage sound geothermal legislation.
4. Present a fair, unbiased picture on the nature of geothermal energy and its development.
5. Encourage the collection and dissemination of basic data related to geothermal development.

To carry out the policies of the Council six committees were organized with the following chairmen: Exploration and Drilling - Bob Greider, Standard Oil Co. of California; Resource Utilization - Fred Dunn, Vice President of Rogers Engineering; Regulation - David Anderson, Geothermal Officer, California Division of Oil and Gas; Environment - W. K. Summers, Staff Advisor, New Mexico Bureau of Mines and Minerals; Economics - Henry Curtis, Northwest Public Power Association; and Education and Information - Robert G. Bates, Administrative Assistant to Washington Commissioner of Public Lands.

The next meeting of the steering committee will be held in Seattle on September 24, where it will be the task of the six committees to submit a list of members, prepare a declaration of purpose, and develop a program of activities.

* * * * *

OBSIDIAN HYDRATION DATING
APPLIED TO DATING OF BASALTIC VOLCANIC ACTIVITY*

By Irving Friedman** and Norman Peterson***

Recent rhyolitic volcanic eruptions have been dated (1) by the thickness of the hydration rind on obsidian associated with these events. The technique is now being applied to a study of the rhyolitic volcanism in the area of Newberry volcano, Oregon, approximately 20 miles (32 km) northeast of Bend, Oregon, and in special cases (as described below) may be used to date basaltic eruptions.

On the north shore of East Lake in the Newberry volcano area, there is a small fissure where fountaining basalt magma tore off pieces of solidified rhyolite from the fissure wall during the eruption. The rhyolite has been remelted and is very vesicular. Thin sections of the remelted rhyolite show that it has a hydration layer that allows us to date the time of the remelting. The hydration thickness in three of these samples is $3.0\text{ }\mu\text{m}$ ($\pm 0.2\text{ }\mu\text{m}$). A hydration rate of $3.1\text{ }\mu\text{m}^2$ per 1000 years (2) yields an age for this event of 2900 ± 400 years. Rhyolite flows within 2 miles (3.2 km) of this fissure, as determined by the obsidian hydration method, date from about the same time; thus, a variety of volcanic activity at about this time is indicated.

During a recent collecting trip to Newberry crater, Peterson (3) mentioned the occurrence of cored bombs - that is, basaltic bombs that contain centers of other rocks, including rhyolite. These cored bombs occurred in some quantity at the Diamond craters, an area of recent volcanism near the center of Harney County in southeast Oregon. The area is in T. 28-29 N, R. 32 E, about 60 miles (96 km) south of Burns. Rhyolitic glass from four of the bombs was examined for occurrence of a hydration rind, and hydration rind was found on all the samples examined (see Fig. 1). All the samples displayed rinds that ranged in thickness from 7.0 to $7.3\text{ }\mu\text{m}$. Using the hydration rate as mentioned above ($3.1\text{ }\mu\text{m}^2$ per 1000 years) gives an age for this explosive volcanicity at Diamond craters of $17,000 \pm 2,000$ years.

Remelted obsidian-like material associated with basalts probably is not uncommon. The presence of such material makes it possible to date basaltic eruptions that remelt the rhyolite, provided that the eruptions occurred in the time interval from 200 to 250,000 years ago (4).

* Reprinted from *Science*, vol. 172, pp. 1028, June 4, 1971. Copyright 1971 by the American Association for the Advancement of Science.

** U. S. Geological Survey, Denver, Colorado.

*** Oregon Department of Geology and Mineral Industries.

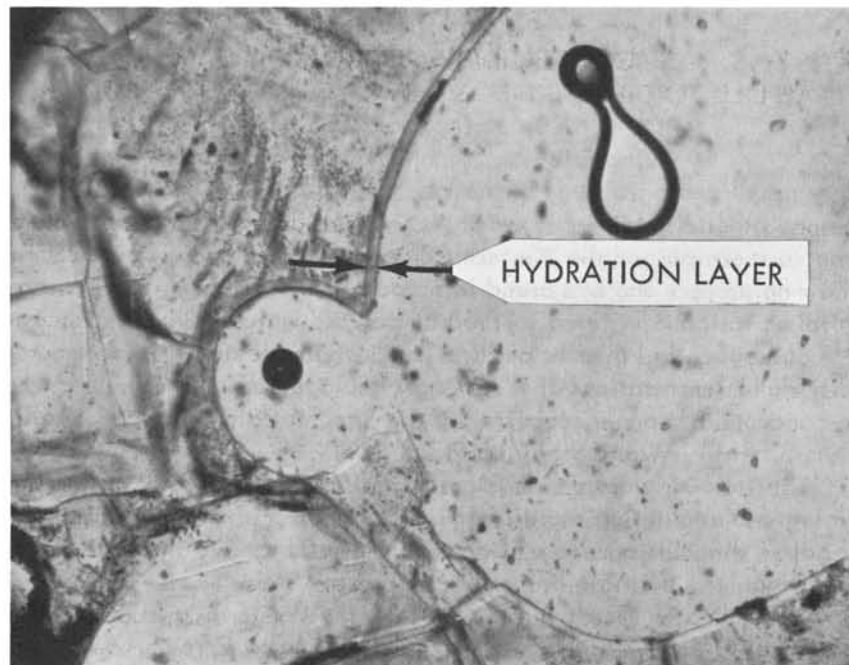


Figure 1. Photomicrograph of a thin section of cored bomb from Diamond craters, Oregon, with the hydration layer ($7\text{ }\mu\text{m}$ thick) indicated.

References and Notes

1. I. Friedman, 1968, *Science* vol. 159, p. 878.
2. L. Johnson, Jr., 1969, *Science* vol. 165, p. 1354, determined a hydration rate of $3.5\text{ }\mu\text{m}^2$ per 1000 years for archeological material found near Newberry. The rate was based on the measurement of hydration thickness on obsidian artifacts from archeological horizons dated by the ^{14}C method. Correcting for the variations in the original ^{14}C content of the atmosphere in past time (the "zero" of the ^{14}C time scale) (H. Suess and M. Rubjn, personal communication) reduces the hydration rate to $3.1\text{ }\mu\text{m}^2$ per 1000 years. For further information, see *Radiocarbon Variations and Absolute Chronology*, Nobel Symposium, 12th, I. U. Olsson, Ed. (Wiley, New York, 1970).
3. N. V. Peterson and E. A. Groh, 1964, *Ore Bin*, vol. 26, p. 29.
4. I. Friedman and R. L. Smith, 1960, *Am. Antiq.*, vol. 25, p. 476.

* * * * *

STRUCTURE OF THE OREGON CASCADES

By J. D. Beaulieu*

In a regional geologic study of the Western Cascades of northern Oregon, Peck and others (1964) presented their interpretation of the larger structures of the northern part of the Western Cascades. Their study was a reconnaissance map project and was broad in scope. It was based in part on a doctoral dissertation completed in 1960 at Harvard University by Dallas Peck.

Subsequently Wheeler and Mallory, who have questioned numerous traditional interpretations of West Coast geology, presented their alternative concepts in a paper submitted at the Second Columbia River Basalt Symposium (Cheney, Washington, 1969).

The following discussion is presented for the purpose of more clearly defining and evaluating the diametrically opposed ideas of the two parties. It is hoped that this article will generate some objective interest in this and related problems by those doing research in the area.

According to Peck and others (1964) the Western Cascades of northern and central Oregon are composed of a volcanic pile of rocks which includes in ascending order the Little Butte Volcanic Series of Oligocene to early Miocene age, the Columbia River Basalt of middle Miocene age, and the Sardine Formation of middle and late Miocene age. The Plio-Pleistocene High Cascades lavas cap the older volcanic rocks to the east. Peck and others envisage the structure of the Little Butte Volcanic Series and the Columbia River Basalt to be downwarped beneath a younger pile of volcanic rocks which they assign to the Sardine Formation.

Wheeler and Mallory (1969), on the other hand, view the Western Cascades of Oregon as an accumulation of Oligocene and early Miocene rocks (their Little Butte Volcanic Series or pre-Ochocoan basement) which has been upwarped to yield the present day topography. According to them the Columbia River Basalt originally overlay significant portions of the present day range and has been subsequently eroded to give its present distribution about the periphery. According to them also, much of the Sardine Formation of Peck and others (1964) has been misdated and should be included in the older Little Butte Volcanic Series. They do not recognize any post-Columbia River Basalt pre-High Cascades volcanism of any consequence in the northern and central Western Cascades of Oregon.

Most geologists are in agreement with the theory that the Western Cascades represent a volcanic pile as described by Peck and others (1964), and that the range is not upwarped to the extent proposed by Wheeler and Mallory (1969). Regardless of the weight of present consensus, however, the writer feels that part of the paper of Wheeler and Mallory warrants

* Stratigrapher, Oregon Department of Geology and Mineral Industries

careful consideration, because it appears to point out some legitimate criticisms of the paper by Peck and others (1964). Moreover, it prompts more refined inquiry into certain aspects of the Cascades which may, in turn, lead to a better understanding of the range.

Geologic conclusions are only as valid as the map from which they are derived. With this axiom in mind the reader must look at both the views of Peck and others and the views of Wheeler and Mallory with some skepticism. The map by Peck and others was compiled in rapid reconnaissance style with much mapping being done from the highway and with actual field contact being limited to grab sampling along the roadside in numerous cases. Moreover, previous maps dating back 30 years or more were relied upon heavily in some areas.

Wheeler and Mallory (1969) present no detailed geologic map, but choose rather to refer primarily to the map of Peck and others in presenting their case. Although this method is useful in pointing out particular areas of conflict, it has a shortcoming in that the consistency or inconsistency of their conclusions cannot be tested in a regional sense on a map of their making.

The above discussion is not intended to be overly critical. It is understood that both parties operated within tight schedules and that both did what could be done in the time available. It is emphasized, however, that the mapping aspects of both studies are not ideal and that the conclusions drawn from them should be evaluated accordingly.

Much of the criticism that Wheeler and Mallory (1969) level at Peck and others (1964) can be traced ultimately to the differing concepts the two parties have employed in identifying the various formations in the field. Much of what is identified as Sardine Formation by Peck and others is labeled Columbia River Basalt by Wheeler and Mallory. For example, on the west wall of Fish Creek Valley (Sec. 26, T. 5 S., R. 5 E.) in Clackamas County, Wheeler and Mallory report Columbia River Basalt overlying rocks which they assign to the Little Butte Volcanics. At the same locality Peck and others (1964) assign all the rocks to the Sardine Formation. Immediately to the north Wheeler and Mallory assign the Sardine Formation of Peck and others to the Columbia River Basalt. The fact that the unit dips northerly and north-westerly away from the Cascade Range suggests to them that the Columbia River Basalt has been upwarped and eroded from the Cascade Range in that area.

Immediately south of the Columbia River Gorge in the Eagle Creek drainage between Sandy River and Portland, beds mapped as Plio-Pleistocene tuffs by most authors are mapped as Little Butte Volcanics by Wheeler and Mallory. From this designation the interpretation that the Columbia River Basalts rise structurally above the Cascades in this area immediately follows.

More examples of contradictory formational assignments by the two sets of authors are present farther to the south in the vicinity of Oakridge south-east of Eugene. Near Lookout Point Reservoir (Sec. 21, T. 20 S., R. 7 E.)

Wheeler and Mallory assign to the Columbia River Basalt outcrops exhibiting a distinctive flow on flow structure. Peck and others (1964) assign the exposures to the Little Butte Volcanic Series.

With regard to the dating of the Sardine Formation by Peck and others Wheeler and Mallory bring out some interesting points. The most notable fact is that several of the floras of reported late Miocene age in the unit are very similar to the Oligocene and early Miocene floras of the Little Butte Volcanic Series reported elsewhere in the text. They conclude that a middle to late Miocene age cannot be applied to the Sardine Formation solely on the basis of floral content and, hence, that much of the argument in favor of erecting the Sardine Formation in the center of the range is invalid. Wheeler and Mallory assign the involved rocks to the Little Butte Volcanic series on the basis of lithology.

Both sets of authors support their structural interpretations with field evidence. The conflict arises because they apply different formational names to the same outcrops. It follows that much of the controversy could be eliminated by more accurate mapping and sampling in the critical areas. Trace element studies might also prove informative. Until such studies are conducted, however, the weight of the evidence seems to lie with Peck and others (1964), for they at least present petrographic data in support of their formation assignments. A check of their sampling localities, however, shows that no samples are reported from the critical localities mentioned above.

Strictly speaking, the Cascade Range may represent neither a "down-warped pile of volcanic rocks" (Peck and others, 1964) nor an upwarped Oligocene-early Miocene basement (Wheeler and Mallory, 1969), but rather a combination of the two. In the center of the range, for example, similarity of deformation and propylitization of both the Little Butte Volcanic Series and the Sardine Formation suggest that part of the Sardine Formation may, in fact, be Little Butte in age. Such an interpretation is in accord with the evidence presented by Wheeler and Mallory.

On the other hand there is little evidence to support the interpretation of Wheeler and Mallory that the present structure and topography of the Western Cascades is due primarily to post-Little Butte upwarping. That is, the Little Butte Volcanic Series may have had a positive topographic expression in the middle Miocene as well as the present. It follows that although flows assigned to the middle Miocene Columbia River Basalt may have been deposited about much of the periphery of the Range, they may never have occupied the interior as proposed by Wheeler and Mallory.

To summarize, the Cascade Range of Oregon is subject to two structural interpretations. When bias is set aside for the moment it is seen that evidence in support of either theory is not ideal, but that both theories have some strong points. It is concluded that more accurate mapping and more critical sampling will be needed, first, to resolve the conflict introduced by Wheeler and Mallory on a scientific rather than a rhetorical basis, and,

second, to define more accurately the complex geologic relationships of the Cascade Range. It is further concluded that the use of a broad term such as Sardine Formation is perhaps ill-advised in that it obscures rather than clarifies many critical relationships.

References

- Peck, D. L., Griggs, A. B., Schlicker, H. G., Wells, F. G., and Dole, H. M., 1964, Geology of the central and northern parts of the Western Cascade Range of Oregon: U. S. Geol. Survey Prof. Paper 449, 56 p.
- Wheeler, H. E., and Mallory, V. S., 1969, Oregon Cascades in relation to Cenozoic stratigraphy: in Proceedings of the second Columbia River Basalt Symposium, Cheney, Washington, p. 97-124.

* * * * *

MINERALIZED AREA IN DOUGLAS COUNTY IN MAPPING PROGRAM

Dr. M. Allan Kays, Associate Professor of Geology at the University of Oregon, has resumed geologic mapping of the May Creek schist belt near Tiller. In two previous field seasons Dr. Kays has completed detailed geologic mapping of an area extending north of Cow Creek in the Days Creek and Tiller quadrangles. Len Ramp, Resident Geologist of the Department of Geology and Mineral Industries' Grants Pass field office, will be working with Dr. Kays to extend the map area into the Evans Creek drainage.

The project is aimed at relating the widely scattered metallic mineralization in this region to the complex structure and geology.

The region is underlain by Triassic and Jurassic schists and gneisses, which are intruded and folded with a sequence of ultramafic-mafic rocks. Field studies will determine the distribution and character of the metamorphic facies. Metamorphism is apparently synchronous with intrusions of Late Jurassic quartz diorite plutons.

* * * * *

DEPARTMENT OFFERS NEW SERVICE IN TOPOGRAPHIC MAPS

For the first time the Department is selling U.S. Geological Survey topographic quadrangle maps of Oregon. The 7½' and 15' maps are \$.50 at the counter and \$.75 mailed. AMS 1:250,000 series maps are \$.75 at the counter and \$1.00 by mail.

* * * * *

DEPARTMENT CONDUCTS STUDY OF CLATSOP AND TILLAMOOK COUNTIES

The winter storms of 1970-71 inflicted heavy damage on the coastal areas of northwestern Oregon in terms of flooding and landsliding. Shortly thereafter parts of Tillamook and Clatsop Counties were designated as disaster areas by the Federal government and funds were appropriated to help finance a study of the geologic hazards of the area. The State of Oregon Department of Geology and Mineral Industries contracted to conduct the study and on June 1 began an extensive investigation of ground stability and potential flooding. The total cost of the project is \$80,000, of which the Federal government is financing 50 per cent, the State Department of Geology 30 per cent, and the counties 20 per cent.

One year will be needed to complete the project. Presently a geologic map is being prepared to serve as a base for more detailed studies to follow. Mapping will cover a coastal strip ten miles wide in the two counties. Well data, discharge data, and other pertinent information regarding ground and surface water is also being assembled. Results of the study will be used as a guide to future development of the area. The study is of particular significance in view of the anticipated high rate of growth.

* * * * *

TEXACO TO DRILL IN CENTRAL OREGON

The Department issued State Permit No. 63 to Texaco, Inc. on August 2, 1971, for a 10,000-foot oil and gas test hole. The location filed was in the SW $\frac{1}{4}$ sec. 31, T. 17 S., R. 23 E., Crook County, along the South Fork of the Crooked River approximately 40 miles southeast of Prineville. The firm has leased holdings in the area of 250,000 acres.

Geologic mapping by D. A. Swanson, 1969 (U.S. Geological Survey Map I-568) shows that the test site is on the crest of a northeast-trending anticline, with the Clarno Formation exposed at the surface. Texaco will have to drill through an estimated 4,000 feet of Clarno volcanics before reaching pre-Tertiary marine rocks. Company representatives indicated that operations would begin in Crook County by the end of August.

The last deep drilling in Crook County was done in 1958 by Sunray Mid-Continent Oil Co. near Post, 23 miles west of the new Texaco location. In 1955, Standard of California drilled a 7600-foot hole at Hampton Butte, 17 miles southwest of the new location. No production was obtained in either hole.

Records and cores from oil and gas drillings are required by law to be filed with the Department of Geology. These are kept confidential for two years and are then available to other interested persons.

* * * * *

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
39.	Geology and mineralization of Morning mine region, Grant County, Oregon 1948: R. M. Allen & T. P. Thayer	1.00
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Grah, editors	3.50
58.	Geology of the Suplee-Izee area, Oregon, 1965: Dickinson and Vigrass	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dale	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Geology, mineral, and water resources of Oregon, 1969	1.50
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970: Roberts	2.00
68.	The Seventeenth Biennial Report of the State Geologist, 1968-1970	Free
69.	Geology of the Southwestern Oregon Coast W. of 124th Meridian, 1971: R. H. Dott, Jr.	3.75
70.	Geologic formations of Western Oregon, 1971: Beaulieu	2.00
71.	Geology of selected lava tubes in the Bend area, 1971: Greeley	in press

GEOLOGIC MAPS

Geologic map of Oregon west of 121st meridian, 1961: (over the counter)	2.00
folded in envelope, \$2.15	
Geologic map of Oregon (12" x 9"), 1969: Walker and King	0.25
Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others	0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37)	0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker	1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts	0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams	1.00
GMS-1: Geologic map of the Sparto quadrangle, Oregon, 1962: Prostka	1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon: 1962, Corcoran et. al.	1.50
GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka	1.50
GMS-4: Gravity maps of Oregon, onshore & offshore, 1967: [Sold only in set] flat, \$2.00; folded in envelope, \$2.25; rolled in map tube	2.50
GMS-5: Geology of the Powers quadrangle, 1971: Baldwin and Hess	1.50

[Continued on back cover]

The ORE BIN
1069 State Office Bldg., Portland, Oregon 97201

The Ore Bin

POSTMASTER: Return postage guaranteed.



Available Publications, Continued:

SHORT PAPERS

- | | |
|---|---------|
| 2. Industrial aluminum, a brief survey, 1940: Motz | \$ 0.10 |
| 18. Radioactive minerals the prospectors should know (2nd rev.), 1955:
White and Schafer | 0.30 |
| 19. Brick and tile industry in Oregon, 1949: Allen and Mason | 0.20 |
| 21. Lightweight aggregate industry in Oregon, 1951: Mason | 0.25 |
| 24. The Almeda mine, Josephine County, Oregon, 1967: Libbey | 2.00 |

MISCELLANEOUS PAPERS

- | | |
|--|------|
| 1. Description of some Oregon rocks and minerals, 1950: Dole | 0.40 |
| 2. Key to Oregon mineral deposits map, 1951: Mason | 0.15 |
| Oregon mineral deposits map (22" x 34"), rev. 1958 (see M. P. 2 for key) | 0.30 |
| 3. Facts about fossils (reprints), 1953 | 0.35 |
| 4. Rules and regulations for conservation of oil and natural gas (rev. 1962) . | 1.00 |
| 5. Oregon's gold placers (reprints), 1954 | 0.25 |
| 6. Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton . . | 1.50 |
| 7. Bibliography of theses on Oregon geology, 1959: Schlicker | 0.50 |
| 7. (Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts . | 0.50 |
| 8. Available well records of oil & gas exploration in Oregon, rev. 1963:
Newton | 0.50 |
| 11. A collection of articles on meteorites, 1968: (reprints, The ORE BIN). . | 1.00 |
| 12. Index to published geologic mapping in Oregon, 1968: Corcoran . . . | Free |
| 13. Index to The ORE BIN, 1950-1969, 1970: M. Lewis | 0.30 |
| 14. Thermal springs and wells, 1970: R. G. Bowen and N. V. Peterson . . | 1.00 |

MISCELLANEOUS PUBLICATIONS

- | | |
|---|------|
| Oregon quicksilver localities map (22" x 34"), 1946 | 0.30 |
| Landforms of Oregon: a physiographic sketch (17" x 22"), 1941 | 0.25 |
| Index to topographic mapping in Oregon, 1969 | Free |
| Geologic time chart for Oregon, 1961 | Free |
| The ORE BIN - available back issues, each | 0.25 |

OIL and GAS INVESTIGATIONS SERIES

- | | |
|---|------|
| 1. Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:
Newton and Corcoran | 2.50 |
| 2. Subsurface geology of the lower Columbia and Willamette basins, Oregon,
1969: Newton | 2.50 |

The Ore Bin



Vol. 33, No. 9
September 1971

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

The Ore Bin

Published Monthly By

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
Head Office: 1069 State Office Bldg., Portland, Oregon - 97201
Telephone: 229 - 5580

FIELD OFFICES

2033 First Street	521 N. E. "E" Street
Baker 97814	Grants Pass 97526

✕ ✕

Subscription rate \$1.00 per year. Available back issues 25 cents each.

Second class postage paid
at Portland, Oregon

✕ ✕

GOVERNING BOARD

Fayette I. Bristol, Rogue River, Chairman
R. W. deWeese, Portland
Harold Banta, Baker

STATE GEOLOGIST

R. E. Corcoran

GEOLOGISTS IN CHARGE OF FIELD OFFICES

Norman S. Wagner, Baker Len Ramp, Grants Pass

✕ ✕

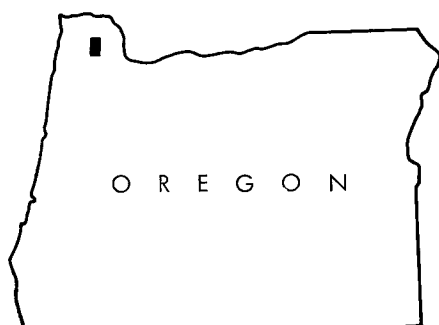
Permission is granted to reprint information contained herein.
Credit given the State of Oregon Department of Geology and Mineral Industries
for compiling this information will be appreciated.

STRATIGRAPHIC RELATIONSHIPS OF THE COWLITZ FORMATION, UPPER NEHALEM RIVER BASIN, NORTHWEST OREGON

By Robert O. Van Atta
Department of Earth Sciences, Portland State University

Introduction

The stratigraphic relationships of the Cowlitz Formation to late Eocene volcanic rocks and to the overlying Keasey Formation in the upper Nehalem River basin have been unclear in the past owing to lack of detailed study. Mapping of these units by the writer was completed in 1970 as part of a doctoral dissertation on the sedimentary petrology of the upper Nehalem River basin (Van Atta, 1971). The refinements in understanding of the stratigraphy proposed in this paper are the result of petrologic analysis of the formations exposed in this area.



Location of map area

In the upper Nehalem River basin of northwest Oregon (see Plate I), the late Eocene

and Oligocene argillaceous marine sediments of the Cowlitz and Keasey Formations and the basalts of the Goble Volcanics are well exposed. Numerous small, deeply incised creeks with fairly high gradients provide good outcrops. Intensive logging activity has made nearly every part of the area accessible by roads and has provided numerous road cuts with large exposures. Several quarries and the recent widening of U.S. Highway 26 have furnished additional exposures of value in interpreting the local stratigraphy.

Previous Work

Warren, Norbistrath, and Grivetti (1945) published a geologic map of northwestern Oregon which included the area of this present study.

Although 22 15-minute quadrangles covered by their study were mapped in just 1½ years (P. D. Snavely, Jr., personal communication, 1962), the mapping is high in quality. They applied the name Goble Volcanic Series to the volcanic rocks along the Columbia River and noted an interfingering relationship between the Goble rocks and the sedimentary Cowlitz Formation in that area. In mapping the upper Nehalem River basin, however, they included similar late Eocene volcanic rocks in the Tillamook Volcanic Series, a unit which they believed to lie unconformably beneath the Cowlitz Formation.

Warren and Norbistrath (1946) elaborated more fully upon the stratigraphy of the upper Nehalem River basin, but made no refinements of the stratigraphic relationships between the Cowlitz Formation and the late Eocene volcanic rocks of the Tillamook Volcanic Series. In that paper, they delineated the contact between the Cowlitz Formation and the overlying Keasey Formation on the basis of megafauna and microfauna.

In 1953, Deacon, in an unpublished master's thesis, proposed a revision of the upper Eocene and lower Oligocene stratigraphy of the upper Nehalem River basin based upon the lithology of the Tertiary sedimentary rocks exposed in the area. Deacon redefined the Cowlitz and Keasey Formations, substituting the name "Rocky Point formation" for the Cowlitz and introducing the name "Nehalem formation" for parts of the lower member of the Keasey Formation.

Purpose of Present Study

The purpose of this paper is to clarify the relationship between the Cowlitz Formation and the late Eocene volcanic rocks of the western part of the upper Nehalem River basin by showing that the youngest part of the Tillamook Volcanic Series of Warren and others (1945) is the Goble Volcanics member of the Cowlitz Formation. Because there is only a slight lithologic distinction between the lower member of the Keasey Formation and Warren and Norbistrath's (1946) "upper shale member" of the Cowlitz Formation, it is suggested that the "upper shale member" of the Cowlitz Formation be included in the Keasey Formation.

Stratigraphy

Cowlitz Formation

The oldest sedimentary unit in the area of this study consists of conglomerate, sandstone; siltstone, mudstone and intercalated volcanic rocks. According to Warren and others (1945) and Warren and Norbistrath (1946, p. 221), the sediments contain a fauna correlative with that of the type Cowlitz Formation in southwestern Washington. These workers informally divided the Cowlitz Formation in the upper Nehalem River basin into

four members: a basal conglomerate member, a lower shale member, a sandstone member, and an upper shale member. It should be noted, however, that none of the rocks in either shale member show fissility and therefore do not fit the definition of shale as given by Twenhofel (1937), Williams and others (1954), and Pettijohn (1957). According to the classification of Folk (1968), all such rocks of the "lower shale member" (siltstone member of this report) are siltstones and all those of the "upper shale member" (lower member of Keasey Formation of this report) are mudstones.

In view of the detailed study of the petrology of the Cowlitz Formation and the writer's interpretation of the stratigraphic relationships of the lithologic units which are included in this formation (Van Atta, 1971), it is proposed that the Cowlitz Formation be divided into three members: a siltstone member, an overlying (?) sandstone member, and the interfingering Goble Volcanics member. Basaltic flows, breccias, sills, and dikes of the Goble Volcanics member are present in both the siltstone and the sandstone members. The evidence supporting these conclusions is presented below.

Siltstone member: In roadcuts along the Sunset Highway west of Timber Junction, exposures of siltstone and sandy siltstone termed the "lower shale member of the Cowlitz Formation" by Warren and Norbistrath (1946, p. 223) crop out. Additional exposures westward along the Sunset Highway indicate that in many places the siltstone is interbedded with basaltic flows and breccia, basaltic conglomerate, and volcanic sandstone. It is concluded that conglomerate is recurrent throughout much of the section and does not represent a basal unit in the Cowlitz Formation as postulated by Warren and Norbistrath (1946).

Characteristically basaltic conglomerates are closely associated with the basaltic flows and breccias from which they were presumably derived. Conglomerate grades laterally away from the volcanics into volcanic sandstone, which in turn passes into the siltstone which constitutes the bulk of the lower part of the Cowlitz Formation. An easily accessible exposure showing these relationships is present along the Sunset Highway 2.2 miles west of the Washington-Tillamook County line.

The character of the conglomerate varies greatly from locality to locality. West of Timber, Oregon it is reported to be over 200 feet thick and composed of poorly sorted sand with basaltic pebbles, cobbles, and a few basalt boulders up to 8 feet in diameter (Warren and Norbistrath, 1946, p. 223). This appears to be exceptional, however, since all other occurrences of conglomerate are no more than 10 to 20 feet thick. Along Lousignont Creek Road (S $\frac{1}{2}$ sec. 18, T. 3 N., R. 5 W.) a few feet of sandy conglomerate grades laterally into greenish volcanic litharenite (classification of Folk, 1968). In other places, such as at the small Columbia County quarry on the Nehalem River a bouldery pebbly conglomerate lense, which grades upward and laterally into sandy siltstone, is intruded



Figure 1. Peel of arkosic sandstone from Cowlitz Formation, Clear Creek. Upper 14 inches cross-laminated with abundant muscovite mica flakes oriented parallel to planes of laminae, which are nearly horizontal. A large burrower hole is seen in the upper left. The lower 20 to 21 inches is indistinctly laminated with 12 to 15 inch cross-laminae. Numerous clots of sand (darker), in which mica is in random orientation, are probably due to activity of burrowing organisms.

by a basaltic sill. Other such relationships are more fully described below in the discussion of the Goble Volcanics member of the Cowlitz Formation.

Because the base of the siltstone member does not appear to be exposed in the area of this study and because of low angles of dip and uncertain correlation, no measurement of thickness was attempted. It is improbable that the siltstone member of the Cowlitz Formation is more than a few hundred feet thick, however.

Sandstone member: Warren and Norbistrath (1946) described a "gray, fine- to medium-grained, micaceous" sandstone which "contains much fragmentary plant material," which they regarded as overlying their "lower shale member" (siltstone member of this report) of the Cowlitz Formation. Stratification is described as fair but cross-bedding and ripple marks are said to be rarely seen (1946, p. 223). They point out that shell fragments are rare and they do not mention other fossils. Typical outcrops are considered by these workers to be exposed along the Nehalem River near Rocky Point and west of Timber. They also mention sandstone along the Nehalem River south of the bridge on the Sunset Highway. For the most part, the lithology of samples taken from the east end of Rocky Point correspond with the descriptions of Warren and Norbistrath.

Numerous cuts along logging roads west of the Nehalem River from Keasey to Rocky Point, in the Clear Creek drainage area, southwest of the Timber-Vernonia junction, and in the Lousignont Creek drainage area expose gray, micaceous, carbonaceous, cross-bedded, arkosic to lithic, silty sandstone interbedded with gray, well-stratified, sandy siltstone, claystone, and some pebbly sandstone. The sandstone is less than 10 percent volcanic glass, is poorly indurated, contains no cement and has only rare concretions. The siltstone is finely laminated with some disrupted laminae and much cut-and-fill structure. The arkosic sandstone in this region resembles littoral or sublittoral sands in both structure and texture (see Figure 1). It differs from the sandstone described by Warren and Norbistrath (1946) farther to the east in that it contains less brown plant debris, less clay, fewer concretions, and is distinctly a lighter gray. No fossils were observed in any of the beds of this member.

The sandstone and interbedded siltstone constitute an easily recognizable member of the Cowlitz Formation. Structural complexity and the lack of certain correlation between outcrops make measurement of thickness difficult. On the basis of present data, Warren and Norbistrath's (1946, p. 224) estimate of 200 to 300 feet appears reasonable.

Although much primary structure is present in the sandstone member, it is generally obscure; however, it is readily observed in peels taken from fresh exposures. In preparing the peels for this study, the methods of Bouma (1969, p. 1-83), as described by Van Atta (1971, p. 46-48), were followed.

Where the rock outcrop is a uniform gray, lamination and grading can be detected only by careful observation, but peels from such exposures show laminae (0.25 to 1.0 cm thick) which are delineated by the presence



Figure 2. Arkosic sandstone with aligned claystone clasts (darker) in sandstone member of Cowlitz Formation. (Clear Creek)

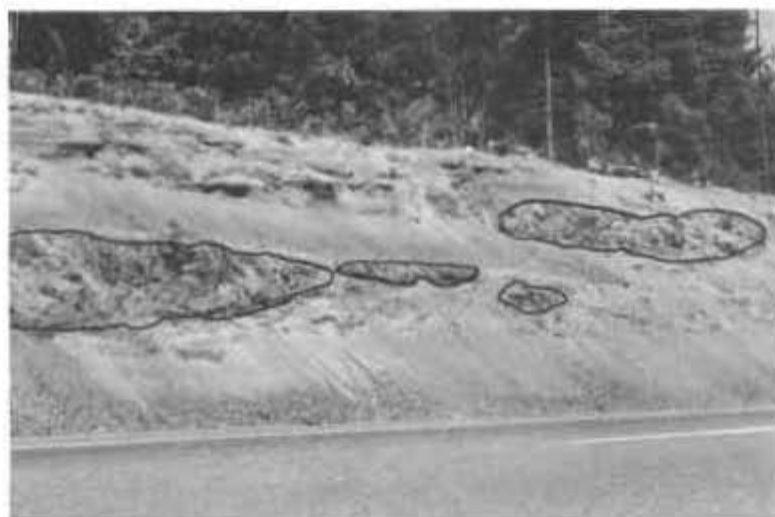


Figure 3. Pebble conglomerate in lower Cowlitz Formation with included blocks and slabs of basalt of Goble Volcanics. U.S. Highway 26, 2.2 miles west of Washington-Tillamook County line.

of much mica and/or finely comminuted plant debris or by fine-scale grading.

Peels reveal that low-angle (a few degrees to 10°) cross-lamination is common, ranging from a few inches to 14 inches in length. Foreset laminae are locally observed with inclinations up to 40°. Current directions range from southeast to southwest; however, lack of stratigraphic correlation between outcrops makes interpretation of these data questionable. Many sets of cross-laminated beds contain scour channels. Laminated siltstone peels from one locality show much contortion and separation of laminae. Although it is possible that the siltstone is a turbidite, such contorted features probably resulted from load deformation.

Another feature seen in peels, but not in outcrops, are borer holes represented by tubes filled with sediment containing unoriented mica flakes or mud (see Figure 1). The holes do not greatly disrupt the bedding.

At several localities two or three bands containing angular silty claystone clasts from 0.5 to 3.0 inches in size are inter-stratified with beds of fine- to medium-grained, cross-laminated, micaceous sandstone. The bands containing the claystone clasts resemble intraformational breccia, except that the clasts are restricted to distinct strata rather than being scattered throughout the sandstone (see Figure 2).

Collectively the primary structures suggest a littoral to shallow marine environment with moderate current action and a moderate sediment supply. Benthonic organisms were also present, suggesting non-toxic bottom conditions. Interbedded siltstone and minor amounts of mudstone within the sandstone member indicate environmental variations both in place and time during deposition.

Almost without exception beds within the sandstone member of the Cowlitz Formation strike northwest to west and dip south to southwest. Reversals in dip within the sandstone member were measured just west of the Timber-Vernonia junction and between Keasey and Rocky Point where dips are to the northeast and east. From attitudes at the Timber-Vernonia junction outcrop it would appear that the sandstone member underlies exposures of the siltstone member which are situated along the Sunset Highway. Further study and more supporting data would be required to substantiate this interpretation, and the view that the siltstone member underlies the sandstone member is adhered to in this report. It is also possible that the sandstone member interfingers with the siltstone member.

The strike of the younger beds of the Tertiary section in the upper Nehalem basin (Keasey Formation) is consistently northeasterly and dips are southeasterly. Strikes displayed by the sandstone member of the Cowlitz Formation are then opposed to the strike of all the younger strata in the area by angles varying from 45° to 90°. This discordance may be indicative of an unconformity between the sandstone member of the Cowlitz Formation and the overlying mudstone. However, Baldwin (oral communication, 1970) states that local warping similar to that which is common throughout the Coast Range could also account for the relationship.



Figure 4. Fan jointing in basalt intrusion (Goble Volcanics) with overlying siltstone, sandstone member, Cowlitz Formation. (Clear Creek, NW 1/4, sec. 28, T. 4 N., R. 5 W.)



Figure 5. Laminated mudstone inclusion (lighter tone) in basalt. (Same location as Figure 4)

Goble Volcanics member: Warren and others (1945) applied the name Goble Volcanic Series to basic flows and pyroclastic rocks which interfinger with tuffaceous sediments of the Cowlitz Formation along the Columbia River north of the upper Nehalem River basin. In the type locality of the Cowlitz Formation, Henriksen (1956, p. 59) reports, "Since the Goble Volcanics are relatively thin here [in the eastern Willapa Hills area, southwestern Washington] and are interfingered with sediments of the Cowlitz Formation [the Olequa Creek member] it is considered justifiable to lower the rank of the Goble Volcanics to a member in this area." Since a similar relationship is apparent in the upper Nehalem River basin, the Goble Volcanics are here referred to as a member of the Cowlitz Formation.

As noted above, in every outcrop consisting of interbedded sedimentary rock and basaltic flows and breccias of the Goble Volcanics member, transitional boulder to pebble conglomerates are also present. The best examples of these relationships can be seen along the Sunset Highway from the Washington-Tillamook County line westward. Road cuts near the county line reveal basaltic flows interfingering with a thin pebble conglomerate which contains subangular basalt boulders. Siltstone and sandstone beds underlie the interbedded lavas and conglomerate. Just south of the highway (center sec. 6, T. 3 N., R. 5 W.) basaltic lava is overlain by 3 to 4 feet of fossiliferous pebble conglomerate and pebbly sandstone composed largely of claystone clasts. On the south side of the highway 2.2 miles west of the Washington-Tillamook County line, a pebble conglomerate rests with a very irregular and steeply dipping contact upon late Eocene basalts of the Goble Volcanics. On the north side of the highway at this locality, there is about 12 feet of pebble conglomerate and claystone containing subangular and rounded blocks of basalt 4 to 5 feet in diameter (see Figure 3). Some blocks have a faint suggestion of pillow structure and contain pyrite, zeolites, and calcite on fracture surfaces and in vugs and veins.

In the sandstone member of the Cowlitz Formation the Goble Volcanics occur generally as dikes and sills which were apparently injected into wet, semiconsolidated sediments. Pillow structure and palagonite, extensive silicification, zeolitization, and pyritization of superjacent sediments are common features in basalt bodies exposed in several quarries in the Clear Creek drainage area. (See Figures 4, 5, and 6)

Additional exposures in which the intrusive relationships are displayed include those at the Columbia County quarry near the Nehalem River, at Rocky Point, and at the ridge crest of Rocky Point. In the Columbia County quarry a basaltic sill appears to be intrusive between an underlying bentonitic, pyritic, silicified mudstone and overlying bouldery pebble conglomerate (see Figures 7 and 8). This exposure has been interpreted by others as a basaltic flow or flows (for example, Deacon, 1953, p. 77). However, the presence of pyrite, zeolites, and calcite in both the upper part of the sill and in the overlying conglomerate, and the thin hydrothermally altered

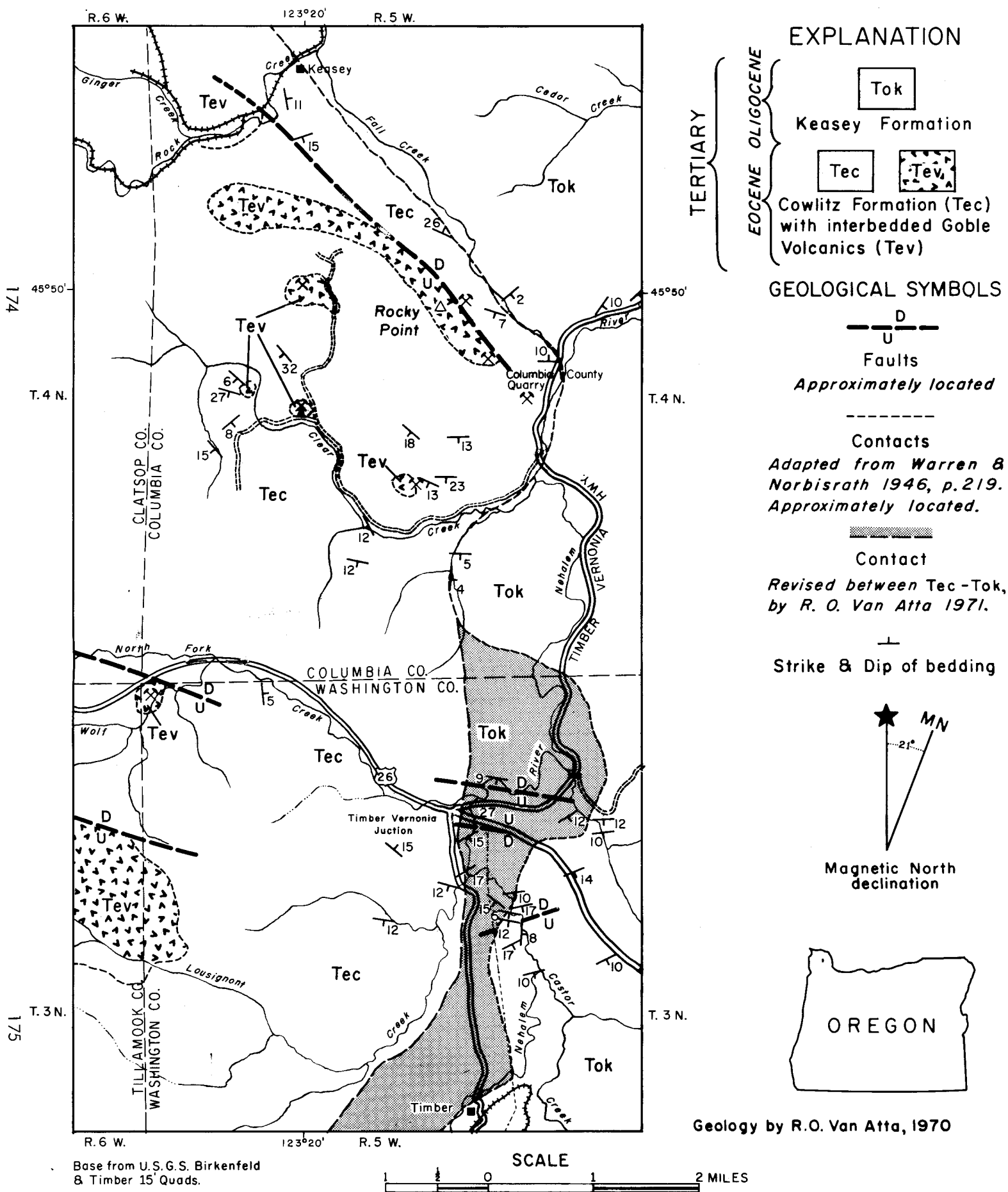


PLATE 1. GEOLOGIC MAP OF PART OF THE UPPER NEHALEM RIVER BASIN, OREGON. STIPPLED AREA ORIGINALLY MAPPED AS COWLITZ FORMATION BY WARREN AND NORBISTRATH (1946) CONSIDERED PART OF KEASEY FORMATION BY VAN ATTA (1971).

zone in the uppermost part of the sill and in the base of the conglomerate, seem to militate against the basalt being flow rock.

Basaltic dikes are exposed in several large quarries and in road cuts along the ridge crest at Rocky Point. At one quarry, hydrothermal mineralization of the basalt and overlying sediments shows the basalt is intrusive. Collapsed vesicles, originally lined with brown (palagonitic ?) glass, which appear as stringers up to 1 cm in length, are oriented nearly vertically. Arkosic siltstone and sandstone assigned to the sandstone member of the Cowlitz Formation crop out in numerous road cuts not more than a tenth of a mile from the ridge crest.

Warren and Norbistrath (1946, p. 219) mapped the basalts at Rocky Point as an uptilted block of the Tillamook Volcanic Series. Although a fault probably parallels the ridge on the northeast flank, as suggested by the presence of much steeper slopes there as compared to the gentle slope of the southwest flank, the intrusive nature of the basalt into the sandstone member of the Cowlitz Formation would make it more reasonable to include the basalt in the Goble Volcanics member of the Cowlitz Formation.

Basalt flows of the Goble Volcanics member are found on Rock Creek, 0.5 mile southwest of Keasey, Oregon, at the west end of a destroyed railroad trestle, interbedded with silicified greenish-gray muddy, volcanic sandstone and gray siltstone. The sedimentary interbeds are reddened and baked at their upper contacts with each of at least three lava flows. Other than this occurrence, no other flows of the Goble Volcanics member were found by this writer interbedded with the sandstone member of the Cowlitz Formation. Interbedded flows of the Goble Volcanics seem more common in the siltstone member of the Cowlitz, whereas intrusives of Goble Volcanics are more common in the sandstone member.

Keasey Formation, lower member

The Cowlitz Formation is overlain by beds of tuffaceous siltstone and mudstone which are assigned to the Keasey Formation. The type section of the Keasey Formation along Rock Creek, from the site of Keasey to a point downstream about 2 miles, was described by Schenck (1927, p. 457-458). Weaver (1937, p. 171-172) regarded the Keasey Formation as early Oligocene in age. Warren and Norbistrath (1946, p. 226) made the division between the Keasey Formation and the underlying Cowlitz Formation in the upper Nehalem River basin on the basis of mega- and microfaunal evidence. They described their upper shale member of the Cowlitz Formation (1946, p. 224) as "marine fossiliferous dark gray shale and fine-grained micaceous shaly sandstones, which contain increasing amounts of interbedded tuffaceous sandstone and water-laid tuff in the upper part." No typical section is specified nor is any thickness given for the unit.



Figure 6. Basalt pillows with included laminated mudstone. (Same locality as Figure 4)



Figure 7. Boulders in conglomerate overlying basaltic sill (lower right corner), related to Goble Volcanics. (Columbia County quarry)

Warren and Norbistrath (1946) proposed division of the Keasey Formation into "a lower dark shale member (type Keasey); a uniform middle member of massive silty tuffaceous shale with cemented beds; and an upper member of stratified tuffaceous sandy shales." These workers acknowledged the difficulty of distinguishing lithologically the beds they considered to be their upper shale member of the Cowlitz Formation from those they described as belonging to their lower member of the Keasey Formation.

One of the most complete sections of sedimentary beds which Warren and Norbistrath (1946) mapped as upper Cowlitz shale and lower Keasey shale is exposed along the Nehalem River, south of the Sunset Highway bridge near the Timber-Vernonia junction. Here, at least 1,115 feet of mudstone, siltstone, and minor fine-grained calcareous silty sandstones, with a few beds of calcareous pebbly sandstone can be traced for about $1\frac{1}{2}$ miles. A measured stratigraphic section of these beds is presented by Van Atta (1971).

The beds in this mudstone-siltstone sequence strike generally east-west to northeast, with local variations ranging from 62° NW to 60° NE, and dip 10° to 16° S. The individual mudstone beds are massive and range from 10 to 40 feet in thickness. Between them, in interbedded sequences of from three to ten beds, are thin layers of dark-gray to green-gray calcareous siltstone, dark-green calcareous pebbly volcanic sandstone, and dark-gray mudstone 0.5 to 2.0 feet thick. The beds of calcareous siltstone and sandstone are more resistant than the mudstone beds and they control the course of the Nehalem River wherever large meanders have developed.

Primary sedimentary structures other than graded bedding are rare in the mudstone, siltstone, and pebbly sandstone of the lower part of the Nehalem River section. Toward the upper part of the section well-laminated siltstone interbedded with thick massive mudstone becomes increasingly common. Calcareous pebbly volcanic sandstone interbeds are much rarer in the upper part of the section than in the lower.

A similar sequence of mudstone and siltstone with interbedded calcareous pebbly volcanic sandstone is exposed along the lower reaches of Lousignont Creek, a tributary of the Nehalem River from the west, and along the lower reaches of Robinson Creek, a tributary of the Nehalem River from the east. Along the Sunset Highway exposures of mudstone and siltstone seem to be similar in lithology to the Nehalem River section, although advanced weathering, slumping, and thick vegetation make observation difficult.

It is the conclusions of this writer that on the basis of lithology the mudstone and siltstone beds overlying the sandstone member of the Cowlitz Formation and exposed to the east of the Nehalem River should be placed in the lower member of the Keasey Formation because of their distinctive lithology as contrasted to that of the sandstone of the Cowlitz. This is in harmony with Article 6 of the Code of Stratigraphic Nomenclature (American Commission on Stratigraphic Nomenclature 1961, p. 650).

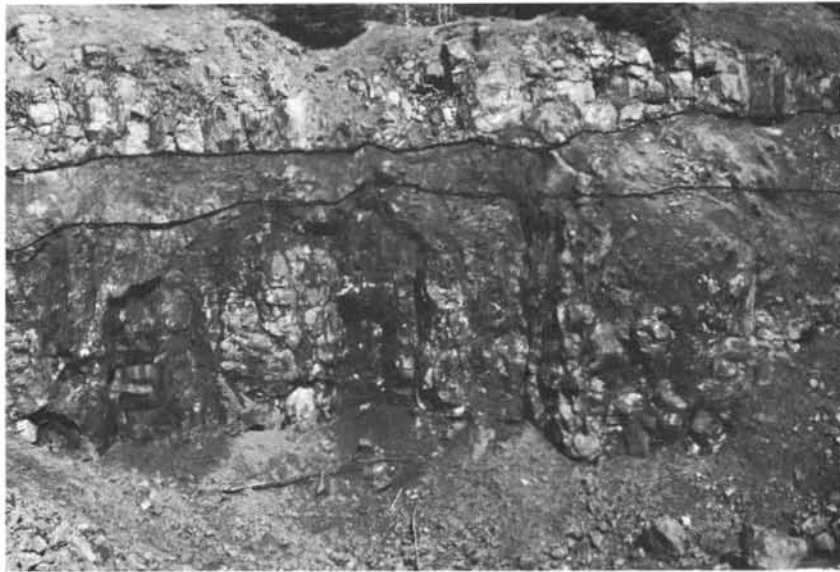


Figure 8. Conglomerate sliver included in basaltic sill. (Same locality as Figure 7)

In addition to the lithologic dissimilarities between the sandstone member of the Cowlitz Formation and the overlying mudstone, the apparent discordance between the two units suggests a possible unconformity as discussed above (see sandstone member).

Conclusion

Careful study of the petrology and stratigraphic relationships of the sedimentary and volcanic rocks west of the Nehalem River in the upper Nehalem River basin shows that the Cowlitz Formation there can be divided into a siltstone member and a sandstone member. The siltstone member is interbedded with volcanic rocks which constitute the Goble Volcanics member of the Cowlitz Formation. Locally, conglomerate is associated with the Goble Volcanics and the siltstone members, having been derived from the volcanics. The Goble Volcanics member is more commonly present as intrusive bodies in the sandstone member of the Cowlitz Formation.

The lithology and stratigraphic relationships of these rocks fully justify the use of the name Cowlitz Formation in the area of this study.

Beds of mudstone and siltstone which overlie the siltstone and sandstone of the Cowlitz Formation and which have been formerly considered to be an upper member of the Cowlitz Formation on the basis of faunal evidence, are lithologically indistinguishable from the lower member of

the Keasey Formation. Therefore, these mudstones and siltstones should be included in the lower member of the Keasey Formation and the name Cowlitz should be applied only to the underlying sandstone, siltstone and intercalated volcanic rocks west of the Nehalem River.

Problems similar to those surrounding the contact between the Cowlitz and the Keasey Formations are found in a number of other parts of the Tertiary section of the Coast Range of Oregon. For example, the distinction between the Yamhill Formation and the upper part of the Tyee Formation is based largely on age. Likewise, shales of the Yamhill and Nestucca Formations are distinguished on the basis of age. An effort should be made to revise those contacts between formations which have been previously established on the basis of faunal distinctions so that they may better conform to the lithologic standards for definition of a formation as presented in the Stratigraphic Code.

Acknowledgments

Special thanks are due Dr. Harold E. Enlows, who supervised the research and preparation of the dissertation upon which this paper is based. Dr. Keith F. Oles also was especially helpful in critically reading the manuscript of the dissertation. Dr. Jon C. Cummings, Dr. Paul Hammond and Dr. Paul Howell, as well as Dr. Enlows and Dr. Oles, accompanied the writer in the field and made a number of valuable suggestions. The help of Dr. G. T. Benson in interpreting some of the structural data is also appreciated. Critical suggestions by Dr. Ewart M. Baldwin aided greatly in interpreting the stratigraphy of the area.

I am grateful for field assistance given by Michael Moran, G. W. Avolio, and Donald Baggs, who accompanied me on several occasions. Petrographic analysis of the Goble Volcanics was very ably done by Frances L. Olson. Several other of my students also contributed numerous other helps.

Bibliography

- American Commission on Stratigraphic Nomenclature, 1961, Code of Stratigraphic Nomenclature: Bull. A.A.P.G., vol. 45, p. 645-665.
- Baldwin, E. M., 1964, Geology of Oregon, 2nd edition: Edwards Brothers, Ann Arbor, Mich., 165 p.
- Bouma, A. H., 1969, Methods of study of sedimentary structures: Elsevier Publ. Co., 458 p.
- Deacon, R. J., 1953, A revision of upper Eocene and lower Oligocene stratigraphy in the upper Nehalem River basin, northwest Oregon: Unpub. Master's thesis, Oregon State University, Corvallis, Oregon 84 p.
- Folk, R. L., 1968, Petrology of sedimentary rocks: Hemphills, Drawer M., University Station, Austin, Texas, 170 p.

- Henrikson, Donald A., 1956, Eocene stratigraphy of the lower Cowlitz River-Eastern Willapa Hills area, S.W. Washington: Wash. Div. of Mines and Geol. Bull. 43
- Pettijohn, F. J., 1957, Sedimentary rocks, 2nd ed.: Harper's Book Co.
- Schenck, H. G., 1927, Marine Oligocene of Oregon: Univ. of Calif., Dept. of Geol. Sciences Bull., vol. 18, no. 12, p. 449-460.
- Twenhofel, W. H., 1937, Terminology of the fine-grained mechanical sediments: Rept. Comm. on Sedimentation for 1936-1937, National Research Council.
- Van Atta, Robert O., 1971, Sedimentary petrology of some Tertiary Formations, upper Nehalem River basin, northwest Oregon: unpublished Ph.D. dissertation, Oregon State University, 229 p.
- Warren, W. C., Hans Norbistrath and Rex Grivetti, 1945, Geology of northwest Oregon, west of the Willamette River and north of latitude 45° 15': U.S. Geol. Survey Oil and Gas Inv., Preliminary Map 42.
- _____ and Hans Norbistrath, 1946, Stratigraphy of upper Nehalem River Basin, N.W. Oregon: Am. Assoc. Pet. Geol. Bull., vol. 30, no. 2, p. 213-237.
- Weaver, C. E., 1937, Tertiary stratigraphy of western Washington and northwestern Oregon: Washington Univ. Publ. in Geol., vol. 4.
- Williams, H., F. J. Turner and C. M. Gilbert, 1954, Petrography: An introduction to the study of rocks in thin section: W. H. Freeman and Co., San Francisco, 406 p.

* * * * *

NEW MINERALS YEARBOOK AVAILABLE

The U.S. Bureau of Mines Minerals Yearbook for 1969 is for sale by the U.S. Government Printing Office, Washington, D.C. 20402. Vols 1-2 (combined) "Metals, Minerals and Fuels," is \$6.00; vol. 3 "Area Reports: Domestic," is \$4.75; and vol. 4, "Area Reports International," is \$4.75.

* * * * *

NOTICE TO ORE BIN SUBSCRIBERS

Beginning in January 1972, all subscriptions to The ORE BIN will be on a yearly basis from January through December. In other words, you will be subscribing for Volume 34, no. 1 through no. 12, in the same way you would to most other professional magazines. This change-over is designed to facilitate record-keeping for both you and us.

The October issue, on the centerfold pages, will give you additional information. Your ORE BIN expiration month and subscription rate adjustments will be included. We think you will like subscribing to The ORE BIN in this new way.

* * * * *

GREEN DIAMOND ABRASIVES

A relatively new and expanding industry in Douglas County that utilizes a waste product from the Hanna Nickel Smelter is a good example of mineral conservation practice. The Mining-Minerals Manufacturing Co. of Riddle, Oregon produces a low-cost, high-quality sandblasting grit, roofing granules, and other specialty sands from granulated smelter slag purchased from Hanna. From a modest beginning in 1961 with three employees, the plant (Figure 1) has grown to a 10-employee operation producing approximately 3000 tons per month.

Sandblasting grit in a variety of sizes that comply with government and industry specifications is the major product. It is marketed in bulk and bags in California and the Pacific Northwest under the name of "Green Diamond Abrasives" (Figure 2). Minor amounts of grit have been sold for use in non-skid coatings and road sanding material. Roofing granules, the next most important product, are marketed in bulk in the Pacific Northwest, mainly in Portland.

During the smelting and refining of ore from Nickel Mountain, the Hanna Smelter generates large quantities of slag which must be disposed of. For ease of handling, the slag is fragmented. Jets of high-pressure water quench the molten material and explosively break it into gray-green spheres, sharp irregular shards, and grains as it is poured into granulation bins near the smelter. The granular material is then conveyed to the ever-growing multi-million ton slag pile that now constitutes an almost inexhaustable source of raw material for the Mining-Minerals Manufacturing Co.

The Green Diamond plant is located about $3\frac{1}{2}$ miles east of the Hanna Smelter along the same spur of the Southern Pacific Railroad. The raw, gray-green granulated slag arrives in bottom-dump rail cars; after coarse screening it is dried and sized, and most is conveyed to appropriate storage tanks for bulk loading or bagging as abrasives. Another circuit of the flow sheet includes crushing and additional sizing for production of roofing granules and other specialty products.

The recent addition of more efficient dust collecting devices insures operation within the minimum standards for air pollution set by the Oregon Department of Environmental Quality.

Chemically the slag is a glass composed of silica (51 percent), magnesium oxide (23 percent), and iron oxide (23 percent). Chromic oxide and aluminum oxide average about 1 percent each. Other elements present occur in only trace amounts.

The slag appears to be quite durable both mechanically and chemically. There is little or no chemical alteration on exposure to weather. It is also known to possess good refractory properties. Continued research into potential new uses of this growing by-product resource should result in expanded markets and increased production.



Figure 1. A general view of the "Green Diamond" plant at Riddle, Oregon 1971. The large storage tanks with their associated conveyors are the bulk loading facility; rotary dryer and screening circuits are behind the storage tanks. The bagging facility is at the left. Piles of granulated slag in the foreground.



Figure 2. Sandblasting grit in a variety of sizes is marketed as "Green Diamond" in 100 lb. bags.

EASTERN OREGON EARTHQUAKES OF JULY 13-14, 1971

by Lawrence H. Jaksha
National Oceanic and Atmospheric Admin., Earth Sciences Laboratory

A mild series of earthquakes took place near the Thief Valley Reservoir on the Powder River in northeastern Oregon on July 13 and 14 of 1971. The locations as determined by National Oceanic and Atmospheric Administration (NOAA) indicates that these events are a continuation of the tectonic readjustment discussed by Couch and Whitsett in 1969.*

The largest earthquake in the series was observed at six seismograph stations. These stations and their associated P phase arrival times are listed below. The three aftershocks were observed only at the Blue Mountains Observatory (BMO).

Station	Location	Arrival Time (GMT)
BMO	Baker Oregon	23h 29m 34.2s
HAN	Hanford, Washington	23h 29m 58.2s
HHM	Hungry Horse, Montana	23h 30m 33.3s
LDM	Libby Dam, Montana	23h 30m 25.8s
LON	Longmire, Washington	23h 30m 16.9s
NEW	Newport, Washington	23h 30m 17.4s

The geographic coordinates of the largest earthquake are 44.8 N latitude, 117.9 W longitude. The epicenter is located approximately 10 km WSW of the Thief Valley Reservoir. The origin time of the event is calculated to be 23h 29m 25.2s GMT on July 13, 1971. The solution of the earthquake suffers somewhat from poor azimuth but the inference of association with the event discussed by Couch and Whitsett is justified.

The P wave arrival times and magnitudes of the series as observed at BMO are as follows:

Date	Time GMT	Magnitude
July 13, 1971	23h 29m	3.0
July 13, 1971	23h 33m	2.0
July 13, 1971	23h 35m	Very Small
July 14, 1971	04h 13m	2.2

The magnitudes given refer to the Richter Scale and were derived from the recorded ground motion at BMO.

Several residents in the sparsely populated country between North Powder and Haines report having both felt and heard this latest quake, and some who experienced the 1969 event felt that this one was the stronger and longer lasting of the two. No damage attributable to the recent quake was reported.

* The North Powder Earthquake of August 14, 1969, by R. Couch and R. Whitsett. The ORE BIN, vol. 31, no. 12, December 1969.

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev. 1940; Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944; Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947; Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963; Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947; Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953; Allison	0.75
39.	Geology and mineralization of Morning mine region, Grant County, Oregon 1948; R. M. Allen & T. P. Thayer	1.00
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956; Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959; Koch	1.00
52.	Chromite in southwestern Oregon, 1961; Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962; Steere and Owen	1.50
57.	Lunar Geological Field Conference guide book, 1965; Peterson and Grah, editors	3.50
58.	Geology of the Suplee-Izee area, Oregon, 1965; Dickinson and Vigrass	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967; Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968; Dole	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Geology, mineral, and water resources of Oregon, 1969	1.50
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970; Peterson & McIntyre	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970; Roberts	2.00
68.	The Seventeenth Biennial Report of the State Geologist, 1968-1970	Free
69.	Geology of the Southwestern Oregon Coast W. of 124th Meridian, 1971; R. H. Dott, Jr.	3.75
70.	Geologic formations of Western Oregon, 1971; Beaulieu	2.00
71.	Geology of selected lava tubes in the Bend area, 1971; Greeley	in press

GEOLOGIC MAPS

Geologic map of Oregon west of 121st meridian, 1961: (over the counter)	2.00
folded in envelope, \$2.15	
Geologic map of Oregon (12" x 9"), 1969; Walker and King	0.25
Preliminary geologic map of Sumpter quadrangle, 1941; Pardee and others	0.40
Geologic map of Albany quadrangle, Oregon, 1953; Allison (also in Bull. 37)	0.50
Geologic map of Galice quadrangle, Oregon, 1953; Wells and Walker	1.00
Geologic map of Lebanon quadrangle, Oregon, 1956; Allison and Felts	0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957; Williams	1.00
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962; Prostka	1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon, 1962; Corcoran et. al.	1.50
GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967; Prostka	1.50
GMS-4: Gravity maps of Oregon, onshore & offshore, 1967; [Sold only in set] flat, \$2.00; folded in envelope, \$2.25; rolled in map tube	2.50
GMS-5: Geology of the Powers quadrangle, 1971; Baldwin and Hess	1.50

[Continued on back cover]

The ORE BIN
1069 State Office Bldg., Portland, Oregon 97201

The Ore Bin

POSTMASTER: Return postage guaranteed.



Available Publications, Continued:

SHORT PAPERS

- | | |
|---|---------|
| 2. Industrial aluminum, a brief survey, 1940: Motz | \$ 0.10 |
| 18. Radioactive minerals the prospectors should know (2nd rev.), 1955:
White and Schafer | 0.30 |
| 19. Brick and tile industry in Oregon, 1949: Allen and Mason | 0.20 |
| 21. Lightweight aggregate industry in Oregon, 1951: Mason | 0.25 |
| 24. The Alameda mine, Josephine County, Oregon, 1967: Libbey | 2.00 |

MISCELLANEOUS PAPERS

- | | |
|--|------|
| 1. Description of some Oregon rocks and minerals, 1950: Dole | 0.40 |
| 2. Key to Oregon mineral deposits map, 1951: Mason | 0.15 |
| Oregon mineral deposits map (22" x 34"), rev. 1958 (see M. P. 2 for key) | 0.30 |
| 3. Facts about fossils (reprints), 1953 | 0.35 |
| 4. Rules and regulations for conservation of oil and natural gas (rev. 1962) . | 1.00 |
| 5. Oregon's gold placers (reprints), 1954 | 0.25 |
| 6. Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton . . . | 1.50 |
| 7. Bibliography of theses on Oregon geology, 1959: Schlicker | 0.50 |
| 7. (Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts . . | 0.50 |
| 8. Available well records of oil & gas exploration in Oregon, rev. 1963:
Newton | 0.50 |
| 11. A collection of articles on meteorites, 1968: (reprints, The ORE BIN). . | 1.00 |
| 12. Index to published geologic mapping in Oregon, 1968: Corcoran | Free |
| 13. Index to The ORE BIN, 1950-1969, 1970: M. Lewis | 0.30 |
| 14. Thermal springs and wells, 1970: R. G. Bowen and N. V. Peterson . . . | 1.00 |

MISCELLANEOUS PUBLICATIONS

- | | |
|---|------|
| Oregon quicksilver localities map (22" x 34"), 1946 | 0.30 |
| Landforms of Oregon: a physiographic sketch (17" x 22"), 1941 | 0.25 |
| Index to topographic mapping in Oregon, 1969 | Free |
| Geologic time chart for Oregon, 1961 | Free |
| The ORE BIN - available back issues, each | 0.25 |

OIL and GAS INVESTIGATIONS SERIES

- | | |
|---|------|
| 1. Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:
Newton and Corcoran | 2.50 |
| 2. Subsurface geology of the lower Columbia and Willamette basins, Oregon,
1969: Newton | 2.50 |

The Ore Bin

"Special Subscription Issue."



Vol. 33, No. 10
October 1971

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Published Monthly By

Published Monthly By

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
Head Office: 1069 State Office Bldg., Portland, Oregon - 97201
Telephone: 229 - 5580

2033 First Street	521 N. E. "E" Street
Baker 97814	Grants Pass 97526

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Subscription rate \$1.00 per year. Available back issues 25 cents each.

Second class postage paid
at Portland, Oregon

[illegible]

Fayette I. Bristol, Rogue River, Chairman
R. W. deWeese, Portland
William E. Miller, Bend

R. E. Corcoran

Norman S. Wagner, Baker Len Ramp, Grants Pass

焚 焚

Permission is granted to reprint information contained herein.
Credit given the State of Oregon Department of Geology and Mineral Industries
for compiling this information will be appreciated.

GEOLOGY MARKERS ALONG OREGON HIGHWAYS

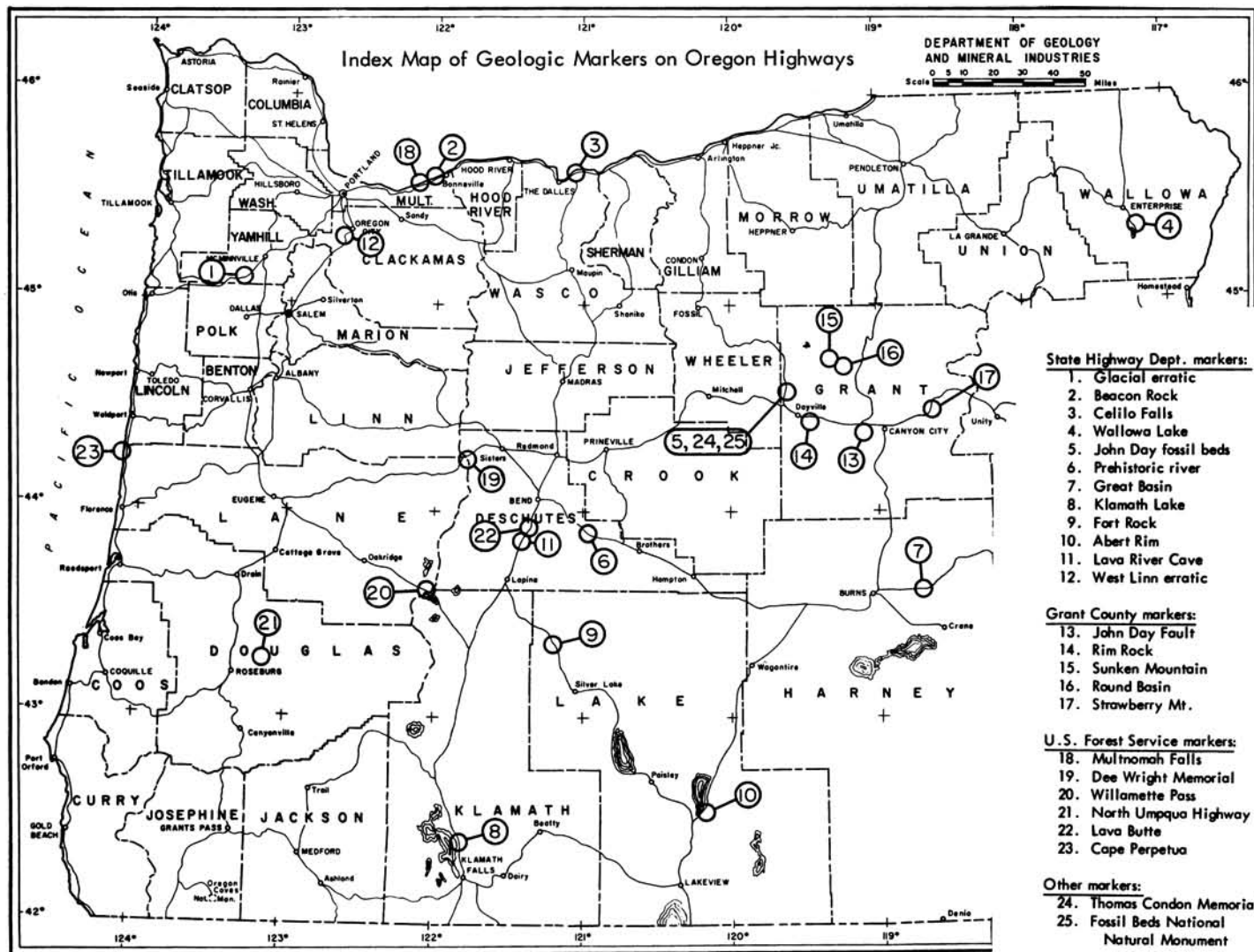
By Erwin F. Lange
Portland State University, Portland, Oregon

Scattered along the highways of Oregon are a number of markers informing the traveler about the geologic features visible on his route. These signs are the work of five different organizations and are described here as well as being indicated by their numbers on the accompanying map.

Oregon Highway Department markers

Among its 80 or more rustic historical markers, the Oregon Highway Department maintains at least 12 that are concerned wholly or in part with geology. Many of Oregon's historical events occurred where they did because of some geological phenomenon, and for this reason markers in these areas focus attention on some phase of geology.

1. On Oregon Highway 18, a short distance west of McMinnville, is a geological marker defining the term "glacial erratic" and pointing to one of the largest of such rocks to have been brought in during the ice age.
2. Beacon Rock, a giant stone pillar of volcanic origin that rises out of the Columbia River on the Washington side, is noted by a historical marker on Interstate 80-N west of Bonneville Dam. This great geological feature was a prominent landmark for the Lewis and Clark expedition and for many explorers who followed.
3. Also along Interstate 80-N, a few miles east of The Dalles, is a marker dedicated to Celilo Falls, ancient fishing grounds of various Indian tribes. The falls are now inundated by the storage basin of The Dalles Dam.
4. In the far northeast corner of Oregon, south of Joseph, is a geological marker describing the formation of Wallowa Lake from the damming action of glacial drift.
5. Looking out across the John Day River to Sheep Rock on Oregon Highway 19 near the intersection with U.S. 26 is a geology marker describing the John Day Fossil Beds. (Fig. 1)



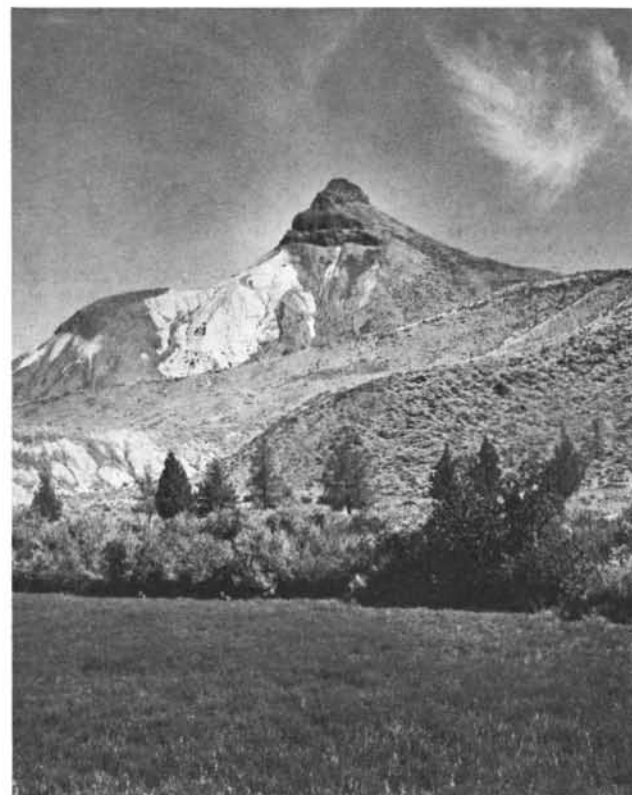
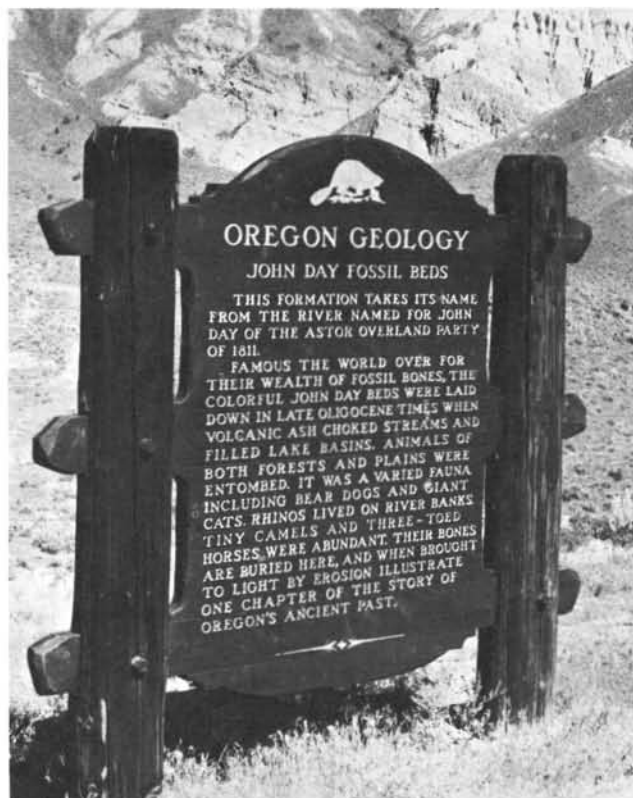


Figure 1. LEFT: One of the three markers on Oregon Highway 19 that calls attention to the John Day fossil beds in Sheep Rock. RIGHT: Across the river from the markers is Sheep Rock, whose strata contain Oligocene and Miocene fossil mammals. (Oregon Highway Division photos).

6. On the Bend-Burns Highway, U.S. 26, about 4 miles west of Millican is a marker that describes a prehistoric river which flowed across the central Oregon desert at this point.
7. On U.S. Highway 20, about 23 miles east of Burns, is a marker that shows the northern limit of the great inland basin, which had no drainage to the sea. A map showing the extent of the basin is included on the marker.
8. A historical marker for Klamath Lake is located on U.S. Highway 97 about nine miles north of Klamath Falls. This marker gives some of the early history relating to the lake and points out that it is the largest body of water in Oregon.
9. A prominent Central Oregon landmark, Fort Rock, is noted by a historical marker on Oregon Highway 31 about 18 miles north of Silver Lake. Not only does the marker refer to the geology of Fort Rock but also to the early inhabitants who lived in a cave nearby. (Fig. 2)
10. Abert Rim, one of the highest fault scarps in the United States, is described by geological markers in two locations, one on Oregon Highway 31 about a mile north of Valley Falls, and the other on U.S. Highway 395 about ten miles north of Valley Falls.
11. A bronze marker describes the origin of a well-preserved lava tube situated on U.S. Highway 97 about 7 miles south of Bend at Lava River Caves State Park. This volcanic feature is not visible from the highway but lies only a few hundred feet to the east.
12. A small glacial erratic bearing a metal geologic plaque is situated at a rest and picnic stop on the west side of I-205 near West Linn. The erratic was transported by an iceberg during the Missoula Flood more than 10 million years ago.

Grant County geologic plaques

The Grant County Planning Commission has placed five geologic markers along the John Day "Loop," a 112-mile route via Mt. Vernon, Kimberly, Long Creek and return. These markers are in the form of stainless steel plaques on which the geology is explained in some detail by diagrams and descriptive text. The Grant County plaques were prepared and installed in 1970 in cooperation with the Oregon Department of Geology and Mineral Industries and the Oregon Highway Department. An illustrated booklet, *The Geologic Setting of the John Day Country*, containing a road log of the John Day "Loop" and a geologic story of the area is available (see list at end of report).

13. A metal plaque at the Holliday Rest Area on U.S. Highway 26 near Mt. Vernon shows by diagram and text the way the strata were broken and displaced vertically about 1000 feet along the John Day fault.



Figure 2. ABOVE: A geologic marker on Oregon Highway 31 tells about the early cave dwellers and the origin of Fort Rock. BELOW: Fort Rock, rising 325 feet above the plateau, is the eroded remnant of a volcano. (Oregon Highway Division photos.)



14. A metal plaque on U.S. 26 about 3 miles east of Dayville points to the rimrock across the valley and tells how a flow of red-hot pumice filled the ancient John Day valley to form this extensive layer of rock.
15. A plaque on Oregon Highway 402 (between Kimberly and Long Creek) 8 miles east of Monument illustrates a place where landslides have created an unusual topography known as Sunken Mountain.
16. On Oregon 402, about 4½ miles east of Sunken Mountain a metal plaque explains the geologic relationships of the features within view: Hamilton fault, Round Basin, and Long Creek Mountain.
17. A metal plaque situated at a viewpoint on U.S. 26 about 5 miles east of Prairie City explains the geology of the vista to the south across the John Day Valley toward Strawberry Mountain, which is an uplifted fault block deeply etched by glaciers.

U. S. Forest Service markers

The U.S. Forest Service has placed geologic signs in several scenic areas where Oregon Highways pass through National Forest lands. In addition, it maintains two roadside visitor-information centers where the local geologic features are explained and illustrated brochures are made available.

18. At Multnomah Falls on Old Columbia River Highway adjacent to Interstate 80-N is a display shelter in which is told the geological story of the Columbia River Gorge and its lava flows and waterfalls.
19. The Dee Wright Memorial at McKenzie Pass on Oregon Highway 242 has a group of three markers that explain the origin of the fresh black lava fields and point to a short, self-guided tour on a foot trail through the lava. (Fig. 3)
20. Just west of the summit on the Willamette Pass Highway (Oregon Highway 58) is a viewpoint with a rustic sign describing the geology of Diamond Peak.
21. A geologic marker at a roadside turnout on the North Umpqua Highway (Oregon Highway 138) near Glide tells about Eocene marine fossil beds along Little and North Umpqua Rivers. (Fig. 4)
22. Lava Butte, a huge cinder cone on U.S. Highway 97 about 6 miles south of Bend, has a visitor's information center at its top and a foot trail at its base. The geology of the volcanic feature is fully explained. (Fig. 5)
23. At Cape Perpetua on U.S. Highway 101, just south of Yachats in the Siuslaw National Forest, is a visitor's information center and trails where the geology and natural history are interpreted. Among the geologic features in view along this part of the highway and explained are sea stacks, spouting horns, caves, churns, and the changing tides.

POPULAR PUBLICATIONS ON OREGON GEOLOGY

<u>Geologic Trips Through Oregon's "Moon Country".</u>	Bulletin 57, 51 pages	\$3.50	_____
Five trips, illustrated with maps, diagrams, photos describe the volcanic wonderland in central Oregon which has been used by all the lunar astronauts as a geologic study area in preparation for their walks on the moon.			
<u>Where to Dig for Fossils in Oregon</u>	Fossil articles	\$1.00	_____
A collection of 9 pamphlets describing the more common fossils, their age, and where to dig for them, plus information on fossil wood.			
<u>Mineral Deposits Map of Oregon</u>	Mineral deposits map	\$.45	_____
The location of 350 mines and mineral deposits is shown on a 22"x34" map. Marginal notes describe 12 of the 43 minerals listed. Placer mining areas are shown on a small map. A key lists mineral localities by name, location, county and mining district.			
<u>Gold Panning for Fun</u>	Miscellaneous paper No. 5	\$.25	_____
Where to go, how to pan, tests for gold and "fool's gold." Plans for sluice boxes and rockers for the more serious prospector.			
<u>Stones From Outer Space</u>	Miscellaneous paper No. 11	\$1.00	_____
Large meteorites have fallen in Oregon -- the Willamette stone, now in Hayden Planetarium; the famous Port Orford stone, still missing 120 years after first report of it. These and others are described, and information on identifying meteorites is given.			
<u>Description of Some Oregon Rocks and Minerals</u>	Miscellaneous paper No. 1	\$.40	_____
Commonly found rocks and minerals are described in non-technical language. Tables, charts and discussions of the various types of rocks and minerals and their formation are also included.			

(Center fold pages may be removed for mailing)

IMPORTANT NOTICE FOR ALL

ORE BIN SUBSCRIPTION NOTICE

On January 1, 1972 all ORE BIN subscriptions will go on a calendar year basis, January through December.

Individual renewal reminder cards will no longer be sent to subscribers. Each Fall a reminder will be printed in The ORE BIN.

Please note: All subscriptions will run for the calendar year January through December. Your expiration date is shown in the box at the bottom of this page. Please check the following schedule for the amount to pay in order to extend your ORE BIN to December 31, 1972.

<u>If your subscription expires:</u>	<u>Your renewal through December 1972 will be:</u>
Sept., Oct., Nov. 1971	\$1.25
Dec. '71, Jan., Feb., Mar. 1972	1.00
Apr., May, June 1972 . . . . .	.75
July, Aug., Sept. 1972 . . . . .	.50
Oct., Nov. 1972 . . . . .	.25
Dec. 1972 . . . . .	.00

Your subscription expires: _____

If this date is after 1972 DO NOT RENEW NOW.

Individual copies - \$.25
(effective July 1, 1971)

ORE BIN SUBSCRIBERS

EXTEND YOUR SUBSCRIPTION NOW TO
DECEMBER 31, 1972

ORE BIN RENEWAL FORM

Enclosed is \$ _____ to extend my ORE BIN thru December 1972.

Name _____

Street _____

City, State _____ ZIP _____

NEW OR GIFT SUBSCRIPTION FORM

Please send The ORE BIN during 1972 (\$1 enclosed) to:

Name _____

Street _____

City, State _____ ZIP _____

Mail form(s) together with remittance to:

The ORE BIN
1069 State Office Building
Portland, Oregon 97201

(Center fold pages may be removed for mailing)

Geology of Selected Lava Tubes in the Bend Area, Oregon Bulletin 71, 47 pages . . . \$2.50 _____
More than 20 lava-tube caves in the Bend area are mapped, described, and
illustrated by photographs.

Geology of Selected State Parks Each pamphlet \$.25; Total _____
Many of Oregon's state parks have superb scenic attractions, and these illustrated
pamphlets explain the geology behind the scenery: faults and folds, volcanism,
fossils, age of rocks.

Beverly Beach _____
Cape Arago _____
Cape Blanco _____
Cape Lookout _____

Cape Sebastian _____
Cove Palisades _____
Florence-Yachats _____
Humbug Mountain _____

Collier _____
Ecola _____
Lake Owyhee _____

Topographic maps Index - free; Maps - \$.50 at counter; \$.75 mailed _____
Elevations of all geographic points, names of streams, mountains and valleys, and dozens
of other bits of information are printed on the 5-color U.S. Geological Survey topographic
quadrangles. Free index of available sheets sent on request. Order by map name and
series. Scales vary with area mapped.

.>

Please send the publications checked above to:

Name _____

Street _____

City, State _____ ZIP _____

Amount for publications \$ _____

Amount for ORE BIN \$ _____

Total amount enclosed \$ _____

For office use only		
Check	M.O.	Cash
Filled by: _____	Shipped: _____	

Mail this form to: Oregon Department of Geology & Mineral Industries
1069 State Office Building, Portland, Oregon 97201

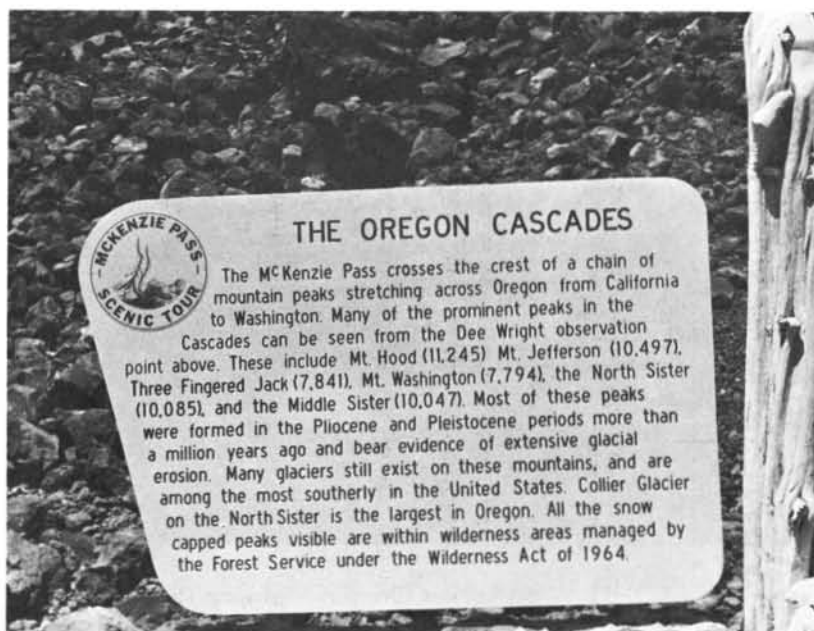
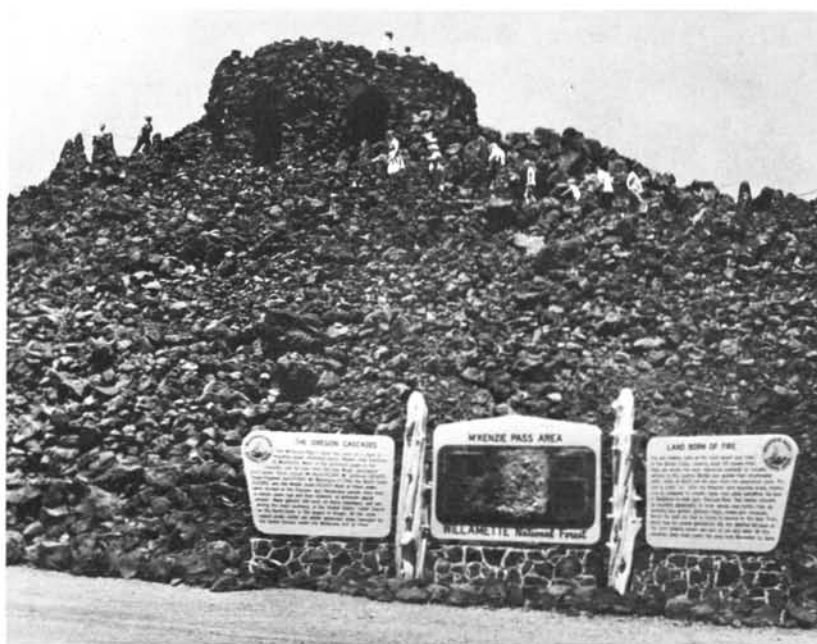


Figure 3. ABOVE: An interpretive sign at McKenzie Pass below the Dee Wright observation point. BELOW: Dee Wright Memorial with the descriptive signs, scenic viewpoint, and self-guided tour through the fresh lava. (U.S. Forest Service photos)



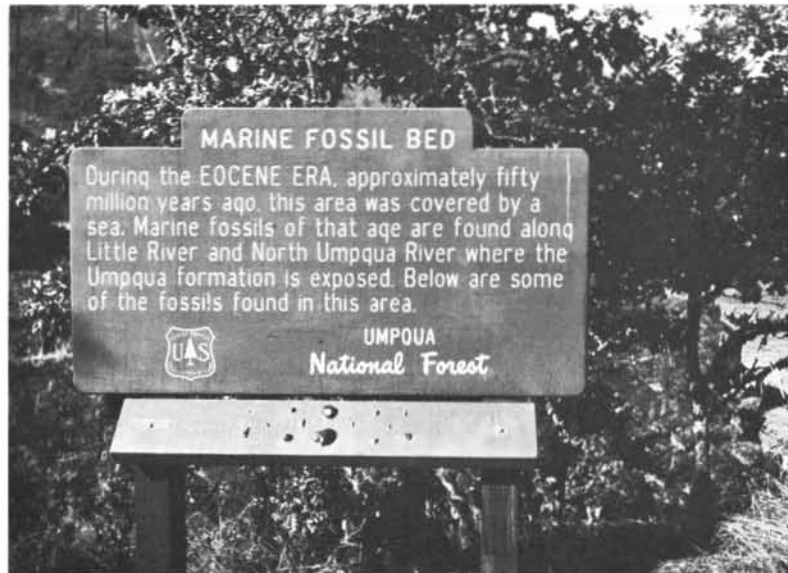


Figure 4. ABOVE: A marker on Oregon Highway 138 near Glide calls attention to the confluence of Little River and the North Umpqua where Eocene marine fossils are numerous. (U.S. Forest Service photo)

Figure 5. BELOW: A marker on U.S. Highway 97 points to nearby Lava Butte, an extinct volcano, with its visitor's information center at the top and a trail over the lava at the base. (U.S. Forest Service photo)



Other highway markers

Three geologic markers have been placed at a viewpoint in Thomas Condon - John Day Fossil Beds State Park opposite Sheep Rock on Oregon Highway 19. One is the State Highway marker No. 5, above, describing the fossil beds; the other two are:

24. The Thomas Condon marker, installed by the Geological Society of the Oregon Country, is a large block of Cretaceous conglomerate bearing a bronze tablet dedicated to Dr. Condon, pioneer pastor and geologist, who came to Oregon in 1853 and was the first to investigate the fossil beds of the John Day Country.
25. A National Parks marker designates the Thomas Condon - John Day Fossil Beds State Park area as a National Natural Landmark.

Oregon is rich in scenic geology; hence, highway markers pointing out and interpreting examples of this natural resource are useful in maintaining a permanent account for motorists and tourists to read. A good beginning has been made in calling attention to Oregon's interesting geology, not only by highway markers but also by interpretive signs at some of the state and federal recreational sites situated away from the main-traveled highways; for example, Painted Hills, Cove Palisades, Paulina Peak, and Steens Mountains. However, there remain many unusual geologic features along Oregon's major highways that could be identified by markers, and such information could materially enhance the education and enjoyment of the traveling public.

The reader is referred to the following publications for more information about the highway markers and the geologic features defined:

Oregon's Historical Markers, by W. M. Scofield, Criterion Publishers, 1966. Small illustrated booklet of the State Highway Department's markers; \$1.95 at Oregon Historical Society and at bookstores.

The Lava Butte Geological Area, by Phil F. Brogan.

Descriptive brochure illustrated by a map and photographs; available free from Deschutes National Forest, U.S. Forest Service.

The Geologic Setting of the John Day Country, Grant County, Oregon.

Information provided by T. P. Thayer and published by the U. S. Geological Survey. Available free from the Oregon Department of Geology and Mineral Industries, the Grant County Planning Commission, or the Oregon State Highway Commission.

The Story of the Condon Memorial, by Jane Erickson.

Published in the July 1954 issue of the Geological Society of the Oregon Country News Letter, p. 59-60.

* * * * *

CORRECT ADDRESS, PLEASE!

Is your address exactly right on this issue? Do we use a street address but you are actually receiving mail at a post office box? Have you moved within the same zip code area and not sent in a correction? Second class mail is returned for what may seem petty differences - this delays your ORE BIN and increases our costs. Please -- and thank you!

* * * * *

LAVA CAVES BULLETIN PUBLISHED

"Geology of selected lava tubes in the Bend area, Oregon," is the title of the latest bulletin published by the Oregon Department of Geology and Mineral Industries. The author, Ronald Greeley, geologist with the Space Science Division of NASA, mapped a large group of caves south and east of Bend, including the one at Lava River State Park. The possibility of similar features on the moon's surface prompted the initial research study by NASA. Among the caves described in the bulletin are two extensive lava-tube systems, one of which was originally a continuous tube 7 miles long before collapse of parts of its roof. The peculiar features that have developed in these lava caves both during and after formation are explained.

The bulletin (No. 71) has 47 pages, 22 photographs, numerous maps, longitudinal sections, and cross sections. It can be purchased from the Department's offices in Baker, Grants Pass, and Portland. Price is \$2.50

* * * * *

BOARD MEMBER NAMED

A Bend mining company executive, William E. Miller, graduate of Stanford University and an Air Force veteran, has been named to the Governing Board of the Oregon Department of Geology and Mineral Industries. He will fill the position formerly held by Harold Banta, Baker attorney.

Miller, native of Bend, is president of Miller Lumber Co. and owner and operator of the Central Oregon Pumice Co., one of the largest operations of its kind in the state. He also heads Miller Ranch Co. near Dufur.

Over the years Miller has taken part in many civic and industrial enterprises in Bend and was a member of the original area Board of Directors of Central Oregon Community College. He is a director of the Bend Industrial Development Corp., and associate director of Equitable Savings and Loan in Bend.

Miller served as mayor of Bend in 1960 and was also a member of the City Commission for four years.

* * * * *

GEOHERMAL RESOURCES COUNCIL HOLDS SECOND MEETING

The second meeting of the Geothermal Resources Council Steering Committee was held in Olympia, Washington on September 24. A report on the first meeting, held July 16 in Sacramento, describing the organization and objectives of the group is in the August 1971 issue of The ORE BIN.

The second meeting of the Council was attended by 15 committee members and 16 observers of whom several are also members of the subcommittees. Among reports presented were those of the subcommittees on Environment, Regulations, Utilization, and Education and Information. Reid Stone, the Interior Department's Council representative, distributed copies of the recently prepared Environmental Impact Statement and commented on the progress of the Federal Leasing Law. Mr. Stone felt all necessary steps would be carried out and that the lands would be made available for leasing by early 1972. Howard Nelson, General Public Representative on the Council, read a resolution from the Washington State Sportsmen's Council urging that research, exploration, and development of geothermal resources be carried out in the shortest time possible because of the ability of this resource to provide electrical power with minimal environmental impact.

Tentative plans are being made for a general meeting and seminar on geothermal resources on February 16 and 17 at El Centro, California, with a field trip to the Salton Sea and Cerro Prieto geothermal fields. Information on registration and other particulars can be obtained by writing to Mr. Sam Dermengian, Citrus College, Business Education Dept., Azusa, California 91702. As plans for the meeting are formulated, they will be announced in The ORE BIN. In addition, the Geothermal Hot Line, published by the California Division of Oil and Gas, will carry the announcements and other information of the Council. This newsletter is available free by writing to: Geothermal Hot Line, Division of Oil and Gas, Room 1316, 1416 Ninth Street, Sacramento, California 95814.

* * * * *

FOSSIL BOOKLET PUBLISHED

"Fossil Mollusks of Coastal Oregon" is the title of a booklet recently issued as Oregon State University Monographs, Studies in Geology No. 10. The author is Ellen James Moore, paleontologist with the U.S. Geological Survey and a west-coast authority on Miocene fossils. Her 64-page booklet contains basic information on collecting and identifying fossil shells and is illustrated by 20 plates of photographs and drawings of Miocene mollusks from Oregon, Washington, and California. The booklet is for sale by Oregon State University Press, Corvallis, Oregon, for \$2.00.

* * * * *

METALLURGICAL INDUSTRY AIDS ENVIRONMENT

Beer distributors in 34 Oregon cities are now redeeming all-aluminum beer cans. Thanks to Reynolds Metals Company, the program, also operating in several other states, has already recovered 80 tons of cans since April in Oregon alone. All-aluminum cans account for 87 percent of all beer cans used in the northwest.

Any continuing environmental program must have an economic incentive to keep it going. Each pound of aluminum cans turned into one of the 97 redemption centers in the state is worth ten cents to the collector. Figured another way, a ton of cans is worth \$200.

The aluminum of beer cans really gets around. The aluminum ore, bauxite, is mined in Jamaica; is reduced to metal, rolled into sheet and made into cans in California; is filled with beer, distributed, sold, emptied, redeemed and chopped into dime-sized chunks in Oregon; is shipped to Alabama to be remelted and rolled into sheet, and is then ready to start over again.

Oregon beer cans are also reappearing here in those aluminum "dollars" that SOLV (Stop Oregon Litter and Vandalism) now sells as a fund-raising project and to focus attention on litter problems.

An even more important factor of the recycling program is that new beer cans will be made from recycled cans and not from imported ore.

* * * * *

ASSESSMENT WORK

The July 15, 1971 Federal Register carried the following proposed rule with regard to annual assessment work:

"Effect of Failure to Perform Assessment Work. a) Failure of a mining claimant to comply substantially with the requirement of an annual expenditure of \$100 in labor or improvements on a claim imposed by Section 2324 of the Revised Statutes (30 U.S.C. 28) will render the claim subject to cancellation. b) Failure to make the expenditure or perform the labor required upon a location will subject a claim to relocation unless the original locator, his heirs, assigns, or legal representatives have resumed work after such failure and before relocation."

Many claim owners interpret the proposed rule as permitting the Department of the Interior to cancel mining claims without court proceedings in those instances in which it determines the claimant has not substantially complied with the annual assessment work requirements.

(Nevada Mining Assoc. News Letter, Sept. 15, 1971)

* * * * *

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
39.	Geology and mineralization of Morning mine region, Grant County, Oregon 1948: R. M. Allen & T. P. Thayer	1.00
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Grah, editors	3.50
58.	Geology of the Suplee-Izee area, Oregon, 1965: Dickinson and Vigrass	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dole,	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Geology, mineral, and water resources of Oregon, 1969	1.50
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970: Roberts	2.00
68.	The Seventeenth Biennial Report of the State Geologist, 1968-1970	Free
69.	Geology of the Southwestern Oregon Coast W. of 124th Meridian, 1971: R. H. Datt, Jr.	3.75
70.	Geologic formations of Western Oregon, 1971: Beaulieu	2.00
71.	Geology of selected lava tubes in the Bend area, 1971: Greeley	2.50

GEOLOGIC MAPS

Geologic map of Oregon west of 121st meridian, 1961: (over the counter)		2.00
folded in envelope, \$2.15		
Geologic map of Oregon (12" x 9"), 1969: Walker and King		0.25
Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others		0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37)		0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker		1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts		0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams		1.00
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka		1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon: 1962, Corcoran et. al.		1.50
GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka		1.50
GMS-4: Gravity maps of Oregon, onshore & offshore, 1967: [Sold only in set] flat, \$2.00; folded in envelope, \$2.25; rolled in map tube		2.50
GMS-5: Geology of the Powers quadrangle, 1971: Baldwin and Hess		1.50

[Continued on back cover]

The ORE BIN
1069 State Office Bldg., Portland, Oregon 97201

The Ore Bin

POSTMASTER: Return postage guaranteed.



Available Publications, Continued:

SHORT PAPERS

- | | |
|---|--------|
| 2. Industrial aluminum, a brief survey, 1940: Matz | 5 0.10 |
| 18. Radioactive minerals the prospectors should know (2nd rev.), 1955:
White and Schafer | 0.30 |
| 19. Brick and tile industry in Oregon, 1949: Allen and Mason | 0.20 |
| 21. Lightweight aggregate industry in Oregon, 1951: Mason | 0.25 |
| 24. The Almeda mine, Josephine County, Oregon, 1967: Libbey | 2.00 |

MISCELLANEOUS PAPERS

- | | |
|--|------|
| 1. Description of some Oregon rocks and minerals, 1950: Dale | 0.40 |
| 2. Key to Oregon mineral deposits map, 1951: Mason | 0.15 |
| Oregon mineral deposits map (22" x 34"), rev. 1958 (see M. P. 2 for key) | 0.30 |
| 3. Facts about fossils (reprints), 1953 | 0.35 |
| 4. Rules and regulations for conservation of oil and natural gas (rev. 1962) . | 1.00 |
| 5. Oregon's gold placers (reprints), 1954 | 0.25 |
| 6. Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton . . . | 1.50 |
| 7. Bibliography of theses on Oregon geology, 1959: Schlicker | 0.50 |
| 7. (Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts . | 0.50 |
| 8. Available well records of oil & gas exploration in Oregon, rev. 1963:
Newton | 0.50 |
| 11. A collection of articles on meteorites, 1968: (reprints, The ORE BIN). . | 1.00 |
| 12. Index to published geologic mapping in Oregon, 1968: Carcáran | Free |
| 13. Index to The ORE BIN, 1950-1969, 1970: M. Lewis | 0.30 |
| 14. Thermal springs and wells, 1970: R. G. Bowen and N. V. Peterson . . . | 1.00 |

MISCELLANEOUS PUBLICATIONS

- | | |
|---|-------------------|
| Oregon quicksilver localities map (22" x 34"), 1946 | Revision In Press |
| Landforms of Oregon: a physiographic sketch (17" x 22"), 1941 | 0.25 |
| Index to topographic mapping in Oregon, 1969 | Free |
| Geologic time chart for Oregon, 1961 | Free |
| The ORE BIN - available back issues, each | 0.25 |

OIL and GAS INVESTIGATIONS SERIES

- | | |
|---|------|
| 1. Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:
Newton and Carcáran | 2.50 |
| 2. Subsurface geology of the lower Columbia and Willamette basins, Oregon,
1969: Newton | 2.50 |

The Ore Bin



Vol. 33, No. 11
November 1971

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

The Ore Bin

Published Monthly By

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
Head Office: 1069 State Office Bldg., Portland, Oregon - 97201
Telephone: 229 - 5580

FIELD OFFICES

2033 First Street	521 N. E. "E" Street
Baker 97814	Grants Pass 97526

X X

Subscription rate \$1.00 per year. Available back issues 25 cents each.

Second class postage paid
at Portland, Oregon

X X

GOVERNING BOARD

Fayette I. Bristol, Rogue River, Chairman
R. W. deWeese, Portland
William E. Miller, Bend

STATE GEOLOGIST

R. E. Corcoran

GEOLOGISTS IN CHARGE OF FIELD OFFICES

Norman S. Wagner, Baker	Len Ramp, Grants Pass
-------------------------	-----------------------

X X

Permission is granted to reprint information contained herein.
Credit given the State of Oregon Department of Geology and Mineral Industries
for compiling this information will be appreciated.

ELECTRICITY FROM GEOTHERMAL, NUCLEAR, COAL SOURCES An Environmental Impact Comparison

R. G. Bowen
Oregon Dept. of Geology and Mineral Industries

Until recently the northwestern states of Oregon, Washington, and Idaho have been able to produce sufficient hydroelectric power for their needs. But the era of building dams across rivers for power purposes is coming to an end and the region is turning to thermal plants to provide electricity for anticipated future demands.

The use of electricity is expanding at a greater rate than the use of any other form of energy. The reasons are that electricity is easily transported, is widely available, convenient, and is clean at its end-use point. Because of the recent ecological awareness by a large segment of the population, this end-use "cleanness" of electricity has been heavily exploited by the marketers of electricity and electrical appliances. Actually, the production of electricity is not necessarily so "clean," for whenever thermal energy in a fuel is converted to electricity waste heat and waste products are produced.

In order to continue to produce electricity at the rate necessary to maintain our present living standard with anticipated population growth, certain compromises or "trade-offs" must be made. It is imperative, therefore, that the public be informed of the way the various sources of electrical energy affect the environment and be able to choose the most acceptable methods for producing electric power in any one region. To that end this paper will discuss the production of electricity from geothermal sources and compare its impact on the environment to that of producing electricity from coal and nuclear resources.

Production of Electricity from Geothermal Resources

Mexico, Italy, New Zealand, Japan, Russia, and the United States are producing electricity from natural underground reservoirs of steam and hot water. In the United States the Geysers field in Sonoma County, California, produces electricity from dry steam as do also the Larderello field in Italy and the Matsukawa field in Japan. The Wairakei field in New

Zealand and the Cerro Prieto field in Mexico utilize hot water. Since at present The Geysers is the only operating geothermal field in the United States, it is necessary to study it to understand the environmental impact of electric power production from this source.

The Geysers field has been in production since 1960, its power output increasing from 12,500 kw with the first unit to the present 192,000 kw, a more than ten-fold growth in 12 years. Presently the development at The Geysers field is sufficient to support an installation of about 800 mw (megawatt equals 1,000 kilowatts) but appears to have even greater potential. In a recent report to the State Senate by the California Geothermal Resources Board, the field was estimated to have an ultimate capacity of from 1,200 to 4,800 mw.

Another geothermal field, the Salton Sea area in Imperial County, California has received a great deal of attention and is being thoroughly studied in the hope that some of the energy known to exist in the field can be developed. The Salton Sea field produces very saline hot water whereas The Geysers produces steam. Environment restrictions on disposing of the saline hot water in the Salton Sea area have been so severe that the discoverers of the field have not as yet been able to produce any power.

Much more energy can be converted to electric power from a given quantity of steam brought to the surface than from the same quantity of hot water. For this reason it is the dry steam fields that are the ultimate goal of the exploration effort and it is this type of field that has the potential to make a significant contribution to the power needs of the West. For example, at The Geysers one kilowatt of electricity can be generated by 20 pounds of steam that is run directly from the ground into the turbo-generator. Of this 20 pounds of steam that passes through the turbine approximately 15 pounds is evaporated in cooling the condenser and the remaining 5 pounds, amounting to $2\frac{1}{2}$ quarts of water, is injected back into the producing reservoir. For a hot water field to produce one kilowatt of electricity, about 80 to 100 pounds of fluid must be brought to the surface; the steam is separated in a flash chamber, then piped to the turbo-generator where it is utilized the same as dry steam. But in this case it is necessary to dispose of 65 to 85 pounds of unused water, or about 10 gallons for each kilowatt of power. Because of the larger volume of water in these fields its disposition would generally present problems. Returning it to the same reservoir would presumably lower the temperature excessively. Rejecting it at the surface could add heat and deleterious elements to surface water. These natural hot waters are usually mineralized, carrying from less than 1 percent to 30 percent dissolved solids. In the steam fields, on the other hand, the steam has been purified by the process of natural distillation deep within the earth and carries essentially no dissolved solids and less than 0.50 percent of other gases. The vast reservoirs of natural hot water that are known to exist in the West present an engineering challenge, and if in the future methods can be found to successfully harness

the energy from hot water to electrical generators, this resource could supply a large part of our needed electricity. In the meantime, the dry steam field can be utilized by the present technology.

Although dry steam is known at present in only a few areas, exploration effort will increase as soon as the public lands become available for leasing under the new Federal law. Natural steam exploration in the United States is at about the same stage of development as petroleum exploration was a hundred years ago. However, geothermal exploration has the tremendous advantage of being able to utilize the well-developed exploration and drilling techniques that have been perfected in oil and gas exploration; this factor will undoubtedly greatly improve the success ratio in finding new steam fields. Experts differ widely in their opinions on how many dry steam fields will be found in the western United States, but most agree that, considering world-wide experience, 5 to 10 percent of the geothermal systems discovered will contain dry steam. If so, this resource could be of considerable magnitude, for in the western United States there are about 1200 known hot springs, many young volcanoes, and numerous recent lava flows which cover hundreds of square miles. All of this indicates widespread areas of high-heat flow and a potential source of geothermal energy.

Recently the U.S. Geological Survey has classified 1.8 million acres of land in the western states as "known geothermal resource areas" (KGRA) and another 96 million acres to have prospective value. It is not unreasonable to expect that within this 96 million acres another 10 or 20 fields the size of The Geysers will be found over the next 50 years, and for every "giant" the size of The Geysers there could be 10 fields with a capacity of 100 to 500 mw. In a recent article on geothermal energy in the Bulletin of Atomic Scientists, Dr. Robert W. Rex of the University of California, Riverside, estimated that a concerted exploration effort over the next 30 years should prove a geothermal potential of between 100,000 and 1,000,000 mw of electrical capacity. By comparison, the present power capacity of the United States is a little over 300,000 mw.

Environmental Effects of Producing Electricity from Thermal Sources

The three methods of power production presently under serious consideration in the Pacific Northwest are nuclear reactors, coal-fired generators, and geothermal plants. New and untried methods of power production, such as magnetohydrodynamics, fast breeder reactors, and fusion reactors are possible methods of producing power sometime in the future. However, they are only in the preliminary developmental stages at this time and cannot be regarded as substantial sources for at least 20 to 30 years. Power plants fueled by oil and natural gas, although used extensively in other parts of the country, are not being considered in the Pacific Northwest because of anticipated rising costs and shortages of these fuels.

To understand properly the impact of electric power production on the environment, it is necessary to evaluate more than just the power plant; the entire cycle from mining, processing, transportation, and disposal of spent wastes must also be considered. The effects of these processes on the environment will be discussed under the major headings of "Impact on the land," "Impact on the air," "Impact on the water," and "Impact on the economy."

Impact on the land

The mining of fuels, be it coal, oil, natural gas, or uranium, has developed into a major activity and dominates the extractive industry. Presently 26 percent of all energy resources are devoted to the production of electrical power, and the annual demand for electricity is increasing at a rate twice as fast as the over-all energy demand. This means that by the year 2000 half of our energy production will be used to generate electricity and the extractive activities will have to increase commensurately.

Both nuclear plants and coal plants require the mining of the fuel and both take a considerable amount of land out of service for this purpose.

The AEC reports that the uranium mining industry currently holds over 28 million acres of land for mining and exploration, most of this in two areas in the northern Rocky Mountains and the Colorado Plateau. Not all of this land is going to be devoted to mining, but any mine either underground or open pit requires a significant amount of land. Many millions of acres of land will be required to fulfill the projected uranium requirements. For example, a 1,000 mw nuclear plant would require over its 30-year expected life about 4050 tons of enriched uranium fuel. In order to produce this much fuel, 16,200 tons of natural uranium must be used. This requires the mining of about 1,620,000 tons of ore over the life of the plant. Most uranium in the United States comes from open-pit mines, which as a rule mine about 9 tons of waste rock for 1 ton of ore. For the life of the power plant a total of 16 million tons would have to be removed, requiring a considerable excavation for this one nuclear power plant. Of course, more than 90 percent of this material is returned to the excavation and the land can be rehabilitated.

In addition to mining, the other steps in the fuel cycle - milling, refining, enrichment, conversion, fabrication, reprocessing, and radioactive waste storage - require the construction of large facilities and take a great deal of land out of service. Figure 1 illustrates the steps in the supply of atomic fuel.

The transportation and handling of nuclear fuels, especially the spent fuels, loom large as a potential environmental hazard. There is currently great concern over the packaging, shipping, and storage of the radioactive fission product wastes. The isolation and storage of the high-level fission

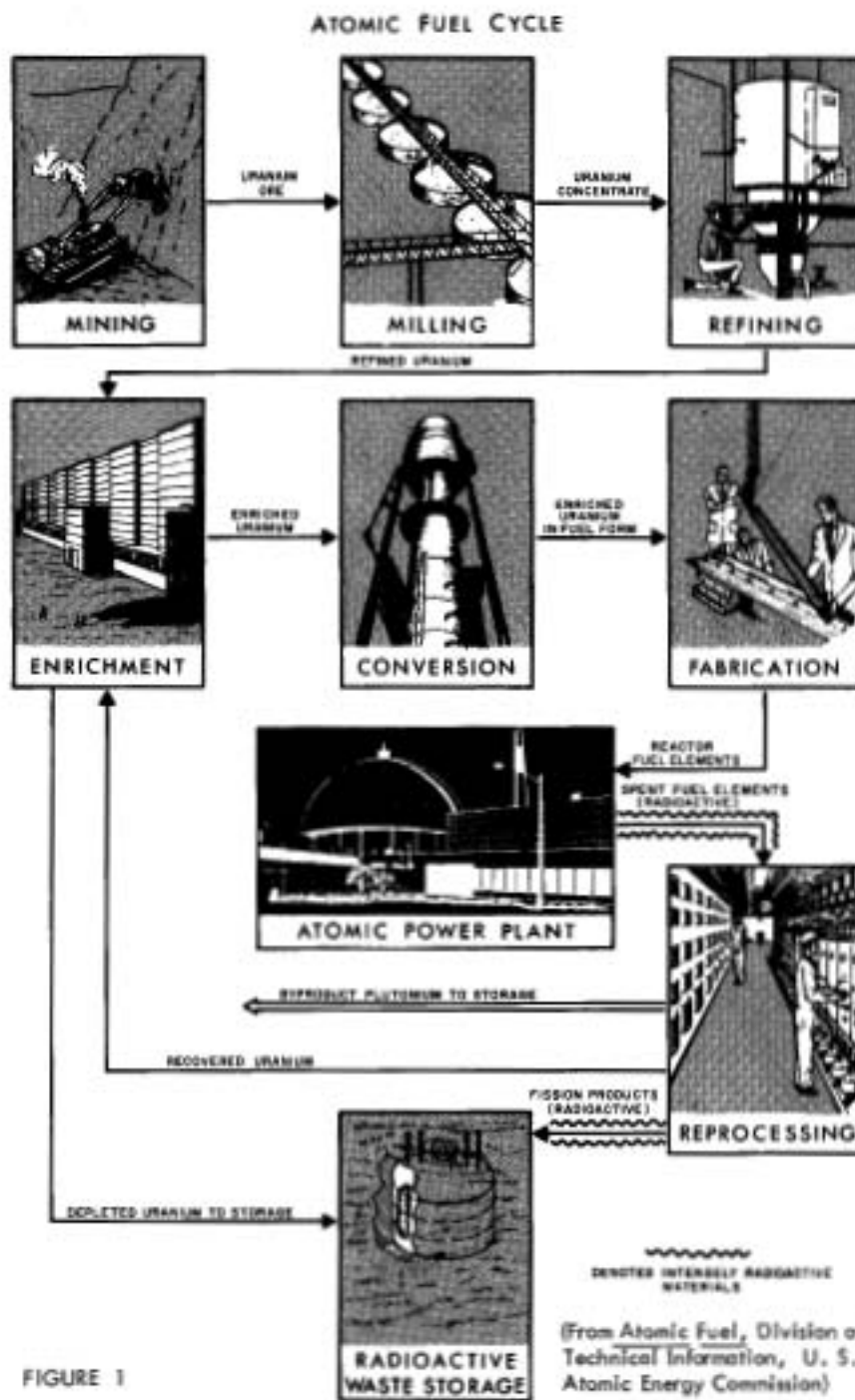


FIGURE 1

(From Atomic Fuel, Division of
Technical Information, U. S.
Atomic Energy Commission)

product wastes, estimated by the AEC to be 60 million gallons produced by commercial reactors by the year 2000, requires large guarded disposal sites. In addition to the high-level wastes that must be isolated, there are large amounts of low-level wastes such as tailings, a waste product generated from the milling of uranium ore. These tailings contain appreciable quantities of radium and other decay products which should be isolated from human contact but are present in large piles adjacent to many of the processing mills. Each of these uses occupies land, and for the high-level wastes this may be for a period of time longer than man's recorded history. It is not possible to estimate the amount of land that may be required by each generating plant, but it appears to be many times greater than the actual power site.

Fossil fuel generating plants, particularly those fired by coal, require a large amount of land for the mine, railroad yards, and coal washing and storage facilities. A coal-fired power plant of 1,000 mw, the same size as the nuclear plant used in the previous example, would require about 100 million tons of coal over the life of the plant. With a ratio of 2:1 overburden to coal this would amount to the movement of about 300 million tons over the life of the plant. Here again the mining operation disrupts the land surface, but with rehabilitation the land returns to its natural state. Coal-fired electric plants usually require more land for the operational facilities than do nuclear plants, but because of the simplicity of the fuel cycle coal-fired electric plants do not require the multiple-step processing, nor do the waste products require guarded isolation.

Coal processing is relatively simple: the coal is separated from waste rock, washed, and then pulverized and blown directly into the boiler furnace. The fly ash from the burning is collected and used as construction material, landfill, or in some instances is put back into the coal mine as fill. This procedure is outlined in figure 2.

The production of electricity from geothermal resources does not require excavation as the natural steam is produced from well bores. Because the steam cannot be moved more than a mile without serious heat loss, the generating plant must be located near the steam wells, thereby localizing the entire environmental impact to the site where the geothermal field is located. Put in its simplest terms, the steam is taken from the ground by wells and collected in pipelines; then it flows by its own energy to the steam turbines at a distance of no more than a mile. Using The Geysers field as an example, present well-flow information indicates that sufficient steam can be produced for a 1,000 mw plant from an area between 4 and 8 square miles. The plants themselves are built among wells in the field to make the pipelines as short as possible. Figure 3 illustrates the cycle for a geothermal field.

Since only a small part of the whole field is required for the wells, pipelines, and generating plants, the rest can be utilized for other purposes such as farming or grazing. For example, at the Larderello field in Italy, where geothermal steam has been utilized for power production for

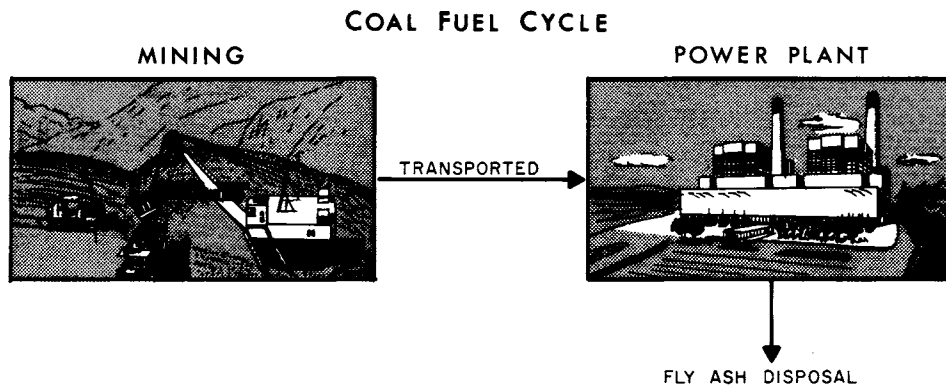


Figure 2. Fuel supply cycle for a coal-fired thermal plant.

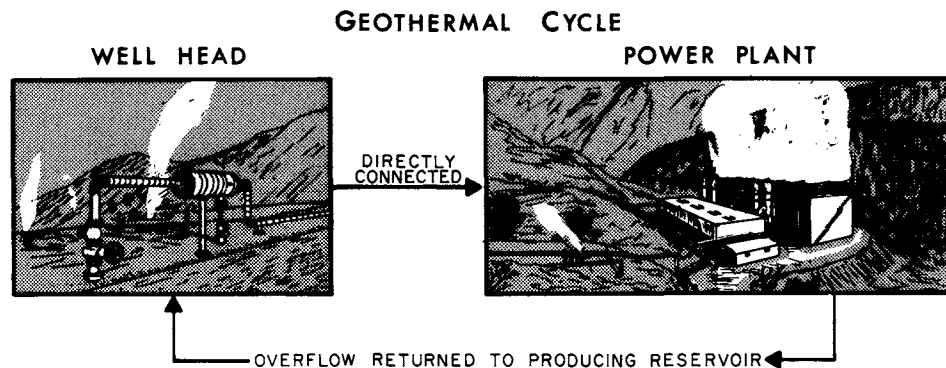


Figure 3. Energy cycle for a natural dry-steam geothermal plant.

nearly 60 years, an intensive agricultural industry is carried on within the steam field, and many vineyards and orchards are interspersed among the pipelines and wells. Figures 4 and 5 are photographs of the Larderello steam field illustrating the agricultural activities carried on within the field while production is going on.

Impact on the air

Gases are rejected into the air from each type of thermal power plant. Nuclear plants emit radioactive gases which are removed directly from the reactor vessel. This gas, mostly tritium, a radioactive isotope of hydrogen, finds its way into the atmospheric processes along with other radioactive products.

Prior to entering the reactor cycle large amounts of radioactive radon gas are released from the mining and milling operations. Radon is a daughter product produced from the natural decay of uranium. Underground mines must be well ventilated at all times to protect the miners from this dangerous gas. In the milling process the uranium is extracted, and the waste rock is sent to the tailings piles where it continues to be radioactive.

It is at the nuclear fuel reprocessing plants that most of the radioactive gases are released. Monitoring of these sites indicates that the amount of radioactivity escaping is below hazard levels, but some scientists point out that as more nuclear plants are built the over-all addition of air-borne radioactivity will increase greatly.

Fossil fuel plants utilize combustion of coal, oil, or natural gas which produce large amount of fly ash, carbon dioxide, nitrogen oxides, and sulfur oxides. This creates visible air pollution as well as other subtle effects and has been the object of most of the complaints against fossil fuel plants. A great deal of success has been achieved in cutting down the amount of fly ash from coal-fired plants by precipitators and other collection devices before the flue gas leaves the chimney. Oil- and natural gas-fired plants do not have as great a problem because the petroleum products contain little if any ash.

Environmental protection rules have caused the fossil fuel plants to cut down on their emissions of both the visible fly ash and the nitrogen and sulfur oxides. A partial solution, at least in urban regions where there is a concentration of these air pollutants, is to move the plants out into the countryside nearer to the mines.

An important point to consider in regard to the impact on the air from fossil fuel plants is that the effects are localized at the point of power production and with modern plants using low-sulfur coal the effects are short-lived. If an extreme temperature inversion occurs, causing peril to life and health, the fossil fuel plant can be shut down and all emissions stopped on very short notice.

The geothermal steam plant operates without combustion and emits no appreciable quantities of deleterious products. Using The Geysers as an example, the steam has an average content of 99.5 percent water. This leaves only 0.5 percent non-condensable gases present in the steam, of which about 90 percent is carbon dioxide with lesser amounts of methane, hydrogen sulfide, and trace amounts of other gases. Because of the remoteness of the area these gases have not been a problem. However, now that the field is being enlarged methods are being developed to eliminate the minor amount of hydrogen sulfide exhausted from the condenser.

Impact on the waters

In order for a thermal electric plant to operate at maximum efficiency the steam must be condensed after passing through the turbine. This forms a



Figure 4. Larderello steam field in Italy showing steam-gathering lines. Note the compatibility of extraction of natural steam with other types of land uses. (Photo by Ira E. Klein, U.S. Bureau of Reclamation)



Figure 5. Larderello power plant with steam-gathering lines passing through an orchard in the foreground. This site has been used for electric power generation for over 60 years with only minimal environmental impact. (Photo by Ira E. Klein, U.S. Bureau of Reclamation)

vacuum which allows further expansion of the steam passing through the turbine and greatly increases its power output. However, to produce the cold sink necessary to condense the steam all thermal plants require large amounts of cooling water. A turbine operating in a noncondensing mode will produce much less power for the same heat input.

One of the most vigorous complaints lodged against thermal plants is that when the cooling water is returned to its source - lake, river, ocean - it has been heated several degrees above its normal temperature. Warming of surface waters may cause a change in the ecological balance, often resulting in the growth of less desirable species of aquatic life.

The alternative involved here is to use cooling towers or to construct cooling lakes if sufficient land is available. Thus by evaporation of a part of the cooling water the temperature of the remainder is brought to near its former level before being returned to its source. Cooling towers or lakes add considerably to the cost of power plants and also need large quantities of water for evaporation. An efficient 1,000 mw fossil fuel plant using cooling towers evaporates 15 to 25 million gallons of water a day, whereas a nuclear power plant, because of its lower thermal efficiency, evaporates about 50 percent more water for the same power production.

The necessity for large quantities of water is becoming one of the limiting factors in the location of thermal generating plants. In the Rocky Mountains, where most of the country's coal resources lie, there is already a shortage of surface and ground water for other uses. Adding the load of several new thermal plants will cause a severe strain on this resource. So great are the requirements for cooling water that at a recent national symposium on "Power Generation and Environmental Change" held in Boston it was estimated that by 1980 one-sixth of the freshwater runoff in the United States will be used to cool power plants, increasing to one-third by the year 2000.

A possible solution to the water shortage problem, but at a greater capital cost, is to use dry cooling towers. The dry tower is based on the same principle as the automobile radiator; it is a series of tubes with air passages that transfer heat directly to the air. By this method there is no loss of water through evaporation, but at times of high ambient temperatures the plant is forced to operate at reduced efficiency, adding to the overall cost.

On the other hand, geothermal plants that utilize dry steam do not require a supplementary source of cooling water. The natural steam, after passing through the turbine, is condensed within the circulating cooling water and thus provides additional water to the cooling towers. By this process an excess of water is produced at The Geysers field and about 20 percent of the fluid brought to the surface is returned to the reservoir where it originated, thus prolonging the useful life of the field. A geothermal plant, thus, is the only type of thermal power plant that does not

compete with other uses of water. Increasing competition for our diminishing supplies of water is probably the single most important reason why our geothermal resources warrant development.

No modern power plant adds any appreciable amount of chemical contaminants to the water supply. However, to get the true picture of the impact on the waters, the entire cycle of mining, milling, refining, enrichment, fabrication, reprocessing, and waste storage involved in the production of both fossil and nuclear fuels must be considered. By comparison, since the dry steam geothermal resources are utilized at the point of production the danger of adverse effects on the waters is minimal and in the case of The Geysers field there is none. But before the hot water fields can come into full production methods for handling the excess fluids will have to be perfected.

Impact on the economy

Along with the environmental impact related to the different methods of producing electrical power, we must also consider the reliability of the energy source. Today when so many diverse uses in our complex civilization depend upon electricity, power failures are damaging, causing loss of revenue and inconvenience at the least. The geothermal plant figures importantly in this respect. Because the geothermal system is self-contained, it needs no outside support to maintain the production of electricity, no railroads nor mines, no complex processing plants that can be put out of service. The reliability of nature's own boiler is paramount and has been used to advantage at The Geysers where, because of the constancy of the steam supply, the plants can be operated automatically. This requires fewer personnel and in actual practice the plant is attended by regular maintenance crews only during the 8-hour daytime shift. It is unattended the rest of the time but monitored by a control station located several miles distant. In the event of a failure within the generating machinery the plant is shut off automatically and started later manually when the problem is located.

The economic success of power production from a dry steam field has been well proven from the 12-years operating experience at The Geysers field, and from nearly 60 years of experience from the Larderello field in Italy. Because all of the steam-generating equipment is inherent in the earth there is no need to construct it on the site. The furnace, boiler and fuel-handling equipment required in a fossil fuel plant, and the reactor-heat exchanger loop in the nuclear plant, are the most expensive parts of those operations. With the geothermal plant only gathering pipelines are needed to deliver the steam to the turbines. Actual plant construction costs are about two-thirds to three-fourths those of a fossil fuel plant and less than half that of a nuclear plant. A lower plant cost means that the

"fixed charges" - that is, the part of the cost of electricity based on paying off the cost of the plant, taxes, etc. - can be lower, thus reducing the over-all cost of the electricity.

Summary

The development of geothermal resources has been delayed in the United States for several reasons: the ready availability of low-cost fossil fuels, the general remoteness from load centers of geothermal areas, and more recently the illusion that nuclear power plants would provide all our needed power at a low cost and with no environmental hazards. Significant, also, is the fact that until a leasing act was passed in 1970 all Federal lands, amounting to nearly half of the land in the Western States, were withdrawn from geothermal exploration.

A major change of values within a large segment of the population has forced the electric utilities to re-evaluate their present and planned power-plant siting criteria. This re-evaluation, along with the passage of the Federal leasing law in late 1970, combined with the demonstrated success of The Geysers field, has made geothermal resources much more economically attractive. Leasing of private and state lands is now underway in many parts of the West and plans are being made for the drilling of exploratory wells. At the same time, however, stringent zoning regulations are being proposed that would effectively ban drilling and development of geothermal wells in even the very remote regions of the states. If such regulations are adopted we will have to pay a much higher price for our electricity, both monetarily and environmentally, than if geothermal power is developed to its full potential.

Suggested Further Reading

- Bodvarsson, Gunnar, 1966, Energy and power of geothermal resources: The ORE BIN, vol. 28, no. 7, p. 117-124, 1 fig.
- Bowen, R. G., and Groh, E. A., 1971, Geothermal - earth's primordial energy: Technology Review, p. 42-47, October/November.
- Bruce, Albert W., and Albritton, Ben C., 1959, Power from geothermal steam at The Geysers Power Plant: Journal of the Power Division, Proceedings of American Society of Civil Engineers, vol. 85, no. PO6, December, Part 1, p. 23-45.
- Electrical World, 1970, Geothermal growing as a power source: Electrical World, June 22.
- Groh, E. A., 1966, Geothermal energy potential in Oregon: The ORE BIN, vol. 28, no. 7, p. 125-135, map.
- Kaufman, Alvin, 1964, Geothermal power, an economic evaluation: U.S. Bur. of Mines Inf. Circ. 8230.

- Lessing, Lawrence, 1969, Power from the earth's own heat: *Fortune*, p. 138-141, 192, 198, illus., June.
- McNitt, J. R., 1963, Exploration and development of geothermal power in California: Spec. Rpt. 75, Calif. Div. Mines and Geology, 45 p., 15 figs., 11 photos.
- Rex, R. W., 1971, Geothermal energy - the neglected energy option: *Bull. Atomic Scientists*, p. 52-56, October.
- State of California Geothermal Resources Board, 1971, The economic potential of geothermal resources in California: California Div. of Oil and Gas, Resources Agency, 34 p.
- White, D. E., Muffler, L. J. P., and Truesdell, A. H., 1971, Vapor-dominated hydrothermal systems compared with hot-water systems: *Economic Geology*, vol. 66, no. 1, p. 75-97.

* * * * *

WORLD MONETARY SYSTEM

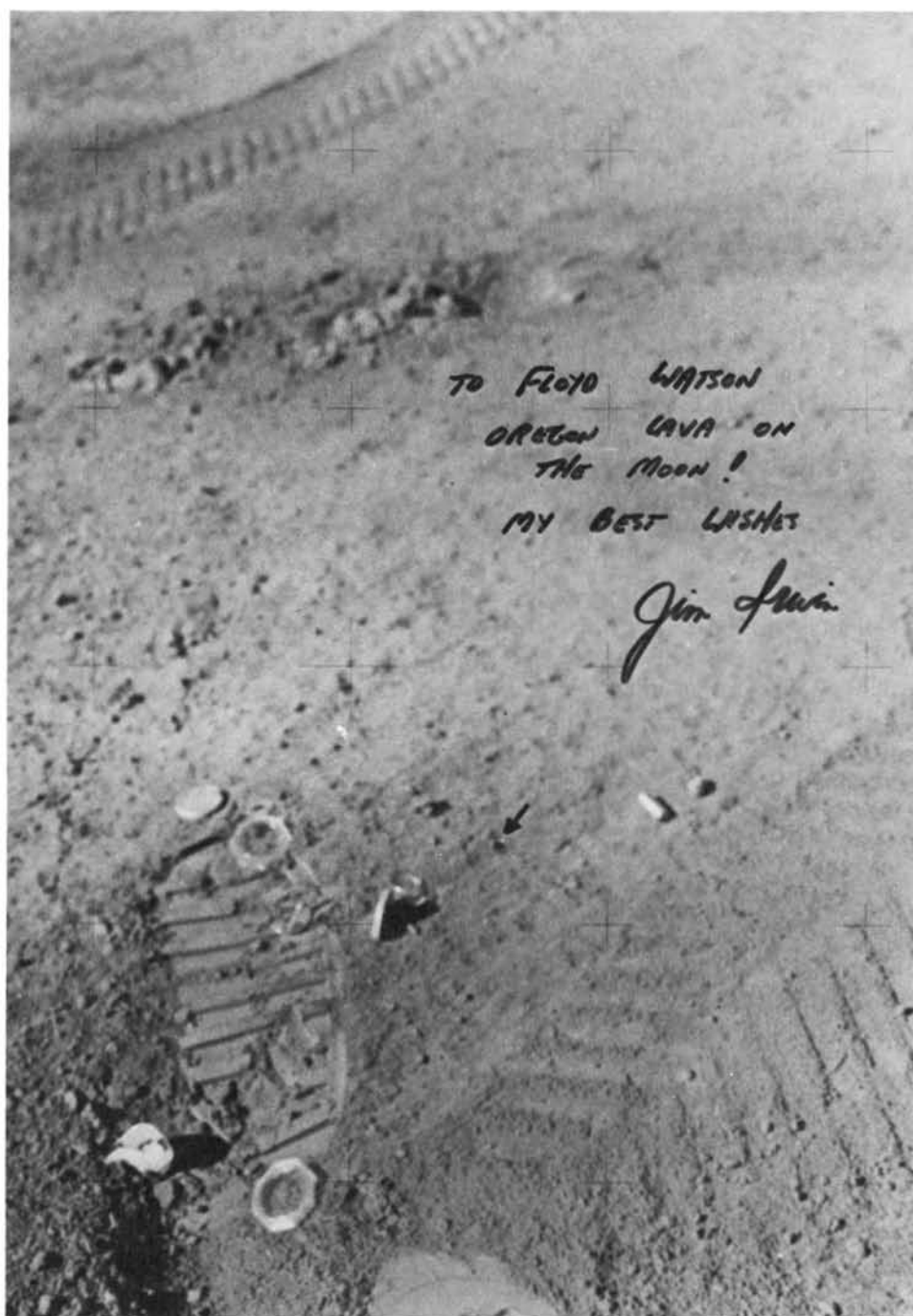
It is anticipated that during forthcoming talks in London regarding the world monetary system key nations will advance a simple arrangement to follow the current period of floating currency; namely, devalue the dollar against gold and make that devaluation part of a broad package of currency adjustments, mainly upward revaluations of other currencies, and lift the U.S. import surcharge. However, President Nixon's economic package was partly designed to force other nations with strong currencies to revalue their currencies upward against the U.S. dollar which would have the same effect as a dollar devaluation. It is the desire of many countries in the Common Market and elsewhere to downgrade or replace the U.S. dollar as a reserve since President Nixon suspended the exchange of each ounce of gold for \$35, which had made the dollar "as good as gold." Mario Ferrari-Aggradi, Italian minister of the treasury, said, "The long-term solution that we desire is the creation of a new international standard not dominated by any currency, whatever the importance of the issuing country."

France and some other countries have long advocated increasing the price of gold and strengthening its role in international finance as a solution to the problem. Nations and international agencies hold about \$41-billion in gold in their reserves and many would benefit considerably from a rise in the price of gold. The U.S. has insisted, however, it will not increase the gold price.

Experts warn that until the dollar is either strengthened or replaced as a major component of international liquidity, periodic bouts of uncertainty may well plague the world monetary system.

(Nevada Mining Assoc. News Letter, Sept. 15, 1971)

* * * * *



Arrow on this photo of the moon points to sliver of lava from Devil's Lake near Bend, Oregon.

CENTRAL OREGON ROCK RESTS ON THE MOON

Phil F. Brogan

There is a bit of rock from Central Oregon on the bright moon these nights as the orb circles the earth. It was placed there by NASA Astronaut James B. Irwin, who, with David R. Scott and Alfred M. Worden, was aboard Apollo 15 on the highly successful mission to the moon this past summer.

The story of how the Oregon rock, a splinter from a chunk of dacite near Devils Lake on the Cascade Lakes Highway west of Bend, found an eternal resting place on the moon starts with a dinner honoring the 16 astronauts who were guests of Bend in 1966.

Various Bend residents were hosts to the astronauts at a welcoming party at the Bend Golf Club. Floyd E. Watson, Bend building inspector, was host to Irwin and during the evening got well acquainted with him.

In time, Watson forgot the astronauts' dinner. Then in July, 1971, in the list of astronauts for the Apollo 15 mission to the moon was Irwin, graduate of the U.S. Naval Academy and University of Michigan.

Watson immediately wrote to Irwin, congratulating him on his appointment to the Apollo 15 command, adding "I am sending you a small sliver of Central Oregon lava which I hope you will be able to deliver to the moon for me. I have five grandchildren who would be eternally grateful to you." One of the grandsons hopes someday to enter the space program and fly to another planet.

Watson little expected to hear from the busy astronaut. Then came a letter from Irwin, who had toured the base of the Apennine Mountains on the moon, rode with Commander Scott over rugged moonscape, drove an \$8 million "moon buggy" to the brink of an awesome rill, and studied billion-year-old rocks.

The letter was brief: "I did carry your sliver of lava to the moon and left it there. I took a picture of the location and will send it to you as soon as it has been properly mounted."

The picture, autographed by Astronaut Irwin, had an arrow pointing to a small black object on the silvery lunar dust. That object was from a tongue of lava which ages ago flowed to the edge of the Devil's Lake basin. Irwin dropped the bit of rock on the moon on July 31, 1971.

The story of the Oregon rock that found its way to the moon aboard Apollo 15 may not be at an end. The Devil's Lake area is in the Bend District of the Deschutes National Forest. Ranger Jack R. Krieger is considering marking the spot, adjacent to the highway, with a roadside sign. That sign, if approved, might read:

"A piece of rock from this site was placed on the moon in July, 1971, by Apollo 15 astronauts."

(The Bulletin, Bend, Oregon, October 2, 1971)

"Geology of Lode Gold Districts in the Klamath Mountains, California and Oregon," by Preston E. Hotz, has been published by the U.S. Geological Survey as Bulletin 1290. The 91-page bulletin includes a multi-colored geologic map and a distribution-production map of the lode gold deposits. Bulletin 1290 is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price is \$1.50.

* * * * *

"Hydrology of Basalt Aquifers in the Hermiston-Ordinance area, Umatilla and Morrow Counties, Oregon," by J. H. Robison, has been issued by the U.S. Geological Survey as Hydrologic Investigations Atlas HA-387.

The Atlas is in two sheets: a geologic map and a hydrologic map, both at a scale of 1:125,000. It gives information on stratigraphy, structure, chemical analyses, and radiocarbon dates of the ground water, and the author's conclusions on the reason for the lowering of water levels in deep wells.

Atlas HA-387 is for sale by the U.S. Geological Survey, Denver Center, Denver, Colorado 80225 for \$1.25.

* * * * *

[illegible]

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
39.	Geology and mineralization of Morning mine region, Grant County, Oregon 1948: R. M. Allen & T. P. Thayer	1.00
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Groh, editors	3.50
58.	Geology of the Suplee-Izee area, Oregon, 1965: Dickinson and Vigrass	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dole	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Geology, mineral, and water resources of Oregon, 1969	1.50
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970: Roberts	2.00
68.	The Seventeenth Biennial Report of the State Geologist, 1968-1970	Free
69.	Geology of the Southwestern Oregon Coast W. of 124th Meridian, 1971: R. H. Datt, Jr.	3.75
70.	Geologic formations of Western Oregon, 1971: Beaulieu	2.00
71.	Geology of selected lava tubes in the Bend area, 1971: Greeley	2.50

GEOLOGIC MAPS

Geologic map of Oregon west of 121st meridian, 1961: (over the counter) folded in envelope, \$2.15		2.00
Geologic map of Oregon (12" x 9"), 1969: Walker and King		0.25
Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others		0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37)		0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker		1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts		0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams		1.00
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka		1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon: 1962, Corcoran et. al.		1.50
GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka		1.50
GMS-4: Gravity maps of Oregon, onshore & offshore, 1967: [Sold only in set] flat, \$2.00; folded in envelope, \$2.25; rolled in map tube		2.50
GMS-5: Geology of the Powers quadrangle, 1971: Baldwin and Hess		1.50

[Continued on back cover]

The ORE BIN
1069 State Office Bldg., Portland, Oregon 97201

The Ore Bin

POSTMASTER: Return postage guaranteed.



Available Publications, Continued:

SHORT PAPERS

- | | |
|---|--------|
| 2. Industrial aluminum, a brief survey, 1940: Motz | S 0.10 |
| 18. Radioactive minerals the prospectors should know (2nd rev.), 1955:
White and Schafer | 0.30 |
| 19. Brick and tile industry in Oregon, 1949: Allen and Mason | 0.20 |
| 21. Lightweight aggregate industry in Oregon, 1951: Mason | 0.25 |
| 24. The Alameda mine, Josephine County, Oregon, 1967: Libbey | 2.00 |

MISCELLANEOUS PAPERS

- | | |
|--|------|
| 1. Description of some Oregon rocks and minerals, 1950: Dole | 0.40 |
| 2. Key to Oregon mineral deposits map, 1951: Mason | 0.15 |
| Oregon mineral deposits map (22" x 34"), rev. 1958 (see M. P. 2 for key) | 0.30 |
| 3. Facts about fossils (reprints), 1953 | 0.35 |
| 4. Rules and regulations for conservation of oil and natural gas (rev. 1962) | 1.00 |
| 5. Oregon's gold placers (reprints), 1954 | 0.25 |
| 6. Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton | 1.50 |
| 7. Bibliography of theses on Oregon geology, 1959: Schlicker | 0.50 |
| 7. (Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts | 0.50 |
| 8. Available well records of oil & gas exploration in Oregon, rev. 1963:
Newton | 0.50 |
| 11. A collection of articles on meteorites, 1968: (reprints, The ORE BIN). | 1.00 |
| 12. Index to published geologic mapping in Oregon, 1968: Corcoran | Free |
| 13. Index to The ORE BIN, 1950-1969, 1970: M. Lewis | 0.30 |
| 14. Thermal springs and wells, 1970: R. G. Bowen and N. V. Peterson | 1.00 |

MISCELLANEOUS PUBLICATIONS

- | | |
|---|-------------------|
| Oregon quicksilver localities map (22" x 34"), 1946 | Revision In Press |
| Landforms of Oregon: a physiographic sketch (17" x 22"), 1941 | 0.25 |
| Index to topographic mapping in Oregon, 1969 | Free |
| Geologic time chart for Oregon, 1961 | Free |
| The ORE BIN - available back issues, each | 0.25 |

OIL and GAS INVESTIGATIONS SERIES

- | | |
|---|------|
| 1. Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:
Newton and Corcoran | 2.50 |
| 2. Subsurface geology of the lower Columbia and Willamette basins, Oregon,
1969: Newton | 2.50 |

The Ore Bin



Vol. 33, No. 12
December 1971

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

The Ore Bin

Published Monthly By

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
Head Office: 1069 State Office Bldg., Portland, Oregon - 97201
Telephone: 229 - 5580

FIELD OFFICES

2033 First Street	521 N. E. "E" Street
Baker 97814	Grants Pass 97526

X X

Subscription rate \$1.00 per year. Available back issues 25 cents each.

Second class postage paid
at Portland, Oregon

X X

GOVERNING BOARD

Fayette I. Bristol, Rogue River, Chairman
R. W. deWeese, Portland
William E. Miller, Bend

STATE GEOLOGIST

R. E. Corcoran

GEOLOGISTS IN CHARGE OF FIELD OFFICES

Norman S. Wagner, Baker	Len Ramp, Grants Pass
-------------------------	-----------------------

X X

Permission is granted to reprint information contained herein.
Credit given the State of Oregon Department of Geology and Mineral Industries
for compiling this information will be appreciated.

OREGON ROADS IN 1910

A recent search through the Department's ancient picture files revealed some wonderful photographs of Oregon roads taken 60 years ago. Some of the pictures are shown on the following pages.

Most of these photographs were taken in 1910 to illustrate Bulletin 1 "Road Materials in the Willamette Valley," published in January 1911 by the then new Oregon Bureau of Mines, an early predecessor of the State of Oregon Department of Geology and Mineral Industries. The bulletin stated as its purpose "... to set forth in plain language the fundamentals of geology as they apply to the principles of scientific road building...." According to the bulletin, the road builder was usually not sufficiently well versed in geology to be able to distinguish good, medium, and poor quality material, and he would often transport his rock long distances at extra cost when as good or better material was close at hand.

The bulletin provided the road builder with information on the location of quarry rock, its origin, composition, and physical properties, its performance under wear, and other basic data. Basalt, which was then and still is abundant in and along the margins of the Willamette Valley, was shown to be the most suitable type of rock for road material. The greater use of Willamette River gravel was highly recommended, however, since it could be dredged, crushed, and put on the road with much less expense than quarry rock. Among the agencies then in existence that assisted the road-materials survey were the Oregon Good Roads Association and the Department of Good Roads, Washington, D. C.

A "good road" in 1910 was apt to be one that you did not get stuck in. It usually had a crown (raised in center) and was drained. A road with no crown and poor drainage became a mudhole (see photos). On the other hand, if the road had too much crown vehicles were forced to straddle the center and eventually wore ruts. Earth and plank roads had their place but the superhighways of the time were the macadam roads. In those days, macadam (named after John McAdam, a British engineer of the 19th century) was not an asphalt pavement but rather a compressed layer of crushed basalt, or "trap rock." Dust was one of its main components.

A good macadam road started with a well-drained, carefully prepared bed about 15 feet wide with a low crown and substantial shoulders. It was topped with a 6-inch layer of crushed rock, grading from about 2½ inches in size down to the fineness of powder, all wedged together by means of

rolling and water-flushing, which compacted the mass and forced the finer particles into the voids.

The nonmetallic industry, which provided the road-building materials, was in its infancy in 1910, but the decade marked the beginning of awareness that geologic information was vital to the prosperity of the people of Oregon and that a State agency to supply such information was essential.



The road to Forest Grove in 1910.



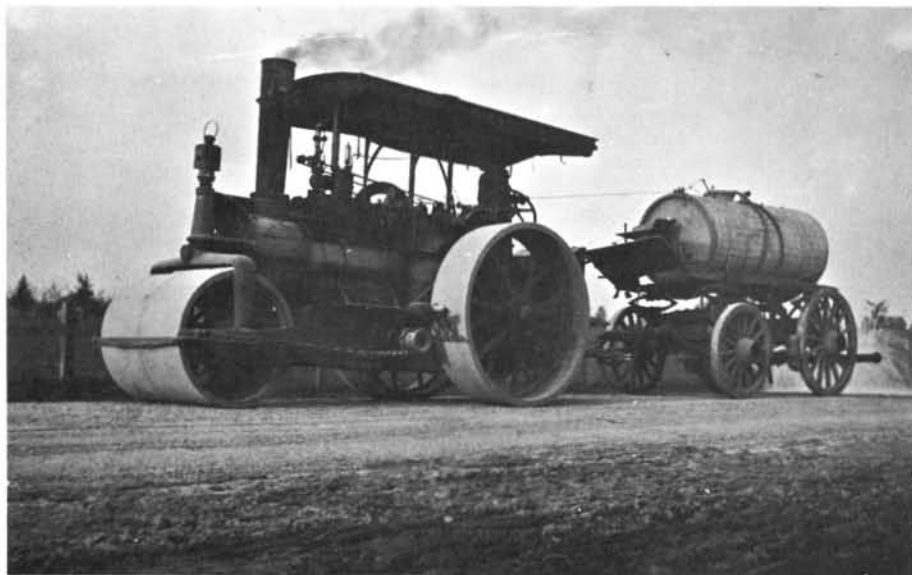
Unidentified basalt quarry in Willamette Valley in 1910.



Ewald quarry, 2½ miles south of Salem in 1910. The dense hard, tough, and profusely fissured basalt was highly suitable for road rock.



Macadam road under construction at Hood River about 1910.



Rolling and water-flushing equipment used in constructing a macadam road in 1910.



Macadam road near the Salem Fairgrounds was designated as "U.S. Object Lesson Road."



Liberty road near Salem in 1910.



Neglected macadam road near Forest Grove in 1910.



Plank road at Forest Grove about 1910.



Earth road near The Dalles about 1910.



Macadam road at Pendleton about 1910; slightly ravelled surface was due to extremely dry weather.



Germantown Road near Portland in 1910 showing proper location of a macadam road in hilly country.



Another view of Germantown Road.



A Sunday drive along the Rogue River from Grants Pass to the Galice gold mines. Date unknown.

MINING INDUSTRY FACES TWO-FOLD CHALLENGE

Meeting the constantly increasing demand for minerals in the future poses a dual challenge to the mining industry, according to Hollis M. Dole, Assistant Secretary of Interior for Mineral Resources.

Speaking before the Fall meeting of the Society of Mining Engineers in Seattle, Washington, September 22, Dole noted that not only would the mining industry have to advance its technology to provide the increased production needed, but also it must make its peace with a public now sensitized to environmental considerations. He warned that the latter task may prove to be the more difficult.

"Mining, indeed industry at large," Dole said, "has emerged as the villain in the bitter controversy over environmental protection." He noted that irresponsible actions on both sides of the controversy had made reconciliation difficult. "The industry was judged, found guilty, and by some extremists at least, sentenced to be hanged by the neck until dead. It is now up to the industry to correct the impression of it that has been implanted in the public mind, and to which its own irresponsible elements have contributed," he said.

Dole went on to point out that no retreat is possible from the high-income, high-production, high-consumption society in which we are living, which fulfills the American aspiration for comforts and conveniences. "More want in than want out," he concluded.

Providing all the minerals the nation needs while giving adequate protection to the environment will add to present costs, Dole warned, and the public must understand this fact. What must be made clear to the public --clearer than it has in the past--is that ecology is closely related to economics, and that if we are to have both affluence and environmental quality we will have to pay more than we did for affluence alone."

Dole said he was encouraged by evidence that the mining industry is now making up for its slow start in the environmental cleanup campaign, and expressed hope that all mining firms would follow the lead of the enlightened operators in controlling and repairing environmental damage. He cited the Mining and Minerals Policy Act passed by the last Congress, and the Mined Areas Protection Act now before the present congress, as examples of needed legislation to enable the mining industry to meet its social responsibilities. He praised the reorganization plan proposed by President Nixon which would create a Department of Natural Resources to handle the Federal government's responsibilities for protecting and developing the nation's natural resources, including those related to energy and minerals.

The Society of Mining Engineers is a national organization affiliated as a constituent society of the American Institute of Mining, Metallurgical and Petroleum Engineers. Its headquarters are in New York.

* * * * *

DESCRIPTION OF THE FERRUGINOUS BAUXITE ORE PROFILE IN COLUMBIA COUNTY, OREGON

Ronald L. Jackson

Graduate Student, Dept. of Earth Sciences, Portland State University

Introduction

A bulk sampling program by Reynolds Metals Company during the summer of 1970 provided good exposures of the Pacific Northwest laterite.* Prior to the opening of the pits, geological observations were limited to drill cores and a few relatively shallow cuts on hillsides. The pit faces in the mining undertaking were nearly vertical, exposing excellent 20- to 40-foot cross-sections of the overburden and ore. Detailed mapping by the author and John W. Hook, District Geologist, Reynolds Metals Co., revealed many features of interest; therefore, the purpose of this report is to supplement previous papers describing the ferruginous bauxites in northwestern Oregon.

The discussion of the laterite in this report pertains mostly to two prospect pits approximately $3\frac{1}{2}$ (pit 1, figure 1A) and $4\frac{1}{2}$ (pit 2, figure 1B) miles northwest of St. Helens, Columbia County, Oregon. Of the features under discussion many also were observed in Washington County, Oregon, and Cowlitz and Wahkiakum Counties, Washington.

For this study, the bauxite ore is arbitrarily defined as: 1) having no more than 10 percent silica, and 2) having no less than 30 percent alumina.

General Stratigraphy

The laterite deposits in northwestern Oregon have developed on the upper flows of the Columbia River Basalt of Miocene age (Libbey and others, 1946). In most areas, a tan to red silty clay formation of Pliocene age overlies the bauxite (Lowry and Baldwin, 1952). The tan silt-like material occurs in the upper portions and transitionally grades at depth to a weathered mottled clay. The thickness of this formation ranges from 0 to greater than 30 feet.

Form of the Ore

The ore horizon lies above the ground-water table as sheet-like deposits along tops of well-rounded hills and ridges. In a few localities, the

* Pit faces are no longer exposed for study. The Reynolds Metals Co. has followed ecological procedures of filling pits, recontouring surfaces, and replanting.

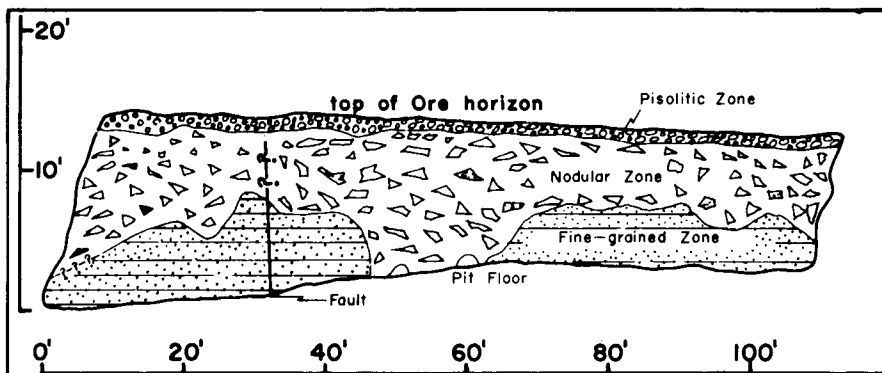


Figure 1A. Profile of the ore horizon at pit 1 showing textural zonation. Note the hummocks of the fine-grained zone. The intermediate nodular zone often drapes over the fine-grained zone and forms an undulating to "V"-shaped profile. Silt overburden is not shown.

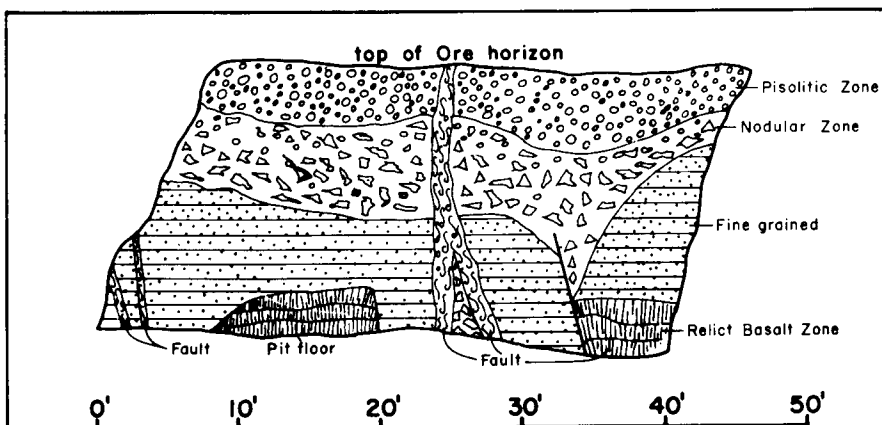


Figure 1B. Profile of the ore horizon at pit 2 showing textural zonation and faults. The fault zone consists of mottled clay with scattered pisolites. Silt overburden is not shown.

bottom and top contacts "drape" over the topographic highs. Locally, the bottom is quite irregular and often grades downward to a varicolored clay. The irregularities may be partially attributed to differential weathering of the basalt flows.

Character of the Ore

The bauxitic material usually contains three mappable textural units referred to here as, in descending order, the pisolitic, nodular, and fine-grained.* Figures 1A and 1B diagrammatically illustrate the "stratigraphic" position of these zones. In some areas, the textural zones are not easily distinguishable.

Allen (1948) and other workers have determined the mineralogy of the ferruginous bauxite and aluminous clays in Oregon. They reported that the chief aluminous mineral is gibbsite; the iron minerals are mainly goethite, hematite, "limonite," ilmenite, magnetite, and titaniferous magnetite, and the aluminous clays are composed predominantly of kaolinite, with minor amounts of halloysite.

Laterization involves a chemical breakdown of the parent material in which iron, titanium, and aluminum are concentrated and silica, alkalis, and alkaline earth are removed by leaching. A typical distribution of the principal laterite elements in Columbia County is shown diagrammatically in figure 2.

Normally, there are distinct visual differences between the top of the ore and the overburden. The ore is tough although friable, reddish and often pisolitic, whereas the overburden is tannish to mottled, plastic-like, soft and clayey.

Pisolitic zone

The pisolitic zone (figures 1A and 1B) contains abundant reddish-brown pisolites in a reddish-brown to red, fine-grained, earthy matrix. Most pisolites are hard, magnetic, well-rounded to sub-rounded, and have a steel-black opaque core surrounded by an earthy oxidized rim. The smallest are less than 1/32-inch in diameter, the largest more than 1/2-inch. Frequently well-rounded to irregularly shaped nodules and pebbles composed entirely of pisolites are scattered through this zone. Libbey and others (1946, p. 16-17) found the pisolitic material is composed of "limonite," magnetite, gibbsite, clenchite, and goethite.

Forty-five core samples from the pisolitic zone at pit 1 and pit 2 averaged 11% SiO₂, 31% Al₂O₃, 35% Fe₂O₃, 5% TiO₂, 16% L.O.I. (loss on ignition). The silica content is relatively high and often exceeds the

*Libbey and others (1946, p. 15) discussed three textural types as pisolitic ... "a softer earthy variety... and a hard porous granular type."

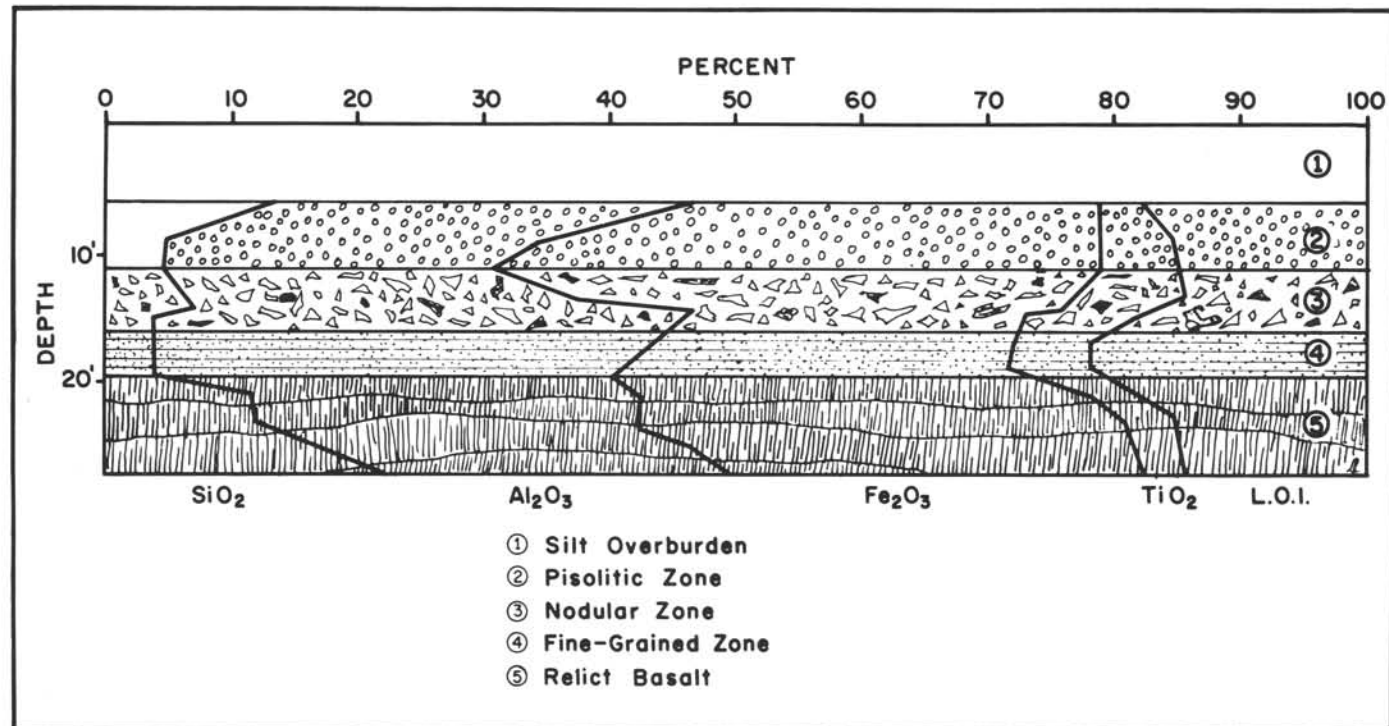


Figure 2. Chemical laterite profile of one core hole at pit 2.

10 percent cutoff for ore. However, recent analysis indicates that much of this is free silica. Livingstone (1966) studied the bauxites in southwestern Washington and identified quartz in the pisolitic material, which would at least account for part of the free silica; the writer suspects free silica also occurs partially in the form of crystalline quartz in Columbia County. Some origins for quartz in the bauxite are: first, quartz is residual from secondary quartz (agate or chalcedony) in the basalt; secondly, it is introduced by wind-blown or water-laid processes; thirdly, it is authigenic, being derived from the overlying silty clay formation. Evidence drawn from field observations tends to best support the authigenic origin. The lower portions of the silt have been weathered to a red mottled clay. Chemical breakdowns of the silicate minerals freed the silica, which was carried downward by solution to be partially precipitated as crystalline quartz in the pisolitic unit.

The contact with the underlying nodular unit is seldom sharp, but usually the transition occurs within 1 to 2 feet.

Nodular zone

The nodular zone (Figures 1A and 1B) consists of unevenly distributed, hard, irregularly shaped gibbsite and "limonite" nodules in an orangish to brownish earthy bauxite matrix. A few pisolites may be scattered throughout the nodular zone. The gibbsite nodules are pink, creamy or gray, and are hard and porcelainous to earthy. The "limonite" nodules are opaque, steel black, and sometimes platy; some have weathered to a yellowish-brown hard, earthy material. Gibbsite nodules are normally less than two inches in their longest dimensions and the "limonite" nodules vary from a few inches to nearly a foot. Also occurring in the nodular zone are patches and streaks of bluish-gray earthy gibbsitic material.

The average chemical composition of 45 core samples from the nodular zone at pit 1 and pit 2 is: 8% SiO_2 , 34% Al_2O_3 , 35% Fe_2O_3 , 5% TiO_2 , 20% L.O.I. Free silica content is nil.

The top of the nodular zone is relatively smooth, but the bottom is irregular and "drapes" over hummocks of the underlying fine-grained zone, giving a distinct undulating to V-shaped profile in cross-section (figure 1A). The contact between the two is gradational, but in some places it is quite sharp where it "drapes" over the hummocks and forms a thin parting.

Fine-grained zone

The fine-grained laterite (Figures 1A and 1B) is characterized by its texture, brownish color, and disseminated block, angular, hard metallic grains. The unit is durable, friable, feels gritty, and has a massive to platy structure. The metallic grains are often equidimensional and display varying degrees of magnetism; sometimes they are concentrated, forming nodules. Most are less than 1/32-inch in diameter. The grains are thought to be

composed of magnetite and ilmenite or a combination of both (titaniferous magnetite).

Fifty-six core samples from the fine-grained material at pit 1 and pit 2 averaged 5% SiO_2 , 35% Al_2O_3 , 33% Fe_2O_3 , 6% TiO_2 , 20% L.O.I. Free silica content is nil. In Columbia County this material was consistently lower in silica and iron and somewhat higher in alumina than either the intermediate nodular zone or the upper pisolitic zone.

The base of this unit is usually the bottom of the ore and physically and chemically changes downward to a kaolinitic-like clay. The bottom of this ore is locally quite irregular owing partially to differential weathering.

Relict basalt zone (usually is not ore, but as a matter of convenience is included in this section)

The relict basalt zone (figure 1B) underlies the ore horizon and is characterized by the spheroidal weathering pattern of the basalt "boulder" with associated fractures containing gibbsite, "limonite," black MnO_2 , and clay. The weathered material is typically clayey, soft, plastic, varicolored, and often has a salt and pepper (basaltic) texture. Dominant colors are shades of purple and pink with bright red to orange streaks along fractures.

At pit 2, a spheroidal weathered basalt boulder approximately 12 inches in diameter was found in this zone. The central portions contained unaltered basalt; the outer portions have been weathered to a bauxitic clay. The boulder is unique because it represents the laterization sequence of basalt in small scale.

The relict basalt zone as discussed here extends to the unaltered parent material and may be greater than 100 feet thick (John W. Hook, personal communication 1971).

Other Features

The ore horizon contained many small faults having slickensides, well-defined strikes, and nearly vertical dips, but little measurable displacement. Most faults were striking in a westerly and northwesterly direction. The fault zones were from a fraction of an inch to more than 2 feet thick and were filled with material similar to the overburden. The most predominant fault at pit 2, for example, contained red mottled clay with scattered pisolites extending from the top of the ore at least 20 feet to the pit floor. In most cases, they did not extend into the overburden. Analysis of the fault zones shows a high silica content, 25 to 35 percent.

Summary and Conclusion

The ore horizon at two prospect pits in Columbia County, Oregon contained three mappable textural zones referred to, in descending order, as the pisolitic, nodular, and fine-grained. The uppermost pisolitic zone tends to have a relatively high silica content. However, recent analysis shows a large portion of this is free silica. The intermediate nodular zone "drapes" over the hummocks of the lowermost fine-grained zone to form a distinct undulating to V-shaped profile in cross-section. Other pits had similar textural zonation. Locally, the bottom of the ore is quite irregular owing in part to differential weathering of the upper flows of Columbia River Basalt. Many other features were found including faults filled with material similar to the overburden.

The physical and chemical mechanism that formed the different textural varieties and zonation is not understood. Libbey and others (1946) concluded that the seasonal fluctuation of the ground-water table may be the most important factor. The information reported in this study is not adequate to allow an interpretation of the origin. Further studies are necessary to decipher the chemical history of the textural phenomena.

Acknowledgments

The author is indebted to John W. Hook for the help he has given in preparation and interpretation. Many thanks to Professor Marvin H. Beeson, Professor John E. Allen, and Dr. John H. Moses for constructive criticism of the manuscript. Grateful acknowledgment to Reynolds Aluminum for use of their chemical data and for their permission to publish this report.

References

- Allen, Victor T., 1948, Formation of bauxite from basaltic rocks of Oregon: *Econ. Geol.*, v. 43, no. 8, p. 619-625.
- Hook, John W., 1971, personal communications.
- Libbey, F. W., Lowry, W. D., and Mason, R. S., 1946, Ferruginous bauxite deposits in northwestern Oregon: *Econ. Geol.*, v. 41, no. 3, p. 246-265; Oregon Dept. of Geology and Mineral Ind. Bull. no. 29, 97 p.
- Livingston, Vaughn E., Jr., 1966, Geology and mineral resources of the Kelso-Cathlamet area, Cowlitz and Wahkiakum Counties, Washington: Washington Div. Mines and Geology Bull. no. 54, 110 p.
- Lowry, W. D., and Baldwin, E. M., 1952, Late Cenozoic geology of the lower Columbia River Valley, Oregon and Washington: *Geol. Soc. Amer. Bull.*, v. 63, no. 1, p. 1-24.

ENGINEERING GEOLOGISTS MEET IN PORTLAND

The Portland Section of the Association of Engineering Geologists hosted the 14th National Meeting at the Hilton Hotel in Portland, October 10-22, 1971. The meeting was attended by more than 400 persons coming from 29 states, the District of Columbia, and three Canadian provinces.

The technical program comprised two concurrent sessions on October 21 and two symposia on October 22. Approximately 30 papers were presented at the session, abstracts of which appear in the AEG program. The symposia, "Instrumentation -- Practical Application and Results" and "Rock Support Systems -- Underground and Open Excavations" are expected to be published in an early issue of the AEG Bulletin.

Included in the 1971 event were three pre-meeting excursions: to the Oregon Coast; to Mount Hood via Bonneville Dam and Hood River; and to features of geologic interest in the Portland area. Engineering works in the Columbia Basin were visited on a 3-day post-meeting field trip.

Co-chairmen R. Kenneth Dodds and Jasper L. Holland had the support and able assistance of officers and members of the Portland Section of AEG, and of exhibiting firms and sponsors. Herbert G. Schlicker, engineering geologist for the Oregon Department of Geology and Mineral Industries, helped lead the Oregon Coast trip; and Norman S. Wagner, geologist in charge of the Department's Baker field office assisted with the Columbia Basin trip.

* * * * *

McKELVEY APPOINTED NEW SURVEY DIRECTOR

Dr. Vincent E. McKelvey was sworn in as the new Director of the U.S. Geological Survey by Secretary of the Interior Rogers C. B. Morton on December 8. Dr. McKelvey was most recently the Survey's Chief Geologist (see July 1971 Ore Bin). As Director of the Survey he succeeds Dr. William T. Pecora, who was named Under Secretary of the Interior Department last May.

* * * * *

CORRECTION ON FOSSIL LOCATION

It has been called to our attention that the location for the Eocene crustacea given in text and on map by Orr and Kooser, June 1971 issue of The ORE BIN (vol. 33, no. 6, pages 119 and 120) is in error. The location should read "T. 35 S." instead of "T. 34 S."

* * * * *

INDEX TO THE ORE BIN

Volume 33, 1971

- Assay service, Department to charge for (33:6:132)
- Assessment work notice (33:10:196)
- Bauxite profiles in Columbia County, by Ron Jackson (33:12:223-229)
- Beverly Beach State Park, Visitor's guide to geology, by P. D. Snively and N. S. MacLeod (33:5:85-105)
- Central Oregon rock on moon, by Phil Brogan (33:11:210-211)
- Chaney, R. W. (in memoriam), by Jane Gray (33:7:142-143)
- Clatsop and Tillamook Counties, Department conducts study (33:8:164)
- Coastal geology, Beverly Beach State Park area, by P. D. Snively and N. S. MacLeod (33:5:85-105)
- Coastal landforms, Florence to Yachats, by E. H. Lund (33:2:21-44)
- Cowlitz Formation, Upper Nehalem basin, by R. O. Van Atta (33:9:165-181)
- Dalles Formation, extension and relation to Ellensburg Formation, Arlington area, by R. C. Newcomb (33:7:133-142)
- Department, Future programs (33:1:18-20)
- Douglas County, Mineralized area in mapping program (33:8:163)
- Earthquakes and seismic energy release in Oregon, by R. W. Couch and R. P. Lowell (33:4:61-84)
- Earthquakes, Eastern Oregon, July 13-14, 1971, by L. H. Jaksha (33:9:184)
- Electricity from geothermal, nuclear, coal sources, by R. G. Bowen (33:11:197-209)
- Ellensburg Formation, relation to Dalles Formation, by R. C. Newcomb (33:7:133-142)
- Energy, President delivers message on (33:7:148)
- Environmental geology (Western Governors' Mining Council recommendations) (33:8:149-156)
- Miningreclamation photos (33:8:152-153)
- Waste -- a mineral resource and geologic problem, by Newton, Mason, Peterson, and Schlicker (33:3:45-58)
- Eocene decapod crustacea, by W. N. Orr and M. A. Kooser (33:6:119-129); Location correction (33:12:230)
- Engineering Geologists meet in Portland (33:12:230)
- Field work in Oregon during 1970 (33:1:12-16)
- Florence to Yachats, Coastal landforms, by E. H. Lund (33:2:21-44)
- Fossil crabs, Oregon Eocene decapod crustacea, by W. N. Orr and M. A. Kooser (33:6:119-129)
- Geology markers along Oregon highways, by E. F. Lange (33:10:185-193)
- Geothermal activity in 1970, by R. G. Bowen (33:1:16-18)
 - Conference in Olympia (33:6:131)
 - Drilling regulations enacted (33:6:131)
 - Electricity production compared to nuclear and coal, by R. G. Bowen (33:11:197-209)
- Resources Council meetings (33:8:157) (33:10:195)
- Green Diamond abrasives (33:9:182-183)
- Jackson, James F. (33:5:108)
- Megadiamonds (33:5:107)
- McKelvy, named new U.S. Chief Geologist (33:7:148); Appointed Survey Director (33:12:230)

Metallurgical industry aids environment (33:10:196)
 Metals, high costs predicted (33:5:106); News, prices (33:7:144-146)
 Metals and Minerals Conference program notice (33:1:7)
 Miller, Wm. E., named to Department Governing Board (33:10:194)
 Mineral act passed, Notice of (33:2:44); Text quoted (33:3:59)
 Mineral and metallurgical industry in 1970, Oregon's, by R. S. Mason (33:1:1-5)
 Mining claim occupancy act to expire (33:3:60)
 Mining industry faces two-fold challenge (H. M. Dole) (33:12:222)
 Mining Council advises Western Governors (33:3:149-156)
 Nehalem Basin, Cowlitz Formation, by R. O. Van Atta (33:9:165-181)
 Obsidian hydration dating, by I. Friedman and N. V. Peterson (33:8:158-159)
 Oil and gas exploration in 1970, by V. C. Newton (33:1:8-12)
 Texaco drills in central Oregon (33:8:164)
 Ore Bin, Notice to subscribers (33:9:181); Correct address (33:10:194)
 * Oregon roads, 1910 (photographs) (33:12:213-221)
 Oregon's mineral and metallurgical industry in 1970, by R. S. Mason (33:1:1-5)
 Portland Hills fault, Evidence for, by J. H. Balsillie and G. T. Benson (33:6:109-118)
 Principal Oregon mineral producers, USBM Yearbook (33:1:5-7)
 Publications announced (Department)
 Geologic formations of Oregon (33:6:130)
 Lava tubes in Bend area (33:10:194)
 Morning mine bulletin revised (33:3:60)
 Powers quad., GMS map (33:7:147)
 Southern Oregon coast (33:3:60)
 Publications announced (U.S. Geological Survey)
 Basalt aquifers, Hermiston-Ordance area (33:11:212)
 Bibliography for 1966 (33:5:107)
 Groundwater in Clatsop dunes (33:5:108)
 Klamath Mts. geology and gold deposits (33:11:212)
 Tectonic structures in Columbia River Basalt (33:5:107)
 Publications announced (other)
 Fossil booklet (U. of O.) (33:10:195)
 Minerals Yearbook for 1969 (33:9:181)
 Oregon Acad. of Science proceedings for 1970 (33:3:59)
 Road log, Florence to Yachats, by E. H. Lund (33:2:35-44)
 Silcock appointed BLM director (33:7:146)
 State minerals research centers proposed (33:7:147-148)
 Texaco drills in central Oregon (33:8:164)
 Topographic maps, Department sells (33:8:163)
 Waste -- a mineral resource and geologic problem, by Newton, Mason, Peterson,
 and Schlicker (33:3:45-58)
 Western Cascades structure (differing concepts), by J. D. Beaulieu (33:8:160-163)
 World monetary system (33:11:209)

Roads, old, Oregon (33:12:213-221)

Mined land reclaim. (33:152-153) photos

AVAILABLE PUBLICATIONS

(Please include remittance with order. Postage free. All sales are final and no material is returnable. Upon request, a complete list of the Department's publications, including those no longer in print, will be mailed.)

BULLETINS

8.	Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller	0.40
26.	Soil: Its origin, destruction, preservation, 1944: Twenhofel	0.45
33.	Bibliography (1st supplement) of geology and mineral resources of Oregon, 1947: Allen	1.00
35.	Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1963: Baldwin	3.00
36.	Vol. 1. Five papers on western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	Vol. 2. Two papers on foraminifera by Cushman, Stewart, and Stewart, and one paper on mollusca and microfauna by Stewart and Stewart, 1949	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
39.	Geology and mineralization of Morning mine region, Grant County, Oregon 1948: R. M. Allen & T. P. Thayer	1.00
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
49.	Lode mines, Granite mining dist., Grant County, Ore., 1959: Koch	1.00
52.	Chromite in southwestern Oregon, 1961: Ramp	3.50
53.	Bibliography (3rd supplement) of the geology and mineral resources of Oregon, 1962: Steere and Owen	1.50
57.	Lunar Geological Field Conference guide book, 1965: Peterson and Groh, editors	3.50
58.	Geology of the Supplee-Izee area, Oregon, 1965: Dickinson and Vigrass	5.00
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00
62.	Andesite Conference Guidebook, 1968: Dale	3.50
63.	Sixteenth Biennial Report of the State Geologist, 1966-68	Free
64.	Geology, mineral, and water resources of Oregon, 1969	1.50
66.	Reconnaissance geology and mineral resources, eastern Klamath County & western Lake County, Oregon, 1970: Peterson & McIntyre	3.75
67.	Bibliography (4th supplement) geology & mineral industries, 1970: Roberts	2.00
68.	The Seventeenth Biennial Report of the State Geologist, 1968-1970	Free
69.	Geology of the Southwestern Oregon Coast W. of 124th Meridian, 1971: R. H. Dott, Jr.	3.75
70.	Geologic formations of Western Oregon, 1971: Beaulieu	2.00
71.	Geology of selected lava tubes in the Bend area, 1971: Greeley	2.50

GEOLOGIC MAPS

Geologic map of Oregon west of 121st meridian, 1961: (over the counter) . . .		2.00
folded in envelope, \$2.15		
Geologic map of Oregon (12" x 9"), 1969: Walker and King . . .		0.25
Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others . .		0.40
Geologic map of Albany quadrangle, Oregon, 1953: Allison (also in Bull. 37) .		0.50
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker . . .		1.00
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts . . .		0.75
Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams . . .		1.00
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka . . .		1.50
GMS-2: Geologic map, Mitchell Butte quad., Oregon: 1962, Corcoran et. al.		1.50
GMS-3: Preliminary geologic map, Durkee quad., Oregon, 1967: Prostka . . .		1.50
GMS-4: Gravity maps of Oregon, onshore & offshore, 1967: [Sold only in set] flat, \$2.00; folded in envelope, \$2.25; rolled in map tube . . .		2.50
GMS-5: Geology of the Powers quadrangle, 1971: Baldwin and Hess . . .		1.50

[Continued on back cover]

The ORE BIN
1069 State Office Bldg., Portland, Oregon 97201

The Ore Bin

POSTMASTER: Return postage guaranteed.



Available Publications, Continued:

SHORT PAPERS

- | | | |
|-----|--|---------|
| 2. | Industrial aluminum, a brief survey, 1940: Motz | \$ 0.10 |
| 18. | Radioactive minerals the prospectors should know (2nd rev.), 1955:
White and Schofer. | 0.30 |
| 19. | Brick and tile industry in Oregon, 1949: Allen and Mason | 0.20 |
| 21. | Lightweight aggregate industry in Oregon, 1951: Mason | 0.25 |
| 24. | The Almeda mine, Josephine County, Oregon, 1967: Libbey | 2.00 |

MISCELLANEOUS PAPERS

- | | | |
|-----|---|------|
| 1. | Description of some Oregon rocks and minerals, 1950: Dole. | 0.40 |
| 2. | Key to Oregon mineral deposits map, 1951: Mason. | 0.15 |
| | Oregon mineral deposits map (22" x 34"), rev. 1958 (see M. P. 2 for key) | 0.30 |
| 3. | Facts about fossils (reprints), 1953 | 0.35 |
| 4. | Rules and regulations for conservation of oil and natural gas (rev. 1962) . | 1.00 |
| 5. | Oregon's gold placers (reprints), 1954 | 0.25 |
| 6. | Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton . . . | 1.50 |
| 7. | Bibliography of theses on Oregon geology, 1959: Schlicker | 0.50 |
| 7. | (Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts . | 0.50 |
| 8. | Available well records of oil & gas exploration in Oregon, rev. 1963:
Newton | 0.50 |
| 11. | A collection of articles on meteorites, 1968: (reprints, The ORE BIN). . | 1.00 |
| 12. | Index to published geologic mapping in Oregon, 1968: Corcoran | Free |
| 13. | Index to The ORE BIN, 1950-1969, 1970: M. Lewis | 0.30 |
| 14. | Thermal springs and wells, 1970: R. G. Bowen and N. V. Peterson . . . | 1.00 |

MISCELLANEOUS PUBLICATIONS

- | | |
|---|-------------------|
| Oregon quicksilver localities map (22" x 34"), 1946 | Revision In Press |
| Landforms of Oregon: a physiographic sketch (17" x 22"), 1941 | 0.25 |
| Index to topographic mapping in Oregon, 1969 | Free |
| Geologic time chart for Oregon, 1961 | Free |
| The ORE BIN - available back issues, each | 0.25 |

OIL and GAS INVESTIGATIONS SERIES

- | | | |
|----|--|------|
| 1. | Petroleum geology of the western Snake River basin, Oregon-Idaho, 1963:
Newton and Corcoran | 2.50 |
| 2. | Subsurface geology of the lower Columbia and Willamette basins, Oregon,
1969: Newton | 2.50 |