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OREGON'S MINERAL AND METALLURGICAL INDUSTRY IN 1967

* By R. S. Mason

Oregon mineral production has surged to an all-time high and passed the $100-million mark for the first time. This milestone serves to point up the vital impact of the industry on the state's economy. It also furnishes one of the best indicators of the growth and development of the state. The mineral industry provides the basic building materials at all levels from the multimillion-dollar dam to the do-it-yourself patio. The industry is self-supporting, tax-paying, and ever responsible to community needs for "growth minerals." Minerals are indestructible but vulnerable to indifference and poor planning. Minerals are inert, but they provide the vital ingredients for our modern way of life.

In 1966, the latest year for which final production figures are available, Oregon's mineral industry exceeded the $100-million mark for the first time--a vigorous increase of 30 percent over 1965. Preliminary estimates by the U.S. Bureau of Mines indicate a decline in value for 1967, but characteristically the preliminary figures are much lower than the final figures released later (table 1). A comparison between the Bureau's estimates and final production figures for the period 1961-1966 is shown in table 2, along with percentage increases over the previous year.

Although the $107 million value reported set an all-time record, it did not include such Oregon-produced metallurgical products as ferronickel, pig aluminum, ferrosilicon, elemental silicon, the various exotic metals, regular and alloy steels, calcium carbide, and other furnace products. The value of these metallurgical products is considerable, but no figures are published to show the dollar total. Mineral production exceeded one million dollars in 19 of the state's 36 counties in 1966 (table 3). The rapid increase in the value of the state's mineral and metallurgical production is perhaps best illustrated by the fact that the value is doubling ever more frequently. Starting in 1942, it required 10 years to double the value, followed by an 8-year period in which it doubled again. The last doubling required only 6 years. Figure 1 shows the growth of the state's mineral industry for the period 1942-1966. During this 25-year period, the

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

Table 1. Some of Oregon's Minerals at a Glance
Preliminary Figures for 1967
(in thousands of dollars)

	1966	1967
Clays	$ 362	$ 328
Gold	10	6
Lime	2,283	1,724
Mercury	309	477
Sand and gravel; stone	68,615	56,000
Pumice; volcanic cinders	1,256	1,138
Miscellaneous*	19,926	17,586
Total	$107,484	$77,259

* Cement, copper, diatomite, iron ore, lead, perlite, nickel, peat.

total value of production soared 664 percent.

In discussing the value of Oregon's mineral production, it must be borne in mind that the dollar values that have been reported reflect values in the pit rather than at the point of sale. Comparisons with other segments of the state's natural-resource economy are of interest, even though the commodities differ widely and the bases for computation vary (see table 4).

Oregon's mineral and metallurgical industry is many things to many people. It supplies the aggregate and concrete for building miles of roads and dozens of bridges. It refines exotic metals for applications in outer, inner, and under space. It provides building stone for beautifying houses and other buildings, bedding material for plants, and pigment for paints. It provides more hours of recreation for "rockhounds" of all ages than any other natural resource in the state. It adds a much-needed stability to an economy plagued by seasonal employment fluctuations. It serves and benefits every community in the state. It provides jobs directly for 12,000 wage earners. Oregon's industrial-mineral producers pay taxes, cater to the varied and ever-increasing demands of growing communities, operate without benefit of federal or state subsidies, locate their own resource materials, develop, mine, and beneficiate them with their own money, and sell a product that has advanced less in price than has the general economy.

Growth Minerals

In 1967 each person living in Oregon used an average of 7.5 tons of sand and gravel, compared to the national average of 6.5 tons. Oregon is a relatively undeveloped state which is shifting the emphasis in its construction to the more durable building materials. The demand for "growth minerals" such as crushed stone and sand and gravel has been increasing rapidly over the years and the curve will be steeply upward in the future. The unit value of a ton of sand and gravel increased 42.5 percent between 1942 and 1966, while the tonnage produced increased 430 percent. Average value for a ton of sand and gravel produced in 1966 was only 96.2 cents. It has been calculated that the demand for sand and gravel in the period 1965

FIGURE 1. Volume & Value of Sand & Gravel and the Total Mineral Production in Oregon (1942-1966)

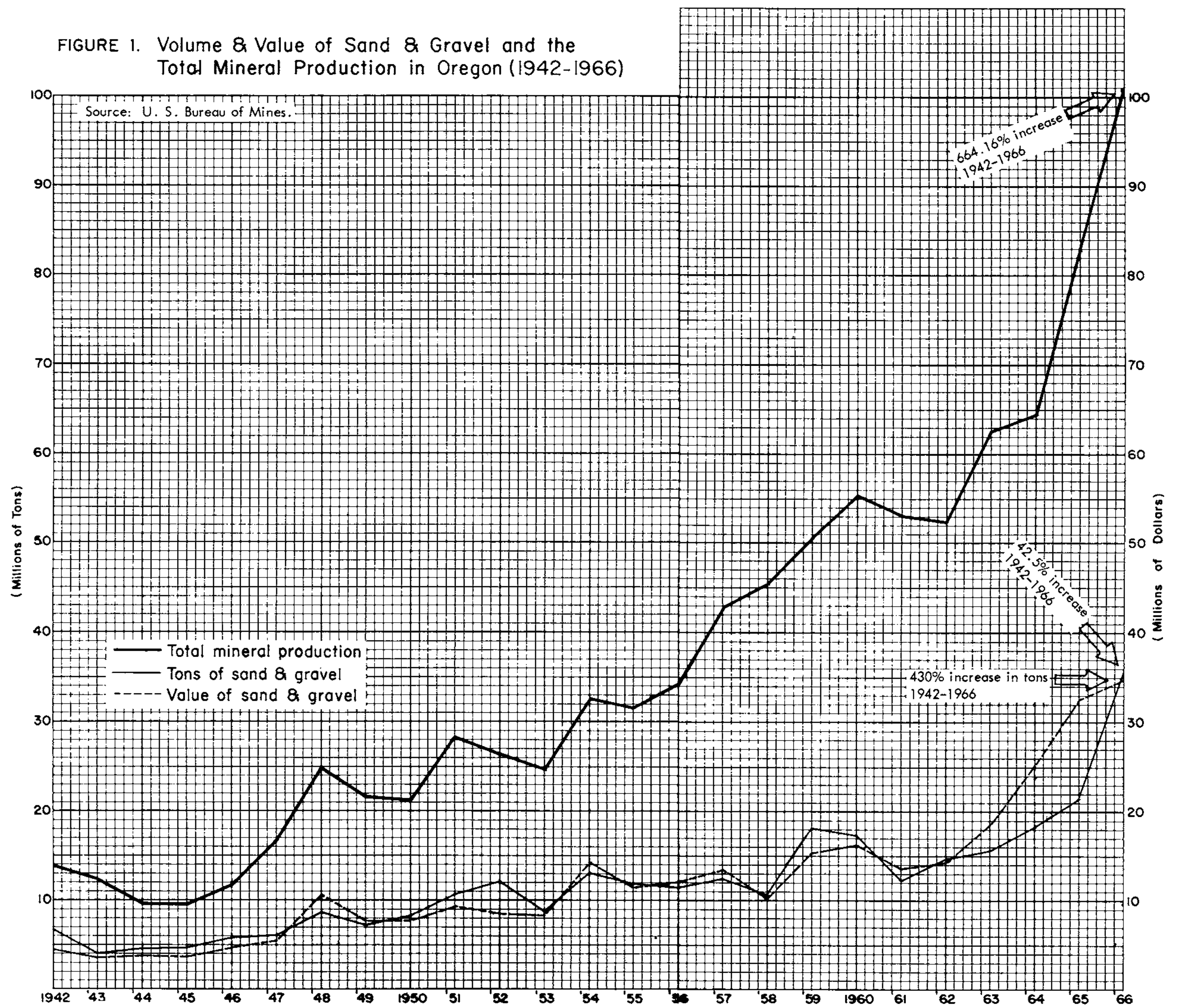

Table 2. Comparison between USBM preliminary estimates and final production figures for Oregon

Year	Estimate	Final	% Error	% Increase
1961	$54,922,000	$51,730,000	+ 6.18	--
1962	49,091,000	52,458,000	- 6.93	4.11
1963	62,693,000	62,692,000	0	19.50
1964	61,103,000	64,269,000	- 5.24	2.52
1965	68,547,000	82,967,000	-21.16	29.09
1966	80,567,000	107,454,000	-33.37	29.50
1967	77,000,000	?	?	?

to 2010 in Oregon will require the equivalent of a pit 30 feet deep, half a mile wide, and 60 miles long. In 1966 alone, a pit a mile square and 26 feet deep would have had to be excavated to equal the volume of sand and gravel produced in the state. The yield of crushed stone is roughly equal to that of sand and gravel. The state has large reserves of both of these vitally important "growth minerals" and, for the most part, they are fairly well distributed with respect to markets. In northwestern Oregon, however, rapidly increasing demand coupled with equally rapid engulfment of potential and existing sources as a result of urban expansion will create serious problems in the not too distant future.

Sand and gravel and crushed stone do not possess the same emotional appeal that other natural resources, such as fish and trees, do. The public is properly concerned over any threats to the destruction of forests, but few outcries are heard when potentially valuable quarry sites are zoned into oblivion. The problem is largely one of timing and planning. Most sand and gravel and crushed-rock operations can be conducted with a minimum of disruption of the economic and esthetic values of a community, provided that adequate provisions are made to buffer the mining activities temporarily, and to plan for restoration of the pits and their final disposition. The necessity for such planning is perhaps better understood when it is realized that a sand and gravel deposit 27 feet thick and covering only an acre of land will produce 43,560 cubic yards of material, which, if mixed with a little cement and sold as concrete, would have a sale value of about half a million dollars.

"Growth minerals" are unique among the state's natural resources. They are available in huge quantities but are nonrenewable. They are inflexible as to point of origin, are not subject to the destructible forces of the renewable resources, and for most applications are irreplaceable. They can, however, be rendered useless by lack of planning. Of all of the state's natural resources, "growth minerals" possess the unusual ability to provide, after a deposit has been exhausted, the basis for an entirely new use. Former

Table 3. The Million Dollar a Year Club*

County	Value	County	Value
Baker	$ 6,499,000	Lake	$ 1,020,000
Clackamas	7,474,000	Lane	8,500,000
Coos	1,112,000	Linn	3,429,000
Deschutes	1,003,000	Malheur	1,091,000
Douglas	9,929,000	Marion	1,145,000
Gilliam	31,950,000	Multnomah	6,200,000
Hood River	1,465,000	Sherman	1,424,000
Jackson	3,402,000	Umatilla	1,820,000
Josephine	1,146,000	Washington	2,466,000
Klamath	2,124,000		

* In addition to the values shown, there was a total of $7,913,000 which could not be assigned to specific counties, plus the production from Lincoln and Morrow Counties, which was concealed to avoid disclosing individual company confidential data.

hillsides may become industrial areas after they have been leveled by quarrying, or a quarry on level ground may become a pit suitable for sanitary fill, a ready-made building excavation, or a lake in a public-use site. A classic example of this multiple return from a mining operation can be seen just west of the city of Bend in central Oregon. Former pumice pits are being used to bury lumber-mill wastes, and the numerous heaps of overburden have been smoothed and prepared for home construction and landscaped areas.

Table 4. Comparison of productive value of Oregon natural resources, 1965 or 1966*

Forest products	1,470,000,000+	1966 estimate
Agriculture	513,570,000	1966
Mining and metallurgy	107,484,000	1966
Commercial fishing	9,300,000	1965 estimate

* Forest products figures are based on an f.o.b. mill price for most items (data from Western Forestry and Conservation Assoc.). Agriculture values are the total cash farm receipts (data from Oregon State Department of Agriculture). Mining and metallurgy figures for industrial minerals are based on the value of the products in the pit (data from U.S. Bureau of Mines). Values for metals are national annual averages. Commercial fishing values are based on the price paid to fishermen (data from Oregon State Fish Commission).

Table 5. Summary of withdrawals of Public Domain from mineral entry during 1967.

County	Acres	Agency Requesting	Use
Josephine	47	U.S. Dept. Agriculture	seed production
Morrow, Grant	50	U.S. Dept. Agriculture	recreation
Clatsop, Tillamook, Lincoln, Lane, Coos, Curry	346	U.S. Bureau Sports Fisheries & Wildlife	wildlife refuge
Curry, Josephine	5223	U.S. Forest Service	botanical area
Lane	430	U.S. Corps Engineers	reservoir
Umatilla	10	U.S. Forest Service	administrative site
Benton	132	U.S. Bur. Land Mgt.	recreation
Coos, Josephine	434	U.S. Forest Service	seed production, recreation
Douglas	1	U.S. Forest Service	roadside strip
Klamath	4	U.S. Forest Service	roadside strip
Umatilla	9	U.S. Forest Service	forest road system
Lane	.22	" " "	lookout
Jackson	155	U.S. Forest Service	administrative site
Grant	160	U.S. Forest Service	public use and recreation
Baker	110	U.S. Bur. Reclamation	reservoir

Federal agency withdrawals of public domain from mineral entry continued at a brisk pace during the year. A summary of the various withdrawals is given in table 5.

A pile of sand and gravel, sacks of cement, and a coil of wire do not look very impressive. When mixed properly, these same ingredients can become one of the most exciting building materials of the time. Prestressed concrete beams 100 feet long have become common, and the variety of thin-walled structural members seems endless. Precast concrete has come a long way from the solid 8x8x16-inch block. More than 100 patterns of concrete block in various colors and consistencies are available. The old solid concrete poured wall is still being used, but many modern buildings have walls that are poured flat and tilted up -- complete with window and door frames, conduits, and reinforcing. Precast wall panels weighing tons and intricately sculptured also have everything except the glass installed when they are delivered on the job. The technology of concrete has come a long way in the past 25 years, but the next quarter of a century will see far greater strides for this number-one building material.

The Metals

The mining and metallurgical industry as a tax-paying, profit-seeking industry must necessarily produce materials that are in demand. There is no government subsidy for not mining and refining ore, nor does the industry get paid for minerals and metals which it has produced but cannot sell. As a result, the industry is both viable and pliable. Over the years Oregon mines and mills have produced minerals and metals as they were required and in the quantities needed, in both peace and war. Years ago the West needed, above all else, two vital ingredients -- manpower and wealth. The mines attracted the men and the men produced gold and silver (wealth) in prodigious quantities. During two world wars Oregon was a major producer of strategic chrome and mercury. Today the federal government has decided that gold and silver are unimportant in our national economy and the emphasis has turned to the modern metals.

Oregon is one of the principal centers for the production of the various exotic metals used in atomic applications and space-age hardware. The state's exotic-metals industry was fully discussed in the October 1967 ORE BIN. In addition to the unique aspects of this branch of metallurgy, some of the new metals are replacing old-line metals where severe corrosion or heat problems exist. Skins of aircraft have changed from canvas to aluminum to titanium, and exteriors of railroad passenger cars have evolved from wood, through steel, to titanium.

Wah Chang Corp. was purchased by Teledyne Inc. during the year and renamed Wah Chang Albany Corp. After the acquisition by Teledyne, the Albany plant increased its capacity for zirconium sponge by 80 percent. Heavy expenditures for fume- and waste-disposal controls were also made. Construction of a new technical center which will house a wet laboratory and spectrographic, X-ray, and neutron-absorption facilities got under way late in the year.

Oregon Metallurgical Corp. became a wholly owned subsidiary of Armco Steel Corp. early in the year and ground was broken in October for a $2.4-million expansion of the titanium-melting complex. Three new vacuum arc melting furnaces will more than double the plant's present capacity. The new furnaces will have the capability of producing 36-inch-diameter ingots weighing 20,000 pounds, the largest in the country. Oremet is primarily concerned with titanium-ingot production. The plant also turns out titanium castings and high-purity vanadium metal. Early in the year the third titanium-sponge reduction unit was completed out of a projected total of eight. Planning for an electrolytic magnesium and a titanium tetrachloride plant was instituted. The two plants would provide raw material for the titanium-sponge operation.

Northwest Industries operated a machining facility for reactive metals used in high-temperature and corrosion-resistant applications.

Construction began in December on two new plants in the Albany area. TiLINE Inc. is building a half-million-dollar facility for casting metal bodies around preformed linings of exotic, corrosion-resistant metals such as titanium. The products will be sold principally to the chemicals industry. REM Metals Corp. has a precision casting plant under construction with completion scheduled for late 1968. REM's products will be used by the aircraft industry.

In the Portland area the Oregon Steel Mills division of Gilmore Steel and the Midland-Ross Corp. began construction of a $35 million steel-producing complex. Oregon Steel is building a melting and rolling-mill facility, Midland-Ross a metallized pellet plant. The plants are the newest additions to the Rivergate industrial area at the confluence of the Willamette and Columbia Rivers. Construction is scheduled for completion early in 1969. The Midland-Ross pellet plant will use iron ore imported from Peru to produce pellets containing a minimum of 95-percent iron. Oregon Steel's new plant will be able to roll plates up to 96 inches wide and from 3/16ths to 3 inches in thickness. The company's original plant on N.W. Front Avenue will continue to produce hot-rolled steel bars.

Also in the Portland area, ESCO Corp. continued to produce high-alloy castings and forgings. ESCO is a world leader in the production of nuclear-quality castings for the generation of atomic power. Precision Castparts, Milwaukie, in the Greater Portland area, is an acknowledged innovator in the manufacture of precision investment castings of alloy steels for space-research jet engines and aircraft.

Precious metals

The production of gold and silver in the state was the lowest since the turn of the century. Rising production costs coupled with, in the case of placer-mining operations, increasing restrictions on stream use, were largely responsible for the decline. The Buffalo mine in eastern Grant County was idle during much of the year. Union Pacific leased the property to A. W. Brandenthaler, who drifted on the 500 level. Omega Mines Co. continued its underground exploration of the North Pole and the E and E mines at Bourne in the Cracker Creek District of Baker County. Gold mines in the area have a productive history extending back into the 1890's.
A detailed report on the Almeda mine in Josephine County was published by the Department during the year. The Almeda mined and smelted copper ore in the period 1905 to 1917.

Base metals

Interest in copper by two companies saw exploration programs inaugurated in the Sparta-Keating area of eastern Baker County. Bear Creek Mining Co. conducted a geological reconnaissance of the Burkemont mine area, and Cyprus Mines Co. drilled on a nearby prospect. Attention to the area followed the announcement of geochemical testing by the Department of Geology and Mineral Industries a few years ago. The Department's field work revealed the presence of a copper anomaly.

Mercury

Despite the continuing high price for mercury, the state's production for the year was small. Active mines included the Black Butte in southern Lane County, the Glass Buttes mine in northeastern Lake County, the Elkhead mine in northern Douglas County, and the Canyon Creek mine in Grant County. Most of the state's production came from the Black Butte and Glass Buttes mines.

Uranium

Renewed interest in uranium was shown by several companies during the year. The Nuclear Fuels Division of Gulf Oil Corp. leased 82,000 acres of state-owned land in south-central Oregon late in the year and announced plans to explore the area. Western Nuclear investigated the White King-Lucky Lass mines area in southern Lake County. The two mines have been the principal uranium producers in the state but have been idle for some time. At year's end three other companies expressed a desire to investigate uranium occurrences in the state.

Nickel

Hanna Nickel Smelting Co. reported a record production of ferronickel for 1967 from its mine and smelter at Riddle in Douglas County. The high production reflects mechanical and metallurgical-process improvements, which are approaching design capacity of the expansion program that took place in 1964 and 1965. Hanna is the only producer of domestic nickel in the United States and furnishes the equivalent of around 10 percent of the Nation's needs.

Industrial Minerals

Cement, lime, and limestone

Production of cement continued from the two plants owned by Oregon

Portland Cement Co. in Baker and Clackamas Counties. Ideal Cement Co. shut down its plant at Gold Hill, Jackson County, in April and converted it into a storage and distribution center. Burnt lime was produced at the Chemical Lime plant near Baker, Baker County, and at the Ashgrove Lime and Portland Cement Co. plant at Portland. Several other lime kilns were active in the state, but their production was immediately consumed by company-owned facilities for such products as calcium carbide, sugar, and pulp.

Limestone was quarried in Baker County for the Lime plant of the Oregon Portland Cement Co. and at the Baboon Creek quarry operated by the Chemical Lime Co. Large tonnages of limestone were again imported into the Portland area from Texada Island, B.C., for use in cement, calcium carbide, and burnt lime.

Lightweight aggregates

Natural pumice and scoria were produced by both Central Oregon Pumice Co. and Cascade Pumice Corp., a subsidiary of Boise Cascade in Deschutes County. Both companies operate their own quarries and crushing, screening, and blending plants. Empire Building Materials Co. produced expanded shale at its quarry and kilns in northern Washington County. The plant first began operating in 1947. A pozzolan mill is operated in conjunction with the plant. The quarry and kiln, operated by Cloverleaf Mines, Inc., south of Vernonia in Washington County, was revamped during the year and was acquired by Smithwick Block Co. of Portland.

Miscellaneous

Production of peat continued at the Jewell's Mother Earth pit and plant near the town of Enterprise in Wallowa County. Bentonite deposits on Camp Creek in eastern Crook County were mined and sold for well-drilling mud, reservoir lining, insecticide carrier, and stock-feed binder by Central Oregon Bentonite Co. Diatomite for pet litter and floor-sweeping compound was produced by A. M. Matlock from a deposit near Silver Lake in Lake County.

Semi-Precious Gemstones

Oregon, which has long been a prime producer of semi-precious gemstones, continued to attract increasing numbers of "rockhounds" to its widespread deposits of quartz-family minerals. "Rockhounding" emerged during the year as the state's number one recreational activity related to a natural resource. "Rockhounds" are out combing the hills the year around, there being no open or closed "seasons" for the hobby or hunting license required. Rockhounding is a family project which includes healthful outdoor activity, combined with home craftsmanship in the preparation of specimens. The state has numerous gem clubs which meet regularly and conduct classes and competitions. In recent years the clubs have made strenuous efforts to improve public relations. The impact of rockhounding can be judged from the one million dollars that this one recreational activity alone brought into Crook County last year. Crook County has been active in promoting rockhounding for many years and sponsors a "powwow" attended by thousands each summer. Similar events were scheduled in several other counties.

Offshore Mineral Exploration

Exploration of Oregon's "under space" was conducted by two federal agencies during 1967. The U.S. Bureau of Mines and the U.S. Geological Survey initiated sampling and bottom-study programs along the coastline. The U.S.G.S. contracted with the Department of Oceanography at Oregon State University for much of the work.

Interest by private firms in state-owned offshore lands continued, but no programs were started owing to lack of state legislation which would permit issuance of prospecting permits and mining leases for hard minerals. Minerals of possible economic importance include gold, platinum, glauconite, magnetite, chromite, and various other "heavy blacks."

The State of Oregon owns a strip bordering the coastline which extends seaward for a distance of 3 nautical miles (a nautical mile equals 6,080.20 feet) or slightly less than 3½ statute miles. The configuration of the seaward boundary is determined by swinging 3-mile-radius arcs from headlands and offshore stacks and islands. The state offshore lands total slightly more than 850,000 acres, of which perhaps 500,000 acres might be suitable for offshore mining.

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USGS PUBLICATIONS CONCERN SOUTHWESTERN OREGON

Two publications recently released by the U.S. Geological Survey are:

1. "Low-temperature reaction zones and alpine ultramafic rocks of California, Oregon, and Washington," by R. G. Coleman. Concerns tectonic origin of peridotite-dunite bodies and accompanying serpentinization. Issued as Bulletin 1247; available from Superintendent of Documents, U.S. Government Printing Office, Washington D. C. 20402, for 25 cents.

2. "Marine sediment sample preparation for analysis of low concentrations of fine detrital gold," by H. E. Clifton, A. Hubert, and R. L. Phillips. Describes Survey's techniques in analysis for gold in black sands on and offshore in southern Oregon. Issued as Circular 545; free on application to U.S. Geological Survey, Washington, D.C. 20242.

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OIL AND GAS EXPLORATION IN OREGON

By V. C. Newton, Jr.*

Oil companies dropped 65 of the 76 Oregon and Washington offshore leases acquired in 1964 as rentals came due in December, 1967. Only eight tracts were retained off the Oregon coast and three off Washington. Pan American Petroleum Corp. and its partners withdrew from further exploration in the Northwest following the drilling of two dry holes this past summer. The six companies remaining in the Northwestern offshore venture are expected to conduct only limited operations in the coming year. An estimated $76 million has been spent on offshore work in Oregon and Washington since operations began in 1961.

Sites which appeared to geologists as prime targets have been drilled and no commercial production was found. Reportedly, sedimentary rocks were as thick as expected but were predominantly fine grained, with very few sand layers. Thus, even though "domes" exist, no reservoir beds were located in which oil and gas could collect. Geologic factors must be reconsidered and new ideas generated before any more exploration is done on the submerged lands.

A new exploration cycle appeared to be building onshore in western Oregon; however, it will undoubtedly be on a much smaller scale than the offshore work. Mobil, Standard, and Texaco leased more than 50,000 acres of land in western Oregon during the spring and summer of 1967. The main interest is centered in Columbia County in the northwestern corner of the state. At the same time, Mobil assembled leases at three other locations in southwestern Oregon (see figure 1).

Offshore Activity

Pan American and others (Atlantic-Richfield, Sinclair, Superior, Canadian Superior, and J. Ray McDermott) drilled a deep test 10 miles southwest of Coos Bay on OCS Tract 102 in April 1967. Oil and gas shows were reportedly encountered but testing proved them to be noncommercial (table 1). The companies moved the floating equipment ("Blue Water II," owned by Santa Fe Drilling Co.) to northern Washington, where they drilled offshore from the mouth of the Hoh River. No shows were obtained and the

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* Petroleum Engineer, Oregon Dept. of Geology and Mineral Industries.

Table 1. 1967 offshore holes.

Company	Location Lambert Coords.		Tract No.	Area	Total Depth	Remarks
Pan Am. et al.	X Y	910,010 602,220	102	Coos Bay, Ore.	6,146'	Abandoned 5/14/67. Shows reported but noncommercial.
Pan. Am. et al.	X Y	1,024,850 266,310	5	Hoh River, Wash.	10,368'	Abandoned 7/9/67.
Shell	X Y	1,022,500 578,350	28	Grays Harbor, Wn.	11,162'	Abandoned 8/20/67.

hole was abandoned at a depth of 10,368 feet.

Shell Oil Co. took the equipment after the second Pan American hole and moved to a location 10 miles seaward from Grays Harbor, Wash., to drill on OCS Tract 28. No hydrocarbon shows were encountered in this hole, total depth 11,162 feet. After Shell plugged the hole on Tract 28, "Blue Water II" was towed south to Long Beach, Cal., where it was docked pending the Santa Barbara sale.

Pan American Petroleum Corp. and its partners did not renew any of its Oregon and Washington offshore leases when rentals came due in December 1967. This left 6 of the 11 companies which began the Northwestern shelf studies in 1961. The remaining participants reduced holdings to just a few tracts (see table 2). Offshore acreage cuts in Oregon and Washington have continued since drilling began in 1965, as follows:

Year	Federal Acreage	Rental
1965	580,800 acres	$ 1,740,000
1966	385,000	1,155,000
1967	64,000	192,000

Shell and Standard cancelled their State submerged land leases south of Reedsport in December 1967. Each firm acquired one State parcel in December 1964. Total rentals and bonuses paid by the two companies over the three-year period 1964 to 1967 amounted to $69,800.

There was little geophysical activity on the Northwest shelf in 1967. The University of Washington Department of Oceanography and Shell Oil Co., separately, ran several seismic traverses off the Washington coast this past summer. Standard Oil Co. and Mobil Oil Co. conducted seismic work off the Oregon coast for a two- or three-week period in 1967.

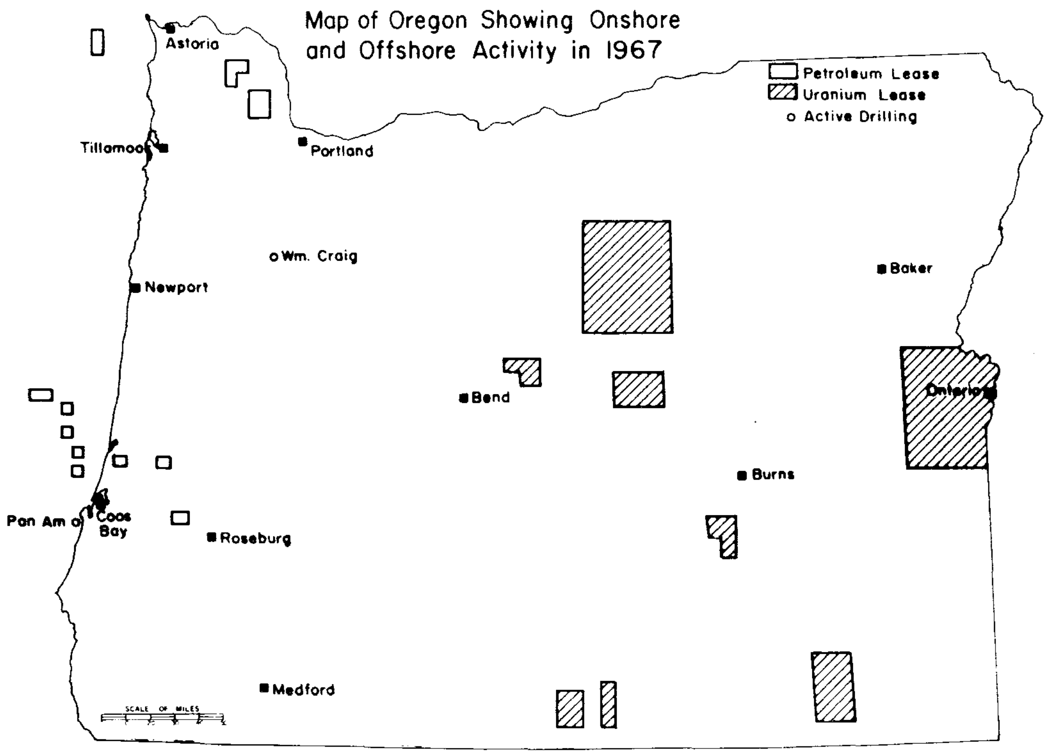

Figure 1. Map showing 1967 oil drillings and lands under lease to oil companies at the start of 1968.

Table 2. Offshore leases renewed, December 1967.

Company	File No.	Tract No.	Area
Shell	OCS-PO 73	19	Tillamook, Ore.
Shell	OCS-PO 75	22	Tillamook, Ore.
Std/Union	OCS-PO 85	39	Florence, Ore.
Std/Union	OCS-PO 86	40	Florence, Ore.
Std/Union	OCS-PO144	10	Hoh River, Wash.
Std/Union	OCS-PO145	11	Hoh River, Wash.
Std/Union	OCS-PO146	12	Hoh River, Wash.
Tex/Atl-Rich/ Mobil	OCS-PO 78	28	Florence, Ore.
Tex/Atl-Rich/ Mobil	OCS-PO113	105	Florence, Ore.
Tex/Mobil	OCS-O 116	113	Florence, Ore.
Atl-Rich	OCS-O 122	126	Florence, Ore.

Onshore Drilling

The Department issued one new drilling permit in 1967, this to Wm. Craig of Tacoma, Wash., for a shallow hole 15 miles south of Salem (see fig. 1). The Craig test was located near a 2800-foot hole drilled by Portland Gas & Coke Co. in 1936. Gas shows in a salt-water sand were reported in the P. G. & C. hole at a depth of 2500 feet. Craig suspended operations in July at a depth of 1560 feet. Footage drilled by Craig was the only new hole made on shore last year (see table 3).

Table 3. Permits active in 1967.

Permit No.	Company	Well name	Location	Depth	Remarks
55	Butte Oil of Oregon	Cowan 1	Sec. 8, T. 1 S., R. 3W., Wash. County	957'	Plugged 12/18/67.
56	M. Lewis	Crossley-Jennings, 2	Sec. 31, T. 6S., R. 4W., Polk County	2100'	Suspended until March 1968
57D	Central Oils	Morrow 1	Sec. 18, T. 12S., R. 15E., Jefferson Co.	3300'	Abandoned 9/12/67
59	Wm. Craig	Gilmour 1	Sec. 24, T. 9S., R. 4W., Marion Co.	1560'	Suspended until March 1968

Oil leasing was initiated again in western Oregon in 1967 when Mobil Oil Co. filed for Columbia County lands. Standard of California and Texaco moved into the area shortly after Mobil's application had been filed. Approximately 50,000 acres of leases were involved in the activity. This was the first major onshore leasing program since 1962, when more than a million acres of leases were taken in the Willamette Valley.

Mobil also leased several thousand acres in Lane and Douglas Counties of southwestern Oregon in May and June 1967. The area is not new to the company, since it conducted geologic studies in southwestern Oregon in the late 1950's and drilled a deep hole 10 miles northeast of the coastal city of Reedsport in the summer of 1957.

Many oil companies today have divisions within the firm that are concerned with resources which are either by-products of refining or related to energy supplies other than petroleum. These subsidiary interests include sulfur, ammonium nitrate, coal, natural thermal power, and radioactive minerals. One example of such auxiliary operations was seen last November when the Nuclear Fuels Division of Gulf Oil Corp. acquired more than 80,000 acres of leases in eastern Oregon for uranium prospecting (see fig. 1). The construction by Shell Oil Co. of an anhydrous ammonia plant near St.

Helens, Ore. in 1965 is another of these operations. Dry natural gas and atmospheric nitrogen are the main raw materials at the Shell plant.

Sedimentary Basins

Oregon can be divided into two marine provinces and several lacustrine basins for the purpose of discussing petroleum prospects (see figure 2). Tertiary marine rocks underlie most of Oregon west of the Cascade Mountains, excluding the Klamath Mountains in southwestern Oregon. Complexes of Mesozoic and Paleozoic marine, volcanic, and intrusive rocks are exposed in the Klamath Mountains, and also in the Blue Mountains of eastern Oregon. Several large intermontane basins formed during late Cenozoic time in central and eastern Oregon. Four of these basins have been explored for oil and gas: western Snake River basin, Harney Lake basin, Goose Lake basin, and the Klamath Lake basin. Of the non-marine basins in Oregon, only the western Snake River and Goose Lake basins are currently regarded as having any possibilities for production of hydrocarbons (mainly gas).

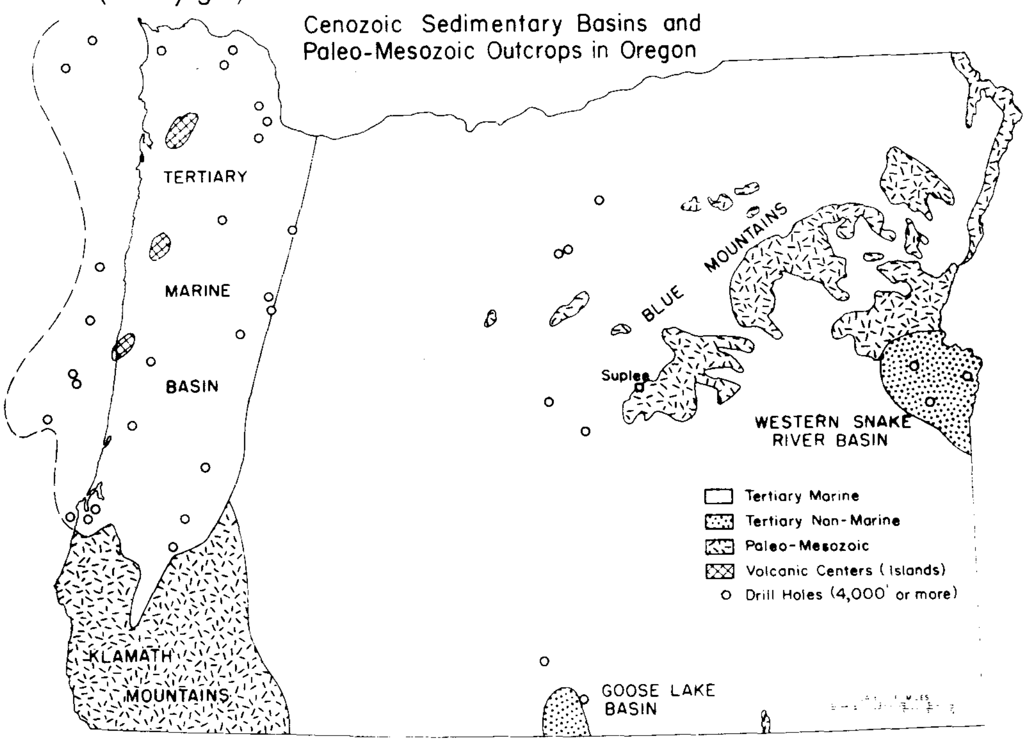

Figure 2. Map showing outlines of outcrop areas in Oregon which are related to possible petroleum source rocks.

Paleozoic-Mesozoic province

Little is known as yet about the Paleozoic rocks in Oregon because of their complex structure and limited exposure. The oldest rocks in the state are those found in the southeastern part of the Klamath Mountains on the California border. These rocks are mainly chlorite and graphite schists believed to be Silurian or older in age (Baldwin, 1959). However, Paleozoic rocks in the Suplee area are much less altered and less distorted than elsewhere in Oregon (Merriam and Berthiaume, 1943). Devonian limestone and marine clastics have been described from the Suplee area (Kleweno and Jeffords, 1961). Generally, the Paleozoic exposures in central Oregon range in age from Carboniferous to Permian.

Mesozoic marine sediments occur in southwestern, central, and eastern Oregon (see fig. 2). More than 34,000 feet of Triassic and Jurassic rocks, predominantly marine, have been described near Suplee in central Oregon (Dickinson and Vigrass, 1965). Although these rocks have been complexly folded, they show little, if any, metamorphism. A great deal of volcanic material is intermixed with the marine sediments, indicating periods of widespread volcanism. Paleogeologic studies by Eardley (1951) suggest the presence of a volcanic landmass in western Oregon during much of Paleozoic-Mesozoic time, when an inland seaway connecting the Puget Trough with the Gulf of California occupied central Oregon.

In several areas of north-central Oregon, particularly near the town of Mitchell (Wilkinson and Oles, 1968) and at Bernard Ranch near Suplee (Dickinson and Vigrass, 1965), there are deposits of Late Cretaceous shales, sandstones, and conglomerates that lie unconformably on older Mesozoic and Paleozoic strata. The Cretaceous beds are not as deformed nor as diagenetically altered as the older formations. They could, therefore, become potential reservoir rocks in places where the necessary conditions for entrapment of petroleum may exist.

Mesozoic marine rocks similar to those in the central Oregon inlier are also exposed in north-central and northwestern Washington. Buddenhagen (1967) suggests that much of the area between the Oregon and Washington exposures now covered by Tertiary lavas may be underlain by unmetamorphosed Mesozoic marine beds.

Tertiary marine province

A eugeosynclinal trough formed in the coastal area and adjacent Willamette lowland of western Oregon in the Tertiary period. Volcanic activity was intense during the initial stages of downwarping. At times a volcanic archipelago formed (Snavely and Wagner, 1963).

Many local downwarps occurred in the eugeosyncline as a result of differential warping of the crustal rocks. An estimated 15,000 feet of sediments collected in the deeper basin areas, beginning in early Eocene time and continuing through Miocene time (Snavely, Wagner, and Bromery, 1964). Later marine deposits were west of the present shoreline except for Pliocene deposition in the Coos embayment (Baldwin, 1966).

The core of the northern Coast Range consists of submarine lavas, while southward these rocks interfinger with marine sediments. Younger marine rocks occur in an arcuate belt around the north end of the volcanic core and extend into the Willamette syncline (Snavely, Wagner, and Bromley, 1964).

Deep drilling in the Tertiary basins of western Oregon has not produced any significant shows of hydrocarbons. Drill-stem tests on sands have all yielded salt water with minor amounts of gas. Structural and stratigraphic conditions were favorable in most cases, but no oil was entrapped.

Cenozoic non-marine basins

Large intermontane basins formed at several locations in eastern Oregon in the Pliocene and Pleistocene epochs. The Klamath and Lakeview basins resulted from block faulting which occurred with the Basin and Range development. Genesis of the western Snake River and Harney basins was also related to faulting (Newton and Corcoran, 1963; Piper, Robinson, and Clark, 1939). All of the eastern basin deposits are a mixture of lacustrine, subaerial, and volcanic debris. Diatomite is common and often thin beds of sub-bituminous coal are found in the basin deposits. Many gas shows have been found in the western Snake River basin, a few of them of significant proportion (Newton and Corcoran, 1963). A total of 19 holes has been drilled in the Oregon portion of the basin; no commercial production was found.

Humble Oil & Refining Co. drilled two deep test holes in the Goose Lake basin in 1960-61, but the objective was to test pre-Tertiary marine rocks. Tertiary lavas and sediments were found to be more than 12,000 feet thick. One interesting gas show in this area was Tri-State Petroleum's "Fisher 1" (Stewart, 1954; Newton, 1965).

What Are Oregon's Prospects?

Oil firms and wildcatters have drilled 183 holes in the state during the past 65 years. However, only 37 were adequate tests, including the 8 deep offshore holes. No significant surface seeps of oil or tar are known in Oregon; only a few very minor occurrences of hydrocarbons. No commercial discoveries have been made in any of the drillings to date and nothing more than traces of oil recovered on drill-stem tests. Widespread volcanic activity produced an environment that was inhospitable for generating petroleum, particularly around volcanic centers. Furthermore, in past geologic time, much of the detritus supplied to the basin areas was fine grained.

These are the main discouraging facts relating to Oregon's future as an oil-producing area. There are positive factors as well. Thousands of square miles of marine sediments have not been tested in the state. Several of the holes drilled thus far have encountered porous and permeable sands. The geologic history of the Pacific margin was one of considerable volcanic activity from Alaska to the Gulf of California. Nonetheless, marine sediments, particularly the Tertiary deposits in the Pacific Trough, have been prolific producers of hydrocarbons.

Besides the geologic factors, political and economic conditions have a decided influence on exploration activity in an area. In the past it has been more profitable for large firms to exploit foreign resources. It is becoming increasingly less profitable to do so. Inequities in the "balance of payments" have forced the present Administration to bring pressure on foreign investments and expenditures. Another economic factor is competition for productive lands in the western hemisphere which drain capital away from the domestic "wildcat" areas. A good example of this is the present outlay for Alaskan development and the coming offshore lease sale in the Santa Barbara Channel of California. This sale alone is expected to net $300 million in bonus payments (Oil and Gas Journal, Dec. 25, 1967).

Oregon shelf lands look much less attractive with eight dry holes than they did four years ago before drilling began, but a vast area of shelf remains to be explored. The attention of industry has been drawn away by competition elsewhere, and further studies and leasing must be put off until later. Therefore, little work can be expected on the Northwest shelf for at least five years. On shore, a new exploration cycle seems to be building up in the northwestern corner of the state. If geologic studies prove interesting, one or more deep test holes will be put down. A significant show in one of these could initiate a great deal of excitement. Oregon will see more exploration in the years ahead because of the growing need for petroleum and because it is one of the few remaining undrilled areas in the United States.

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OAS TO MEET AT OREGON STATE

The Oregon Academy of Science will hold its annual meeting February 24 at Oregon State University, Corvallis. Presentation of papers will begin at 9:30 a.m. and continue through the day. Dr. Jack Green, geologist for Douglas Aircraft Co., will give a talk before the Academy on interpretation of the lunar features based on the latest orbiter photographs. Cyrus W. Field and Robert E. Frenkel are co-chairmen of the geology-geography section.

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OCEANIC EXTENSION OF COASTAL VOLCANICS: NORTHWESTERN OREGON

By David A. Emilia*, Joseph W. Berg, Jr.** and William E. Bales*

Introduction

The object of this paper is to give an estimate of the oceanic extension of coastal volcanics in northwestern Oregon by correlating land and ocean geophysical data with land geologic data.

Volcanic flows and intrusions of intermediate to basic composition usually have high magnetic susceptibilities, in contrast to marine sedimentary and fine pyroclastic rocks. Magnetic surveys usually evidence these susceptibility contrasts as magnetic anomalies superimposed on a regional magnetic field. If volcanic formations are continuous from land to ocean, then, as long as there are susceptibility contrasts associated with them, the magnetic anomalies related to the volcanics on land should be observable at sea. Also, volcanic flows and intrusions sometimes have different densities than the surrounding rocks, thus giving rise to gravity anomalies. These gravity anomalies should also give an indication of the oceanic extent of the volcanic formations--providing the density contrasts extend from land to ocean. Magnetic and gravity anomalies may also arise from variations in depth to a volcanic surface or from local variations in thickness of a volcanic formation.

The total magnetic-field values used in this paper were taken from Emilia, Berg, and Bales (1966) and from Bromery and Snavely (1964). The former present a 50-gamma-contour map constructed from ship-towed magnetometer data and the latter present an aeromagnetic profile along the coast. Free-air gravity anomaly values were taken from the 10-milligal-contour maps for Oregon (Berg and Thiruvathukal, 1967) and for off-shore Oregon (Dehlinger and others, 1967). The geological information used during the course of this research was taken from Bromery and Snavely (1964).

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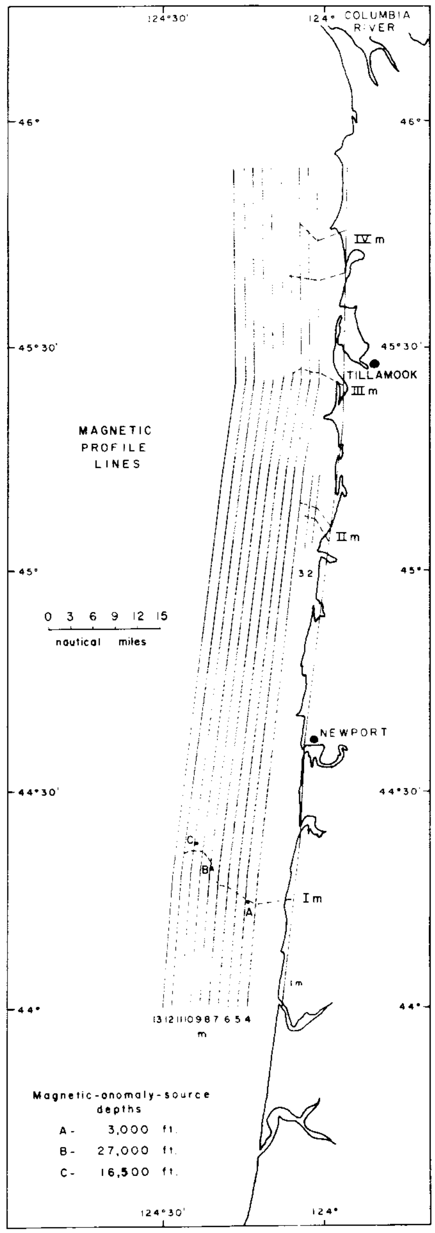

Figure 1. Magnetic profile lines. The dashed lines trace the locations of the correlated magnetic anomalies (see fig. 3).

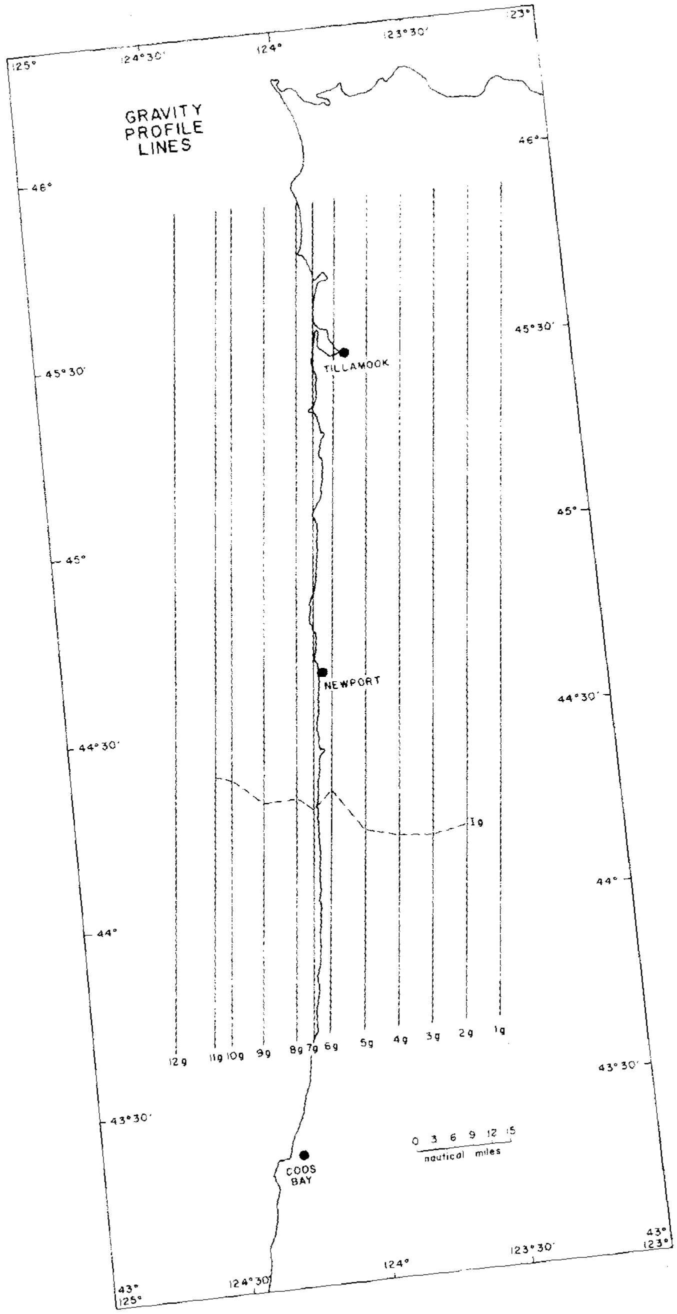

Figure 2. Gravity profile lines. The dashed line traces the location of the correlated gravity anomaly (see fig. 4).

Data Reduction and Presentation

Figures 1 and 2 show the magnetic and the gravity profiles lines (designated by the letters m and g, respectively) along which data were taken for the purpose of this study. These lines were drawn on the magnetic and gravity contour maps and the values of the fields along them plotted. Figures 3 and 4 show the resulting magnetic and gravity profiles. For example, profile 7m in fig. 3 corresponds to profile line 7m in fig. 1. The only profile not taken from a contour map is 1m, which is from Bromery and Snavely (1964). Thus, all the other profiles contain the errors intrinsic in contour maps and are not to be regarded as exact.

Since sea gravity measurements were not made closer than 5 miles from shore, there is a region on the contour map of Dehlinger and others (1967) where contours are the result of interpolation between their measured sea gravity values and the measured land gravity values of Berg and Thiruvathukal (1967) which extend to the coast. These interpolated contours probably give only a smoothed representation of the near-shore gravity field. Profile lines 7g and 8g (fig. 2) lie in this region of interpolation.

Figure 5 is a land-geology map showing the surface volcanics of the area under consideration.

Discussion and Interpretation

Examination of the magnetic profiles in fig. 3 yields four regions along the coast of northwestern Oregon where land and ocean magnetic anomalies can be correlated. These correlations are represented by correlation lines Im through IVm. Figure 4 shows only one region of strong correlation for land and ocean gravity anomalies (correlation line Ig). It is possible that the land-gravity anomaly located between 44°40' and 45°00' (fig. 4) may extend out to sea, but no definite correlation is apparent because the previously mentioned smoothing due to interpolation has probably obscured its seaward expression. We will not consider this anomaly further. The arrows in fig. 5 show where the correlation lines of figs. 1 through 4 cross the coast.

The sea-land correlation of gravity and magnetic anomalies is quite evident in region I (Im and Ig in figs. 3 and 4), and the gravity correlation extends well inland. Comparison of Im in fig. 1 with Ig in fig. 2 shows that they terminate at about the same place over the ocean and cross the coast very close to one another (see also fig. 5). Since each of these lines represents correlation of a different geophysical parameter, and, assuming that they result from the same geologic body, one would not expect them to coincide everywhere, but would expect them to have roughly the same characteristics. The similarity of location and directional trend of Im and part of Ig is quite evident, and we can only conclude that they do in fact represent the same body.

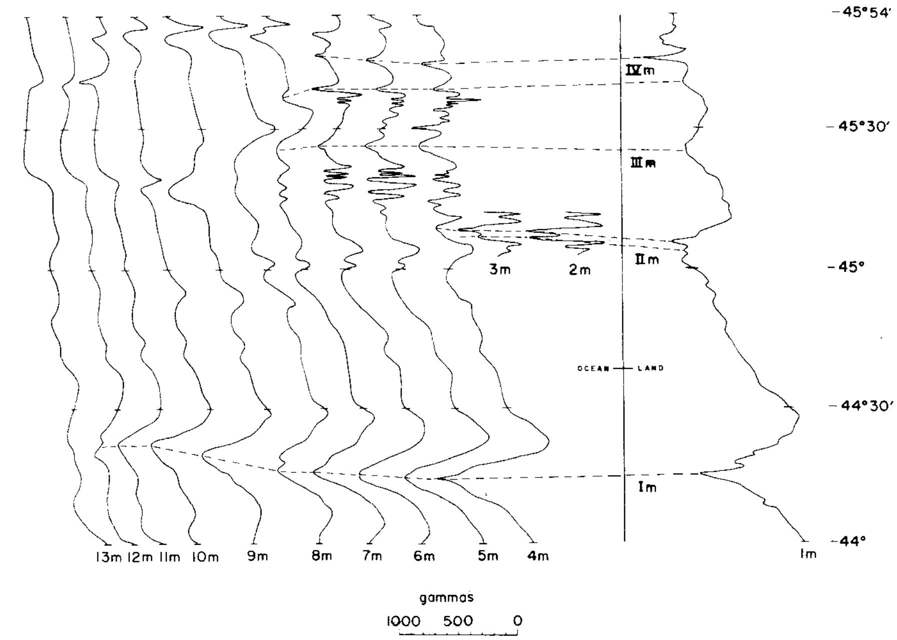

Figure 3. Magnetic values along correspondingly numbered profile lines in fig. 1

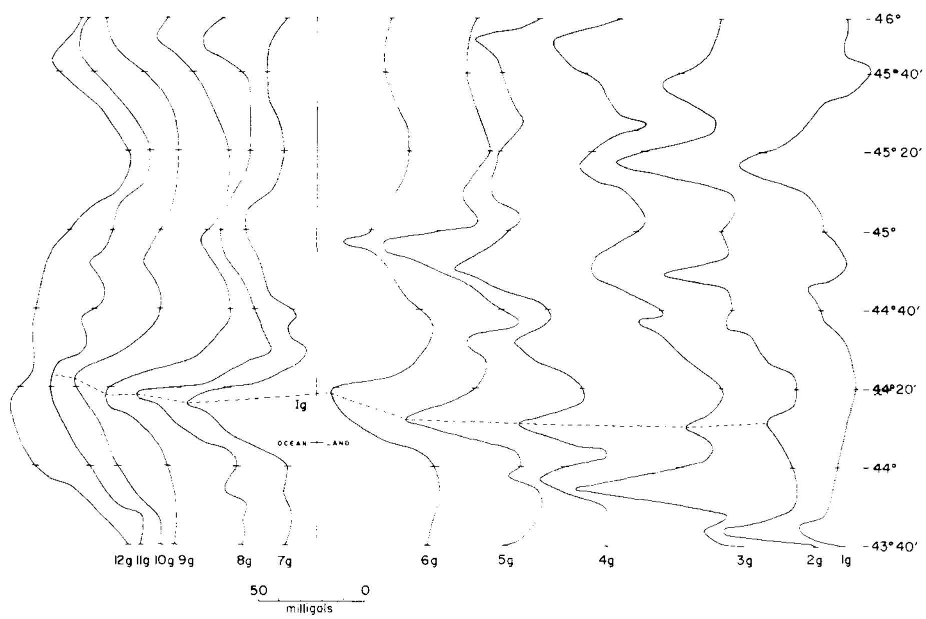

Figure 4. Gravity values along correspondingly numbered profile lines in fig. 2.

Whitcomb (1965) did a marine geophysical survey of region I, out to 124°30', and postulated the existence of a large crystalline rock mass off Cape Perpetua (44°15', 124°07'). He placed the top of this "broad body containing areas of large magnetic susceptibility changes" at a depth less than about 3000 feet, five nautical miles off the cape (A in fig. 1). Emilia, Berg, and Bales (in press) have also made magnetic-anomaly-source depth calculations for anomalies off the coast at positions B and C in fig. 1. They compute maximum depths of 27,000 feet and 16,500 feet respectively. These calculations, as well as the calculation by Whitcomb, fall on, or nearly on, correlation lines Im and Ig.

Bromery and Snavely (1964) concluded that the magnetic and the gravity anomalies measured over land in region I are due to the early to middle Eocene volcanics known as the Siletz River Volcanic Series, and not to the relatively thin upper Eocene alkalic basalt shown exposed in fig. 5. Their analysis indicates that the Siletz Series starts as far east as longitude 123° 06', at latitude 44°09', and, at a depth less than about 5000 feet, continues to where it intersects the coast at Cape Perpetua. Also, they concluded that, moving south from Newport, the Siletz Series rises abruptly from a depth of 15,000 feet to within less than 5000 feet of the surface in region I, thus causing an arcuate gravity high. The free-air gravity contour maps that we have used show that this high is closed and extends from land to ocean. We feel that the gravity high in region I, as evidenced by the maps we have used (no regional correction applied), may not be entirely the result of shallowing of the Siletz River Volcanic Series but may in part be due to intrusions and/or deformation beneath the series. This latter interpretation is feasible, since the gravity anomaly under consideration is closed.

It is evident from the above data that correlation lines Im and Ig are partially determined by the Siletz River Volcanic Series. But, there appears to be a discrepancy in estimates of its eastern limit. Correlation line Ig (fig. 2) extends eastward only to 124°35' while, as already mentioned, Bromery and Snavely show the Siletz River Volcanic Series extending eastward to at least 123°06'. Since the gravity contour lines between 123°35' and 123°06' are nearly north-south (Berg and Thiruvathukal, 1967), our profile lines showed little or no correlation of gravity peaks. However, Bromery and Snavely constructed a geologic section by using a nearly east-west gravity profile line which would more readily show significant field variations due to a north-south-trending geological structure on the eastern end of the profile. An aeromagnetic profile along 123°00' has been published by Agocs, Rollins, and Bangs (1954), but is not presented in fig. 3 because comparison of this profile with profile 1m (fig. 3) indicated that any correlation of anomalies would be extremely tenuous. This difficulty of correlation is to be expected because of the large separation of these profile lines and because the geological structure at Cape Perpetua is different from that to the east.

If we assume that the gravity and the magnetic trends near the coast in region I are mainly due to the Siletz River Volcanic Series, then this Series appears to extend under the ocean, at a depth of about 3000 feet, for about 5 nautical miles until it dips sharply to a depth of 27,000 feet. Following the path represented by correlation lines Im (fig. 1) and Ig (fig. 2), these volcanics then shallow to 16,500 feet at longitude 124° 23'. The magnetic and the gravity anomalies give no indication that they extend farther to the west.

Bromery and Snavely (1964) show the Siletz River Volcanic Series to extend northward, along the coast, from Cape Perpetua at least to 45° 05'. In a northwest-southeast trending geologic cross-section ending on the coast at 45° 05', they also show the Siletz River Volcanic Series at the coast to be at a depth of about 16,000 feet and dipping steeply seaward.

Our geophysical data give no indication of an oceanic extension of this series between Cape Perpetua and 45° 05', but lines of correlation IIm (figs. 1 and 5) intersect the coast very near the northern point and seem to indicate oceanic extension of the steeply dipping Siletz Series. However, even though the character of the anomalous magnetic field in region II does not lend itself to anomaly-source depth calculations, the high frequencies in profiles 2m and 3m (fig. 3) imply a source much shallower than 16,000 feet. Since Bromery and Snavely's cross-section strongly suggests oceanic extension of the Siletz River Volcanic Series at 45° 05', we must look closely at our data to determine whether or not this is actually the case. We see from figure 3 that the section of profile 1m which determines correlation lines IIm is a broad positive anomaly with high frequency anomalies superimposed. If this profile were made at sea level, instead of from a flight elevation of 4000 feet, the superimposed anomalies would be of a much higher frequency and the broad anomaly would change very little. It is also apparent from figure 3 that profiles 2m and 3m consist of broad, positive anomalies with higher frequency anomalies superimposed. We postulate oceanic extension of both the Siletz River Volcanic Series and the relatively thin and shallow late Eocene volcanics which are shown exposed in figure 5. The latter probably cause the superimposed high frequency anomalies while the former probably causes the broad positive anomaly of profiles 1m, 2m, and 3m in figure 3. Correlation lines IIm (fig. 1) then indicate that parts of these formations extend to the northwest under the ocean floor, their anomalous magnetic expression being no longer evident past the western ends of these correlation lines. Although the magnetic correlation is quite strong (fig. 3), no strong gravity correlation exists (fig. 4). This situation could result from a susceptibility contrast without an accompanying density contrast.

Two additional regions of correlation are shown in figs. 1 and 5 (IIIm and IVm). Here again no gravity correlation is evident (fig. 4). No theoretical cross-sections or magnetic-anomaly-source depths are available for these areas, but the abundant surface expression of early to middle Eocene volcanics (Tillamook Volcanic Series) in the vicinity of IIIm (fig. 5) suggests a possible seaward extension of this series. Lines IVm show positive correlation of anomalies from land to sea, and the high magnetic gradients of these anomalies indicate a relatively shallow source depth. These anomalies could result from a seaward extension of the Tillamook Series and/or the exposed basalt flows and breccias in this region.

It is evident from figs. 3 and 4 that susceptibility contrasts are more pronounced and offer a better correlation parameter than density contrasts. If the Siletz River Volcanic Series terminates and if a density contrast exists between it and the adjoining rock, then the lateral boundary of this series should be evidenced by a step-like gravity anomaly. Between 44°17' and 45°54' we find no such anomaly to exist. This absence of a step-like gravity anomaly may indicate that the Siletz River Volcanic Series and the Tillamook Volcanic Series form a continuous series beneath the ocean floor in this area. Indeed, the correlation of magnetic anomalies along IIm and IIIm may represent susceptibility contrasts within a continuous north-south unit.

Acknowledgments

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* * * * *

DETERMINATION OF SURFACE RIGHTS CONTINUES

The determination of surface rights for mining claims under provisions of Public Law 167, which contains the "multiple use" concept, is still continuing. The Bureau of Land Management last year examined 386,059 acres in Oregon. The Bureau has completed work on a total of 1,920,587 acres since passage of Public Law 167 on July 23, 1955. A summary of the Bureau's activities with respect to mining claims, and mining leases, permits, and licenses appears in the box. Areas currently under examination or soon to be examined by the Bureau include the following:

Township	Range	Township	Range
11 S.	3 E.	11 S.	4 E.
12 S.	3 E.	22 S.	1 W.
22 S.	2 W.	22 S.	3 W.
23 S.	2 W.	23 S.	3 W.
37 S.	32-3/4 E.	37 S.	33 E.
38 S.	34 E.	39 S.	34 E.
41 S.	34 E.	39 S.	35 E.
40 S.	35 E.	41 S.	35 E.
41 S.	39 E.	13 S.	40 E.
17 S.	41 E.	40 S.	42 E.

Item	Oregon FY 1966	Oregon FY 1967
Mineral patents issued-----	1	1
Mineral permits & licenses-	2	--
Mineral leases------------	39	6
P.L. 167 determinations completed, acres-------	125,077	386,059
Cumulative determinations, acres-----------------	1,534,528	1,920,587
Claims retaining surface rights, number-----------	95	99
acres------------	1,900	1,980
Percent of mineralized area on which P.L. 167 action is completed----	45	56

Mining claimants holding claims in the above areas who are not familiar with the rules and regulations regarding determinations under Public Law 167 should request this information from the Bureau of Land Management. Announcements of specific areas to be investigated are published in the official county newspapers for the areas in question.

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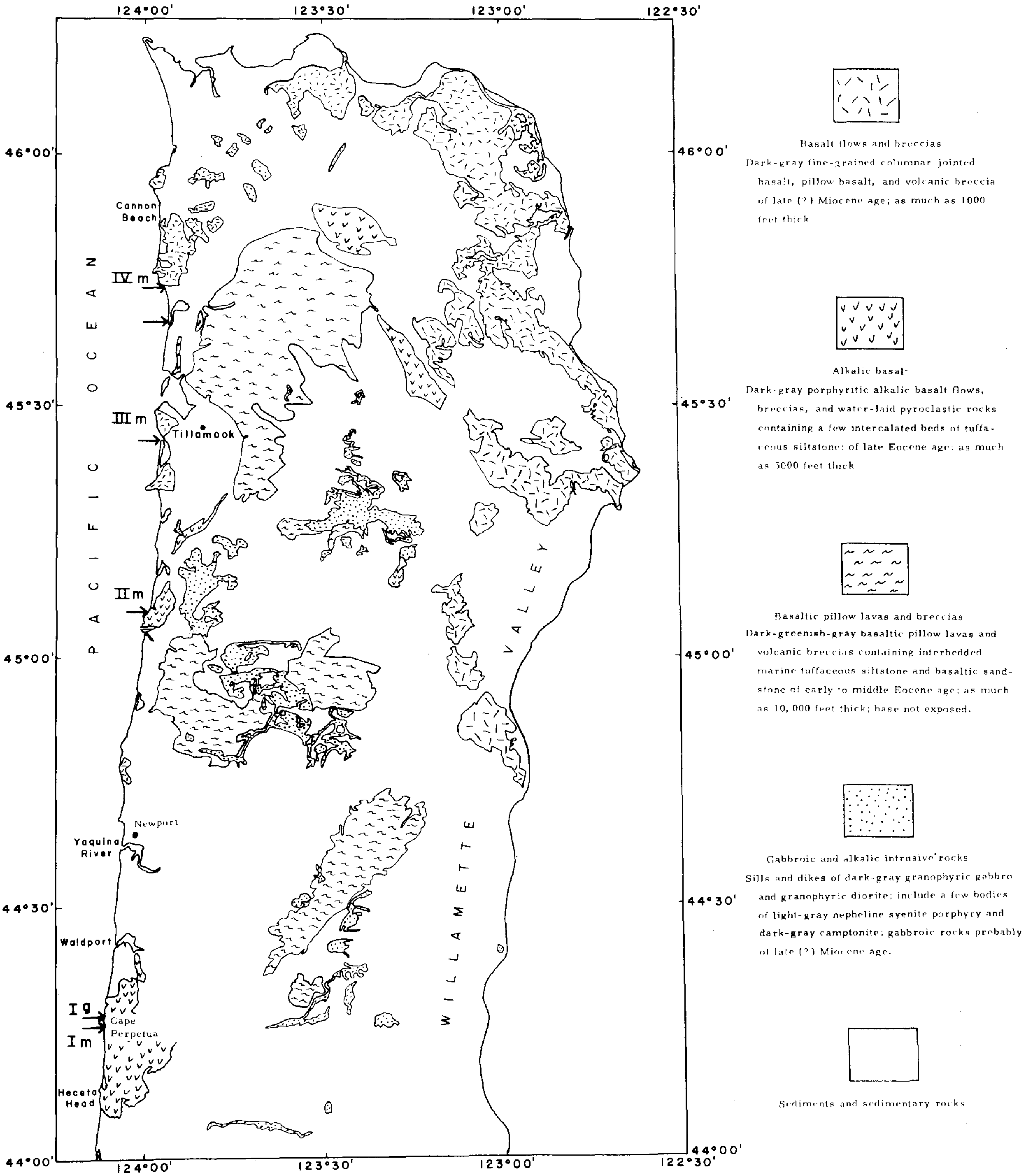
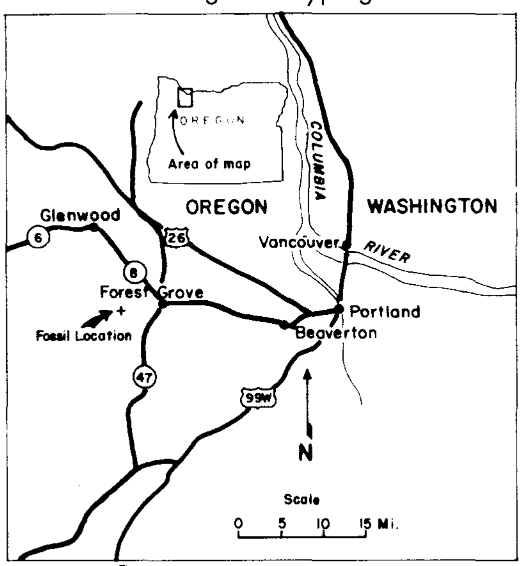


Figure 5. Land geology map of the area of interest. Adapted from Bromery and Snavely (1964). Arrows indicate where the magnetic and gravity correlation lines cross the coast.

A LARGE FOSSIL SAND SHARK OF THE GENUS <u>ODONTASPIS</u> FROM OREGON

By Shelton P. Applegate*

An association of numerous preserved hard parts of a single fossil shark are only rarely encountered in the Cenozoic marine beds. Therefore, we were quite excited when a package arrived from the Oregon Department of Geology and Mineral Industries which contained not only fossil invertebrates and fish scales but remains which from their similar size and close occurrence must have come from a single individual shark. The fossils in question were collected by geologists with the Oregon Department who also provided the geologic summary quoted below. Acknowledgment is made to the following members of the Museum staff: to Anita Daugherty for her assistance in editing the manuscript, to Pearl Hanback for the fine illustrations, and to Dorothea Barger for typing the manuscript.



The fossils occurred in a blackish gray marine shale associated with small pelecypods and gastropods. A few plant fragments were also present, as well as a number of bony fish scales and a pair of fish-ear bones (otoliths). In cross section some of the sediment showed foraminifera.

The following description of the fossil site was provided by the Oregon Department of Geology and Mineral Industries:

"The locality is in the bed of Scoggin Creek about 40 miles by road west of Portland and about 5 airline miles southwest of Forest Grove (see index map). The rocks containing the fossil shark remains belong to the Yamhill Formation, which crops out in a north-trending belt about a mile wide. Here the formation is composed of about 2000 feet of siltstone and thin-bedded black shale which weathers to a yellowish color. The beds dip to the southeast from 7° to 15° and are well exposed in the

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*Associate Curator, Vertebrate Paleontology, Los Angeles County Museum of Natural History.

creek bed at time of low water.

"The sediments have been dated as late Eocene from microfauna by W. W. Rau (written communication, 1962), who states that the foraminiferal assemblage is diagnostic of the Narizian stage of Mallory, A-2 zone of Laiming, and typical of that found at the type locality of the Yamhill Formation along Mill Creek about 30 miles to the south.

"The Yamhill Formation lies between older Eocene marine sediments and associated volcanic rocks that make up the Coast Range to the west and sandstone of the Spencer Formation of later Eocene age to the east."

Since the conditions for preserving vertebrate fossils must have been excellent, the abundance of this material gives us promise of finding other interesting vertebrate remains. Such a find as this is probably another indication of the rich undescribed fossil marine fish fauna that occurs along the Pacific Northwest. If more of these fossils are collected and described, we will know a great deal more about the history and distribution of fossil fishes.

The shark material consists of 22 vertebrae, one of which is shown in figure 3B. There are numerous patches of hollow cubes of calcified cartilage which form a mosaic (figure 3A is a sketch of such a patch in place); each cube is called a tessera. In living sharks these cubes make up the skull (chondocranium), jaws, and gill and fin supports (Applegate, 1967). Fossil tesserae are more often than not dissolved by ground water or at least detached, so that they are either missing or overlooked. The tesserae in this specimen appear to be similar to those which occur in the living sand-shark genus Odontaspis. The vertebrae in cross section (figure 3C) are of the typical lamnoid type, showing radial supports with branching similar to what is found in Recent Odontaspis. The illustrated vertebra is from the caudal region. Figure 1 shows a typical member of this genus Odontaspis taurus.

The most important part of these fossil remains is a single tooth (figures 2, A & B). By comparing this with those teeth in Recent sand-shark jaws, a method which I have discussed elsewhere (Applegate, 1965), it becomes apparent that the tooth is a second lower right anterior, or the

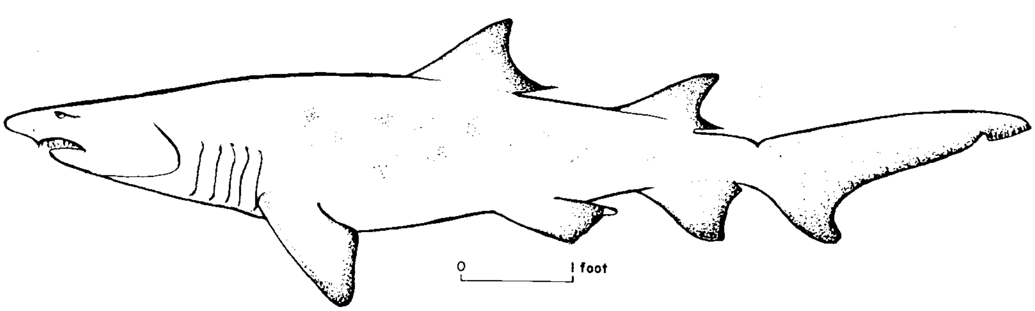

Figure 1. Drawings of the Recent Odontaspis taurus, which is related to the nine-foot Oregon sand shark.

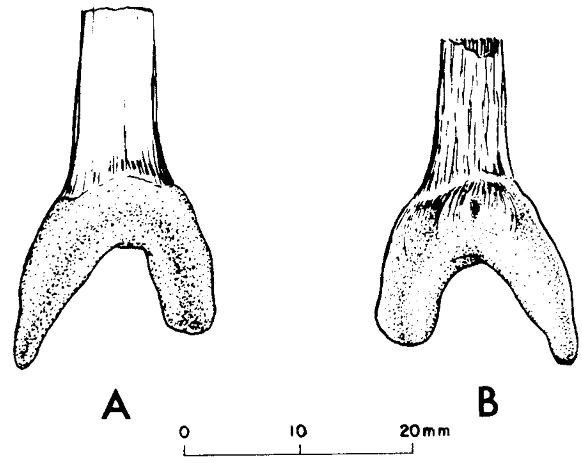

Figure 2. Two views of the shark tooth.

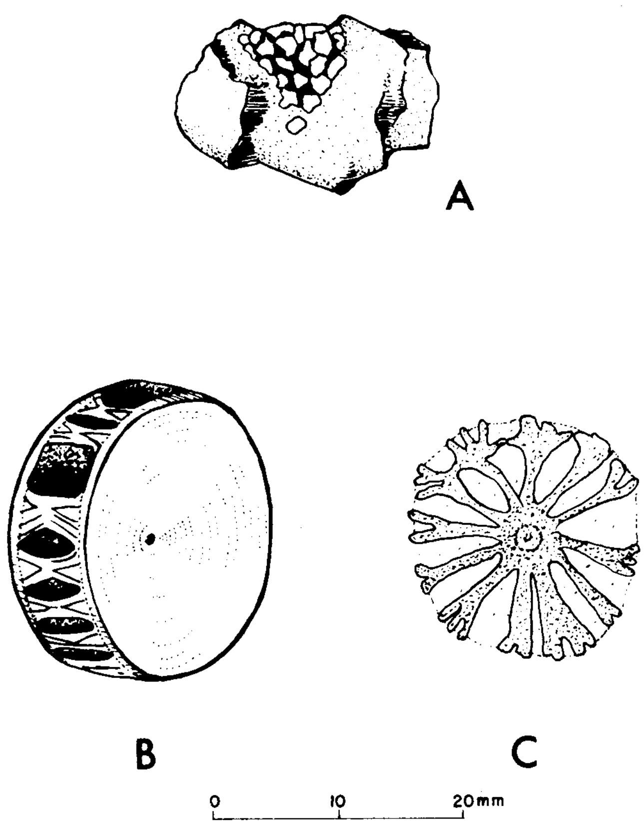

Figure 3. Vertebrae and cartilage of the sand shark.

third tooth from the center line. The greatest width of the tooth base is 17 mm. The height of the tooth is 28 mm., to which must be added a good portion of what is missing. A similar tooth from a female sand shark, (No. 12) (Applegate, 1965), had the following measurements: width 17 mm., height 34 mm. The total length of this shark was 273 cm., or approximately nine feet. The fossil shark might be assumed to have had a similar length.

On the inner surface of the crown the tooth has definite razed lines or striations (fig. 2). There is a tendency for some of these striations to be faint. Some branch, and others join together. Such striations are known from only a few species of fossil sand sharks.

Undoubted fossil odontaspids are known from the Cretaceous to the present. The Cretaceous genus Scapanorhynchus, related to the Recent deep-sea goblin shark Mitsukurina, has very strong, straight, well-defined striations on the inner crown surface; at least two species in Scapanorhynchus are close to Odontaspis, a situation that needs further investigation by the establishment of artificial tooth sets as suggested by Applegate, 1965. In the Paleocene at least three species of small odontaspids with striae occur: Odontaspis substriata substriata, Odontaspis substriata atlasi, and Odontaspis whitei. All three species have been found in the Midway near Fort Benton, Ark., L.A.C.M. Locality 6510. O. whitei and substriata are also known from the Paleocene of Africa, and from the beds that range from Thanetian to upper Ypresian age in Africa we find O. substriata atlasi. According to White, another species Odontaspis striata (his O. macrota striata) is characteristic of the early Eocene of England, while the most recent recognized striated species O. macrota is more characteristic of the late Eocene. Probably O. whitei or O. substriata is the ancestor of O. striata which in turn gives rise to O. macrota. The teeth of the Paleocene species are quite small, averaging around one-half inch or less in total length; those of O. macrota and O. striata are longer, more than one inch. Those of O. macrota are said to be the longer and thicker of the two. This general type of tooth occurs also in the Miocene, and is here interpreted as being from O. macrota. I believe that the Oregon tooth is also referable to O. macrota.

It is of special interest that the Recent sand shark Odontaspis taurus shows occasional striations on its crown. Since the O. macrota type of tooth is close in many ways to those of O. taurus, it may be the ancestor of this modern form.

Fossil teeth of the O. macrota-O. striata type are known from Europe, Russia, Africa, New Zealand, and North America. They have been taken at the L.A.C.M. Locality 2024 called "Pipehill," in Baja California (Tepatate Formation, thought to be late Paleocene). Another example from the Pacific Coast is known from Trabuco Canyon, Orange County, Cal., where it was found in the topsoil: its age is not known, but it is probably Eocene or lower Miocene. A few small teeth of this complex are known from L.A.-C.M. Locality 1649, Tejon Formation, in the Santa Ynez Mountains, Cal.

In the eastern United States, Odontaspis cf. macrota is known from Miocene beds at New Bern, N.C.; near Charleston, S.C.; and near Wallmeyer Fish Camp, Va. Any or all of these teeth could represent reworking from underlying Eocene sediments.

The genus Odontaspis is rare in typical West Coast Miocene beds and the few that are known are referable to the O. ferox type. The only living sand shark in the eastern Pacific is Odontaspis ferox, reported by Daugherty (1964) on the basis of two specimens taken off California. This species is also represented in the L.A.C.M. collection by the jaw of a third specimen purchased by Mr. Donald Cocke in La Paz, Baja California. O. ferox is a deepwater shark with almost world-wide distribution in temperate waters, though most commonly taken in the Mediterranean. The tooth crowns of this shark are smooth, and the teeth quite different in shape and number of lateral denticles from the Oregon specimen.

If we may assume that O. macrota was the ancestor of O. taurus, it may have occupied a similar niche. The modern taurus is a comparatively sluggish fish-eating shark, capable of short bursts of speed. It is a bottom dweller, occurring in very shallow water from about 1 to 15 fathoms. It is known from the eastern United States, Brazil, Europe and the Mediterranean, South Africa, and perhaps Australia. Recently, the possibility of its occurring in Japan has been brought to my attention by Mr. Toru Taniuchi; yet there is no record of its having ever been taken in the eastern Pacific. If O. macrota had a similar distribution to that of O. taurus and similar teeth, and was the ancestor of taurus, we can at least theorize similar habits. The Pacific Eocene forms may have inhabited ancient shallows and bays which were lost during later mountain building. The fact that these coastal sharks seem to shun the tropics or very cold water plus the presence of the Isthmus of Panama may be what has kept the eastern Pacific free of this species since the Miocene. Certainly as we discover more fossils, our knowledge of these interesting sharks will become clearer. One should keep in mind that fossil fishes can tell us a great deal about past climates, currents, continental outlines, and the evolution of life.

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THE PORTLAND EARTHQUAKE OF JANUARY 27, 1968

By Donald F. Heinrichs and Leonard J. Pietrafesa
Department of Oceanography, Oregon State University

Introduction

The earthquake of January 27, 1968 occurred at 12:28 am., PST.; the epicenter was near the eastern edge of the city of Portland. This shock was the first sizeable disturbance in the immediate area since the damaging shock, and accompanying aftershocks, of November 5, 1962 (Dehlinger and Berg, 1962; Dehlinger and others, 1963). The estimated magnitude is 3.7, in contrast to a magnitude of 5 for the 1962 Portland earthquake. The depth of focus is between 20 and 24 km, similar to the estimate of 15 to 20 km for the 1962 shock.

The earthquake was recorded at a number of seismic stations, and the data are presently being analyzed. The detailed results from this shock will be reported at a later date, but sufficient information has been received to make several preliminary comments and conclusions.

Seismology

The epicenter and the origin time of a shock indicate the location on the earth's surface and the time of occurrence of the initial source motion. The depth of focus is the distance of the source below the surface. The direction of the initial source motion controls the directions of ground displacements resulting from the incident compressional wave at the receiving stations. The source is considered to be a fault in which the rupture travels along the fault surface for the duration of the shock. It is estimated from the seismograms of the shock that the source motion lasted no more than a few seconds.

The shock was recorded at the stations named in Table 1, with initial P-wave arrival times indicated by Pacific Standard Time. Not included in the table are later arrivals, compressional, shear, and surface waves, which were used to help determine the location of the epicenter and the depth of focus. We have studied only the records from Corvallis and Portland; the other times and motions have been received by letter or telephone.

Epicenter and origin time

From the known arrival times and the local travel-time curves prepared for the Pacific Northwest states (Dehlinger and others, 1965), the earthquake

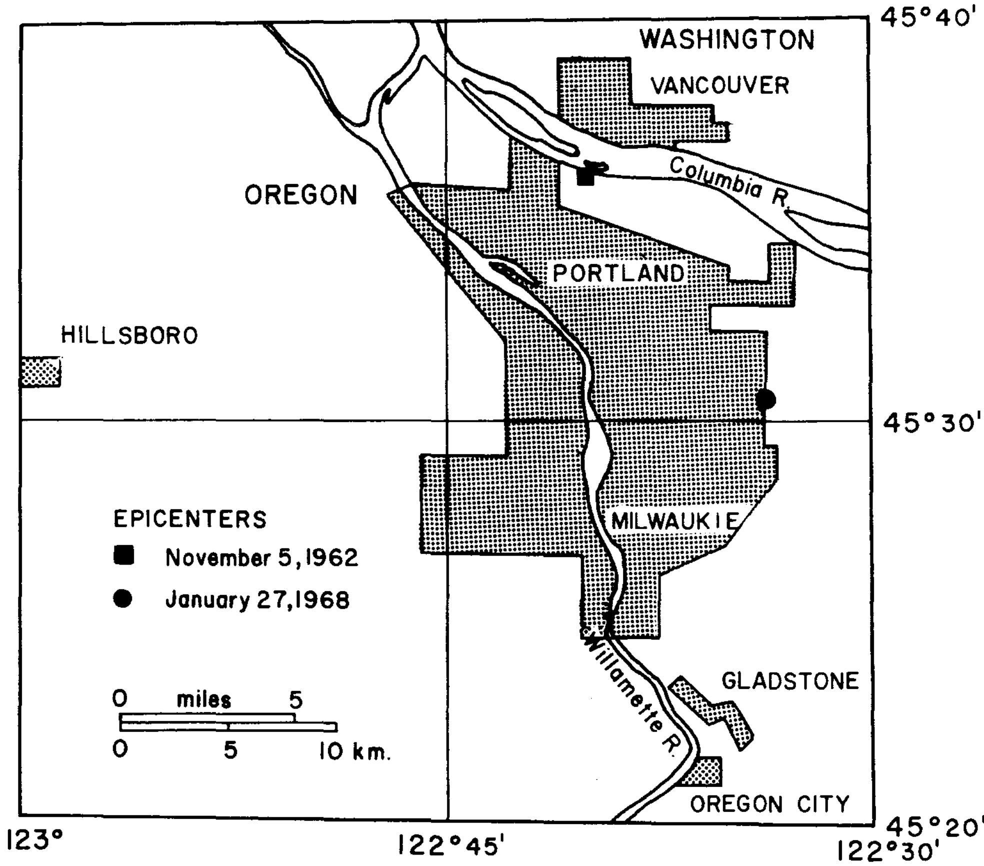

Figure 1. Base map of Portland area with earthquake epicenters.

Table 1. P Wave Arrival Times.

	hr.min.sec.
Portland (Oregon Museum of Science and Industry)	00:28:28.3
Corvallis, Ore.	00:28:43.3
Baker, Ore. (Blue Mt. Seis. Obs.)	00:29:22.3
Longmire, Wash.	00:28:45.4
Tumwater, Wash.	00:28:46.2
Seattle, Wash. (Marshall)	00:28:55.2
Spokane, Wash.	00:29:33.0
Newport, Wash.	00:29:36.0
Victoria, B. C.	00:28:51

epicenter was placed at latitude 45°30.5' N., 122°33.8' W., which is south of the Columbia River and near the eastern Portland city limits (figure 1). The shock origin time is estimated to be 0 hr. 28 min. 23.7

sec. a.m., PST, January 27. These values give a very good fit to the travel-time curves for the Corvallis, Baker, Tumwater, Spokane, and Victoria stations, except for an early shock origin time for Tumwater. Longmire, with a good seismic signal, and Newport and Seattle, with weak signals, exhibit some additional scatter. The seismic amplitudes were so large at the Portland station that only the initial P wave was observed; the later phases were obscured by excessive pen motion. This station was not used in the epicenter determinations.

Depth of focus

The depth of focus of the earthquake was between 20 and 24 km. Depth calculations were based on epicentral distances and travel times to the Portland, Corvallis, and Tumwater seismic stations. Focal depth calculations depend on the average seismic velocity of the crustal and subcrustal layers and are quite sensitive to small variations in velocity. Average velocities were chosen based on earlier work by Dehlinger and others (1963, 1965) and reflect the diverse local structures in the Northwest. Velocities of 6.1 km/sec and 7.67 km/sec to Corvallis give a focal depth of 19.2 km. Velocities of 6.4 km/sec and 7.9 km/sec to Tumwater give a depth of 20.3 km. The calculated shock origin time and an unpublished calculated velocity log for the Portland station give a depth of 24 km. The average velocities used in the above calculations are consistent with the arrival times on the travel-time curves.

Magnitude

The magnitude of the shock is estimated to be 3.7 on the Richter scale. Magnitudes according to this scale are based on ground amplitudes recorded at seismic stations. The scale ranges on a logarithmic scale from 0, the smallest recorded shocks, to 8 3/4, the largest and most destructive earthquakes (Richter, 1958, p. 340). The information for the magnitude estimate was supplied by the Blue Mountain Seismological Observatory at Baker, Ore., one of the most sensitive seismic stations in the world.

Source motion

The initial ground motion at Corvallis was down, south, and west; at Portland up (?) with the other two components not recorded. We do not have complete information from all the other seismic stations, but we do know whether the first motion was a dilatation or compression. All stations, except Baker and Portland, had a dilatation as a first motion. The observed initial ground motions are consistent with a right-lateral displacement along a northwesterly trending strike-slip fault. The first motions will fit equally well a northeasterly trending strike-slip fault with a left-lateral displacement. The data are not consistent with a predominantly vertical fault motion.

The faulting cannot be primarily normal or reverse; however, some vertical motion may have accompanied the strike-slip motion.

Discussion

The epicenter locations for both the 1968 and the 1962 Portland earthquakes are plotted in figure 1. This preliminary analysis and the more complete investigation of the 1962 earthquake (Dehlinger and others, 1963) show a striking similarity between the two shocks. The depth of focus and the first motions of displacement are the same. The two epicenters are located along a northwesterly trending zone, the same direction indicated by the observed first motions for a right-lateral strike-slip motion. Even though the present evidence (two shocks) is not conclusive, it appears likely that the two earthquakes have a common source. This source would be a northwesterly trending strike-slip fault, or fault zone, with right-lateral displacement. We do not wish to imply motion on any specific mapped surface faults in the area. The 15-20 km focal depths are well below the sedimentary section and the fault may not extend to the surface.

The seismic data will have to be analyzed in more detail before additional results on the source mechanism and the crustal structure can be determined. The earthquake data will be important in extending our knowledge of the seismicity of Oregon and adjacent regions.

Acknowledgments

The following people supplied arrival-time data and are gratefully acknowledged: Mr. H. Butler of the Blue Mountain Seismological Observatory; Dr. W. G. Milne of the Dominion Astrophysical Society, Victoria, B. C.; Mr. Normal Rasmussen of the University of Washington; Mr. Mark Castner of Gonzaga University; Mr. F. Brecken of the Oregon Museum of Science and Industry; and Mr. R. J. Brazee of the Environmental Science Services Administration, Rockville, Md.

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Volume 30, No. 3
March 1968

1968 - THE YEAR OF THE METEORITE

By Erwin F. Lange
Professor of General Science, Portland State College

-1968-
The Year of the Meteorite

The year 1968 has been designated in Oregon as the year of the meteorite by a committee consisting of Hollis M. Dole, State Geologist, Phil F. Brogan, science writer and former associate newspaper editor at Bend, and the writer. This group firmly believes that there are in Oregon undiscovered meteorites that might be found if many people became more observing of their surroundings, and the group also feels that there may be undescribed or unreported meteorites in the possession of people who are unfamiliar with their importance to science.

Because of the tremendous interest in space exploration, meteorites as objects of scientific study have assumed a new importance. Unlike most geological specimens needed for research, scientists cannot go to a certain area and pick up more specimens as they are needed. For meteoritic specimens science is largely dependent upon lay people or amateurs in science to help uncover new materials. Meteorites are the only authentic samples of space matter now available for direct study. When the first astronauts return from the moon they will bring back rocks for research purposes, some of which will be examined in Oregon laboratories.

Considerable evidence exists that undiscovered meteorites have fallen somewhere in Oregon. Stories of someone knowing about a meteoritic fall are heard in many localities around the state. Nineteen hundred sixty-eight is the year that all of these stories should be investigated and, if true, the meteorites should be made known to science. Each year several brilliant meteors or fireballs streak across the Oregon skies, giving evidence that matter from space is reaching the earth*. What can be accomplished by

* A future article will deal with meteors and observed meteoritic falls.

carrying on a planned program of search for new meteorites is best exemplified by the results obtained by H. H. Nininger of Sedona, Ariz., who has found more new meteorites than any other person. When he first began his search in Nebraska in 1931 only 9 meteorites had been found in that state, while during the next 12 years 20 unknown meteorites were uncovered. Nininger had similar success in Wyoming where only one was known before 1933. By 1940 nine discoveries were listed.

Oregon, one of the larger states in the West, has had but four authentic meteoritic discoveries, and two of these are listed as lost meteorites. In the 1850's a government geologist, Dr. John Evans, forwarded a piece of meteorite along with other mineral specimens for analysis to a chemist in Boston. Before he could lead an expedition to Oregon to recover the main mass, estimated to weigh 10 or 11 tons, he died and with his death was lost the location of the find which was described as being on Bald Mountain 30 or 40 miles from Port Orford. The search for the Port Orford meteorite has continued for more than 110 years, but as yet the great meteorite has not been found, even though one often hears rumors to the contrary.

Some time in the distant past southern Oregon had a shower of iron meteorites, of which five individuals have been found in the Sams Valley area north of Medford. The largest individual piece weighed about 15 pounds and the rest were in the one- or two-pound size. Pieces of this shower are displayed in the museum of natural history at the University of Oregon and at the Jacksonville Museum. Other undiscovered pieces probably exist in the Sams Valley area.

In 1902 Ellis Hughes discovered the largest meteorite yet found in the United States, the 15.5-ton Willamette iron, a short distance from West Linn. After several court cases concerning the ownership of the celestial object, the great meteorite was sold and given to the American Museum of Natural History in New York, where it is viewed by thousands of visitors every year in the Museum's Hayden Planetarium.

The fourth Oregon meteorite was a 30-pound mass found near Klamath Falls about 1952. A piece was brought in for analysis to J. D. Howard, who sent it to H. H. Nininger. It proved to be authentic. The owner apparently never returned for the analysis and the small piece from the Klamath Falls iron is in the Nininger collection of meteorites at Arizona State University at Tempe while the main mass appears to be lost.

Where does one look and what does he look for in the search for new meteorites? This question has often been asked. The answer is rather complex, but helpful hints can be given. Meteorites may be found almost any place. They have been found lying on the top of the ground, and in the top several feet of soil. The plow has uncovered more of these than has any other instrument. A few have fallen through buildings. The writer believes that a major problem in finding new specimens of space matter is one of identification and recognition. Meteorites fall into three general classes:

1. The irons. These attract attention because they are heavy and are made up almost entirely of alloys of nickel-iron.

2. The stones. These resemble terrestrial rocks and are the most difficult to recognize. They are composed of silicates through which tiny particles of bright nickel-iron are distributed.

3. The stony-irons. These are an intermediate class being made up of a network of bright nickel-iron which is filled with the mineral olivine. These are called pallasites and are quite rare.

The following points are useful in the identification of meteorites:

1. All are heavier than the common volcanic rocks.
2. All are magnetic, except that stony meteorites may be only slightly magnetic.
3. Newly fallen specimens have a black or brown fusion coating and shallow pits resembling thumb prints.
4. They are irregular in shape.
5. Weathered specimens may appear very rusty in color.
6. Certain identifying tests can be done best in a scientific laboratory.

If one finds a specimen suspected of being meteoric what should he do? The committee hopes to involve a great many people in this search, particularly many high-school science teachers. It is hoped that science teachers all over the state will discuss meteoritic properties with students, and will also make the preliminary examination of specimens thought to be different from ordinary rocks. If the science teacher thinks that a new meteorite has possibly been uncovered, the information can be forwarded along with a small sample to any member of the committee. The sample will be analyzed and returned to the owner.

The following paperback books may be consulted for a more complete description and account of meteorites:

Heide, Fritz, 1964, Meteorites: University of Chicago Press, $1.95.
Nininger, H.H., 1952, Out of the Sky: New York, Dover Pubs., $1.85.
Watson, Fletcher, 1962, Between the Planets: New York, Doubleday & Co., $1.25.

Also, in hardback form:

Mason, Brian, 1962: Meteorites: New York, John Wiley & Sons, $7.95.

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SENATE VOTES TO LIFT GOLD COVER

A bill eliminating the requirement that Federal Reserve notes in circulation be backed by gold equivalent to 25 percent of their value was passed in the Senate March 14 by a vote of 39 to 37. The measure had passed the House earlier by nine votes. The bill now goes to the President for his signature.

Several amendments were proposed, but all were defeated. These included proposals to retain a $12\frac{1}{2}$ percent gold cover and to deny gold conversion privileges to nations behind in their debt repayments to the United States. [American Mining Congress News Bulletin, March 15, 1968]

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A TWO-PRICE SYSTEM FOR GOLD

On March 17, the Central Banks Governors of the "gold pool" nations announced that they would no longer furnish gold to private buyers but would continue to buy and sell gold at the official monetary price of $35 an ounce in transactions with monetary authorities.

In a related action the Department of the Treasury stated that it would no longer purchase gold in the private market nor will it sell gold for industrial, professional, or artistic uses. The Treasury has amended its Gold Regulations to permit domestic producers to sell and export gold freely to foreign buyers as well as to authorized domestic users. [American Mining Congress Memorandum, March 18, 1968]

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MINERAL LEASING NO THREAT TO SISKIYOU NATIONAL FOREST

Future mining activity along a portion of the Rogue River in Curry County will be permitted only under the mineral leasing laws, if a U.S. Forest Service application for withdrawal from all forms of appropriation under the mining laws is approved. Reason for the proposed withdrawal, which embraces a total of 256 acres, is for "the protection and administration of the Siskiyou National Forest." The land involved lies in portions of T. 34 S., R. 11 W., and T. 35 S., R. 12 W., which is near Agness a famous fishing resort area at the confluence of the Illinois and Rogue Rivers. Placer mining has been conducted on both of these gold-bearing streams for more than 100 years. The Rogue is considered to be one of the prime fishing streams in the West, apparently little affected by a century of mining activity.

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GEOLOGY OF THE HORSE SIGN BUTTE BLACK SAND DEPOSIT AND VICINITY, CURRY COUNTY, OREGON

By Ewart M. Baldwin
Department of Geology, University of Oregon

Introduction

The Horse Sign Butte black sand deposit is situated in Curry County on the ridge between Horse Sign Creek and the Illinois River, about 2 miles northeast of Horse Sign Butte and 7 miles south of Agness (figure 1). The deposit was located before 1914 by Frank Berry of Agness, and it has been of interest to prospectors and geologists for many years.

Butler and Mitchell (1916), the first to report on the black sand near Horse Sign Butte, suggested that the magnetite in the sandstone was nonsedimentary and had impregnated the Myrtle Formation near an intrusion. Allen and Lowry (1942) recognized the sedimentary nature of the black sand, but also included it in the Myrtle. The writer concludes that the black sand is unconformable upon the Myrtle and older formations and that it is much more restricted in tonnage than previously estimated. He assigns it to the middle Umpqua Formation of early middle Eocene age, as described by Baldwin (1965).

This investigation was undertaken to determine the nature and extent of the black sand deposit and to relate it to the geology of the area as part of a regional study that the writer has been working on for many field seasons. The work pertaining to the black sand was supported by the U. S. Geological Survey's heavy-metals program Grant No. 14-08-0001-11058. The writer is indebted to H. Edward Clifton of the U.S. Geological Survey for aid and advice during field study and preparation of this report. He was accompanied in the field by LeRoy Maynard.

Geography and Access

The black sand deposit lies in a rugged part of the northern Klamath Mountains incised by a rejuvenated Illinois River and its tributaries. Many slopes are precipitous, and relief is approximately 3000 feet. The climate is hot and dry during the summer and fall, and snow and rain make roads impassable during the rest of the year. The closest water supply is Horse Sign Creek.

Extremely poor access to the black sand deposit has retarded its exploration. The shortest approach is through the brush from Oak Flat and Horse

Sign Creek. A circuitous approach by way of the Game Lake trail is longer, but perhaps easier. A good road connecting with the Hunter Creek Road is being constructed by way of Collier Butte to Game Lake by the U.S. Bureau of Public Roads. It may be extended toward the deposit following an old jeep road that is now usable as a foot trail.

The geologic map, Figure 1, which accompanies this report includes the northeastern corner of the Collier Butte quadrangle, heretofore unmapped, the southeastern corner of the Agness quadrangle (Diller, 1903), the southwest corner of the Marial quadrangle, which is being mapped by the writer, and the northwestern corner of the Pearsoll Peak quadrangle (Wells and others, 1949).

Stratigraphy

The black sand deposit is situated in a structurally complex belt about 5 miles wide between the Dothan Formation and the Colebrooke Schist. A great expanse of peridotite and serpentine border and may underlie a north-plunging faulted syncline of sedimentary rocks of the Myrtle Group and middle Umpqua beds, which obscure structural relationships between the older rocks. The Dothan Formation and a western belt of volcanic rocks similar to and herein assigned to the Rogue Formation lie east of the belt, whereas the Colebrooke Schist lies to the west.

The Colebrooke Schist, Rogue, and Dothan Formations are considered to be pre-Nevadan and presumably Jurassic in age, but their chronological order is uncertain. In describing these formations, the Colebrooke Schist is treated first because of its greater state of alteration and not because of any new evidence as to chronolgical age.

Colebrooke Schist

The Colebrooke Schist was named by Diller (1903). It is a platy schist or phyllite that is dark gray to black where freshly exposed and silvery gray where weathered. In places the schist contains pods of gabbro and greenstone that may represent dikes, sills, or plugs, as well as piles of lava extruded during deposition of the original rock. If the Colebrook Schist and Galice Formation in the northern end of the Agness quadrangle are equivalent in age, as is believed by the writer, then these greenstone pods would be related to similar bodies within the Galice Formation. However, in the Collier Butte quadrangle the origin of the Colebrooke Schist is unknown. Dott (1966) proposes that it is derived from the Dothan Formation in this area. Coleman (Blake, Irwin and Coleman, 1967) is currently studying the Colebrooke Schist in detail.

Rogue Formation

The Rogue Formation, named by Wells and Walker (1953), includes the belt of extrusive volcanic rocks that lies between the Dothan and Galice Formations in southwestern Oregon. The formation is well exposed along Interstate 5 south of Canyonville. Similar lavas are interbedded with the Dothan and Galice Formations and with the Colebrooke Schist. On most geologic maps relatively small bodies of volcanic rocks are also included within those three formations, and the term "Rogue Formation" is reserved for the thicker and more continuous belts.

In the map area and to the north a thick unit of volcanic rocks parallels the western edge of the Dothan Formation. It crops out in Mule Creek drainage, along the Rogue River, in Shasta Costa, Indigo, and Silver Creeks, and extends southward along the Illinois River toward the Big Craggies. The formation is nearly 10,000 feet thick in the Mule Creek drainage. Wells and Peck (1961) map this as Dothan volcanic rocks, but the writer believes that these rocks are part of the Rogue Formation and that they have been repeated by faulting.

The Rogue Formation rocks seem to grade into coarse-grained gabbro such as that occurring along the North Fork of Indigo Creek and along the Illinois River at Colliers Bar. Were it not for the gradational character of textures, these might be considered to be intrusive bodies, and indeed some of them may be. The writer believes the gabbro is a local metamorphic facies of the volcanic belt.

Dothan Formation

A thick section of rhythmically bedded sandstone and siltstone of the Dothan Formation occupies the eastern edge of the mapped area and extends eastward across the Pearsoll Peak and Marial quadrangles. According to Wells and Walker (1953), the Dothan Formation is 18,000 feet or more thick and dips mostly eastward. The relationship of the western margin of the Dothan to the volcanic rocks of the Rogue Formation is uncertain. A major fault probably underlies the western belt of the Rogue Formation, but it is largely covered to the north by the Umpqua Formation.

Nevadan intrusive rocks

During the interval between deposition of the pre-Nevadan and post-Nevadan sedimentary rocks, there were intrusions of peridotite and diorite. The peridotite was later serpentinized and in some places squeezed into new positions along fault zones. Large masses of peridotite and serpentine are present in the mapped area and no doubt extend beneath Myrtle and Umpqua beds.

Diorite and quartz diorite intrusions generally equivalent in age and

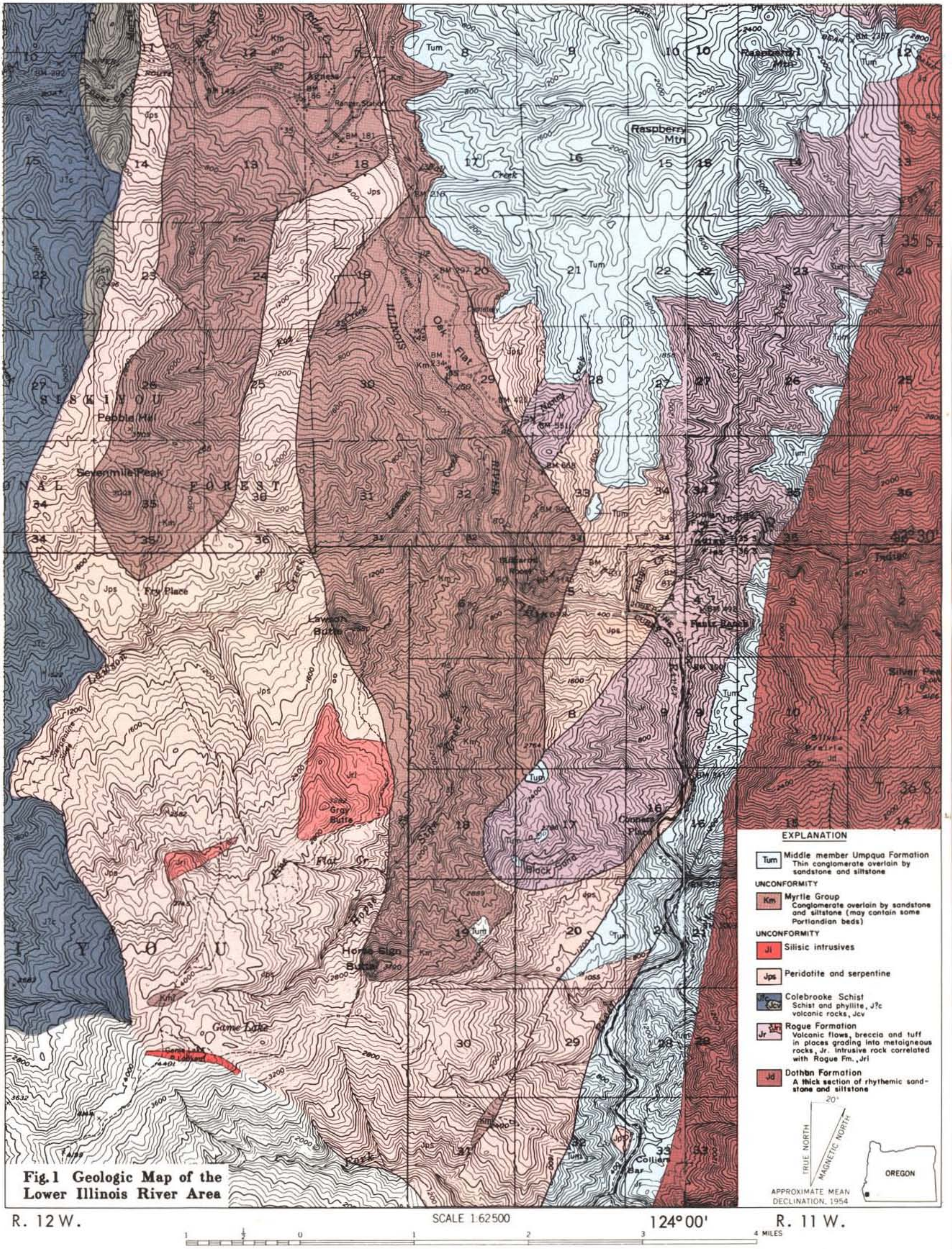

Fig. 1 Geologic Map of the Lower Illinois River Area

composition to the Pearce Peak Diorite (Koch, 1966) are present in Collier Butte to the southeast, but the only intrusion of this type found within the mapped area -- a silicic dike at the Game Lake Lookout -- is probably derived from these intrusions.

Myrtle Group

The sedimentary rocks of the Myrtle Group contain a basal, well-sorted chert-pebble conglomerate that crops out in Horse Sign Butte, Pebble Hill, Lawson Butte, and Buzzards Roost within the area mapped and which may be traced intermittently northeastward toward the Riddle and Days Creek Formations of the Myrtle Group as defined by Imlay and others (1959). The Riddle Formation was considered to be Late Jurrassic and the Days Creek Early Cretaceous, but later evaluation of the faunas by David Jones (written communication, 1967) indicates that the Riddle is also Early Cretaceous. It is likely that the Myrtle Group in the Illinois drainage is also wholly Cretaceous.

The basal conglomerate is a well-sorted chert-pebble conglomerate which was probably laid down during an onlap of the Early Cretaceous seas. The beds grade upward into finer clastic sedimentary rocks. The lithology bears more similarity to the Myrtle Group near Days Creek described by Imlay and others (1959) than to the Humbug Mountain Conglomerate and Rocky Point Formations of Koch (1966). The upper part is characterized by the fossil pelecypod *Buchia crassicollis*, which is also present in the Days Creek Formation and in the Rocky Point Formation of Koch (1966). Because of the obscurity of the contacts, units within the Myrtle Group were not differentiated.

Umpqua Formation

The Umpqua Formation in southwestern Oregon was divided into three members by Baldwin (1965), who at that time concluded that the beds in Raspberry Mountain and southward were a part of the upper member of the Umpqua Formation. Later work indicates that the southward termination of the upper member is in Green Knob on the north side of Shasta Costa Creek north of the map area. It is the middle member that extends across Raspberry Mountain and southward along the Illinois River to the vicinity of Colliers Bar, and also includes the black sand deposits near Horse Sign Butte.

Basal middle Umpqua beds of the Illinois River drainage contain coarse, roughly bedded conglomerates, some with boulders more than a foot in diameter. Pebbles and boulders are composed of a variety of rock types, such as diorite, gabbro, greenstone, chert, and sandstone. This assemblage is not greatly different from that along the Illinois River now. It is probable that during middle Eocene time a river entered a narrow north-trending arm of the sea that opened upon a broader marine embayment farther north.

Faulting was likely in progress during deposition of the Umpqua sediments.

Umpqua beds occupy a narrow graben along the Illinois River east of Horse Sign Butte, and the basal beds in the graben are more than 2000 feet lower in elevation than the black sand deposits.

Wells and others (1949, p. 15) state: "At the mouth of Silver Creek the formation is disturbed considerably by a high angle reverse fault that has brought the basalts and sandstone of the Dothan over the Arago (Umpqua)." Movement along this fault may have been in part pre-Umpqua and the sediments may have been deposited against a pre-existing fault scarp. Only the Umpqua beds east of Raspberry Mountain are seen to cross the contact between volcanic rocks and the Dothan in the area mapped.

Wells and others (1949, p. 15) found a fauna along the Indigo Prairie trail in sec. 35, T. 35 S., R. 11 W. Fossils collected from this locality by the writer contain middle Eocene species that are common in both middle and upper Umpqua beds.

Black Sand Deposits

Description of the areas

Four small outcrop areas of Umpqua Formation were found along the ridge northeast of Horse Sign Butte. These may be numbered from 1 to 4 in a northerly direction. However, only No. 2 contains an appreciable amount of black sand. The deposits are plainly unconformable upon the older greenstone and are less well indurated and less distinctly bedded than the Myrtle Formation.

Area No. 1: The Umpqua in area No. 1 in the center of sec. 19 consists largely of coarse conglomerate. No concentrations of black sand were seen.

Area No. 2: Area No. 2 lies in a saddle on the line between secs. 17 and 18. Virtually all of the black sand known in the region is concentrated in this small deposit. A bulldozer had been used to strip much of the soil and vegetation from the sand, leaving most of it quite well exposed.

The strata dip gently southward against greenstone. It is not known whether this is a fault contact or initial deposition against a topographic high, but the latter appears to be the more likely. Only a few scattered pebbles were noted at the base, and the deposit grades upward into sandstone with an increasing content of black sand. The richest part lies at the southeastern end on the Illinois River side of the divide, whereas the sandstone to the northwest contains a lesser amount of black sand.

A sample of leaner sandstone from the north side of the saddle was examined by Sam Boggs of the University of Oregon Geology Department. It contained: quartz, 6 percent; feldspar, 5 percent; opaque minerals, 21 percent; rock fragments (including quartzite, chert, and schist), 3 percent; non-opaque heavy minerals (many grains altered), 45 percent; and a matrix of altered iron-stained material.

The deposit as paced is approximately 125 feet wide and 250 feet long. It has not been penetrated in the thicker part, but maximum depth is probably less than 50 feet. The black sand makes up only a part of the deposit and if concentrated into one layer it would be less than 10 feet thick. On the basis of these dimensions there may be between 35,000 and 50,000 tons of black sand at this locality.

Allen and Lowry (1942) show the deposit extending nearly 300 feet down the slope toward the Illinois River. This sand had not been exposed by recent bulldozing or test pits, and it was not determined whether the lower part is float from above or a separate small deposit. It is doubtful that the material in this small body will add appreciably to the tonnage of black sand.

In describing the composition of the black sand layer, Allen and Lowry (1942) state that it is composed predominantly of magnetite particles (as much as 95 percent of the mass) with smaller percentages of ilmenite (also probably chromite), hornblende, zircon, quartz, garnet, tremolite, chrysotile, and pyrite.

Spectrographic tests of some of the samples were made by the State of Oregon Department of Geology and Mineral Industries (Allen and Lowry, 1942). Magnetic separates of samples P927-933 showed the following composition:

V	.1-1%	Si	1% plus
TiO_2	.1-5%	P	trace
Cr	2-5%	As	trace
Fe	more than 10%	Ca	trace
Al	.1-1%		

A chemical assay made by Larch Brothers, Hibbing, Minn., was reported by Allen and Lowry (1942) as follows: Fe, 54.94%; S, 0.114%; V, 0.37%; TiO_2, 2.70%; and P, 0.004%.

Tests conducted by the U.S. Geological Survey on two samples indicated gold contents of 0.01 ppm and 0.05 ppm (H. E. Clifton, written communication, December 27, 1967). These are grab samples from the richest concentration of black sand as exposed in the bulldozer cut southeast of the saddle.

Area No. 3: Umpqua sandstone caps a small terrace against a higher outcrop of greenstone a short distance north of the main deposit of black sand. This area has been opened by shallow bulldozed trenches, but very little black sand was in evidence. It is not known whether this deposit of Umpqua is faulted against the greenstone or rests upon an irregular surface, but the latter appears to be more plausible.

Area No. 4: The most northerly patch of Umpqua mapped on the ridge is not well exposed. A few pebbles embedded in the soil indicate that the lower part of this relatively thin deposit is conglomerate which grades upward into sandstone. Some pieces of float contain streaks of black sand which compose less than 50 percent of the rock. This area might be examined through test pits to see if a significant tonnage is present.

Other areas

The other outcrop areas of Umpqua Formation shown on Figure 1 have been visited in reconnaissance, but no concentrations of black sand were seen. The contact of the middle Umpqua with older rocks was followed around the south end of Raspberry Mountain. The basal conglomerate here was found to be very thin to absent and most of the sandstone is medium grained without an appreciable black sand component.

Origin of black sand deposits

The black sands are composed of heavy minerals that are common in the Klamath Mountains and in the Illinois River drainage. The distribution of Umpqua deposits indicates filling of a narrow north-trending marine embayment at the mouth of an ancient stream. Basal beds were mainly poorly sorted conglomerates. Part of the basin may have been down-faulted while sedimentation was taking place, for the narrow block opposite Silver Creek trends northward and appears to be continuous with the terrace-like deposits just south of Indigo Creek. The concentration of black sand in area No. 2 may have occurred as a beach deposit in a cove or small bay shielded by greenstone.

The black sand along the coast generally contains abundant chromite. However, according to Griggs (1945, p. 125), "In the deposits near the Rogue River, magnetite and ilmenite together outweigh chromite 10 to 1." The Horse Sign Butte black sand is similar to that mentioned by Griggs. The high magnetite content in this deposit may be explained by its derivation from the large bodies of peridotite and serpentine in the Rogue-Illinois River region. Magnetite may form during serpentinization of peridotite. It is also possible that the volcanic rocks of the Rogue Formation were the source of some of the magnetite.

Conclusion

The Horse Sign Butte black sand deposit contains a small tonnage of iron and chromium and is highly inaccessible. Accessory materials such as gold and vanadium are present in such minor amounts that they do not appear to be economic within the foreseeable future. In beds where the black sand makes up less than half of the rock there would be a problem of separation and concentration that would detract from their value. It is doubtful if the ancient black sand of the Illinois River drainage basin is at present of economic value.

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NATIONAL SCENIC RIVERS HEARINGS HELD

Hearings on proposals to establish a National Scenic Rivers System were held March 7 and 8 by the Subcommittee on National Parks and Recreation of the House Interior Committee. Several bills are pending before the committee, including H. R. 8416, introduced by Rep. Wayne N. Aspinall (Colo.), and a Senate-passed bill, S. 119.

On March 7 testimony was heard from members of Congress on individual rivers and from Edward C. Crafts, director of Interior's Bureau of Outdoor Recreation, speaking in support of the legislation.

Crafts pointed out that, while both H.R. 8416 and S. 119 would continue the applicability of U.S. mining and mineral leasing laws and would not affect valid mining claims existing on the date of the Act, the House bill provides that, with respect to claims located after the date of the Act, patents thereto would give the claimant title only to the mineral deposits in the claim, together with the right to use the necessary land surface. In addition, H.R. 8416 would withdraw minerals in federal lands that constitute the bed or bank of a river included in the system as well as the minerals on federal lands within a quarter of a mile of such a river. Also, H.R. 8416 withdraws for further study, for not more than an eight-year period, minerals in federal lands adjacent to rivers listed in the bill. He said the Department prefers the mining provisions contained in H. R. 8416.

On March 8 members of Congress and spokesmen for the Department of Agriculture and national conservation groups were heard. The only expressed opposition to the legislation came from the National Reclamation Association, which stated that the legislation did not "conform to the principles of multipurpose development...."

Hearings will continue on March 18 and 19, when opportunity to testify will be afforded representatives of local organizations and private citizens. [American Mining Congress News Bulletin, March 15, 1968]

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LEASE MINING NOT HARMFUL TO RECREATION

The U.S. Forest Service has reaffirmed that mining conducted under the federal mineral leasing laws is compatible with recreational activities. The Forest Service has filed an application with the Bureau of Land Management for the withdrawal of 297 acres in the Whitman National Forest from appropriation under the mining laws but not from leasing under the mineral leasing laws. The applicant desires to set aside the Grande Ronde Guard Station and River Campground and the Woodley Campground in Union County for recreation and administration purposes. This withdrawal, if approved, will decrease still further the areas available for the discovery and production of metals and minerals under the mining laws from the public domain.

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REGULATION OF SURFACE MINING ASKED

The Administration, on March 11, sent to the Congress proposed legislation to provide for regulation of surface mining and the reclamation of surface-mined land through the joint efforts of the federal government and the states. Introduced as S. 3132 by Sen. Henry Jackson (Wash.), chairman of the Senate Interior Committee, Sen. Frank Lausche (Ohio) and Sen. Gaylord Nelson (Wis.), the bill would apply only to surface mines operating on the date of the bill's enactment and those commencing operation after that date.

Under the legislation, states would be given the opportunity to provide within two years of the bill's enactment suitable surface mining control programs that fit local conditions. The federal government would share up to 50 percent of a state's cost of developing, administering, and enforcing the plans.

Two years after enactment of the bill, regulations would be developed by the Secretary of the Interior, after consultation with advisory committees, and applied to surface mining operations in any state that had not submitted a plan or where federal approval of a state plan had been withheld.

The bill provides that mined land reclamation regulations on federal lands must be "at least equal" to any law or regulation under an approved state plan or any federal regulation applicable in a state.

Hearings have been scheduled by the Senate Interior Committee for April 30 and May 1 to consider this bill. Also pending before the committee are S. 217, introduced by Senator Lausche, which would restrict surface mining regulations to coal only, and S. 3126, introduced by Senator Nelson, which covers previously surface-mined lands as well as all future surface mining operations.

In his transmittal letter, Interior Secretary Udall pointed out that the Department hopes to propose a workable program for the reclamation of previously mined areas "in the not too distant future."

As to underground mining, Udall said, "at the direction of the President we will be submitting to him by April 1, 1969, a report, based on studies now being conducted, on the appropriate measures to be taken to prevent and control adverse effects to the environment resulting from underground mines and underground mining operations, and the washing, sizing, or concentrating of minerals." [American Mining Congress News Bulletin, March 15, 1968]

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EOLA-AMITY HILLS GROUND WATER DESCRIBED

"Ground Water in the Eola-Amity Hills Area, Northern Willamette Valley, Oregon," by Don Price has been published by the U.S. Geological Survey as Water-supply Paper 1847. The 66-page report may be obtained for 75 cents from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402.

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The Fossil Woods near Holley in the Sweet Home Petrified Forest, Linn County, Oregon

By Irene Gregory*

Introduction

Scattered deposits of Tertiary fossil (petrified) woods are to be found throughout most of the Western Cascades adjoining the eastern side of Oregon's Willamette Valley, but those deposits making up the area known as the Sweet Home Petrified Forest in Linn County are among the most abundant and well known.

The abundance of the area's fossil wood is evident even to the casual traveler. It may be seen crushed or as fill in driveways, in fences and retaining walls, and in decorative garden work. Larger pieces -- stumps and logs -- mark driveway entrances and hold up mailboxes; barn floors have been built of it and abandoned wells filled with it. Farm people of an earlier day considered it a great nuisance -- a feeling perhaps carried over, justifiably, by today's landowners at times harried by avid rock hunters.

Of particular interest to the author is a small area near Holley which has yielded, and which still contains, much significant paleobotanical material in the form of almost perfectly preserved and exquisitely detailed silicified fossil woods with much variety as to species. This small area is on the J. J. Marker ranch (SW$\frac{1}{4}$ sec. 12, T. 14 S., R. 1 W.) located 5 miles by road east of the town of Holley in Linn County, Oregon. This is the locality with which we are mainly concerned in this report (figure 1).

It has seemed appropriate to undertake a study of this fossil wood location on the Marker ranch, since it and much of the adjacent land will be flooded eventually by impoundment of the waters of the Calapooia River behind a dam at Holley. The dam, which is in the planning stage by the U.S. Corps of Engineers, would raise the waters in the reservoir to the 694-foot contour. The present elevation of the Calapooia at the dam site is about 540 feet. A preliminary map drawn up by the U.S. Engineer District, Portland, shows that our collecting area will be included within this maximum pool boundary (figure 2).

Although the main purpose of this report has been to describe the fossil woods at the Marker ranch and theorize on their origin, it seemed appropriate to add a section on wood identification. Because of the wide interest in fossil wood and the lack of published information on identifying it without the aid of a high-powered microscope

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* Mrs. James M. Gregory received her Bachelor of Science degree at the University of Minnesota, majoring in botany. Since she has been living in Oregon she has transferred this interest to the Tertiary paleobotany of the Pacific Northwest and has studied with Wallace Eubanks, authority on fossil wood anatomy.

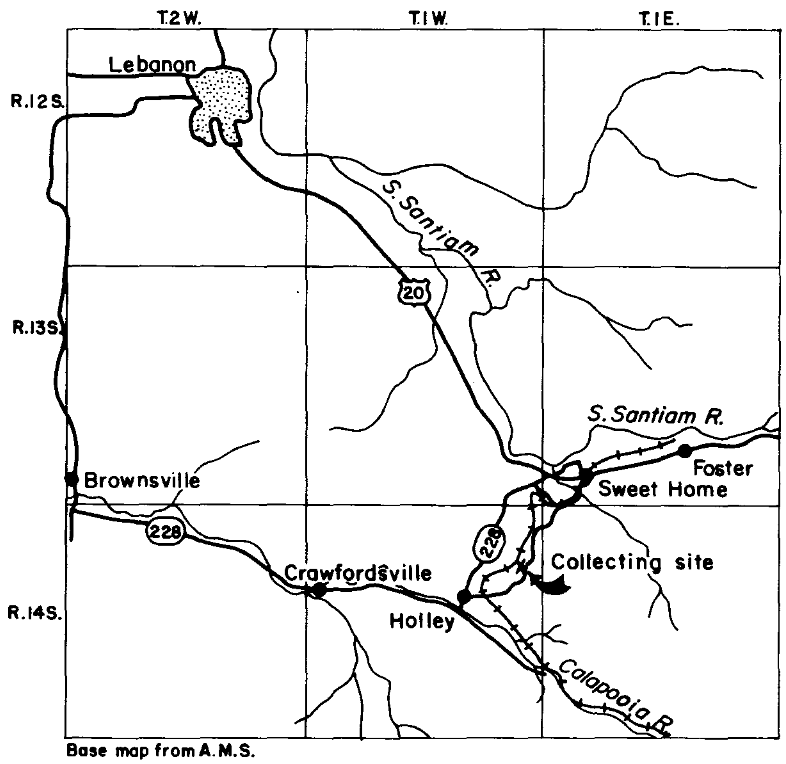

Figure 1. Index map of the Holley-Sweet Home area, showing location of the collecting site.

and technical training, it was felt that a summary of pointers on how to recognize some of the fossil woods in the Sweet Home area on the basis of gross anatomy would be useful to the amateur.

Acknowledgments

Grateful acknowledgments are extended to staff members of the Oregon Department of Geology and Mineral Industries for help and guidance in compiling this report, for geologic assistance in the field, and for photographic work. Special appreciation is expressed to Mr. and Mrs. J. J. Marker for their always pleasant cooperation and kind permission to carry on field work at their Holley ranch. Appreciation is also extended to Her Majesty's Stationary Office, London, England, for permission to reproduce 16 photomicrographs of wood anatomy from the Forest Products Research Laboratory in England.

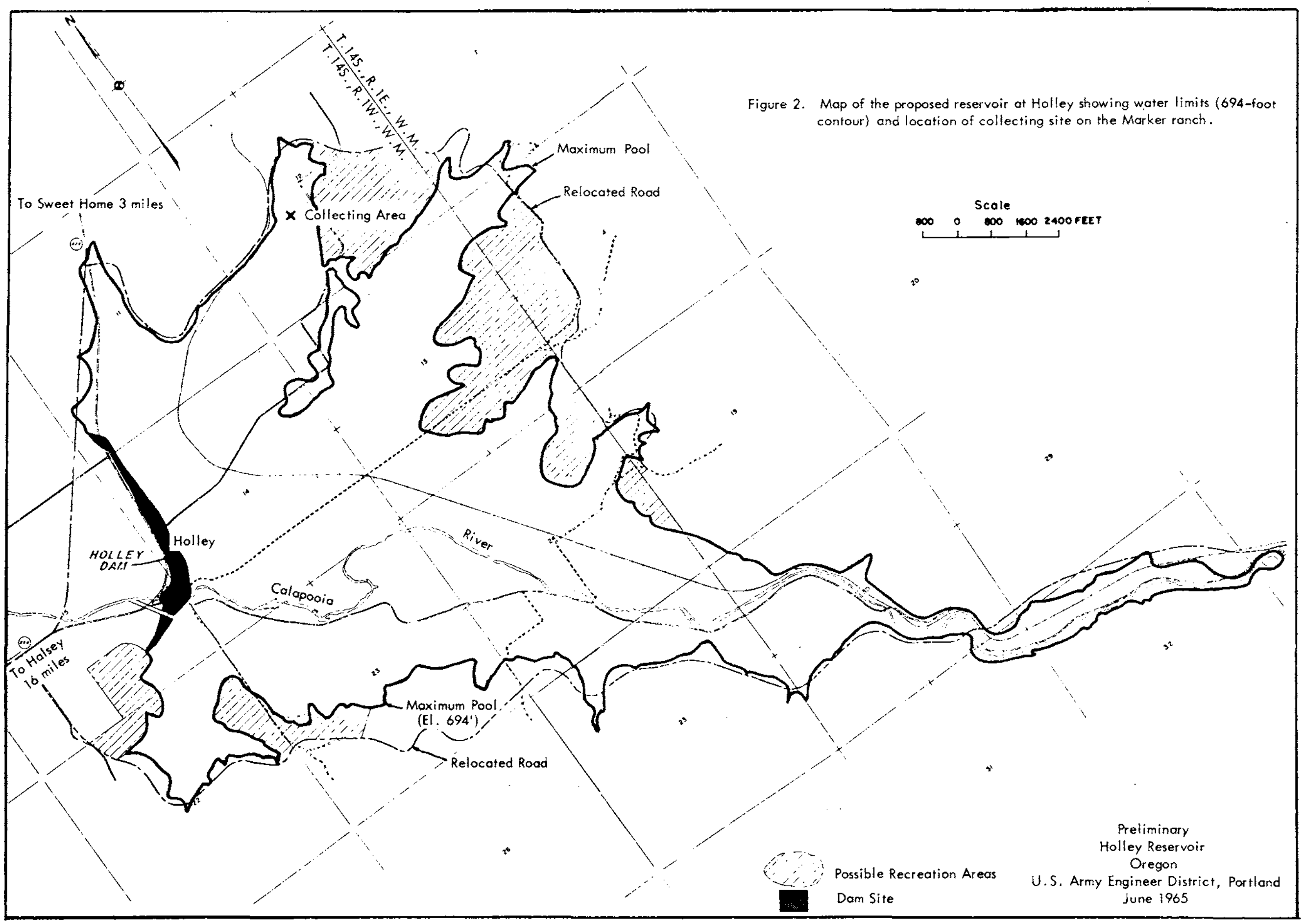

Figure 2. Map of the proposed reservoir at Holley showing water limits (694-foot contour) and location of collecting site on the Marker ranch.

Fossil Wood Studies as Applied to the Area

Published paleobotanical records of fossil wood in the Sweet Home area are scarce. Hergert and Phinney (1954) report specimens of a vessel-less angiosperm and describe and figure Trochodendroxylon beckii as the type of the new form genus Trochodendroxylon. Richardson (1950), in a master's thesis on the Sweet Home Petrified Forest, records several localities with trees petrified in situ. Beck (1944) has referred to the large number and exotic character of unidentified woods at Sweet Home and expresses himself as "completely at a loss to account for them." But in no case has the fossil wood flora, as such, been described.

Geologic Studies as Applied to the Area

The most comprehensive geologic study depicting the stratigraphy, structure, and petrology of the Western Cascade Range is by Peck and others (1964). Their work places the Sweet Home-Holley area in the Little Butte Volcanic Series of Oligocene to early Miocene age. This series of volcanic rocks, which is hundreds of feet thick and wide spread, consists of lava flows and vast amounts of tuff and ash that erupted from local volcanoes over a period of several millions of years. It is in these deposits of tuff and ash that the fossil wood is so abundant.

The plant-bearing rocks interfinger to the west in the vicinity of Brownsville with marine beds of the Eugene Formation, which contains fossil sea shells. Because similar relationships of terrestrial and marine environment occur elsewhere along the eastern margin of the Willamette Valley, geologists have been able to reconstruct the paleogeography of the region and give some idea of what the area looked like between 20 and 30 million years ago. Williams (1953) has shown that the Cascade Range as it appears today was not in existence, but, rather, the region was occupied by large volcanoes, their lower flanks clothed in luxurious vegetation. Rivers whose headwaters may have reached far back into central Oregon flowed westward to the sea.

Snavely and Wagner (1963) provide a geologic map of Oligocene-Miocene time that shows our area to have had a coastal environment located in a large marine embayment extending well into the present Willamette Valley (figure 3). Staples' (1950) discovery of salt crystals replaced by quartz in some of the fossil wood of the Holley area furthers the seacoast theory by showing that the wood was impregnated by salt from sea water before petrification.

There is evidence in the Sweet Home-Holley area to indicate that in later Miocene time the land was elevated and the sea withdrew. Lavas related to the Columbia River Basalt to the north poured out on a surface of hills and valleys that had been eroded in the older rocks. One area occupied by the basalt is at the site of the proposed Holley dam where this resistant rock already forms a natural constriction in the valley of the Calapooia River.

Description of the Collecting Site

The collecting site on the Marker ranch is situated in one of the northern fingers of the reservoir area (figure 2). The site is drained by a small stream that flows southwestward into the Calapooia River. A study of topographic maps (Sweet Home and Brownsville quadrangles) reveals that this small, intermittent creek occupies a well-defined valley (figure 4) which extends from the Calapooia near Holley to the South Santiam near Sweet Home. An explanation for its presence is suggested by Richardson,

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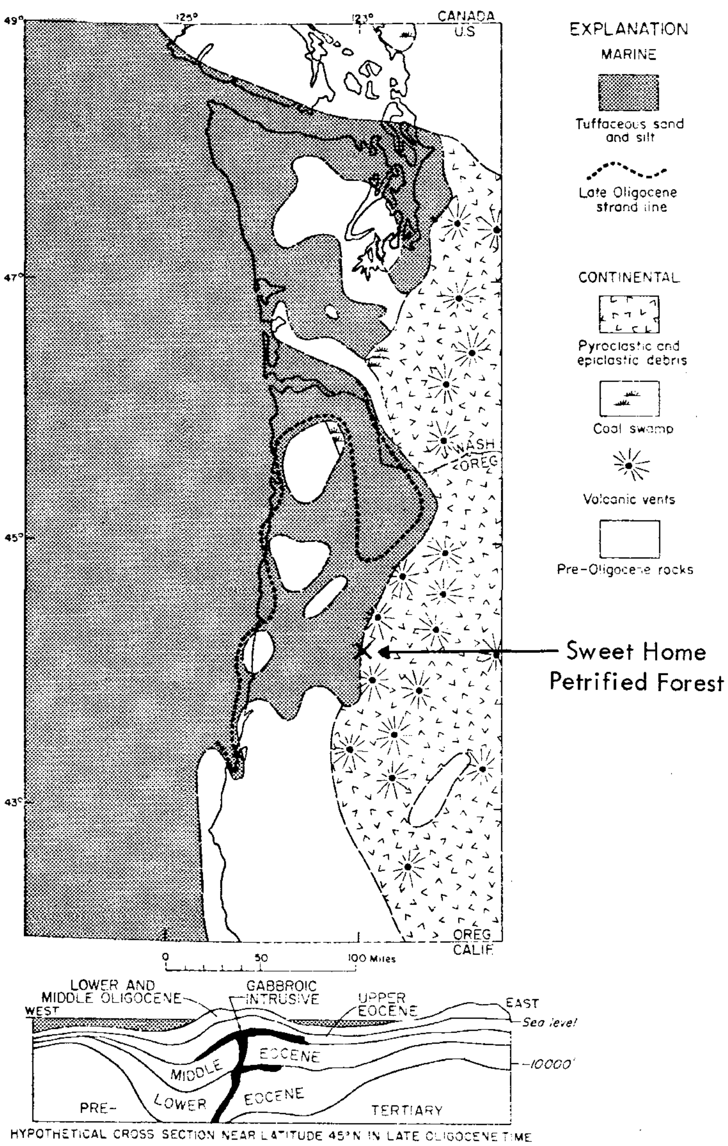

Figure 3. Paleogeologic map of western Oregon and Washington during Oligocene time (from Snavely and Wagner, 1963). Location of Sweet Home Petrified Forest area is indicated.

Figure 4. View looking southeast across valley at Marker ranch. Small body of water is a stockpond.

Figure 5. Layer of fossil wood exposed in bed of creek on the Marker ranch.

who indicates the possibility of either the Calapooia or the South Santiam having flowed through this gap at some time in the past.

The valley floor at the Marker ranch is underlain by a layer of closely packed pieces of fossil wood (figure 5), and it is possible that this layer extends throughout the lower portion of the reservoir area. The margins of the reservoir and the hills above it are composed of volcanic ash and tuff containing an abundance of fossil wood, some of it still standing in place as stumps (figure 6). Erosional processes that carved the valley system apparently removed the particles of ash and tuff that surrounded the wood and left the heavy silicified material behind as a lag product or residual deposit on the floor. The pieces of wood are fairly large and angular and thus have not been carried far. Presumably the trees had already been silicified and fragmented by earth pressures before accumulating as a concentration of alluvium.

The individual pieces of wood at the Marker ranch bear no relationship whatsoever to each other as to species. Theories to explain the anomalous association of varieties are offered below.

Variety of Species

Systematic list

Fifty-four different fossil woods from this small collecting area of about two acres have thus far been identified by the author (table 1). These represent only a portion of the material collected; many additional specimens remain to be thin-sectioned and identified. As a convenience, the commonly used name of each is listed first, followed by the generic name of the most similar extant species together with its family.

Possible sources of specimens

It is at once apparent that the list of identified specimens in table 1 represents members of several types of plant communities, some of which, by the durable nature of even unsilicified wood, may have been transported long distances from their place of growth.

So as a departure from usual paleobotanical form, rather than attempt to reconstruct a picture of the physical growth environment of this fossil flora by separating its component parts into ecological associations as we know them today, we shall instead speculate and theorize as to the possible origins of the species that have accumulated here:

1. Tropical woods present could well represent Eocene species -- remnants of an earlier, warmer climate adapted to the later but still moderate Oligocene seacoast environment of our area, much as palms have adapted today to the climates of England and northern Scotland. Interesting correlations may be noted here with the Goshen flora (Chaney and Sanborn, 1933).

2. Many trees were petrified _in situ_, having been covered by rapid and repeated falls of ash from erupting volcanoes located nearby and to the east. At present, remains of some stand upright in place in several Sweet Home locations (Richardson, 1950). Notable among these are the sycamores (_Platanus_), typical stream-bank, bottom-land species. Tops of stumps of a large grove of sycamore trees are visible at ground level in a valley on the McQueen property (on border of sections 7 and 18) where their bases have been covered by material eroded from the surrounding steep

Table 1. Check List of Species Identified.

Common Name	Genus	Family	Common Name	Genus	Family
Pine	Pinus	Pinaceae	Sweetgum	Liquidambar	Hamamelidaceae
Larch	Larix	Pinaceae	Katsura	Cercidiphyllum	Cercidiphyllaceae
Fir	Abies	Pinaceae	Sycamore	Platanus	Platanaceae
Redwood	Sequoia	Taxodiaceae	Cherry	Prunus	Rosaceae
Dawn Redwood	Metasequoia	Taxodiaceae	Honey Locust	Gleditsia	Leguminosae
Incense Cedar	Libocedrus	Cupressaceae	Kentucky Coffee Tree	Gymnocladus	Leguminosae
Cypress	Cupressus	Cupressaceae	Yellowwood	Cladrastis	Leguminosae
Willow	Salix	Salicaceae	South American Cedar	Cedrela	Meliaceae
Cottonwood	Populus	Salicaceae	Entandrophragma	Entandrophragma	Meliaceae
Walnut	Juglans	Juglandaceae	Holly	Ilex	Aquafoliaceae
Hickory	Carya	Juglandaceae	Maple	Acer	Aceraceae
Birch	Betula	Betulaceae	Maple	Acer pseudoplatanus	Aceraceae
Alder	Alnus	Betulaceae	Buckeye	Aesculus	Hippocastanaceae
Bluebeech	Carpinus	Betulaceae	Cascara	Rhamnus	Rhamnaceae
Hazel	Corylus	Betulaceae	Grape	Vitis	Vitaceae
Beech	Fagus	Fagaceae	Sterculia	Sterculia	Sterculiaceae
Chestnut	Castanea	Fagaceae	Schima	Schima	Theaceae
Chinquapin	Castanopsis	Fagaceae	Tupelo	Nyssa	Nyssaceae
Sweet Indian Chestnut	Castanopsis indica	Fagaceae	Dogwood	Cornus	Cornaceae
Oak	Quercus	Fagaceae	Alniphyllum	Alniphyllum	Styracaceae
Elm	Ulmus	Ulmaceae	Persimmon	Diospyros	Ebenaceae
Magnolia	Magnolia	Magnoliaceae	Ash	Fraxinus	Oleaceae
Myrtlewood	Umbellularia	Lauraceae	Devilwood	Osmanthus	Oleaceae
Camphorwood	Cinnamomum	Lauraceae	Cordia	Cordia	Boraginaceae
Sassafrass	Sassafrass	Lauraceae	Reptonia	Reptonia	Myrsinaceae
Trochodendron	Trochodendron	Trochodendronaceae	Catalpa	Catalpa	Bignonaceae
Actinidia	Actinidia	Actinidiaceae	Virburnum	Viburnum	Caprifoliaceae

Figure 7. Fossilized tree bark that had been riddled by boring insects before petrification. Enlargement (below) of upper left portion shows insect tunnel filled with silicified eggs.

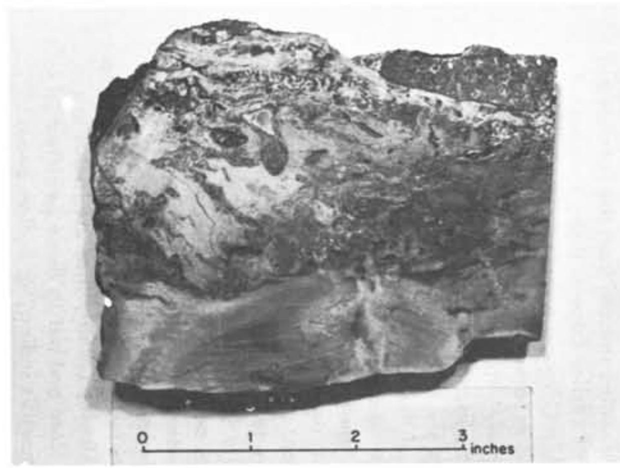

Figure 6. Fossilized stump of a hardwood tree standing where it grew 30 million years ago.

hillsides.

3. Westward-flowing streams, carrying quantities of pyroclastic debris originating from volcanoes to the east, constructed large deltas where they reached the coast. Specimens of fossil wood which show considerable transportation wear might well represent live-woods of the time carried by flooded streams from the interior and deposited as a part of such deltas. Fossil woods of earlier Eocene time, transported and buried in a similar manner, could be present in Oligocene rocks in much the same way that the Cretaceous fern, Tempskya, is found in later Eocene Clarno deposits in in the Greenhorn Mountains of northeastern Oregon. Here the fossilized wood was eroded from the enclosing rocks and redeposited in younger sediments.

4. Asiatic species reported to occur only rarely in Tertiary fossil woods could have arrived as random logs of driftwood by way of the sea. An example of this is Actinidia, not previously reported as a fossil wood and found at Holley thus far as a single specimen consisting of an almost complete trunk section. Logs transported as driftwood from offshore islands of the time (or from unlimited distances in the Eastern Hemisphere) and carried into the marine embayment may have been entrapped in coastal swamps and petrified after burial in stream sediments or falls of ash. Another wood -- the Asiatic genus Schima of the tea family (Theaceae) -- might have had such a source. The absence of branches and twigs and the preponderance of woods representing trees rather than shrubs help give credence to the idea that at least some of the material arrived at the locality as stripped-down, water-worn tree trunks.

5. Many of the specimens collected have inclusions of quartz pseudomorphs after halite crystals. We have found thus far, as did Staples (1950), that the inclusions were contained only in the fossil woods found as float and not in those petrified in place in the area. A collected specimen of Castanopsis indica, or Indian sweet chestnut (Asiatic), whose structure shows it to be a portion of a large tree trunk, is almost completely replaced with quartz pseudomorphs after halite. The distribution of the halite indicates that the solution had access from all sides as in floating and might have been absorbed during a long period at sea.

Preservation of Detail

The process of petrification still remains somewhat of a mystery and scientists are not in agreement as to what actually takes place. A number of mineral substances can cause petrification, but the most common is silica. Silica in ground water infiltrates the buried wood and by some complex chemical process is precipitated within the plant tissues. Cellulose and lignin are often still present in the silicified wood.

Whatever the particular process involved in the petrification of the highly silicified wood at Holley, it has resulted in the preservation of its finest anatomical details to such a degree that in many instances it comes close to being identical with its living counterpart of today. Furthermore, many of the specimens show little, if any, distortion in either shape or size of the structures required for identification. This is of much importance in wood recognition where comparative size of an anatomical feature -- ray width for example -- could be the critical factor in deciding to which genus that specimen should be assigned.

Indeed, so accurate is the preservation that wormholes with castings, insect eggs, grub holes, pitch pockets, dry rot, fungus growths, growth abnormalities of all kinds, plus all manner of the ills and defects that trees may fall heir to, are faithfully reproduced (figure 7). Also preserved are inclusions of gums, crystals, and other foreign substances sometimes found in the cells of living woods. These can be of value

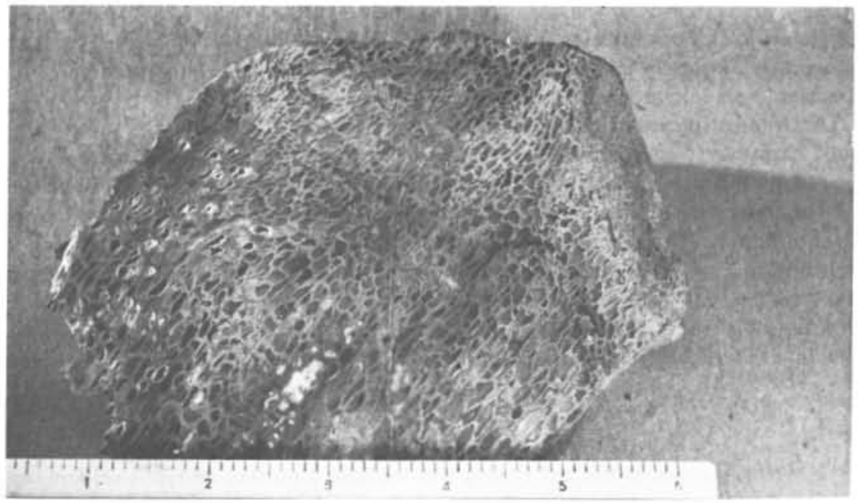

Figure 8. Pocket rot cavities in incense cedar, commonly mistaken for palm wood.

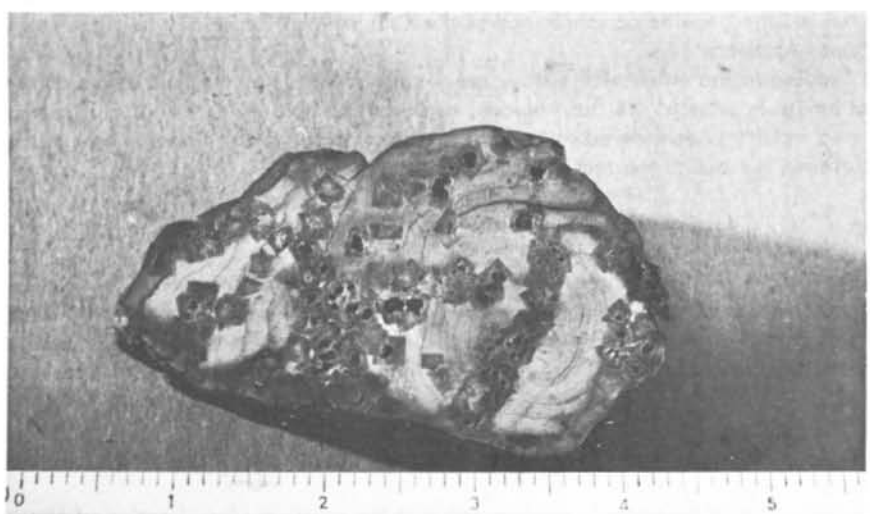

Figure 9. Quartz pseudomorphs after halite crystals in wood that was impregnated by salt water before petrification.

in differentiating one species from another. Honey locust (Gleditsia), for example, has deposits of gum in its vessels, while the wood of the closely related and similar-appearing Kentucky coffee tree (Gymnocladus) does not.

An interesting side light here is the proper identification of so-called "palm-wood" specimens, many of which have been collected in the Sweet Home-Holley area. Figure 8 shows a piece of incense cedar (Libocedrus) riddled with pocket-rot cavities caused by a fungus (possibly Polyporus, which causes such rot in this species of wood today). The empty cavities were subsequently filled with clear silica during petrification. A cut made at an angle across the tube-shaped cavities produces the same "eye" effect that palm wood's vascular bundles do when cut. Examination with a 10x lens will show the "eyes" to be the empty pocket rot cavities, whereas true palm "eyes" will be filled with material having well-defined organized cell structure.

Rarity and Uniqueness

The fossil woods at the collecting site include a number of types seldom reported elsewhere. Among these are the Trochodendron, a vessel-less hardwood of great interest to wood anatomists because of its unique and primitive structure (Hergert and Phinney, 1954). Other rare woods present are Reptonia, Sterculia, Schima, and Actinidia, none of which grow in North America today but which are found as live woods in Asiatic countries. Their presence in the Marker ranch assemblage suggests the probable occurrence of other exotic species among specimens collected by the author but not yet identified.

Among the interesting woods that no longer grow natively in this region are Cinnamomum, the genuine camphorwood of the Orient, and Cedrela, the cigar-box wood of South America.

Adding to the value of the study area is the presence of the quartz pseudomorphs after halite in some of the fossil woods, as described by Staples (1950). This mineralogical oddity is considered to be unique to the Holley area, since no other such occurrence has been reported in the literature.

Conclusions Regarding the Collecting Site

While the original sources of our specimens may remain uncertain, we can be sure that 1) the abundance of fossil wood, 2) the variety of species present, 3) the faithful preservation of minute anatomical details, and 4) the rarity and uniqueness of some have made this collecting area a valued paleobotanical study and research area.

Wood Identification Based on Gross Anatomy

While it must be strongly emphasized that the positive identification of fossil woods (based on thin-sectioning and a microscopic study of their minute anatomy) lies entirely in the realm of the specialist (Eubanks, 1960), the serious hobbyist can achieve much enjoyment and personal satisfaction in tentatively identifying his material on the basis of its gross anatomy with the aid of a 10x hand lens.

In the Tertiary fossil woods of the Pacific Northwest there are many species that had advanced to such a degree that they very closely resemble their living counterparts of today; persons familiar with wood-grain patterns may readily recognize a common live-wood, such as oak, in their fossil materials. In this regard it is helpful to bear in mind that any live-wood "know-how" is quite readily transferable to the fossil material, excepting, of course, the diagnostic qualities of odor, taste, feel, weight, and color. Color in fossil woods derives entirely from minerals present in the host rock during petrification and in no way relates to the species of the wood.

Preparation of specimens

In this more elementary identification process observations and comparisons are made mainly on the transverse (across the grain) view of the wood -- that is, the cut made in sawing off a log for firewood. To compare a fossil wood with a known live-wood, both must be oriented so that a transverse view can be cut (or found, as can often be done with a piece of fossil wood collected in the field). The living wood cells will have been crushed in sawing and will appear "fuzzy" at 10X. To get a clear picutre of the pore and ray pattern, an old-fashioned straight-edged razor which has been well sharpened or an "Exacto-type" woodcarving knife should be used to shave off carefully a thin, even horizontal layer on just a small area of the cut surface of the wood. A half-inch square will generally be ample. This surface should then provide a clear, uncrushed view of the wood cells. Avoid a sloping cut into the wood, which will give a distorted, untrue wood-grain pattern. Moistening the cut surface will sharpen the details in some live-woods, but will blur others. Both methods should be tried.

The fossil wood, cut by rock saw (or as found), can be studied more easily if it is sprayed lightly with any of the transparent plastic finishes available today. Even hair-spray will suffice. Often a well-preserved petrified wood specimen will have a weathered or naturally bleached outer surface that will give a much clearer picture of its structure than will the inner cut surface. For this reason it is well to work with a "heel" of material, where both cut and natural surfaces are available for viewing.

Comparing specimens

The wood specimens should be held so that a good light falls on the cut surface. Hold the lens close to the eye and gradually bring the cut surface up toward the lens until the cell structure is clear and in focus. At this point the fossil wood must be examined painstakingly over its whole surface to find the area where the vessel (hole) and ray (line) pattern is clearest and appears "normal" as compared to live-woods. A pitfall to watch here is that during petrification sometimes either vessels or rays or both may have faded out or have become extremely distorted as to size. This can lead to much confusion on the part of the novice and expert alike, and points up the necessity for painstaking examination to locate what seems to be the most "true-to-life" appearing section of the specimen.

The same kind of comparison with a specimen of correctly identified fossil wood is another way to track down the kind of wood involved.

Use of Photomicrographs in Wood Identification

Perhaps the most valuable tools in wood identification are photomicrographs of the anatomy of selected wood specimens chosen because they so well typify that particular species. However, such material is generally not available in any significant quantity. Thus, we are fortunate in having obtained permission to reproduce a series of such photomicrographs from Bulletin 26, "An Atlas of End-grain Photomicrographs

PLATE I.

(Furnished by Forest Products Research Laboratory, London, England.)

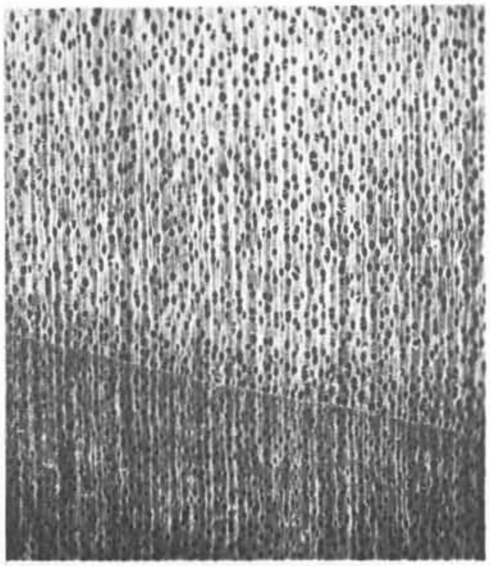

Figure a: <u>Salix</u>
Willow

Figure b: <u>Carpinus</u>
Hornbeam

(All photographs 10 x)

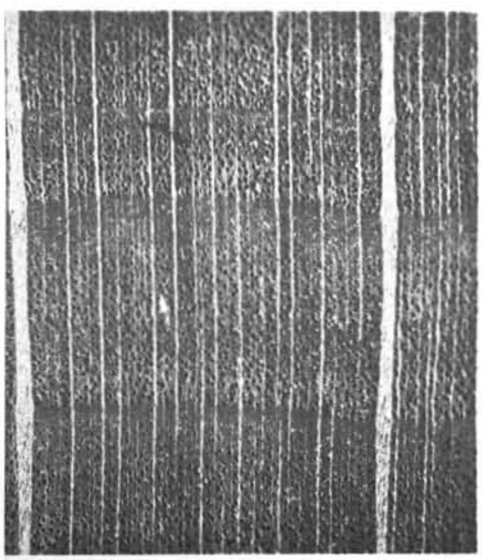

Figure c: <u>Fagus</u>
Beech

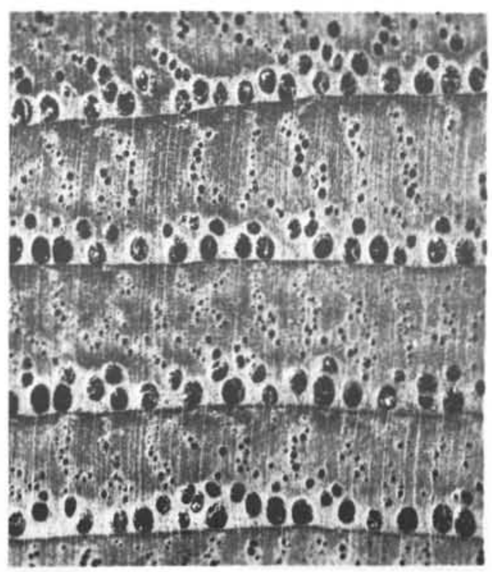

Figure d: <u>Castanea</u>
Chestnut

PLATE II.

(Furnished by Forest Products Research Laboratory, London, England.)

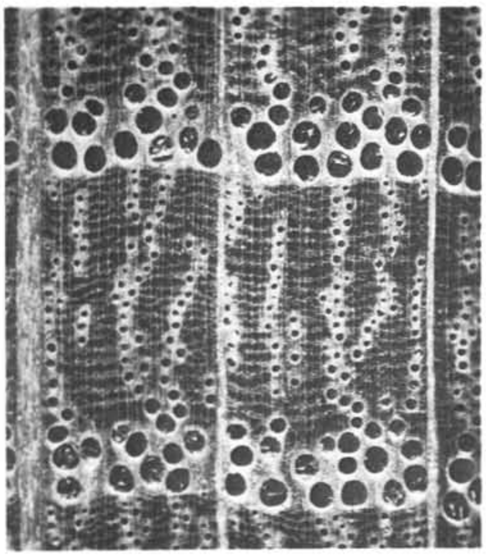

Figure e: Quercus / Oak

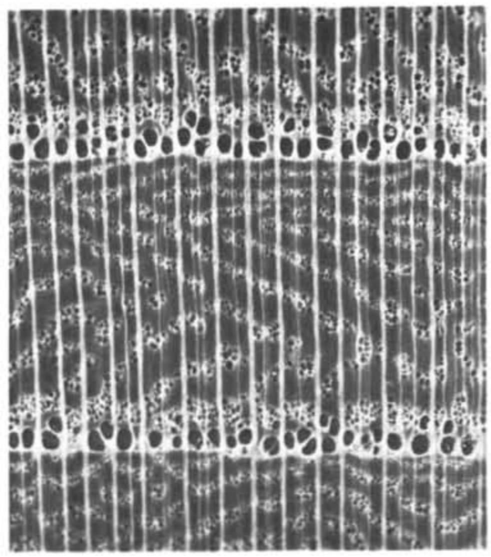

Figure f: Ulmus / Elm

(All photographs 10 x)

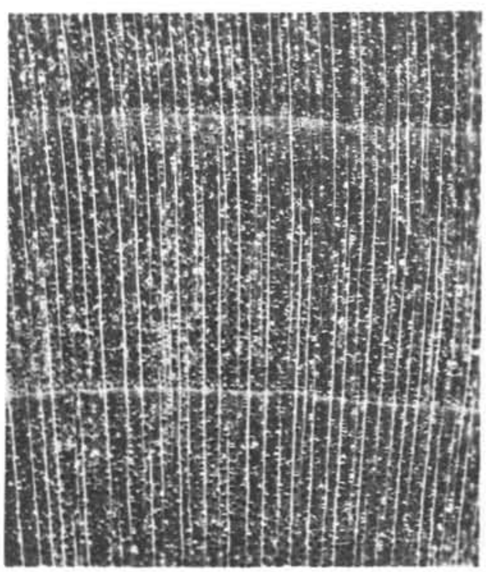

Figure g: Magnolia / Magnolia

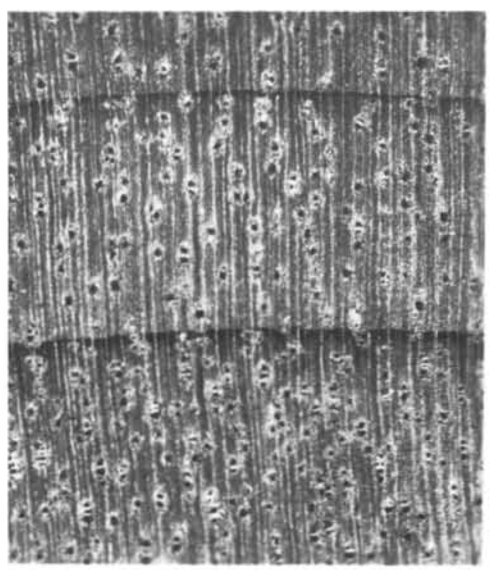

Figure h: Umbellularia / Myrtlewood

PLATE III.

(Furnished by Forest Products Research Laboratory, London, England.)

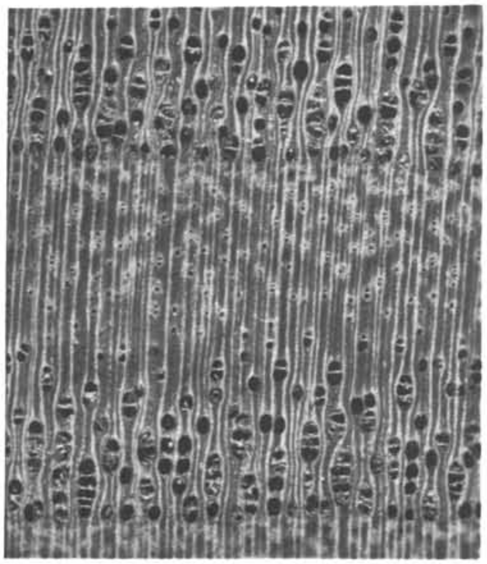

Figure i: Sassafras
Sassafras

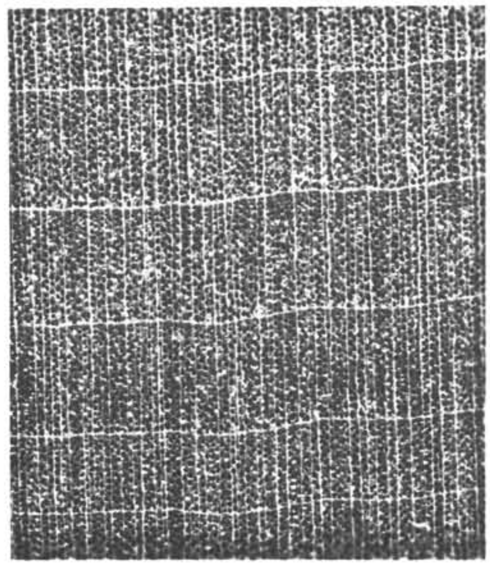

Figure j: Cercidiphyllum
Katsura

(All photographs 10 x)

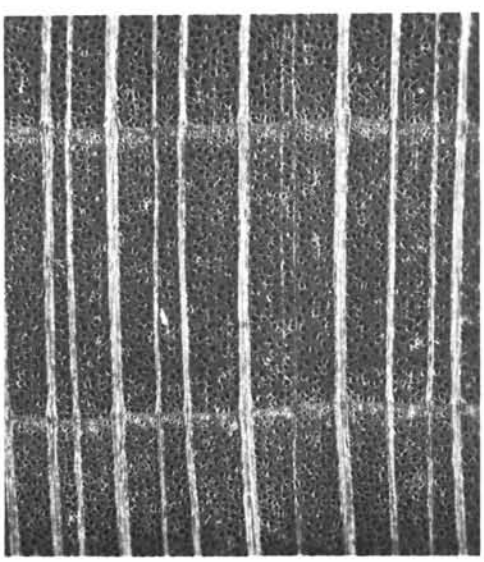

Figure k: Platanus
Sycamore

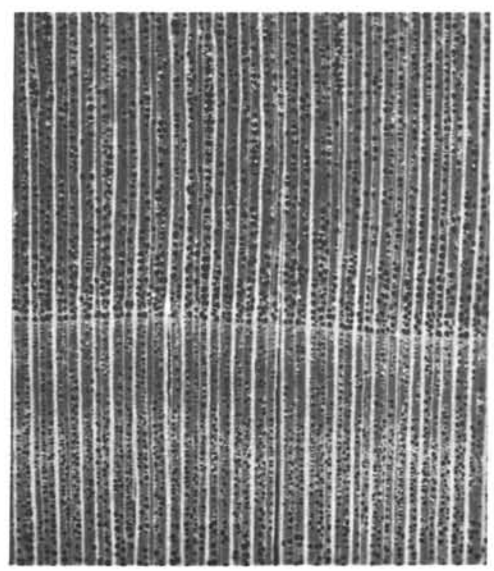

Figure l: Prunus
Cherry

PLATE IV.

(Furnished by Forest Products Research Laboratory, London, England.)

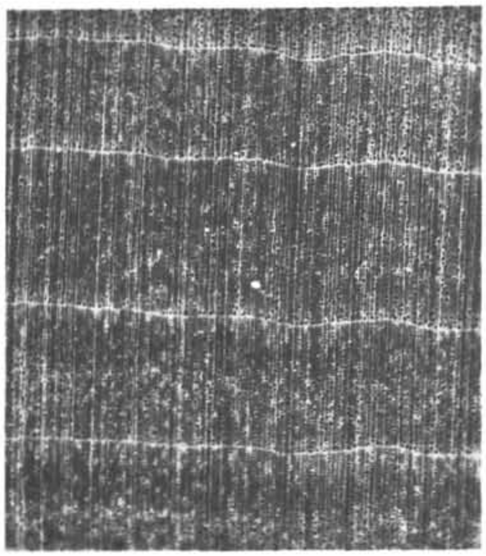

Figure m: Aesculus
Buckeye

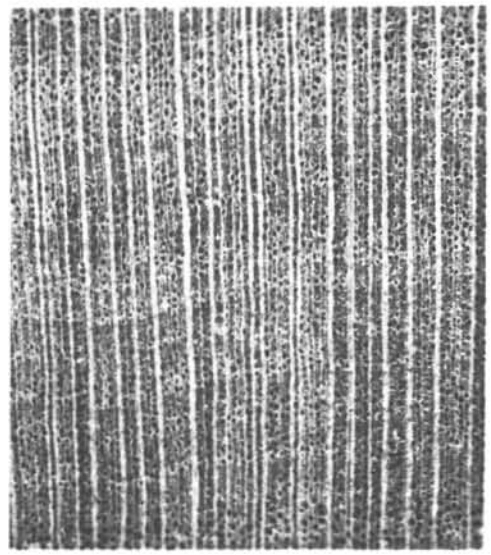

Figure n: Cornus
Dogwood

(All photographs 10 x)

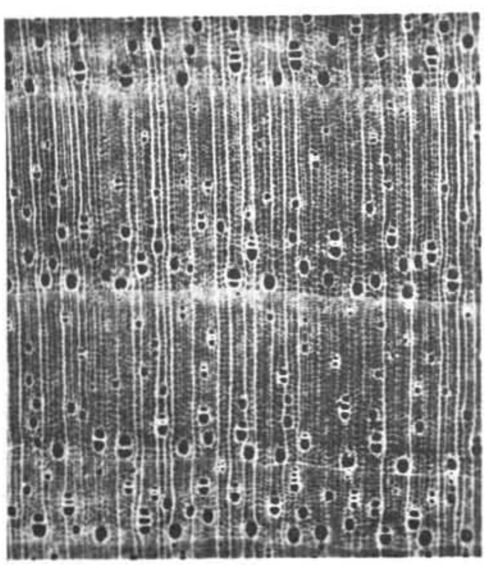

Figure o: Diospyros
Persimmon

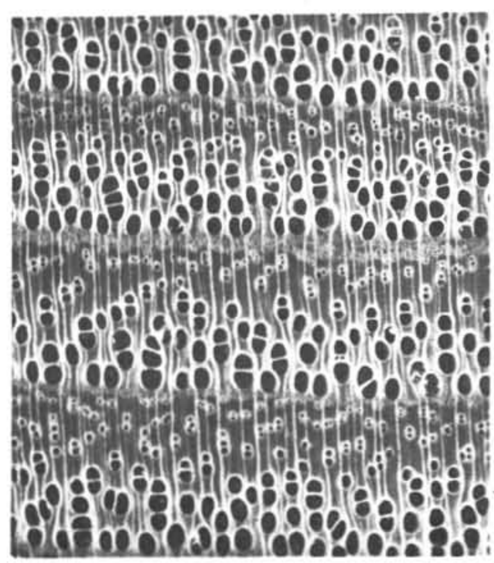

Figure p: Fraxinus
Ash

for the Identification of Hardwoods" prepared by Forest Products Research Laboratory, England (plates 1 through 4). The species illustrated represent familiar live-woods of today which have been found as fossil woods at the Holley collecting area and in other Pacific Northwest Tertiary petrified wood deposits.

Close examination of petrified specimens might well disclose the presence of any of these woods in individual collections. A similar cut of the same species of live-wood, if available, prepared for viewing as described above and combined with its matching photomicrograph will provide an invaluable basis for identifying a similar fossil specimen.

Features to observe

In such a comparison based on gross anatomy, the aim is to learn to recognize over-all grain patterns. The 10-power lens mentioned is most suitable for this, since a higher power will enlarge and blur the condensed design or pattern we wish to recognize.

The patterns are based on varied arrangements of pores or vessels (which appear as holes) and rays (lines of cells running like a radius from the bark toward the center of the tree).

Growth rings

Most woods show concentric circles on cross-section. These rings indicate annual growth, and are distinct in woods where the cell size varies greatly at different times of the year. Early spring wood will have large, fast-growing cells; later, slow-growing summer wood cells are small and dense. In tropical climates woods do not usually show distinct annual rings, since growth rate is constant throughout the year and each year's growth merges into the next with little perceptible change in cell size. This is an interesting feature to watch for in fossil woods.

Porous and nonporous woods

Other points to notice are the difference between woods with no pores (nonporous), which includes most coniferous or "needle-trees," which are also called "softwoods," and woods with pores (porous), which generally include the "hardwoods."

The porous woods or hardwoods can be further divided into ring-porous woods in which the larger spring pores form a well-defined band at the annual growth ring, as sassafrass and ash, and diffuse-porous woods, in which the pores are distributed evenly throughout the growth ring, as magnolia and katsura.

Pore arrangements

Also significant are pore arrangements. They may be grouped in many ways -- in clusters, in groups of two or three, in straight or radial chains (chestnut), in slanting chains called echelons and in many other ways. In conifers scattered resin canals may sometimes occur. On cross section these appear to be extra large "pores," but are actually canals running vertically along the grain.

Rays

Rays appear as straight lines on the transverse surface, varying in width from heavy (oak) to too fine to be seen with the naked eye. Comparative width of rays is often a diagnostic feature. Sycamore, with broad rays of generally uniform width, can thus be differentiated from beech, whose broad rays are fewer and separated by groups of distinctly narrower width.

Parenchyma

Soft tissues (parenchyma cells) are short, thin-walled cells not usually distinguishable individually with a hand lens. But collectively they form innumerable varied patterns that are useful in identifying woods. Persimmon is characterized by a fine, net-like or reticulate parenchyma pattern. Myrtlewood can be verified by its typical "halos" formed by parenchyma cells that encircle each pore. Straight and wavy bands of varying widths running crosswise to the rays frequently occur. Terminal parenchyma at the annual growth ring is a feature of other woods, such as magnolia, where it appears as a light line easily visible to the naked eye. Many other types and combinations of types occur.

Forestry and botany texts will provide detailed information and references on wood anatomy, nomenclature, and classification of plants that may be applied to fossil wood. Paleobotanical texts such as "Ancient Plants and the World They Lived In" (Andrews, 1964) often carry sections with brief botanical summaries expressly written to provide the necessary basic information needed for venturing into the field of fossil plant life.

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* * * * *

GEOLOGY OF WILDLIFE REFUGE AREAS PUBLISHED

Studies related to Wilderness-Wildlife Refuges by the U.S. Geological Survey and the U.S. Bureau of Mines (under the Wilderness Act of September 1964) have resulted in publication of brief reports on the geology of several areas in Oregon, as indicated below. Issued under the Survey's Bulletin series, each report contains the available geologic information on the area, illustrated by maps and photographs.

Bulletin 1260-F, G, H (in one volume):
Summary on the geology and mineral resources of the Flattery Rocks, Quillayute, Needles, and Copalis National Wildlife Refuges, Washington; Oregon Islands National Wildlife Refuge, Oregon; and Three Arch Rocks National Wildlife Refuges, Oregon; by A. E. Weissenborn and Parke D. Snavely, Jr.

Bulletin 1260-L, M (in one volume):
Summary report on the geology and mineral resources of the Harney Lake and Malheur Lake areas of the Malheur National Wildlife Refuge, north-central Harney County, Oregon; and Poker Jim Ridge and Fort Warner areas of the Hart Mountain National Antelope Refuge, Lake County, Oregon, by G. W. Walker and D. A. Swanson.

Both booklets are for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Bulletin 1260-F, G, H is 55 cents; Bulletin 1260-L, M is 20 cents.

* * * * *

ASHLAND MILL REACTIVATED

The 50-ton gravity mill at the old Ashland mine has been revamped by the Ashland Development & Mining Co., Inc., and ore from an outcrop on the ridge above the workings is being milled. The work is being conducted under the supervision of Tom Brown, mine superintendent.

The Ashland mine has a history that dates from the 1890's. Total production, mainly in gold, has been estimated to amount to $1,300,000, with the bulk of the gold produced at the "old" pre-1934 price. Underground workings include tunnels, shafts, and raises having a total of 11,000 feet of development. The vein is explored to a depth of 1200 feet on the dip.

* * * * *

OSU NAMED FOR SEA GRANT

Oregon State University has been named by the National Science Foundation as one of the first three universities in the nation to receive sea-grant awards for broad-based programs of training, research, and advisory services related to the sea. The other two are the University of Washington and the University of Rhode Island.

OSU's sea-grant efforts will include marine fisheries, agriculture, seafood-processing, marine minerals and mining, marine economics, ocean engineering, and oceanography.

* * * * *

BAUXITE EXPERIMENTS CONDUCTED AT ALBANY

"Recovery of Alumina and Iron from Pacific Northwest Bauxites by the Pedersen process," by O. C. Fursman, H. E. Blake, and J. E. Mauser, at Albany Metallurgy Research Center, U.S. Bureau of Mines, has been issued by the bureau as Report of Investigations 7079. The report gives results of research in the bureau's continuing program to develop economic methods for producing aluminum from domestic low-grade resources. Experiments carried out on Salem Hills bauxite and using the Pedersen process were successful in recovering more than 90 percent of the alumina.

R. I. 7079 is available free of charge from the Publications Distribution Branch, Bureau of Mines, U.S. Department of the Interior, 4800 Forbes Ave., Pittsburg, Pa., 15213.

* * * * *

INDUSTRIAL USE OF GOLD GROWS RAPIDLY

The growing use of gold in industry often tends to be overlooked because of the metal's exclusive association with currency. Total world gold production has increased by about 15 percent since 1940. In the same period, however, United States industrial consumption alone has increased by more than 500 percent. This indicates the likely future trend of gold consumption by industry.

Gold is currently used in the chemical, textile, electrical, ceramic, instrument and space industries. Also, it is used in medicine and dentistry, for such things as spinnerettes, thread, contacts, resistance wire, pottery decoration, photo-sensitive glass, missiles and satellites, transistors, and computers. (From "News from South Africa," March 27, 1968.)

* * * * *

OREGON LUNAR ROCKS ANALYZED

"Simulated Lunar Rocks" by David E. Fogelson, U.S. Bureau of Mines, is a 51-page report on the engineering properties and petrography of a suite of rocks selected for use by the bureau in its extraterrestrial resource utilization studies. The work was performed at the bureau's Twin Cities Mining Research Center, Minneapolis, Minn.

The group of 14 materials studied consisted of a wide range of volcanic rocks, including rhyolite, dacite, basalt, and pumice. In addition, two ultramafic rocks (dunite and serpentine), a gabbro, and a granodiorite were selected in order to complete the range of the moon's possible surface composition.

Out of the 14 samples chosen for the research, 9 volcanic rocks came from the Bend-Madras-Newberry region of central Oregon and 2 ultramafic rocks from southwestern Oregon. The State of Oregon Department of Geology and Mineral Industries assisted in the project by collecting much of the Oregon material.

In addition to its lunar research applications, the publication is of interest to geologists wanting detailed chemical, physical, and petrographic information on some of Oregon's rocks. A copy of the booklet may be consulted at the Department's library.

* * * * *

ADEQUACY OF MINERAL SUPPLY THREATENED

The Subcommittee on Minerals, Materials, and Fuels of the Senate Interior Committee held hearings March 21 on mineral shortages and problems. Walter R. Hibbard, Jr., retiring director of the U.S. Bureau of Mines, presented testimony that drew "attention to a situation that is emerging which appears to threaten both the adequacy and dependability of our supply of minerals and mineral fuels." This was the conclusion of a long-range study initiated by the bureau a year ago. Nine categories of essential issues have been developed and defined during the study. According to Hibbard, the three most important are:

Maintaining an adequate mineral capability -- The United States will find it increasingly difficult to compete with foreign ores unless technology improves.

Insuring essential overseas supplies -- Access to world supply must continue to be sought through mutually advantageous agreements with friendly nations.

Accommodating to changing end-use patterns -- We must develop effective techniques for recognizing the events that foretell significant changes in demand patterns.

In Hibbard's opinion, "The successful application of technology to meet the mineral demands of the future is the most recurring theme in the appraisals of the projected supply-demand relationship." Also, foreign investments and mergers will have "far-reaching implications" on the future of U.S. mineral policy and should be taken into account in any future planning.

Hibbard concluded by stating that information is now available on which to base a minerals policy. He recommended a high priority for looking at the situation in depth and for formulation of policy. (American Mining Congress News Bulletin, for March 29, 1968.)

* * * * *

TREASURY AMENDS GOLD REGULATIONS

Pursuant to agreements announced by the central banks of Belgium, Germany, Italy, the Netherlands, Switzerland, the United Kingdom, and the United States on March 17, 1968 in Washington, D.C., the Treasury Department has issued amendments of the Treasury gold regulations effective immediately.

The Treasury will no longer purchase gold in the private market, nor will it sell gold for industrial, professional, or artistic uses. The private holding of gold in the United States or by U.S. citizens and companies abroad continues to be prohibited except pursuant to existing regulations.

The gold regulations have been amended to permit domestic producers to sell and export freely to foreign buyers as well as to authorized domestic users. Authorized domestic users regularly engaged in an industry, profession, or art in which gold is required may continue to import gold or to purchase gold from domestic producers within the limits of their licenses or authorizations in the regulations.

* * * * *

TITANIUM SYMPOSIUM TO BE HELD JUNE 12

Oregon's role as a leader in the rare and refractory metals industry will bring to Portland national authorities in the field of metallurgy for a one-day symposium on titanium, June 12, at the Sheraton Motor Inn.

With the theme of "The challenge of titanium," the symposium is being sponsored by the Economic Development Division of the Oregon Department of Commerce, under the State Technical Services program. Cooperating with the EDD are the American Society for Metals and the American Institute of Mining and Metallurgical Engineers.

Leading authorities in the metals field who will be speaking at the symposium are listed below in the general program, together with the subject of their talks.

The first speaker of the morning will be G. J. Arnold, general manager of the advanced materials division of Armco Steel Corp., Baltimore, Md., who will talk on the economic outlook. He will be followed by Robert Bealle, project coordinator of the U.S. Bureau of Mines, Albany, Oregon, for a discourse on titanium casting in Oregon. Other morning speakers will be J. G. Wenzel, ocean systems manager of the Lockheed Missile and Space Division, Sunnyvale, Cal., whose subject will be hydrospace, and Stewart Paterson, production project chief of the SST Division of the Boeing Co., Seattle, Wash., with a topic of aerospace.

"The Albany Story" will be the subject of the keynote address, which will be delivered at the luncheon by Dr. Earl T. Hayes, Deputy Director of the U.S. Bureau of Mines, Washington, D. C.

The afternoon program will be opened by George Glenn, assistant chief of the Metallurgical Processing Branch, Manufacturing Technology Division, Air Force Materials Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio, with a talk on the application of titanium in aircraft engines, past, present, and future. He will be followed by Robert Kane of the Application and Development Center, Titanium Metals Corp., West Caldwell, N.J., whose subject is to be the uses of titanium in the chemical process industries.

The final speaker of the afternoon will be Dr. Robert Jaffee, chief of the metal science department of Battelle Memorial Institute, Columbus, Ohio, who will address the meeting on titanium in the U.S. and the U.S.S.R., a contrast of titanium base alloys.

The afternoon's program will close with a social hour for which the following firms will be hosts: Rem, Inc., TiLINE, Inc., Oregon Metallurgical Corp., Wah Chang Albany Corp., OMARK Industries, Inc., Precision Castparts Corp., and ESCO Corp.

Further information on the symposium can be obtained from P. Anthony Michaelson, Technical Services Coordinator, EDD, 560 State Office Building, Portland, Oregon, 97201.

* * * * *

HOW HIGH IS MOUNT HOOD?

A 10-foot discrepancy has been discovered in the elevations shown for the summit of Mount Hood on two U.S. Geological Survey topographic maps. The correct elevation, 11,235 feet, appears on the $7\frac{1}{2}$-minute Timberline Lodge topographic map. On the state base map published at a scale of 1:500,000 the elevation is shown as 11,245. The 11,235 figure was determined in 1958.

* * * * *

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

2.	Progress report on Coos Bay coal field, 1938: F. W. Libbey	$ 0.15
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.	(1st vol.) Five papers on Western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	(2nd vol.) Two papers on Western Oregon and Washington Tertiary foraminifera, 1949: Cushman, Stewart, and Stewart; and one paper on mollusca and microfauna, Wildcat coast section, Humboldt County, Calif., 1949: Stewart and Stewart	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
44.	Bibliography (2nd supplement) of geology and mineral resources of Oregon, 1953: Steere	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
56.	Fourteenth biennial report of the State Geologist, 1963-64	Free
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
59.	Fifteenth biennial report of the State Geologist, 1964-1966	Free
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00

GEOLOGIC MAPS

Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others . . .	0.40
Geologic map of the St. Helens quadrangle, 1945: Wilkinson, Lowry & Baldwin .	0.35
Geologic map of Kerby quadrangle, Oregon, 1948: Wells, Hotz, and Cater . .	0.80
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
Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set] flat . . folded in envelope, $2.25; rolled in map tube, $2.50	2.00

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18.	Radioactive minerals the prospectors should know (2nd rev.), 1955: White and Schafer	0.30
19.	Brick and tile industry in Oregon, 1949: J.E. Allen and R.S. Mason	0.20
20.	Glazes from Oregon volcanic glass, 1950: Charles W. F. Jacobs	0.20
21.	Lightweight aggregate industry in Oregon, 1951: Ralph S. Mason	0.25
23.	Oregon King Mine, Jefferson County, 1962: F.W. Libbey and R.E. Corcoran	1.00
24.	The Almeda Mine, Josephine County, Oregon, 1967: F. W. Libbey	2.00

MISCELLANEOUS PAPERS

2.	Key to Oregon mineral deposits map, 1951: Ralph S. Mason	0.15
3.	Facts about fossils (reprints), 1953	0.35
4.	Rules and regulations for conservation of oil and natural gas (revised 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: H. G. Schlicker	0.50
7.	(Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: M. Roberts	0.50
8.	Available well records of oil & gas exploration in Oregon, rev. 1963: Newton	0.50
10.	Articles on Recent volcanism in Oregon, 1965: (reprints, The ORE BIN)	1.00

MISCELLANEOUS PUBLICATIONS

Oregon mineral deposits map (22 x 34 inches), rev. 1958	0.30
Oregon quicksilver localities map (22 x 34 inches) 1946	0.30
Landforms of Oregon: a physiographic sketch (17 x 22 inches), 1941	0.25
Index to topographic mapping in Oregon, 1961	Free
Index to published geologic mapping in Oregon, 1960	Free
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EVIDENCE FOR POSSIBLE PLACER ACCUMULATIONS ON THE SOUTHERN OREGON CONTINENTAL SHELF

By

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Introduction

The oceans of the world cover nearly three-quarters of the earth's surface and constitute a virtually unlimited resource for the ever-increasing needs of mankind. Oceanographic research has made significant advances in the past 20 years and is the foundation on which man will explore and exploit the resources of the ocean. Although both seawater and the deposits beneath the seas contain minerals of economic importance, only a few of these resources have been exploited profitably.

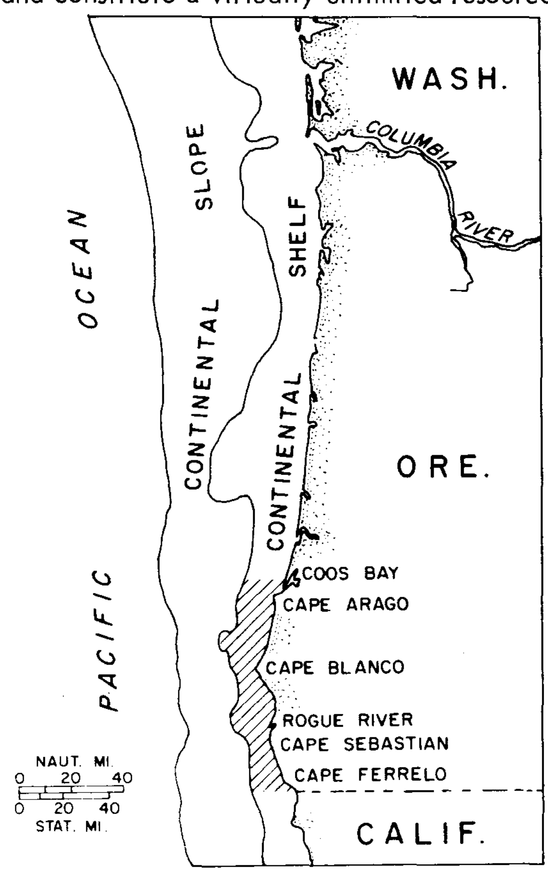


Figure 1. Location map. Lined area shows region of present investigation.

Exploration on submerged lands for petroleum products is already well established, but the search for hard-mineral deposits is just beginning. Since there are numerous profitable land-mining operations in the modern and raised beaches and alluvial deposits around the world for such valuable minerals and metals as gold, tin, rutile, and zircon, it is reasonable to assume that such deposits also exist on the adjacent continental shelf. Inasmuch as ocean mining technology is still in its infancy, the shallow submerged lands must be the first areas to be exploited.

In February 1967, the U.S. Geological Survey established a joint five-year study of the continental margin (continental shelf and slope) off Oregon with the Department of Oceanography, Oregon State University. This study is being conducted as a part of the Survey's Heavy Metals Program, which was developed in response to the increasing depletion of the supply of heavy metals, such as gold, platinum, silver, tin, and mercury.

One of the major objectives of the Heavy Metals Program in Oregon is to conduct a three-dimensional geologic-geophysical analysis of the continental margin. Such an analysis will permit an appraisal of the mineral and the energy resources on and beneath the sea floor and provide insight into the geological processes operating in the marine environment.

The continental shelf between Coos Bay, Oregon, and the Oregon-California border was selected for the initial phase of research and exploration for submerged mineral deposits (fig. 1). Beach placer deposits containing economic quantities of gold, platinum, and chromium occur onshore in southern Oregon and are a primary consideration in the selection of offshore exploration sites. Both stream and beach placers no doubt occur on the continental shelf off southern Oregon, but whether they are of commercial value is yet to be determined. This report is a preliminary synthesis of the results of the first year of research and exploration on the southern Oregon continental shelf, and it describes some of the probable areaswhere economic accumulations of heavy metals may occur.

The first year of exploration and research on the southern Oregon shelf has just been completed; it included both a reconnaissance and a detailed study of the area. Continuous seismic profiling was conducted on the shelf to determine the general structure, thickness of unconsolidated sediment, and nature of Pleistocene drainage. A reconnaissance magnetometer survey was made in selected areas to locate possible placer deposits. More than 300 surface and subsurface sediment samples were collected with grab samplers and short corers for analysis. Several hundred under-water photographs were taken on the continental shelf and upper slope to survey in detail portions of the sea floor. Rock dredges were also used to determine the nature and the composition of the rocks on the sea floor.

Geologic Setting

The geomorphology of the Oregon continental shelf and slope south of Coos Bay has been described in some detail by Byrne (1963). The shelf varies in width from about 9 to 17 nautical miles (17 to 31 km); its outer edge generally occurs at depths of from 90 to 100 fathoms (165 to 183 meters); and it has a slope which ranges from 0°18' to 0°40'. Off southern Oregon the shelf is narrower, deeper, and steeper than the world average shelf.

A prominent submarine bank on the outer shelf, Coquille Bank, disrupts

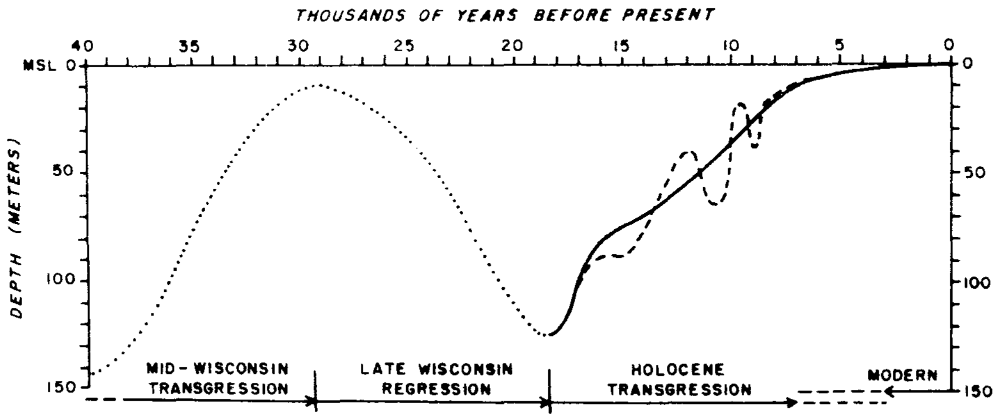


Figure 2. Late-Quaternary fluctuations of sea level (after Curray, 1965). Dotted curve is largely based on speculation. Solid curve based on selected published and unpublished radiocarbon dates. Dashed curve represents postulated fluctuations and shows probable complexity of Holocene Transgression.

the generally smooth surface of the shelf between the Coquille River and Cape Blanco. Although other rocks crop out elsewhere on the shelf, they are not as prominent as Coquille Bank. The outer edge of the shelf northwest of the mouth of the Rogue River is cut by the Rogue Submarine Valley which originates in about 70 fathoms (128 meters) of water.

The numerous eustatic sea-level fluctuations during the Quaternary, brought about by alternating periods of glaciation and deglaciation, have had a pronounced effect on the geomorphology and the sediments of the continental shelves of the world. Only from the past 20,000 years is there sufficient reliable information to postulate the times and the magnitudes of these fluctuations. The events that followed the Wisconsin glaciation (fig. 2) are described by Curray (1965). The stand of sea level, which is believed to mark the end of the late Wisconsin glaciation and the beginning of the Holocene Transgression, occurred between 20,000 and 17,000 years before the present (B.P.) and is represented by a present water depth of about 65 fathoms (120 meters). From 17,000 to 7000 years B.P., there followed a rather rapid transgression (Holocene Transgression) of the sea, with postulated minor regressions interrupting the general Holocene Transgression. The rate of the rise of sea level slowed from 7000 B. P. to the present; whether sea level has been stable or fluctuating during the past 3000 to 5000 years still is a moot question. If the postulated minor regressions occurred during the general Holocene Transgression (Curray, 1965), and there is some independent evidence that suggests this is the case (van Andel and Sachs, 1964), a number of submerged shorelines may be expected between the 65 fathom (120 meter) depth contour and the present-day shoreline. The water depth in which these submerged shorelines may occur today depends upon the tectonic stability of the continental margin. Deformation of the emergent

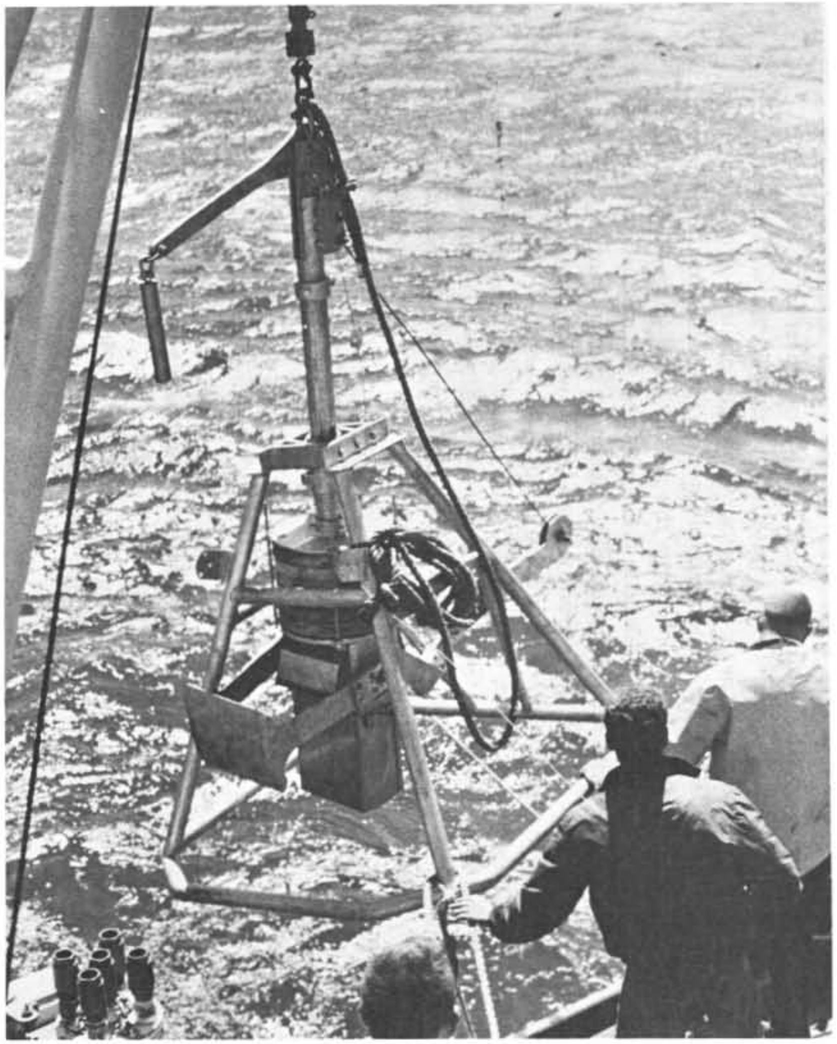
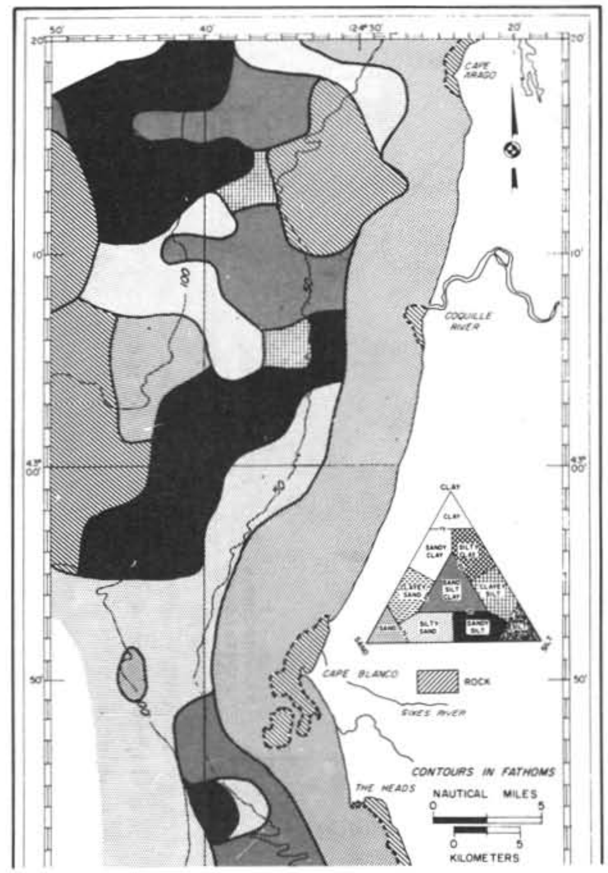


Figure 3. Box corer. After the corer has penetrated the sediment, the large knife cuts through the sediment closing off the bottom of the rectangular box.



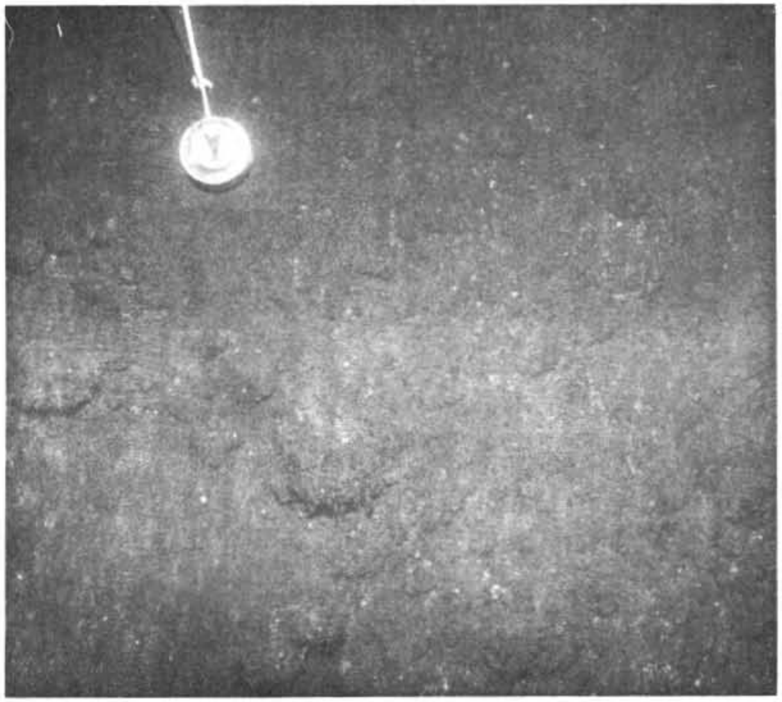


Figure 5. Gravel deposit on inner continental shelf. Water depth 33 fathoms (60 meters). Location 43° 11.5' N and 124° 29.5' W.

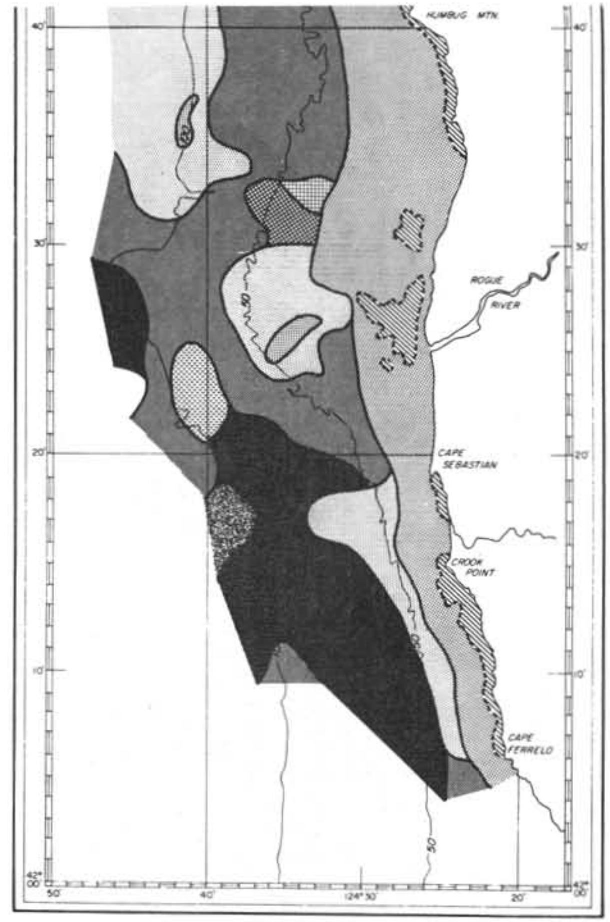


Figure 4. Distribution of surface sediment types. Sediment classification according to Shepard (1954).

terraces onshore, such as the Elk River terrace on Cape Blanco (Baldwin, 1945), indicate that at least minor tectonic instability exists along the southern Oregon coast. The shorelines that formed off southern Oregon may not occur at the same water depths that would be expected on a more stable continental shelf.

Beaches may have formed during these periods of sea-level oscillation or even during earlier oscillations if sea level stabilized for a long enough period of time. Each time sea level was lowered, the coastal streams cut channels across the continental shelf to the shoreline of that time. Both the beaches and the stream deposits were submerged during the final rise of sea level. We might expect to find placer accumulations in both the beach and the stream deposits, provided that the proper conditions for concentration existed in the offshore region where there is an adjacent continental source of valuable minerals.

Sampling and Treatment of Samples

The location of the sampling stations and the positioning for the magnetometer and continuous seismic profiling surveys were determined with the aid of radar fixes on distinctive coastal features or on land-based radar transponders. The navigational accuracy is believed to be better than ± 0.25 nautical mile (0.5 km) up to 5 miles (9 km) offshore.

Surface sediments were collected on a two-mile grid from Coos Bay to Cape Blanco in 1964 and 1965, with additional samples collected in the vicinity of Cape Blanco and between Coquille River and Cape Arago in the summer of 1967. Samples collected on the two-mile grid were analyzed by Runge (1966). Surface sediments south of Cape Blanco were sampled along profiles with additional samples taken in selected areas. Where a more detailed sediment survey was desired, a one-mile grid of stations was occupied. Such a closely spaced grid was used off Cape Blanco and between Cape Sebastian and Cape Ferrelo.

A variety of sampling equipment was used to obtain the surface and subsurface sediments from the continental shelf; these devices include a Smith-McIntyre grab, Shipek sampler, box-corer, and piston corer. The Shipek sampler and the grab sampler were used primarily to obtain homogeneous sediments from the sandy areas on the shelf in water depths shallower than 50 fathoms (92 meters). A total of 157 samples was collected on both R/V YAQUINA and R/V CRIPPLE CREEK (U.S. Bureau of Mines vessel under charter to Oregon State University) cruises. The box-corer used in the sampling program is similar to the one described by Bouma and Marshall (1964), with a few minor modifications (fig. 3). This type of sampler takes an essentially undisturbed sample, even in sandy bottoms, and has a capacity of 0.1 m^3. The box corer is used to obtain large samples up to 45 cm in length; the cores then can be subsampled onboard ship or in the laboratory. Fifty-two box cores were taken on the continental shelf, largely in the vicinity of Cape Blanco and the Rogue River, and several piston cores ranging up to 4 meters in length also were collected on the shelf.

All unconsolidated sediment samples, including subsamples, were analyzed for sediment texture and heavy mineral content; selected samples were analyzed for their authigenic mineral content. The textural parameters have been determined for approximately 311 surface and subsurface samples on the southern Oregon continental shelf. Particle settling techniques were used to analyze all sediment samples for their textural properties. The sand fraction (> 0.062 mm) was analyzed with the Emery (1938) settling tube, while the fine fraction (< 0.062 mm) was analyzed by a soil hydrometer. The results of these two analyses were then combined for each sample to complete the textural analysis. Only the sand-silt-clay percentages, according to the nomenclature of Shepard (1954) are presented here.

Heavy mineral analyses were made on 173 surface and 71 subsurface samples. The heavy mineral separation was made with tetrabromoethane (specific gravity 2.96); only the sand fraction of the sediment was used.

The magnetic content of the sand fraction of selected samples was determined by passing a horseshoe magnet over the sediments. The magnetic minerals consist chiefly of the opaque mineral magnetite, minor amounts of ilmenite, and non-opaque minerals with magnetic inclusions. The magnet was passed over the samples several times until the number of non-opaque minerals with magnetic inclusions exceeded the number of opaque magnetic minerals in the magnetic fraction. The total magnetic content of the sediment samples was then computed on a weight basis.

Sediments

Areal distribution of sediment types

The surface sediment distribution pattern on the southern Oregon continental shelf is quite varied and irregular (fig. 4). The sand zone, which generally consists of detrital quartz, feldspar, and ferromagnesian minerals, extends from the shoreline out to a water depth of approximately 40 fathoms (73 meters) along most of the shelf. The width of the sand zone varies with the width of the shelf in this area. For example, the shelf is narrow south of the Rogue River and the sand zone also narrows to the south. Much of the inner shelf sand is probably relict transgressive material deposited during the last rise in sea level (Runge, 1966). These sands are extensively reworked by benthonic organisms and lack internal structures. Deposition of modern sands, those sands which are in equilibrium with the present environment, is confined largely to the water depths shallower than 10 fathoms (18 meters). Sediments immediately seaward of the sand zone generally consist of either silty sand or sand-silt-clay. Seaward of these two sediment types, sandy silt or clayey silt are most common. Deposits of gravel (fig. 5), sand, and silty sand occur on the outer continental shelf and are surrounded by or partially covered with the modern fine-grained silts and clays derived from local coastal rivers. The sandy sediments on the outer shelf appear to be mostly relict sediments which are out of equilibrium with their present environment. They consist of either detrital quartz and feldspar or the authigenic mineral glauconite, or both. Glauconite is confined to the continental slope and generally is absent in water depths shallower than 100 fathoms (183 meters), except in the vicinity of Coos Bay and the Coquille River, where it occurs in waters as shallow as 60 fathoms (110 meters).

Rocks crop out in numerous areas on the continental shelf, particularly between Cape Arago and Cape Blanco. Most of these areas are associated with anticlinal structures and may have a thin veneer or pockets of unconsolidated sediment covering portions of the rocky surfaces. Bottom photographs taken over these rocky areas show a general lack of sediment, which indicates that shelf currents tend to sweep these surfaces clean of sediments, except on topographic lows.

The nature of the sediments at depth generally is known only in the upper few tens of centimeters; a limited number of piston cores provide information in the upper two to four meters. Sediments containing approximately 100 percent sand generally are confined to the inner shelf in water depths shallower than 25 fathoms (46 meters). However, cores taken on the outer continental shelf also may have a high detrital sand content. In general, there is an increase in the percentage of sand with depth in the cores. Reversals in sand content are notedin a few cores and may reflect the minor regressive cycles suggested by Curray (1965) for the Holocene Transgression which started about 17,000 years ago.

The unconsolidated sediment distribution and thickness on the continental shelf was determined from data obtained from a 5000-joule EG and G sparker system. Sparker records show that there is usually only a thin veneer of sediment less than 15 meters thick over the majority of the shelf which lies between Cape Blanco and Cape Arago. However, small isolated pockets of unconsolidated sediment probably occur in the rocky areas on this part of the shelf. Between Cape Blanco and Cape Ferrelo the unconsolidated deposits range in thickness from less than 15 meters to more than 35 meters, but average only about 20 meters in thickness.

Heavy mineral concentrations

Several well-defined heavy mineral concentrations occur in the surface sediments on the continental shelf off southern Oregon (fig. 6). The heavy mineral percentages range from 1 to more than 40 percent of the total sand fraction. The most extensive and most prominent heavy mineral zones occur in the vicinity of the Rogue River. This large surface concentration is 20 miles (37 km) long and extends 10 miles (19 km) north and 10 miles (19 km) south of the river mouth and apparently extends from the shoreline

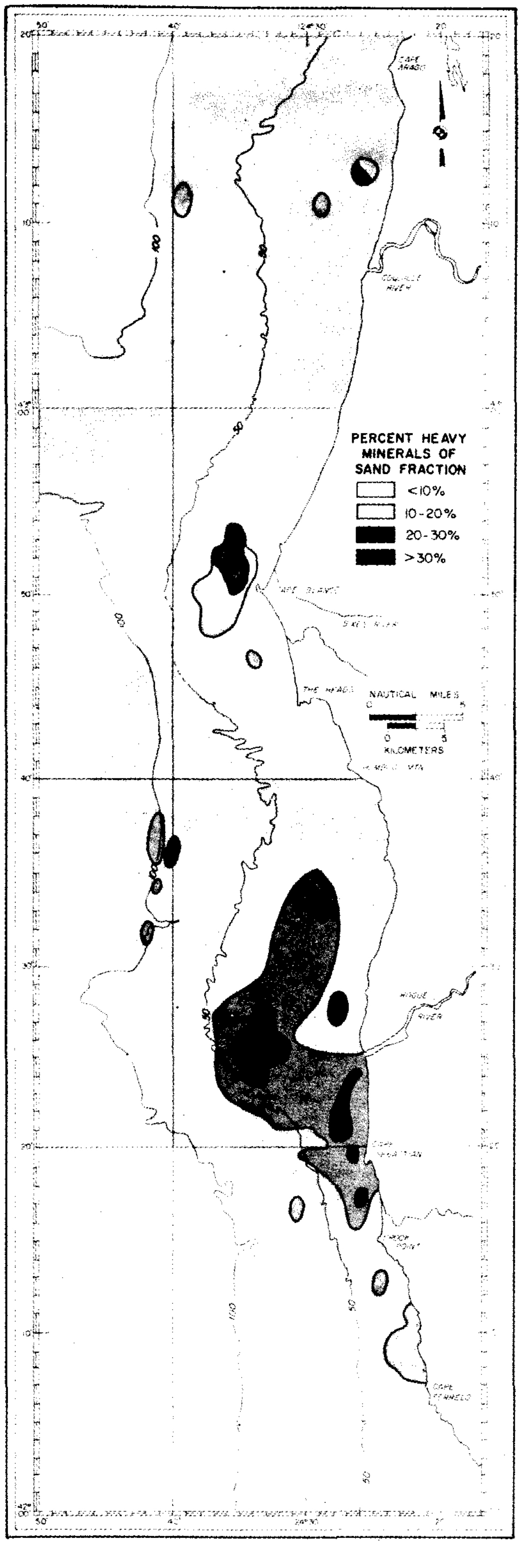


Figure 6. Heavy mineral concentrations in surface sediments.

out to a depth of 50 fathoms (90 meters). It is not known whether the tongue-shaped body of heavy minerals, which lies north of the mouth of the Rogue River, has a shoreward extension; the Rogue Reef just north of the river mouth has limited the sampling in this area. Richer heavy mineral concentrations, 20 to 30 percent, occur within this large surface deposit. One of these concentrations is located due west of the mouth of the Rogue River in water depths ranging between 30 and 45 fathoms (55 to 82 meters); it has been confirmed by repeated sampling. Another heavy mineral concentration of similar magnitude is located immediately south of the Rogue River in 3 to 25 fathoms (6 to 46 meters). This linear concentration bends towards the river mouth, indicating that the Rogue River is indeed the major source of heavy minerals. Isolated patches of surface heavy mineral concentrates occur to the south of the one just described, between Cape Sebastian and Crook Point, and are located in similar water depths.

Somewhat smaller heavy mineral surface concentrations occur between Crook Point and Cape Ferrelo and may extend from the shoreline out to approximately 32 fathoms (60 meters). These concentrations do not exceed 20 percent heavy minerals by weight.

A less extensive but higher concentration of heavy minerals lies off Cape Blanco and the Sixes River. This concentration is approximately 7 miles (13 km) long and 3 miles (6 km) wide; it is found in water depths ranging between 10 and 30 fathoms (18 and 55 meters). The concentration ranges up to 33 percent in heavy minerals.

An exceptionally high heavy mineral concentration (43 percent at the surface) was found at 81 fathoms (150 meters) midway between Cape Blanco and the Rogue River (42°35.9', 124°41.0'). The area was sampled with a piston corer and has the highest percentage of heavy minerals found to date in the surface sediments off southern Oregon. Other surface samples taken in this area frequently contain more than 20 percent heavy minerals.

Surface samples taken between Cape Arago and the Coquille River have failed to reveal any large or extensive heavy mineral concentrations on the inner part of the continental shelf. The region to the west of the small-sized concentration at approximately 10 to 20 fathoms (18 to 36 meters) is extremely rocky and probably has only a thin veneer of sediment. If high concentrations are present in this area, they probably occur in isolated patches or pockets.

The subsurface concentrations of heavy minerals, with few exceptions, are similar to those observed in the surface sediments (fig. 7). All of the subsurface samples analyzed for their heavy mineral content contain more than 75 percent sand-size material. Piston core 6708-43 (81 fathoms) has 56 percent heavy minerals a few centimeters below the surface. This is the highest concentration of heavy minerals found to date in cores or at the surface. All sediments sampled in this core produced more than 40 percent heavy minerals. At approximately the same water depth, core 6708-44 displays a marked increase in heavy minerals (more than 30 percent) near the bottom of the core.

With the exception of the two cores just described, the highest heavy mineral content found in the cores off southern Oregon to date occurs in the vicinity of the Rogue and the Sixes Rivers. A number of cores in these areas show a slight decrease in heavy mineral content with depth, while others increase or remain constant.

Magnetic content of sands

Virtually all of the placer deposits in southern Oregon contain an appreciable quantity of black sand, which commonly consists of chromite, ilmenite, and magnetite. Magnetite content varies from one placer to another in the land deposits, but it is generally present in sufficient quantity to produce a substantial magnetic attraction, which can be detected with a magnetometer. In the vicinity of the Rogue River, the magnetite:chromite ratio is about 10:1 and the magnetite:ilmenite ratio about 10:1 (Griggs, 1945).

The magnetic content (chiefly magnetite with some ilmenite and nonopaque minerals with magnetic inclusions) of the sand fraction of the unconsolidated sediments was determined in a number of box cores, piston cores and surface samples (fig. 8). In general, the percentages of magnetic material in the surface and subsurface samples is highest south of the Rogue River and significantly decreases northward to the vicinity of the Coquille River. Near the Rogue River the magnetic content of all sediments averages about 10 percent; near Cape Blanco the average magnetic content is 5 percent; and off the Coquille River magnetic contents average about 1 percent. Data from previous studies (Day and Richards, 1906) show that the percentage of magnetite in the beaches and elevated marine terraces decreases markedly from the Oregon-California border. The offshore content of magnetite and other magnetic minerals coincides with the trends of the onshore deposits.

The highest percentage of magnetic material (up to 18 percent) found in the sediments occurs throughout piston core 6708-43 and at the base of box core 6708-44; both cores were taken on the outer continental shelf at 82 and 81 fathoms (150 and 148 meters), respectively. Other sediments high in magnetic material occur in the large surface concentration of heavy minerals west and north of the Rogue River (fig. 6).

In the cores the magnetic content is generally the same in the subsurface as it is at the surface or varies slightly with depth. In the vicinity of the Rogue River, with a few exceptions, there is a general increase in magnetics with depth, but in the vicinity of Cape Blanco there seems to be a slight decrease with depth. No specific trends were noted in the only core examined off the Coquille River.

Heavy metal analyses

A number of surface sediment samples have been analyzed for their gold

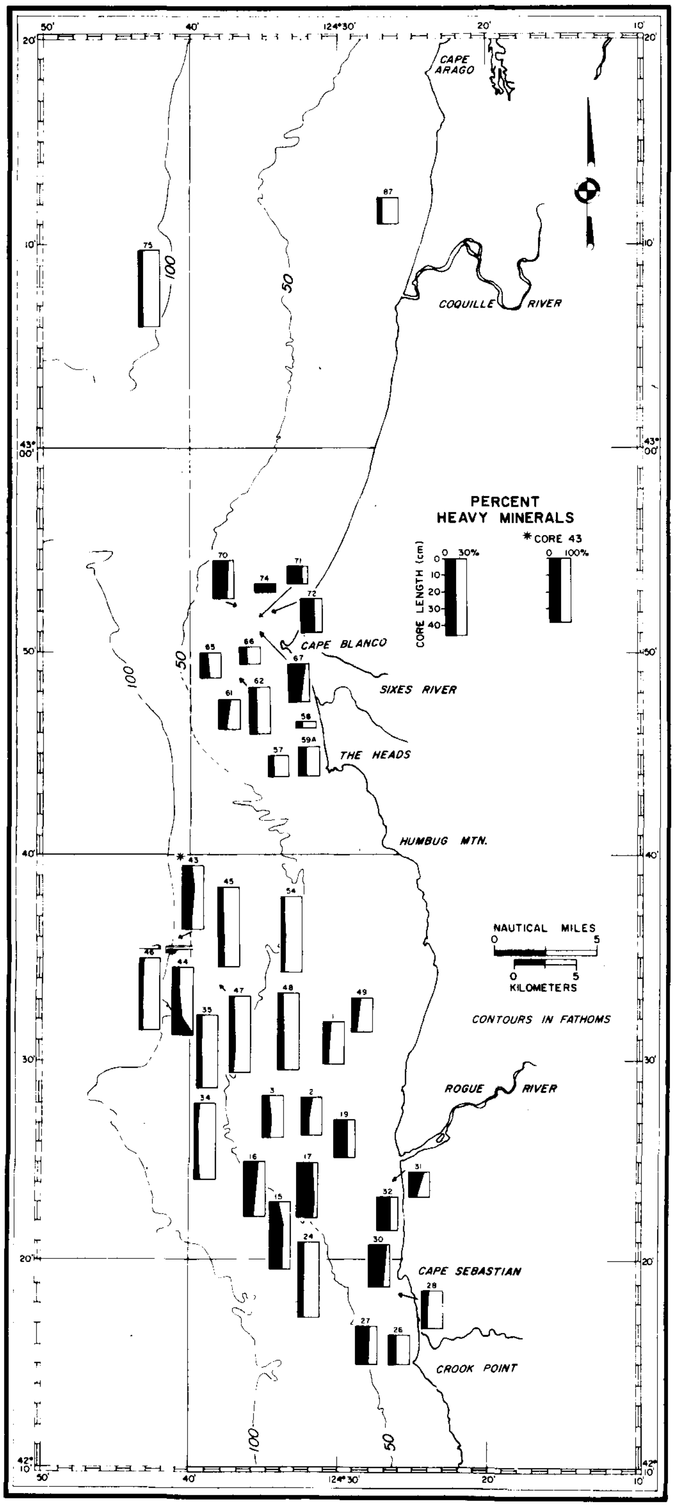


Figure 7. Distribution of heavy minerals in box cores. Sample number or arrow indicates core location. Note that the concentration scale in all cores ranges from 0-30%, except core 43 which is 0-100%.

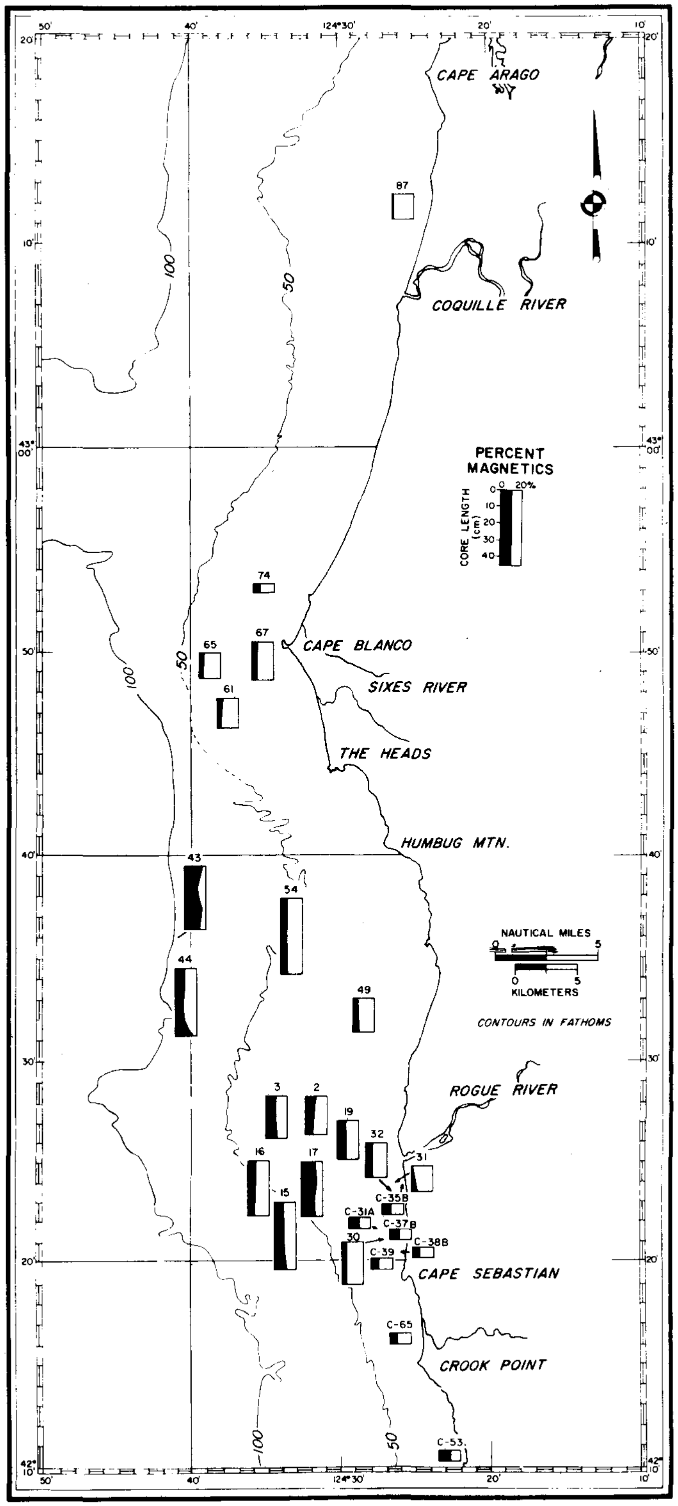


Figure 8. Distribution of magnetic materials in box cores. Sample number or arrow indicates core location.

content by the U.S. Geological Survey. The results of the analyses are summarized in a separate report (Clifton, 1968).

Magnetometer Survey

A reconnaissance magnetometer survey was made off the Rogue, Sixes, and Coquille Rivers where the surface and the subsurface concentrations of heavy minerals, and sediment texture, suggested the existence of possible placer accumulations. Approximately 72 nautical miles of magnetometer track lines were run off these rivers (fig. 9).

The total intensity magnetic field was measured with a ship-towed proton precession magnetometer which has an instrumental accuracy of $\pm$ 5 gammas. Our magnetograms were compared with the magnetograms from Tucson, Ariz., to determine the effect of magnetic storms. No storms were noted on any of our records.

Magnetic anomalies

Several prominent magnetic anomalies (A through H) were discovered in the magnetic survey (figs., 10, 11, 12; refer to fig. 9 for the locations of the anomalies on the shelf). These anomalies range in magnitude from 10 to 300 gammas. They are narrow and steep sided, which suggests that the source is very shallow and rather narrow in dimension. These anomalies could be small intrusive or extrusive bodies, or magnetite-bearing black sand deposits.

The largest anomalies occur in the vicinity of the Rogue River. Peaks of anomalies A, E, and F occur at water depths of 45, 37, and 40 fathoms (83, 70, and 73 meters), respectively (fig. 10). Another prominent anomaly, B, is located at a depth of 20 fathoms (37 meters). A group of large, narrow anomalies was observed immediately south of the entrance of the Rogue River in about 10 fathoms (18 meters) of water (fig. 11, C). The most prominent anomalies observed anywhere occur directly off the entrance of the Rogue River, along an imaginary line projected seaward from the general trend of the river mouth onshore (fig. 11, D). Each anomaly peak falls on this line, which was traversed at a number of different points.

Two less prominent magnetic anomalies (G and H) occur in the vicinity of the Sixes River and Cape Blanco (fig. 12). The anomalies occur as doublets along each profile and are located between 16 and 25 fathoms (29 and 46 meters) on two different east-west magnetometer tracks spaced approximately 2 miles (4 km) apart.

Magnetic anomalies also were observed off the Coquille River area but are less definitive and are not discussed here.

Analysis of magnetic data

An attempt has been made to determine the dimensions and the magnetic

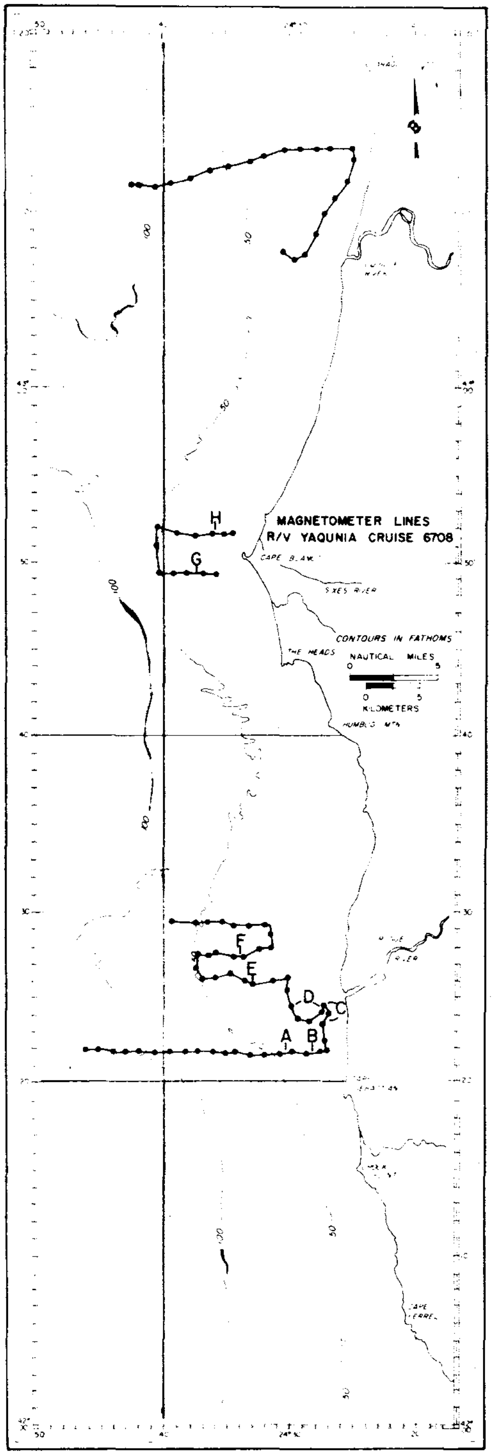


Figure 9. Magnetometer survey profiles. Letters indicate locations of magnetic anomalies. (See figures 10, 11, and 12.)

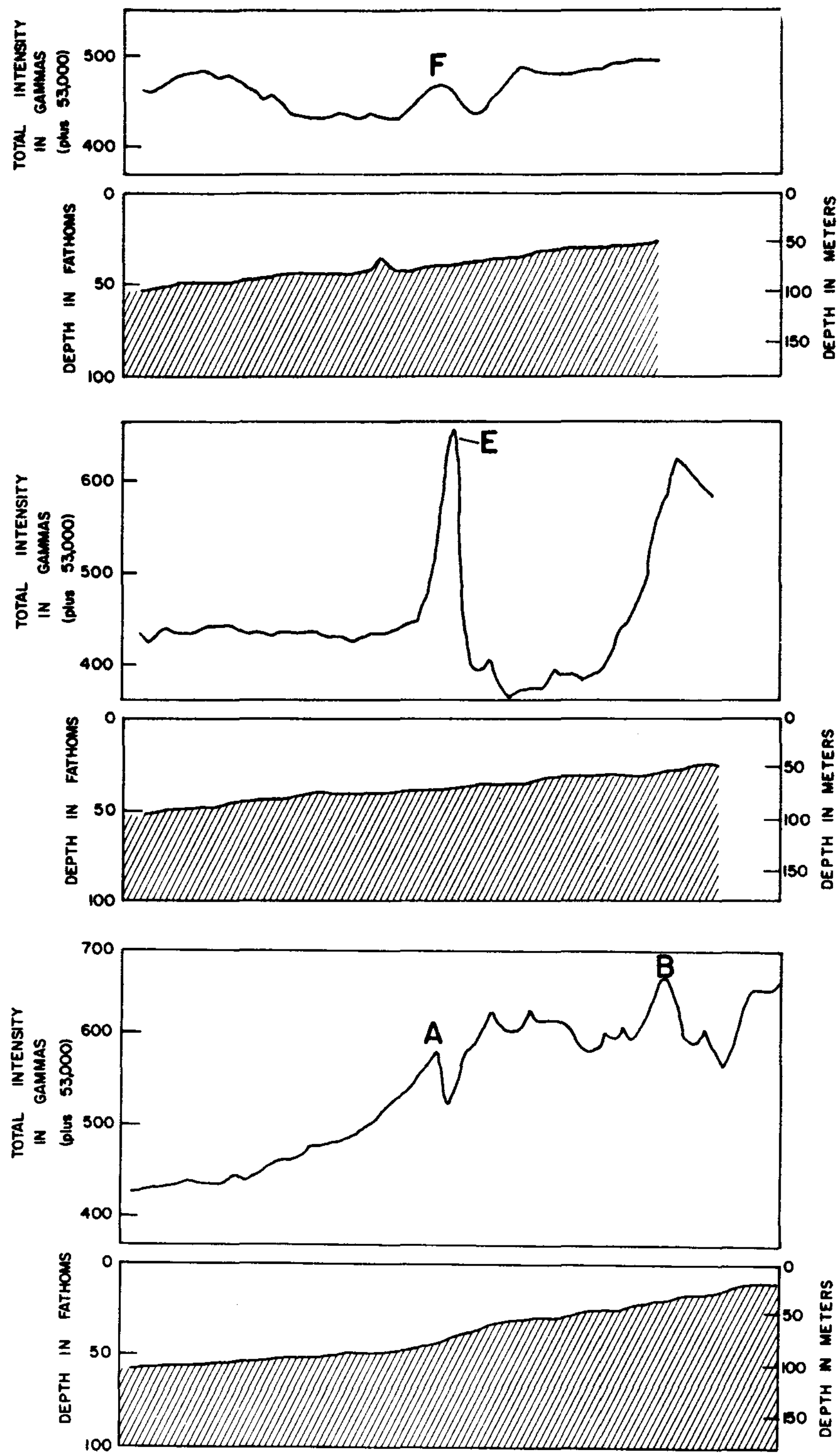


Figure 10. Total magnetic intensity values and bathymetry along three east-west profiles off the Rogue River. Letters indicate magnetic anomalies. (See figure 9 for location.)

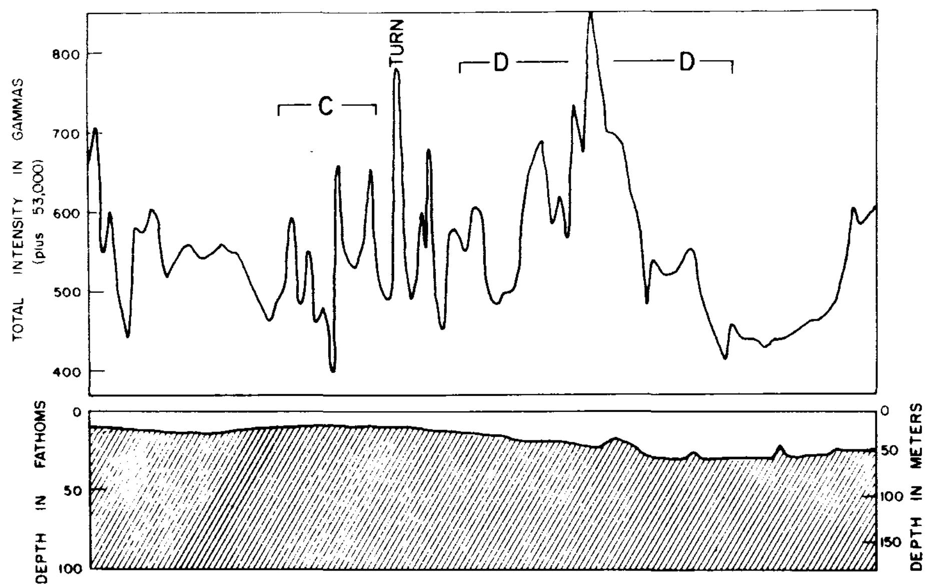


Figure 11. Total magnetic intensity values and bathymetry immediately south of the Rogue River (left-hand side) and off mouth of Rogue (right-hand side). TURN indicates separation between profiles. Letters indicate magnetic anomalies. (See figure 9 for location).

susceptibility of the bodies causing the magnetic anomalies E (Rogue River), and G (Sixes River) on the continental shelf. A number of hypothetical models were constructed with the aid of a computer to simulate the magnetic anomalies observed at these two locations.

The assumption is made that the magnetic anomalies are produced by magnetite-bearing placers with dimensions and a magnetic susceptibility similar to the black sand deposits in the modern beaches and the elevated marine terraces explored and exploited on land. Pardee (1934) and Griggs (1945) give a detailed explanation of the physical characteristics of these deposits. An additional assumption is made that the anomalies are produced by submerged beach placers which parallel the general trend of the present-day shoreline. Only the width and the thickness of the body can be considered because the anomalies are but single profiles across the source.

The steep-sided, large magnetic anomaly observed off the Rogue River (fig. 10, E) could be produced by two placer bodies each 10 meters thick and 25 meters wide and spaced 45 meters apart (fig. 13). Depth to source calculations indicate that the tops of the bodies are approximately 75 meters below sea level or close to the sediment-water interface. A magnetic content of from 12.6 to 20.9 percent in body no. 1 and 7.5 to 12.4 percent in body no. 2 is sufficient to produce the magnetic susceptibility required to construct the anomaly E. The magnetic content measured in the surface and the subsurface sediments off the Rogue River, where the anomaly was

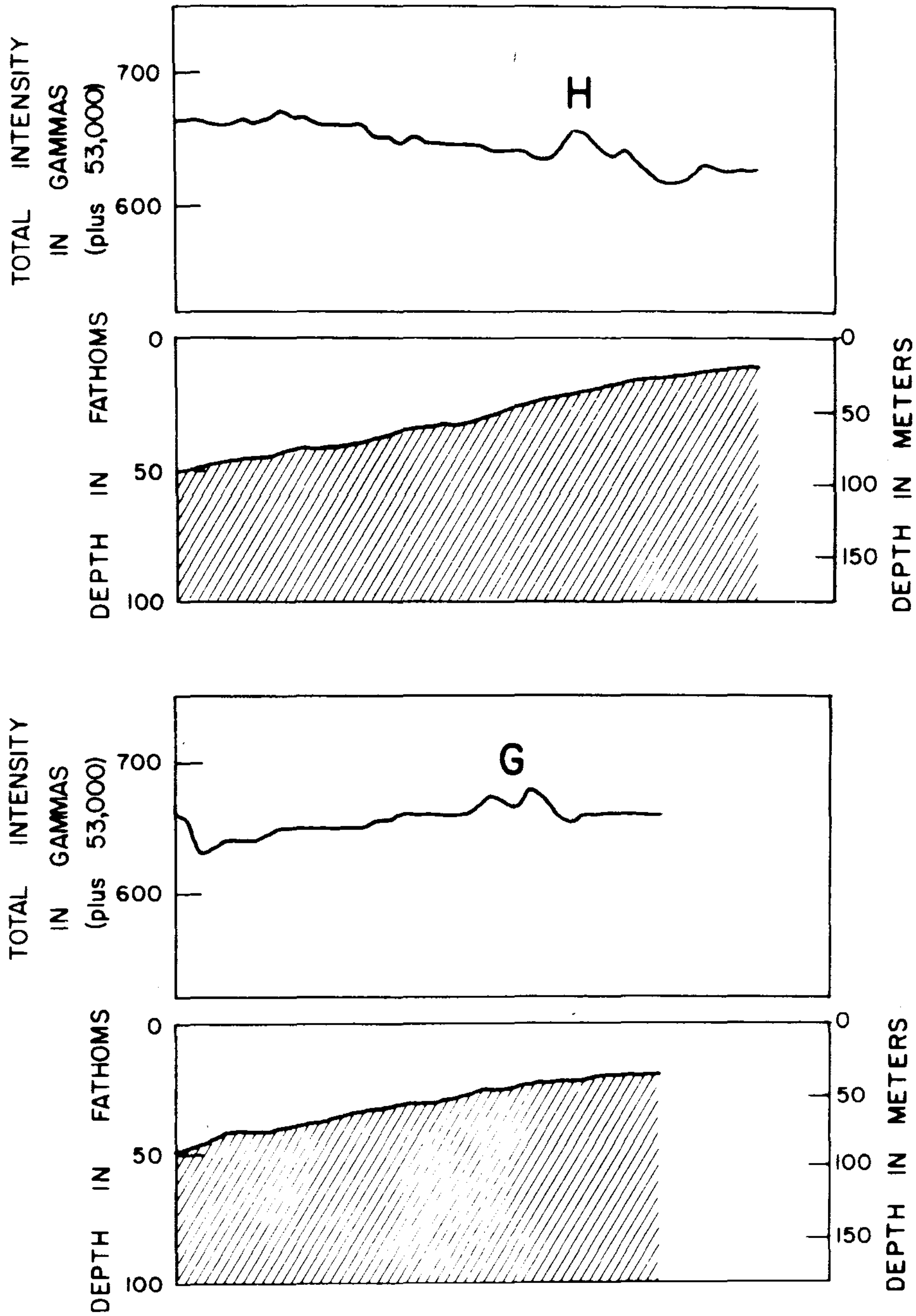


Figure 12. Total magnetic intensity values and bathymetry along two east-west profiles off Cape Blanco. Letters indicate magnetic anomalies. (See figure 9 for location.)

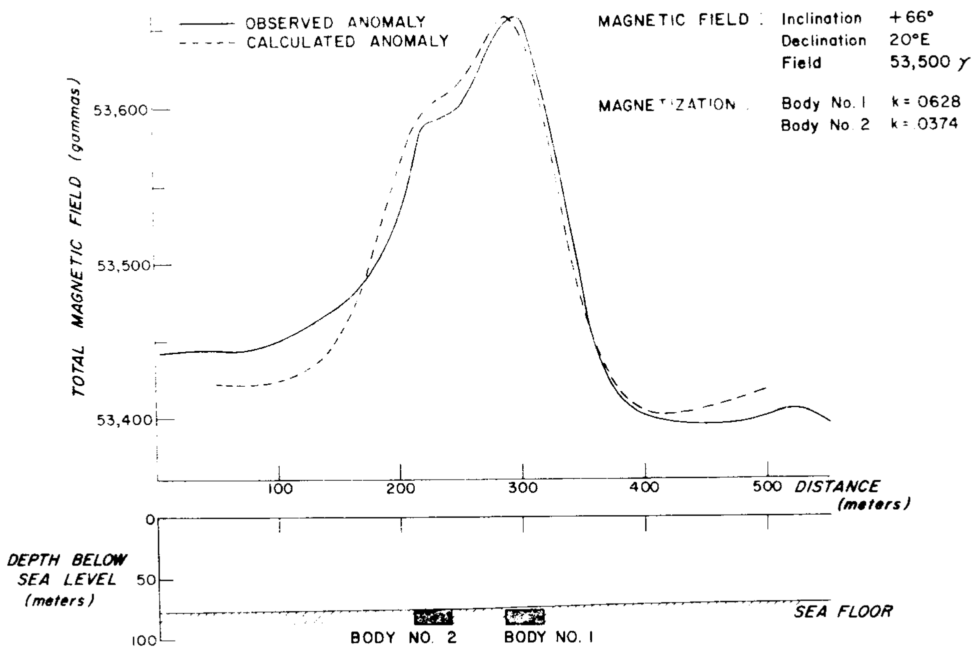


Figure 13. Calculated anomaly for simple model of magnetic anomaly E (Rogue River). (See figure 10 for complete profile.)

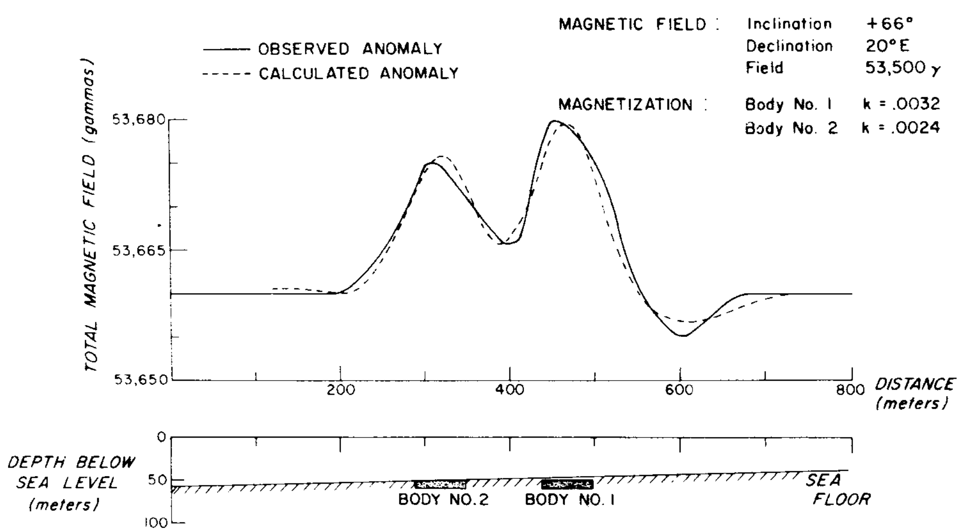


Figure 14. Calculated anomaly for simple model of magnetic anomaly G (Cape Blanco). (See figure 12 for complete profile.)

observed, is as high as 15 percent and averages about 10 percent (fig. 8). The total thickness of unconsolidated sediment in this area is approximately 21 meters.

The closely spaced double magnetic anomalies observed off Cape Blanco (fig. 12, G) can be produced by two magnetic bodies 10 meters thick and 60 meters wide with a magnetic content of 0.6 to 1.1 percent (body no. 1) and 0.45 to 0.83 percent (body no. 2) (fig. 14). These estimates are minimum magnetic percentages since the model uses large source bodies. The magnetic content of the sands off Cape Blanco averages about 5 percent (fig. 8). Depth to source calculations indicate that the tops of the anomalies are 50 meters below sea level or close to the sediment-water interface. The unconsolidated sediment cover is approximately 12 meters thick in the area where the anomaly was observed.

Magnetic anomalies were also observed between the Coquille River and Cape Arago, but they are not as large nor as definitive as those observed to the south. The lower magnetic content in the sands (less than 2 percent) in this area may be too small to produce well-defined anomalies that can be detected by a magnetometer with a ± 5 gamma accuracy.

Although the models of the observed magnetic anomalies give us some indication of the general dimensions and the magnetic susceptibility of the anomaly source, it is reasonable to assume that the entire body is probably not a homogeneous placer with an even distribution of magnetite. Pardee (1934, p. 5) states that "the backshore of the present beach and the ancient beach at an altitude of about 170 feet have been the most productive. The pay streak generally ranges from a few feet to 200 or 300 feet in width, is 3 or 4 feet thick in the middle, and tapers towards the edges. It consists largely of alternating layers of black and gray sand with more or less cobbles, boulders, and driftwood and in the ancient beach, is mostly covered with a barren sand 'overburden' 20 to 60 feet thick." It is most likely that the submerged placers will have similar physical and compositional characteristics and that the anomalies observed are an average of several thin, magnetite-rich superimposed layers of varying thicknesses.

Discussion of Results

Several lines of evidence, magnetics, and heavy mineral content, suggest that magnetite-bearing placer deposits may exist on the continental shelf off southern Oregon. Both stream and beach placers may be present, although buried stream channels have not as yet been defined and the existence of stream placers is suggested only by magnetometer data.

Surface and subsurface concentrations of heavy minerals in the marine sands are distinctly related to major streams, such as the Rogue River and Sixes River, which have sources of economic minerals in their drainage basins. Most of the largest and richest concentrations, with a few exceptions, are found from 1 to 7 miles (2 to 13 km) seaward of the present-day river mouths and in waters as deep as 50 fathoms (92 meters). An even higher concentration of heavy minerals is found on the outer edge of the continental shelf between the Rogue River and Cape Blanco in 80 to 100 fathoms (146 to 185 meters).

Modern beach sand generally is not transported offshore much below surf base (Dietz, 1963) or wave-induced surge (Vernon, 1966) or to water depths greater than about 10 fathoms (18 meters), except where submarine canyons intersect the littoral zone such as those which occur off southern California (Emery, 1960). Furthermore, Kulm and Byrne (1966) have shown that Oregon estuaries tend to trap sand within their estuarine systems. Only the suspended or silt-clay load of the rivers is carried seaward and deposited either on the central part of the shelf or on the continental slope as a mud facies; there appears to be a general lack of deposition on the outer continental shelf as pointed out by Curray (1965). The sands on the southern Oregon shelf that lie between the 10-fathom (18-meter) contour and the beginning of the central shelf mud facies at 40 fathoms (73 meters) are presumably relict Holocene Transgressive sands deposited during the last rise of sea level. These sands and their associated heavy mineral concentrations are apparently relict materials which are out of equilibrium with their present environment. Although these sands may be reworked periodically by shelf bottom currents, the persistence of the heavy mineral concentrations at depth in the cores and the association of these concentrations with their continental sources indicate that these zones have not been formed by the present environmental conditions. The isolation of the heavy mineral zone off Cape Blanco from the present shoreline also suggests that these deposits are not in equilibrium with their present surroundings; the same reasoning applies to the heavy mineral zones that occur 12 miles (22 km) from shore and in 80 fathoms (146 meters) of water. The relict deposits on the inner shelf probably were formed in a beach environment during one of the postulated regressions which interrupted the general Holocene Transgression. Several stillstands of the sea would be necessary during this complex period to concentrate the placers in the beaches.

The surface and near-surface concentrations of heavy minerals by themselves are not sufficient evidence to suggest that placer accumulations are nearby. However, the large magnetic anomalies associated with these deposits suggest that the concentrations may be black sand deposits with vertical and horizontal dimensions similar to the adjacent land placers. Some or all of the observed magnetic anomalies could be caused by intrusive or extrusive bodies in the earth's crust; however, the steepness and the shape of a number of the anomalies generally are not typical of these features and depth to source calculations indicate that the anomaly source is at or near the sea floor. Although igneous rocks are capable of producing some of the anomalies in the vicinity of the Rogue River, such rocks are not known in the vicinity of Cape Blanco. A regional magnetics survey of the southern Oregon shelf (Emilia and others, 1968) shows that there are no positive anomalies in the Rogue River and Cape Blanco areas; however, this survey was restricted to water depths greater than 40 fathoms (73 meters).

The only way to determine whether or not magnetic anomalies are placers of commercial importance is to sample them in depth by drilling and coring. Before such an exploratory drilling program is attempted, a more detailed magnetometer survey will be made of the magnetic anomalies to determine their orientation and lateral continuity. In addition, a high resolution seismic survey will be made in the areas of the anomalies and heavy mineral concentrations to detect sand and gravel deposits which might be associated with former shorelines or fluvial deposits.

Conclusions

1. Preliminary geological and geophysical data suggest that magnetite-bearing placer deposits may exist on the southern Oregon continental shelf.

2. Several well-defined surface and near-surface heavy mineral concentrations (ranging up to 56 percent of the total sand sample) have been discovered on the shelf in water depths ranging between 10 fathoms (18 meters) and 100 fathoms (183 meters). These concentrations are believed to be relict deposits formed in an environment different from that which exists in the area where these deposits occur today. Heavy mineral concentrations of similar magnitude are found in the modern-day beaches and in the older elevated marine terraces in southern Oregon. The offshore concentrations are located off the mouths of the Rogue River and Sixes River, which have sources of heavy metals in their drainages.

3. Associated with the offshore heavy mineral concentrations are high percentages of magnetic constituents, chiefly magnetite. There is a marked decrease in the percentage of magnetic constituents from the Oregon-California border to the vicinity of the Coquille River.

4. Large magnetic anomalies are associated with the surface and near-surface heavy mineral concentrations. Simulated model studies of these anomalies show that submerged placer deposits with the dimensions and the magnetic content of the onshore placers could give rise to the observed anomalies.

5. There appears to be some correlation of the heavy mineral concentrations and their associated large magnetic anomalies with the minor regressions that are postulated by Curray (1965) to have interrupted the general Holocene Transgression. If stillstands of the sea did occur and if there was sufficient time for a beach to develop, placer accumulations may be expected at depths ranging between 65 and 10 fathoms (120 and 18 meters). Because of the tectonic instability of the southern Oregon continental margin, no correlation of submerged shorelines in this area can be made with those in more stable areas without further investigation.

6. Further geophysical investigation is needed to determine the orientation and the lateral continuity of the probable placer deposits on the

southern Oregon continental shelf. A detailed magnetometer survey and a high-resolution seismic survey are necessary before the probable deposits are drilled and cored.

Acknowledgments

We express our sincere appreciation to Drs. John V. Byrne and H. Edward Clifton for their critical review of this manuscript. We also wish to thank the following people for their help in collecting and analyzing the data presented herein: G. A. Fowler, D. R. McKeel, R. Hunter, E. A. Crecelius, L. Phillips, F. J. Gunther, R. C. Roush, K. Scheidegger, J. J. Spigai, D. W. Allen, J. R. Duncan, R. L. Stewart, W. E. Bales, A. J. Mackay, and H. Findley. Funds for the research and the ship time were provided by the U.S. Geological Survey, Contract No. 14-08-0001-10766.

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Editor's note: As the foregoing paper went to press, the U.S. Geological Survey simultaneously published its Circular No. 587, entitled "Gold distribution in surface sediments on the continental shelf off southern Oregon: a preliminary report." This circular, written by H. E. Clifton, is obtainable free of charge from the U.S. Geological Survey, Washington, D.C. 20242. The publication describes the gold distribution on the shelf as it relates to the possible placer deposits described by Kulm, Heinrichs, Buehrig, and Chambers and thus complements their paper. These studies have resulted from a joint research program between the U.S. Geological Survey and the Department of Oceanography, Oregon State University, under contract. They have been conducted as part of the Geological Survey's Heavy Metals program, for the purpose of exploring the potential for economic concentrations of black sand on the continental shelf off southern Oregon. These two papers, combined, summarize the tentative conclusions reached as a result of the first year of this joint study.

GOLD AND SILVER IN OREGON PUBLISHED

The long-awaited, but timely, volume "Gold and Silver in Oregon" has been published by the Department as Bulletin 61. The 337-page publication represents 5 years of compilation by the authors, Howard C. Brooks and Len Ramp, geologists with the Department. Their sources of information consisted of an enormous collection of unpublished and published data, together with their own first-hand knowledge of the subject.

The bulletin describes the history, production, mineralization and geologic occurrence of gold and silver in the state. In all, some 500 lode and placer mines and prospects are discussed. Bulletin 61 is for sale by the Department at its Portland, Baker, and Grants Pass offices, for $5.00.

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THE GOLDEN YEARS OF EASTERN OREGON

By Miles F. Potter and Harold McCall

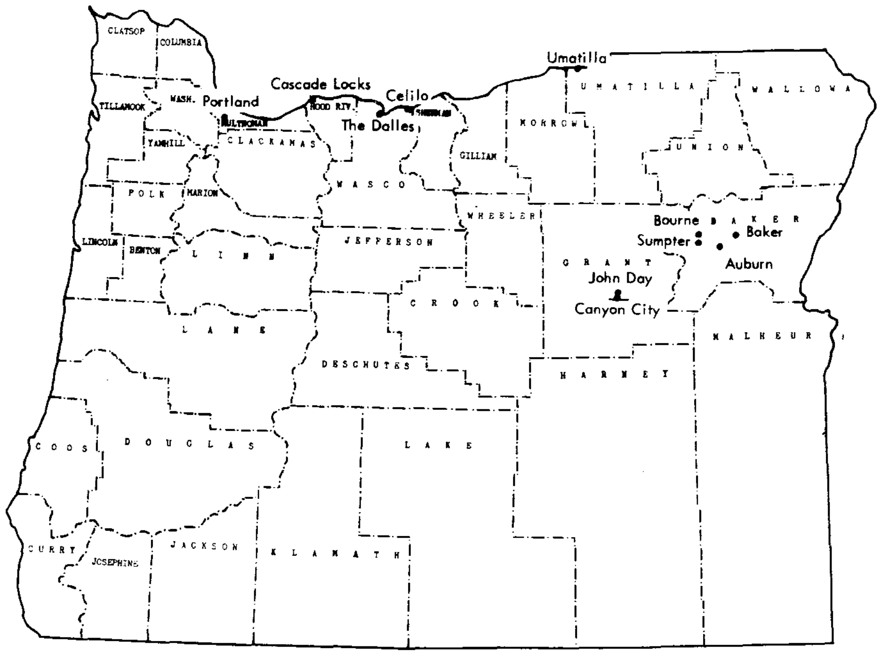
The following pictorial article on the golden years of eastern Oregon, by Miles F. Potter and Harold McCall, is an abstract from their manuscript of a forthcoming book they are calling "Golden Pebbles." Potter is a long-time resident of eastern Oregon and an amateur historian of some of the early gold camps in Grant and Baker Counties. McCall is a photographer in Oregon City with a keen interest in the history of gold mining. The two authors have been working together for a number of years assembling photographs and data from many sources for their book. Their article and the accompanying pictures in this issue of The ORE BIN remind us of a commonly forgotten fact: that the discovery of gold in eastern Oregon had a tremendous impact on the economy and development of the entire region which is still felt a full century later.

Gold mining was also the mainstay of the early economy of southwestern Oregon and played an equally significant role in the development of that region (see: "Lest We Forget," by F. W. Libbey, June 1963 ORE BIN). Ed.

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

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

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

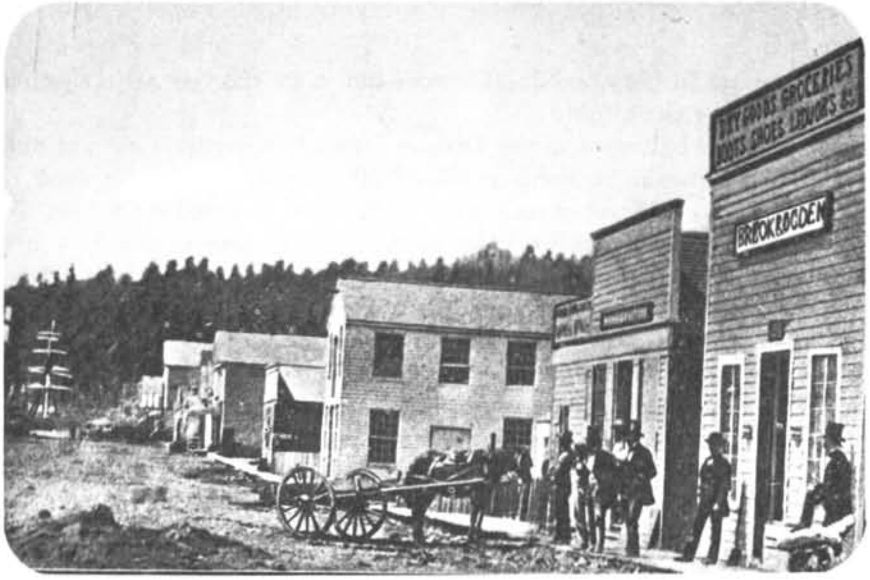


Index map of Oregon, showing transportation points along the Columbia River and gold-mining centers in Baker and Grant Counties

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

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

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



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

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

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

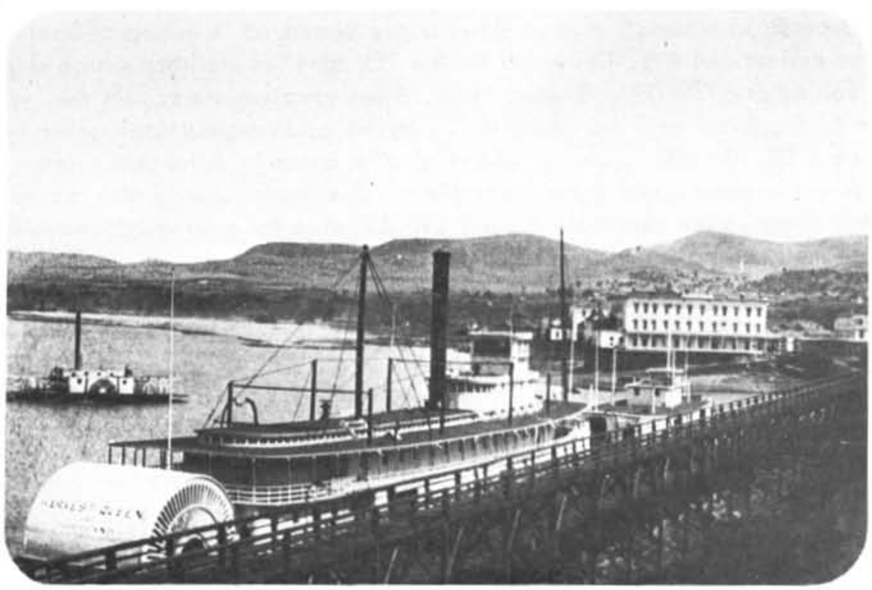
At the outset, and with no competition, transportation costs on the river to The Dalles varied between $40 and $50 per ton. The passenger fare was $20 with meals extra. The freight on a dozen brooms was a dollar and it was not until 1869, when a trail was opened through the Gorge for cattle and pack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

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

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

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

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



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

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

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

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

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

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

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

(Text continued on page 118.)

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

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

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

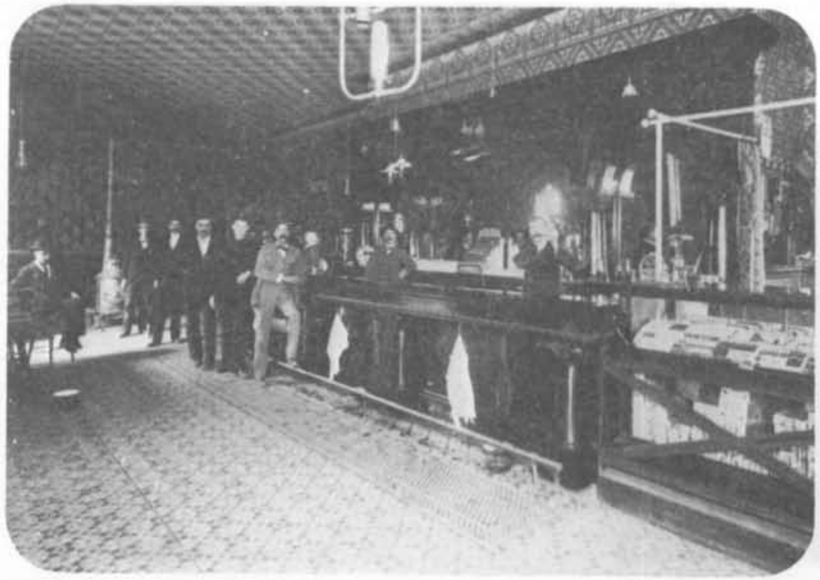
Bourne, once known as Cracker City, is situated 6 miles north of Sumpter on Cracker Creek and is surrounded by some of the best mining property in the state -- the North Pole, E & E, Columbia, Golconda, and many other noted lode properties. Founded in 1890, Bourne soon had a population of 1500, with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

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

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

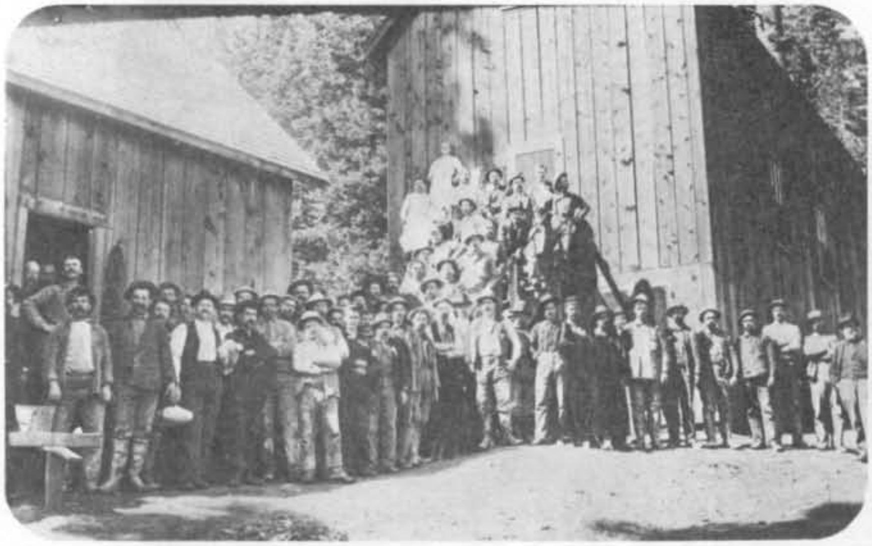
The small, but rich, Great Northern mine, "on the north side of Canyon Mountain" near Canyon City in Grant County, was discovered by Ike Guker, standing in the center. Man on right, standing on bank, is Frank McBean, old-time stage driver to Winnemucca. It is known that Guker let visitors pick nuggets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

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



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

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



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

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

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

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

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

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EAGLE ROCK QUADRANGLE, CROOK COUNTY, MAPPED

A geologic reconnaissance map of the Eagle Rock quadrangle in Crook County by A. C. Waters and R. H. Vaughan has been issued by the U. S. Geological Survey as Miscellaneous Geologic Investigations Map I-540. The quadrangle, bounded by lat. 44° 00' and 44° 15' and by long. 120° 30' and 120° 45', lies between Prineville and Post. It includes the new Prineville Reservoir and State Park on the Crooked River; however, these two features are not shown because the base map was made prior to their development. The map is in multicolor at a scale of one inch to the mile. An explanation column briefly describes the geologic units, which comprise Clarno and John Day Formations, Columbia River Basalt, Pleistocene lava flows, and Recent landslide materials and alluvium. Map I-540 is for sale by the U.S. Geological Survey, Federal Center, Denver, Colo. 80225 for 75 cents.

* * * * *

METEORITE ARTICLES REPRINTED

"A Collection of Articles on Meteorites" has been issued by the Department as Miscellaneous Paper No. 11. The 39-page, illustrated booklet contains reprints of seven papers, many of them out of print, which have appeared in The ORE BIN in recent years. Six of the articles are by Dr. Erwin F. Lange, professor of general science at Portland State College and local authority on meteorites. Also reprinted is the report on the Port Orford Meteorite by E. P. Henderson, U.S. National Museum, and Hollis M. Dole, State Geologist. The booklet has been published to celebrate 1968 as "The Year of the Meteorite" for Oregon. During this year a concerted effort is being made throughout the State to locate unreported meteorites -- either in the field or in private collections -- in the interest of extending our knowledge of outer space.

Miscellaneous Paper No. 11 is for sale by the Department's offices in Portland, Baker, and Grants Pass for $1.00.

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McBIRNEY TO HEAD UO GEOLOGY DEPARTMENT

Dr. Alexander R. McBirney, who has been in charge of the new Center for Volcanology at the University of Oregon, has been assigned the chairmanship of the Department of Geology. He fills the position of Dr. Lloyd W. Staples, who has headed the department for the past 10 years. Following a year of sabbatical leave, Staples will devote full time to teaching and research. Replacing Dr. McBirney as director for the Center for Volcanology will be Dr. Daniel F. Weill, associate professor of geology.

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GOLD AND SILVER IN OREGON

Issued by
State of Oregon Department of Geology and
Mineral Industries

"GOLD AND SILVER IN OREGON" PUBLISHED

"Gold and Silver in Oregon" has been published by the State of Oregon Department of Geology and Mineral Industries as Bulletin 61. Authors are Howard C. Brooks and Len Ramp, who have assembled a wealth of information that was previously scattered through a great number of published and unpublished records.

The bulletin reveals that between 1850 and 1965 Oregon produced about 5.8 million fine ounces of gold and 5.4 ounces of silver, worth a total of about $210,-000,000 at today's prices; probably 60 percent of the gold was mined before 1900. The information given in the bulletin is more than of historical interest, however. Should an improved economic climate for gold materialize, the volume will serve as a guide to future exploration and possible large-scale development.

Bulletin 61 is presented in three parts: Part I is a general discussion of the economics of gold and silver and a review of the production, history, and geologic occurrences of these metals in Oregon; Part II describes the principal gold-mining areas in eastern Oregon, particularly those in the "Gold Belt of the Blue Mountains"; and Part III presents the principal gold-mining areas in the Klamath Mountains and Western Cascades in western Oregon. In all, some 500 lode and placer mines and prospects are discussed.

The 337-page publication, the largest ever issued by the Department, contains selected mine maps, index maps of mining areas, tables and graphs of production statistics, and historical photographs. It is for sale by the Department at its Portland, Baker, and Grants Pass offices. The price is $5.00.

WATER SUPPLY IN CLATSOP DUNES

"Availability of Ground Water in the Clatsop Plains Sand-dune Area, Clatsop County, Oregon" has been issued as an open-file report by the U.S. Geological Survey Ground Water Division in cooperation with Clatsop County. The author, F. J. Frank, reports that the extensive area of low dunes between Fort Stevens and the Necanicum River contains a large body of good quality ground water. Nearly 80 percent of the annual precipitation infiltrates into the dune sand, and test wells yield 100 gallons per minute. The dune sand is about 75 feet thick and rests on a platform of Astoria Formation. Geologic and hydrologic maps are included in the report. A copy is on file at the Oregon Department of Geology and Mineral Industries library in Portland.

* * * * *

OCEAN FLOOR MAPPED OFF OREGON

A new map, covering 14,000 square miles of sea bottom off the Oregon coast, has been published by the Coast and Geodetic Survey of the U. S. Department of Commerce.

The map's coverage extends 100 miles offshore for a 140-mile stretch of coast between Heceta Head and Tillamook Head. Depths shown range from a few feet near the coastline to 9800 feet about 80 miles west of Heceta Head. Among the prominent underwater features delineated are Heceta Bank, about 35 miles offshore, rising to within 150 feet of the ocean surface, and Stonewall Bank, about 17 miles from the coastline and about 78 feet below the surface.

The Map (1308N-22) may be purchased from the Coast and Geodetic Survey, 121 Customhouse, San Francisco 94126, for 50 cents.

* * * * *

BAKER COUNTY MINING NEWS

Copper prospects in the general vicinity of Sparta are being investigated by two companies, Cyprus Mining and Bear Creek Explorations, a subsidiary of Kennecott. Both companies are conducting diamond-drilling programs to test the feasibility of establishing open-pit operations. The old mining properties at Bourne are being explored by Omega Mines. Omega has been on the ground for the past three years and is currently driving new exploratory headings, opening up old workings, and diamond drilling.

The Steinmetz-Underwood placers on Pine Creek above the town of Halfway are being reopened, and a bedrock channel cut to drain the deep placer ground which has been plagued with water in the past.

* * * * *

ANDESITE GUIDEBOOK AVAILABLE

A guidebook designed primarily for the Andesite Conference which was held in the Bend region June 30 to July 5 under the sponsorship of the Upper Mantle Committee, the Center for Volcanology, and the State of Oregon Department of Geology and Mineral Industries, is now available to the public.

The Andesite Conference Guidebook is made up of a series of papers by a number of contributors. It includes two field-trip logs, one to the Santiam-McKenzie area by E. M. Taylor and the other to Newberry Caldera by M. W. Higgins and A. C. Waters. An article by W. S. Wise describes the geology of Mount Hood volcano. For the Crater Lake area there are three reports -- one on the volume of ash from Mount Mazama, by Howel Williams and Gordon Goles; another on compositional variations of the climactic eruption, by A. R. McBirney; and the third on aeromagnetic and gravity surveys of H. R. Blank, Jr. The final article is a summary of the petrochemistry of Cascade andesite volcanoes in general, by A. R. McBirney. The cover picture is a microdrawing of andesite from the highest peak of Mount Mazama.

The 107-page volume is abundantly illustrated by photographs and colored maps. It was published by the Department as Bulletin 62 and is for sale at our offices in Portland, Grants Pass, and Baker. The price is $3.50.

WILKINSON MINERAL COLLECTION RECEIVED

Leonard J. Wilkinson, Prineville, Oregon, has donated an outstanding collection of more than 100 kinds of minerals, fossils, and rocks to the Oregon Department of Geology and Mineral Industries. The specimens are from many places in the United States, and some are from foreign countries. All are of prime quality and represent some of the finest material available from the source region. Among the group are fossil ferns, trilobites, fish, a variety of polished agates, large crystals of barite, selenite, and sphalerite, a rare specimen of native copper and silver, and many exceptionally fine examples of minerals such as purpurite, mariposite, kroehnkite, and cornwallite.

The collection is housed at present in two display cases in the Department's museum in Portland.

In addition to the display specimens, Mr. Wilkinson gave the Department his library of reference books on rocks, minerals, gems, fossils, and general geology. This large group of books and pamphlets will be arranged according to subject matter and parts of it will be available in the fall for loan to rock clubs and other interested groups.

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AMMONITE PAPER AVAILABLE

"Lower Jurassic (Pleinsbachian and Toarcian) Ammonites from Eastern Oregon and California" by R. W. Imlay has been issued as Professional Paper 593-C by the U.S. Geological Survey. The Oregon fossils described are from the Nicely, Suplee, and Snowshoe Formations in east-central Oregon and from the Hurwal Formation in the Wallowa Mountains. The succession of ammonite faunas is compared with other Pacific Coast and European sequences.

Professional Paper 593-C has 51 pages plus 9 plates of photographs. It is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402. The price is 65 cents.

* * * * *

EARL MOLLARD DIES

Earl S. Mollard of Myrtle Creek, Western States Representative for Hanna Mining Co. and formerly general manager of the Hanna Nickel operation at Riddle, died May 31. Mollard was appointed to the Governing Board of the Department of Geology and Mineral Industries in April 1961 and resigned a year later when he was transferred to Hanna's head office in Cleveland, Ohio.

* * * * *

GOLD RESERVES COMMISSION ESTABLISHED

Among bills introduced in the U.S. Senate last month is S. 3506 to establish joint commission on gold reserves, by Sen. Tower of Texas, Committee on Banking and Currency. It would authorize the President to establish a commission composed of the Secretary of the Treasury as chairman, the Secretary of Commerce, The Director of the Budget Bureau, six Senators, six Representatives, and eight public members, none of whom shall be associated or identified with the gold industry, to study U.S. gold policies. (American Mining Congress Legislative Bulletin, June 7, 1968.)

* * * * *

RECENT EPOCH CHANGED TO HOLOCENE

The Geologic Names Committee, U.S. Geological Survey, headed by George V. Cohee, adopted the term "Holocene" in place of "Recent" at its January 23, 1968 meeting. The Survey gives Holocene a series rank equal to that of Pleistocene. The use of Holocene, meaning "wholly recent", was endorsed in 1967 at the annual meeting of the American Commission on Stratigraphic Nomenclature, and the term has already been adopted officially by various geological organizations. The change is desirable because of the wide use of Holocene in Europe and the ambiguity arising from the word "recent."

* * * * *

OIL DEEPENING PERMIT ISSUED

The Department issued Deepening Permit No. 60-D to R. F. Harrison of Seattle, Wash. on May 27, 1968. Harrison will deepen the Central Oils, Inc. "Morrow 1" located in the SW$\frac{1}{4}$ sec. 18, T. 12 S., R. 15 E., Jefferson County. The hole was originally drilled to a depth of 3300 feet in 1954 by Northwestern Oils, Inc. Central Oils, Inc. was formed after the first corporation was dissolved. Central Oils, Inc. took out a deepening permit in 1966 but no new footage was drilled. Harrison will deepen the hole to more than 5000 feet to test Mesozoic marine formations.

* * * * *

McCALL APPOINTS BRISTOL TO GEOLOGY BOARD

Governor Tom McCall appointed Mr. Fayette I. Bristol to the Governing Board of the Department of Geology and Mineral Industries April 15, 1968. Mr. Bristol is president of the Bristol Silica Co., Rogue River, Oregon.

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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

2.	Progress report on Coos Bay coal field, 1938: F. W. Libbey	$ 0.15
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.	(1st vol.) Five papers on Western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	(2nd vol.) Two papers on Western Oregon and Washington Tertiary foraminifera, 1949: Cushman, Stewart, and Stewart; and one paper on mollusca and microfauna, Wildcat coast section, Humboldt County, Calif., 1949: Stewart and Stewart	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
44.	Bibliography (2nd supplement) of geology and mineral resources of Oregon, 1953: Steere	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
56.	Fourteenth biennial report of the State Geologist, 1963-64	Free
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
59.	Fifteenth biennial report of the State Geologist, 1964-1966	Free
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00

GEOLOGIC MAPS

Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others	0.40
Geologic map of the St. Helens quadrangle, 1945: Wilkinson, Lowry & Baldwin	0.35
Geologic map of Kerby quadrangle, Oregon, 1948: Wells, Hotz, and Cater	0.80
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	

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18.	Radioactive minerals the prospectors should know (2nd rev.), 1955: White and Schafer	0.30
19.	Brick and tile industry in Oregon, 1949: J.E. Allen and R.S. Mason .	0.20
20.	Glazes from Oregon volcanic glass, 1950: Charles W. F. Jacobs . . .	0.20
21.	Lightweight aggregate industry in Oregon, 1951: Ralph S. Mason . . .	0.25
23.	Oregon King Mine, Jefferson County, 1962: F.W. Libbey and R.E. Corcoran	1.00
24.	The Almeda Mine, Josephine County, Oregon, 1967: F. W. Libbey . .	2.00

MISCELLANEOUS PAPERS

2.	Key to Oregon mineral deposits map, 1951: Ralph S. Mason	0.15
3.	Facts about fossils (reprints), 1953	0.35
4.	Rules and regulations for conservation of oil and natural gas (revised 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: H. G. Schlicker . .	0.50
7.	(Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: M. Roberts	0.50
8.	Available well records of oil & gas exploration in Oregon, rev. 1963: Newton	0.50
10.	Articles on Recent volcanism in Oregon, 1965: (reprints, The ORE BIN) .	1.00

MISCELLANEOUS PUBLICATIONS

Oregon mineral deposits map (22 x 34 inches), rev. 1958	0.30
Oregon quicksilver localities map (22 x 34 inches) 1946	0.30
Landforms of Oregon: a physiographic sketch (17 x 22 inches), 1941	0.25
Index to topographic mapping in Oregon, 1961	Free
Index to published geologic mapping in Oregon, 1960	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: V. C. Newton, Jr., and R. E. Corcoran	2.50

The Ore Bin

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DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

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FRESHWATER FISH REMAINS FROM THE CLARNO FORMATION OCHOCO MOUNTAINS OF NORTH-CENTRAL OREGON

By Ted M. Cavender
Museum of Zoology, University of Michigan

Introduction

Recent collecting at exposures of carbonaceous shale in the Clarno Formation west of Mitchell, Oregon has produced a small quantity of fragmentary fish material representing an undescribed fauna. The fossils were found in the Ochoco Mountains along U.S. Highway 26 where it crosses the mountains near Ochoco Summit. The fossil-bearing site in the black shales is named the Ochoco Pass locality and the fish remains described herein are referred to the Ochoco Pass local fauna. Although this fauna, at present, is a small one, it holds considerable interest from two standpoints. First, it is an older Tertiary fish fauna of later age than the famous middle Eocene Green River fauna, but earlier than the more numerous middle Tertiary fish faunas of western North America. Second, the fossils may help to shed some light on the depositional environment of the Ochoco Pass black shales. The shales at one time or another have been regarded as marine sediments (Pigg, 1961, p. 61).

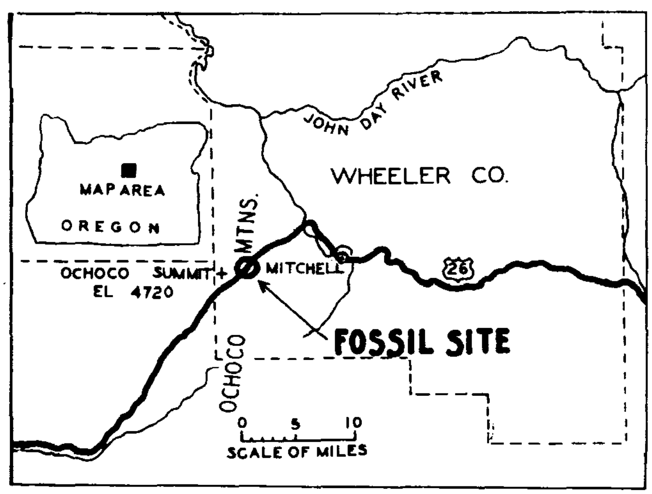


Figure 1. Map showing location of the Ochoco Pass locality.

This paper is intended as an initial systematic account of the fish remains at the Ochoco Pass locality. At present, the known fossil fish material is so scant and poorly preserved that only tentative identifications are possible. Considerable effort has been made to compare the Ochoco Pass fossils with pertinent forms previously described from early to middle Tertiary deposits in North America, and with similar Recent forms.

Of the Ochoco Pass specimens I have studied, one of the first to be collected and recognized as fish was loaned to me by its collector, Margaret Steere, geologist for the State of Oregon Department of Geology and Mineral Industries. The bulk of material and some of the best specimens were collected during several visits to the locality in 1963 and 1966 by Lee Jenkins of Hood River, Oregon. I am very grateful to the latter for his considerable contribution to this project. Other specimens were collected in August 1966 by a field party consisting of Michael Uhtoff, Michael Lappé, Lee Jenkins, and the author.

Location and Geology

All of the fossil fish material came from a deep road cut on U.S. Highway 26, 13.5 miles west of Mitchell, in the W½ sec. 17, T. 12 S., R. 20 E., Wheeler County, Oregon. This road cut is approximately 2.7 miles northeast of Ochoco Summit. The fossil site is indicated on the map (fig. 1). Good exposures of carbonaceous shale occur in the vertical cuts on both sides of the road. The fossils were found on slabs of shale pried loose from the walls in the basal 10 feet of the road cut (fig. 2).

The geology in the vicinity of the fossil fish locality is summarized by the Oregon Department of Geology and Mineral Industries as follows:

> The Ochoco Pass locality is underlain by the Clarno Formation, which is widely distributed throughout central Oregon. According to Wilkinson (1959), the formation is composed largely of terrestrial volcanic rocks having similar lithologies from place to place but representing variable times of deposition. Of particular importance in the Clarno are lenses of tuffaceous sediments containing fossil plants and a mammalian fauna. The formation rests unconformably on Cretaceous marine beds in the vicinity of Mitchell and is unconformably overlain by the John Day Formation of late Oligocene to early Miocene age. This relationship, in addition to fossil studies and several potassium-argon dates, places the age of the Clarno as Eocene to early Oligocene.
>
> In respect to the stratigraphic horizon occupied by the fossil fish described in this paper, the particular shale bed is in the lowest of three Clarno units mapped by Swarbrick (1953) in an unpublished master's thesis on the geology of this area. Swarbrick (p. 36-44) writes: "Unit 1 of the Clarno Formation consists of extensive andesitic mudflows, volcanic flow breccia, and localized leaf-bearing tuffs and tuffaceous sediments. The sediments include interbedded tuffaceous, carbonaceous shale and sandstone, overlain by tuffaceous volcanic cobble conglomerate."
>
> "Total thickness of unit 1 is about 2100 feet of which 600 feet are tuffaceous sediments and 1500 are volcanic breccia and andesitic mudflow."
>
> The younger Clarno rocks in the area mapped by Swarbrick consist of unit 2, basaltic flows and flow breccia; and unit 3, local dacite flows.

Preservation of Fossils

Most of the fossils are disarticulated fish bones and scales, some of which are fragmented. The bone is usually in the form of a thin, carbonaceous film, but typically a full imprint of the bone is preserved. The very fine surrounding sediment is pitch black to dark gray and much compacted, forming dense shale layers that fracture conchoidally. Some of the rock resembles a mudstone. Smooth fracture (shear) planes also are apparent at angles to the bedding planes. The shale layers are so broken that only small pieces could be removed from the outcrop.

Figure 2. Above: Road cut, Ochoco Pass locality. Individuals approximately opposite site of fish beds; looking northeast. Below: Closeup showing fish-scale horizon where individuals are working.

Methods of Study

The specimens were prepared for study by removing the carbonized bone. Latex casts were then made from the resulting imprints. This technique produces a fairly good duplication of the original bone. Ammonium chloride was used to highlight surface features on the casts which were stained black by means of India ink mixed with the liquid latex. Photographs were made of the casts using a 35-mm Miranda single-lens reflex camera, bellows attachment and 50-mm Soligor lens, incandescent lighting or electronic flash, and Plus-X film.

I have made full use of the osteological collections of the University of Michigan Museum of Zoology (UMMZ) for making comparisons with the various fossil fish bones. The abbreviation "SL" means standard length, which is the distance from the most anterior part of a fish's snout to the base of its caudal fin.

The scale terminology is that of Lagler (1947). Except where stated, the Ochoco Pass fossils are housed in the University of Michigan Museum of Paleontology (UMMP). Comparative fossil material studied is housed in the Harvard Museum of Comparative Zoology (MCZ), the American Museum of Natural History (AMNH), the United States National Museum (USNM), and the National Museum of Canada (NMC).

Paleontological Descriptions

Amiidae (bowfins)
cf. Amia Linnaeus
Plate I, 7. Plate II, 2 and 3.

Material -- 15 isolated scales, most of them complete; the largest is 16 mm, the smallest is 6 mm long.

Remarks -- Among the scales of the living freshwater fishes of North America, those of *Amia calva* are very distinctive (Lagler, 1947). Scales of fossil *Amia*, including those from the Ochoco Pass locality, differ very little from the scales of the Recent bowfin. *Amia* or amiid scales are known from freshwater deposits extending, in age, through much of the Tertiary of western North America. These deposits include the Eocene Bridger Formation, Wyoming (Cope, 1884), Eocene Green River shales (Yale Peabody Museum No. 3009), Eocene Horsefly River beds of British Columbia (NMC collections), Oligocene Florissant Lake Beds, Colorado (Cope, 1884), Oligocene Ruby shales, Montana (UMMP collections), and Oligocene Grant shales, Montana (UMMP collections). For the age determinations applied to the last three fossil-bearing deposits, I have referred to the following authors: MacGinitie (1953) - Florissant Lake Beds; Becker (1961) - Ruby shales; and Becker (1962) - Grant shales.

Hiodontidae (mooneyes)
cf. Hiodon Leseur
Plate I, 8 and 9. Plate II, 9.

Material -- several isolated scales.

Remarks -- The existence of a hiodontid in the Ochoco Pass fauna is based on identification of scales alone. The scales illustrated here, when compared with those of

Hiodon tergisus and Hiodon alosoides, show no marked differences. The scale of Hiodon possesses around 10 to 15 basal radii, the lateral basal corners are strong, the focus is apical in position and transversely ovoid in shape, the circuli are very fine, and a few faint, incomplete radii are usually observable in the apical field. Most Hiodon scales are not symmetrical but have one side longer then the other. Some of the fossil scales show this character, also.

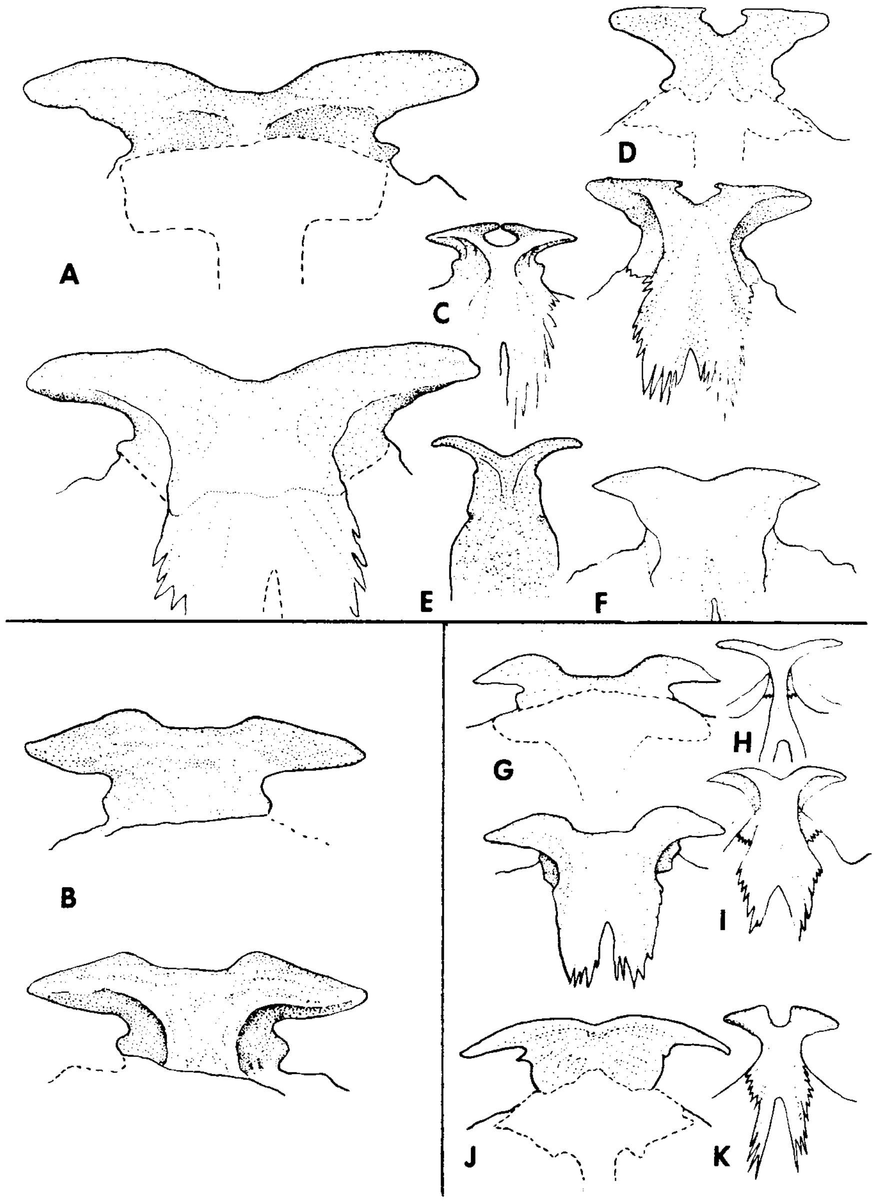
Siluriformes (catfishes)
Family: indeterminate
Plate IV, 1-3

Materials -- a nearly complete supraethmoid, broken left cleithrum, and a complete (right?) pelvic bone.

Remarks --The bones in question are not readily assignable to any New or Old World catfish family. Catfish in general have a number of very characteristic skeletal elements, two of which are the supraethmoid of the skull and the cleithrum of the pectoral girdle. Unfortunately, in this case, where the supraethmoid and cleithrum are disarticulated and broken, taxonomic determination even to family is exceedingly difficult or impossible. Tilak (1963b) found that the complete pectoral girdle is a useful systematic character at the family level in siluriforms and the same appears to be true of the ethmoid region. Figure 3 gives a general idea of the form of the supraethmoid in a few fossil and Recent catfishes. A shallow and broad anterior notch in the supraethmoid is found in many siluriforms, usually where the premaxillary supporting processes are well developed. The deeper, partly enclosed, notch of Ictalurus (Ictaluridae) (fig. 3D) is repeated in Mystus planiceps (Bagridae), (fig. 3C).

The catfish supraethmoid from the Ochoco Pass locality (fig. 3B; plate IV, 1) has the broad, shallow notch in the anterior margin. In this character, it resembles somewhat the ictalurid Pylodictis olivaris, and, among the North American fossils, "Ameiurus" primaevus Eastman (1917), fig. 3F, and "Rhineastes" sp. (MCZ 8500, fig. 3A). Dorsally, the supraethmoid is constricted between the nasal capsules into a fairly narrow bridge connecting the premaxillary supporting processes to the frontals. This ethmoid bridge is excavated at each side, forming the mesial walls of the nasal capsules as in Ictalurus. It should be noted for comparative purposes that, posteriorly, the supraethmoid in Ictalurus covers, in part, the anterior extension of the brain case into the ethmoid region (Starks, 1926). Tilak (1965) stated that such an anterior cranial cavity is characteristic of most siluriforms with the main exception of the Ariidae. The anterior portion of the supraethmoid consists of the processes (mentioned above) which are large and directed laterally. To these are attached, ventrally, the premaxillary tooth plates. In the possession of a constriction between the nasal capsules in combination with lateral excavation, the Ochoco Pass supraethmoid resembles that of Ictalurus furcatus (fig. 3D) and a number of Old World catfishes. "Ameiurus" primaevus does not have this constriction and "Rhineastes" sp. (MCZ 8500) shows only a slight indication of such. Underneath the constriction, the Ochoco Pass supraethmoid (mesethmoid) is expanded into a broad oval plate of bone that forms a seat for the head of the vomer and also sutures, posteriorly, with the anterior end of the parasphenoid. Rhamdia (Pimelodidae) does not have such a noticeable expansion of the supraethmoid, nor do the ariids, Arius (Galeichthys) and Potamarius. The ventral supraethmoid plate is well defined in ictalurids.

The Ochoco Pass cleithrum (plate IV, 3) consists only of the middle portion of



the bone; both the anterior and dorsal extensions are missing. There is a strong humeral process. Large confluent ridges cover the lateral surface of the cleithrum.

Of particular importance is the single pelvic bone. Although it resembles that of a number of the Old World catfishes of Europe and Asia (fig. 4), it can be distinguished from the pelvic bones of the Recent North American ictalurids. The characters I have stressed in a comparison of pelvic bones from a limited number of species belonging to seven catfish families are the presence (however weak) of an ossified posterior ischial process (Weitzman, 1962) -- also found in other Ostariophysi:

Figure 3. Comparison of siluroid supraethmoids, fossil and Recent (dorsal aspect except where stated): A. "Rhineastes" sp. MCZ 8 500, Eocene Bridger Basin, Wyo., ventral aspect above, dorsal aspect below, X1.4. B. Indet. UMMP V56361, Ochoco Pass locality, Oregon, ventral aspect above, dorsal below, X2.2. C. Mystus planiceps (Bagridae) UMMZ 15568 5, SL 205mm, Sumatra, X1.2. D. Ictalurus furcatus (Ictaluridae) UMMZ 169031-S, SL 327 mm, Mo., ventral aspect above, dorsal below, X1.5. E. Clarius lazera (Claridae) UMMZ 169015-S, SL 189mm, Egypt, X2.7. F. "Ameiurus" primaevus? AMNH 9499, Eocene Green River Formation, Wyo., X1.8. G. Parasilurus asotus (Siluridae) uncat. spec. (J-66), SL 405mm, Japan, ventral aspect above, dorsal below, X1.4. H. Rhamdia guatemalensis (Pimelodidae) UMMZ 178542-S, Mexico, X1.5. I. Pelteobagrus nudiceps (Bagridae) UMMZ 183856-S, SL 167mm, Japan, X2.4. J. Pangasius micronemus (Schilbeidae) UMMZ 186691-S, SL 315mm, Thailand, ventral aspect, X1.4. K. Arius felis (Ariidae), UMMZ 179147-S, SL 192mm, Fla., Gulf of Mex., X1.3.

Characidae, Cyprinidae, Catostomidae -- and the form and relative proportions of the posterior margin. Those catfishes that typically have six or close to six pelvic rays in each fin (five of the seven families: Bagridae, Schilbeidae, Pimelodidae, Ariidae, Clariidae [Regan, 1911]) possess a short, nearly straight articular surface along the posterior margin for seating the pelvic fin rays. Those catfishes with typically more than seven pelvic rays in each fin (Ictaluridae and Siluridae: Silurus, Parasilurus, Kryptopterus, Wallagonia) possess wide, somewhat rounded, posterior margins, that are uninterrupted by notches and do not give rise to any kind of ossified projection at their postero-mesial corners. Although not illustrated, the Plotosidae, an Old World, largely marine, family can also be placed in this category. Except for these last three families, and possibly some of the Eocene Green River forms, all the others included in this comparison (along with the Ochoco Pass catfish) have pelvic bones with ossified ischial processes variously developed. Not enough Recent specimens have been examined to determine whether the rounded posterior margin and lack of an ossified ischial process are correlated with a high number of pelvic fin rays or reflect an anatomical specialization of the pelvic region associated with reproduction (or both may be linked together). Use of the pelvic fins by species of ictalurids in tending their eggs has been described by Breder (1935). Similarity in pelvic structure may indicate a genetic relationship (Tilak, 1963a, has allied the Siluridae to the Plotosidae). The number of rays is known to vary within some currently defined family groups, for example, from 5 to 8 in both the Bagridae and Pimelodidae, 6 to 14 in the Siluridae, and also within a genus, for example, 6 in Pangasius larnaudii, 8 in Pangasius micronemus.

The Ochoco Pass pelvic bone appears to have the short posterior (articulating) margin for seating the pelvic fin rays. Thus it is unlike the typical ictalurid condition.

Catostomidae (suckers)
Gen. and sp. indet.
Plate III, 4-7.

Material -- a small right opercle, right quadrate, fragment of a pharyngeal arch, left interopercle, incomplete basioccipital, and numerous scales.

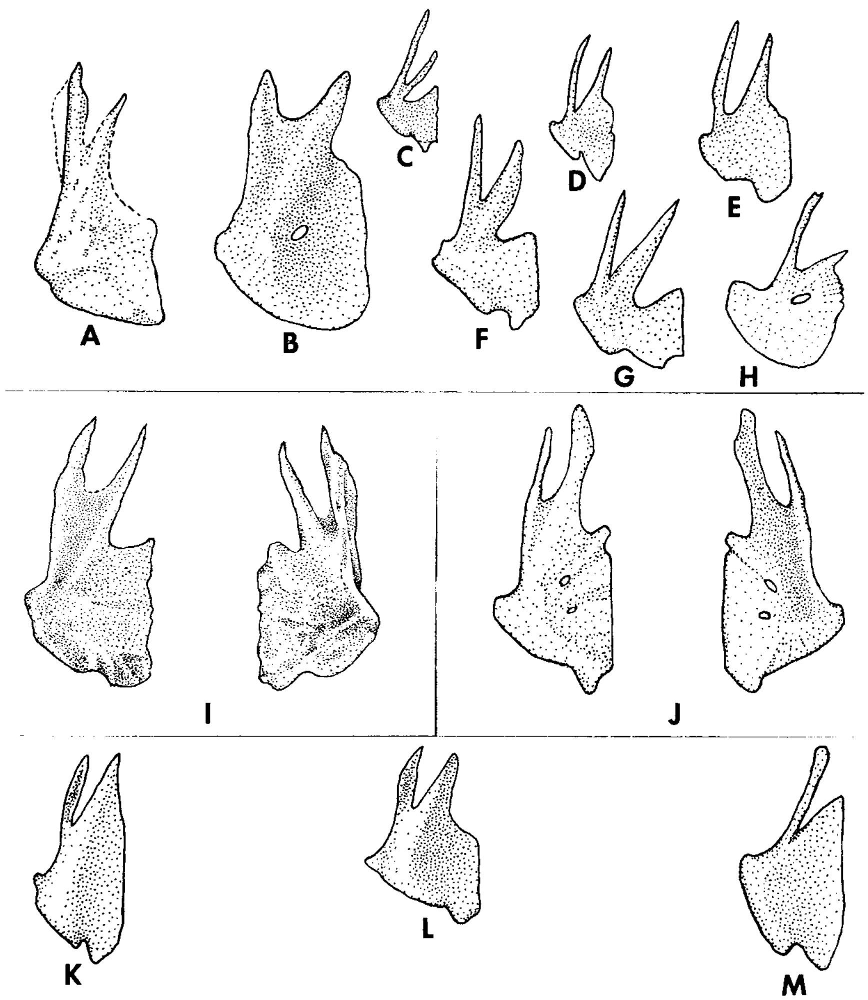


Figure 4. Comparison of siluroid right pelvic bones, ventral aspect except where stated: A. Undescribed species, AMNH 6888, SL 143mm, Eocene Green River Fm., Wyo. X4. B. Ictalurus punctatus (Ictaluridae) UMMZ 186239-S, SL 370mm, Va., X1.5. C. Clarias lazera (Claridae) UMMZ 166654, SL 159mm, Egypt X1.6. D. Rhamdia guatemalensis (Pimelodidae) UMMZ 184738-S, SL 173mm, Mexico, X1.3. E. Arius felis (Ariidae) UMMZ 179147-S, SL 192mm, Fla., X1.3. F. Pelteobagrus nudiceps (Bagridae) UMMZ 183855, SL 112mm, China, X2.8. G. Mystus planiceps (Bagridae) UMMZ 155685, SL 205mm, Sumatra, X1.6. H. Parasilurus asotus (Siluridae) uncat. spec. (J66-), SL 405mm, Japan, X1.6. I. Indet. UMMP V56360, Ochoco Pass locality, Ore., ventral aspect to left, dorsal to right, X3. J. Pangasius micronemus (Schilbeidae) UMMZ 186691-S, SL 315mm, Thailand, ventral aspect left, dorsal to right, X1.4. K. Bagroides macropterus (Bagridae) UMMZ 186765, SL 163mm, Thailand, X2. L. Leiocassis siamensis (Bagridae) UMMZ 186722, SL 80mm, Thailand, X3. M. Pseudopimelodus zungaro (Pimelodidae) UMMZ 66312, SL 123 mm, Bolivia, X2.

cf. Amyzon Cope
Plate I, 1,4; Plate II, 1; Plate III, 1-3.

Referred material -- left opercle, left frontal, right dentary, scales.

Remarks -- Study of the scales indicates that more than one kind of sucker is represented in the collection. Scales (plate I, 1,4; plate II, 1) are typical of the "Amyzon type" and can be duplicated in the numerous Amyzon scales from the Oligocene Grant lake shales of Montana (UMMP collections). This type of scale, from the flank region of the body, is characterized by width as great as or greater than the length, the focus is typically basal in position, there are as much as a dozen fine basal radii, strong primary radii in the apical field (with more numerous and weaker secondary radii in older scales), well-defined lateral basal corners that are marked interiorly by the shape of the circuli, and numerous fine circuli (ridges) that thicken slightly, are more widely spaced, and become fluted in the apical field*. The Amyzon scale differs from scales of all Recent catostomids in the above combination of characters and is particularly distinctive in its basally positioned focus. In this latter feature, it agrees with scales of some of the Old World cyprinids -- especially certain species of Leuciscus.

A second type of sucker scale (plate I, 5,6; plate II, 4) represented in the Ochoco Pass locality resembles the "Amyzon type" except that it is (1) proportionally not as deep as long, (2) has a more centrally positioned focus, (3) the basal radii are more numerous, and (4) the lateral basal corners are not as well defined, some being almost rounded. Besides the scales, a left opercle (plate III, 2) appears to belong to the genus Amyzon and resembles some of the opercles found with Amyzon remains from the Oligocene Florissant Formation, Colorado, and from the Grant lake shales, Montana. The dentary (plate III, 3) resembles that of Amyzon brevipinne (Lambe, 1906) and the frontal is close to that of a second deeper bodied Amyzon species, illustrated (but misidentified as Amyzon commune Cope) by Lambe (1906) from the Horsefly River locality, British Columbia. Figure 5 compares the Ochoco Pass frontal with frontals of Amyzon and some Recent catostomids. In general, these frontals fall into two groups. One has a projecting postorbital process and notch in the orbital rim to seat the supraorbital bone; this group contains Amyzon, Ictiobus, and Carpiodes. The other group has no projecting postorbital process of the frontal, no supraorbital bone, and the orbital rim nearly parallels the midline of the skull. Catostomus, Moxostoma, Erimyzon and Hypentelium form the second group. Cycleptus, Myxocyprinus and Minytrema are somewhat intermediate since they have a supraorbital, but no well-developed postorbital process on the frontal.

Discussion

The three identified fish families present in the Ochoco Pass fauna: Amiidae, Hiodontidae, and Catostomidae, as well as an included (but as yet unidentified) catfish family, are, to my knowledge, not known together in any other Eocene or Oligocene fish fauna from western North America. A fossil mooneye is unknown from the

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* Fragments of this same type of sucker scale, or one very similar to it, were collected and sent to me by Lee Jenkins from an outcrop of leaf-bearing mudstone on Gray Butte in Jefferson County, Oregon.

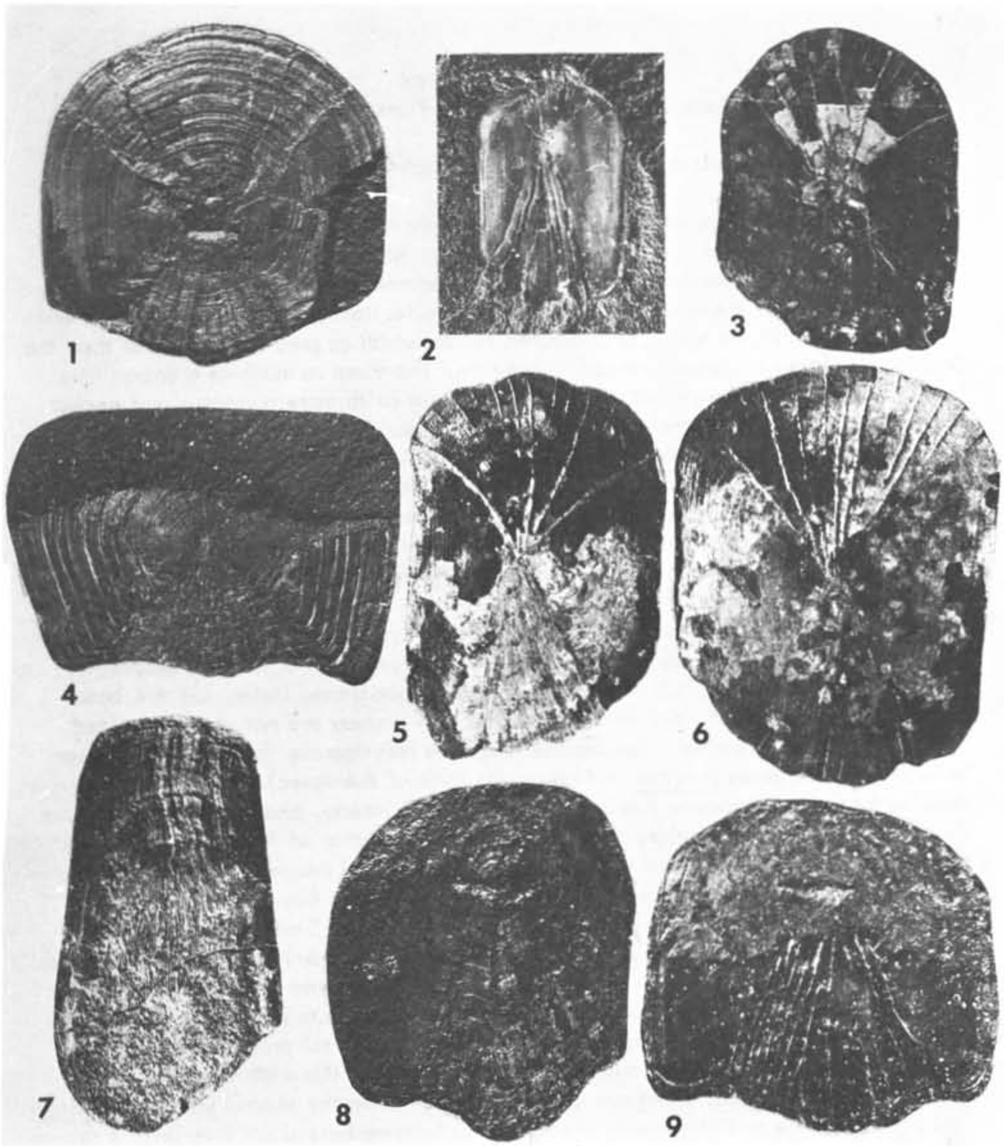


Plate I. Isolated scales from Ochoco Pass locality, Ore.: 1) regenerated catostomid scale, cf. Amyzon, UMMP V 56350, X5. 2) Indet. scale, possibly a hiodontid, UMMP V56374, X2. 3) regenerated catostomid scale, Oregon Dept. Geology and Mineral Industries, X3.5. 4) catostomid scale, apical field missing, cf. Amyzon UMMP V56347, X4.4. 5) catostomid scale, Oregon Dept. Geol. and Min. Ind., X4.4. 6) catostomid scale, Oregon Dept. Geol. and Min. Ind., X4.6. 7) regenerated amiid scale, cf. Amia UMMP V56363, X4. 8) hiodontid scale, cf. Hiodon UMMP V56368, X5.9. 9) hiodontid scale, cf. Hiodon, UMMP V56370, X7.8.

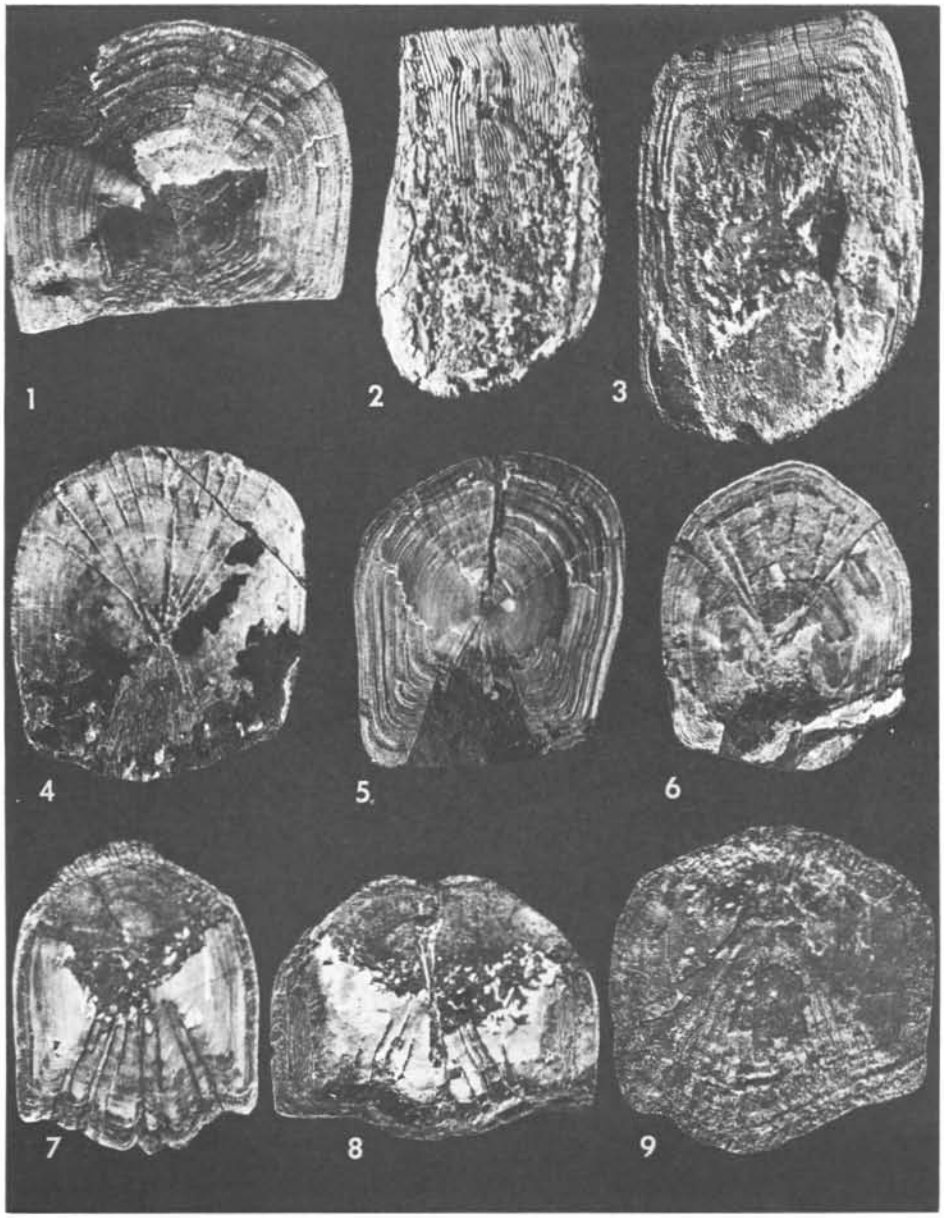
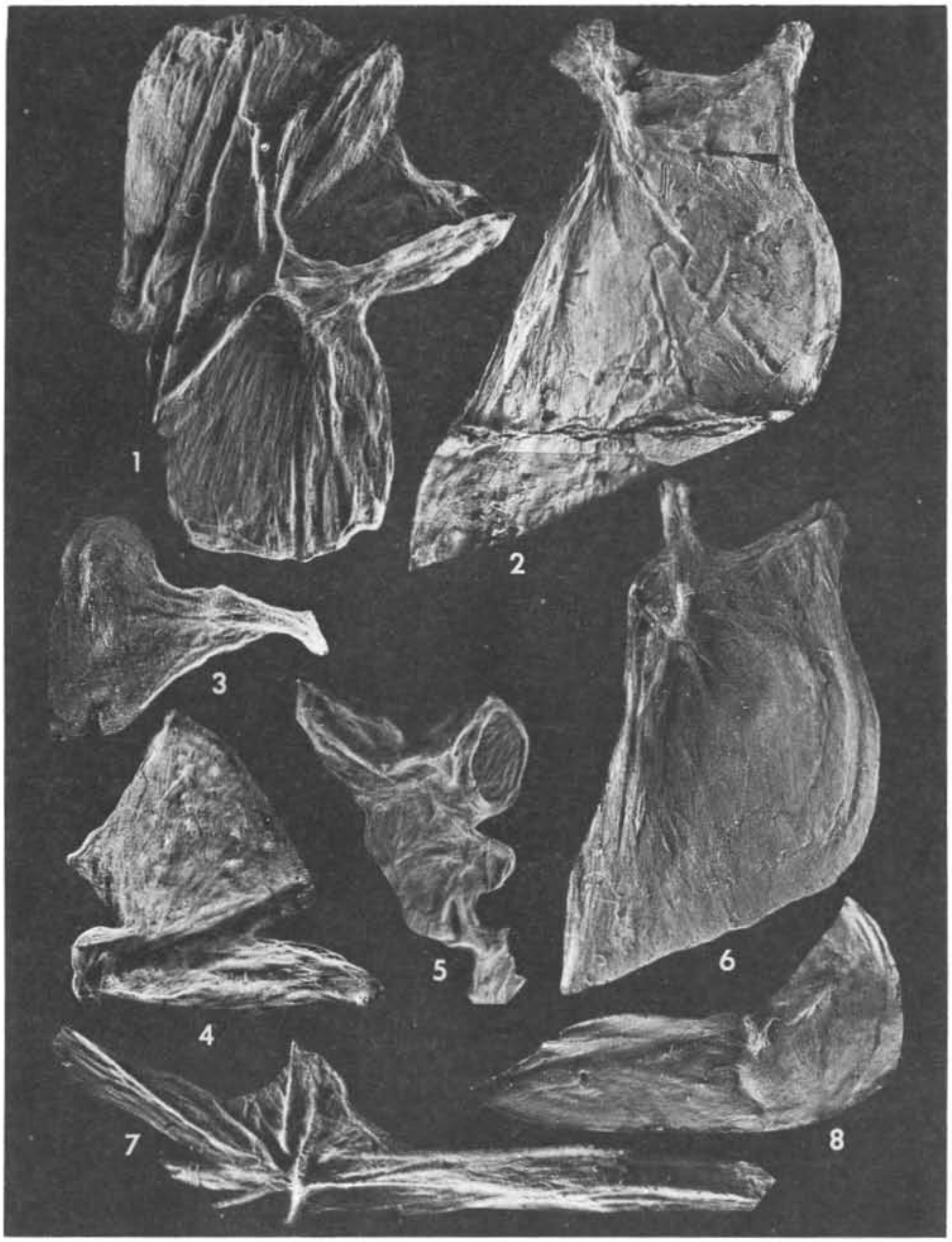


Plate II. Isolated scales from Ochoco Pass locality, Ore.: 1) catostomid scale, cf. Amyzon UMMP V56358, X4.3. 2) regenerated amiid scale, cf. Amia, UMMP V56364, X8.2. 3) regenerated amiid scale, cf. Amia, UMMP V56366, X3.8. 4) catostomid scale, Oregon Dept. Geol. and Min. Ind., X3.8. 5) catostomid scale, UMMP V56357, X4. 6) catostomid scale, cf. Amyzon, UMMP V56351, X6.6. 7) Indet. scale, possibly a hiodontid, UMMP V 56375, X6.5. 8) Indet. lateral line scale, possibly a hiodontid, UMMP V56371, X5.5. 9) hiodontid scale, cf. Hiodon, UMMP V56369, X6.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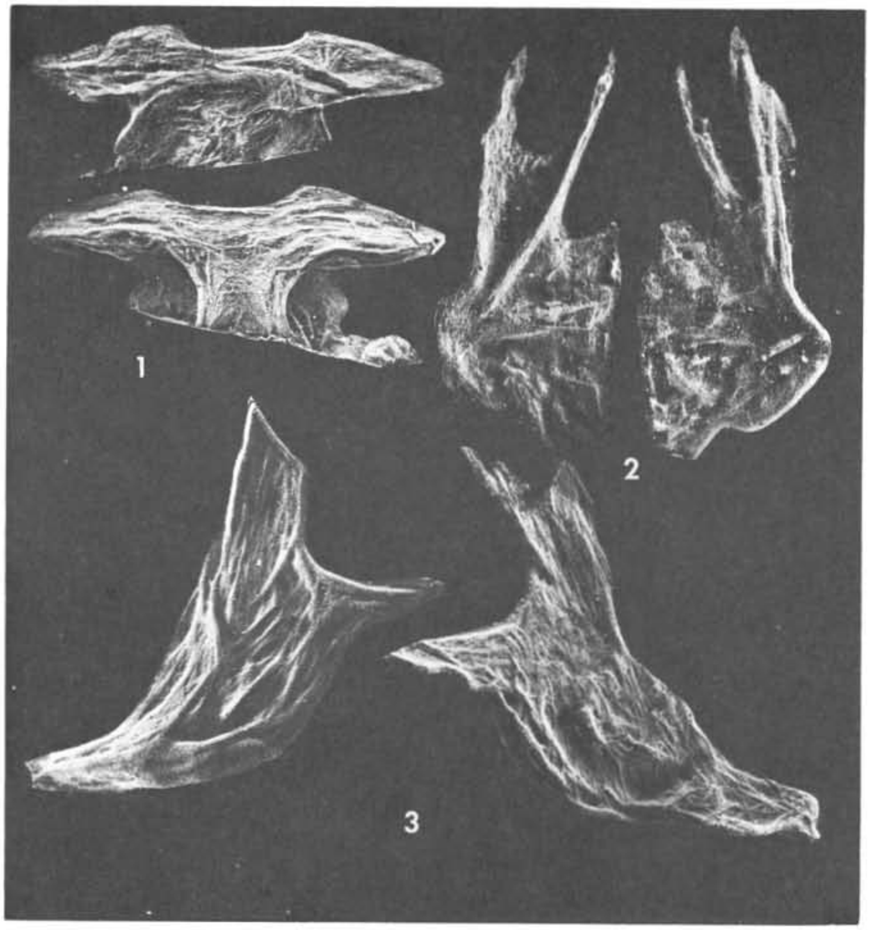

Plate III. Isolated catostomid skull elements from Ochoco Pass locality, Ore. 1) left frontal, ventral aspect, cf. Amyzon, UMMP V56341, X2.7 2) left opercle, cf. Amyzon, UMMP V56346, X1.5. 3) right dentary, cf. Amyzon, UMMP V56345, X3.8. 4) right quadrate, mesial aspect, gen. and sp. indet., UMMP V56354, X2.9. 5) incomplete basioccipital, gen. and sp. indet., UMMP V56356, X3.2. 6) right opercle, mesial aspect, gen. and sp. indet., UMMP V56344, X3. 7) parasphenoid, gen. and sp. indet., UMMP V56343, X3.8. 8) left interopercle, gen. and sp. indet. UMMP V56355, X3.9.

Plate IV. Isolated siluroid skeletal elements from Ochoco Pass locality, Ore. 1) supraethmoid, ventral aspect above, dorsal below, UMMP V56361, X2.7. 2) right pelvic bone, ventral aspect to left, dorsal to right, UMMP V56360, X4.5. 3) left incomplete cleithrum, lateral aspect at left, mesial at right, UMMP V56362, X3.2. (above)

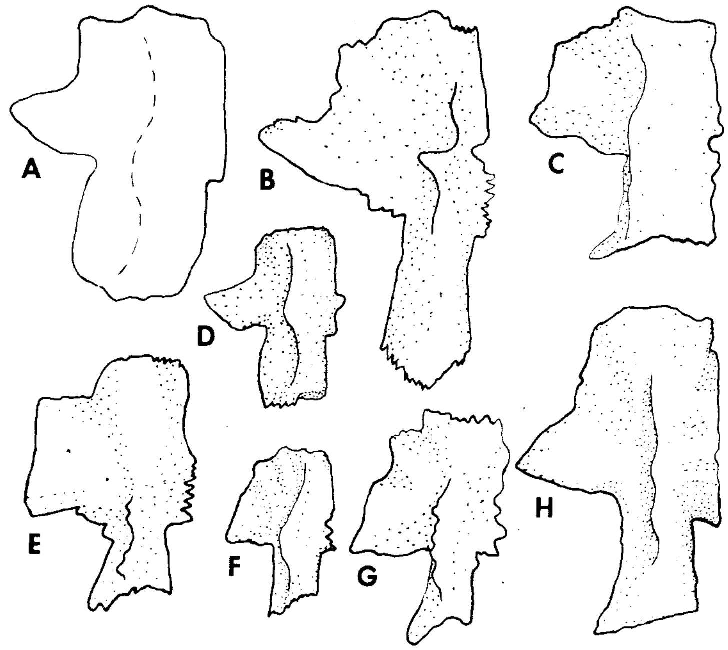

Figure 5. Comparison of catostomid left frontal bones, dorsal aspect. A. cf. Amyzon, UMMP V56341, Ochoco Pass locality, Oregon, X1.7. B. Ictiobus bubalus, uncat. spec., Texas, est. SL350mm, X1.5. C. Cycleptus elongatus, UMMZ 176973-S, SL 404mm, Texas, X1.5. D. Amyzon sp., NMC 1686, est. SL 185mm, Eocene Horsefly R. locality, Brit. Col. X1.8. E. Catostomus commersoni, UMMZ 160983, SL 135mm, Ky., X1.8. F. Myxocyprinus asiaticus, AMNH 11629, SL 59mm, China, X5.4. G. Minytrema melanops, UMMZ 179906, SL 206mm, Ky., X1.5. H. Amyzon, sp., USNM 4085 and 5508, est. SL 190mm, Oligocene, Florissant, Colo., X2.2.

Green River Formation or from the Florissant Lake Beds, although the other three families have been reported from the latter. Suckers are unknown in the Green River shales. At the Eocene Horsefly River locality in British Columbia and the Oligocene lake shales near Grant, Montana, a fossil mooneye has been found along with suckers and a bowfin. Catfish have not been discovered at these two localities as yet. The Eocene Horsefly River hiodontid may be equivalent to Eohiodon rosei from the Tranquille beds at Kamloops Lake, British Columbia (Cavender, 1966).

As more collecting is done at the Ochoco Pass locality, new elements in the fish fauna will probably appear. One of the scales (UMMP V56373) that has not been identified suggests that a cyprinid might have been present. Determination is difficult because Amyzon scales early in development can look similar to it. This scale is very small (4mm long) with a basal focus, no visible basal radii, about a dozen apical radii (5 of which are primary) and the scale has lateral basal corners. It resembles scales of Richardsonius balteatus. The oldest North American cyprinids now known are from the basal part (Bridge Creek flora horizon) of the John Day Formation in Oregon. A potassium-argon date of this stratigraphic horizon has been determined as 31.1 million years (Evernden and others, 1964).

Three of the above families mentioned, the Amiidae, Hiodontidae, and Catostomidae, are considered by Darlington (1957) as primary freshwater groups which are today restricted to fresh water and apparently have been thus confined through much or all of their evolutionary history. Since the catfish has not been definitely assigned to a specific family, it does not provide substantial evidence for a freshwater habitat, although catfishes today live predominantly in fresh water. Some members of the marine catfish family, Ariidae, do inhabit the lower parts of freshwater streams along the tropical coasts of Central America (Miller, 1966). Skeletal evidence, however, does not indicate that the Ochoco Pass catfish(es) is an ariid. A more probable affinity is with the Bagridae or Ictaluridae, both freshwater families according to Darlington (1957). Freshwater catfishes have a fossil record throughout most of the Cenozoic in western North America (John Lundberg, oral communication, 1967), and when this record is compared with that of some of the other freshwater families, it stands out as a fairly good one. Eocene catfish fossils representing a number of different families have been reported from Europe, Africa, Asia, South America, and (Oligocene) Australia, as well as North America (Romer, 1966). It is apparent that by early Tertiary time, the evolutionary history of siluroids was already quite complicated.

The fossil hiodontid scales from the Ochoco Pass locality vary from 3mm to 7mm in length. In Recent Hiodon, a similar size range can be found on very small to large juveniles up to 200 mm SL. Two living species, Hiodon tergisus and H. alosoides, and an extinct middle Eocene species, Eohiodon rosei, mentioned above (also the undescribed hiodontid species from the Grant lake shales, Montana), make up this family which is endemic to North America. The Hiodontidae have no close living relatives; they are relict fishes, survivors of an early stage of teleost evolution.

Potassium-argon dates from Eocene sediments in British Columbia containing the oldest known North American Catostomidae range from 45 to 49 million years (Rouse and Mathews, 1961). Suckers appear to be one of the major components both in numbers and species (except in the Green River fauna as stated above) of the early to middle Cenozoic freshwater faunas of western North America. The Eocene and Oligocene species known from complete specimens possess a long dorsal fin and seem to belong to or have a close relationship with the extinct genus Amyzon.

Of the four groups of fishes known in the Ochoco Pass fauna, only one, the Catostomidae, lives in the same area today. Hiodontids, catfishes and bowfins are not native to the Columbia River Basin (Miller, 1959). Catfish, however, are known from the Pliocene-Pleistocene "Idaho Lake" fauna, Columbia and Snake River drainage (Miller, 1965; Miller and Smith, 1967).

Fossil remains other than fish scales and bones occasionally are found at the Ochoco Pass locality. Various plant fragments occur as imprints on the shale slabs. One piece shows a single, broken beetle wing.

Since some of the scales are fragmented and all the bones are disarticulated, transportation of the remains may have taken place before burial. Stream carry into a quiet body of water which had a highly organic mud bottom is a possibility. However, partial to almost complete decomposition of dead fish (along with a large amount of plant material) near or on a lake bottom is perhaps a better explanation for this type of preservation. The evidence gathered from this study of the fish remains indicates that the Ochoco fish occupied, in life, a freshwater habitat.

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* * * * *

POST QUADRANGLE GEOLOGICALLY MAPPED

"Reconnaissance Geologic Map of the Post Quadrangle, Crook County, Oregon," by A. C. Waters, has just been published by the U.S. Geological Survey as Miscellaneous Geologic Investigations Map I-542. The Post quadrangle lies about 25 miles southeast of Prineville and immediately east of Eagle Rock quadrangle, a geologic map of which was issued recently by the Survey as Map I-540 (see June 1968 ORE BIN). No text accompanies the map, but the legend explains the various geologic units shown by color and pattern. Formations in the area range from Eocene Clarno to Holocene alluvium.

Map I-542 is for sale by the U.S. Geological Survey, Federal Center, Denver, Colo. 80225, for 75 cents.

* * * * *

WITHDRAWAL SPARKED BY HIGH-TENSION DEMAND

Bonneville Power Administration has applied to the U.S. Bureau of Land Management for the withdrawal from all forms of appropriation under the public land laws, including the mining laws but not mineral leasing laws, of 111.51 acres of land in northwestern Umatilla County. Bonneville plans to construct a substation on the site if the withdrawal is approved.

* * * * *

WESTERN GOVERNORS ADOPT RESOLUTIONS ON MINING

At the annual meeting of the Western Governors' Conference, which was held in Honolulu, Hawaii May 12 to 15 and at which Governor Tom McCall of Oregon was chairman of the Committee on Natural Resources, the following resolutions pertaining to the mining industry were approved.

Federal-state relations

WHEREAS the national Congress has, from time to time, enacted laws which have infringed upon areas traditionally reserved for the state either through pre-empting state powers or by making categorical grants to states conditioned upon states' compliance with strict federal standards; and

WHEREAS this can be shown by examination of numerous federal programs including but not limited to federal air and water pollution control; the proposed federal controls on surface mining; the proposed federal five percent mining severance tax; the federal occupational Health and Safety Act; and the proposed national airways trust fund; and

WHEREAS the National Governors' Conference has gone on record as favoring block grants to achieve greater flexibility and more adequate state and local controls over programs assisted by federal grants, thus avoiding the central controls inherent in categorical grants which mandate detailed standards and requirements; and

WHEREAS the President of the United States has expressed a desire to work more closely with the states and to move away from categorical grants toward block grants; and

WHEREAS notwithstanding a recent tendency evidenced by Congress to avoid infringement upon states' rights in some areas, some items of legislation are still inconsistent with state control over purely state and local matters, and numerous administrative agencies have demonstrated increasingly an arbitrary determination to take over functions of government heretofore reserved to the states;

NOW, THEREFORE, BE IT RESOLVED that the Western Governors' Conference in Honolulu, Hawaii strongly opposes any further legislation or administrative action of a preemptive nature which infringes upon the rights of the states; and

BE IT FURTHER RESOLVED that the Western Governors' Conference supports state-federal cooperation which, wherever practicable, will allow grants from the federal government to the states to be in the form of block grants rather than categorical grants; and

BE IT FURTHER RESOLVED that this resolution be presented to the Executive Committee of the National Governors' Conference with the request that the subject matter be scheduled for discussion by the Governors of all the states at the annual meeting of the National Governors' Conference in July, 1968.

Mined land reclamation

WHEREAS the problem of mined land reclamation should be approached with full realization that where surface disturbance is unavoidable, mining operations must be conducted in such a manner as to provide adequate protection to the public and to other resource values on mineral lands; and

WHEREAS widely diverse topography, climate, economic conditions and esthetic standards require a precision of remedy which cannot be attained by uniform national regulations for mined land reclamation;

NOW, THEREFORE, BE IT RESOLVED by the 1968 Annual Meeting of the Western Governors' Conference in Honolulu, Hawaii that:

1. Adequate state legislation be enacted for regulation of mined land reclamation;
2. The states be urged to ratify the Interstate Mining Compact; and
3. The Congress be urged to avoid uniform national regulations or preemption of state activities in the field of mined land reclamation.

Mineral discovery*

WHEREAS the timely availability of an adequate supply of this nation's mineral resources depends upon the retention in the mining law of the traditional incentive which has motivated mineral discovery and production on the public domain; namely, the right to search for and acquire by discovery the private ownership of minerals;

NOW, THEREFORE, BE IT RESOLVED that the 1968 Annual Meeting of the Western Governors' Conference in Honolulu, Hawaii declares that existing public land laws should not be altered by restrictive legislation, nor should congressional intent be circumvented by administrative regulation or decision. Present laws could be made more effective by legislation providing for the right of the prospector to hold claims for such time as may be determined by the Congress as sufficient to validate his location by discovery of mineral, and for the right to acquire land for necessary purposes incidental to mining. Effective use of public lands for mineral exploration and development should be curtailed only when clearly in the broad public interest, and any limitation should be subject to periodic reconsideration.

(* Governor Daniel J. Evans of Washington was recorded as abstaining.)

Gold

WHEREAS domestic gold consumption for 1967 for industrial, defense, dental and art use reached approximately six million ounces, a substantial increase over 1966, while domestic gold production for 1967 remained virtually static at 1.8 million ounces; and

WHEREAS the domestic consumption of gold at over three times our annual productive capacity creates a significant drain upon our national gold monetary reserves; and

WHEREAS to supply domestic consumptive needs it will be necessary to import five million ounces or more of gold per year, payment for which will have a substantial adverse effect upon our balance of payments;

NOW, THEREFORE, BE IT RESOLVED that the 1968 Annual Meeting of the Western Governors' Conference in Honolulu, Hawaii supports action and incentives by the federal government which will stimulate, encourage and revitalize our domestic gold mining industry.

Silver

WHEREAS the world silver supply is critical to our national well-being, and the imbalance of demand over supply can be corrected only by new sources of this most versatile metal; and

WHEREAS the continued drain on Treasury silver should be reduced from the expected level of 2,000,000 ounces per week in order to maintain a reasonable level of Treasury stocks; and

WHEREAS it is desirable to establish fully a free private market for industrial silver;

NOW, THEREFORE, BE IT RESOLVED that the 1968 Annual Meeting of the Western Governors' Conference in Honolulu, Hawaii supports immediate action toward gradual reduction of the amount of silver sold by the Treasury and continued minting of coins with silver content.

* * * * *

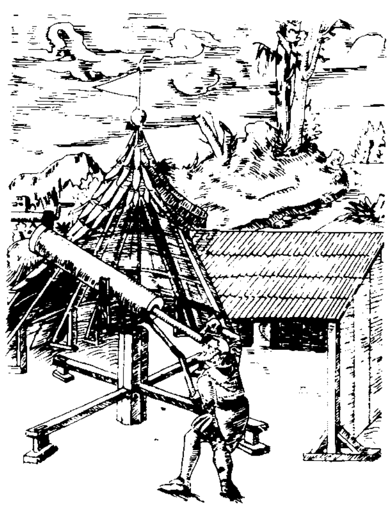
BEND QUADRANGLE MAP ON OPEN FILE

"Reconnaissance Geologic Map of the East Half of the Bend Quadrangle, Crook, Wheeler, Jefferson, Wasco, and Deschutes Counties, Oregon" has been made available as an open-file report by the U.S. Geological Survey, The map, compiled by Donald A. Swanson from pre-existing published and unpublished information, covers the east half of the Bend AMS Sheet, between 120° and 121° long. and 44° and 45° lat. Although the map is uncolored and difficult to follow in its present form, it presents a considerable amount of correlative information on Tertiary units in this region. The open-file report consists of two sheets: one has the geologic map, a tectonic map, and cross sections; the other has a very detailed explanation for each unit and a bibliography.

The report may be consulted at the Department's library at 1069 State Office Building in Portland. Material from which a copy can be made at private expense is available from the U.S. Geological Survey's Spokane office, 678 Court House Bldg., Spokane, Wash. 99201.

* * * * *

HAVE YOU FOUND YOUR METEORITE?



-1968-
The Year of the Meteorite

This is a reminder that this is "The Year of the Meteorite." The project, a brainchild of Dr. Erwin Lange, Portland State College, Phil Brogan, Bend astronomer, and Hollis Dole, State Geologist, has already attracted widespread interest. Nearly 100 specimens have been received by the Department, but unfortunately they have all been classified by Lange as "meteor-wrongs" and not meteorites. Dr. Lange did garner one bona fide specimen, which was given to him by one of his students. The stone was from the famous Canyon Diablo site in Arizona. It seems logical that in the 96,000 square miles of Oregon there are still meteorites to be found, rediscovered, or brought to public attention. Why don't you join in the search?

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

2.	Progress report on Coos Bay coal field, 1938: F. W. Libbey	$ 0.15
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.	(1st vol.) Five papers on Western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	(2nd vol.) Two papers on Western Oregon and Washington Tertiary foraminifera, 1949: Cushman, Stewart, and Stewart; and one paper on mollusca and microfauna, Wildcat coast section, Humboldt County, Calif., 1949: Stewart and Stewart	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
44.	Bibliography (2nd supplement) of geology and mineral resources of Oregon, 1953: Steere	1.00
46.	Ferruginous bauxite deposits, Salem Hills, Marion County, Oregon, 1956: Corcoran and Libbey	1.25
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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
56.	Fourteenth biennial report of the State Geologist, 1963-64	Free
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
59.	Fifteenth biennial report of the State Geologist, 1964-1966	Free
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00

GEOLOGIC MAPS

Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others . . .	0.40
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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
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Oregon quicksilver localities map (22 x 34 inches) 1946	0.30
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Index to topographic mapping in Oregon, 1961	Free
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Geologic time chart for Oregon, 1961	Free

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The ORE BIN
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FIREBALLS, METEORITES, AND METEOR SHOWERS

By Erwin F. Lange
Professor of General Science, Portland State College

About once each year a brilliant and newsworthy fireball* passes across the Northwest skies. The phenomenon is visible evidence that a meteorite is reaching the earth from outer space. More than 40 percent of the earth's known meteorites have been recovered at the terminus of the fireball's flight. Such meteorites are known as "falls" as distinguished from "finds," which are old meteorites recovered from the earth's crust and not seen falling.

To date only two falls have been noted in the entire Pacific Northwest. The more recent occurred on Sunday morning, July 2, 1939, when a spectacular fireball or meteor passed over Portland just before 8:00 a.m. Somewhat to the east of Portland the meteor exploded, causing many people to awaken from their Sunday morning slumbers as buildings shook, and dishes and windows rattled. No damage was reported. Several climbers on Mount Hood and Mount Adams reported seeing the unusual event. The fireball immediately became known as the Portland meteor and stories about it appeared in newspapers from coast to coast. For two days the pre-Fourth of July fireworks made front-page news in the local newspapers.

J. Hugh Pruett, astronomer at the University of Oregon and Pacific director of the American Meteor Society, in an attempt to find the meteorite which had caused such excitement, appealed to all witnesses of the event to report to him their observations. The data he desired included the direction of the fireball when first seen, direction when fireball ceased to be luminous, height above the horizon, color of the light, and the presence or absence of a smoke trail. He soon received over 90 replies, many from observers more than a hundred miles from Portland. The data plotted on a map indicated that the fireball came in from the direction of the Pacific Ocean, passed over Portland, and dropped to the east of the city, possibly into the Columbia River.

Between 1932 and 1939 Pruett had collected enough data from cooperating observers to be able to trace 13 bright fireballs that had passed over the Northwest skies. After each meteor, people sent him a variety of rocks

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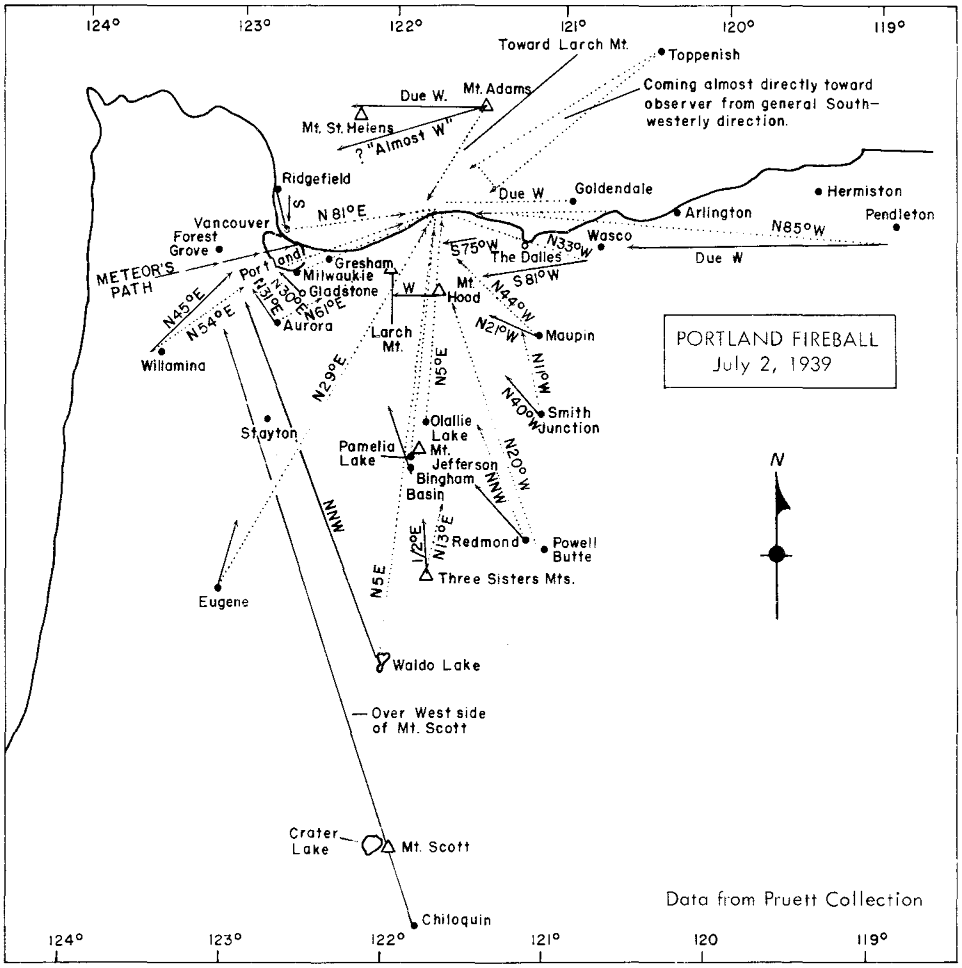
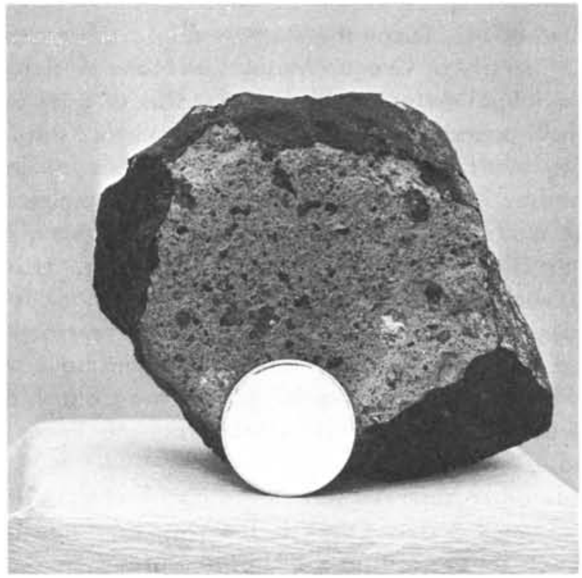
* See glossary at end of article.



Map showing reported sightings in the Pacific Northwest of the 1939 Portland Fireball. Solid line indicates first sighting; dotted line shows direction last seen. Note that the dotted lines of most of the accurate observations point to the area where the fireball was last seen. Beyond this area, in the direction of flight, one should be able to find the meteorite or fragments of the meteorite if it became disrupted.

and minerals which suddenly seemed different to them. None, however, proved to be meteorites until August 18, 1939, more than six weeks after the Portland meteor had ceased to make news, when he received in the mail a small box containing a fine, freshly fallen stony meteorite. It had been sent by Jerry E. Best, Washougal, Wash., who had found the interesting stone inhis back yard on July 3. Having no interest in retaining the specimen, he presented it to Pruett. The Portland meteor then became the



The Washougal meteorite found on July 3, 1939, the day after the Portland fireball exploded to the east of Portland, Oregon. The meteorite is on exhibit at the Museum of Natural History at the University of Oregon. The size is compared with that of a dime.

The two pictures above are from old drawings. On the left is a fireball; on the right is a meteor shower -- probably the great meteor shower of November 13, 1833.

Washougal meteorite. Today the stone is displayed in a meteorite collection in the University of Oregon Museum of Natural History.

The Washougal meteorite is about the size of a tennis ball and weighs almost one-half pound. It has a light gray interior, throughout which are scattered many small nickel-iron particles. A fine, smooth, black fusion coating formed by its fiery passage through the atmosphere covers the entire surface. The Washougal stone belongs to a rather rare class of Howardites which are very friable and often break up in falling. It is almost inconceivable that such a small stone could create the shock felt on that early Sunday morning of July 2, 1939. Very likely it represents only one small specimen of a meteoritic shower. Some specimens have probably gone undetected, while others may have fallen into the Columbia River. Since Howardites weather rapidly, it is unlikely that specimens of this fall will still be found.

The only other observed fall in the Pacific Northwest occurred on May 26, 1893, near Beaver Creek in the West Kootenai District of British Columbia, a few miles north of the United States-Canada boundary and about 10 miles above the point where Beaver Creek flows into the Columbia River. Two stony meteorites were recovered from this fall, one weighing about five pounds, the other a larger mass of 25 pounds.

Observing a fireball or brilliant meteor is one of the most awesome sights a person can experience. It is strange that more meteorites have not been recovered, since the evidence indicates that many meteorites have fallen over the Northwest. It is hoped that the Year of the Meteorite will make some of these past falls known.

Many people have been curious about the source of meteorites in space. Today most scientists believe that meteorites have their origin in the asteroid or planetoid belt between the orbits of the planets Mars and Jupiter. In recent years a number of asteroids, following very elliptical paths, have passed rather close to the earth. These include Apollo, which came within two million miles of the earth in 1932, and Adonis, which in 1936 approached within a million miles. In 1937 Hermes came within 500,000 miles of the earth and then disappeared into space. Great public interest was generated this spring with the announcement that in June the asteroid Icarus would approach the earth within a distance of four million miles. This asteroid is of great interest, since it comes 12 million miles closer to the sun than does the planet Mercury, the sun's nearest neighbor. As small asteroids are deflected from their regular orbits by gravitational forces of bodies within the solar system, they could well come into the influence of the earth's gravitation and fall as meteorites.

A person watching the heavens on a clear night can almost always see a streak of light shooting across the sky. The light is called a meteor and is caused by a particle of matter penetrating the earth's atmosphere at high speed and becoming luminous from the heat of atmospheric friction. Most meteors are caused by particles no larger than grains of sand.

At certain times of the year the light streaks come in such large numbers as to form magnificent meteor streams or showers. One of the greatest meteor showers on record occurred on the night of November 13, 1833, when thousands of meteors could be seen every hour. The event has been compared to the falling of snowflakes in a heavy snow storm. This shower is referred to as the Leonids because all of the meteors appeared to originate in the constellation Leo. The spectacular Leonids of 1833 were seen all over the United States, and were widely reported on in scientific journals and in diaries of hunters and trappers in the Far West.

Each year on the same date a few of the Leonid meteors can be seen, but every 33-1/3 years they become impressive. The last great Leonid shower took place on November 17, 1966. Astronomers noted that the great Leonid showers occurred at the same time the Comet 1866 I, or Tempel's comet, made its appearance. This observation, along with that of other meteor showers and comets, has led scientists to believe that meteor showers are related to comets. Among the other common meteor showers are the Perseids, visible around August 12 and associated with the Comet 1862 III; the Orionids of October 22, related to Halley's Comet; and the Taurids of November 1, related to Encke's Comet, which completes its path around the sun in about 3-1/3 years, the shortest period of any known comet.

Comets, in nearing the sun, give off gaseous materials which appear as a streaming tail across the night sky. Because of light and radiation pressures as the comet nears the sun, material is lost from the comet as it completes each round trip. Some comets, such as Biela's, have disintegrated entirely and only meteor showers are seen. As the earth's atmosphere passes through the debris left in the comet's path, meteors are formed. Most of the materials vaporize and probably nothing more than meteoritic dust filters down through the atmosphere.

It is worthy of note that not a single known meteorite can be associated with the common meteor showers, while almost half of the known meteorites can be directly connected with an observed fireball. The fact that so many bright fireballs have passed over the Pacific Northwest in years past and so few meteorites have been recovered gives encouragement to the belief that the search for new meteorites will be successful, if many people become involved in looking.

Glossary of Terms

Many of the terms used in connection with meteorites are often misunderstood. It is hoped that the following explanations will be helpful.

1. Asteroids or planetoids. In our solar system nine planets revolve around the sun. Between the orbits of the planets Mars and Jupiter are

thousands of small objects sometimes called minor planets or asteroids. The largest is about 500 miles in diameter. The asteroid Icarus is thought to be but half a mile in diameter. These solid objects may have resulted from the disruption of one or more larger bodies, or they may represent material that did not form a larger object.

2. Comets. Comets are also members of the solar system revolving around the sun. Comets have a relatively large volume but small mass. They are largely composed of solid material that would be gaseous at the temperatures on the earth. As comets approach the sun, a glowing tail develops that often spreads across much of the night sky. Usually 6 to 10 comets appear each year, most of which are visible only with a telescope. Comets have very elliptical orbits cutting across the orbits of the planets.

3. Fireball. The word fireball is a common term for a very bright light or meteor that is seen passing overhead. The light is caused by the intense heat of atmospheric friction as matter from space plunges towards the earth. An exploding fireball is sometimes called a bolide.

4. Meteor. The light phenomenon produced by matter from space passing through the atmosphere is called a meteor.

5. Meteorite. Matter that reaches the earth from space is called a meteorite. The word meteoroid is often used to designate the matter while still in space.

6. Meteoritics. The science or study of meteorite is called meteoritics.

* * * * *

BUREAU OF MINES FORECASTS ENERGY NEEDS

How much energy will the U.S. economy need in 1980 and 2000? What amounts of resources will meet the demand? What mix of fuels will be used? The U.S. Bureau of Mines has made some predictions and presents the facts and formulas on which they are based in a new technical report. Total projected U.S. demand for energy in 1980 is 88 quadrillion British thermal units, and in the year 2000, 168 quadrillion BTU's. This is more than triple the 1965 use of 53.8 quadrillion BTU's. Principal sources predicted for 1980 and 2000: bituminous coal, 737 and 856 million short tons, respectively; natural gas, 24.6 and 40.4 trillion cubic feet; crude oil and gas liquids, 6665 and 9626 million barrels. The Bureau forecasts electric power generation of 2739 and 9036 billion kilowatt hours. Information Circular 8384, "An energy model for the United States, featuring energy balances for the years 1947 to 1965 and projections and forecasts to the years 1980 and 2000," is on sale for 70 cents from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402.

* * * * *

NEW HORIZONS IN HISTORICAL RESEARCH: THE GEOLOGISTS' FRONTIER

By Kenneth L. Holmes
Chairman, History Department, Linfield College, Oregon

Few people realize the tremendous influence that early geological exploration and mineral discovery had on Oregon's social and industrial development, because so little has been written about them. The Department staff has felt for some time that here was an excellent thesis for historians of the American West, and has endeavored to encourage them to delve into this subject. One product of this endeavor was an article in the June ORE BIN on early gold mining in eastern Oregon by amateur historians Miles F. Potter and Harold McCall.

Dr. Kenneth L. Holmes, whose undergraduate training and early teaching experience was in geology and general science before he turned to history as a profession, is keenly aware of the significant role frontier geology played in history and of the lack of literature on it. He writes: "Over the last few years the contemplation of the disparity between the influence of science in our culture and the neglect of the history of science as a discipline has impelled me to look in the direction of my first love, and I have sought greater understanding of the history of geology." His article in this issue of The ORE BIN is adapted from a paper he presented at the Pacific Northwest History Conference, April 22, 1962. In it he suggests three aspects of pioneer geology he believes could serve as the basis for fruitful historical research. Ed.

Introduction

In an article in the Pacific Historical Review for September 1943, entitled "The Scientist in the West, 1870-1880," Howard D. Kramer opened with the following statement:

"The scientists and geologists who took part in this work encountered their full share of the hardships and dangers which always accompany a penetration into wild and little-known country. Their exciting adventures, together with their comments on the West as they saw it, are buried in a mass of geological and technological material (underlining by Holmes). Once in a great while, though, the man of science departed temporarily from his customary detachment and it is in these rare passages that the historian can discover information which is helpful to him." (Kramer, 1943, p. 239)

Now, if we overlook the casual way in which Kramer speaks of "scientists and geologists"; if we bypass his description of some of the most undetached men of science in American history as working in "customary detachment," it is apparent that the "mass of geological and technological material" which Kramer passed over in order to find "rare passages" wherein the historian might "discover information which is helpful to him" constitutes the distilled essence of the explorations made by the creative spirits of the profession during the heroic age of American geology. Beginning with the two names known even to most historians, let us list just a few: Clarence King, John Wesley Powell, John S. Newberry, Clarence E. Dutton, Josiah Whitney, Joseph LeConte, Thomas Condon, Grove Karl Gilbert, Othniel C. Marsh, and Edward Drinker Cope, giants in the land who revolutionized American geology and had a profound influence on the discipline on a world-wide scale.

Along with such classics as James Hutton's Theory of the Earth, Lyell's Principles of Geology, and Darwin's Origin of Species, the reports of these pioneer American geologists constitute such a veritable mother lode of description, observations on method, and expressions of the geologist's philosophy that they became the criterion for subsequent research. Anyone who has taken the time to open their massive tomes, published by the United States Government, and to walk where the great frontier geologists walked has reaped rewards that have proved invaluable to him in teaching, research, and in sheer inspiration in his field, be it geology or history.

Geology Moves Westward

Joseph LeConte, first Professor of Geology at the University of California, summarized "A Century of Geology" in the Smithsonian Annual Report for 1900 (LeConte, 1900, p. 265) by saying, "Geology is one of the youngest of the sciences. It may almost be said to have been born of the present century." Then he summed up the great reconnaissance in the following manner: "It is interesting to note the ever-increasing part taken by American geologists in the advance of this science. There has been through the century a gradual movement of what might be called the center of gravity of geological research westward, until now, at its end, the most productive activity is here in America. This is not due to any superiority of American geologists, but to the superiority of their opportunities." That is one thing the frontier offered: superiority of opportunities.

Clarence King, in his first Annual Report (King, 1880, p. 4) as Director of the Geological Survey, claimed it all really began in 1867. Before that, he wrote, geology had been "a sort of camp-follower to expeditions whose main object was topographical reconnaissance." In 1867, however, King remembered that "Congress ordered the geological exploration of the 40th parallel, a labor designed to render geological maps of the country about to be opened by the Union and Central Pacific Railroads, then in process of construction. In this work geology was the sole object.

For the first time a government geologist found himself in independent command, able to direct the movements and guide the researches of a corps of competent professional assistants. At the same session of Congress, Dr. Hayden's 'Geological and Geographical Survey of the Rocky Mountain Region' was likewise placed in the field." Then King went on to say, "Eighteen hundred and sixty-seven, therefore, marks in the history of national geological work, a turning point, when the science ceased to be dragged in the dust of rapid exploration and took a commanding position in the professional work of the country."

George P. Merrill in his First Hundred Years of American Geology (Merrill, 1924, p. 251) suggested the transformation from military to geological explorations in mid-nineteenth century had developed in the following order: "some purely military, some military and geographic, with geology only incidental, and others for the avowed purpose of geological and natural history research."

There were three groups, which sometimes overlapped. Some men stayed east and received rock samples and fossils by shipment from the West and described the specimens in scientific papers. Others came west and stayed west, becoming professors in the new universities and colleges in that region, men such as Thomas Condon at the University of Oregon and Joseph LeConte at the University of California. A third group came west on expeditions for the Government, or took time off from teaching in the East, or financed themselves out of personal funds to penetrate the Great West for geological knowledge. They became pioneer teachers and founders of geology departments in eastern educational institutions; they carried out state geological surveys; they became the principal motivating force in the national geological activities.

Suggested Paths of Research

Before going farther, it must be said that the intent of this paper is not to be a definitive summary of conclusions, the result of years of research, but it is to be, rather, suggestive, pointing the way for research in the future. It is meant as much to raise questions, to posit opportunities for future historical studies, to turn a few furrows of a field that has hardly been cultivated. There are a few good works already done, but not a tithe of what has been written on the continental fur trade, for instance. The following three themes are but a triad of many, and they might be expanded fruitfully:

1. The American West contained vast stretches of land with very little ground cover, revealing land forms, geological structures, and mineral deposits in a sheer nakedness before the trained observer.
2. The West was a repository of fossil sources without precedence.

3. The West made necessary and desirable a unified approach to geology by the Federal Government.

These three themes are discussed as follows:

<u>The West was an open book to the geological explorer</u>

This new breed of geologist found a land in the arid part of the West that lay bare to the observer of geological phenomena. The geological explorers never tired of commenting on this. Consider the soaring words of J. S. Newberry, for whom Newberry Crater south of Bend is named, as he describes the region of the upper Colorado River in 1876:

> Could one be elevated to a sufficient height over the center of this region, and be gifted with superhuman powers of vision, he would see beneath him what would appear to be a great plain, bounded on every side by mountain ranges, and here and there dotted by isolated mountain masses, rising like islands above its surface. He would see, too, the profound chasm of the Colorado Cañon scoring with tortuous and diagonal course the plain, throughout the entire length of its greatest diameter; for nearly five hundred miles the stream flowing from 3000 to 6000 feet below the general level, and at all points bordered by abrupt, frequently perpendicular crags and precipices. Most of the surface beneath him he would perceive to be arid and desert-like; barren wastes of rock and sand; nowhere continuous forests or carpets of herbaceous vegetation; only here and there dwarfed and scattered pines and cedars and threads of green along the streams; the surface marked with long lines of mesa walls, the abrupt, often vertical sides of broad valleys of erosion; over considerable areas the denudation of soft materials, of varied and vivid colors, having fretted the surface into wonderfully truthful imitations of Cyclopean cities, crumpled by time, or devastated by fire, giving double force to the sense of desolation which the scene inspired.
>
> Such, in general terms, are the external features of the plateau country west of the Rocky Mountains, through which the Colorado flows. Perhaps no portion of the earth's surface is more irremediably sterile, none more hopelessly lost to human occupation, and yet it is but the wreck and ruin of a region rich and beautiful, changed and impoverished by the deepening channels of its draining streams; the most striking and suggestive example of over-drainage of which we have any knowledge.
>
> . . . .
>
> Though valueless to the agriculturist; dreaded and shunned

> by the emigrant, the miner, and even the adventurous trapper, the Colorado plateau is to the geologist a paradise. Nowhere on the earth's surface, so far as we know, are the secrets of its structure so fully revealed as here (Newberry, 1876, p. 53-54).

Clarence E. Dutton said of the same region in 1880, "In no other portion of the world are the natural laws governing the processes of land sculpture exemplified so grandly; nowhere else are their results set forth so clearly" (Dutton, 1880, 1881). He suggested that the processes of land sculpture, denudation, and erosion could be studied in the West as nowhere else.

Israel C. Russell, who pioneered in the geological exploration of eastern Oregon and Washington, wrote, "When investigators of surface geology and geography made their bold explorations into the vast arid region ...they discovered a land of wonders, where the mask of vegetation which conceals so many is absent, and the features of the naked land are fully revealed beneath a cloudless sky" (Russell, 1898, p. IX-X).

Read with me the words of John Wesley Powell as he observed the gap by which the Green River penetrates through the heart of the Uinta Mountains in eastern Utah. He wrote in 1875 as follows:

> To a person studying the physical geography of this country, without a knowledge of its geology, it would seem very strange that the river should cut through the mountains, when, apparently, it might have passed around them to the east, through valleys, for there are such along the north side of the Uintas, extending to the east, where the mountains are degraded to hills, and, passing around these, there are other valleys, extending to the Green, on the south side of the range. Then, why did the river run through the mountains?
>
> The first explanation suggested is that it followed a previously formed fissure through the range; but very little examination will show that this explanation is unsatisfactory. The proof is abundant that the river cut its own channel; that the cañons are gorges of corrasion. Again, the question returns to us, why did not the stream turn around this great obstruction, rather than pass through it? The answer is that the river had the right of way; in other words, it was running ere the mountains were formed; not before the rocks of which the mountains are composed, were deposited, but before the formations were folded, so as to make a mountain range (Powell, 1875, p. 152).
>
> . . . .
>
> We may say, then, that the river did not cut its way <u>down</u> through the mountains, from a height of many thousand feet above its present site, but, having an elevation differing but

> little, perhaps, from what it now has, as the fold was lifted, it cleared away the obstruction by cutting a cañon, and the walls were thus elevated on either side. The river preserved its level, but mountains were lifted up; as the saw revolves on a fixed pivot, while the log through which it cuts is moved along. The river was the saw which cut the mountains in two (Powell, p. 153).
>
> . . . .
>
> The mountains were not thrust up as peaks, but a great block was slowly lifted, and from this the mountains were carved by the clouds -- patient artists, who take what time may be necessary for their work (Powell, 1875, p. 154).

So Powell, as he looked down upon the naked land and formulated the necessary terms to describe it, postulated: "I propose to call such valleys...antecedent valleys" (Powell, 1875, p. 163). This concept has been fundamental to geologists ever since. Our own Columbia River is an antecedent stream. It was there before the Cascade Mountains were formed by successive uplifts and by layer on volcanic layer of lava. It was an ageless battle between the river and the rising mountains, and the river won, and continues to win, providing for us the scenic grandeur of the Columbia Gorge.

The West was a repository of fossil sources

The second theme is that the American West made available fossil sources that were without precedence. To mention just three: the Brea Tar Pits in southern California, the John Day beds discovered by Dr. Thomas Condon in eastern Oregon, and the Mesozoic beds in which dinosaur and mammal remains were found in Colorado, Utah, and Wyoming.

The eminent paleontologist, George Gaylord Simpson, calls the post-Civil War era in America a classical age of paleontology. During this period, he says, "Paleontology became evolutionary and developed the theories of phylogeny....This was the golden age of discovery when most of the major fossil fields of the continent were found" (Simpson, 1942, p. 131).

The two paleontological giants who towered above the rest were Othniel C. Marsh of the Peabody Museum at Yale University, and Edward Drinker Cope of the University of Pennsylvania. Both were wealthy men who used their financial resources to vie with each other in funding exploration of the fossil beds of the West. Both of them, incidentally, visited Thomas Condon in Oregon. We shall not deal with the amazing feud that developed as these two wealthy scientists tried to outdo each other in finding, collecting, and describing the fossil treasures. A comparison of the sections on Mesozoic reptiles in succeeding editions of a book such as James Dwight Dana's Manual of Geology reveals the landslide of reptilian fossils that this duo turned up as the years went by. They made the term "dinosaur" a household word.

Edward Drinker Cope's monograph in the Hayden Survey volumes, familiarly known as "Cope's Primer," is a fat work of more than 1000 pages and 137 plates, about as big as an unabridged dictionary. Cope discovered and named more than a third of all the fossils of the 3200 vertebrates of North America known at the time of the establishment of the U.S. Geological Survey in 1879, and had spent some $80,000 of a legacy left to him by his father in this pursuit. He is credited with 600 articles and books. George P. Merrill wrote of him that his haste sometimes led to superficiality and quotes a contemporary who charged him with describing one form "wrong end to," but adds that "his intuition was better than his logic" (Merrill, 1930, p. 421).

O.C. Marsh, Cope's protagonist in this bone-chilling contest, found and described something like 80 new forms and 34 new genera of dinosaurs. Marsh must be considered as a major contributor in exploring and understanding some of the evolutionary concepts put forward by Darwin. In commenting on the American paleontologist's monograph on the _Extinct Toothed Birds of North America,_ published in 1880, Darwin wrote to Marsh saying that "your old birds have offered the _best support_ to the theory of evolution" (Marsh, 1895, p. 181).

When Thomas Huxley came to the United States in 1876, he went to New Haven to visit Marsh. He asked if he might examine some of the horse fossils. As Marsh brought forth box after box of fossil horse material collected in the West, Huxley exclaimed, "I believe you are a magician. Whatever I want you conjure it up" (Huxley, 1909, v. 1, p. 495). There were 30 species represented. Marsh had already concluded, and Huxley agreed, that "the evolution of the horse was beyond question, and for the first time indicated the direct line of descent of an existing mammal."

The West unified the Federal Government's approach to geology

The third theme we proposed to broach is that the West made necessary and desirable a unified approach to geology by the Federal Government. As long ago as 1893 Frederick Jackson Turner in a classic essay, "The Significance of the Frontier in American History," suggested that "the legislation which most developed the powers of the national government and played the largest part in its activity was conditioned on the frontier" (Turner, 1893, p. 217).

This was true in the case of geology, too. Most of the explorations were carried out in territories under federal control -- not yet states -- and called for decisive action by the national government, which entered the field for several reasons, among them being that: (1) It was playing a major role in pushing through the railroads; (2) with the California gold rush and subsequent rushes that followed mineral riches were opened up beyond belief, (3) there was need for understanding and consistent laws and administration in dealing with the public lands -- especially arid public lands -- in the West.

Clarence King summed it up briefly in 1880 as he discussed the purpose of the newly formed United States Geological Survey: "Two special and distinct branches of duty are imposed upon the Director of the Geological Survey: 1. the classification of the public land; and 2. the examination of the geological structure and mineralogical resources" (King, 1880, p. 5).

The Survey, described by G. K. Gilbert as "a great instrument of research" (Gilbert, 1902, p. 640), became just that under Clarence King and John Wesley Powell, its first two Directors, and it continues as a vital research arm of the United States Government. The part played by the West as its huge laboratory is obvious. There is a maxim that the best geologist is the one who handles the most rocks. Here was the opportunity for the geologist to see and handle rocks in abundance -- and to be paid for doing so by the Federal Government.

King's close personal friend, Henry Adams, wrote an accolade of tribute to his geological companion in a memorable passage in The Education of Henry Adams:

> King's abnormal energy had already won him success. He had managed to induce Congress to adopt almost its first modern act of legislation. He had organized, as a civil -- not military -- measure, a Government Survey. He had paralleled the Continental Railway in Geology; a feat as yet unequalled by other governments which had as a rule no continents to survey. He was creating one of the classic scientific works of the century (Adams, 1918, p. 312).

In discussing these men and their contributions, James Gilluly of the Geological Survey says, "That most of these men were exceptionally able is generally agreed, but it seems to me that the impact they made upon science was even larger than their abilities would normally have justified. The combination of great challenge, mutual stimulus, and the financial support that enabled them to study many facets of geology, not only areally but also in depth, made possible the flowering of the science in America" (Gilluly, 1963, p. 220).

Often their intuitions overwhelmed their logic, and we know now that there were times when both their intuitions and their logic were wrong, but as we look upon the careers and achievements of these giants in the land, who today is able to bend their bow?

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LAND WITHDRAWALS FOR RECREATION

The Bureau of Land Management has announced the proposed withdrawal of 621.07 acres of O&C and public domain land from location under the mining laws in Clackamas, Marion, Benton, and Douglas Counties. The land is to be used for four recreation sites.

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ATLANTIC-RICHFIELD BUYS URANIUM REDUCTION PLANT

The uranium reduction plant north of Lakeview, Oregon, has been purchased by Atlantic-Richfield Co. The plant was built in 1958 by Lakeview Mining Co. at a cost of about $2,800,000, and Atlantic-Richfield becomes the sixth owner. (Examiner photograph, 1959)

Atlantic-Richfield, a major oil- and gas-producing corporation which is also engaged in uranium exploration, acquired the plant July 17 from Commercial Discount Corp. of Chicago for an undisclosed amount. A company spokesman for the purchaser told Chick Chaloupka, local agent for Commercial Discount, that no immediate plans have been made for utilization of the mill, but that an engineering study will be made this year to determine its mechanical condition.

The Lakeview plant was built to produce uranium oxide (U-308) from the ores of the White King and Lucky Lass mines which the plant builder, Lakeview Mining Co., had leased. The plant, using the acid leach process, went on stream in November 1958 and was operated by that company until November 1960, when it was shut down, and it has not operated since that date.

On March 27, 1961, Kerr-McGee Oil Industries of Oklahoma City announced its subsidiary, Kermac Nuclear Fuels, had obtained ownership of the plant, and on November 12, 1964, a group of Lakeview investors organized as Oregon Pacific Industries bought the plant with the intent of getting an industry into it. This group included Don Clause, Jim Farleigh, Jim Olson, Roy Matchett, and Nancy and Ed Taylor.

On March 10, 1966, sale of the plant by Oregon Pacific to Continental Mining & Milling Co. of Chicago was announced. The latter firm announced extensive plans for processing uranium plus other circuits for a number of minerals. These plans did not materialize, and a mortage against Continental was foreclosed in 1967 by Commercial Discount Corp., which took ownership and has now sold to Atlantic-Richfield.

The uranium story in Lake County began in 1955. In July discovery of the White King on Augur Creek, 12 miles northwest of Lakeview, was announced by Don Tracy, Wayland Roush, John Roush, Walter Leehmann, Sr. and Jr., the prospect having been found in March by Tracy. The following week, Don Lindsey, Bob Adams, Clair Smith, and Choc Shelton announced discovery of the Lucky Lass, about one mile from the King.

These events set off wholesale prospecting and claim taking in wide areas of the county, with upwards of 3000 claims filed. That fall, both of the original discoveries were leased to Thornburg Brothers of Grand Junction, Colo. The latter, Dr. Garth W. Thornburg and Vance Thornburg, joined with the Richarson-Bass interests of Fort Worth, Tex., and the Murchison Trusts of Dallas, Tex., to form Lakeview Mining Co., which explored the properties and in 1958 built the reduction plant.

The plant initially processed ore from the King and some from the Lass. When underground mining operations at the White King proved difficult and expensive, the operation shifted to open pit and this method produced all the ore it could by late 1959. The King was shut down then, and the mill continued operating for about one year, using ores shipped in from Nevada and California. The Lucky Lass owners did some extensive open-pit work in 1964, shipping its ores to Salt Lake City for processing. In July, 1966 the White King group of 19 claims was leased to Western Nuclear, Inc., of Denver, and in December of that year Don Tracy announced he had leased his Lucky Day group of claims on Thomas Creek to that firm. Since taking the White King lease, Western Nuclear has done extensive core drilling, which is still continuing. (Lake County Examiner, July 25, 1968)

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MOUNT JEFFERSON ROCKS ANALYZED

"Petrography and Petrology of Volcanic Rocks in the Mount Jefferson Area, High Cascade Range, Oregon," by Robert C. Green, has been published by the U.S. Geological Survey as Bulletin 1251-G. It is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The price is 30 cents.

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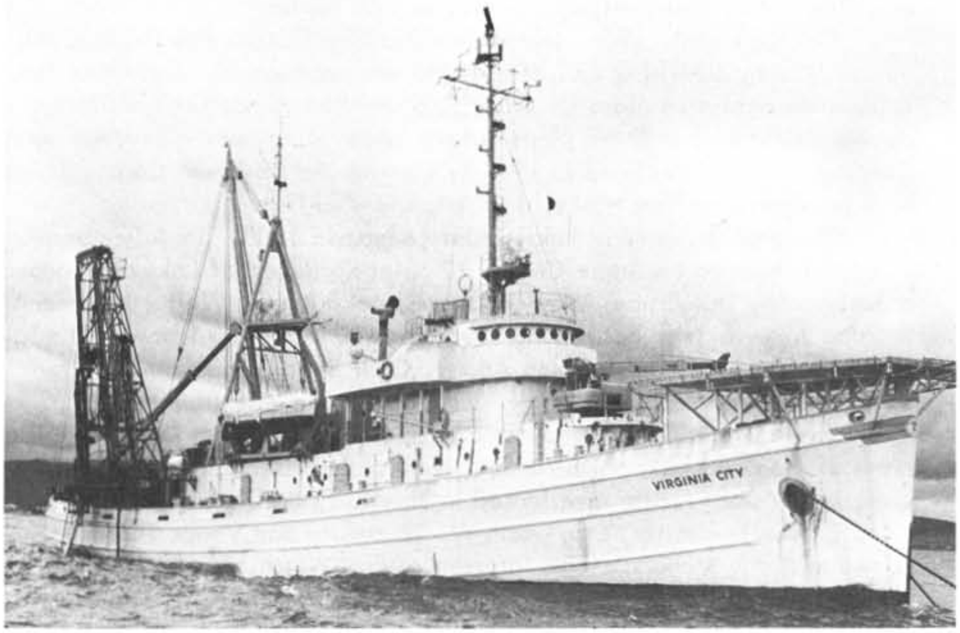

USBM MARINE DRILLING VESSEL - THE R/V VIRGINIA CITY

The R/V Virginia City, shown in the above photograph, left the U.S. Bureau of Mines Marine Mineral Technology Center at Tiburon, Cal., August 18 to work off the southern Oregon coast. The vessel is expected to be in the vicinity of Port Orford the week of September 1 and near Gold Beach the week of September 9. Drillings will be made in four areas having concentrations of heavy minerals, mainly gold, platinum, chromite, magnetite, and zircon. The four areas are situated in the ocean, mostly in lands under State control, six miles north of Coquille, at Cape Blanco, north of the mouth of the Rogue River, and at the mouth and south of the mouth of the Rogue. Location of the drilling sites is indicated on maps in the May ORE BIN and in U.S. Geological Survey Circular 587.

The ship has a capability of core drilling to a depth of 240 feet from the ocean surface. Several years of work by the Department of Oceanography at Oregon State University and by the Office of Marine Geology and Hydrology of the U.S. Geological Survey identified the deposit areas. This cooperative work is part of the Department of Interior's Heavy Metals Program.

The concentrations of heavy minerals off the coast of southern Oregon had their origin in the mineralized and ultramafic rocks of the Klamath Mountains, and lie as submerged beaches and stream channels off the mouths of the larger rivers.

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PARTICIPANTS OF THE ANDESITE CONFERENCE

Fifty-two scientists from 11 countries attended the second international conference on Oregon's volcanic rocks. The Andesite Conference, held at Bend June 30 to July 5, 1968, was under the sponsorship of the International Upper Mantle Committee, the Center for Volcanology at the University of Oregon, and the State of Oregon Department of Geology and Mineral Industries. Headquarters for the meetings were at Central Oregon College at Bend; college buildings can be seen in background of photograph. (Photograph by Earl C. Roarig, Bend, Oregon.)

The Department published the conference guidebook, which was included in the Upper Mantle Committee's scientific report series. Like the guidebook which the Department published for the Lunar Geological Field Conference in 1965, and which is in its third printing, the volume for the Andesite Conference (Bulletin 62) contains many photographs and colored geologic maps to illustrate field trips, road logs, and discussions on Oregon Cascade rocks. The first definitive work to be published on the geology of Mount Hood is included in the bulletin. Other areas covered are the Santiam-McKenzie Pass area, Crater Lake, and Newberry caldera.

"Andesite Conference Guidebook" should be enjoyed as much by the layman and tourist as was its predecessor, "Lunar Geological Field Conference Guidebook."

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NATIONAL OCEANOGRAPHY CONFERENCE SCHEDULED

Oregon Governor Tom McCall and Admiral J. M. Lyle, president of the National Security Industrial Association, announced August 19 that Oregon will host a National Conference of Coastal States December 11, 12, and 13 in Portland. The conference will bring together representatives of the 23 coastal states and of industries interested in ocean resources.

The purpose of the conference is to develop specific guidelines on hard metal mining from the ocean-submerged lands under state control. Representatives from the petroleum, commercial fisheries, recreation, and mining industries will meet with state people from the executive and legislative branches of government and the public to develop guidelines under the multiple-use concept. More than 100 official delegates are being named, with many other industry, government, public, and conservation organizations from the entire nation expected to attend as observers.

The conference is the first in a planned annual series of Governor McCall's Conservation Congresses, each to consider an individual resource problem.

This conference is a joint effort by the Sea Grant Program of Oregon State University, the Governor's Committee on Oceanography, and the Committee on Natural Resources. Joining with Oregon in sponsoring the workshop is the Ocean Science and Technical Advisory Committee of the National Security Industrial Association of Washington, D.C.

Further information may be obtained from Commander John H. Jorgenson, OSTAC Executive Committee, 1030 15th N.W., Suite 800, Washington, D.C. (20005) or from Kessler Cannon, Governor's Office, Salem, Oregon (97310).

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METAL PRICES AND PREDICTIONS REPORTED

<u>SILVER</u>:- The price of silver has dropped to $2.09 per troy ounce. At the first silver sale since June in which General Services Administration offered commercial (99.9% fine) silver, all bids were rejected by the Government.

<u>COPPER</u>:- Producers and dealers predict that a drop in the present price of 42 cents a pound for domestic copper is almost a certainty. The prediction is based on the drop in the price of U.S. scrap, a decline in copper quote on the London Metal Exchange, a recent decrease in the price of Canadian copper sold to Canadian users and increased production of new copper. Dealers' forecasts range from a modest 1 cent per pound drop to retrenchment as far as the 38-cent price prevailing before the $8\frac{1}{2}$-month copper strike was ended last March. (Nevada Mining Assn. News Letter, August 15, 1968)

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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

2.	Progress report on Coos Bay coal field, 1938: F. W. Libbey	$ 0.15
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.	(1st vol.) Five papers on Western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	(2nd vol.) Two papers on Western Oregon and Washington Tertiary foraminifera, 1949: Cushman, Stewart, and Stewart; and one paper on mollusca and microfauna, Wildcat coast section, Humboldt County, Calif., 1949: Stewart and Stewart	1.25
37.	Geology of the Albany quadrangle, Oregon, 1953: Allison	0.75
44.	Bibliography (2nd supplement) of geology and mineral resources of Oregon, 1953: Steere	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
56.	Fourteenth biennial report of the State Geologist, 1963-64	Free
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
59.	Fifteenth biennial report of the State Geologist, 1964-1966	Free
60.	Engineering geology of the Tualatin Valley region, Oregon, 1967: Schlicker and Deacon	5.00

GEOLOGIC MAPS

Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others . . .	0.40
Geologic map of the St. Helens quadrangle, 1945: Wilkinson, Lowry & Baldwin .	0.35
Geologic map of Kerby quadrangle, Oregon, 1948: Wells, Hotz, and Cater . .	0.80
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
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A PRELIMINARY INVESTIGATION OF THE HEAVY MINERAL SUITES OF THE COASTAL RIVERS AND BEACHES OF OREGON AND NORTHERN CALIFORNIA

By

By L. D. Kulm*, K. F. Scheidegger*,
J. V. Byrne*, and J. J. Spigai*

Introduction

Coastal rivers of Oregon, Washington, and northern California are the primary suppliers of sediments to the adjacent continental shelf, slope, and deep-sea environment. The Columbia River is the largest supplier of terrigenous materials to the entire northeastern Pacific Ocean. Silts and clays from the Columbia and the smaller coastal drainage areas are spread over large portions of the northeast Pacific. These fine-grained sediments account for a large volume of the marine deposits, but it is difficult to trace them to specific continental drainage basins. The sand portion of marine sediments, on the other hand, can be traced to continental sources with greater accuracy through heavy mineral assemblages, provided that it has not been extensively modified during or subsequent to transportation. Although the heavy minerals may reflect the general nature of the continental source rocks from which they were derived, the relative contribution of the sediment sources may be more accurately defined when the heavy mineral suite of individual drainage basins is known.

The sands of coastal rivers and beaches of Oregon and northern California, with some exceptions, are compositionally diverse and immature. The diversity and immaturity are reflected in the more than 30 heavy mineral species present; the large percentages of unstable minerals, such as hypersthene and augite (Pettijohn, 1957); and the low quartz/feldspar ratios and abundant lithic fragments (Kulm, 1965 and Whetten, 1966). These data suggest that most of the coastal sediments were derived from source areas characterized by high relief and rapid mechanical erosion. Such conditions do, in fact, exist in the coastal drainages of Oregon and northern California where rainfall and river runoff are high.

One of the objectives of the present study is to determine the nature

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of the heavy mineral suites in each of the major coastal drainages of Oregon and northern California that contribute sediment to the ocean. Once the heavy mineral suites of the beach sands and continental shelf and deep-sea sediments are defined, areal and temporal variations in sediment sources can be detected. With a knowledge of the heavy mineral suites in the river drainages, an attempt is made in this study to determine the predominant direction of littoral drift or sediment transport along the coast.

Sampling and Sediment Analysis

One sample was collected in each of the 26 major coastal rivers of Oregon and northern California; two were collected in the Columbia River. With the exception of the Columbia, samples were taken upstream of tidal influence to eliminate the effects of the intrusion of marine sediments. Sand-size sediments were taken at a number of sites, such as the channels, exposed sand bars, and adjacent river terraces, depending upon the accessibility of the deposit. An attempt was made to collect sediments in the fine and very fine sand class (Wentworth, 1922) in order to obtain the majority of the heavy mineral species present in each drainage basin. Five beach samples were selected for analysis from a total of 70 collected from the upper foreshore along the northern California and Oregon coast.

River sediments were sieved according to the size classes of Wentworth (1922). Three size classes (62-125, 125-250, and 250-500 microns) were chosen for heavy mineral identification and to determine if there was selective sorting of the mineral assemblage. For the beaches an unsized sand sample was used. A plot of the percentage of each of the major heavy mineral species against the median diameter of the total sediment shows that the heavy mineralogy of most sediments is not controlled by selective sorting.

The heavy mineral separation was made with tetrabromoethane (specific gravity 2.96). Magnetic minerals, chiefly magnetite and some ilmenite, were removed from the heavy mineral fraction and weighed. This fraction was examined to see if nonopaques were included; in some cases, small amounts of hypersthene with magnetic inclusions were removed. The heavy minerals were mounted in Canada balsam and identified with the aid of a petrographic microscope. At least 200 nonopaque, nonmicaceous grains were counted for each of the three size fractions. A 300-grain count was made for the beach samples. The combined heavy mineral assemblage of all three size classes of the rivers and the beach assemblages are given in table 1.

Heavy Mineralogy of Coastal Drainages

Heavy mineral suites of the major coastal rivers of Oregon and northern California can be conveniently discussed with respect to the continental watersheds defined by Hagenstein and others, 1966 (figure 1). The four basins include 1) the Klamath-South Coast Basins, 2) the Umpqua and Mid-Coast Basins, and 3) North Coast Basin, and 4) all basins drained by the Columbia River. Each of the watershed basins generally has a characteristic heavy mineral suite that distinguishes it from the adjacent basins.

The relative amount of sediment transported to the ocean from the various drainage basins can be determined by assuming a direct correlation between river runoff and sediment load. The annual freshwater discharge for the four drainage basins described above is shown in figure 1. Heavy mineral assemblages in these four drainage basins are given as the weighted averages of the mineral values for all the rivers sampled within a particular basin (table 2). The weighted average of a particular heavy mineral species in a basin is obtained by summing the products of river runoffs and their respective heavy mineral percentages and dividing this sum by the total runoff of all rivers in the basin. The runoff data for the rivers and basins were obtained from Lockett (1965), Hagenstein and others (1966), and the U.S. Geological Survey Surface Water Records for California (1964) and for Oregon (1966).

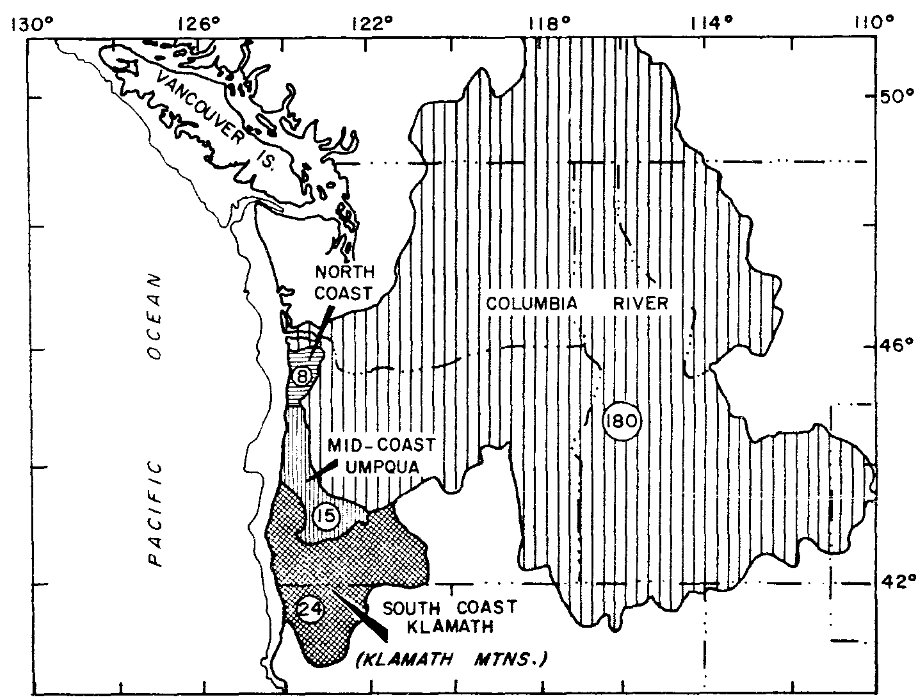

Figure 1. Continental drainage basins of northwestern United States. Circled numbers are approximate average annual runoff in millions of acre feet. (Modified from Duncan, 1968.)

TABLE 1

COMBINED HEAVY MINERAL COUNTS OF NON-OPAQUE GRAINS
FOR COASTAL RIVERS AND BEACHES

Numbers are given in percent of total assemblage
Symbol "T" denotes mineral contents less than one percent

RIVER

MINERAL	Columbia	Necanicum	N. Fk. Nehalem	Nehalem	Miami	Kilchis	Wilson	Trask	Tillamook	Nestucca	Little Nestucca	Salmon	Siletz
Amphibole Group	28	4	4	3	T		T	T	1	1	T		2
Actinolite-Tremolite	1												
Glaucophane													
Hornblende	27	4	4	3	T		T	T	1	1	T		2
Basaltic	4												
Blue-Green	6												
Brown	8		3	T	T			T	T	T	T		2
Green	9	4	1	3	T		T	T	T	T			
Apatite											T		
Epidote Group	1	T											
Clinozoisite	T												
Epidote	T	T											
Zoisite													

MINERAL	Yaquina	Alsea	Siuslaw	Umpqua	Millicoma	Coos	Coquille	Sixes	Elk	Rogue	Pistol	Chetco	Smith	Klamath
Amphibole Group	18	9	18	25	34	31	28	47	66	75	15	37	42	76
Actinolite-Tremolite				2	T	1	4	1	16	6	3	3	7	4
Glaucophane							1	8		T	2			T
Hornblende	18	9	18	23	33	30	23	38	50	69	10	34	35	72
Basaltic	1				3	1	T		T	1	1			
Blue-Green				11	7	6	7	19	19	28	2	12	11	41
Brown		4	7	5	9	7	5	3	2	10		1	4	5
Green	17	5	11	7	14	16	11	16	29	30	7	21	20	26
Apatite	5	T	T	T							T			T
Epidote Group	14	T	2	5	7	14	6	6	7	5	12	5	3	3
Clinozoisite				2	3	4	2		3	2	5	3	1	2
Epidote	14	T	2	3	4	9	4	6	4	1	7	2	2	1
Zoisite						1				2				T

BEACH

MINERAL	Arch Cape	Otter Rock	Yachats	Coquille	Cape Sebastian
Amphibole Group	18	26	24	53	57
Actinolite-Tremolite	6	3	2	14	21
Glaucophane			1	4	6
Hornblende	12	23	21	35	30
Basaltic	T	2	4	1	2
Blue-Green	1	4	1	7	14
Brown	3	10	9	13	2
Green	8	7	7	14	12
Apatite	T	1	1	3	
Epidote Group	5	4	1	3	5
Clinozoisite					
Epidote					
Zoisite					

Garnet Group	1			T			T		T					14	T	18	2	21	15	7	5	2		2	2		1	13	6	15	7	4
Clear	1			T			T									7	1	6	8	3	5	1			1		1	1	1	2		
Pink	T								T						T	11	1	14	7	4		1		2	1		T	8	3	10	5	2
Salmon																T		1										4	2	3	2	2
Kyanite	T																											3			T	T
Monazite														4															T	T	T	
Olivine Group	2			2	T	2	T	1	1	1	1		1				T		T		1	1	2		4	28	T	2	1	1	2	2
Pyroxene Group	64	93	94	92	97	98	97	98	96	98	97	100	97	29	88	46	64	23	28	49	30	19	17	55	44	21	12	43	43	35	18	12
Orthopyroxenes	36	4	2	5	T				T	2	T	T	T	1	T	2	22	1	2	3	4	2	5	5	5	3	3	4	12	8	7	8
Enstatite	T	T	T	T						T					T		T	T	T					4	1	1	1	1	2	2	3	2
Hypersthene	36	3	2	4	T				T	2	T	T	T	1		2	21	1	2	3	4	2	5	1	4	2	2	3	10	6	4	6
Clinopyroxenes	28	89	92	87	97	98	97	98	96	96	96	100	97	28	88	44	42	22	26	46	26	17	12	50	39	18	9	39	31	27	11	4
Augite + Diopside	28	86	89	87	97	98	95	92	95	86	92	95	89	28	87	43	42	22	26	46	25	17	12	50	39	18	9					
Titanaugite	T	3	3	T			2	6	1	10	4	5	8		1	1			T		1											
Rutile															T	3	T	2	T	2	1	T			T		1		1	3	4	2
Sillimanite	T																					T										
Sphene														5		2	T	2	1	T					T			6	3	3	1	2
Spinel																	T										T		T		1	
Staurolite																	T	T	T				T	T				2	2	4	T	2
Topaz																													T			
Tourmaline	T		T												T	T		T	T				T	T			T		T	1		5
Zircon				T			T				T			7	T	9	1	6	5	3	1	2		13	4	T		4	1	3	4	2
Other Minerals + Unknowns	4	3	2	3	3		3	1	2		2			4	3	2	2	5	6	5	9	3	1	3	4	6	7	4	12	9	4	7

TABLE 2

HEAVY MINERAL SUITES FOR THE MAJOR COASTAL DRAINAGES

Percentages are based on weighted averages

Note pyroxene/amphibole ratios at the bottom of the table

Mineral	Columbia River Basin	North Coast Basin	Umpqua and Mid-Coast Basins	Klamath-South Coast Basins
AMPHIBOLE GROUP	28	2	20	65
Actinolite and Tremolite	1	--	1	5
Glaucophane	--	--	--	1
Hornblende	27	2	19	59
Blue-Green	6	--	6	29
Brown + Green + Basaltic	21	2	13	30
EPIDOTE GROUP	1	--	4	4
GARNET GROUP	2	--	5	2
OLIVINE GROUP	2	1	1	4
PYROXENE GROUP	64	96	61	19
Orthopyroxenes	36	1	14	3
Clinopyroxenes	28	95	47	16
Augite + Diopside	27	91	47	16
Titanaugite	1	4	--	--
OTHER MINERALS	3	1	9	6
Pyroxene/Amphibole Ratios				
Weighted Average	2.3	48.0	3.1	0.3

Klamath-South Coast Basins

The Klamath and Smith Rivers of northern California and the Chetco, Pistol, Rogue, Elk, Sixes, Coquille, Coos, and Millicoma Rivers of southern Oregon make up the Klamath-South Coast Basins. Two of these rivers, the Klamath and Rogue, have a combined drainage area of 20,775 square miles (84 percent of the total land area of the basins) and have an average annual yield of 21.5 million acre feet (68 percent of the total average annual yield of the drainage).

The Klamath-South Coast Basins are characterized by an amphibole assemblage which consists principally of blue-green and green hornblende, with lesser amounts of actinolite-tremolite. This suite of heavy minerals is present in all of the rivers of the Klamath-South Coast Basins and only in the Coquille, Pistol, and Chetco Rivers is the pyroxene group quantitatively larger than the amphibole group. The pyroxene/amphibole ratio (based on weighted averages) is 0.3 for these basins. One-half of the southern drainage basins, including the Klamath and Rogue, contain minor amounts of glaucophane. Although present in small amounts, glaucophane is a diagnostically important mineral because it appears only in these drainages. Epidote and clinozoisite-zoisite also occur in virtually all of these drainages, but are not restricted to them. The Smith River of northern California is unique because it contains a substantial amount of olivine. In addition, unusually high percentages of garnet are present in the Coos and Millicoma Rivers. The combined heavy mineral assemblage of blue-green hornblende, actinolite-tremolite, glaucophane and the epidote group show the strong metamorphic character of the source rocks in the Klamath-South Coast Basins.

The Klamath and Rogue Rivers have their headwaters in the Pliocene and Recent lava flows of the High Cascades to the east and flow westward across the Klamath Mountains of southwestern Oregon and northwestern California. Paleozoic and Mesozoic metasedimentary, metavolcanic, and sedimentary rocks of the Klamath Mountains, which have been intruded by granitoid and ultrabasic rocks (Baldwin, 1964), are probably responsible for the distinctive mineralogy. According to Irwin (1960), the metamorphic grade of the Abrams and Salmon Formations of the central metamorphic belt of the Klamath Mountains is the almandine zone of the regional, greenschist facies as defined by Barrow and Tilley for the Scottish Highlands. Typical minerals of this facies include: epidote, tremolite, hornblende, and almandine (Turner and Verhoogen, 1960). Glaucophane is derived from glaucophane-bearing schists of the Franciscan Formation of northern California and the Dothan (?) Formation of Oregon (Irwin, 1960). According to Taliaferro (1943) the glaucophane and related schists are the result of pneumatolytic metamorphism by the emanations accompanying the intrusion of mafic and ultramafic rocks. If this origin is correct, this could account for the patchiness of the glaucophane distribution in the rivers.

Along the coast the Smith, Chetco, Pistol, Elk, Sixes, Coquille, Coos, and Millicoma Rivers drain the western slopes of the Klamath Mountains and the Miocene-Pliocene and Quaternary marine formations of the southern end of the Oregon Coast Range.

Umpqua and Mid-Coast Basins

The Umpqua, Siuslaw, Alsea, Yaquina, Siletz, and Salmon Rivers comprise the Umpqua and Mid-Coast Basins. Seventy-two percent of the drainage area and 51 percent of the river discharge are associated with the Umpqua River. It drains the northern tip of the Klamath Mountains and a segment of the Cascade Mountains on the eastern border of the basin, but the largest portion of the basin is located in the southern Oregon Coast Range.

A diverse heavy mineral assemblage occurs in the Umpqua, Siuslaw, Alsea, and Yaquina drainages. Although the Siletz and Salmon Rivers are part of the Mid-Coast Basins, their heavy mineral suite is similar to that of the North Coast Basin and they will be discussed in the following section. The Umpqua River sediments are dominated by pyroxenes which account for 64 percent of the heavy mineral suite; hypersthene makes up one-third of this assemblage, which is the highest percentage found in any of the coastal rivers of Oregon except the Columbia River to the north. The rather high hypersthene content of the Umpqua River may be associated with sources in the Cascade Mountains. Glenn (1965) reported that hypersthene is abundant in sediments derived from the Cascade Mountains. Blue-green hornblende and actinolite-tremolite which are typical of the rivers to the south are also present in the Umpqua River, but in smaller quantities. The metamorphic minerals were probably derived from that portion of the Umpqua drainage which includes the northern part of the Klamath Mountains. Glaucophane appears to be absent in this drainage.

To the north the Siuslaw, Alsea, and Yaquina Rivers are characterized by a pyroxene assemblage, but with only minor amounts of hypersthene. High percentages of garnet have replaced blue-green hornblende in these drainages. As in the Umpqua, green and brown hornblende generally account for more than 10 percent of the heavy mineral suite. In the Umpqua and Mid-Coast Basins the weighted average for the pyroxene/amphibole ratio is 3.1.

Most of the rocks in the southern Coast Range are composed of volcanic materials, largely basalt, and Eocene sedimentary rocks (Baldwin, 1964).

North Coast Basin

The North Coast Basin includes all of those rivers from the Salmon to the Necanicum. Based on drainage area and river runoff, the North Coast Basin contributes the smallest quantity of sediment to the ocean of all the basins examined.

The North Coast Basin is characterized by a heavy mineral assemblage consisting almost entirely of clinopyroxenes and a high pyroxene/amphibole ratio (48.0). This assemblage also occurs in the Siletz and Salmon Rivers, which are considered to be a part of the Mid-Coast drainage basin (Hagenstein and others, 1966). Minor heavy mineral constituents in this basin include green and brown hornblende and olivine. Titanaugite occurs in all but two of the rivers. Although titanaugite occurs in small quantities, it appears to be a diagnostically important mineral for the North Coast Basin. Snavely, Wagner and MacLeod (1965) noted that titaniferous augite is quite common in the basalt flows and breccias of the central Oregon Coast

Range.

Basic igneous rocks (principally basalt) and marine sedimentary rocks, derived from the weathering and erosion of basic igneous rocks, appear to be the source for the relatively simple heavy mineral suites of the rivers in the North Coast Basin. Thick submarine volcanic flows, breccias, and tuffaceous sedimentary rocks of the early Eocene Siletz River Volcanics constitute most of the central core of the Coast Range in this basin (Baldwin, 1964). The Tyee Formation, the most widespread formation in the Coast Range, extends as far north as Hebo, Oregon, and is composed of massive arkosic and micaceous sandstones and sandy siltstones (Baldwin, 1964). The small percentages of metamorphic minerals that are found in the Alsea and Yaquina Rivers were probably derived from the weathering of the Tyee sandstones in the central Coast Range (Kulm, 1962).

Columbia River Basin

The Columbia River has the third largest drainage of all rivers in the United States (Highsmith, 1962), and drains an area of approximately 259,000 square miles. It originates in the Canadian Rockies and flows south and west 1200 miles to the Pacific Ocean, where it discharges annually approximately 180 million acre feet of water (Lockett, 1965). The Columbia River transports annually approximately 14,500,000 cubic yards of suspended sediment (U.S. Army Engineers, 1962). Lockett (1965) reports a bedload of 1,780,000 cubic yards measured at Vancouver, Wash. When the drainage area and annual flow of this river are compared with that of the other drainage basins discussed, it is obvious that the sediment discharge of this river should dominate the terrigenous sediments of the adjoining marine environment.

In the lower channel of the Columbia River the heavy mineral assemblage consists mainly of pyroxene; hypersthene accounts for more than one-half of this assemblage. Glenn (1965) also found large percentages of hypersthene in the tributaries of the Willamette River which drain portions of the Cascade Mountains and eventually empty into the Columbia. According to Glenn, the Cascade Mountains' heavy mineral suite is characterized by large percentages of augite and hypersthene. Continental shelf surface sediments directly off the mouth of the Columbia also contain abundant hypersthene (Runge, 1966). Hornblende, including the blue-green variety, is prominent in the Columbia heavy mineral suite, while epidote, garnet, and olivine appear to be minor constituents. Many other mineral species are also present but occur in only trace amounts. The blue-green hornblende in the Columbia River sediments does not appear to be nearly as abundant as it is in the Klamath-South Coast Basins. Our limited heavy mineral analyses as well as those of Glenn (1965) show that glaucophane is absent in the Columbia River. Studies of the adjacent marine environments (Runge, 1966; Carlson, 1967; Nelson, 1968; and Duncan, 1968) which

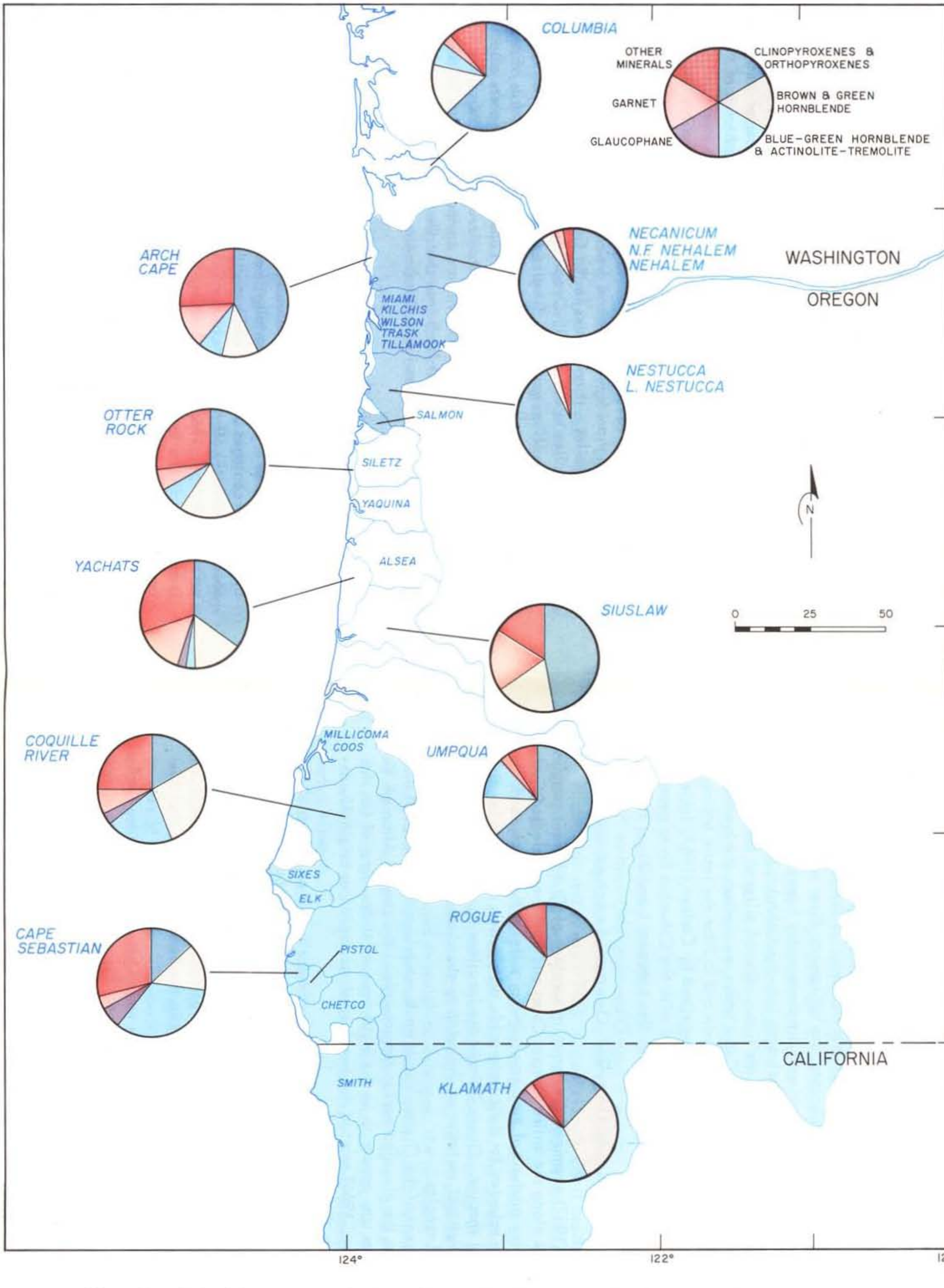

Figure 2. Typical heavy mineral suites of coastal drainages and beaches of northern California and Oregon. See Figure 1 for geographic distribution of continental watersheds.

receive sediments from the Columbia River also show that glacophane is absent. It appears that glacophane occurs only in the Klamath-South Coast Basins and, when present, it is a diagnostic indicator of the sediments in these basins.

Whetten (1965) indicates that clinopyroxenes are quantitatively equal to or greater than the orthopyroxenes in three downstream Columbia River reservoirs - Bonneville, The Dalles, and McNary. If these reservoirs tend to trap the coarse-grained sediments, the Willamette River with its augite-hypersthene assemblage may dominate the present-day heavy mineral assemblage below the point where it discharges into the Columbia.

Although the composition of the heavy mineral suites of the Columbia River Basin and the Klamath-South Coast Basins are similar, the pyroxene/amphibole ratio is 2.3 for the former basin and 0.3 for the latter basins, based on weighted averages. Data summarized by Carlson (1967, table 10, p. 114) showed that sediments associated with the Columbia River generally have a pyroxene/amphibole ratio which lies between 1 and 3.

Heavy Mineralogy of Oregon Beaches

Spigai (1967) examined the heavy mineralogy of 70 different samples of beach sands along the entire Oregon Coast and from these selected five for a preliminary analysis of the heavy mineral suites. The beach sands analyzed were selected for their geographic distribution as well as for diversity of mineral species. Figure 2 shows the locations of the sampling sites and the geographical variation of the relative abundance of the important heavy mineral species.

The sources of the Oregon beach sands are primarily the coastal drainages as well as the elevated marine terraces along the coast. Although the marine terraces now appear to be the major sources of the material for the beaches (Runge, 1966) most of the beach sand no doubt was originally derived from river drainage.

Along the southern Oregon coast, particularly in the vicinity of Cape Sebastian and the Coquille River, the hornblende assemblage of the Klamath-South Coast Basins is evident in the beach sands. The large percentage of blue-green hornblende and actinolite-tremolite, which are characteristic of these basins, is also reflected in the adjacent beaches. The diagnostic mineral glaucophane occurs in the beaches as far north as Yachats in this investigation and Kulm (1965) reported it in the beach sands near the Yaquina River to the north.

The beaches near Yachats have the varied heavy mineral suite similar to that of the Umpqua and Mid-Coast Basins. Pyroxenes and garnet increase at the expense of the amphiboles. Garnet is abundant in these beach sands and probably originates in the Coos, Millicoma, and Siuslaw Rivers to the south.

Farther north along the central Oregon coast the heavy mineral suite shows a marked contrast to the pyroxene assemblage present in the adjacent North Coast Basin. Although pyroxenes, particularly clinopyroxene, dominate the mineral suite of the beaches in the vicinity of Otter Rock and Arch Cape, the sources of the remainder of the suite no doubt are the Columbia River or the drainage basins south of the North Coast Basin, or both.

There is a systematic increase in the percentage of pyroxene and a decrease in amphibole content from the southern Oregon beaches to the northern ones. The percentage of metamorphic minerals, such as blue-greene hornblende, actinolite-tremolite, and epidote, also decrease from south to north. All of these trends and the presence of glaucophane in the beach sands of southern and central Oregon suggest that the predominant direction of sediment transport is from south to north along the Oregon coast.

Conclusions

A preliminary investigation of the heavy mineralogy of the coastal rivers of northern California and Oregon shows that four distinct heavy mineral assemblages can be defined in the continental watershed basins defined by Hagenstein and others (1966): Klamath-South Coast Basins, Umpqua and Mid-Coast Basins, North Coast Basin, and all basins drained by the Columbia River.

The Klamath-South Coast Basins are characterized by a hornblende assemblage which contains abundant blue-green and green hornblende and lesser amounts of actinolite-tremolite. About one-half of the drainages contain the diagnostic mineral glaucophane, which appears to occur only in these basins. Based on weighted averages, the pyroxene/amphibole ratio is 0.3 or the lowest ratio of all basins investigated. Although the bulk of the non-opaque heavy mineral suites of this region consists of minerals derived from both basic and acid igneous sources, it is the metamorphic terrane of the Klamath Mountains that produces this characteristic suite of heavy minerals.

The Umpqua and Mid-Coast Basins display a diverse heavy mineral suite. Umpqua River sediments are dominated by pyroxenes, with abundant hypersthene, and all other amphiboles, except glaucophane, are present but in smaller quantities than in the Klamath and Rogue Rivers. Rivers of the Mid-Coast Basin are also characterized by pyroxenes, but in this case, the clinopyroxenes predominate. In the majority of these smaller drainages large percentages of garnet replace the blue-green hornblende. The sources of the garnet are unknown at this time. Sediment sources for these drainages lie in the northern end of the Klamath Mountains and the southern Oregon Coast Range.

Sediments of the North Coast Basin consist almost entirely of clinopyroxene with only minor amounts of green and brown hornblende and olivine. Titanaugite is a minor but diagnostic constituent in most drainages and originates in the basalt flows and breccias of the central Oregon Coast

Range (Snavely and others, 1965). The bulk of the heavy mineral suite is derived from basic igneous and marine sedimentary rocks of the central and northern Oregon Coast Range.

Limited heavy mineral data for the sediments near the mouth of the Columbia River show that the pyroxenes predominate; the orthopyroxenes, particularly hypersthene, are the most abundant. Hornblende is also common, but neither the blue-green nor the green varieties are as abundant as they are in the Klamath-South Coast Basins. Our data, as well as other investigations of Columbia River sediments, indicate that glacophane is absent in the Columbia. A multitude of rock types occur in the Columbia River Basin and no attempt is made here to identify them, except that it appears that augite and hypersthene-rich sediments are derived from the Cascade Mountains and are carried to the Columbia by the Willamette River.

Each of the four continental watersheds can be defined on the basis of the weighted averages of the pyroxene/amphibole ratios (table 2): Klamath-South Coast Basins, 0.3; Umpqua and Mid-Coast Basins, 3.1; North Coast Basin, 48.0; and Columbia River Basin, 2.3.

The heavy mineral assemblage of the beach sands along the southern Oregon Coast reflects the mineral assemblages of the adjacent drainages, whereas those of the central and northern Oregon Coast exhibit a more diverse mineral suite than occurs in the adjacent drainages. The pyroxene/amphibole ratio is 0.2 near Cape Sebastian off southern Oregon and increases gradually to 2.4 near Arch Cape off northern Oregon. Glaucophane, which apparently occurs only in the southern rivers, is found as far north as the Yaquina River. Heavy mineral data suggest that the predominant direction of littoral drift or sediment transport is south to north along the Oregon coast.

Acknowledgments

We wish to express our appreciation to the several graduate students in the Department of Oceanography, Oregon State University, who aided in the collection of the river and beach samples. Special thanks go to Drs. J. R. Duncan, Jr., N. J. Maloney, and E. J. Runge, Jr. for their assistance and helpful discussions. This research was sponsored by the Office of Naval Research Contract Nonr 1286(10).

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OCEAN MINING LAW CONFERENCE AGENDA OUTLINED

A tentative agenda for the "Coastal States Conference on a Multiple Use Approach to Ocean Mining Law," to be held at the Portland Hilton Hotel, Portland, Oregon December 11, 12, and 13, 1968 is as follows:

P. M. - Tuesday 10 December 1968

1400 - 2200 - Registration desk open - Lobby, Portland Hilton Hotel.

A. M. - Wednesday 11 December 1968

0800 - Registration desk open.

0900 - Call to order - Kessler R. Cannon, Conference Chairman and Executive Secretary, Governor McCall's Committee on Natural Resources.

Welcome - The Honorable Tom McCall, Governor of Oregon.

0910 - Keynote address - Dr. John Byrne, Head, Department of Oceanography, Oregon State University.

0920 - OSTAC Mining Panel report - RADM. L. D. Coates, USN (Ret.), Lockheed-California Co.

0935 - OSTAC Petroleum Panel report - C. B. Siebenhausen, Shell Oil Co.

0950 - OSTAC Recreation Panel report - H. F. Larson, Outboard Marine.

1005 - OSTAC Fishing Panel report - W. C. Foster, Ralston Purina.

1020 - Question and answer period with OSTAC panel chairmen.

1120 - Survey of problems of ocean mining law:
Operational aspects - C. O. Ensign, Jr., Copper Range Co.
Legal aspects - Wm. L. Griffin, Washington, D.C.

1200 - Luncheon.

P. M. - Wednesday 11 December 1968

1315 - Call to order - Chalmer G. Kirkbride, Conference Co-Chairman, Chairman OSTAC and Vice President (R & E), Sun Oil Co.

1320 - U.S. Department of the Interior - Plans and policies:
Bureau of Commercial Fisheries;
Bureau of Sport Fisheries and Wildlife;
Bureau of Outdoor Recreation;
Geological Survey;
Bureau of Mines;
Water Pollution Control Administration;
Bureau of Land Management.

1515 - Environmental Science Services Admin. - Plans and policies.
1535 - U.S. Coast Guard - Presentation.
1555 - Public Land Law Commission - Presentation.
1615 - Industry presentation.
1645 - Question and answer session with afternoon speakers.
1715 - Recess.

Evening, Wednesday 11 December 1968
1900 - Reception.
2000 - Dinner with honored guests and banquet speaker.

A. M. Thursday 12 December 1968
0830 - Workshops meet as follows:
Petroleum Panel - Legal advisor, Northcutt Ely;
Fishing Panel - Legal advisor, David Browning;
Recreation Panel - Legal advisor, Thomas Clingan;
Mining Panel - Legal advisor, Wm. Griffin.
1000 - Mining Panel separates to furnish participants to each of the other four workshops.
1200 - Luncheon.

P.M. Thursday 12 December 1968
1300 - Workshops resume.
1530 - General assemble for report of findings of the separate workshops.
1630 - Open conference adjourns.

A. M. Friday 13 December 1968.
0830 - Conference steering group meets to set down findings and recommendations.
1200 - Adjournment.

* * * * *

APPLICATION OF THE COLEMAN CASE: CONVERSE v. UDALL

"Attempts by proponents of mining claims to limit the effect of the Supreme Court's decision in the Coleman case to claims involving building stone or common variety materials appear to have been squelched by the Ninth Circuit's decision of August 19, 1968, in Converse v. Udall. The court squarely held that a showing that mineral can be extracted, removed and marketed at a profit - the so-called 'marketability test' - is proper to be applied to all mining claims, whether they be for building stone or for precious metals." So writes Justice Department Attorney George R. Hyde in the August 1968 issue of the Land and Natural Resources Division Journal of the Department of Justice. (American Mining Congress Memorandum, Sept. 24, 1968.)

* * * * *

TSUNAMI ON THE OREGON COAST FROM AN EARTHQUAKE NEAR JAPAN

By June G. Pattullo*, Wayne V. Burt*, and Gerald B. Burdwell**

Just before 3. a.m. on May 16, 1968, tsunami [pronounced "soo-nóm-ee"] waves began arriving on the Oregon coast and were observed on the tide recorder at the Marine Science Center at Newport, Oregon. These waves, commonly called "tidal waves," were generated 10 hours earlier by a strong earthquake off northern Japan. Fortunately, the waves at Newport were not large (about half a foot high), so no serious damage was caused. The tsunami waves reached Crescent City, California, at almost the same time they reached Newport, but the amplitude of the waves at Crescent City was as high as 4 feet. The initial change in water level was a fall at both Newport and Crescent City, whereas most other tide stations around the Pacific Ocean initially experienced a rise in water level.

There were two important results of the May 16th tsunami: (1) The tsunami warning system worked; local authorities had been warned of the coming waves long before they hit the coast, and people in most of the potential danger areas had been evacuated before the waves arrived. (2) Some features of future tsunamis can now be predicted because of the information learned from this small set of waves.

Participation of the Marine Science Center in a warning system, and in regular monitoring of sea level at the coast, affords a new measure of safety and information to Oregon coastal residents. Such local monitoring was lacking in 1964 when a tsunami hit the coast with considerable loss of property and some loss of life. Some results of that tsunami were described in The ORE BIN by Schatz, Curl, and Burt, 1964. These safety measures have been established by cooperation among the Coast and Geodetic Survey of the Environmental Science Services Administration (ESSA), staff of the Oceanography Department of Oregon State University, and ESSA's recently established Weather Bureau Marine Station at the Marine Science Center.

The tsunami warning system was established by the Coast and Geodetic Survey in 1948. The system was based on the use of seismographs to detect and locate earthquakes, and tide gages to detect passing tsunami waves.

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* Dept. of Oceanography, Oregon State University, Corvallis, Oregon.
**ESSA - Weather Bureau, Marine Science Center, Newport, Oregon.

The communications and warning center is at ESSA's magnetic and seismological observatory in Honolulu and it is continuously manned (Coast and Geodetic Survey, 1965).

A "tsunami watch" is issued when seismographs indicate that the location and magnitude of an earthquake are favorable for the generation of a tsunami. A "tsunami warning" is issued whenever the existence of a tsunami has been confirmed, and this confirmation usually comes from tide stations nearest the disturbance. Because tsunamis are of very long wavelength, their velocity is controlled by the depth of the ocean. Thus, arrival times at various points can be predicted once the generating area has been located.

The equation used to compute the speed of the waves is $C = \sqrt{gD}$, where C is the speed of the waves, g is the acceleration of gravity (32 feet per second per second), and D is the depth of the water. For much of the Pacific Ocean the water depth is about 14,000 feet, so the waves travel 670 feet per second or 460 miles per hour. This computed rate is close to the speeds actually observed on 16 May.

Tsunami watches and warnings issued by ESSA's Honolulu Observatory are relayed not only to the United States but also to other participating nations. In the United States, the State Civil Defense organizations are responsible for relaying the warnings to the local population. Although other agencies such as the Weather Bureau, Coast Guard, and police may cooperate in the warning dissemination, Civil Defense has primary responsibility and must establish methods by which warnings and watches are relayed to persons living in danger areas.

Following the earthquake in Japan on May 16, tsunami waves (although low in amplitude) were detected at several Pacific Islands and a

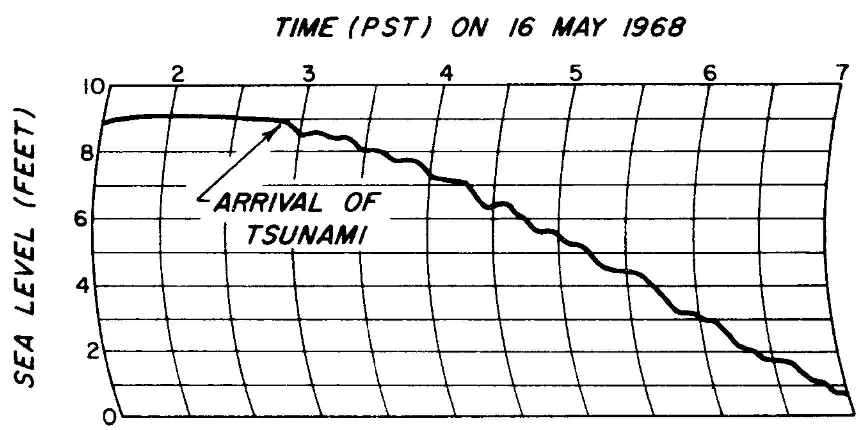

Figure 1. Partial copy of the tsunami trace recorded at the tide gage at Newport, Oregon. Sea level is measured from average height of the lower of the two low waters every day.

tsunami warning was issued. The waves at Newport continued for about two days, from 2:50 a.m., PST, 16 May, until about 5:00 a.m., PST, 18 May. This is a commonly observed feature in tsunamis; the waves in the harbors last much longer than the earthquakes that caused them. The waves varied both in period (time between successive maximum heights) and height (elevation between high and low levels) (see fig. 1). On the average there were 3-1/3 peaks or high waters per hour, or an average interval of about 18 minutes between successive high waters.

Detailed examination of this set of records will make possible better predictions of future tsunami waves in this region. It has been found that each harbor has its own way of reacting to tsunamis (Miller, 1964). Once a harbor's response has been measured and described, the response can be used to help predict the wavelengths of future tsunami waves. For example, we can probably expect some waves of periods near 16 to 20 minutes whenever we have a tsunami near Newport. However, the details are complicated. Data from this tsunami and others, as they occur in the future must be compared with everyday records collected in the bay. Some studies have been begun (for example, Gilbert, 1967).

Additional research will continue to improve the accuracy and increase the scope of tsunami warnings. At present, only arrival time can be estimated accurately; no reliable system is available for prediction of wave height and other characteristics. An improved understanding of tsunamis and their generation, propagation, and response to different shorelines will permit more comprehensive warnings -- and help save lives when the great waves strike.

Acknowledgment

This work has been supported in part by Office of Naval Research Contract number Nonr 1286(10).

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THE PORTLAND EARTHQUAKE OF MAY 13, 1968 AND EARTHQUAKE ENERGY RELEASE IN THE PORTLAND AREA

By

Richard Couch*, Stephen Johnson*, and John Gallagher*

Introduction

The earthquake of May 13, 1968 occurred at 10:52 a.m., PST. The earthquake epicenter was between the northeastern edge of the city of Portland and the Columbia River. The estimated magnitude is 3.8. This compares with the 3.7 magnitude shock of January 27, 1968 (Heinrichs and Pietrafesa, 1968) but is smaller than the magnitude 5 shock of November 5, 1962 Portland earthquake (Dehlinger and others, 1963). The estimated depth of focus is 4 to 12 km, less than half the depth of the January 1968 and November 1962 shocks.

The earthquake was recorded at a number of seismic stations, permitting a preliminary determination of the location of the epicenter and estimates of magnitude and depth of focus. Sufficient information has been received to make several preliminary comments and conclusions.

Seismology

The epicenter is the location on the earth's surface above the source, and the depth of focus is the depth of the source below the surface. The origin time of a shock is the time of occurrence of the initial source motion. The direction of the initial source motion controls the directions of ground displacements at the receiving stations resulting from the incident compressional wave. The source is considered to be a fault in which the rupture travels along the fault surface for the duration of the shock.

The earthquake was recorded at the stations listed in Table 1, with initial P-wave arrival times indicated in Pacific Standard Time. Not included in the table are later arrivals, compressional and shear, which were used to help determine the location of the epicenter and depth of focus. The epicenter was determined primarily by P arrivals owing to the difficulty of determining the onset of shear-wave motion. The Corvallis, Portland, and Klamath Falls records were studied; the other times and motions were received by letter or telephone.

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

TABLE 1

P-WAVE ARRIVAL TIMES

	PST hr.min.sec.
Portland (Oregon Museum of Science and Industry)	10:52:20.0
Corvallis, Oregon	10:52:37.8
Longmire, Washington	10:52:40.2
Tumwater, Washington	10:52:41.1
Seattle, Washington	10:52:52.0
Victoria, B.C.	10:52:57.4
Baker, Oregon (Blue Mountains Seismological Observatory)	10:53:17.1
Newport, Washington	10:53:35.0

Epicenter and origin time

The earthquake epicenter was placed at 45°35.7' N. latitude and 122°36.4' W. longitude, which is along the south side of the Columbia River near the northeastern city limits of Portland (figure 1). This determination is based on the known arrival times and the local travel-time curves prepared for the Pacific Northwest states by Dehlinger and others (1965). The earthquake origin time is estimated to be 10 hrs. 52 min. 17.3 sec. a.m., PST, May 13. These values give a very good fit to the travel time curves for Seattle, Longmire, Baker, and Corvallis. Tumwater also gives a good fit if 1.0 sec. is added to the shock origin time to adjust for Tumwater's characteristically early arrival times. Victoria and Newport received weak seismic signals and consequently add additional scatter to the epicenter determination. The seismic wave amplitudes, although large and well defined at the Portland station, were not used in determining the epicenter.

Depth of focus

The depth of focus of the earthquake is estimated between 4 and 12 km. Depth calculations were based on the P-wave arrival time at Portland. Focal depth calculations depend on the average seismic velocity of the crustal and subcrustal layers and are quite sensitive to small variations in velocity. An average crustal velocity of 6.1 km/sec is estimated for western Oregon (Dehlinger and others, 1965). However, the shallow depth of focus indicates that the P-wave travel time is determined by the upper layers of the crust. The upper layers of the crust generally exhibit a velocity less than the average crustal velocity and, therefore, may increase the travel time to Portland. Also, local geology suggests the presence of basalt layers of higher-than-average velocity which may reduce the P-wave travel time. Consequently, the average crustal velocity between the earthquake focus and the Portland receiving station may be as low as 5.0 km/sec or as high a 6.4 km/sec. The velocities of 5.0 km/sec and 6.4 km/sec result in depth of focus estimates of 3.6 and 11.4 km, respectively. The available data did not permit an additional independent depth estimate.

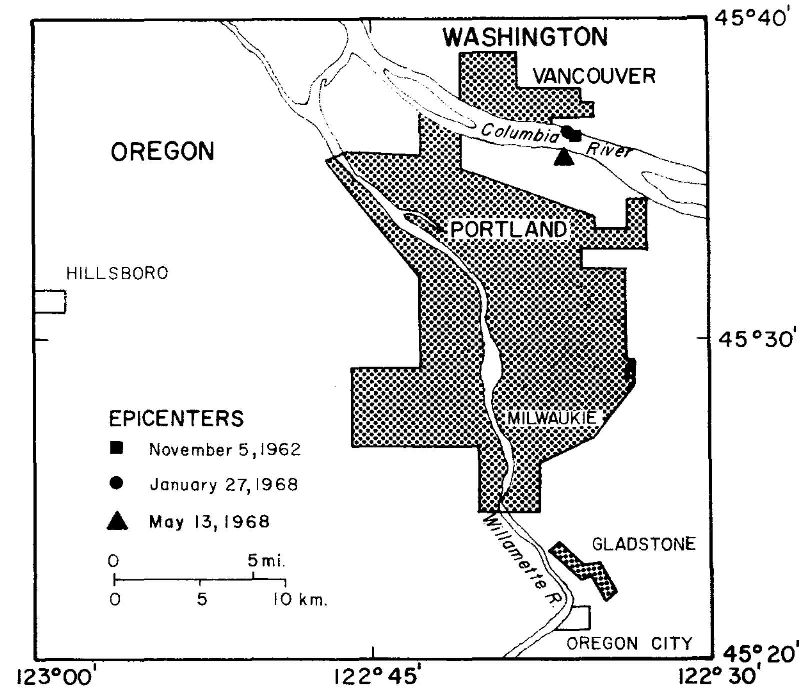

Figure 1. Map of Portland area showing the location of earthquake epicenters.

Magnitude

The magnitude of the earthquake is estimated to be 3.8 on the Richter scale. Magnitudes according to this scale are based on ground amplitudes recorded at seismic stations. Magnitudes are logarithmically scaled and range from 0 or less for the smallest recorded shocks to 8-3/4 for the largest and most destructive earthquakes (Richter, 1958, p. 340). The magnitude estimate was furnished by the Blue Mountains Seismological Observatory at Baker, Oregon.

Intensity

The maximum intensity is placed at IV on the Modified Mercalli Intensity Scale of 1931. Intensity estimates are based on observed or felt effects of the earthquake. The M. M. scale extends from intensity I, which is not felt, to intensity XII, in which damage is nearly total (Richter, 1958, p. 137). Although the Portland earthquake of May 13, 1968 rattled windows and caused hanging objects to swing, no damage was reported.

Source motion

The first motion of the vertical seismographs at Corvallis, Longmire, Tumwater, and Portland was down, indicating a dilatation. The first motion at Baker was up, indicating a compression. The observed initial ground motions are consistent with a right-lateral displacement along a north-northwesterly trending strike-slip fault. The first motions fit equally well an east-northeasterly trending strike slip fault with a left lateral displacement.

Redetermination of epicenters

Dehlinger and others (1963) used preliminary travel-time curves to locate the epicenter of the November 5, 1962 Portland earthquake. Development of travel time curves for the Pacific Northwest now permits a more precise epicenter determination. The published arrival times (Dehlinger and others, 1963), combined with the newer travel time curves (Dehlinger and others, 1965), relocate the epicenter of the November 5, 1962 earthquake at 45°36.5' N. latitude and 122°35.9' W. longitude, approximately 4 km east of the original location. Dehlinger and others (1963) estimated a depth of focus of 15 to 20 km and the U.S. Coast and Geodetic Survey estimated a depth of focus of 44 km for the November 5, 1962 earthquake.

An origin time adjustment of the January 1968 Portland earthquake (Heinrichs and Pietrafesa, 1968) relocates the preliminary epicenter at 45°36.6' N. latitude and 122°36.3' W. longitude, approximately 10 km north-northwest of the original location. This origin time adjustment also results in a revised depth estimate. A 6.1 km/sec crustal velocity, a 7.7 km/sec mantle velocity, and the travel time to Portland result in depth of focus estimate of 35 km. This depth estimate is based on an assumed 20 km crustal thickness beneath Portland.

Discussion

The epicenter of the May 13, 1968 earthquake and the revised epicenters for the November 5, 1962 and the January 27, 1968 earthquakes are plotted in fig. 1. The revised location of the epicenters of the November 5, 1962 and January 27, 1968 earthquakes very nearly coincide with epicenter of the May 13, 1968 earthquake. Chronologically, the three earthquakes show a decreasing focal depth. The source motions of all three earthquakes are similar. These observations suggest that the three earthquakes occurred along a common fault or fault zone. Gallagher (1969) reports a fault plane solution for the November 5, 1962 Portland earthquake which indicates that motion occurred either along a normal fault trending N. 54° E. and dipping 80° SE. or along a right lateral strike slip fault trending N. 12° W. and dipping 22° W. The records of each of the three earthquakes were reviewed in an attempt to use the shear and surface wave motion to determine which of the two fault planes represents the actual fault. Shear and surface wave information was inconclusive; however, the ground motion indicated by the Corvallis seismograms is most consistent with a N. 54° E. trending normal fault which has a left lateral strike slip component.

Earthquake energy release in the Portland area

To determine the average elastic energy released during earthquakes in the Portland area, intensities of historical earthquakes were compiled from Berg and Baker (1963) and from records of the OSU seismograph station. The intensities were converted to equivalent magnitudes using the table given by Richter (1958, p. 353). This relation is empirical and approximate; however, because the earthquakes examined are predominantly shallow and limited to a small locale, the conversion from

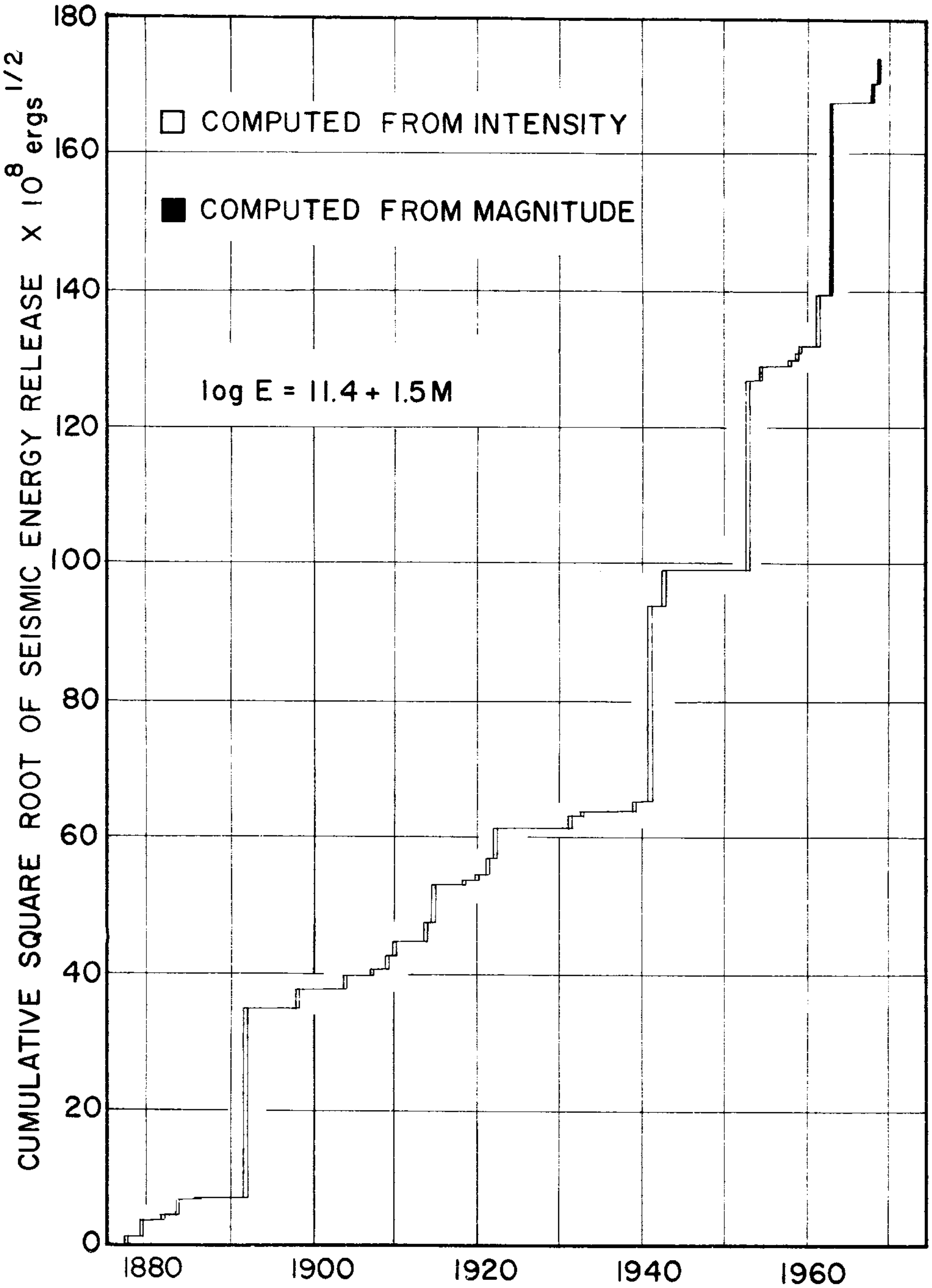

Figure 2. Cumulative seismic energy release in the Portland area.

intensity to magnitude is sufficiently accurate for discussion purposes. The energy released per earthquake was computed from the magnitude using the relation $\log E = 11.4 + 1.5 M$ (Richter, 1958, p. 366). Figure 2 shows the cumulative square root of the seismic energy released in the Portland area between 1877 and 1968.

From 1877 to approximately 1950 the average yearly energy release was 1.4×10^{16} ergs/year. From approximately 1950 to 1968 the average energy release was 1.4×10^{17} ergs/year. Figure 2 indicates that beginning about 1950 the rate of seismic energy release in the Portland area increased approximately 10 times. Historical records span too short a time period to indicate whether the change in rate of energy release is a singular event or a cyclic change wherein the 1.4×10^{16} ergs/year and 1.4×10^{17} ergs/year may represent minimum and maximum rates of earthquake energy release. The minimum rate of energy release is equivalent to one magnitude 4.5 (unified magnitude scale) (intensity V) earthquake each year. The maximum rate of energy release is equivalent to a magnitude 4.8 (intensity V-VI) earthquake each year or to one magnitude 5 (intensity VI-VII) earthquake each 5 years.

Rasmussen (1967) has noted in his compilation of Washington State earthquakes that an increase in seismic activity is noted in the Puget Sound region beginning about 1949. The coincidence of the change in seismic activity in the Puget Sound region and the Portland area suggests an interrelationship between the two centers of tectonic activity. A common driving force or strain release at opposite ends of a common crustal block could produce a coincidence of change in seismic activity in the Portland area and the Puget Sound region.

Acknowledgments

The following people supplied arrival-time data and are gratefully acknowledged: F. Brecken of the Oregon Museum of Science and Industry; N. Rasmussen and C. Aiken of the University of Washington; Dr. W. G. Milne of the Dominion Astrophysical Observatory, Victoria, B.C.; L. Jackshaw and D. Newsome of the Blue Mountains Seismological Observatory; and A. Travis of Newport, Wash.

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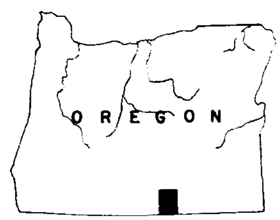
THE WARNER VALLEY EARTHQUAKE SEQUENCE: MAY AND JUNE, 1968

By

Richard Couch [1] and Stephen Johnson [1]

Introduction

A series of earthquakes struck the Warner Valley in southeast Oregon in May and June, 1968. The earthquakes caused rockslides and building damage in and near the community of Adel, Oregon and were of sufficient intensity to rattle dishes in Lakeview, Oregon, 30 miles west of Adel.



Location of study area.

The largest earthquake with an estimated magnitude of 5.1 on the Richter Magnitude Scale occurred on May 29, 1968. The epicenter of this earthquake is located between Crump Lake and Hart Lake in the Warner Valley. An earthquake of estimated intensity VI on the Modified Mercalli Scale occurred during the evening of June 3, 1968. The epicenter of this earthquake, which caused the major damage in the Adel area, is located near the southeast edge of Crump Lake approximately 6 miles north of Adel. Many smaller shocks were felt during the month of June. The Warner Valley earthquake sequence represents the largest seismic energy release in Oregon since the Portland earthquake of November, 1962.

Geology

The epicenters of the earthquakes lay generally in the Warner Valley in southeast Oregon. The steep cliffs which form the east and west walls of the Warner Valley are upraised blocks or horsts while the valley, containing shallow lakes, is formed by a down-dropped crustal block or graben. The north-south trending horsts and graben which form the Warner Valley are transected obliquely by many, predominantly northwest-southeast trending faults. The horst and graben structure of southeast Oregon is characteristic of the physiographic Basin and Range province and extends over Utah, Nevada, Arizona, New Mexico, and parts of Idaho and California. The upper crustal layers of the Basin and Range province in Oregon are formed of thick sequences of Miocene and Pliocene basaltic flows and tuffaceous sedimentary rocks. The valley floor is covered with Pleistocene to Recent alluvium, except at the base of stream-cut gorges where large deposits of unconsolidated deltaic material occur. Nearly vertical slickensides suggestive of high-angle faulting are visible along the west wall.

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Hill and Pakiser (1966) conclude from their seismic refraction studies that the earth's crust in the Basin and Range province of Idaho and Nevada is composed of an upper crustal layer approximately 8 kilometers thick and an intermediate layer, possibly basalt, approximately 35 kilometers thick. Thiruvathukal (1968) estimated a crustal thickness of approximately 50 kilometers in the area about the Warner Valley. He based his estimate on gravity data which indicate a Bouguer gravity anomaly of -150 to -190 milligals in southeastern Oregon. These studies suggest the earth's crust in the vicinity of the Warner Valley is relatively thick and composed of a thin upper crustal layer and a thick intermediate layer.

Seismology

Recording stations

The larger earthquakes of the Warner Valley earthquake sequence were of sufficient magnitude to be recorded at many seismograph stations in the United States and Canada. Seismic data were obtained from the records of 21 stations. Because of their relative proximity to the source, these stations provided most of the data used in determining the epicentral locations. The locations of the stations are listed in Table 1.

Of the 21 stations listed in Table 1, 20 stations are permanent and one (AOT) is temporary. Dr. Alan Ryall of the University of Nevada installed the temporary station (AOT) in the vicinity of Adel, Oregon to record the continuing seismic activity of the area.

Tables 2, 3, 4, and 5 list the P-wave arrival times, at the recording seismograph stations, of the four largest earthquakes of the Warner Valley earthquake sequence.

Travel-time curves

Accurate travel-time curves are of prime importance in locating earthquake epicenters. The diverse crust and subcrustal structures and the petrologic differences of subsurface rocks in Oregon and surrounding states cause large variations in seismic wave velocities. In particular, the velocities of earthquake-generated seismic waves radiating from the Warner Valley area are not well known and apparently vary with azimuth. To arrive at a best fit for the travel times of the seismic waves generated by the Adel earthquakes, a combination of local travel-time curves and velocity estimates were used. Travel-time curves for the Pacific Northwest states west of the Cascades, prepared by Dehlinger and others (1965), were used with arrival times recorded at seismograph stations in Corvallis, Longmire, and Tumwater; travel-time curves for the Pacific Northwest states east of the Cascades (Dehlinger and others, 1965) were used with arrival times at Blue Mountain and Klamath Falls, Oregon and Butte and Hungry Horse, Montana. Velocity estimates (Pg = 6.00 km/sec, P_n = 7.86 km/sec) by Ryall and Jones (1964) were used with the arrival times at Unionville, North Reno, Eureka, and Boulder City, Nevada and Dugway, Utah. Velocity estimates (P_n = 7.8 km/sec) by Lomnitz and Bolt (1966) were used with the arrival times at Mineral, Oroville, Arcata, Ukiah, Jamestown, Mount Hamilton, and Priest, California.

TABLE 1

SEISMOGRAPH STATIONS

STN.	LOCATION	LATITUDE	LONGITUDE
AOT	Adel, Oregon	42.166	119.904
KFO	Klamath Falls, Oregon	42.267	121.746
UNN	Unionville, Nevada	40.442	118.150
MIN	Mineral, California	40.345	121.606
NRR	North Reno, Nevada	39.572	119.849
ORV	Oroville, California	39.555	121.500
BMO	Blue Mountains, Oregon	44.849	117.306
COR	Corvallis, Oregon	44.586	123.303
ARC	Arcata, California	40.877	124.075
EUR	Eureka, Nevada	39.484	115.970
UKI	Ukiah, California	39.137	123.211
JAS	Jamestown, California	37.948	120.438
LON	Longmire, Washington	46.750	121.811
MHC	Mt. Hamilton, California	37.342	121.642
TUM	Tumwater, Washington	47.008	122.909
DUG	Dugway, Utah	40.195	112.814
BCN	Boulder City, Nevada	35.982	114.835
PRI	Priest, California	36.142	120.666
NEW	Newport, Washington	48.263	117.103
BUT	Butte, Montana	46.013	112.563
HHM	Hungry Horse, Montana	48.350	114.028

Epicenters

The location of the 13 earthquakes listed in Table 6 are shown in Figure 1. The epicenters of two earthquakes (11, 13) were located by the U.S. Coast and Geodetic Survey. The numbered epicenters represent the locations of the four earthquakes of greatest magnitude. The epicenters are scattered over the center of the Warner Valley, with the greatest activity centered about Crump Lake. The accuracy attainable in locating the epicenters does not permit assigning the earthquakes to any known faults. The two earthquakes of magnitude 4.7 were the strongest noted in Adel. Their epicenters are located near the west side of the valley within 10 to 15 kilometers of Adel.

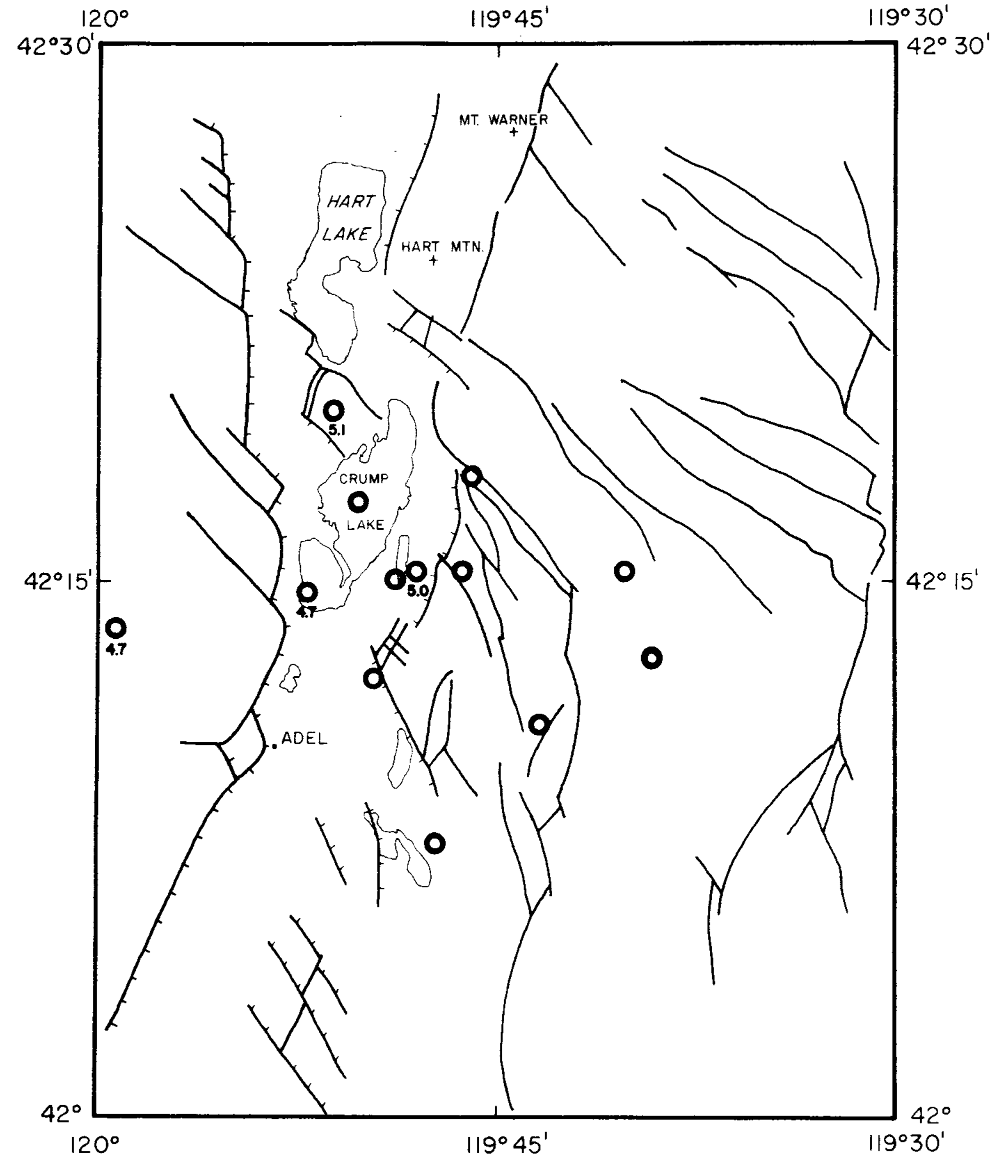

Figure 1. Location of 13 earthquake epicenters of the Warner Valley earthquake sequence. Magnitudes are given for the four largest earthquakes. Heavy lines are faults; hachures are on the downthrown side.

TABLE 2

P-WAVE ARRIVAL TIMES

May 29, 1968	PST hr. min. sec.	Initial motion
Klamath Falls, Oregon	16:36:23.5	D
Unionville, Nevada	16:36:33.7	--
Mineral, California	16:36:35.2	C
North Reno, Nevada	16:36:41.5	--
Oroville, California	16:36:45.2	C
Baker, Oregon (Blue Mt. Obs.)	16:36:48.8	--
Corvallis, Oregon	16:36:52.0	C
Arcata, California	16:36:58.9	C
Eureka, Nevada	16:37:01.9	--
Ukiah, California	16:37:03.0	--
Jamestown, California	16:37:05.3	C
Portland, Oregon	16:37:08.0	--
Mt. Hamilton, California	16:37:16.3	D
Dugway, Utah	16:37:24.2	--
Priest, California	16:37:30.9	C
Newport, Washington	16:37:34.0	--
Hungry Horse, Montana	16:37:47.7	--

Depth of focus

The epicenters of the earthquakes were located using P_n arrival times from all the stations listed in Table 1 except Klamath Falls. According to the travel time curves of Dehlinger and others (1965) the P direct, P* and P_n waves arrive nearly simultaneously at the approximately 158 kilometer epicentral distance of Klamath Falls and, therefore, the identity of the first arriving wave is in question. Examination of the Klamath Falls short period seismograph records shows the first motions to be large and distinct; characteristic of P arrivals at short epicentral distances. The first arrivals at the other stations show smaller amplitudes with less definite onsets, characteristic of P_n first arrivals at the observed epicentral distances. Examination of the first motion on the seismograph recordings shows a 180° difference in direction of first motion between Klamath Falls and all other stations in the same radiation quadrant. Because of the amplitude and direction of first motion the first arrival at Klamath Falls was initially assumed to be a P direct wave. The observed travel time is insufficient

TABLE 3

P-WAVE ARRIVAL TIMES

June 3, 1968	PST hr. min. sec.	Initial motion
Klamath Falls, Oregon	05:28:13.2	D
Mineral, California	05:28:15.2	C
Unionville, Nevada	05:28:15.6	--
North Reno, Nevada	05:28:21.1	--
Oroville, California	05:28:25.0	--
Baker, Oregon (Blue Mt. Obs.)	05:28:30.2	--
Corvallis, Oregon	05:28:33.7	D
Arcata, California	05:28:40.9	--
Eureka, California	05:28:41.5	--
Jamestown, California	05:28:44.9	C
Mt. Hamilton, California	05:28:55.9	C
Dugway, Utah	05:29:04.0	D
Butte, Montana	05:29:13.0	--
Hungry Horse, Montana	05:29:29.5	--

for a P direct wave to propagate from the Warner Valley to Klamath Falls at the estimated P wave velocity of 6.09 kilometer/second (Dehlinger and others, 1965) expected in Oregon east of the Cascades.

An alternative possibility is that the first arrival at Klamath Falls is a P wave traveling in the intermediate layer at a P* velocity. Dehlinger and others (1965) indicate a 6.6 kilometer/second P* wave velocity for eastern Oregon. In the Basin and Range province in Idaho and Nevada, Hill and Pakiser (1966) have noted a thick intermediate layer with measured velocities of 6.7 to 7.0 kilometers/second. Calculations assuming an intermediate layer velocity of 6.8 kilometers/second show a range of depths from approximately 8 kilometers to 34 kilometers with most near 20 to 25 kilometers. These earthquakes appear to occur in the intermediate layer. The short travel time indicated by the Klamath Falls arrivals may also be due in part to propagation along crustal layers which dip toward the east. Propagation along east dipping layers would effectively either decrease the estimated intermediate layer velocity or reduce the computed depths of focus. Table 6 lists the estimated depths of focus of 11 earthquakes.

Source motion

The direction of first motion of the vertical seismographs for 10 of the earthquakes listed in Table 6 were reviewed as a possible indicator of the direction of

TABLE 4

P-WAVE ARRIVAL TIMES

June 3, 1968	PST hr. min. sec.	Initial motion
Klamath Falls, Oregon	18:34:39.9	D
Mineral, California	18:34:49.0	C
Unionville, California	18:34:51.2	--
North Reno, Nevada	18:34:57.6	--
Oroville, California	18:35:03.4	--
Corvallis, Oregon	18:35:08.5	C
Arcata, California	18:35:12.5	--
Eureka, California	18:35:17.9	--
Mt. Hamilton, California	18:35:31.7	--
Longmire, Washington	18:35:32.0	C
Dugway, Utah	18:35:40.1	--
Priest, California	18:35:41.9	C
Newport, Washington	18:35:48.0	--
Butte, Montana	18:35:52.5	--
Hungry Horse, Montana	18:36:05.5	--

faulting. The direction of first motions for the four largest earthquakes of the sequence are listed in Tables 2, 3, 4, and 5. The data are few in number and the observing stations are located primarily west of the earthquake epicenters, consequently the fault trends cannot be accurately defined. Two patterns of first motion are evident in the 10 earthquakes. The first motions of earthquakes 1, 2, 3, 4, 5, 6, 7, and 10 are nearly identical and are consistent with motion caused by a north-south trending normal fault along which the west side moves down relative to the east side. The observed first motions of shocks 8 and 9 suggest strike slip faulting with a dip slip component. Motion along a right lateral strike slip fault oriented N. 80° W., or a left lateral strike slip fault oriented N. 10° E. would produce first motions consistent with the observed first motions. The major crustal readjustment suggested by the source motions is a reduction of an east-west tensional stress. If crustal adjustment is occurring along old fault planes which originally formed the Warner graben, the indications of the first motions and the location of the earthquake epicenters suggest the blocks forming the central graben moved down relative to the blocks forming the east wall. The two earthquakes indicating strike slip motion and the numerous minor shocks probably occurred along several of the many faults which obliquely transect the Warner graben and the upraised crustal blocks on either side.

TABLE 5

P-WAVE ARRIVAL TIMES

June 4, 1968

	PST hr. min. sec.	Initial motion
Klamath Falls, Oregon	20:52:21.6	D
Mineral, California	20:52:33.5	C
North Reno, Nevada	20:52:39.6	--
Unionville, Nevada	20:52:41.9	--
Oroville, California	20:52:42.2	--
Baker, Oregon (Blue Mt. Obs.)	20:52:46.7	--
Corvallis, Oregon	20:52:49.8	D
Arcata, California	20:52:58.5	C
Eureka, Nevada	20:53:00.0	--
Ukiah, California	20:53:02.6	--
Jamestown, California	20:53:03.1	D
Berkeley, California	20:53:10.5	--
Mt. Hamilton, California	20:53:14.0	C
Dugway, Utah	20:53:21.7	--
Priest, California	20:53:26.8	D
Newport, Washington	20:53:30.0	--
Butte, Montana	20:53:33.9	--
Hungry Horse, Montana	20:53:46.3	--

Magnitude

Magnitude estimates are based on instrumental observations and range, on a logarithmic scale, from less than 1 for small shocks to 8-3/4 for the largest earthquakes (Richter, 1958, ch. 22). The earthquake of largest magnitude and consequently greatest energy occurred on May 29, 1968 at 04:36 p.m. PST. A 5.1 magnitude is estimated for this earthquake. Earthquakes of magnitudes 5.0, 4.7, and 4.7 occurred on June 3, 1968 at 5:27 a.m. and 6:34 p.m., and on June 4, 1968 at 08:51 p.m. PST respectively. Thirteen earthquakes with magnitudes greater than 4.2 are listed in Table 1. Twenty-four shocks had magnitudes greater than 3.5. The total energy released in the Warner Valley earthquake sequence is estimated to be about 3.7×10^{19} ergs.

Intensity

Intensity estimates are based on observed or felt effects of the earthquake. The Modified Mercalli Scale (1956 edition), abbreviated M.M., extends from intensity I, which is not felt, to intensity XII in which damage is nearly total (Richter, 1958, p. 137). The earthquake which occurred on June 3, 1968 at 6:34 p.m. PST caused the larger observed and felt disturbance. The intensity is estimated to be intensity VII on the M.M. scale. The June 3, 1968 earthquake caused the greatest damage at Adel, Oregon where chimneys were toppled, dishes shattered, weak mortar structures were severely damaged, and numerous objects were thrown about inside houses.

Observations of surface effects were limited by the low population density of the region and, therefore, data do not permit drawing an isoseismal map. Observations and comments by persons living along the Winnemucca to the Sea Highway (Oregon Highway 140) between Adel and Lakeview, Oregon suggest the center of maximum intensity was either very near Adel or slightly west of Adel. The two earthquakes exhibiting the largest magnitudes were not felt as the largest earthquakes, possibly because their epicenters were located in a sparsely populated area. The community of Adel is located on an alluvial fan and, therefore, may have experienced greater relative ground motion than was felt on the more solid rock of the horst structure to the west.

Foreshocks and aftershocks

In the Warner Valley earthquake sequence, the first recorded shock noted on the record of the Klamath Falls seismograph occurred on May 24, 1968. Earthquake activity continued, with the shocks showing a general increase in magnitude, until May 29, when the earthquake of magnitude 5.1 occurred at 04:36 p.m. PST. On June 3, three earthquakes of magnitudes 5.0, 4.7, and 4.7 occurred at 5:27 a.m., 6:34 p.m., and 08:51 p.m. PST respectively. A series of smaller earthquakes was recorded between the large shock of May 29, 1968 and the three large shocks of June 3 and 4, 1968. Numerous smaller shocks have been recorded following the three earthquakes of June 3 and 4, 1968. Approximately 122 earthquakes attributable to the Warner Valley earthquake sequence were noted on the Klamath Falls seismograph records between May 24 and June 24, 1968. Of the earthquakes in this time interval, 24 had magnitudes greater than 3.5 and 13 had magnitudes greater than 4.2. The earthquakes show a general decrease in magnitude with time.

Earthquake activity generally decreases in magnitude until it becomes imperceptible to the seismometers of the standard seismograph stations. Smaller earthquakes continue to occur, however, long after the major earthquake sequence. The smaller earthquakes are called microearthquakes and are detectable only with sensitive instruments located in the immediate vicinity of the earthquakes.

Dr. Alan Ryall of the University of Nevada is continuing a study of the microearthquakes associated with the Warner Valley earthquake sequence. His preliminary results indicate that microearthquake epicenters are located predominantly along the west wall of the Warner graben and that the microearthquake foci are generally of shallow depth (Ryall, 1968, personal communication).

Field Observations

Field observations consist of information obtained during a post-quake field survey on June 4 and 5, 1968 by the authors, with the assistance of Norman Peterson

TABLE 6

WARNER VALLEY EARTHQUAKES: MAY-JUNE 1968

	Earthquake	PST hr. min. sec.	Location Latitude	Longitude	Magnitude*	Depth (km)
1.	May 27	16:08:48.0	42.25°	119.67°	4.4	21
2.	May 28	04:55:42.8	42.25°	119.81°	4.4	34
3.	May 29	16:35:58.8	42.33°	119.85°	5.1	22 (24*)
4.	June 3	05:27:39.7	42.25°	119.80°	5.0	--
5.	June 3	18:34:14.5	42.24°	119.87°	4.7	25 (25*)
6.	June 3	22:22:17.0	42.20°	119.83°	4.3	26
7.	June 4	02:58:22.4	42.26°	119.77°	4.2	25
8.	June 4	20:51:56.3	42.23°	119.99°	4.7	25
9.	June 4	21:12:35.4	42.30°	119.77°	4.4	--
10.	June 11	17:46:21.9	42.13°	119.79°	4.3	8
11.	June 21*	12:33:27.5	42.21°	119.65°	4.3	23
12.	June 22	01:39:52.9	42.18°	119.72°	4.3	0
13.	June 24*	03:03:17.3	42.29°	119.84°	4.2	33

* Data from U. S. Coast and Geodetic Survey

of the State of Oregon Department of Geology and Mineral Industries and Robert Crawford of Adel, Oregon, and from personal interviews with residents of Adel, Lakeview, and outlying ranches. A heavy rain on 5 June 1968 prevented a thorough examination of the epicentral area and may have obscured some of the lesser surface effects.

Earthquake damage

Minor damage was sustained by nearly all of the dwellings in the vicinity of Adel, Oregon. The chimney was toppled on the Community Hall (Figure 2) toward the east. Two chimneys were toppled on a frame house (Figure 3) owned by the M.C. Ranching Co., one mile south of Adel. These chimneys fell to the east and west. The wall plaster within the house was not cracked; however, mortar on outside supporting walls was cracked in random directions. The wall of a storage building owned by the M. C. Ranching Co. collapsed (Figure 4). The wall was made of stone and low-strength mortar. Cement blocks forming a chimney on a house 2½ miles south of Adel were rotated without toppling.

Many small objects were thrown about in dwellings. Groceries were thrown to the floor and glassware broken at the Adel store. Books in the Adel school were thrown toward the east from shelves on the west wall, but not off shelves along the north wall. Cement blocks near the north and southeast corners of the school building were cracked where they joined the roof beams (Figure 5). No structural members specifically designed to withstand shear stress were evident in the schoolhouse. House trailers reportedly rocked "a foot" in each direction, spilling dishes, cans, and tools. Rockslides damaged an irrigation dam, irrigation pipe, and several fences.

EARTHQUAKE DAMAGE

IN

ADEL AREA, OREGON

MAY-JUNE 1968

Fig. 2

Fig. 3

Fig. 4

Fig. 6

Figure 2 (upper left). Toppled chimney at Adel Community Hall. Steep face of west wall of Warner Valley in background. View looking northwest.

Figure 3 (upper right). Chimney damage on frame house of M.C. Ranching Co. a mile south of Adel.

Figure 4 (lower left). Damage to northwest corner of storage building at M. C. Ranching Co.

Figure 6 (lower right). Earthquake-caused rockslide blocking State Highway 140 west of Adel. (Photograph courtesty of Earl Worden, Klamath Falls, Oregon.)

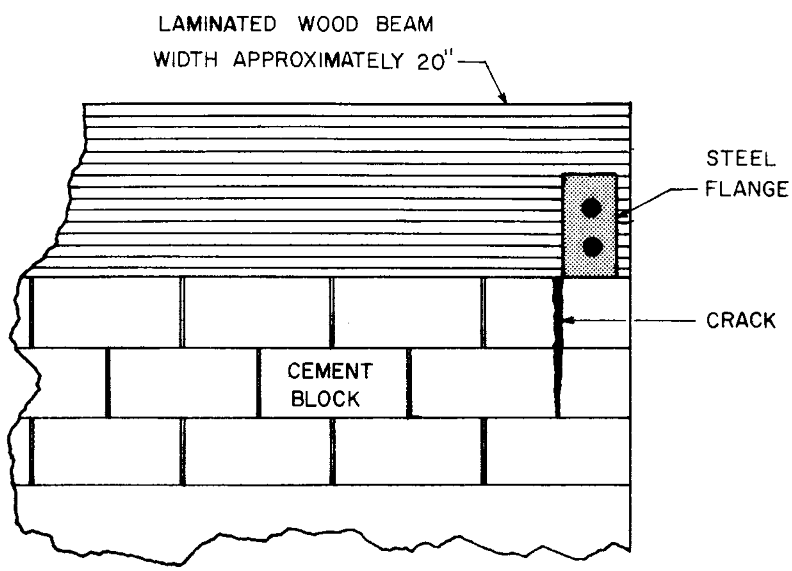

Figure 5. A crack in the northeast corner of the Adel Primary School.

Sights and sounds

During the earthquake which exhibited the largest intensity at Adel, it was reported that the ground appeared to undulate and then change to a circular motion. The ground "waves" appeared to come from the north or northeast and to pass toward the south or southwest. The shaking was estimated to last from a few seconds to 30 seconds, during which time it was difficult to stand.

The larger earthquakes were "heard" before the arrival of the ground waves. The sounds were described as of distant thunder, the roar of a geyser, landslides, or of a bear crawling across the roof, and in nearly every instance were reported to come out of the north and pass to the south.

Faulting and slumping

Cracks $\frac{1}{2}$ to 1 inch in width were observed in the asphalt and along the south shoulder of State Highway 140 about 1 mile west of Adel. These cracks appear to have been caused by slumping of unconsolidated load fill. One-inch-wide slump cracks oriented N. 10° W. were noted in unconsolidated fill 1 mile south of Adel. Many rocks were dislodged from fractured and jointed basalt flows exposed along the west wall of the Warner Valley. Rock falls and accompanying dust clouds were reported seen all along the fault scarp which forms the west wall of the Warner Valley near Adel. Rock falls temporarily blocked State Highway 140 west of Adel (Figure 6). Some boulders crossed this road and knocked boards loose from an irrigation dam in Deep Creek. Others damaged a 24-inch irrigation pipe running along Deep Creek canyon. Road crews reported no rockslides occurred along the road on the east side of the Warner Valley.

Slickensides, exposed along the fault scarp which forms the west valley wall, were examined for possible motion. No apparent movement was detected along the faults which were examined. A survey along the east side of the valley north to the Cox ranch showed no evidence of surface faulting, although a heavy rain falling at the time may have obscured minor movement.

Geysers and hot springs

Several geysers and hot springs occur in the Basin and Range province of Oregon. Most notable are the Crump geyser in the Warner Valley approximately 3 miles north of Adel, and Hunters Hot Springs and geyser approximately 4 miles north of Lakeview. Charles Crump reported that he noted no apparent change in the activity of the Crump geyser during or following the series of larger earthquakes. Opinions were mixed concerning changes in the geyser at Hunters Hot Springs. The authors obtained a cycle time of 17-18 seconds for the pulsations of the Hunters Hot Springs geyser. An increased flow of water from a hot spring 1 mile north of the Cox ranch in the Warner Valley was thought possibly due to earthquake activity. No changes were reported in the flow of hot springs in the southern part of the Warner Valley. Lack of quantitative data concerning cycling, flow rates, and temperature of hot springs and geysers prevents detection of small changes which may occur from earthquake activity.

It is concluded that no pronounced changes occurred in hot spring or geyser activity in the epicentral area before the field survey.

Discussion

Personal remembrances of the residents and recorded history, although noting earthquakes on either side of the Warner Valley, do not recall any large earthquakes in the valley. The magnitudes, intensities, and total energy of the Warner Valley earthquakes are comparable to those of the Portland earthquake of November 1962. Only the sparse population of the area limited the damage and notoriety of this series of Oregon earthquakes.

The Basin and Range province of western United States is a region of continuing minor to moderate earthquake activity. The north-south trending horst and graben structure of the province is characteristic of a region subject to an east-west tensional stress. The tensional stress is believed due to subcrustal forces, possibly related to penetration of the North American continent by the world-encircling oceanic ridge-rise system (Cook, 1965).

It is quite likely that the Basin and Range province of southeastern Oregon will experience earthquake activity in the future. Recent advances in geodetic measuring devices, strain meters, and seismometry suggest the possibility of detecting accumulating strain prior to faulting.

Acknowledgments

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Institute. Dr. Alan Ryall of the University of Nevada supplied Nevada travel time curves and arrival times from the Nevada seismological network; Norman Peterson, geologist, the State of Oregon Department of Geology and Mineral Industries, assisted in the field survey of the Warner Valley; and Robert Crawford, Adel, Oregon, supplied valuable personal observations and assisted the authors in the field survey.

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HIGHER PRICE FOR GOLD PREDICTED

BARRON'S for October 21, 1968 reported that a poll of the 300 experts and attendees at the second International Monetary Seminar held in London in mid-October showed that no one thinks that gold will be worth less than $35 in the Free Market one year from now, 40 percent think it will be between $35 and $50 an ounce, and 60 percent foresee prices between $50 and $100.

Dr. J. E. Holloway, diplomat and former South African Treasury Aide and participant in the Third Gold and Money Session held in Portland, Oregon in 1967, stated at the conference that the world is approaching the end of a long period of subterfuge in monetary matters. Recalling that the jawbones of pigs were used by primitive men as money, he declared: "Special drawing rights and similar paper tokens are worth no more, no matter how much the jawbones of official asses may work to persuade us otherwise. The monetary morass is about to engulf the world."

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EARTHQUAKES OFF THE OREGON COAST: JANUARY 1968 TO SEPTEMBER 1968

By Richard W. Couch* and Leonard J. Pietrafesa*

Introduction

Twenty-two earthquakes larger than magnitude 3.6 occurred off the coast of Oregon between January 1, 1968 and September 1, 1968. The largest of these earthquakes, with an estimated magnitude of 6.3, occurred at 04:17 a.m. PST on May 8, 1968. The earthquake of May 8, 1968 was closely followed by four aftershocks. The four aftershocks of magnitudes 4.1, 4.3, 4.8, and 5.2 occurred on May 8 at 09:54 a.m., 01:53 p.m., 02:17 p.m., and 07:03 p.m., PST respectively. Seismic waves generated by the main earthquake and the four aftershocks were recorded at a number of seismic stations, permitting a preliminary determination of the location of the epicenters and the magnitudes.

Seismology

Epicenters and origin times

The epicenter of the main shock of May 8, 1968 was placed at 43°29.5' N. latitude and 127°46.5' W. longitude, which is approximately 200 kilometers west of Cape Blanco, Oregon. This determination is based on the known arrival times, the local travel-time curves prepared for the Pacific Northwest by Dehlinger and others (1965), local travel-time curves for the Pacific Northwest, prepared by Rinehart (1964) for earthquakes occurring offshore, and velocity estimates for northern California reported by Lomnitz and Bolt (1966). The origin time of the main shock is estimated to be 04 hrs. 17 min. 13.2 sec. a.m., PST, May 8, 1968. The P-wave arrival times used to locate the epicenter are listed in Table 1.

The origin time of the first aftershock is estimated to be 09 hrs. 54 min. 54.6 sec. a.m., PST, May 8, 1968. The origin time of the second aftershock is estimated to be 01 hrs. 53 min. 03.9 sec. p.m., PST, May 8, 1968. The third aftershock origin time is estimated to be 02 hrs. 17 min. 10.4 sec. p.m., PST, May 8, 1968. The fourth aftershock origin time is estimated to be 07 hrs. 03 min. 01.8 sec. p.m., PST, May 8, 1968. Numerous smaller shocks were also noted. The P-wave arrival times of the four aftershocks are listed chronologically in Tables 2, 3, 4, and 5.

Depth of focus

The depth of focus of these earthquakes is unknown. The wave characteristics noted on the seismograph records suggest the earthquake foci are shallow. Shallow focal depths are characteristic of earthquakes occurring along the axis of the mid-ocean ridge system.

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TABLE 1
MAIN SHOCK, MAY 8, 1968
P-WAVE ARRIVAL TIMES

	PST hr. min. sec.	Initial motion
Corvallis, Oregon	04:18:05.8	C
Klamath Falls, Oregon	04:18:25.4	D
Portland, Oregon (OMSI)	04:18:16.0	--
Baker, Oregon (Blue Mt. Seis. Obs.)	04:19:04.1	C
Jamestown, California	04:19:09.8	D
Fresno, California	04:19:28.6	D
Arcata, California	04:18:11.5	D
Mt. Hamilton, California	04:19:07.6	D
Priest, California	04:19:09.6	D
San Andreas Geo. Obs., California	04:19:14.4	D
Berkeley, California	04:18:57.3	D
Bellingham, Washington	04:18:49.2	C
Spokane, Washington	04:19:15.4	C
Tonto Forest, Arizona	04:21:00.6	--
Golden, Colorado	04:21:13.8	C
Denver, Colorado	04:21:17.1	C
Eureka, Nevada	04:19:36.9	--
Bozeman, Montana	04:20:07.2	C
Uinta Basin, Utah	04:20:32.8	--
Dugway, Utah	04:20:01.7	C

	magnitude
Tonto Forest, Arizona	6.3
Uninta Basin, Utah	6.2
Palisades, New York	6.25-6.50

Magnitude and intensity

The estimated magnitudes on the Richter scale of the five earthquakes which occurred on May 8, 1968 at 04:17 a.m., 09:54 a.m., 01:53 p.m., 02:17 p.m., and 07:03 p.m. PST were 6.3, 4.1, 4.3, 4.8, and 5.2, respectively. Magnitudes according to this scale are based on ground amplitudes recorded at seismic stations. They are logarithmically scaled and range from 0 or less for the smallest recorded shocks to 8-3/4 for the largest and most destructive earthquakes (Richter, 1958, p. 340). The magnitudes were determined by the USC&GS of ESSA; Lamont Geological Observatory, Seismograph Station; University of California, Berkeley; and the Seismological Laboratory, California Institute of Technology. The magnitudes listed are the average of those listed in Tables 1 through 5 estimated by the foregoing stations.

No estimate of intensity is usually made for earthquakes located at sea. The major earthquake of May 8, 1968 was reportedly felt by inhabitants of the coast of

TABLE 2
FIRST AFTERSHOCK, MAY 8, 1968
P-WAVE ARRIVAL TIMES

	PST hr. min. sec.	Initial motion
Baker, Oregon (Blue Mt. Seis. Obs.)	09:56:38.1	C
Corvallis, Oregon	09:55:40.0	--
Jamestown, California	09:56:48.4	C
Longmire, Washington	09:56:04.0	--
Tonto Forest, Arizona	09:58:38.2	--
Uinta Basin, Utah	09:58:16.7	--

	magnitude
Baker, Oregon (Blue Mt. Obs.)	4.2
Tonto Forest, Arizona	3.9

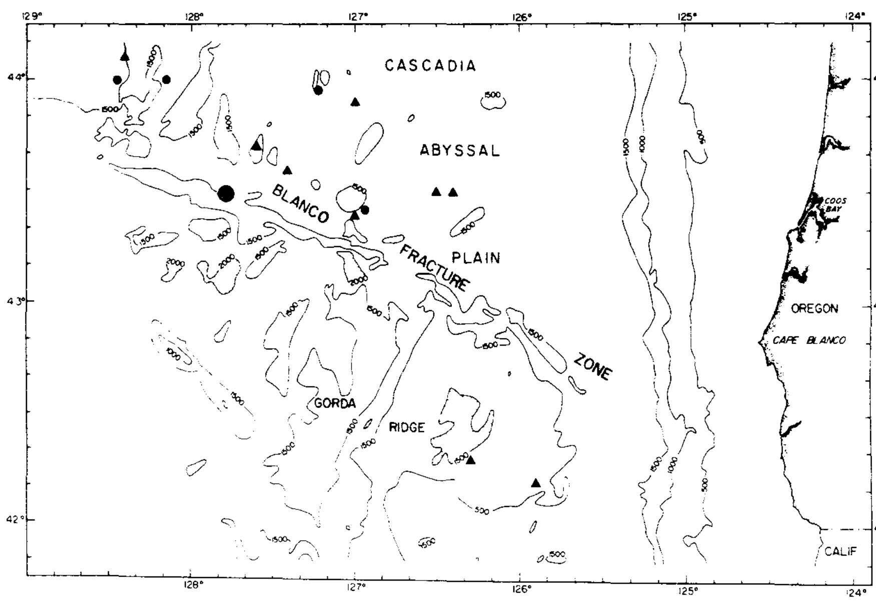

Figure 1. Earthquake epicenters: January 1968 to September 1968. Circles indicate the location of the epicenters of the May 8, 1968 earthquake sequence. The circle with a ring locates the main 6.3 magnitude shock. Triangles indicate nine additional shocks located by the USC&GS. Bathymetric contours are in fathoms.

TABLE 3
SECOND AFTERSHOCK, MAY 8, 1968
P-WAVE ARRIVAL TIMES

	PST hr. min. sec.	Initial motion
Berkeley, California	13:54:55.6	--
Bellingham, Washington	13:55:26.9	--
Baker, Oregon (Blue Mt. Obs.)	13:54:56.5	--
Bozeman, Montana	13:56:49.5	C
Golden, Colorado	13:57:07.4	--
Portland, Oregon	13:54:07.5	--
Corvallis, Oregon	13:53:57.3	C
Denver, Colorado	13:57:12.2	D
Dugway, Utah	13:55:55.4	--
Eureka, Nevada	13:55:33.2	--
Jamestown, California	13:55:05.5	C
Spokane, Washington	13:55:07.8	--
Tumwater, Washington	13:54:15.0	--
Longmire, Washington	13:54:22.5	--
Newport, Washington	13:55:08.0	--
Tonto Forest, Arizona	13:56:56.7	--
Uinta Basin, Utah	13:56:27.0	--

	magnitude
Baker, Oregon (Blue Mt. Obs.)	4.5
Golden, Colorado	3.5
Dugway, Utah	4.3
Longmire, Washington	5.0
Tonto Forest, Arizona	4.3

northern California. Local newspapers of southwest Oregon, however, did not note the occurrence of the earthquake.

Source motion

The first motion observed at each seismograph station is listed in Tables 1, 2, 3, 4, and 5. "D" indicates the first P-wave motion is a dilatation and "C" indicates a compression. The observed initial ground motions of the main shock of May 8, 1968 are consistent with right lateral displacement along a west-northwesterly trending strike slip fault. The first motions fit equally well a north-northeasterly trending left lateral strike slip fault. The first motions of the four aftershocks show a very similar pattern. The limited first motion data of the aftershocks are consistent with ground motion expected from a northwest-trending right lateral strike slip fault or a northeast-trending left lateral strike slip fault.

TABLE 4
THIRD AFTERSHOCK, MAY 8, 1968
P-WAVE ARRIVAL TIMES

	PST hr. min. sec.	Initial motion
Berkeley, California	14:19:03.2	--
Bellingham, Washington	14:18:57.5	--
Baker, Oregon (Blue Mt. Obs.)	14:19:06.5	C
Bozeman, Montana	14:20:18.5	--
Tumwater, Washington	14:18:28.0	--
Longmire, Washington	14:18:32.5	--
Golden, Colorado	14:21:17.7	C
Portland, Oregon	14:18:17.0	--
Corvallis, Oregon	14:18:07.7	C
Denver, Colorado	14:21:20.6	C
Dugway, Utah	14:20:05.3	--
Eureka, Nevada	14:19:43.5	--
Jamestown, California	14:19:15.9	C
Spokane, Washington	14:19:16.2	--
Priest, California	14:19:31.6	--
Newport, Washington	14:19:20.0	--
Tonto Forest, Arizona	14:21:04.0	--
Uinta Basin, Utah	14:20:37.4	--

	magnitude
Baker, Oregon (Blue Mt. Obs.)	4.8
Longmire, Washington	4.3
Golden, Colorado	4.4
Dugway, Utah	4.9
Eureka, Nevada	5.1
Tonto Forest, Arizona	5.2

Discussion

A section of the world-encircling mid-ocean ridge and rise system lies 200 to 300 kilometers off the west coast of southern Oregon and northern California. The axis of this section of the mid-ocean rise is termed the Gorda Ridge. The Gorda Ridge exhibits a median valley termed the Escanaba Trough. The Gorda Ridge and Escanaba Trough show continuing moderate seismic activity typical of mid-ocean ridges (Sykes, 1968). The Gorda Ridge is terminated at the northern end by the Blanco Fracture Zone and at the southern end by the Mendocino Fracture Zone. Moderate seismic activity occurs along the Blanco Fracture Zone west of southern Oregon and along the portion of the Mendocino Escarpment between the Gorda Ridge and the coast of

TABLE 5
FOURTH AFTERSHOCK, MAY 8, 1968
P-WAVE ARRIVAL TIMES

	PST hr. min. sec.	Initial motion
Berkeley, California	19:04:36.6	D
Baker, Oregon (Blue Mt. Obs.)	19:04:44.3	C
Bellingham, Washington	19:04:39.5	--
Bozeman, Montana	19:05:48.8	--
Golden, Colorado	19:06:53.1	--
Portland, Oregon	19:03:57.7	D
Corvallis, Oregon	19:03:45.7	C
Denver, Colorado	19:06:56.6	D
Dugway, Utah	19:05:39.5	C
Eureka, Nevada	19:05:15.6	--
Fresno, California	19:05:08.3	--
Jamestown, California	19:04:50.2	D
Klamath Falls, Oregon	19:04:02.0	--
Spokane, Washington	19:04:58.4	D
Newport, Washington	19:05:02.2	--
Priest, California	19:05:08.2	--
Adak, Alaska	19:09:40.5	--
Tonto Forest, Arizona	19:06:38.3	--
Uinta Basin, Utah	19:06:11.5	--

	magnitude
Baker, Oregon (Blue Mt. Obs.)	5.6
Dugway, Utah	5.6
Eureka, Nevada	5.5
Tonto Forest, Arizona	4.6
Uinta Basin, Utah	4.9

California. Seismic acticity is also noted in the Gorda Basin between the Gorda Ridge and continental slope and shelf of southern Oregon and northern California (Bolt, Lomnitz and McEvilly, 1968). Earthquakes occurring in this region are occasionally of sufficient magnitude to be felt by coastal inhabitants of northern California and southern Oregon.

Fault plane and first motion studies indicate that normal faulting is typical along ridge axes, whereas strike-slip motion is predominant along fracture zones. The shock sequence of May 8, 1968 exhibits first motions characteristic of strike slip faulting. The observed motions agree with motions anticipated from right lateral strike slip faulting occurring along the Blanco Fracture Zone. The strike of the fault planes suggested by the observed first motions parallels in general the trend of the

TABLE 6

Earthquakes west of the Oregon Coast:
January 1968 to September 1968

Earthquake	PST hr. min. sec.	Location Latitude	Longitude	Magnitude
9 Jan. 68	03: 44: 52	43. 7°	127. 6°	4. 4
29 Jan. 68	17: 21: 07. 5	43. 5°	126. 5°	4. 1
19 Feb. 68	10: 03: 10. 4	43. 6°	127. 4°	4. 8
13 Mar. 68	03: 06: 33	43. 5°	126. 5°	4. 0
21 Mar. 68	04: 31: 46. 9	42. 3°	126. 2°	4. 6
8 Apr. 68	19: 03: 01. 8	43. 4°	127. 0°	5. 2
8 May 68	09: 54: 55	43. 9°	127. 0°	4. 3
8 May 68	13: 53: 02. 9	43. 9°	128. 2°	4. 6
8 May 68	14: 17: 13. 8	43. 9°	128. 2°	5. 0
13 Jun. 68	02: 33: 34	44. 6°	129. 2°	4. 0
12 Jun. 68	22: 40: 38	44. 5°	129. 2°	4. 2
12 Jun. 68	23: 04: 20	44. 6°	129. 4°	3. 6
12 Jun. 68	23: 12: 08	44. 5°	129. 5°	3. 8
13 Jun. 68	08: 39: 53	44. 5°	129. 4°	3. 9
13 Jun. 68	12: 51: 30	44. 3°	127. 9°	4. 3
12 Jun. 68	22: 29: 06. 5	44. 7°	129. 5°	4. 2
12 Jun. 68	22: 33: 00	44. 6°	129. 2°	4. 6
14 Jun. 68	10: 33: 05	44. 7°	129. 5°	4. 1
25 Jun. 68	20: 35: 24	42. 2°	125. 9°	4. 1
01 Jun. 68	07: 29: 31	44. 3°	129. 9°	3. 8
20 Aug. 68	12: 15: 52. 0	44. 1°	128. 4°	4. 4
12 Aug. 68	10: 44: 17. 5	43. 5°	126. 4°	4. 2

Blanco Fracture Zone. Bolt and others (1968) presented a fault plane solution based on first P motions for the main shock of May 8, 1968. Their solution indicates that either right lateral strike slip motion occurred along a fault oriented N. 66° W. and dipping 90°, or left lateral strike slip motion occurred along a fault oriented N. 24° E. and dipping 90°. Gallagher (1969) considered amplitude variations in addition to first P motions and suggested that motion occurred either along a normal fault oriented N. 52° W. and dipping 41° N.E., or along a normal fault oriented N. 30° W. and dipping 50° S.W. The locations of the shocks of May 8, 1968 are shown in Figure 1 by circles. The 6.3 magnitude earthquake is shown as a ringed circle.

Numerous earthquakes occur each year off the Oregon Coast. Table 6 lists 18 additional earthquakes with magnitudes greater than 3.6, which occurred between January 1, 1968 and September 1, 1968 off the Oregon Coast. This list was compiled from Preliminary Determination of Epicenter Cards issued by the USC&GS, and indicates the general level of earthquake activity associated with the section of the mid-ocean ridge-rise system west of the Oregon Coast. The epicenters of the 18 earthquakes located by the USC&GS are shown as triangles in Figure 1.

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EMERY AND EMERYLIKE ROCKS OF THE WEST-CENTRAL CASCADE RANGE, OREGON*

By

Jack C. White [1/], Jerry J. Gray [1/], and Joseph W. Town [2/]

Abstract

A suite of high-temperature alumina-silica-iron emerylike contact metamorphic rocks containing mullite has been identified from float specimens obtained from the west-central Cascade Range, Oregon. The material is dense, fine-grained, and variable in texture. The emery rocks are composed of corundum-magnetite and mullite-hercynite. Cristobalite-mullite and tridymite-mullite-hercynite occur in associated emerylike rocks. X-ray, chemical, and optical methods were used in the investigation. The rocks evidently were formed by pyrometamorphism of argillaceous and bauxitic materials.

Introduction

A cobble of unusual dense black rock was brought to the Bureau of Mines, Albany, Oregon, for identification (see accompanying map for location). Spectroscopic analyses showed that the sample consisted essentially of aluminum, iron, and silica with trace amounts of alkali metals and calcium. X-ray diffraction data indicated that the rock was composed of mullite and a spinel group mineral. Although the alumino-silicate mineral could not be positively identified as mullite, the authors believe that the evidence justifies use of the term mullite rather than sillimanite throughout the manuscript. Similar black cobbles were found near the bottom of excavations

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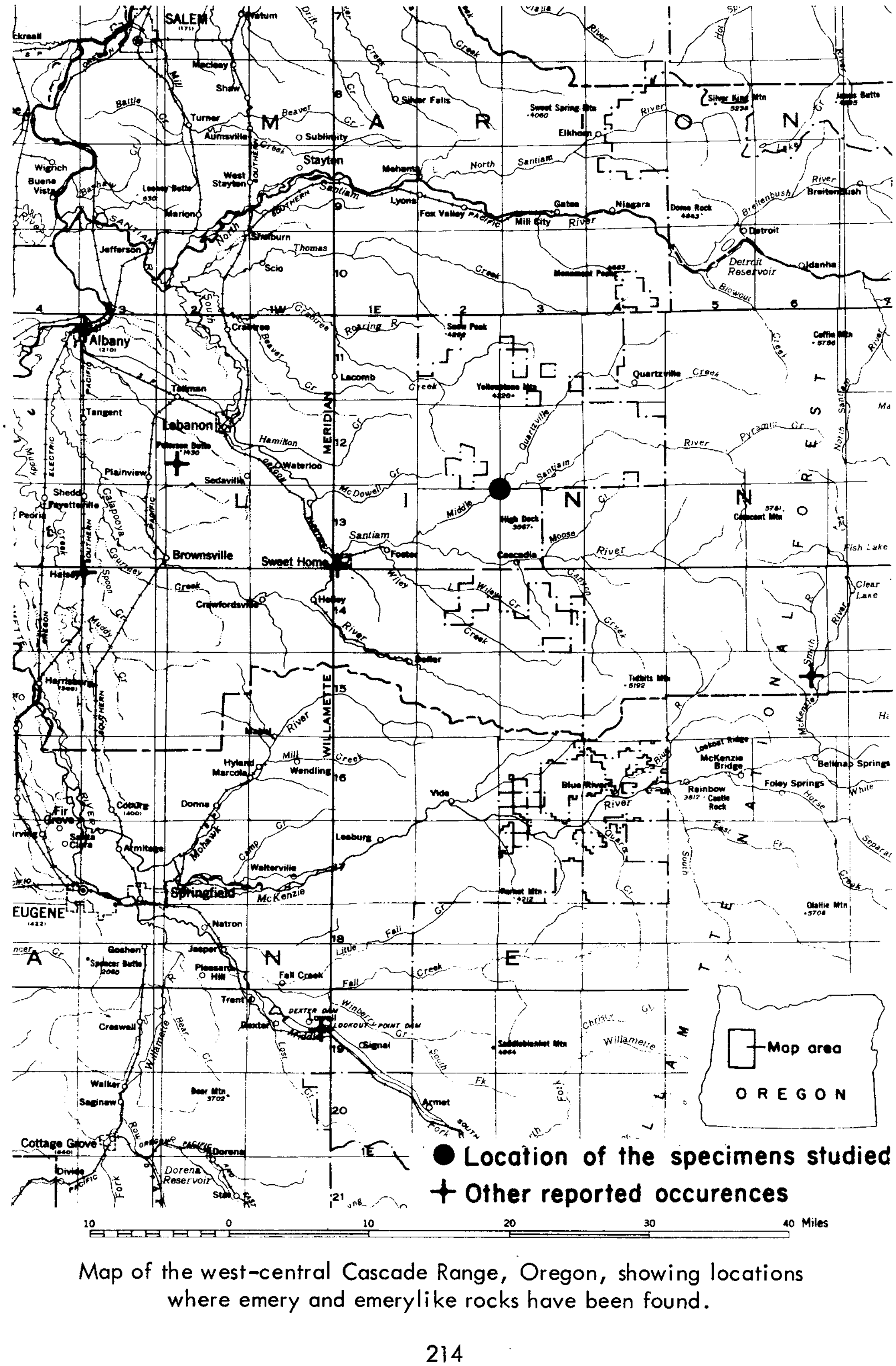
* Approved for publication by Director, U.S. Bureau of Mines.



Map of the west-central Cascade Range, Oregon, showing locations where emery and emerylike rocks have been found.

for the Green Peter Dam on the Middle Santiam River, and a few specimens have been found on gravel bars along the Willamette River between Albany and Junction City, Oregon. Additional samples have been found on gravel bars of the Willamette River near Lookout Point Reservoir approximately 10 miles southeast of Eugene, Oregon, and at the Karmen-Smith Dam on the upper McKenzie River. One naturally polished boulder weighing approximately 200 pounds was found on the south side of Peterson's Butte approximately 3 miles southwest of Lebanon, Oregon. Further investigation was undertaken because emery has not been reported from Oregon, because mullite is rarely found as a naturally occurring mineral, and because of the widespread occurrence of these unusual mullite-spinel rocks.

The black emery cobbles may be identified in the field by their naturally polished, unaltered surfaces and by their hardness and "heft." The emerylike specimens generally have a light bluish-gray color and a somewhat glossy, unaltered surface. In the field they resemble andesite and other light-colored volcanic rocks and it takes practice to recognize them.

A collection of emery rocks was made from the Green Peter Dam waste dump. Some of the black cobbles contained light-colored inclusions of emerylike material composed of mullite-cristobalite. X-ray diffraction data indicated that some of the black cobbles contained corundum in addition to mullite and spinel. One light-gray cobble consisted essentially of corundum.

The Middle Santiam River drainage above Green Peter Dam is composed of Cascade volcanics, suggesting that the suite of related high-temperature rock types described in this paper was formed by thermal metamorphism of aluminous materials in contact with lava extruded during Cascade volcanism.

Ten rock specimens were selected for analysis. Selection of specimens, based on visual-arc spectroscopic analysis, color, texture, hardness, and specific gravity, was designed to obtain as large a range of rock types as possible.

Petrography and Mineralogy

In general, the 10 rock specimens are very fine grained, and microscopic identification of minerals is difficult or impossible except for a few scattered, larger crystals. Therefore, minerals were identified by X-ray diffraction as shown in table 1.

Specimen 1 is medium-gray rock with a fine-grained, mottled appearance that contains a few small, light-colored inclusions. It is composed principally of corundum with a minor amount of magnetite.

Specimen 2 is a medium-gray, fine-grained, mottled rock with a large light tan to light bluish-gray inclusion. The gray matrix is composed mainly of cristobalite, with a minor amount of tridymite and mullite and trace amounts of quartz. The light-colored inclusion is mullite-cristobalite, with

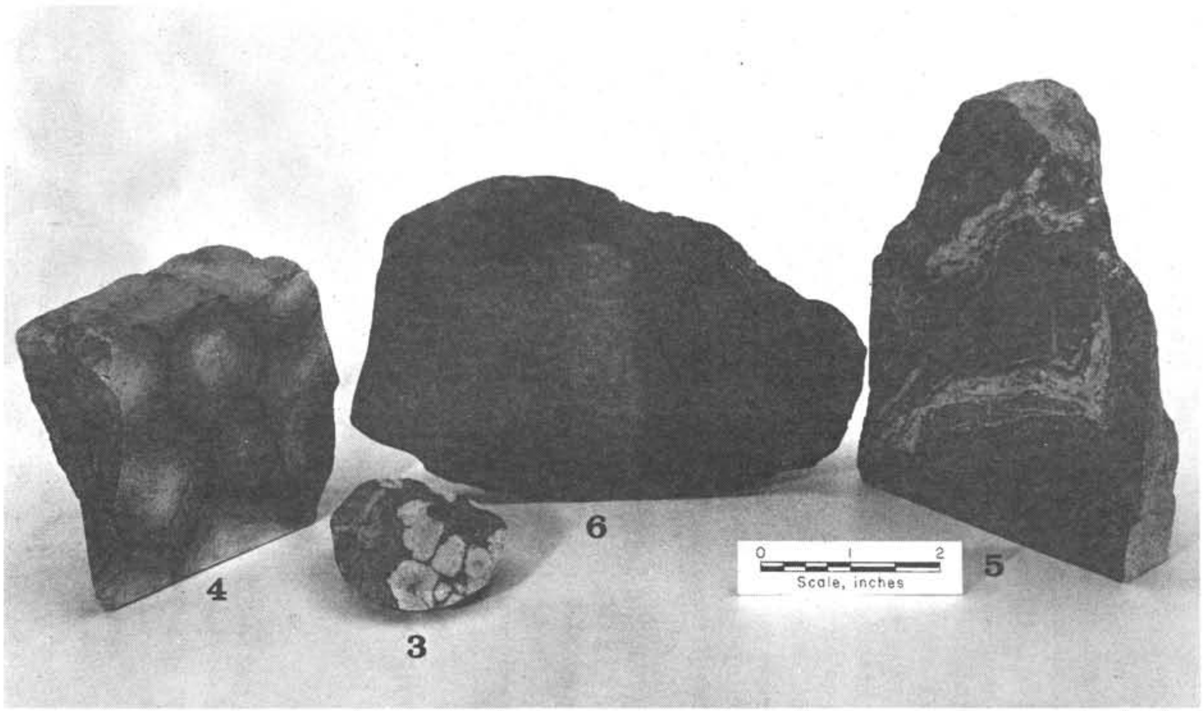


Figure 1. Photograph showing rock textures. Specimen 3 - podlike inclusions; specimen 4 - columnar polygonal blocks; specimen 6 - flow structure; specimen 5 - flow structure.

a trace of tridymite.

Specimen 3 has a fine-grained, mottled-gray groundmass, containing white pod-shaped inclusions noted in figure 1. The gray groundmass is cristobalite-mullite, with a minor amount of magnetite. The white inclusions are mullite-cristobalite. Flow structure is evident in the groundmass adjacent to the white inclusions.

Specimen 4 is a light-tan to light-gray, fine-grained rock composed of columnar polygonal blocks with black interstitial fracture fillings. The texture of this sample varies from polygons about 1 cm across, defined by a network of fracture fillings less than a millimeter thick, to polygons 5 cm across, defined by fracture fillings 1 to 3 millimeters thick (figure 1). Light-colored centers of the larger polygons are mullite-cristobalite, and the black fracture-fillings are tridymite-hercynite, with a minor amount of magnetite and traces of corundum and mullite. Gray concentric-diffusion bands similar to liesegang bands and presumably of higher iron content occur along the margins of the larger polygons (figure 1). Scattered crystals of perovskite approximately 40 microns in diameter were identified in the mullite-cristobalite portion of the sample by electron microprobe X-ray analysis.

Specimen 5 contains streaks of white, fine-grained material and pods and stringers of mottled fine-grained, medium-to-dark gray material. The banding appears to be a flow structure. The sample is essentially tridymite, with minor amounts of mullite and hercynite (figure 1).

Specimen 6 is composed of mottled dark-gray irregular podlike inclusions in a black matrix. Flow structure is evident in the matrix (figure 1). The sample is principally mullite-hercynite with a trace of cristobalite.

Specimen 7 is a mottled, dark-gray, fine-grained rock with indistinct darker bands along one side. It is composed chiefly of mullite-hercynite and quartz, with a minor amount of cristobalite.

Specimen 8 is a fine-grained black rock with a few percent of large magnetite grains. It is composed principally of hercynite, with a minor amount of mullite and cristobalite, and a trace of tridymite.

Specimen 9 is a megascopically textureless black rock, composed essentially of hercynite, with minor mullite. Thin sections show fine, very contorted vermicular banding (figure 2).

Specimen 10 is a dense black rock with faint macroscopic and pronounced microscopic banding (figure 2). It is composed mainly of corundum and magnetite, with a trace of mullite and alpha quartz. Small clusters of corundum crystals, intergrown with minute, green crystals of a spinel group mineral of unknown composition, can be identified in thin sections. The bulk of the rock, however, is too fine grained for microscopic mineral identification.

Specimens 1 and 10 are considered to be emery; 6, 8, and 9, spinel emery; and the lighter colored emerylike specimens, 2, 3, 4, and 5, are buchites. The classification and association of sample 7 are uncertain.

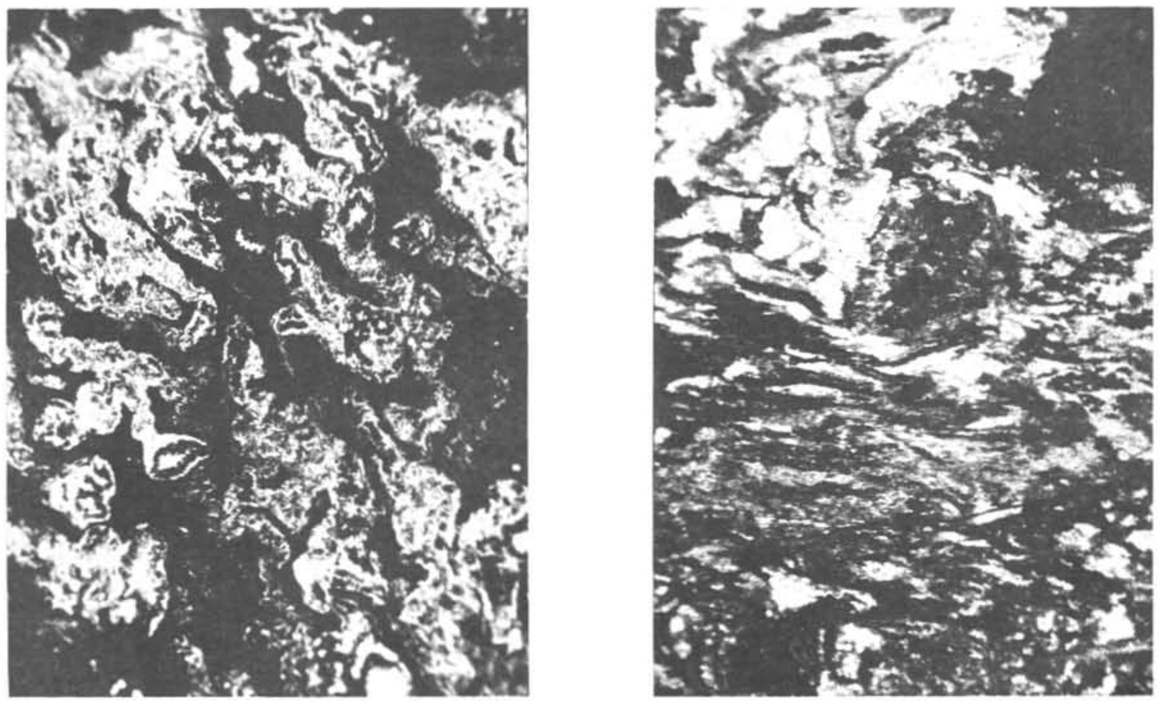


Figure 2. Photomicrographs (60X). Left: specimen 9, showing vermicular banding; right: specimen 10, showing contorted banding.

Table 1. Mineralogical composition of the specimens.

Mineral [1]	Specimen number												
	1	2 gray	2 white	3 black	3 white	4 black	4 white	5	6	7	8	9	10
Corundum	A					D							B
Cristobalite		B	B	B	B		B		D	C	C		
Hercynite (spinel)						B		C	B	B	A	A	
Magnetite	C			C		C							B
Mullite		C	B	B	B	D	B	B	B	B	C	C	D
Quartz		D								B			D
Tridymite		C	D			B	D	A			D		
Unidentified	C	D	D	C	D		D						

[1] Estimated amounts of constituents: A - 40 to 100 percent; B - 20 to 60 percent; C - 5 to 30 percent; D - less than 10 percent

X-ray diffraction results indicate that the predominant spinel phase has unit cell dimensions that vary from 8.20A to 8.22A as determined from the (400) peak on diffractometer traces. This spinel-group mineral probably is a solid solution between hercynite and magnetite (Heinrich, 1956). It is not certain whether the green spinels identified in thin sections of sample 10 correspond to this hercynite-magnetic composition. A separate magnetite phase was identified microscopically in some samples.

Preliminary X-ray diffraction results indicated that several rock samples contained either mullite or sillimanite. An attempt was made to determine which of the two minerals was present. An essentially pure sillimanite concentrate was made by means of heavy-liquid and magnetic separation of sillimanite-magnetite rock from Benson Mines, N.Y. A portion of the relatively pure sillimanite was converted to mullite by heating for 4 hours at 1650° C. Diffractometer traces of the sillimanite and mullite were made and were compared with diffractometer traces of the rock samples. Calculation of accurate lattice parameters of mullite-sillimanite in the rock samples was impossible because of weak diffractometer peaks in the back reflection region. It was noted, however, that the relative intensity of the 5.4A peak was 18 for pure sillimanite and 64 for mullite made from sillimanite. The relative intensity of the 5.4A peak ranges from 13 to 29 for rock samples containing from 20 to 60 percent mullite (table 1). This intensity is greater than would be expected if the mineral in question were sillimanite.

In addition, a 3.84A peak with a relative intensity of 40 was observed

Table 2. Semiquantitative spectrographic analyses of the specimens.

Sample number	Estimated ranges, percent > 10	3-30	1-10	0.3-3	0.1-1	0.03-0.3	0.01-0.1	0.003-0.03	0.001-0.01	0.0003-0.003	0.0001-0.001
1	Al, Fe			Mg, Si, Ti			Cr, Ga, Mn, V, Zr	Cu, Ni			
2 Gray	Al, Si	Fe		Ti		Mg, Na	Ca, Mn, Ni, V, Zr	Ga	Cr, Cu		Ag
2 White	Al, Si		Fe			Ca, Mg, Na	Mn, Ti	Cu	Ga, Ni, V		
3 Black	Al, Si	Fe		Ca, Mg, Ti	Na		Zr, Ga, Mn	Ni, V	Cr, Cu		
3 White	Al, Si		Fe	Mg	Ca	Mn, Na	Ga, Ti	Zr	Cu, Ni		Ag
4 Black	Al, Fe, Si			Mg, Ti		Ni	Na, Zr	Mn, V, Cu, Ga	Cr		
4 White	Al, Si		Fe	Ti		Mg	Ga, Na, V	Cr, Cu, Mn, Ni, Zr			
5	Al, Si	Fe		Mg, Ti		Mn, Ni	Na, V, Zr	Ga	Cr, Cu		
6	Al, Si	Fe		Ti		Mg, Ni	Mn, Na, V, Zr	Cr, Ga	Cu		
7	Al, Fe, Si			Mg, Ti		Mn, Ni	Na, V, Zr	Ga	Cr, Cu		
8	Al, Fe, Si			Mg, Ti		Ni	Mn, Na, V, Zr	Cr, Ga	Cu		
9	Al	Fe, Si		Mg, Ti	Mn		Cr, V, Zr	Cu, Ga, Ni			
10	Al	Fe, Si		Ti		Mg	V, Zr	Cr, Cu, Ga, Ni	Ag, Mn		

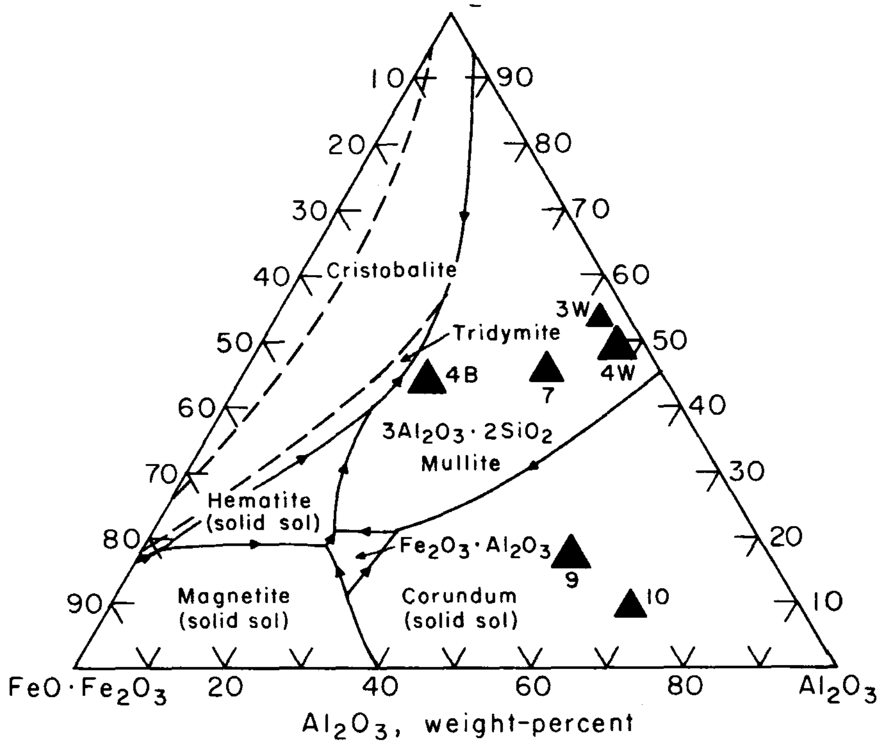


FIGURE 3.-Six Partial Rock Analyses Plotted on Morey's (1964) Iron Oxide-Al_2O_3-SiO_2 Phase Diagram.

3W White (mullite and cristobalite) 7 (mullite, hercynite and quartz)
4B Black (tridymite and hercynite) 9 (hercynite and mullite)
4W White (mullite and cristobalite) 10 (corundum and magnetite)
Area of triangles corresponds to titania plus constituents not accounted for by chemical analyses

66-73X

Table 3. Partial chemical analyses of specimens 3, 4, 7, 9, and 10.

	3 White	4 Black	4 White	7	9	10
SiO_2	51.9	42.3	47.6	43.9	15.4	7.62
TiO_2	0.40	1.50	1.62	1.90	3.25	2.79
Al_2O_3	42.6	23.3	45.6	38.7	55.6	67.3
Fe_3O_4	1.96	29.4	2.60	13.3	24.2	20.7
MgO	0.18	0.03	0.04	0.04	0.59	0.01
Total	97.04	96.53	97.46	97.84	99.04	98.42

in diffractograms of pure sillimanite. No 3.84A peak was observed for either the prepared mullite or in any of these rock samples.

The authors consider the X-ray results to be a strong indication, but not absolute proof, of the presence of mullite in the samples. Other evidence tending to substantiate the presence of mullite includes occurrence in a volcanic terrain, high-temperature mineral associations, and mullite-cristobalite inclusions with the approximate Al/Si ratio of kaolinitic clay.

Chemistry and Petrogenesis

Individual minerals could not be mechanically separated for analysis because of the very fine-grained nature of these rocks. Spectrographic analyses of all samples are shown in table 2, and partial chemical analyses of six samples are shown in table 3. Analyses show all specimens are principally composed of SiO_2, Al_2O_3, and iron oxide.

The six chemically analyzed samples from four specimens were plotted on the iron-oxide, SiO_2, Al_2O_3 phase diagram of Muan (1957b) as modified by Morey (1964) and as noted in figure 3. Magnesium was included with iron, and titanium was excluded from the plot. Iron oxide was calculated as Fe_3O_4. Mineralogical composition determined by X-ray diffraction (table 1) corresponds reasonably well with that predicted by the phase diagram.

Temperature of initial fusion of these naturally occurring materials is uncertain. Muan (1957b) states that, "At low O_2 pressures, a liquid phase may appear at temperatures as low as 1088° C., whereas liquid is present only at temperatures above 1380° C, when the atmosphere is air." Water vapor pressure may provide the oxygen required to maintain the higher fusion temperatures; whereas, other constituents would tend to lower the initial fusion temperature.

Sample 4 appears to represent an initial stage of thermal metamorphism. The authors interpret the polygonal structure of this sample as dessication cracking of clay followed by metamorphism of the clay to mullite-cristobalite and the introduction of iron and silica as fracture fillings. Concentric bands are better defined farther from polyhedra surfaces; and the size of dark crystals increases inward, suggesting liesegang banding caused by diffusion of iron into the polyhedra (figure 1).

Sample 3 represents a more advanced stage of thermal metamorphism in which flow structure is evident in the groundmass adjacent to the well-rounded white inclusions.

White portions of samples 3 and 4 have alumina-to-silica ratios of 0.82:1 and 0.96:1, respectively, compared to 0.85:1 for kaolinite, indicating that these materials could have been kaolinitic clays before thermal metamorphism. Samples 9 and 10 have alumina-to-silica ratios of 3.6:1 and 8.8:1 , respectively, indicating that these black specimens were ferruginous bauxites before metamorphism.

All evidence indicates that these emery and emerylike rocks were formed by pyrometamorphism of argillaceous and bauxitic materials by contact with volcanic heat sources. Future discovery of the outcrop sources may allow a more detailed account of the origin of these unusual rocks.

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Glossary of Mineral and Rock Names

Buchite - A type of partially fused rock resulting from the contact of clay or shale with molten magma.

Corundum - Aluminum oxide: Al_2O_3.

Cristobalite - Silicon dioxide: SiO_2 - a stable form of silica at high temperatures.

Emery - A tough rock composed of a mixture of corundum, hercynite, and magnetite. Domestic emery does not necessarily contain corundum.

Hercynite - Iron spinel: $FeAl_2O_4$.

Mullite - Aluminum silicate: $3Al_2O_3 . 2SiO_2$ - Forms from sillimanite above 1600° C. Found in fused argillaceous inclusions in Tertiary lavas on the island of Mull, Scotland.

Perovskite - Calcium titanate: $CaTiO_3$.

Sillimanite - Aluminum silicate: Al_2SiO_5.

Tridymite - Silicon dioxide: SiO_2 - a stable form of silica at medium temperatures.

* * * * *

SUMMARY STATEMENT OF PRINCIPLES AND RECOMMENDATIONS CONCERNING LAWS RELATING TO MINING

Presented by the American Mining Congress
Before the Public Land Law Review Commission*

1. The maximum benefit to the public will be obtained by continuing the basic principle of the present mining laws, namely, the right of individuals to go on public lands and search for, discover, develop and acquire title to metals and minerals lying within the public domain.

2. One who discovers a buried and unknown mineral deposit in the public domain should have, as a reward for discovery of this resource of our Nation, the right to acquire for a nominal price, title to the mineral deposit, together with the right to use so much of the surface as may be needed for mining and related purposes.

3. The mining laws should be amended to provide one kind of mining claim for exclusive use in locating all locatable minerals; the existing distinction between lode and placer claims should be abolished.

4. The mining laws should be amended to require that (a) boundaries of new claims on surveyed land conform as nearly as practicable to the lines of the public survey and the claims be described by legal subdivision, and (b) boundaries of new claims on unsurveyed land be tied by courses and distances to a corner of a public survey or a United States mineral monument or some natural object or permanent monument.

5. The mining laws should be amended to eliminate extralateral rights in future mining locations.

6. The mining laws should be amended to specify requirements in making a location to the exclusion of all state location requirements.

7. Documents relating to unpatented mining claims should be required to be filed or recorded in only one office and that is the recording office for the county in which the mining claims are located.

8. The mining laws should be amended to provide for payment (at fair market value) of nonmineral surface resources when title to the surface is acquired by the patentee.

9. Because mineral exploration today is chiefly directed to discovery of nonoutcropping and often deeply buried mineral deposits and to encourage the expenditure of large sums necessary to carry forward needed mineral explorations, the existing mining laws should be amended to provide reasonable prediscovery protection.

* The complete statement, as presented to the Public Land Law Review Commission by the American Mining Congress, has been published in a booklet entitled "The Mining Industry and The Public Lands." Copies may be obtained from the American Mining Congress.

10. The mining laws should be amended to provide a simple way to clear the public domain of abandoned mining claims, i.e., to provide that a mining claim is conclusively presumed abandoned if notice is not filed in the appropriate county office at least once every three years.

11. The law permitting geological, geochemical and geophysical surveys to be used as assessment work should be amended so as to remove requirements for public disclosure of confidential information obtained in such work and unwarranted limitations on use of surveys as assessment work.

12. As the Nation's hidden mineral resources cannot be developed and their value to the Nation determined until they are discovered, and because constantly improving tools and techniques of mineral exploration and mining are resulting in mineral discoveries in lands heretofore considered nonmineral in character, the public domain should be kept open to mineral exploration and location of new discoveries except in those cases where there is a compelling national interest for closing them.

13. Congress should not, nor should it permit administrative agencies to, lock up buried and unknown mineral deposits by patenting surface rights and then withdrawing mineral deposits from location under the mining laws or leasing under the mineral leasing laws.

14. One who discovers a mineral deposit should have the right to acquire, adjacent to a mineral discovery, a reasonable acreage of ground for plant facilities and waste disposal areas on paying the fair market value for the ground.

15. Existing federal statutes authorizing land exchanges should be amended in order to facilitate exchanges of public lands required for uses incidental to mining for other lands acceptable for government use.

16. The Classification and Multiple Use Act, as amended, should be permitted to expire on December 31, 1970, and, as of that date, all classifications and segregations made under the act should be terminated except to the extent that they meet criteria recommended by the Public Land Law Review Commission.

17. Congress should explicitly and with care spell out the limits within which administrative agencies are permitted or required to act in administering public lands, and, to the extent possible, make all mining and mineral leasing laws self-executing (applicable to all legislation).

18. In order to encourage exploration for and development of leasable mineral resources in public lands, the federal mineral leasing laws should be amended in the following respects:

(a) To prohibit imposition of new and burdensome obligations on lessees whether by regulation or by amendment of the lease contract.

(b) To establish legislative guidelines requiring classification of public lands for issuance of prospecting permits except where workability and minability of a valuable commercial deposit is known.

(c) To make reasonable increases in acreage limitations where required to provide an adequate resource base to justify the required investment.

(d) To require that the preference right outlined in a prospecting permit set forth fully the terms and conditions of the lease which will be issued under the permit, and to provide that these terms and conditions cannot be subsequently changed except with consent of the permittee.

(e) To establish reasonable statutory time limits for adjudication of applications for permits, and require the Secretary to issue permits and leases on vacant lands not withdrawn or otherwise appropriated if the application is in order.

19. Interior Department procedures and practices in public land matters should be changed in the following respects:

(a) A full Administrative Procedure Act-type hearing be made available in every public land case where there is a genuine issue of material fact.

(b) Appeal to the director of the Bureau of Land Management be abolished.

(c) All judicial functions, both trial and appellate, be placed directly under a judicial officer within the office of the Secretary of the Interior, entirely separate from the office of the solicitor.

(d) The Rules of Practice of the Department of the Interior be modernized along the lines of the present rules of procedure of federal courts, as interpreted by those courts.

(e) The right of review of the final decisions of the Secretary of the Interior by the United States District Court in accordance with existing venue statutes be clearly affirmed and modified in certain respects.

(f) The time for decision by the Secretary be limited to not more than one year from the date of the examiner's decision.

(g) The status of public land matters under the Administrative Procedure Act be clarified so that it can no longer be contended that they are exempt from that act.

(h) The practice of selective certification in connection with appointment of hearing examiners be abolished.

20. The rule for discovery of a valuable mineral deposit is the prudent man test. In applying this test the Department of the Interior and the courts should give major weight to the prospective value of the deposit.

21. A correct definition of "common varieties," as used in section 3 of the Surface Resources Act (30 USC § 611), means a common variety of one of the classes enumerated in section 3, for example, stone, and does not mean a common variety of a particular type of stone, such as limestone.

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Vallier, Tracy L., The geology of part of the Snake River Canyon and adjacent areas in northeastern Oregon and western Idaho: Oregon State Univ. doctoral diss.

* * * * *

UNDERGROUND EXCAVATION METHODS URGED

Two of America's greatest challenges -- resource conservation and the urban crisis -- cannot be met fully without a technological revolution in underground excavation methods, according to a report prepared for the U.S. Bureau of Mines.

The report, written by the National Academies of Sciences and Engineering, recommends a $200 million government effort to promote new excavation methods that would save the land surface from mining operations, allow access to deep mineral deposits now out of man's reach, and provide a "third dimension" for urban expansion.

Today surface excavation methods are much more economical and efficient than underground techniques, the report points out. As a consequence, 85 percent of America's mineral output now comes from surface mines, many of which have undesirable environmental effects. But the volume of surface operations will continue to increase (if underground mining becomes no more attractive) because the nation's mineral needs are growing, and because depletion of high-grade deposits will require bigger surface mines to exploit large, low-grade ore bodies. Meanwhile, deeper and perhaps richer deposits will lie idle because they cost too much to mine.

The 10-year research effort recommended by the Academies would aim at making underground excavation three times faster and 30 percent cheaper than it is today. Areas in which basic research is needed, declares the report, include tunneling through hard rock, underground materials handling, advance determination of underground geological conditions, ground support, and measurement of stresses in underground rock formations.

Copies of the report can be purchased for $2.50 each from the National Academy of Sciences, Printing and Publishing Office, 2101 Constitution Avenue, Washington, D.C. 20418. (American Mining Congress News Bulletin, August 30, 1968).

* * * * *

EXPLORATION INCENTIVE ANNOUNCED

The Department of the Interior will accept requests for oil and gas development contracts in areas in the Western public land States which are relatively unexplored for these minerals. This program is similar to the program for remote areas of Alaska. This 'special treatment' is an incentive for exploration in high risk areas. The contract program gives an operator temporary exemption of a large block of Federal leases from the acreage limitation on holdings and control. The operator must commit a definite program of exploration, a performance timetable, and a substantial expenditure. (AGI Report, November 4, 1968).

* * * * *

NIXON CALLS FOR NATIONAL MINERALS POLICY

Richard M. Nixon, in an October 18 CBS radio address entitled "A Strategy of Quality: Conservation in the Seventies," touched on several points of interest to the mining industry.

The President-elect pointed out that we are actually faced with the task of preserving our environment and at the same time preserving our high standard of living. "It is a battle which will have to be fought on every level of government, not on a catch-as-catch-can basis, but on a well-thought-out strategy of quality which enlists the aid of private industry and private citizens."

Nixon emphasized the need for a national minerals and fuels policy. "...we must create a national minerals and fuels policy if we are to maintain production needed for our economy and security. The strategy of quality looks upon the oil well and the mine as vital parts of the American economy and of American power. There is no contradiction between preserving the natural beauty of America and assisting the mineral industries which are the primary sources of American power. Economic incentives, including depletion allowance, to encourage the discovery and development of vital minerals and fuels, must be continued."

Also of interest was his reference to public lands and related resources. "...federal laws applicable to public lands and related resources should be brought up to date. These lands will be managed to ensure their multiple use as economic resources and recreation areas." (American Mining Congress News Bulletin, November 8, 1968.)

* * * * *

PROPOSED SAFETY STANDARDS TO BE PUBLISHED

Under Secretary of the Interior David S. Black has designated a three-man steering committee to expedite preparation of proposed standards under the Federal Metal and Nonmetallic Mine Safety Act. The Department's stated intent is to publish notice of the proposed rule making on or before December 31, 1968.

Members of the committee are Dr. Earl Hayes, deputy director, U.S. Bureau of Mines; Julian Feiss, staff geologist, Office of the Assistant Secretary of the Interior (Mineral Resources); and Bruce Wright, associate solicitor, Mineral Resources and General Legal Services. (American Mining Congress News Bulletin, November 8, 1968.)

* * * * *

OCEAN MINING LAW CONFERENCE TO BE HELD IN OREGON

The coastal states conference on "A Multiple Use Approach to Offshore Mining Law" will be held in Portland, Oregon December 11, 12, and 13.

* * * * *

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

2.	Progress report on Coos Bay coal field, 1938: Libbey	$ 0.15
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.	(1st vol.) Five papers on Western Oregon Tertiary foraminifera, 1947: Cushman, Stewart, and Stewart	1.00
	(2nd vol.) Two papers on Western Oregon and Washington Tertiary foraminifera, 1949: Cushman, Stewart, and Stewart; and one paper on mollusca and microfauna, Wildcat coast section, Humboldt County, Calif., 1949: Stewart and Stewart	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
56.	Fourteenth biennial report of the State Geologist, 1963-64	Free
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
61.	Gold and silver in Oregon, 1968: Brooks and Ramp	5.00
62.	Andesite Conference Guidebook, 1968: Dole, editor	3.50

GEOLOGIC MAPS

Preliminary geologic map of Sumpter quadrangle, 1941: Pardee and others . . .	0.40
Geologic map of the St. Helens quadrangle, 1945: Wilkinson, Lowry & Baldwin .	0.35
Geologic map of Kerby quadrangle, Oregon, 1948: Wells, Hotz, and Cater . .	0.80
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
Gravity maps of Oregon, onshore and offshore, 1967: [Sold only in set]: flat . . folded in envelope, $2.25; rolled in map tube, $2.50	2.00

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18.	Radioactive minerals the prospectors should know (2nd rev.), 1955: White and Schafer	0.30
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20.	Glazes from Oregon volcanic glass, 1950: Charles W. F. Jacobs . . .	0.20
21.	Lightweight aggregate industry in Oregon, 1951: Ralph S. Mason . . .	0.25
23.	Oregon King Mine, Jefferson County, 1962: F.W.Libbey and R.E.Corcoran	1.00
24.	The Almeda Mine, Josephine County, Oregon, 1967: F. W. Libbey . .	2.00

MISCELLANEOUS PAPERS

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3.	Facts about fossils (reprints), 1953	0.35
4.	Rules and regulations for conservation of oil and natural gas (revised 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: H. G. Schlicker . .	0.50
7.	(Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: M. Roberts	0.50
8.	Available well records of oil & gas exploration in Oregon, rev. 1963: Newton	0.50
10.	Articles on Recent volcanism in Oregon, 1965: (reprints, The ORE BIN) .	1.00

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Oregon mineral deposits map (22 x 34 inches), rev. 1958	0.30
Oregon quicksilver localities map (22 x 34 inches) 1946	0.30
Landforms of Oregon: a physiographic sketch (17 x 22 inches), 1941	0.25
Index to topographic mapping in Oregon, 1961	Free
Index to published geologic mapping in Oregon, 1960	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: V. C. Newton, Jr., and R. E. Corcoran	2.50

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RECONNAISSANCE GEOLOGY OF THE SNAKE RIVER CANYON BETWEEN GRANITE CREEK AND PITTSBURG LANDING, OREGON AND IDAHO

By Tracy L. Vallier
Indiana State University

Introduction

This report describes some of the major geologic and topographic features in the Snake River Canyon between Granite Creek and Pittsburg Landing (figure 1), and is part of a continuing project of mapping the canyon from Farewell Bend near Huntington, Oregon to the mouth of the Grande Ronde River, a distance of more than 150 miles. The information presented here synthesizes the results of geologic mapping during the summer of 1968 and adds to investigations previously reported by Brooks and Vallier (1967).

Geologic mapping was of a reconnaissance nature only, and was principally confined to the lower elevations of the canyon (see accompanying geologic map and cross sections, pages 243 to 246). Therefore, geologic age assignments and contacts between rock units are subject to revision as detailed work is completed. Stratigraphy, structure, and intrusive sequences are so complex that many relationships will require additional study.

In the 1967 report by Brooks and Vallier (The ORE BIN, December 1967, now out of print), the major stratigraphic units between Farewell Bend and Granite Creek were described. In this report the geology north along the canyon from Granite Creek to Pittsburg Landing is discussed. As work progresses in the canyon, future articles will cover the results.

Previous Geologic Mapping

Very little geologic mapping has been completed in the part of the canyon described in this report. Wagner (1945) compiled a reconnaissance geologic map which included part of the area; however, he made no attempt to separate the pre-Tertiary rocks except at Pittsburg Landing. Hamilton (1963) included a small part of the canyon on the geologic map in his report. A 20-mile section of the canyon, downstream from Pittsburg Landing near the mouths of the Imnaha and Salmon Rivers, was mapped by Morrison (1963). White (1968) mapped a Mesozoic pluton sequence in the adjacent

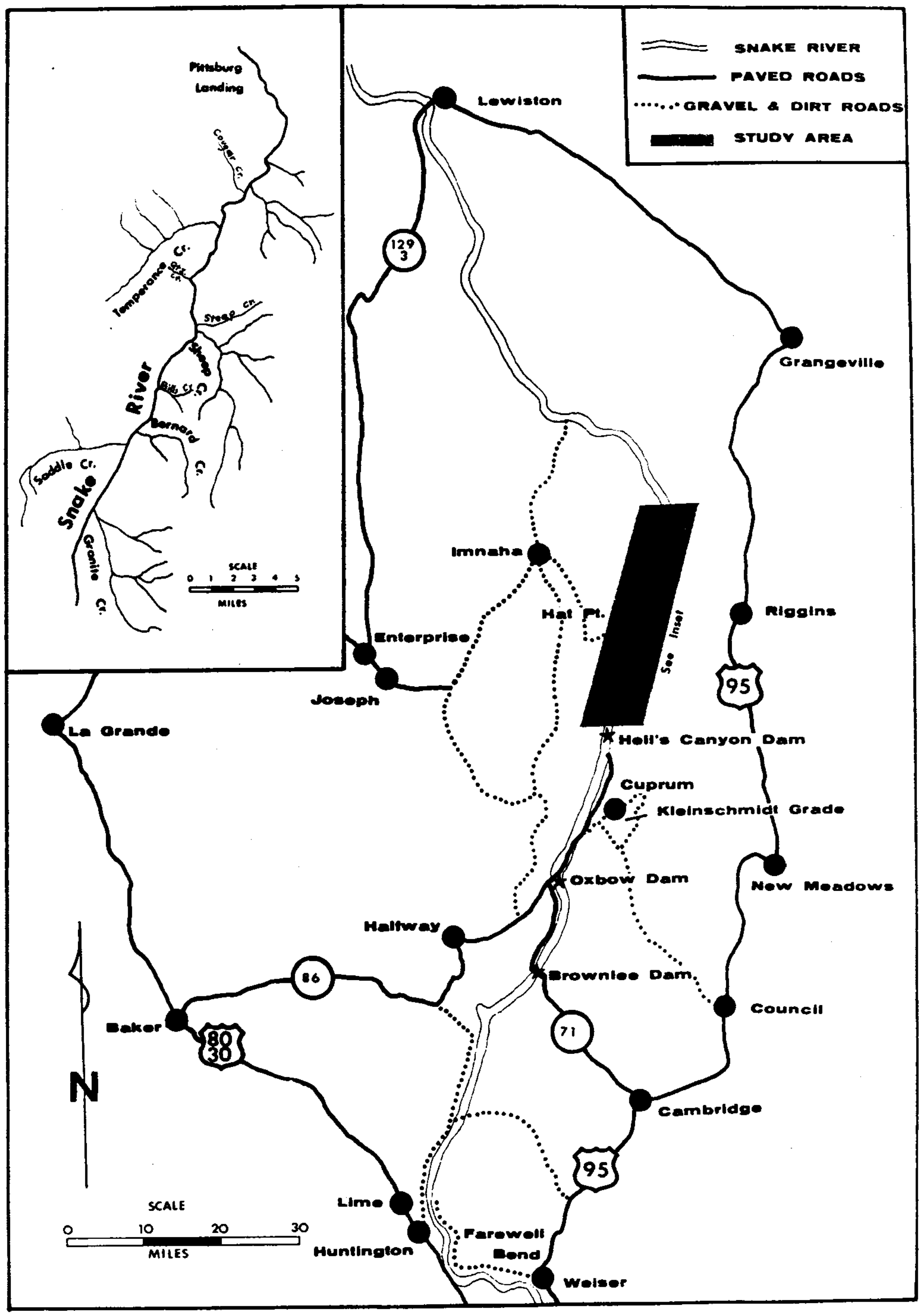


Figure 1. Index map of the Snake River Canyon region, Oregon-Idaho, showing the area described in this report.

Seven Devils Mountains. His interpretations of age relationships should be of valuable assistance to later workers in northeastern Oregon and western Idaho.

Geography

General setting

The Snake River plunges into a relatively narrow, steep-walled canyon a few miles north of Oxbow, Oregon. This part of the canyon, known as Hells Canyon of the Snake River, is the deepest gorge in North America (figure 2). At Hat Point, on the west rim of Hells Canyon, rocks tower more than 5500 feet above the river, and on the east the Seven Devils Mountains loom 8000 feet above the canyon floor (figure 3). Cliffs, benches, irregular steps, and sharp ridges characterize the terrain, and narrow V-shaped tributary canyons incise the main canyon walls. In some places the river channel is walled by steep cliffs; in others it winds sinuously between terraces (figure 4). Skilled boatmen in high-powered jet boats navigate the white waters of the many rapids with safety, but small craft are easily upset.

Summer temperatures commonly exceed 110° F. near the canyon floor and winter temperatures are mild. At higher elevations, winters are severe. Cactus, shrubs, small trees, and hardy grasses are the major types of vegetation in the lower parts of the canyon where summers are characteristically dry. Patches of conifer timber, mostly Douglas fir and ponderosa pine, grow above 4000 feet.

Access

Geologic mapping in this part of the Snake River Canyon has been hindered by the very poor accessibility. One road from U.S. Highway 95 near Whitebird, Idaho leads into the canyon at Pittsburg Landing, but use of it is limited to trucks and 4-wheel drive vehicles. River boats provide the most convenient transportation. The jet boats can reach Granite Creek from Lewiston, Idaho, a distance of more than 100 miles, in less than six hours and can return in about three hours. The only other means of transportation are helicopters, horses, or private airplanes whose skilled pilots land on river terraces.

Mineral Deposits

Very little mining has been done in this part of the Snake River Canyon. Prospect pits and a few tunnels mark the endeavors of optimistic men. Orange-stained strata near Sluice, Willow, and Quartz Creeks plus scattered, narrow veins of copper sulfides and copper carbonates suggest that a

Figure 2. Hells Canyon of the Snake River near Granite Creek. Rugged, somber brown walls rise more than 1 mile above the canyon floor.

closer look might be worthwhile. Known areas of mineralization in the adjacent Seven Devils Mountains are described by Livingston and Laney (1920) and Cook (1954). Reports that describe mineral deposits in other parts of the Snake River Canyon are by Swartley (1914), Moore (1937), Libbey (1943), and Brooks and Ramp (1968).

Geology

The deep gorge of the Snake River exposes rocks of pre-Tertiary and Tertiary ages which are separated by an angular unconformity. Deformed and metamorphosed pre-Tertiary rocks were eroded in late Mesozoic and early Tertiary times. Then, during parts of the Miocene and Pliocene epochs, basalt flows were extruded onto the rugged terrain. The vast lava plateau that subsequently formed was uplifted in the late Pliocene and Pleistocene epochs. The Snake River cut the present canyon in just a few million years. According to Livingston (1928) and Wheeler and Cook (1954), the present course of the Snake River is different from the course it followed in most of late Tertiary time.

Figure 3. The rugged peaks of the Seven Devils Mountains of Idaho rise more than 8000 feet above the Snake River Canyon floor.

Figure 4. The Snake River winds sinuously between river terraces near Temperance Creek.

Pre-Tertiary rocks

The pre-Tertiary rocks in the Snake River Canyon between Granite Creek and Pittsburg Landing are similar to pre-Tertiary rocks in parts of the eastern Blue Mountains of northeastern Oregon and in parts of the Seven Devils Mountains of western Idaho. A wide variety of eugeosynclinal stratified rocks and several plutons are represented.

Metamorphosed eugeosynclinal strata include volcanic flow rocks, volcaniclastic rocks, limestone, conglomerate, graywacke, and shale. Total thickness of the strata is estimated to be from 20,000 to 30,000 feet, and ages are Permian, Middle and Late Triassic, and Middle Jurassic. Major rock types in the Permian system are volcaniclastic rocks, volcanic flow rocks, conglomerate, and graywacke. Middle and Upper Triassic rocks are volcaniclastic rocks, volcanic flow rocks, graywacke, conglomerate, limestone, and shale. Black shale and dark brown graywacke comprise most of the Middle Jurassic strata.

Plutonic rocks cut the eugeosynclinal strata and occupy a significant part of the total area in this particular section of the Snake River Canyon. All gradations occur between intensely sheared and metamorphosed gabbro, diorite, and quartz diorite to unsheared and essentially unmetamorphosed diorite, quartz diorite, and granodiorite. Thayer and Brown (1964) recognized two major and distinct plutonic events, of Early Permian-Late Triassic and Early Cretaceous ages, in northeastern Oregon. However, work by White (1968) indicates that plutonism in the southern Seven Devils Mountains occurred from Late Triassic to Early Cretaceous times. The 11 plutons mapped by White represent three episodes of plutonism that in part straddle the time interval between the Permian-Triassic plutonism and the middle Cretaceous-early Tertiary Idaho batholith. Most of the plutons in the Snake River Canyon between Granite Creek and Pittsburg Landing apparently are related to the older two intrusive episodes described by White and therefore are of probable Triassic and Jurassic ages.

Regional metamorphism probably occurred during parts of the Middle and Late Jurassic Period. Minerals of the greenschist facies are characteristic in most pre-Tertiary rocks. Major changes that occurred in the rocks were albitization of feldspars, silicification, and chloritization of mafic minerals.

The pre-Tertiary rocks trend northeast throughout most of the area. Prevailing northeast strikes are characteristic of bedding, schistosity, fluxion structure, flow banding, major fold axes, and faults. Even the plutons are crudely aligned in northeast directions, particularly those associated with a wide shear zone that occurs south of Pittsburg Landing. Bedding dips to the northwest in most outcrops.

Figure 5. Middle and Upper (?) Triassic stratified rocks along the north side of Saddle Creek Canyon.

Tertiary rocks

Tertiary rocks are mostly basalt flows of the Miocene-Pliocene Columbia River Group. These flows are nearly horizontal and overlie the truncated pre-Tertiary rocks. Maximum thicknesses range between 2000 and 3000 feet. High-angle faults and broad folds are the result of Pliocene-Pleistocene deformation in adjacent areas. Basalt flows at an elevation of 3000 feet along the west side of the canyon probably are the same ones that occur at elevations greater than 7000 feet in the Seven Devils Mountains.

Geologic Traverse along the Snake River Canyon from Granite Creek to Pittsburg Landing

The geology of the Snake River Canyon between Granite Creek and Pittsburg Landing is described in four parts from south to north. The total river distance is about 30 miles.

Sec. 1. Granite Creek to Bernard Creek

Several thousand feet of Middle and Upper (?) Triassic rocks are exposed along the Snake River Canyon between Granite Creek and Bernard Creek, both in Idaho (figure 5). Dr. N. J. Silberling (written communication, September 26, 1968) reported that flat clams collected near Saddle Creek are Daonella degeeri Boehm and Daonella frami Kittl of Middle Triassic (early Ladinian) age. These fossils were collected in folded, argillaceous limestone near the floor of the canyon (figure 6). Overlying rocks several thousand feet thick may be partly of Late Triassic age (figure 5). In the lower elevations of the canyon, green flows of spilite are separated by beds of conglomerate, limestone, and volcaniclastic rocks. Monolithic spilite conglomerate and pillow lavas are common. At higher elevations, younger rocks are predominantly volcaniclastic; flow rocks are less abundant.

The structure between Granite and Bernard Creeks is uncomplicated. Most deformation is portrayed by broad folds and high-angle faults. Rocks mostly dip to the northwest.

Sec. 2. Bernard Creek to Temperance Creek

Most of the stratified rocks between Bernard Creek, Idaho, and Temperance Creek, Oregon, are Permian in age. An area north of Bernard Creek on the Idaho side contains rocks of uncertain age that show some similarities to known Permian strata.

One major intrusive, of probable Late Triassic or Early Jurassic age, cuts the older rocks. The body, informally named the Bills Creek intrusive, crops out along both sides of the Snake River Canyon for nearly two miles. The northern contact trends northeast and apparently joins the west contact of the deeply incised intrusive that is exposed in Sheep Creek. Rock types are metadiorite, metagabbro, and metamorphosed quartz diorite. Structures within the intrusive include platy flow structures such as aligned hornblendes, aligned xenoliths, and parallel schlieren. Secondary foliation, also called fluxion structure, is mostly absent. Contacts are sharp and, along the northern contact, older country rocks display a zone of fluxion structure more than 200 feet wide. The Bills Creek intrusive is a composite pluton; several plutons could be distinguished by careful mapping. From compositional, structural, and metamorphism studies, the writer believes that this intrusive complex might be correlated with the mafic suite described by White (1968, p. 19-54) in the nearby Seven Devils Mountains. Of particular interest are the similar northeast trends.

Except for a small intrusive in the Willow Creek drainage area about two miles to the north, most of the rocks between the Bills Creek intrusive and Temperance Creek are of Permian age. Productid brachiopods, similar

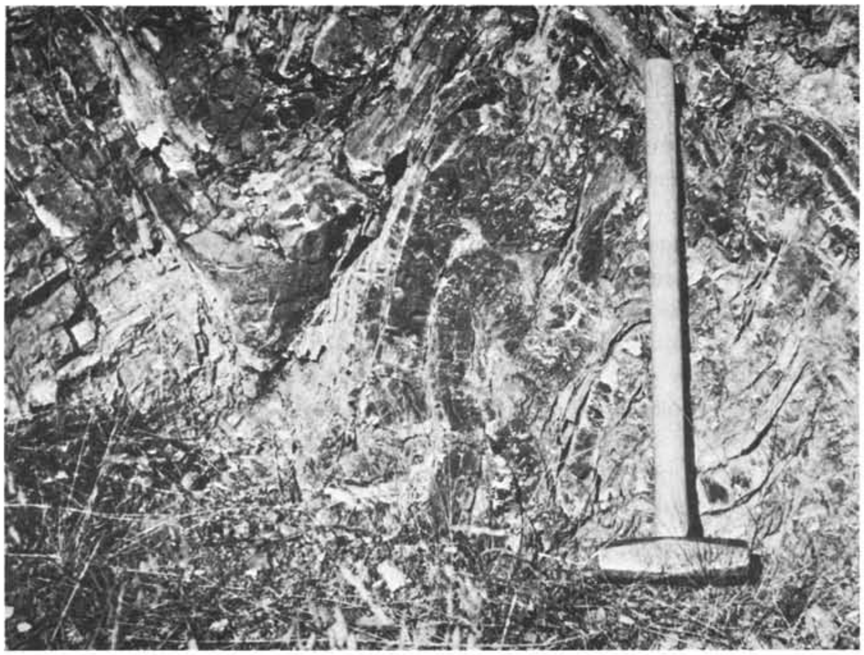


Figure 6. Contorted, thin-bedded argillaceous limestone south of Saddle Creek along the Snake River Canyon. Flat clams (Daonella degeeri Boehm and Daonella frami Kittl) collected here are of Middle Triassic (early Ladinian) age.

Figure 7. Permian rocks near Quartz Creek. Orange-stained strata (in dashed lines) may indicate mineralization at depth.

to the genus Megousia, were observed near the mouth of Sheep Creek. Excellent exposures of Permian rocks occur along the north sides of the canyons of Sheep and Steep Creeks where more than 2000 feet of strata could be measured and described. Good exposures also occur near Quartz Creek (figure 7).

Structure is complex in this section of the Snake River Canyon. A fractured and schistose zone in Permian rocks occurs between the west contact of the Bills Creek intrusive and the Snake River south of Sheep Creek. Here the valley is much wider, because the Snake River was able to cut away the more easily eroded rocks. Effects of deformation also are greater north of Quartz Creek where crushing and recrystallization increase to the southern boundary of a wide shear zone near Temperance Creek. Many faults cut the rocks throughout this section of the canyon between Bernard and Temperance Creeks; careful work is necessary for accurate mapping.

Sec. 3. Temperance Creek to Pittsburg Landing

The area between Temperance Creek, Oregon and Pittsburg Landing, Idaho displays a rugged topography, a complex structure, and numerous rock types. A northeast-trending shear zone, named the Cougar Creek shear zone for the exposures in Cougar Creek, is the dominant geologic feature (figures 8 and 9). Although the Cougar Creek shear zone is only 3 to 4 miles wide, the Snake River follows a tortuous route through it for nearly 7 miles, in some places paralleling the northeast-striking structures and in other places cutting perpendicularly across the structures.

The Cougar Creek shear zone is composed of sheared and mylonitized intrusives and older country rocks. Intrusives were emplaced at least four different times into volcanic flow rocks and volcaniclastic rocks of probable Permian age. Rock types are sheared and metamorphosed gabbro, diorite, quartz diorite, diabase, volcaniclastic rocks, and volcanic flow rocks with amphibolite, mylonite, gneiss, albite granite, schist, and phyllite (figures 10 and 11). Exposures of undeformed and essentially unmetamorphosed diorite are rare. Foliations are caused by fluxion structure, schistosity, and some platy flow structure. Strikes are N. 50° to 70° E. and dips range from 60° to vertical. Lineations created by quartz alignments in mylonite, by prismatic hornblendes, and by slickensides on chlorite-plastered foliation planes approach the horizontal in three widely separated locations, plunging northeast between 10° and 16°.

Similarities between the Cougar Creek shear zone and the Oxbow-Cuprum shear zone (Taubeneck, 1966; Vallier, 1967, 1968; White, 1968) are remarkable. Structural styles and trends, rock types, and probable ages are about the same. Most deformation and intrusive activity in both shear zones occurred before regional metamorphism, although later intrusives were localized along the shear zones. Foliated plutonic clasts in Upper Triassic (Karnian) conglomerates at nearby Pittsburg Landing indicate that plutonism

Reconnaissance Geologic Map: Granite Creek to Pittsburg Landing, Oregon and Idaho -- Explanation.

Q	Quaternary deposits; alluvium, terrace deposits, and landslide debris.
Tb	Tertiary basalt; correlates with Columbia River Group.
Js	Upper Jurassic black shale and graywacke; minor limestone. Tightly folded.
Ji	Jurassic (?) intrusive; weakly metamorphosed diorite, gabbro, and quartz diorite.
TRp	Upper Triassic Pittsburg Formation; marine conglomerate, shale, sandstone, and volcaniclastic rocks. Minor andesite flows.
TRu	Middle (?) and Upper Triassic undifferentiated; marine volcaniclastic rocks, spilite flows, and minor limestone.
TRi	Triassic (?) intrusives; diorite, quartz diorite, albite granite, and gabbro of the Cougar Creek Complex. Strongly foliated. Contains younger undeformed intrusives.
PTR	Permian or Triassic volcaniclastic rocks and flow rocks. Most are hornfelsed.
Pu	Permian undifferentiated; marine volcaniclastic rocks, spilite and keratophyre flow rocks and small spilite intrusives. Minor amounts of limestone and argillite.

? Unconformity; questioned where uncertain.

Shear zone; strongly foliated, schistose and mylonitic.

U / D Fault; U, upthrown side; D, downthrown side; dashed where approximately located.

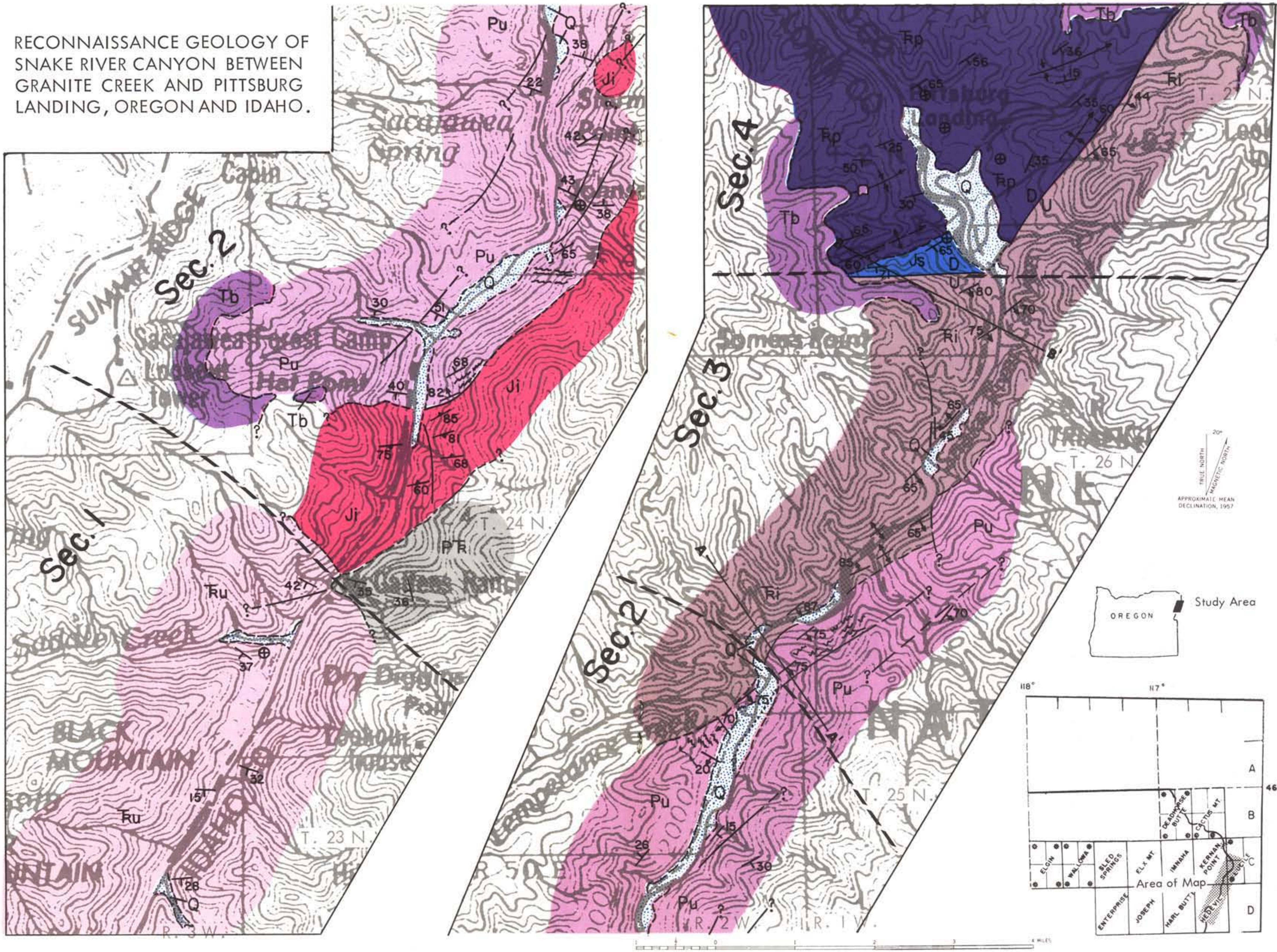
Axes of folding; anticline, syncline.

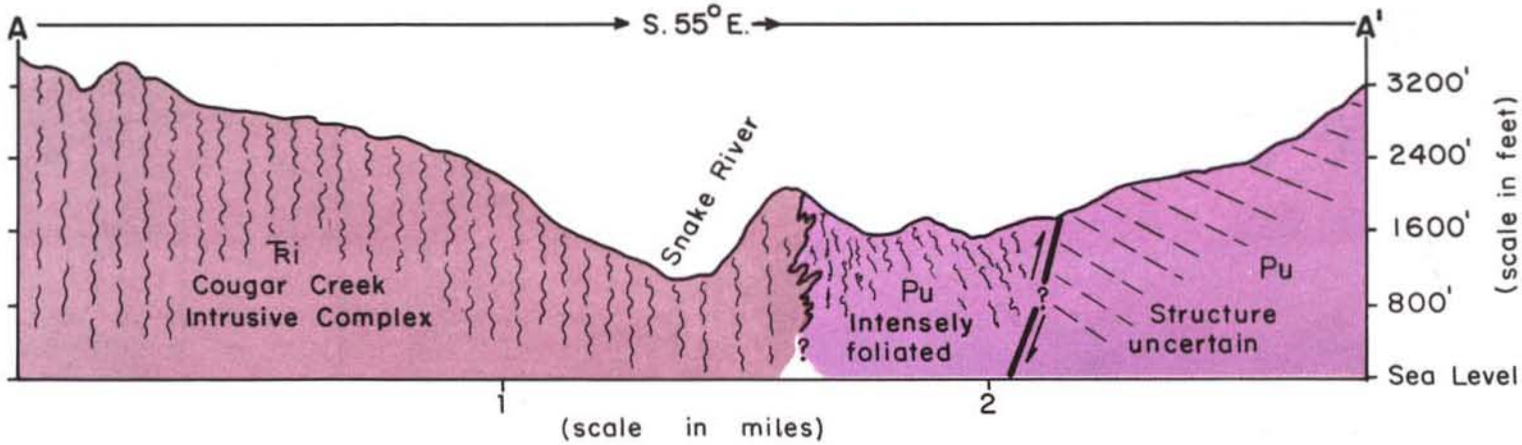
Strike and dip of bedding.
Strike and dip of vertical bedding.
Strike and dip of igneous foliation.
Strike and dip of vertical igneous foliation.
Strike and dip of metamorphic foliation.
Strike and dip of vertical metamorphic foliation.
Significant fossils.

? Contact; dashed where approximately located; questioned where uncertain.

Topographic base from U.S.G.S. 30-minute Grangeville quadrangle map. Contour interval 200 feet.

RECONNAISSANCE GEOLOGY OF SNAKE RIVER CANYON BETWEEN GRANITE CREEK AND PITTSBURG LANDING, OREGON AND IDAHO.

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S. 55° E.
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2400'
1600'
800'
Sea Level
(scale in feet)
Snake River
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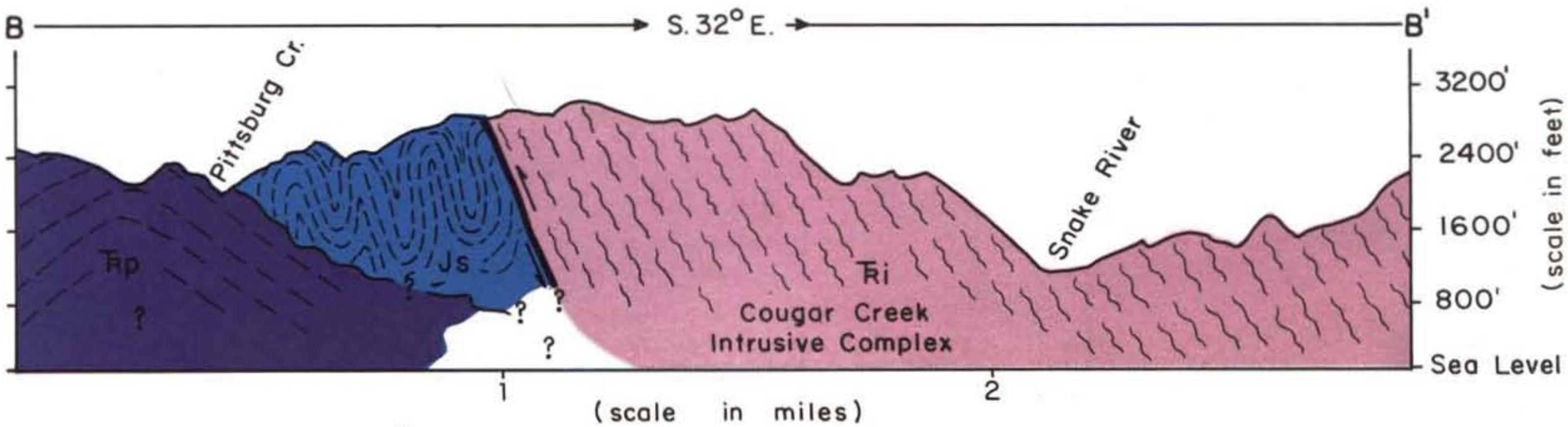
Intrusive Complex
Pu
Intensely
foliated
Pu
Structure
uncertain
1
2
(scale in miles)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(scale in feet)
Pittsburg Cr.
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Cougar Creek
Intrusive Complex
Snake River
1
2
(scale in miles)

had occurred and that foliated plutons, perhaps in the Cougar Creek shear zone, had been eroded. If so, plutonism and deformation had begun at least by Late Triassic time and probably continued through the Jurassic; some intrusives were emplaced after regional metamorphism (Late Jurassic [?]).

The width of the shear zone, intense deformation, localization of intrusives, and horizontal slickensides make this area of great value to anyone interested in the tectonic events of northeastern Oregon and western Idaho. The writer suggests that this shear zone may have been another zone of lateral movement during the Mesozoic Era.

Sec. 4. Pittsburg Landing area

A great diversity of rock types is exposed in the vicinity of Pittsburg Landing. Stratified rocks of Late Triassic and Middle Jurassic ages (written communications from Drs. N. J. Silberling and Ralph Imlay provided age data) are separated from the Cougar Creek shear zone by a high-angle thrust fault (figure 12).

The stratified rocks are separable into two major mappable units. The older unit, the Pittsburg Formation described by Wagner (1945), is at least 2000 feet thick and consists of conglomerate, shale, sandstone, and volcanic flows. Wagner believed that the formation was of Carboniferous age, but flat clams (Halobia) and ammonites indicate a Late Triassic age. A 900-foot stratigraphic section was measured. The lower boundary was tentatively placed at the base of the first thick shale unit, but later revision will certainly be necessary as more studies are completed on the rocks downstream. Rocks of the Pittsburg Formation are only slightly deformed; large open folds are the rule (figure 13).

The younger unit, still unnamed, consists of black shale and dark brown sandstone. These relatively incompetent beds are isoclinally folded; the greater deformation is due to the proximity of the fault that separates the black shales from the Cougar Creek shear zone. Although the shale displays pencil cleavage, ammonites are surprisingly abundant. According to Dr. Ralph Imlay, ammonites collected near the base of the unit are of latest Middle Jurassic age and ammonites of Late Jurassic age may be present in the younger strata. This unit probably is equivalent in part to the Upper Jurassic Idorwa Formation (Morrison, 1963) that was mapped about 30 miles north of Pittsburg Landing.

Future Work

The writer and assistants will continue mapping northward along the Snake River Canyon. It is planned that the pre-Tertiary rocks at the more accessible lower elevations of the canyon, from Pittsburg Landing to the mouth of the Grande Ronde River, will be mapped by the fall of 1969. Mapping of the upper levels of the canyon will follow. The results of these

Figure 8. Rugged topography of the Cougar Creek shear zone, looking south from Pittsburg Landing.

Figure 9. Cougar Creek shear zone looking southwest near Cougar Creek. Notice the steep dips of the northeast-striking foliations in the upper right corner of the photograph.

geologic studies along the Snake River Canyon should help solve some of the riddles in the complex geology of northeastern Oregon and western Idaho.

Acknowledgments

The writer is particularly grateful to David White for assistance and companionship in the field. Howard Brooks of the State of Oregon Department of Geology and Mineral Industries assisted the writer in the field and also provided a knowledge of regional relationships that was invaluable for some interpretations. However, the conclusions presented here are solely the responsibility of the writer. Thanks are extended to Dr. Rolland Reid and the Idaho Bureau of Mines and Geology for monetary assistance and encouragement. Special acknowledgment is given to Hollis M. Dole and the State of Oregon Department of Geology and Mineral Industries for monetary assistance and continued enthusiasm for the project. The Sigma Xi-RESA research fund also provided a grant that helped defray expenses. Fossil identifications were made by Dr. Ralph Imlay of the U.S. Geological Survey and Dr. N. J. Silberling of Stanford University. Floyd Harvey of Hells Canyon Excursions Inc. provided campground facilities and boat transportation which greatly expedited the field work.

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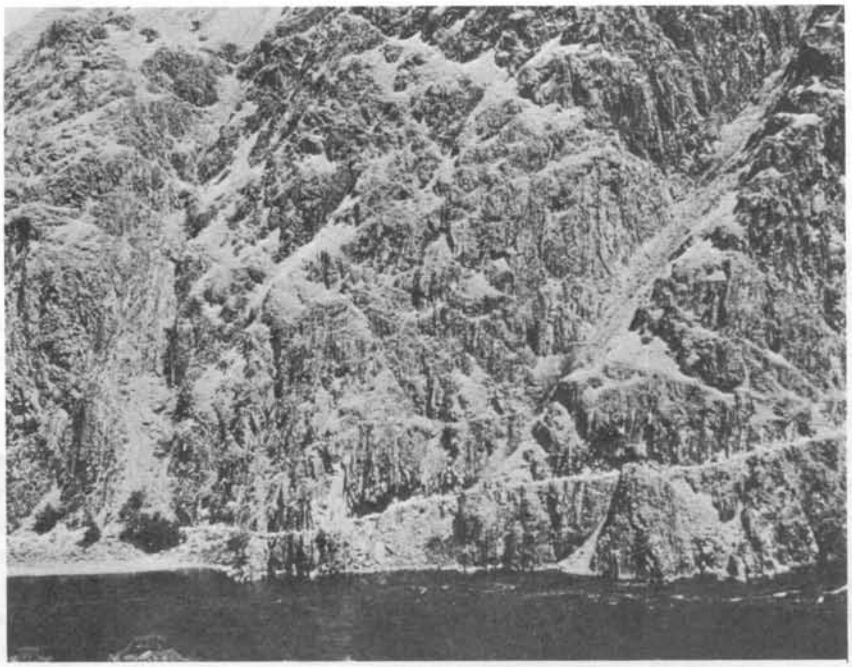

Figure 10. Vertical, fluxion-structured intrusives (mylonites) along the Snake River in the Cougar Creek shear zone. This exposure is about half a mile south of Kirkwood Creek.

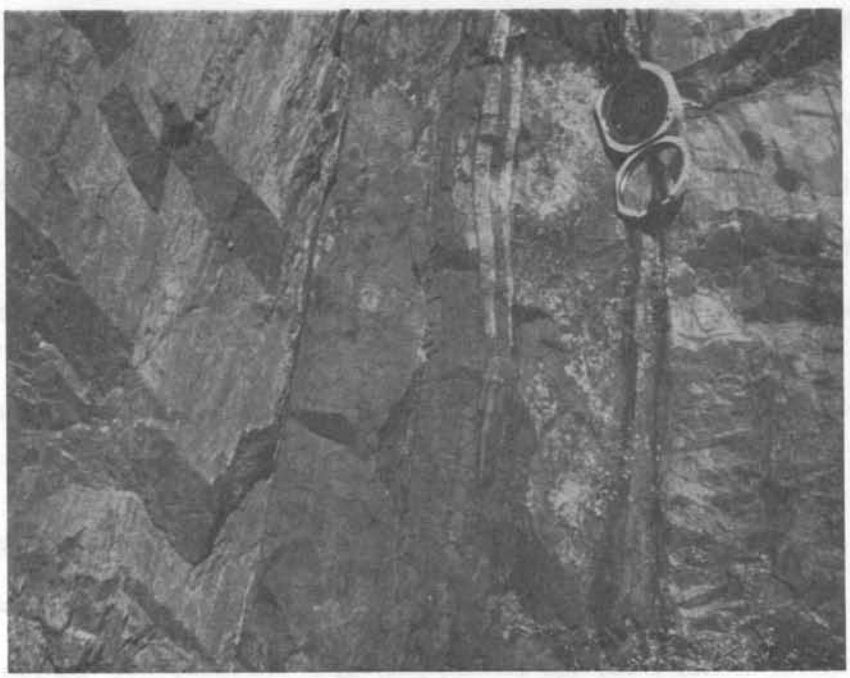

Figure 11. Mylonitized diorite and sheared diabase dikes in the Cougar Creek shear zone.

Figure 12. Rocks exposed on the Oregon side of Pittsburg Landing. A solid line separates rocks of the Cougar Creek shear from Middle Jurassic black shale along a fault. Dashed lines separate Middle Jurassic black shale from Upper Triassic clastic rocks along an unconformity.

Figure 13. Synclinal structure in the Pittsburg Formation at Pittsburg Landing. Overlying horizontal basalt flows are the Columbia River Group. The unconformity is marked by a dashed line.

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OCHOCO REGION GEOLOGICALLY MAPPED

Two maps recently issued by the U.S. Geological Survey complete a block of geologic mapping in the Ochoco Mountains east of Prineville. They are: Map I-541 - "Reconnaissance geologic map of the Ochoco Reservoir quadrangle, Crook County, Oregon," by A. C. Waters and R. H. Vaughan; and Map I-543 - "Reconnaissance geologic map of the Lookout Mountain quadrangle, Crook and Wheeler Counties, Oregon," by C. M. Swinney, A. C. Waters, and C. P. Miller.

The two adjacent quadrangles are underlain principally by andesitic and basaltic rock of the Clarno Formation of Eocene age, consisting of lava flows, mudflows, tuffs, vent breccias, plugs, and dikes. Overlying the Clarno rocks are patches of rhyolitic rocks of the John Day Formation comprising tuffs, welded tuffs, lava flows, domes, and intrusive bodies of upper Oligocene to lower Miocene age. Basalt flows of the Columbia River Group of middle Miocene to lower Pliocene age occupy fairly large areas in the eastern part of the mapped region. Pleistocene basalt and andesite flows occur south of Ochoco Reservoir on the west. Holocene (Recent) deposits include alluvium and landslide materials.

The multicolored 1:62,500-scale maps are obtainable at 75 cents each from U.S. Geological Survey, Denver Center, Denver, Colo. 80225.

* * * * *

LAVA BUTTE ATTRACTS THOUSANDS OF VISITORS

By Phil F. Brogan, Bend, Oregon

A 500-foot-high volcanic cone 10 miles south of Bend on U.S. Highway 97 was visited in the 1968 tourist season by more than 40,000 persons. It was the duty of this writer, serving as director of the U.S. Forest Service information center atop the old volcano, to greet the visitors and to tell them the ancient story of a tiny volcano that challenged the Deschutes River in its northward race. The aerial photograph shows Lava Butte from the south.

Visitors to the center were not only told the story of the butte, its 1678-acre lava flow and the vent from which this lava spilled to dam the Deschutes, but were given information about the rugged lavalands visible from the butte. Not overlooked was the great, white, southward stretch of Cascade volcanoes from Mount Adams, visible to the north in Washington, to Mount Scott in Crater Lake National Park.

Also related for visitors was the history of the Lava Butte country from the first recorded penetration, just to the south, by Peter Skene Ogden in 1826 to the coming of Nathaniel Wyeth and his fur-seekers in 1834 and the exploration by John C. Fremont and his men in 1843.

The 500-foot summit of Lava Butte is reached over a spiral road. On the high northeast lip of the deep crater is a glass-enclosed visitors' center, surmounted by a lookout house. Parking space on the summit was at a premium at times in the 1968 summer as the thousands of visitors made their way to the top. Many hiked around the crater trail to look over the south rim, where a great flood of molten rock long ago broke through cinders to send waves of lava west to the Deschutes and northward a distance of 6 miles.

Visitors were greatly impressed. They asked why the spectacular viewpoint was not included in western America tourist literature. The view of the Cascades was described by some as the most impressive seen on their western tours.

The U.S. Forest Service has recognized the importance of the viewpoint, and is making plans for enlargement of the center, development of trails over the jagged lava, marking of points of volcanic interest, and improvement of a limited network of roads that will make easily accessible such cinder and lava cones as Mokst Butte, high in the north Paulinas.

About a third of high Mokst Butte was torn away some 6000 years ago when lava breached the southwest wall. On his visit to this region in 1925, Geologist H.T. Stearns said that visible from high cones of the area is more "spectacular volcanism than can be seen from any other point in America."

The visitors' center planned by the Forest Service at the south base of Lava Butte will be developed as a base for the interpretation of the volcanic story of the region, noted for its lava caves, buttes, great fissures, spatter cones, and flows of basalt.

* * * * *

MERCURY TRENDS FORECAST

From January through July the price of mercury per 76-pound flask ranged from $600 to $500; it is currently $524. In 1968, GSA entered the market with 25,357 flasks available for disposal at monthly auctions and through the first 9 months of 1968 marketed 15,125 flasks to local commercial and industrial bidders. In addition, it presented, through AID, 2400 flasks to India and about 1800 flasks to other government agencies, leaving 6032 flasks in the GSA stockpile. If monthly offerings by GSA are at 1500 flasks per month, sales will extend into 1969; but if monthly offerings are at 2500 flasks, the supply could be exhausted by the end of 1968. However, new sources of supply are expanding, the most important of which is Cominco Ltd's Pinchi Lake mine in Canada, which recently began production a few months ahead of schedule. Capacity estimated at around 20,000 flasks a year will probably be reached during 1969. Another important gain in production is projected in Turkey, whose 1967 output amounted to about 4000 flasks, but according to U.S. Bureau of Mines reports is slated to jump to 25,000 flasks by 1970. In 1969, expanded Turkish and Pinchi Lake output may compensate for the loss hereafter of the 20,000-25,000 flasks which GSA is supplying this year. (Nevada Mining Assn. News Letter No. 188, Nov. 15, 1968.)

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