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OREGON'S MINERAL PRODUCTION INCREASES SHARPLY

By Ralph S. Mason*

Oregon mineral production for 1963, spurred on by a more than nine percent increase in value over that of 1962, reached another all-time high with an estimated total of $57,400,000. Oregon led all of the neighboring states in the rate of increase over the previous year; greater production of construction materials, such as sand and gravel and stone, was largely responsible for the record.

Production of clays, lime, and nickel showed little change. Gold and silver increased markedly, although their value is only a small fraction of what it once was. Interest in offshore oil and gas exploration continued at a high level, with several companies conducting seismic surveys and shallow coring programs. Extension of natural gas pipelines to most of the larger communities in the state was accomplished during the year. A study by the Department of Geology and Mineral Industries was started to assess the impact of this development of existing and potential mineral resources. Work was continued on a long-range geochemical study of mineralization which will eventually include nearly all of the state.

Industrial Minerals

Stone, sand and gravel

Stone and sand and gravel accounted for almost two-thirds of the total dollar value of all minerals produced in Oregon in 1963. The rapidly growing importance of these basic construction raw materials is clearly shown on the accompanying graph (see page 2). With but few exceptions, these materials are produced and consumed a few miles apart. Since heavily populated areas are the largest users of sand and gravel, these same areas must

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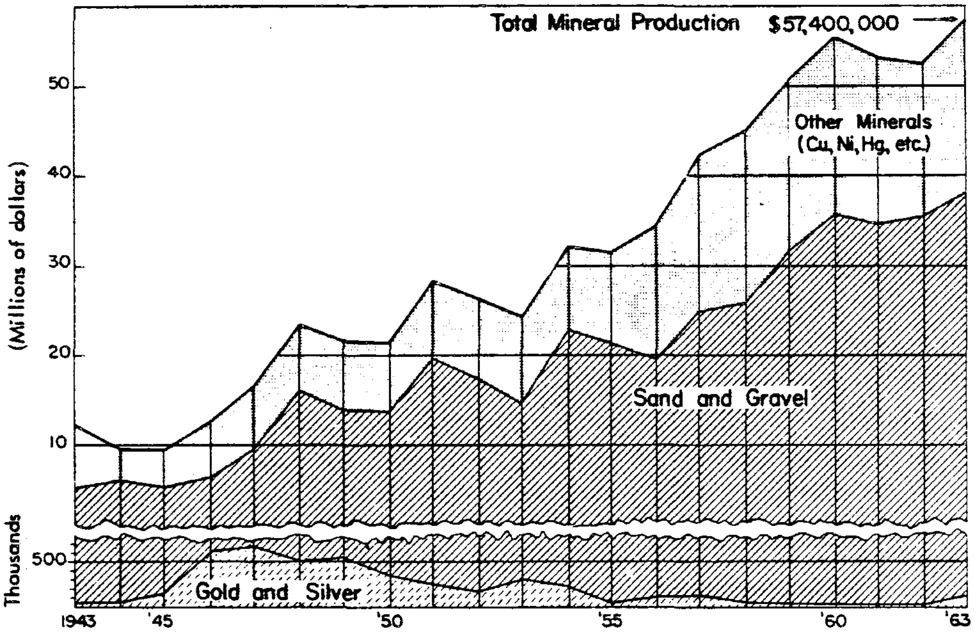
* Mining Engineer, State of Oregon Dept. Geology & Mineral Industries.



Graph showing rapid growth of sand and gravel and stone production as compared to the total mineral production of the state.

necessarily be the source, also, for most of the material used. Growing competition for land for urban expansion and for production of substances suitable to supply building materials for the urbanization has aroused some responsible agencies to action. Studies by local planning commissions, assisted by personnel of this department, are being made of several critical community areas in western Oregon. Identification of potential and existing sources of supply is the first step of the multi-phase project which, when completed, should provide the communities with a plan for a maximum of essential construction materials with a minimum of inconvenience to the inhabitants, at the lowest possible cost.

Portland area gravels were used in prestressed concrete piles, pile caps, and beams for a two-mile section of the Astoria interstate bridge at the mouth of the Columbia River. Empire Prestress, Inc., began moving the units from the Portland plant late in the year. The piles, some of which weigh 35 tons and average 95 feet in length by 4 feet in diameter, are barged to the site after a short haul on specially designed truck and trailer units.

Rigid specifications and a short supply of suitable local material made it necessary to barge large jetty rock from Government Cove, a few miles upstream from Bonneville Dam, 151 miles down the Columbia River to a jetty at its mouth. During the year considerable investigation was made by the department in an endeavor to locate quarry sites which could produce quantities of large blocks having sufficient density and resistance to sea-water to make them suitable for jetty repair and construction. Intrusive masses in the northern portion of the Coast Range were studied and will be the subject of a forthcoming report.

Lightweight aggregates

Little change was reported in the lightweight aggregate industry. Two plants in Washington County produced expanded shale for concrete aggregate and for use as a pozzolan in cement. Empire Building Materials added a third kiln to its plant at Sunset Tunnel in Washington County and fired it up in mid-December. Empire produced a special screened and uncrushed 5/8 - No. 4 fraction for monolithic concretes. Low absorbency of the kiln-coated pellets makes it possible to produce concretes weighing 105 pounds per cubic foot with crushing strengths ranging from 3,500 to 4,000 pounds per square inch. Lightweight prestressed concrete has become a standard construction material in the area. Numerous construction projects started during the year used a wide variety of prestressed beams, girders, and roof and floor slabs.

In the Bend area of central Oregon, pumice and volcanic cinder producers supplied sized and blended aggregate for monolithic concrete and unit-block manufacturers. Shipments were made to most of the important centers in the West. Large blocks of shaggy scoria from Tetherow Butte near Redmond were sold for rockery and wall construction. Lump pumice from Newberry Crater in southern Deschutes County was hand sorted and cobbed for filtering vinegar in a northwest plant. Other lumps of pumice were shipped to the Chicago area for abrasive purposes and to Oregon and California localities for landscaping stone.

Pacific Diatomite Corp. of Eugene processed and packaged diatomite from a deposit in Lake County. The diatomite is sold mainly as a sweeping compound and is distributed throughout the West. The company also announced plans to erect a perlite popping plant at Eugene to treat ore screened in a plant constructed during the year at the Tucker Hill deposit near Paisley, in Lake County. The expanded perlite will be used as an insulation additive in fibre wallboard. Archie M. Matlock of Eugene, one of the principals in Pacific Diatomite, has been developing uses and markets for Lake County diatomite and perlite for a number of years.

Two firms in the Portland area continued to pyroprocess ores imported from outside the state. Supreme Perlite Co. expanded crude perlite shipped from Nevada and vermiculite obtained largely from Montana. Vermiculite

Northwest, Inc., expanded vermiculite from Montana.

Lime and limestone

Ashgrove Lime & Portland Cement Co. started construction of a large lime plant at the Rivergate area near Portland. The structure will be completed in early 1964 and will use limestone barged from Texada Island, British Columbia. First shipments of stone were being stockpiled at the plant late in the year. Chemical Lime Co. increased production of burnt lime at its plant near Baker. A new quarry on Baboon Creek a few miles west of the company's Marble Creek pit was opened early in 1963 and began supplying stone in October.

Oregon Portland Cement Co. quarried limestone and shale from pits in Baker County for its cement plant at Lime. High-calcium stone for the company's Oswego operation was imported by ocean-going barge from Texada Island and supplemental stone was obtained from the company-owned quarry near Dallas in Polk County. Ideal Cement Co. quarried high-grade limestone from its quarry at Marble Mountain in Josephine County and trucked it to kilns at Gold Hill.

Silica

Bristol Silica Co. quarried and processed silica from its quarry in Jackson County. Small amounts of a high-silica altered tuff were shipped from the Rannells deposit on Quartz Mountain in Douglas County. The silica went to various metallurgical plants for the production of ferrosilicon, silicon carbide, silicon, and refractories.

Building stone

Most of the ornamental and building stones in Oregon are comparatively young, geologically speaking. The industry, however, is beset with the age-old problems of financing, distribution, and marketing. With but one or two exceptions, most of the quarries are small, intermittently operated enterprises using little if any mechanical stone-cutting equipment. At the Rainbow quarry near Pine Grove in Wasco County a spectacularly banded volcanic tuff was sawed out of the solid with rail-mounted travelling circular saws. The strips thus formed were resawed and guillotined into market stock. The Willowdale quarry in northern Jefferson County also produced a colorful tuff from a pit which has been active for many years. In the Bend-Redmond area several ornamental stones were quarried and sold, either in rubble form or as crushed and sized pieces.

Metals

Gold and silver

Production of lode and placer gold reached a five-year high during 1963, with a total of 1,529 fine troy ounces valued at $54,000. By historical standards the gold production for the state was still at low ebb (see graph, page 2). A strengthening price for silver on the world market not only spurred local mining effort but added to the dollar value per ounce as well. In 1962, a total of 6,047 ounces of silver was recovered from Oregon mines for a value of $7,000. Average price paid for the year's production was $1.16. In 1963, a total of 53,729 ounces worth $69,000 was mined at an average of $1.28 per ounce.

Principal lode mines active during the year were the Oregon King (silver) in Jefferson County and the Buffalo mine (gold) in Grant County. Two small high-grade gold mines were active in Jackson County. The Warner mine, which has been worked intermittently during the last 40 years, has both free gold and auriferous arsenopyrite. Values along the narrow vein have varied from a few dollars to more than $4,000 per ton. The Little Arctic mine in the same district has also been worked in a small way for many years. It is noted for spectacular, though extremely thin, plates of leaf gold which occur along seams in the rock.

Some of Oregon's Minerals at a Glance
Preliminary Figures for 1963
(in thousands of dollars)

	1962	1963
Clays	$ 305	$ 306
Gold	29	54
Sand & Gravel	14,556	15,700
Stone	20,977	22,500
Misc.*	14,956	17,253
Estimated total	$52,458	$57,399

* Asbestos, cement, copper, gem stones, iron ore, lead, mercury, pumice and volcanic cinder, nickel, uranium ore.

Twenty-two gold placers, most of them small seasonal operations, helped contribute to the state total.

Of great interest to gold miners, bankers, and economists was the AIME Gold and Money Session held in Portland in April 1963. Papers presented by various authorities at the meeting were subsequently edited by the department and privately published.

ACTIVE MINES IN OREGON, 1963

Gold Placer

Mine	County
Hobson	Baker
Nash	Baker
Washington Gulch	Baker
Winterville	Baker
Bandon black sand plant	Coos
Emily Cabin	Curry
Tennessee Gulch	Douglas
Upper Hogum	Douglas
De Janvier	Jackson
Palmer Creek	Jackson
Aphir	Josephine
Baer	Josephine
Brown	Josephine
Goff	Josephine
Gold Bar	Josephine
Joe Joe	Josephine
Leopold	Josephine
Maloney	Josephine
Oscar Creek	Josephine
Princess	Josephine
Speaker	Josephine
Standard Industries, Inc.	Malheur
Camp Carson	Union

Uranium

Lucky Lass	Lake

Gold Lode

Mine	County
Golden Eagle	Curry
M. C.	Curry
Mule Mountain	Curry
Buffalo	Grant
Morning	Grant
Double Jack	Jackson
Little Arctic	Jackson
Lucky Bart	Jackson
Warner	Jackson
Dark Canyon (Red Rose)	Josephine
Gold Plate	Josephine
Reno	Josephine

Copper

Standard	Grant
Oregon King	Jefferson

Mercury

Canyon Creek	Grant

Nickel

Hanna Nickel Co.	Douglas

Building Stone

Mine	County
Willowdale	Jefferson
Rainbow	Wasco
Red Rock	Deschutes
Cinder Hill	Deschutes
Hawaiian Travertine	Wasco

Limestone and Lime

Chemical Lime Co.	Baker
Ideal Cement Co.	Josephine
Oregon Portland Cement Co.	Baker, Polk

Silica

Big Quartz	Douglas
Bristol Silica Co.	Jackson

Sand and Gravel, Crushed Stone

Active commercial producers in every county and nearly every community in the state total more than 200. Numerous additional quarries operated by state, city, county, and federal agencies, and by logging companies using aggregate for private use.

Iron ore

In mid-year the Bunker Hill Co. filed applications with the State Land Board and the Clatsop County Court for leases to several thousand acres of iron-bearing sand in the Clatsop Spit area. Although the sands contain only a low percentage of magnetite, an iron oxide, Bunker Hill is hopeful that efficient mining and concentrating techniques can be perfected to make the extraction feasible.

Mercury

Production of mercury declined almost to the vanishing point. A few flasks were retorted at a property on Canyon Creek in Grant County. A comprehensive report on the mercury resources of the state was published by the department in mid-year. The Office of Minerals Exploration entered into an exploration program with Pacific Minerals & Chemical Co. to develop the Mother Lode, Cobar, and Lookout Mountain groups of mercury claims in Crook County. Actual work on the project will commence in June, 1964.

Aluminum

Reynolds Metals Co. purchased more than 500 acres of bauxite-bearing land in the Salem Hills area of Marion County from Harvey Aluminum Co. Harvey formerly had optioned and explored nearly 3,000 acres in the district lying immediately south of Salem. Reynolds is leasing back to the owners the land, which is composed largely of small tracts, and is holding the property as a hedge against a national emergency when foreign ores would not be available. The Aluminum Co. of America holds considerable acreages of bauxite-rich land in Washington and Columbia Counties for the same purpose. The deposits in northwest Oregon were discovered by the department. Interest in the aluminum ores by several of the aluminum companies followed shortly after results of the department's initial exploration work was published in August, 1944.

Copper

Geophysical investigations of some of the copper sulfide deposits in southwestern Oregon were conducted by a private organization during the year. Several deposits in the Takilma-Waldo area of Josephine County were surveyed and at year's end a diamond drilling program was started at some of the more promising areas. Copper was first discovered in the district in 1860, although little development occurred until 1903. A smelter to treat the ore from the Queen of Bronze mine was erected in 1904.

Exotic metals

The city of Albany continued to expand its exotic metals activities during the year. Oregon Metallurgical Corp., Wah Chang Corp., Northwest Industries, and the U.S. Bureau of Mines Electrometallurgical station were deeply engaged in the processing of crude ores, beneficiating concentrates, reducing, melting, rolling, casting, pelletizing, powdering, and fabricating more than half a dozen of the space-age metals. Martin Metals Co. opened a $750,000 research laboratory in the Beaverton area to develop new metal alloys for high-temperature applications. Steadily stiffening specifications by governmental and private consumers saw installation of additional research and testing facilities designed to identify impurities farther and farther to the right of the decimal point.

Electroprocess Industries

Hanna Nickel Smelting Co. continued to mine and smelt nickeliferous laterite from its hilltop deposit near Riddle. The year-around operation employs nearly 450 men in the production of ferronickel pigs. National Metallurgical Corp. announced plans at year's end to revamp and enlarge the original portion of its Springfield plant. Cost of the reconstruction will be nearly $500,000. National produces silicon metal in electric furnaces from a mixture of silica and wood chips. In the Portland area, Electrometallurgical Corp. and Pacific Carbide & Alloys furnaced lime and carbon to make calcium carbide. The Troutdale plant of Reynolds Metals Co. announced plans in April to the effect that approximately $500,000 would be spent in plant modernization. The Harvey Aluminum Co. plant at The Dalles was in continuous operation throughout the year.

Federal mining leases and permits

A total of 5,400 acres in federal coal leases was held by two lessees in 1963. Mandrones Coal Mining Co. of Molalla worked a seam near Wilhoit in Clackamas County. Pacific Power & Light Co. held approximately 4,800 acres in the Eden Ridge district of southern Coos County, where it has been conducting extensive exploration of several coal seams in connection with a proposed coal-fired base-load steam plant for supplying electrical energy to the Coos Bay area.

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OIL AND GAS EXPLORATION IN OREGON

By V. C. Newton, Jr.*

Offshore Studies

Interest mounted in 1963 over prospects of finding oil on the continental shelf adjacent to Oregon. Recent studies indicating thickening of Tertiary marine sediments westward from shore have led geologists to believe that there has been extensive basin development on the shelf lands (Byrne, 1962, 1963). Eight oil companies (see table below) participated in offshore exploration in 1963, and five other companies are expected to commence studies next summer.

Offshore Exploration Permits, 1963

Company	Permit	Type Survey	Est. Period of Operation (months)
Shell Oil Co.	SL-2	Sparker - gas exploder Conventional seismic Bottom sampling and coring	7
1/ Union Oil Co.	SL-3	Bottom sampling and coring	3
2/ Standard Oil Co. of Calif.	SL-4	Conventional seismic	2½
Richfield Oil Corp.	SL-6	Sparker Bottom sampling and coring	2

1/ Union and Standard jointly conducted sampling and coring operations.
2/ Standard was operator for a 5-company group: Humble, Pan American, Texaco, and Phillips.

A federal lease sale of outer continental shelf lands in northern California in May 1963 interested Oregon officials, because bidding on these lands would reflect what might be expected on submerged lands in Oregon. Oil companies leased a total of 310,000 acres of the 670,000 acres of California shelf lands nominated. Cash paid for the leases amounted to nearly $13 million. The majority of leases were in water more than 200 feet deep, and leases offshore at the Klamath River outlet near Eureka were in water 300 to 1,200 feet deep.

Bidding on shelf lands in Washington netted little more than minimum

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

ONSHORE DRILLING PERMITS ISSUED IN 1963

Permit No.	Company	Well Name	Location	Total Depth	Operations Commenced	Abandon Date
51	E. M. Warren & Assoc.	Coos County 1-7	SE¼ sec. 7, T. 27 S., R. 13 W., Coos County	6,337'	5-13-63	6- 5-63
52 PB	Marvin Lewis (Reserve Oil & Gas Co.)	Roy-L&G- Bruer 1	NE¼ sec. 31, T. 6 S., R. 4 W. Polk County	5,549'	6- 6-63	Idle
53	Gulf Oil Corp.	T. J. Porter 1	NE¼ sec. 27, T. 13 S., R. 4 W. Linn County	8,471'	11- 9-63	1-10-64

rental in 1963. Superior Oil Co. leased most of Washington's submerged lands in 1962 for minimum rental.

Oil companies were asked by the U.S. Department of Interior to indicate which areas of the federal submerged lands (lying beyond the state 3-mile limits of Oregon and Washington) they thought should be open to leasing. Selections were to be submitted by the end of October 1963. The Pacific Outer Continental Shelf Office of the Bureau of Land Management in Los Angeles is expected to announce by mid-February the areas to be offered for leasing.

Tentative plans of the Department of Interior call for a sale of federal submerged lands in October 1964. This date was chosen so that companies short on seismic data could utilize another summer season to collect data before making bids. With this timing it appears that no drilling can be done prior to May 1965.

The Oregon State Land Board is in the process of platting a lease map covering state-owned tide and submerged lands and is studying the procedure for giving public notice and accepting bids. It is anticipated that a great deal of interest will be shown in state lands when the Bureau of Land Management announces the areas to be offered for lease.

Exploration Onshore

The department issued two drilling permits and one plugback permit in 1963 as compared to six permits in 1962. Total wildcat footage for the year was 13,837 feet. E. M. Warren, San Antonio, Texas, drilled a 6,300-foot test in Coos County, approximately 3 miles south of where Phillips Petroleum Co. drilled in 1944. The Phillips well encountered lower Eocene volcanic rocks at 2,325 feet.

Gulf Oil Corp. started a test in October 3½ miles northwest of Halsey in the central Willamette Valley. The well was abandoned on January 10, 1964 after reaching a depth of 8,471 feet (depth on December 31, 1963 was 7,500 feet). Information obtained from this well will help determine the extent of marine deposition during Eocene-Oligocene time in the southern half of the Willamette Basin. The Gulf well is located 16 miles southwest of a well drilled by Reserve Oil & Gas Co. in 1962. Reserve suspended work on its well pending further study and has not as yet officially abandoned it.

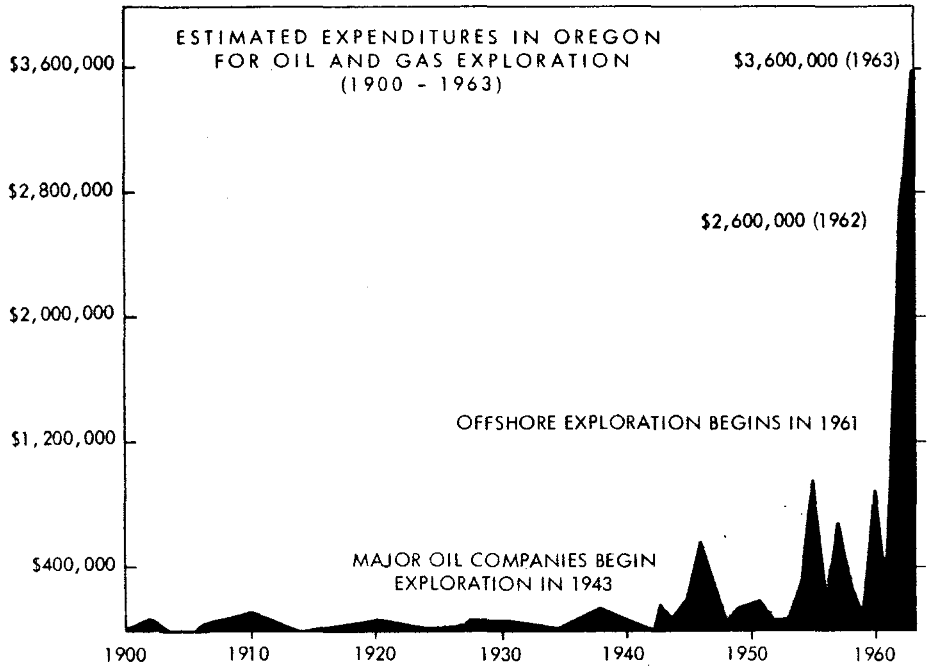
At least three oil companies made geological studies along the coast onshore in Oregon this past year. One firm engaged in an auger-drilling program in order to obtain paleontological information.

At the close of 1963, Gulf, Superior, Humble, Texaco, Standard, Richfield, and Reserve were holding leases in western Oregon. Gulf held the greatest amount of acreage of the seven companies. E. M. Warren & Associates retained a portion of their leases in Coos County, and Wesley G. Bruer & Associates retained lease holdings in Marion County. Leasing in Oregon east of the Cascade Mountains has been inactive since 1962 except for occasional filings on federal lands.

The accompanying graph shows estimated expenditures for petroleum exploration in Oregon over the past 63 years. Significant increases can be noted on the graph for 1943, when major companies began exploration in the state, and later in 1961, when studies commenced on shelf lands. Estimates were based on footage drilled, land costs, administrative expense, supervisors' salaries, and contingencies. During 1963, approximately $2.5 million was spent offshore and $1.1 million onshore.

Further Exploration Encouraged

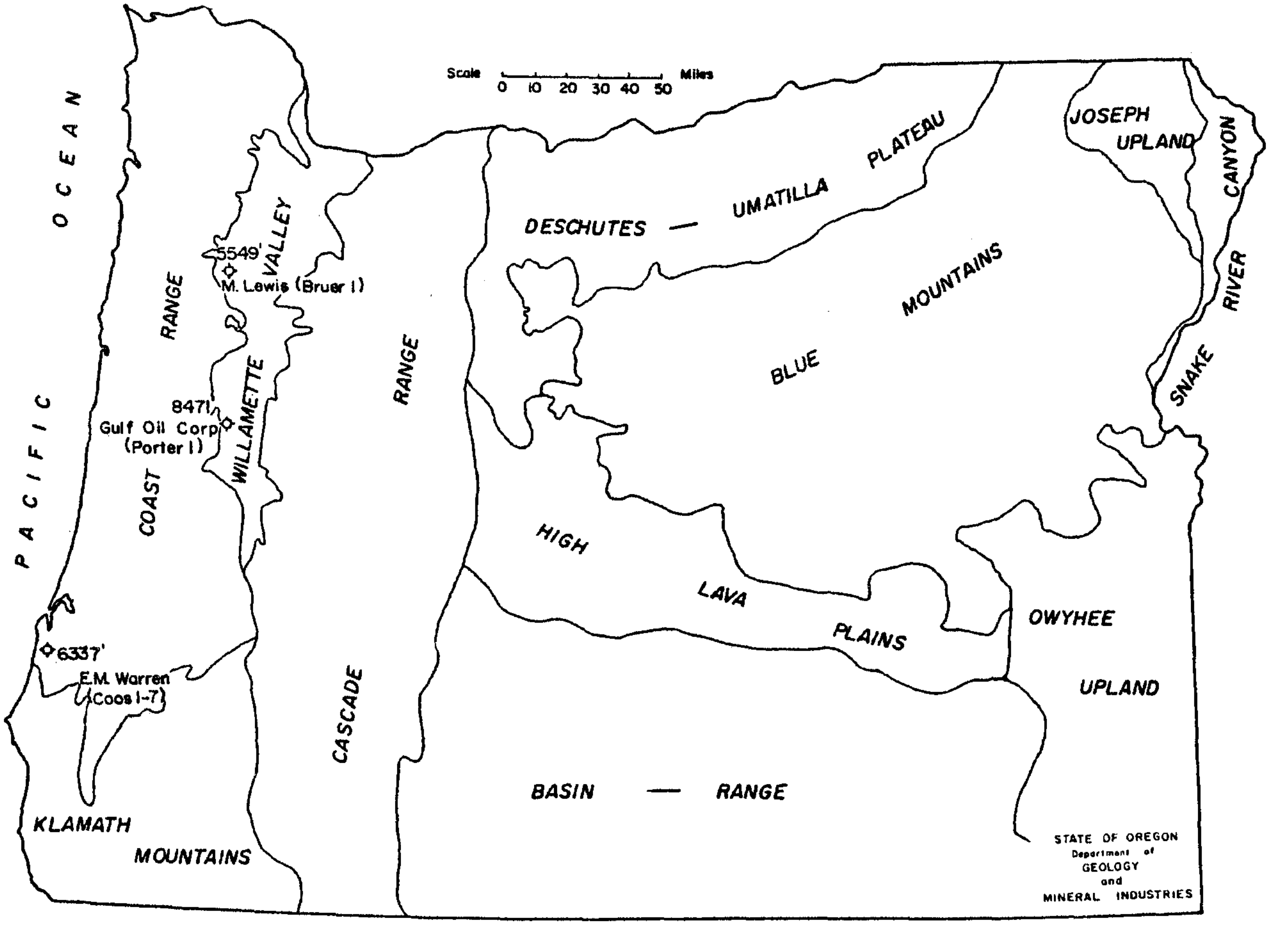
A history of prolific production from the Tertiary marine rocks of California led oil companies to explore sedimentary rocks of the same age in Oregon, Alaska, and Washington. Tertiary marine rocks, together with continental sediments, comprise the major portion of the Coast Range and Willamette Valley geomorphic divisions (see accompanying map, page 13).



Rocks in these two regions are principally tuffaceous sedimentary and volcanic strata, which are thought to reduce the petroleum potential. However, recent discovery of significant production in Eocene continental sediments at the Swanson River Field in the Cook Inlet area of Alaska has renewed hope of finding oil in western Oregon. Production at the Swanson River Field is from the "Hemlock Sand" near the base of a Tertiary sedimentary and volcanic section similar to that found in western Oregon and Washington.

In a large area of central Oregon, unmetamorphosed pre-Tertiary marine rocks which could provide the right environment for oil deposits presumably underlie a thin layer of younger volcanic rocks. Upper Mesozoic marine sediments crop out at many locations along the southwestern portion of the Blue Mountain geomorphic division (see accompanying map). Crude oil filling cavities in fossils and geodes have been found at several localities in this region. Only three or four deep test holes have been drilled thus far to investigate the prospects of the pre-Tertiary rocks.

The Deschutes-Umatilla Plateau, Joseph Upland, High Lava Plains, and the Owyhee Upland (see map) are all a part of the Columbia Intermontane Province. Rocks of this region are predominantly Cenozoic volcanic rocks which are covered at places with thin layers of lake and stream sediments. A few large, deep intermontane basins exist within the province. One such basin is found in the Owyhee Upland, where downwarping of lavas



Map showing the geomorphic divisions of Oregon and location of oil drillings during 1963.

in the Ontario-Payette area of eastern Oregon and western Idaho forms a deep depression into which at least 10,000 feet of continental sediments were deposited during late Tertiary time (Newton and Corcoran, 1963). Numerous showings of gas have been encountered in wells drilled in this basin over the past 50 years, but as yet no commercial deposits have been found. Nearness of the El Paso Natural Gas Co. Northwest pipeline system makes the area attractive for additional exploration. Formation tests of porous zones in the basin thus far have all yielded fresh to brackish, gassy water; dry gas blows have been obtained in less permeable horizons.

Basin and Range topography extends over a large portion of the state (see map) and is an extension of the main province covering most of Nevada. Two deep test drillings were made by the Humble Oil & Refining Co. in the Goose Lake and Summer Lake graben basins of south-central Oregon. Objectives of the drilling were Mesozoic and Paleozoic rocks presumed to be underlying younger continental volcanic and sedimentary rocks. The drilling showed there was possibly in excess of 20,000 feet of Tertiary sedimentary rocks and intercalated lava flows filling these basins (written communication, Quintin A. Aune, California Division of Mines, 1963). Although Humble apparently lost interest in the area after drilling the two test holes, it is still possible these extremely deep intermontane basins may produce commercial quantities of gas.

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PORTLAND HOST TO AMC IN SEPTEMBER

Arrangements for the 1964 metal mining and industrial minerals convention of the American Mining Congress, which will be held at Portland, Ore., September 13-16, are rapidly taking shape under the direction of General Chairman Earl S. Mollard, western states representative, Hanna Mining Co., Myrtle Creek, Ore., who is chairman of AMC's western division.

Wesley P. Goss, president, Magma Copper Co., Superior, Ariz., has accepted the important post of national chairman of the program committee. Under Goss' guidance, industry leaders representing all mining areas of the nation will hold an April meeting to formulate a program embracing major subjects of widespread appeal to the industry.

Convention sessions covering new developments and progress in exploration, open-pit and underground mining, minerals beneficiation, safety and management--together with sessions on mineral policies, labor relations, taxes, public lands, and gold and monetary policies--are expected to attract a large attendance of top industry executives and technical and management personnel from all phases of production. In addition, high-level government officials from the Executive Department and members of both Houses of Congress will be on hand to discuss topics of significant concern to the mining industry.

Entertainment events at the mining convention will include the traditional reception on Sunday, September 13; a welcoming luncheon on Monday, September 14; a "miners' cruise" that evening; and an annual banquet on Wednesday evening, September 16. For the many ladies who will attend the convention, special events are being arranged.

Hotel reservations will be handled through the American Mining Congress housing bureau operated by the Portland Convention Bureau, 1020 Southwest Front Avenue, Portland, Oregon 97214. First assignments of accommodations will be made in late May or early June, but it is suggested that requests for reservations specifying arrival and departure dates be sent in promptly to the housing bureau. (AMC News Bulletin, Jan. 17, 1964.)

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NOTICE

Effective with this issue, new and renewal subscriptions to The ORE BIN will be $1.00 per year. Available back issues will be 10 cents each.

OREGON ACADEMY OF SCIENCE TO MEET IN MARCH

The Oregon College of Education at Monmouth will be the host for the 22nd annual meeting of the Oregon Academy of Science on Saturday, March 7, 1964. The public is cordially invited to attend.

The Geology and Geography Section will hold morning and afternoon sessions. The chairman, Norman V. Peterson, is a geologist on the staff of the Grants Pass office of the State Department of Geology and Mineral Industries. Plans for the meeting are not entirely completed, but an interesting and varied program is anticipated. Those who expect to present papers are urged to submit titles and abstracts to Dr. F. A. Gilfillan, who is Secretary of the Oregon Academy of Science, Oregon State University, Corvallis, Oregon.

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BUNKER HILL TO EXPLORE CLATSOP SPIT

The State Land Board and the Clatsop County Court have prepared leases covering fairly substantial acreages of land in the Clatsop Spit area of Clatsop County for signature by the Bunker Hill Co. of Kellogg, Idaho. Bunker Hill is expected to sign the instruments promptly and to begin exploration work immediately. Application for a lease was made by the company in August (see August 1963 ORE BIN, page 128). Before a lease form was prepared, the Land Board consulted with seven state natural resource agencies and canvassed six other states for royalty and rental structures.

The lease is for a primary period of 25 years. During the first 5 years Bunker Hill will pay an annual rental of 25 cents per acre. The rental increases to one dollar per acre at the end of the 5-year period. Royalties of 20 cents per each long dry ton of iron ore or concentrates produced must also be paid during the first 10-year lease period. The royalties increase 5 cents per ton during the next 5-year period of the lease, and another 5 cents per ton increase occurs at the beginning of the 16th year.

The lease requires Bunker to commence exploration operations within 180 days of the signing of the lease, and the company must spend not less than $7,500 during the first lease year. This amount increases to $25,000 in the aggregate for the second year. Construction on a reduction plant must begin within 7 years from signing and be completed by the tenth lease year. Although differing slightly in certain respects, the Clatsop County lease is patterned closely after the state lease.

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DIAMOND CRATERS, OREGON

By Norman V. Peterson* and Edward A. Groh**

Introduction

Diamond Craters is the name given to an isolated area of recent volcanism near the center of Harney County in southeastern Oregon. The area lies about 60 miles south of Burns in Tps. 28 and 29 S., R. 32 E.

The whole of this volcanic feature is not easily described, but it probably fits most correctly the definition of a small shield volcano. The first volcanic activity produced a field of lava that was shaped much like a huge pancake about 6 miles across (see plate 1). This lava welled up and flowed out in radial directions from a now-hidden vent near the center. Slight irregularities in the topography over which the coalescing tongues of lava flowed created a design at the perimeter resembling the scalloped edges of a lace tablecloth. Later on, sporadic volcanism, both explosive and quiet, domed, split, and pockmarked the original relatively smooth surface producing a concentrated variety of stark, fresh volcanic landforms.

Diamond Craters were known to the early settlers of eastern Oregon and were named about 1875 for their proximity to the Diamond Ranch. This ranch took its name from the diamond-shaped cattle brand used by Mace McCoy, an early settler. The name Diamond was also given to a small community and post office nearby. Even though the craters are remote from population centers, access is not difficult. The easiest route is southeast from Burns on Oregon State Highway 78 to the junction at New Princeton, then south and west by well-marked, all-weather roads that skirt the east and south parts of the Diamond Craters. A well maintained dirt road crosses the broad, cratered and domed area from east to west on its southern flank. This road passes between or near many of the most interesting landforms, as shown on the index map in plate 1.

The names given to the numbered features on the index map and referred to in the text are only for the purpose of the report.

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* Geologist, State of Oregon Dept. of Geology & Mineral Industries.

** Privare Geologist, Portland, Oregon.

Previous investigations

I. C. Russell (1903), one of the first geologists to make a reconnaissance of eastern Oregon, visited Diamond Craters in 1902. He gives a rather comprehensive description of many of the craters and other features. From his observations he described lapilli cones and lava cones as the principal features of the area. He mistakenly interpreted the low dome on the northeast side, feature No. 5, to be a cone built up of layers of lava flows. If he had been able to view this feature from above or to see aerial photographs of it, he would most certainly have realized that this is a structural dome, bowed up by the pressure of intruding magma. Russell gives an interesting description of the large crater complex (feature No. 1) at the center of the Diamond Craters field and also details of the small graben (feature No. 7) which he calls a gulf. He also mentions the peculiar spherical lava balls or bombs found in the low rims of most of the craters of explosive origin but does not postulate as to their origin.

Rocks of the Diamond Craters have been mapped as "late basalt and ejectamenta" of latest Pleistocene to Recent age (Piper and others, 1939). The lack of any appreciable erosion was believed to indicate that some of the volcanic activity may have taken place only a few hundred to a few thousand years ago. Piper and others (1939) refer to the Diamond Craters as "a basaltic lava field whose predominant feature is a lava dome whose crest is broken by a linear pit."

Field work

This study of Diamond Craters is part of a project of the State of Oregon Department of Geology and Mineral Industries to evaluate the recent volcanic landforms of Oregon. The field work was done on the ground on August 6, 7, and 8, 1963. On August 21 the area was viewed and photographed from various elevations in a small airplane. Available aerial photographs from government sources were also used to help determine the sequence of volcanic activity.

Geologic Setting

The Diamond Craters area is at the very southern edge of the broad alluvial plain of the Harney Basin. Just to the south are the dissected uplands of the long westward slope at the northern end of Steens Mountain. From this dissected upland the Donner und Blitzen River, Kiger Creek, and McCoy Creek enter the Harney Basin to meander to Malheur and Harney Lakes, shallow playa lakes that form the sumps for the large undrained basin. Riddle Creek, a little farther to the east, once joined the Donner und Blitzen just west of the Diamond Craters, but its course was dammed by the first flows of the Diamond Craters lava and it now turns northward and empties into shallow Barton Lake. Kiger Creek was also forced to the south and west by the encroaching Diamond Craters lava.

The rocks immediately beneath and surrounding the Diamond Craters are geologically young. Piper and others (1939) have separated them into three mappable units. The oldest rocks are the Danforth Formation of Pliocene age, made up of stratified siltstones, sandstones, and tuffs with at least one prominent layer of welded tuff. This is the most widespread rock unit directly beneath and surrounding the Diamond Craters on the south and west. A younger Pliocene formation, the Harney Formation, contains massive basaltic tuffs and breccia layers, sandstone, and siltstone, with a prominent capping layer of basalt. The Harney Formation is present to the north and east of the Diamond Craters as isolated mesas and other erosional remnants perched on the Danforth Formation. The youngest of the three units is a lava field that Piper and others (1939) have called the "Voltage Lavas." This lava flowed out on an erosional surface and surrounded the isolated remnants of the Harney Formation. Its surface shows some weathering and a thin layer of soil is present. From this evidence it is estimated (Piper and others, 1939) that the lava was probably erupted during Pleistocene time, much earlier than the Diamond Craters lava.

Volcanic History of the Diamond Craters

The original land surface, before the first eruptions of the Diamond Craters lava, was very nearly as it is now. Erosion had removed all but a few patches of the Harney Formation from the basin. Alluviation of the central part had already begun, because drainage to the Malheur River and ultimately to the Snake River to the east had effectively been dammed by the flows of Voltage Lavas. The streams draining the western slopes of Steens Mountain were bringing in more sediment as they meandered across the flat valley floor to Malheur Lake.

The first event in the formation of the Diamond Craters was the eruption of a very fluid olivine basalt from a single, or a few closely spaced, vents along a zone of weakness that trends northwest through the area. The eruptions were probably preceded by earth tremors as a fissure opened at depth and the magma began its upward rise from a small independent reservoir. The lava flowed out from a source the type and location of which cannot now be determined because of obliteration by later volcanic activity. It probably existed in the vicinity of what is now the Central Crater Complex, indicated by the radial pattern of the lava flows. The lava spread out

Figure 1. Aerial view ot the pahoehoe lava surface in the northeast part of the Diamond Craters lava field. As the flood of fluid lava spread farther from its source, a thin, rubbery, undulating crust was formed. The waning supply of lava drained beneath the cooling crust through a system of lava tubes and channelways. The lava roofs, already weakened by shrinkage joints and cracks, collapsed into the voids to form sinks of many sizes and shapes. In this view some of the depressions resemble giant foot tracks 100 to 200 feet long; others are small and nearly circular. These collapse depressions are characteristic of pahoehoe lava fields.

Figure 2. Oval Crater. The west end of a long, oval crater which formed as the vent shifted from east to west over an extended period of sporadic explosivity. The low, rounded rims are made up of lapilli and bombs. The truncated edges of pahoehoe lava flows can be seen in the crater walls. At this west end it is 900 feet from rim to rim; the long oval crater extends for 2,000 feet to the east.

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rapidly as pahoehoe flows to cover roughly a 6-mile-diameter circular area. In the final stages much of the pahoehoe crust foundered into drained lava tubes producing abundant, well developed collapse depressions (figure 1). Thickness of these lava flows is estimated to be 75 to 100 feet in the center of the field, thinning to a foot or so at the margins.

Following this initial relatively quiet eruption of lava, the sequence and time duration of volcanic events becomes slightly more obscured, but from viewing the aerial photographs and examing the features in the field, it is judged that their general sequence is probably thus:

A. A renewed upward surge and lateral intrusion of basaltic magma into the sediments of the Danforth Formation bowed up parts of the newly formed circular lava field into three low, rounded domes, aligned generally northwest-southeast above the fissures through which the magma rose. The most westerly of these is just north of the Twin Craters on the index map. The second and highest elongate dome is now modified by the Central Crater Complex, and the third has been somewhat modified by Oval Crater.

B. Accompanying and closely following this doming, gas from the vesiculating magma plus steam, which was generated as the magma heated water-saturated rocks, furnished energy for explosions of varying violence to form craters of different sizes and types. Many of these craters were subsequently enlarged by engulfment or collapse after the explosive eruptive stage, leaving little or no rims of ejecta. Twin Craters, and Oval Crater (figure 2) are two examples. Others such as Malheur Maar (figure 3) and Cloverleaf Crater (figure 4) have rims of ejecta containing a considerable number of accidental fragments and show evidence of little or no collapse. Red Bomb Crater (figure 5) and Big Bomb Crater, on the other hand, have built shallow cones made up of lapilli, scoria, and a multitude of red and black spherical and ellipsoidal cored bombs (described in more detail on page 29). These craters are more like cinder or scoria cones,

Fig. 1

Fig. 2

Figure 3. Malheur Maar. This lake-filled explosion crater and an adjoining one fit the original definition of a maar. The feature is 250 feet in diameter and 100 feet deep. It was probably formed by one or more gas eruptions or steam blasts. Very little or no magmatic material was erupted and only low rims of broken rock fragments are present. On the pahoehoe surfaces in the background are low, rounded to oval bulges called "tumuli." These are believed to form when the partly congealed lava crust is raised by a local build-up of lava immediately beneath it. The tops of many of the tumuli are cracked open, and molten lava from below has squeezed up into some of the cracks.

Figure 4. Cloverleaf Crater. Brief sporadic explosions from separate, closely spaced vents formed this multiple-lobed crater rim that surrounds individual shallow craters. The several small craters occupy an area about 600 feet in diameter.

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since there is a larger addition of magmatic material in their composition.

C. At the close of the above eruptive phase, new activity was concentrated at the Central Crater Complex (figure 6). Additional doming by intrusion of the magma was followed by violent explosive eruptions that perforated the roof and showered broken rock and ash high into the air. To a contemporary observer, a mushrooming cloud of vapors and ash would have been seen billowing to a great height. Pulverized rock and comminuted ash fell back from this cloud to form a thin masking layer about 5 miles in diameter surrounding the erupting vent. This mantle of debris can be seen in the aerial photo (plate 1) as a halo encircling the Central Crater Complex. Eruptions continued less frequently and less violently from vents that shifted within the eruptive center until at least 17 funnel-shaped crater pits, of which not all are represented on the index map, were formed amid the hummocky debris. These inner crater rims, like the rims of the smaller explosive features to the south and east, contain basaltic lapilli, scoria, and similar cored bombs mixed with rock fragments of many sizes and varieties. Fragments and blocks of gray welded tuff characteristic of the Danforth Formation are common to abundant, and a large outcropping of this same tuff is present high in the wall of one of the smaller inner craters. This is strong evidence for the conclusion that considerable doming had taken place prior to the eruptions. After all the explosive activity had ceased, fluid basaltic lava again welled up and formed several small flows which filled in slight depressions at the outer edges of the crater complex.

This volcanic feature is certainly an unusual one, and a detailed study would probably show that many individual volcanic episodes are responsible for its present configuration. The explosive eruptions must have fractured the whole mass, causing subsidence or collapse, which action has also been a factor in producing the shape of this crater complex. The

Fig. 3

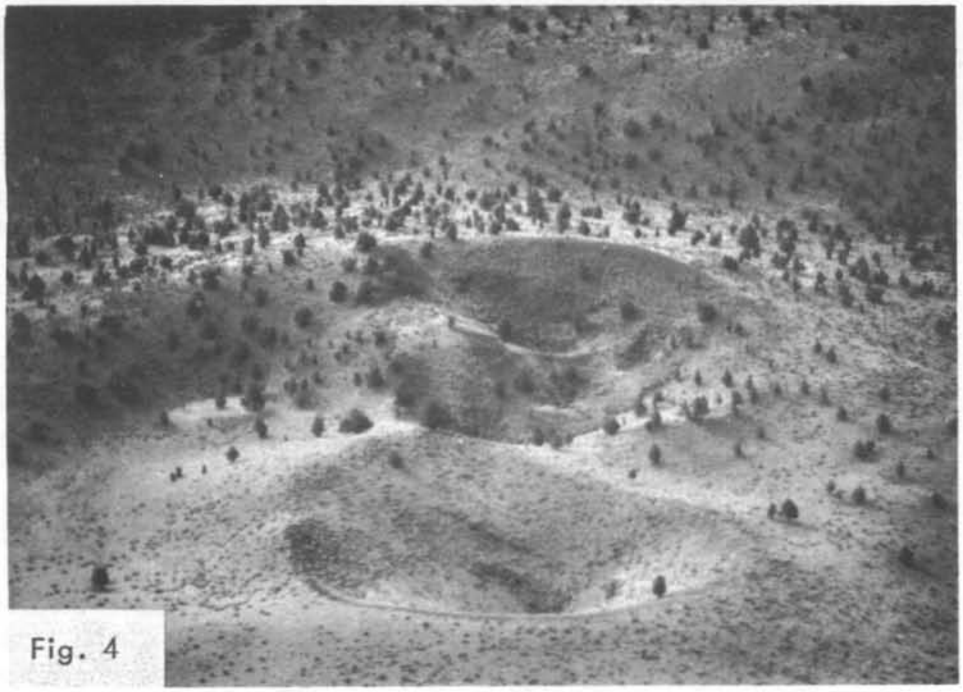

Fig. 4

Figure 5. Red Bomb Crater. A portion of Red Bomb Crater showing a scalloped rim and multiple funnel-shaped crater pits within a larger one that is more than 900 feet in diameter. The latest explosive eruption came from the crater in the lower left. The rims consist of accretionary lapilli and numerous bombs.

Figure 6. A small part of Central Crater Complex. Rather than being round or oval like most craters, it is rectangular with rounded corners. The feature is 1 mile long and 3,500 feet wide. The crater floor is as much as 200 feet below the rims near the outside edges, but the center is choked with piles of debris that are as high as the encircling rims. Within the hummocky debris there are at least 17 individual funnel-shaped craters with steep slopes and narrow bottoms. Part of this debris is accidental and part is magmatic in the form of cinders, scoria, and bombs. Fresh black lava in small amounts has stoped upward to fill depressions near the edges of the crater.

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funnel-shaped bottoms of the inner craters and the loose debris still lying at steep angles on the walls attest to a very recent origin, probably within the last 1,000 years.

D. Another surge of magma, this on the eastern edge of the area, intruded to form another bulge, Graben Dome, now marked by an almost textbook example of a graben (figure 7). The graben appears to have been formed by subsidence when lava broke out at lower elevations and drained away, thereby withdrawing support. The outflow of fluid black lava occurred at many places low on the south and east flanks of the rising dome. Lava rose within some of the older explosion craters and formed small pools of lava in the crater bottoms. Before the lava pools had cooled, drainage occurred within the conduit, leaving round, steep-walled pit craters with floors of jumbled, thin black lava crusts such as Keyhole Crater (figure 8) and Lava Pit Crater (figure 9). Over other vents small spatter cones were built. Fluid lava from half a dozen sources joined to fill depressions and cover another $1\frac{1}{2}$ square miles (stippled area on index map). The exposed surfaces are glassy and show the ropy texture and collapsed crustal features so common on thin pahoehoe flows.

E. Intruding magma next manifested itself to the northeast of Graben Dome and formed Northeast Dome, the western end of which joins Graben Dome. As the brittle lava overlying the Northeast Dome was bowed upward, tension caused fractures to form the pattern that can be so easily seen from the air (figure 10). On the ground these open fissures are as much as 15 feet wide and 50 feet deep. It appears that the magma which raised up this dome did not break out at the surface to form lava flows, but instead, it is probably now cooling at some depth as a laccolithic mass.

The nature of the underlying Danforth Formation has probably made it possible for these domes to form in the Diamond Craters. Magma rising from a fissure could move laterally between the incompetent claystone and

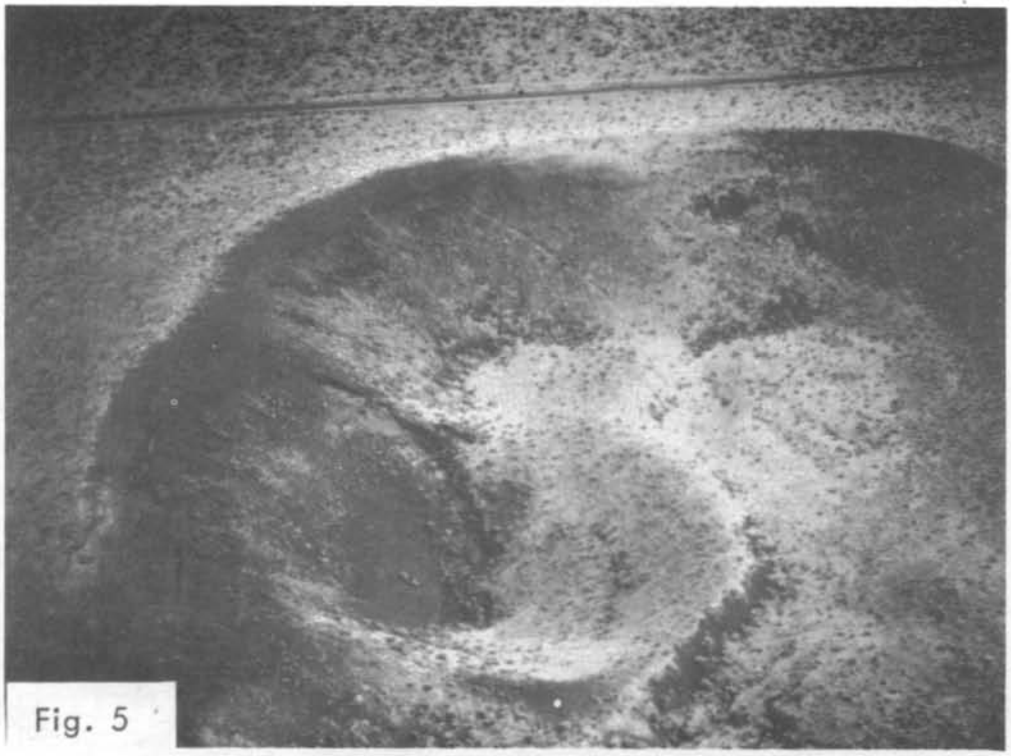
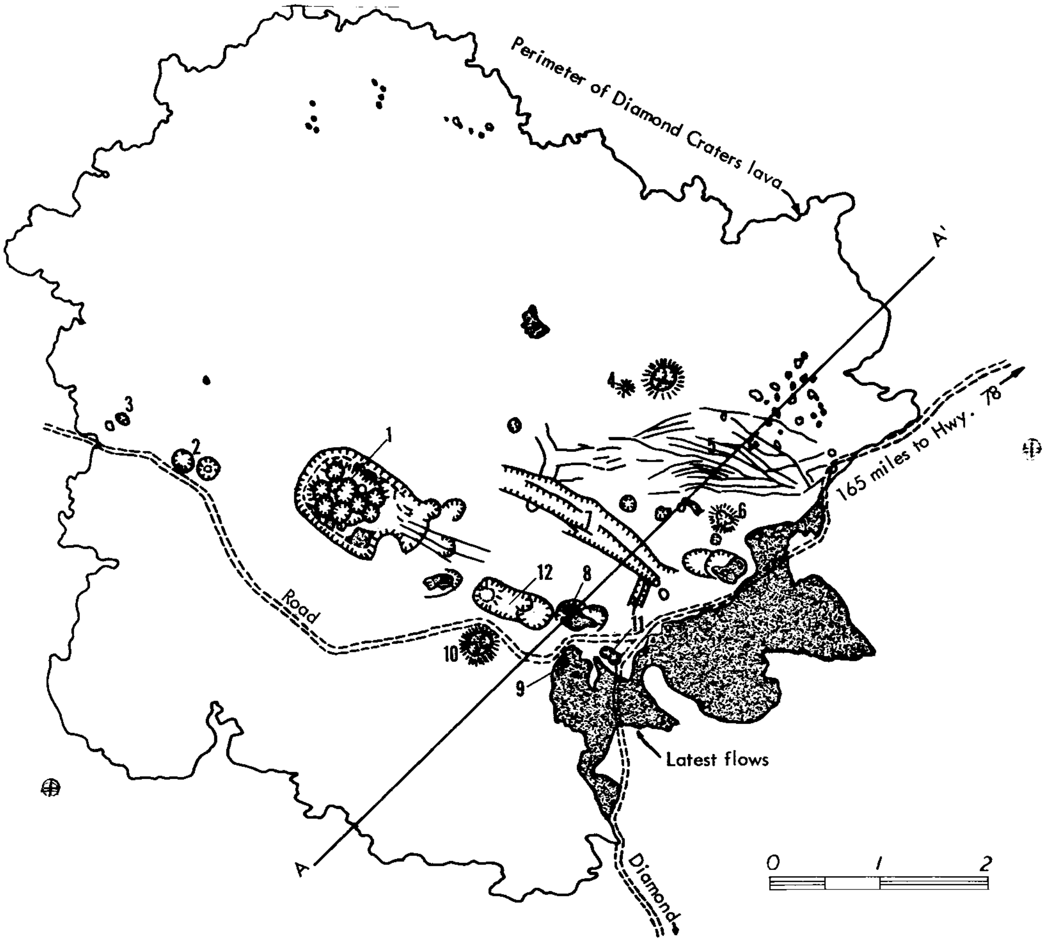


Fig. 5

Fig. 6



GEOLOGIC CROSS SECTION

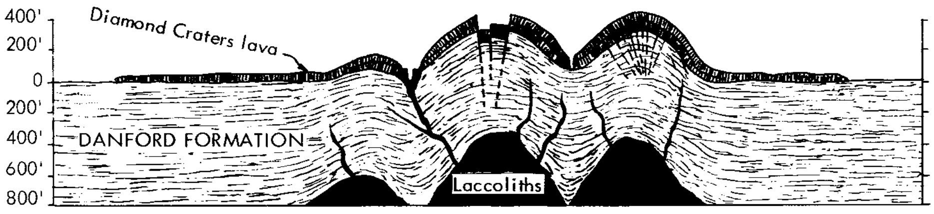
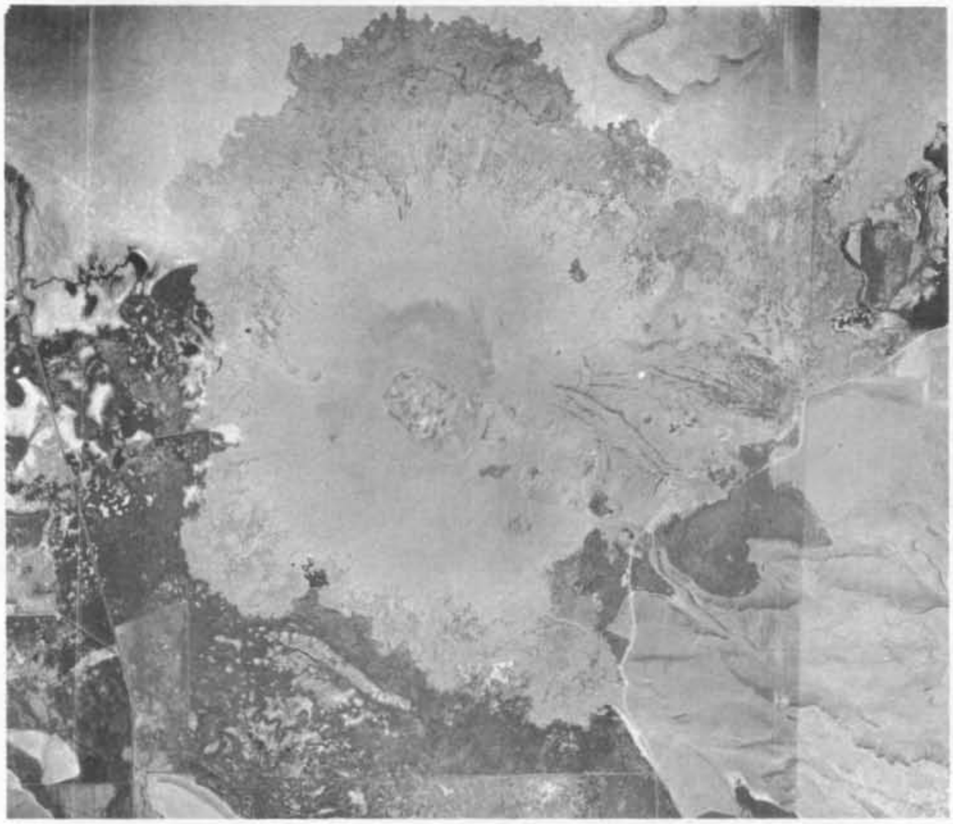


Plate 1. Index map and aerial



Feature	Name		
1.	Central Crater Complex	7.	Graben Dome
2.	Twin Craters	8.	Keyhole Crater
3.	Malheur Maar	9.	Lava Pit Crater
4.	Little Red Cone	10.	Red Bomb Crater
5.	Northeast Dome	11.	Big Bomb Crater
6.	Cloverleaf Crater	12.	Oval Crater

ograph of Diamond Craters, Oregon.

Fig. 7

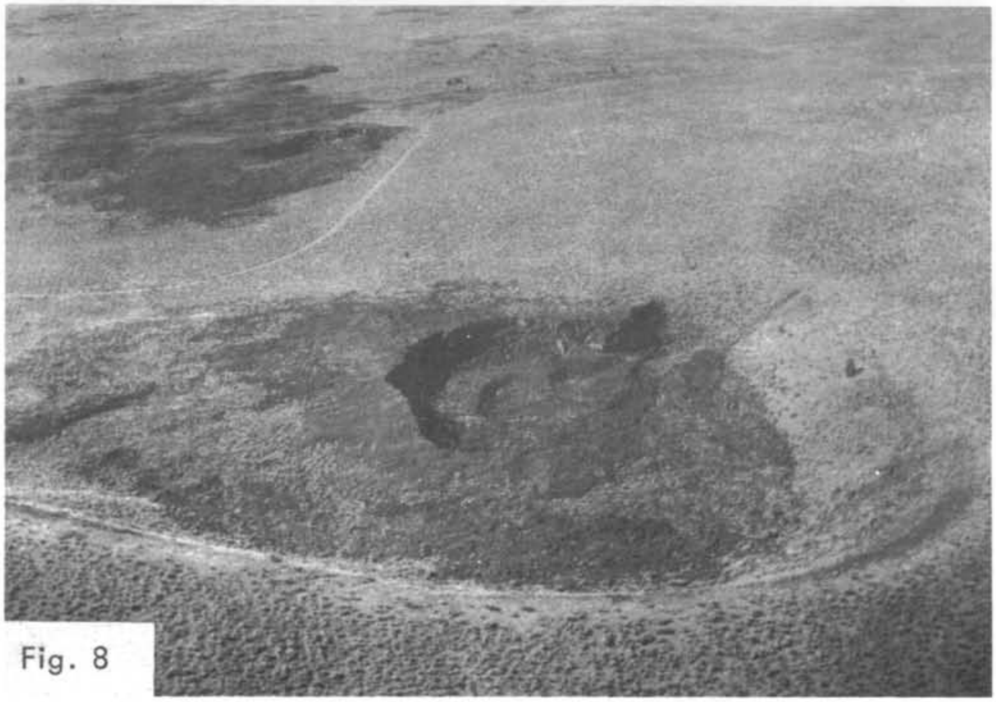


Fig. 8

Figure 7. Looking west along the crest of Graben Dome. Shown is the graben that developed as a collapse feature when the magma which domed up the lava surface broke out at lower elevations to the south and west, withdrawing support. The graben is well developed for 7,000 feet and averages about 1,250 feet in width. Displacement of the down-dropped block is as much as 100 feet. Two accessory grabens cross the main graben at nearly right angles.

Figure 8. Keyhole Crater. The inner, steep-walled pit in stark, black lava is about 400 feet in diameter and 100 feet deep. Fluid basalt welled up to form a lava lake that filled the floor of an existing broad explosion crater. Then the magma column above the vent drained through some subterranean channelway and the thin crust collapsed to form the steep-walled pit. Part of the west wall of hardened basalt was carried back down the vent. Lava benches show that drainage of the lava was intermittent.

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sandstone layers and remain confined at depth except for that portion extruded to the surface by various conduits. The geologic cross-section (plate 1) shows the general relationship of the laccolithic masses believed to underlie the domes.

F. Still later sporadic volcanic eruptions produced features such as Little Red Cone (figure 11), which looks almost as though it were formed yesterday. Volcanism and magmatic intrusion in the Diamond Craters are now presumed to be dormant. No fumarolic activity or hot springs are known to exist.

Cored bombs

The crater rims, floors, and even the debris-covered flat areas near the explosion craters commonly contain unusual spherical to ellipsoidal cored volcanic bombs. They range from the size of a pea to as much as 2 feet in diameter. Most of them are made up of accretionary layers of black or reddish lava surrounding an angular accidental rock fragment. Siltstone, diatomite (?), sandstone, welded tuff, and a variety of other volcanic fragments are all present as cores. These xenoliths have been thermally metamorphosed. In some of the bombs, the lake-bed stiltstone fragments have been burned to a reddish color, the sandstone has been sintered, and welded tuff fragments have been partially to completely melted to a frothy glass. The more basic lava fragments show a lesser degree of alteration.

The origin of these interesting bombs is not completely known, but they probably began as rock fragments which were broken from the walls of the conduit, coated with lava, and carried through the vent into the air by the exploding gases and steam, only to fall or roll back into the vent from which

Fig. 9

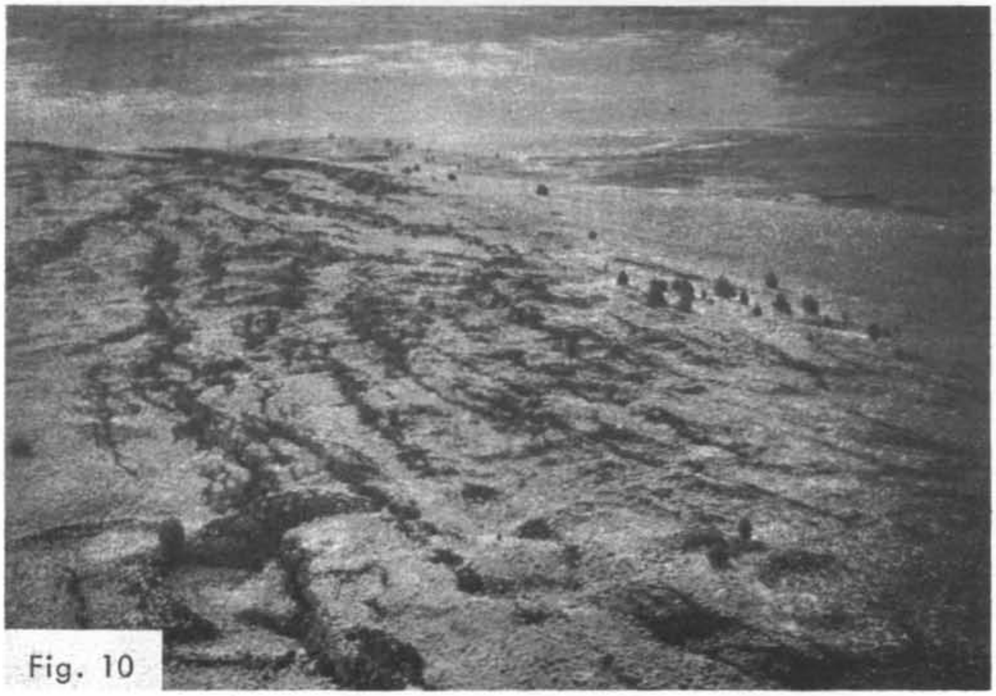

Fig. 10

Figure 9. Lava Pit Crater. This feature is so similar to the small basaltic shield volcanoes with summit pits of Iceland that it could probably be called a miniature shield volcano. Lava welled up slowly on a gently sloping surface. As it overflowed, small lava-tube distributaries carried off the lava in all directions to build up the low, broad dome that is typical of the larger shield volcanoes. Then, just as at Keyhole Crater, drainage of the lava resulted in collapse over the vent to form this steep-walled pit.

Figure 10. Looking eastward along the crest of Northeast Dome, showing the jagged fractures opened by tension as a rising magma domed an area more than a mile long and 3/4 mile wide. Like glacier crevasses, these open cracks are hazards to travel. Some of the largest cracks are 15 feet wide, 40 to 50 feet deep, and extend for long distances. There is no apparent displacement of the basalt walls on either side of the cracks, indicating that little or no subsidence has taken place at the dome crest.

they came. With further churning in the vent, these fragments received another coating of lava, were thrown out again when a more violent blast occurred, and finally, after repeated activity, came to rest on the rim of the crater. Such a combination of processes is probably responsible for the smooth, rounded shape of most of these unusual bombs.

A further, more detailed study of the composition and texture of the accretionary coatings and cores is being made in order to determine more details about their origin. Figures 12a and 12b show a group of typical, cored bombs from various crater rims in the Diamond Craters area.

Conclusion

Diamond Craters lie in an isolated recent volcanic field at the southern edge of Harney Basin. The nearest recent volcanic areas are the Four Craters Lava Field about 100 miles to the west and the Jordan Craters about 60 miles to the east. Diamond Craters present many unusual features that exist at no other recent volcanic areas in Oregon. Three of these features stand out above the rest for special interest. One is the Central Crater Complex, for which one can neither give a simple explanation of its origin nor provide a simple description of its physical characteristics. A second unique feature is the graben at Graben Dome, which can be examined as though it were a model for classroom study, since almost no detail has been destroyed by weathering and erosion. Lastly, the system of fissures on Northeast Dome, a multitude of gaping cracks, provides an outstanding example of what happens to a brittle sheet of lava when it is rapidly warped upward. These structures, along with the many other recent volcanic forms, provide variety to anyone interested in delving into the processes of volcanism.

Fig. 11

Fig. 12a

Fig. 12b

Figure 11. Little Red Cone. This small cinder cone, only 250 feet in diameter and less than 75 feet high, has smoothly rounded rims of reddish cinders and scoria. It was born of one of the most recent explosive eruptions at Diamond Craters and is one of the least eroded features in the area. Partly obliterated older craters show that Little Red Cone is built over a vent that has a history of explosive eruption.

Figure 12. Cored bombs. a) A variety of the peculiar and interesting cored bombs from a crater rim within the large Central Crater Complex. Fragments of shale, mud, welded tuff, and basalt are the most common cores that have been encased in concentric layers of black and red lava. b) An assortment of sizes and shapes of cored bombs. These objects can range from the size of a pea to 3 feet in diameter. Most are round or oval, but some are merely lava-coated angular fragments.

Another aspect of the Diamond Craters which deserves further investigation is their possible potential for the development of geothermal energy. Since the most probable cause for the domes is the formation of small laccoliths, these may be at a moderate depth, perhaps no more than a few hundred feet below the surface. The recency of the latest volcanism leads one to believe that considerable heat may still exist in these intrusive bodies and surrounding rock, even though no fumarolic activity or hot springs are known in the area. Geophysical exploration might confirm the presence of these intrusives and determine their approximate depth. If conditions were found to be favorable, the drilling of a test hole could prove the existence of steam or superheated water at depth. Engineering studies on the amounts of steam and/or superheated water which could be produced, its temperature and pressure, corrosiveness, and other properties would then determine the commercial feasibility of generating power.

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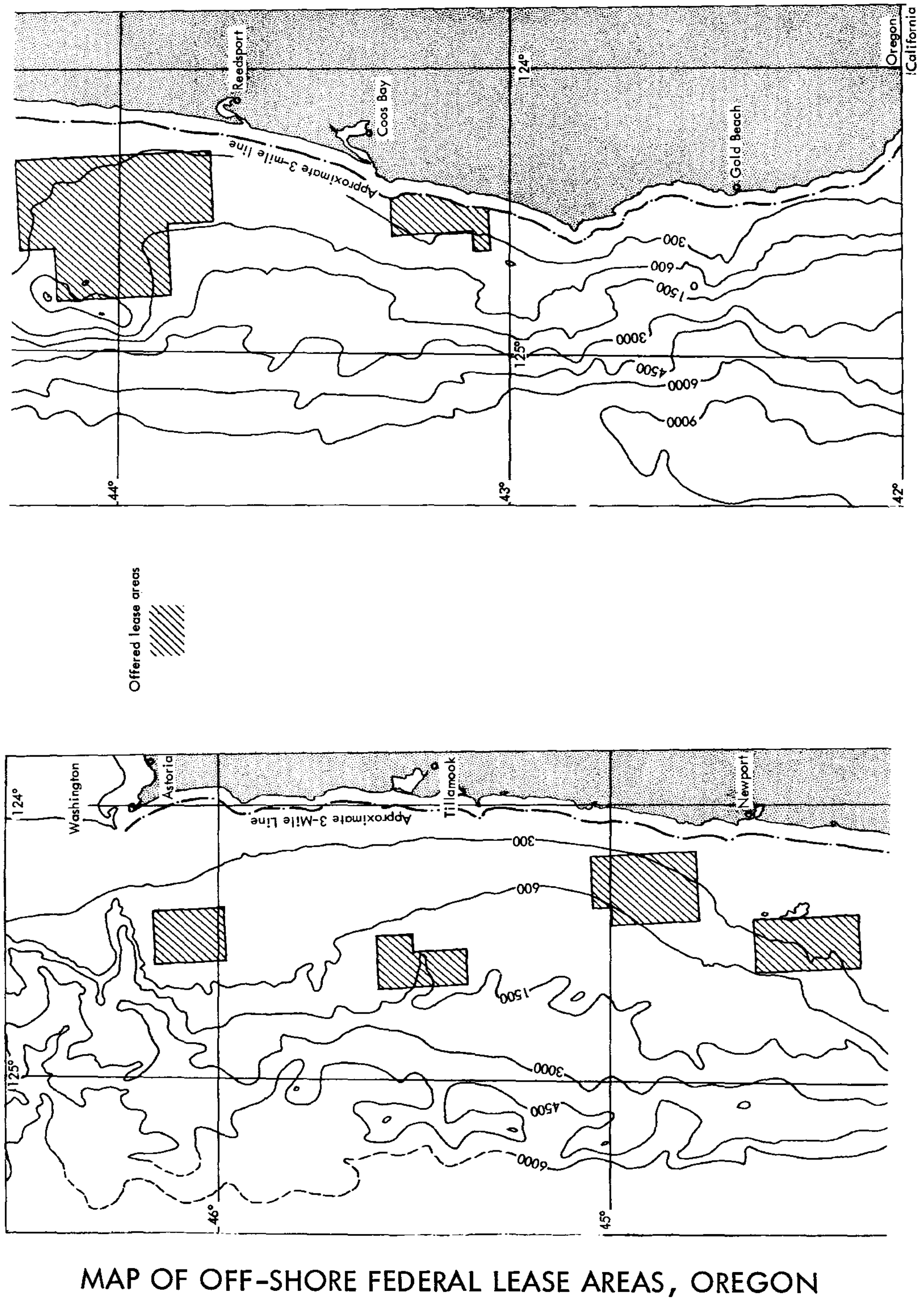
DEEP-WATER OIL DRILLING ASSURED IN THE NORTHWEST

The U.S. Department of the Interior announced February 18, 1964 that 1,090,000 acres of shelf lands were opened to oil leasing along the coasts of Oregon and Washington. The offered lease blocks (see map for Oregon blocks) represent areas of major interest which were selected from 3,000, 000 acres suggested by the various oil firms. Deep-water leases offered adjacent to the northern California coast in May, 1963, received bids that netted $13 million. Comments by industry spokesmen indicate that more money will be bid on the Oregon-Washington lands.

A total of 836,000 acres (1,300 square miles) offshore from Oregon and 254,000 acres (396 square miles) offshore from Washington is available for leasing. Rental has been established at $3 per acre per year, plus a minimum bid of $5 per acre. Thus, the federal government has set a minimum value of the lands offered at $8,720,000.

Oil companies began exploration along the northwest coast in 1961 and have been making extensive geophysical and geological studies for the past 3 years. In order to obtain areas for drilling, the companies must submit sealed bids to the U.S. Bureau of Land Management by October 1, 1964, at which time the leases will be awarded to the highest bidders. The federal government issues its leases in 3-by-3-mile parcels (5,760 acres). Data on federal lease blocks is given in the table on page 36.

The State Land Board, preliminary to conducting a lease sale of state-owned submerged lands, approved an offshore lease form on February 25, 1964, and announced the availability of state submerged lands for oil and gas leasing. The board also continued preparing bidding procedure and hearing schedules as provided for in the Oregon Tide and Submerged Lands Act of 1961. Oil companies will probably be asked to make their selections by the end of May; opening of sealed bids will be in October of this year.



MAP OF OFF-SHORE FEDERAL LEASE AREAS, OREGON

Federal Lease Blocks

Area	Acreage	No. of Parcels	Average Water Depth
Skipanon-Seaside	69,120	12	300 feet
Rockaway-Netarts	69,120	12	1,500
Cascade Head- Cape Foulweather	132,480	18	300
Newport-Waldport	103,680	26	360
Yachats-Florence	401,360	41	360
Coos Bay-Bandon	47,360	11	240

Oregon, because of its irregular shoreline and east-west boundaries, has divided its parcels by extending the east-west federal lease grid lines to the shore. A total of 102 parcels has been designated within the state boundary. The largest parcel is 11,800 acres and the smallest is 6,100; the parcels average 8,000 acres.

Governmental policies as well as the interest expressed in federal shelf lands will determine the success of the leasing on state lands. The state-controlled area is a very minor portion of accessible shelf land. However, 811,500 acres of submerged land are contained in the three-and-a-half mile strip bordering the coastline and an additional 42,200 acres are contained in the Columbia River estuary west of the 124th West Meridian.

Federal outer continental shelf land offered for lease abuts state lands only along the Coos Bay-Bandon block. The state land adjacent to this area will very likely be placed for bid in October. State land in the Coos Bay-Bandon block totals 36,000 acres and will be presented in 5 parcels of approximately 8,000 acres each. Other areas of state leases along the coast may be offered if companies nominate them.

Exploration activity has progressed to the point where deep drilling is necessary for further evaluation of the oil potential. A variety of deep-water drilling techniques may be tried in the next two years. Perhaps a vital new industry is being established in Oregon.

* * * * *

AMERICAN MINING CONGRESS NATIONAL MEETING

Portland, Oregon September 13-16, 1964

Portland is going all out to make this next Mining Convention the most successful one ever held. You won't want to miss it, so mark your calendar. Application forms for hotel reservations will be mailed in April.

The ORE BIN
Volume 26, No. 3
March, 1964

AIRPORT GRAVITY BASE STATION NETWORK IN OREGON

By

Wilbur Rinehart*, R. G. Bowen**, and E. F. Chiburis*

Introduction

The force of gravity or gravitational attraction is familiar to all, but not everyone knows that the value of gravity at any point on the earth's surface is a variable that depends upon latitude, elevation, tidal effects, topography, and the density distribution of the rocks beneath the surface.

Gravity surveying is commonly used today in the search for oil and gas or metallic minerals, but long before gravity measurements became prospecting tools it was realized that such measurements could give information on the shape of the earth and the nature, thickness, and mechanical properties of its crust.

The accelerating pace of geophysical measurements has resulted in the need for more base stations of standard gravity values to which this constantly increasing volume of new information can be related. The Geophysical Research Group, Department of Oceanography, Oregon State University, and the Oregon Department of Geology and Mineral Industries, seeing the need for base stations in Oregon for both their own work and that of others coming into the area, have cooperated in establishing a series of 23 gravity base stations at secondary airports in central and southern Oregon (see figure 1). This survey was carried out by using a light four-place airplane (Cessna 172). A Worden Master Gravity Meter, No. 575, was flown between the gravity stations. By this method a wide area was covered in a minimum of time and with a minimum expenditure of funds. The work was done in the spring of 1963 and took a total of 40 flying hours.

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* Geophysical Research Group, Department of Oceanography, Oregon State University, Corvallis.

** State of Oregon Dept. of Geology & Mineral Industries, Portland.

Measurement of Gravity

Gravity measurements are obtained by either of two methods: pendulum or gravity meter. The pendulum method requires specially constructed pendulums and highly accurate crystal clocks. The pendulum oscillations are timed for a period of several hours and a direct determination of the acceleration of gravity can be calculated. The accuracy obtained depends upon the timing and the freedom from losses due to friction in the pendulum. This is the method by which all gravity measurements were formerly taken, but it has now been largely supplanted by the gravity meter.

Gravity meters are relative-reading devices which indicate the change in acceleration of gravity between known stations. This change is measured by determining the relative position of a spring-supported weight through the use of highly sensitive optical magnifiers. The accuracy of a gravity value obtained with a gravity meter depends on the accuracy of the primary base station, the knowledge of the meter's calibration constant, and the precision of measurement. The precision of the meter and its operator may be determined by statistically analyzing the variations in readings made between one station and another. The gravity meter tends to have a varying amount of drift that is dependent upon such factors as time, temperature, and vibration. Ideally, temperature and vibration of the meter can be controlled and the time drift is a straight line factor. The data collected by gravity meters must be referred to a known base value of gravity in order to be used in regional and geodetic gravity surveys, and the more often this data can be tied in to a base station the more accurate it will be.

Earlier Gravity Stations in Oregon

In the State of Oregon, gravity values were first obtained in 1910 by the U.S. Coast and Geodetic Survey, using a pendulum device (Duerksen, 1949). These readings were obtained at coastal stations and in the Willamette Valley. A control network at airports in the United States was completed in 1958 (Woollard, 1958), using gravity meters. This network contains 9 Oregon stations located at Portland (2), Salem, Corvallis, Eugene, North Bend, Medford, Roseburg, and Pendleton. These gravity stations were tied to the primary West Coast base stations located at Seattle, Washington, and San Francisco, California. In turn, these base stations, which are part of the North American Western Standardization Range, were tied by Woollard to the gravity base station located at the University of Wisconsin. The gravity value there is based on ties made by Woollard (1950) to 11 international gravity base stations tied directly to Potsdam, Germany.

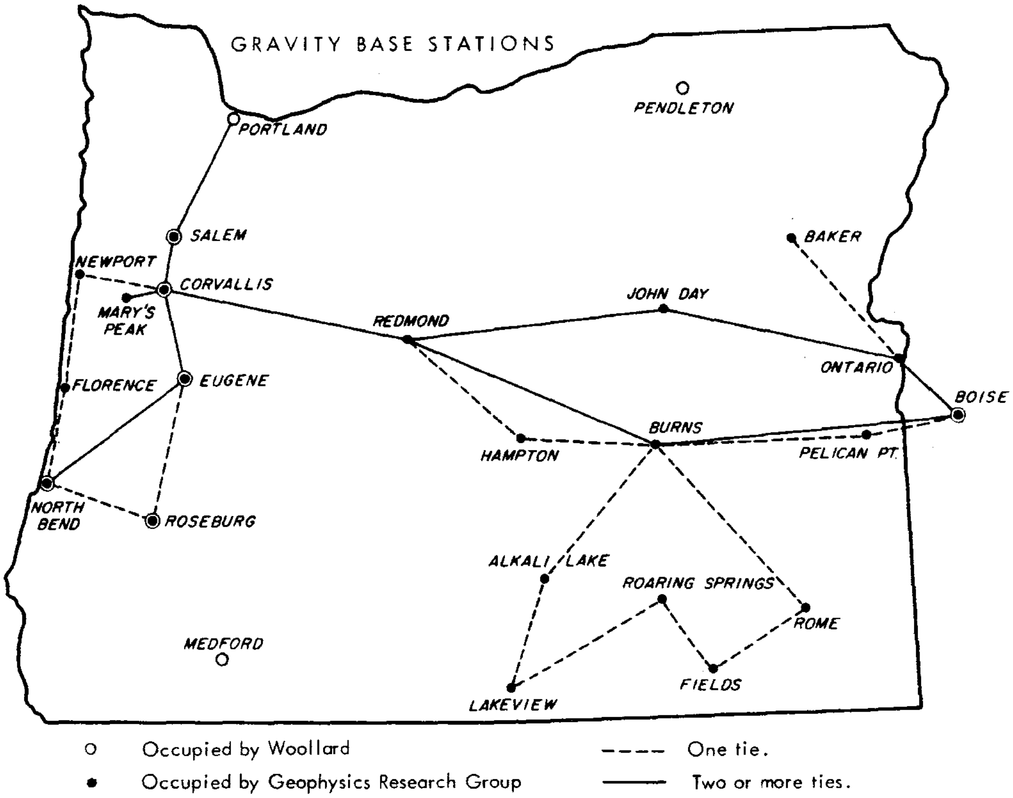

Figure 1. Index map showing location of gravity base stations in Oregon.

Base Stations Added in 1963

The locations of the 23 airport stations are shown as solid circles in figure 1. The solid connecting lines indicate multiple ties between stations and constitute a first order gravity base network. The dashed connecting lines indicate one tie between stations and constitute a second order gravity base network, because the precision of measurement, and consequently its accuracy, could not be evaluated.

Figure 2 (see pages 53, 54, 55, and 56) shows a plan view of each site, which should permit reoccupation of the stations to within 5 feet. Where it was possible, sites were chosen near permanent structures, but in some instances sites were located at the wind sock, a nearby bench mark, or at a road intersection.

Occupying sites described by Woollard (1963), primary ties were made between the Portland airport and the Salem, Corvallis, and Eugene airports. Secondary ties were then made between the Corvallis and Redmond airports.

Table I. Observed gravity values in Oregon.

1	2	3	4	5	6	7
Station (Airport)	Ties	OSU Observed Gravity (mgal)	Woollard Observed Gravity (mgal)	USCGS Observed Gravity (mgal)	Differences	
					(col 4-col 3) (mgal)	(col 5-col 3) (mgal)
Portland (Primary Base Station)			980648.3			
Corvallis	4 a	980569.0	980570.1		-1.1	
Salem	4 a	980583.3	980583.7		-0.4	
Eugene	6 ab	980514.6	980514.8		-0.2	
North Bend	3 b	980492.2	980493.5		-1.3	
Redmond	2 b	980260.8				
John Day	2 c	980242.4				
Pelican Point	1 c	980208.5				
Ontario	2 c	980303.5				
Baker	1 c	980286.6				
Burns	2 c	980105.9				
Hampton	1 c	980095.1				
Rome	1 c	980039.7				
Fields	1 c	979972.9				
Roaring Springs	1 c	979985.6				
Lakeview	1 c	979901.5				
Alkali Lake	1 c	980046.6				
Roseburg	1 b	980427.7	980429.4		-1.7	
Newport	1 b	980596.2				
Florence	1 b	980550.0				
Boise, Idaho	2 b	980207.1	980208.2		-1.1	
Medford			980237.5			
Pendleton			980511.7			
OSU Physics-Chemistry Building	15 ab	980573.4				
Portland Custom House	5 a	980647.5	980647.4	980649.	+0.1	-1.5
Eugene Pendulum Station	1 b	980489.8	980490.2	980493.	-0.4	-3.2
Mary's Peak	2 b	980362.6				

a- Tied to Portland Airport
b- Tied to Corvallis Airport
c- Tied to Redmond Airport

All stations east of the Cascade Mountains were tied to the Redmond airport station, and the coastal and Willamette Valley stations were tied to the Corvallis airport station.

Column 2 of table 1 indicates the number of ties made to one of these three stations (Portland, Corvallis, or Redmond). Column 3 lists the observed gravity obtained by the Geophysics Research Group; column 4 lists the observed gravity reported by Woollard; and column 5 lists the observed gravity reported by the U.S. Coast and Geodetic Survey. The difference (column 4 minus column 3) between Woollard's value and the G.R.G. value is listed in column 6. The difference (column 5 - column 3) between the U.S.C. and G.S. value and the G.R.G. value is listed in column 7.

The difference between the G.R.G. and Woollard's observed value at the Corvallis airport is approximately the same as the differences between values at North Bend and Roseburg, Oregon, and Boise, Idaho. The North Bend, Roseburg, and Boise stations are tied directly or indirectly to the Corvallis airport station. Woollard's value at Medford, Oregon, is 1.1 mgals higher than the gravity value observed by Harrison and Corbato (1963).

Using the G.R.G. value obtained at the Corvallis airport, ties have been made to a geodetic gravity station established by Harrison and Corbato (1963) located on the Oregon State University campus. This tie resulted in a difference of 0.04 mgal. The Harrison and Corbato value for the O.S.U. campus station was based on the observed gravity at the Geology-Chemistry Building at the University of California, Los Angeles, which, in turn, was determined by ties to the North American Western and Pacific Coast Standardization Ranges (Woollard and Rose, 1963).

Conclusion

The relative accuracy of this survey depends upon the precision with which the measurements were made and can be statistically calculated. The standard errors of measurement of nine groups of observations ranged from 0.00 mgal to 0.11 mgal. The pooled estimate of the standard errors is 0.06 mgal. Over all, the G.R.G. gravity measurements at all bases established during this work are accurate to at least 0.1 mgal relative to the Portland airport value.

The absolute values used in this survey depend only upon the value accepted as representing true gravity at the Portland airport. The reliability of Woollard's nationwide airport network is reported as greater than 0.5 mgal (1958). An independent measurement at the Portland airport by Harrison and Corbato (1963) was within 0.2 mgal of Woollard's observed value.

Acknowledgments

This research was supported by a grant from the Graduate School General Research Fund, Oregon State University, the National Science Foundation Grant No. G 24353, and the Office of Naval Research, Contract No. Nonr 1286(10) Project No. 083-102. The authors wish to thank Drs. J. C. Harrison and C. E. Corbato for their kindness in supplying their unpublished data and Dr. J. W. Berg for critically reading the manuscript.

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Woollard, G. P., and Rose, J. C., 1963, International gravity measurements, Soc. Explor. Geophysicists, Tulsa, Oklahoma.

(Illustrations continued on pages 53 to 56.)

* * * * *

STATE SUBMERGED LANDS OPENED TO LEASING

The State Land Board has set May 1, 1964, as the deadline for accepting nominations for state submerged lands to be considered for oil and gas leasing. Selections of state lands must be made by parcel numbers established by the land board and platted on an official lease map. The map may be inspected at the State Land Board office, 106 State Capitol Building, Salem, or copies can be purchased at a cost of $15 each, plus postage. Nominations for leasing of fractional parcels will not be accepted.

Nominations should be placed in a sealed envelope within a larger envelope so they can be held confidential until all selections can be considered simultaneously. Designation of parcels to be considered for leasing will be by number only and will be announced by mid-May. No fee is required for filing nominations.

* * * * *

AMERICAN MINING CONGRESS CONVENTION

Portland, Oregon September 13 - 16, 1964

GRAVITY FIELD OVER ZONES OF MAJOR TECTONISM, SOUTHWEST OREGON

By

M. A. Kays and J. L. Bruemmer*

Introduction

A long-range program involving structural, petrographic, and gravimetric analysis was initiated during the summer of 1963 to better understand the tectonic framework and evolution of the pre-Tertiary Klamath Mountain complex of southwest Oregon. As indicated in figure 1, the most obvious structural features of this region are north-northeast trending faults. Work thus far has proceeded on the premise that basic to a better understanding of the tectonic framework is a detailed examination of these major structural features. The fact that many of the dense ultramafic bodies in the pre-Tertiary of this region have been emplaced in direct contact with less dense rocks along major faults makes gravity work a cogent tool in enhancing our knowledge of the structure. Large density differences between rock bodies in fault contact (Δ d = 0.2-0.4 gram/cc) are sufficient to contribute considerably to development of local gravity anomalies depending upon inclination, depth, and extent of the rock bodies. Thus gravity work allows more meaningful interpretations based upon detailed surface studies of structure and petrography.

General Geology and Rock Densities

The area of investigation, largely in the Galice quadrangle, is of particular interest for its location in the heart of the Klamath Mountain complex in southwestern Oregon and for the presence of five major faults (fig. 1). The general geology and age relations of the major units in the area have been summarized in modified form (fig. 2) from Wells and Walker (1953). Contact relations indicate rock bodies that approximate a series of slabs striking N. 10° to 30° E. and dipping on an average of 60°

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* Department of Geology, University of Oregon, Eugene, Oregon.

SE.; trends of the major faults are closely conformable to the strike of the major units. Coincident with each of the five major faults, Hansen Saddle, Cedar Mountain, Hungry Hill, East and West Hellgate, are narrow elongate lenses or pods of partially serpentinized peridotite and serpentinite. With exception of the Hansen Saddle-Cedar Mountain fault system, where contact relations are complicated by quartz diorite to the west and amphibolite gneiss to the east, the peridotite-serpentinite association is found in sharp contact with eugeosynclinal sedimentary and volcanic rocks (fig. 2).

Densities for the major rock types in the Galice quadrangle are reported in Table I from measurements of 49 rock samples. It should be emphasized that the rock densities are average values, and local values may be greater than given for the most dense assemblage (up to 3.2 gram/cc) and less than given for the least dense assemblage (as low as 2.4 gram/cc). The average density for the Galice and Dothan Formations combined is 2.67 gram/cc which is the value used in Bouguer reduction* procedures. Therefore, average density differences between peridotite, amphibolite, quartz diorite, and the adjacent eugeosynclinal sedimentary and volcanic rocks are taken to be 0.31, 0.27, and 0.16 respectively (fig. 3). The average density difference between recrystallized sedimentary and volcanic rocks along faults and the adjacent unrecrystallized sedimentary and volcanic rocks ranges from 0.27 to 0.31. In this case, no distinction can be made between peridotite and recrystallized rocks along the fault. The differences in density between major rock types, however, should certainly be reflected in the Bouguer gravity distribution where each rock type occurs in a body of appreciable extent. From the surface distribution of the rock bodies together with the superposed gravity pattern, it should be possible to deduce the inclination of these bodies and their extent in depth; in short, to interpret the geometry of the complex in three dimensions.

Gravity Observations

The gravity distribution (fig. 2) conforms remarkably well to the pattern of major lithologic units. In general, areas underlain by unrecrystallized sedimentary rocks (and some intrusive granitic rocks) are associated with broad, open gravity lows. The Dothan Formation in the northwestern and western parts of the Galice quadrangle and the Galice Formation in the eastern part of the quadrangle show this relationship. Belts of recrystallized sedimentary and volcanic rocks, partially serpentinized peridotite,

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* Bouguer reduction: a correction made in gravity work to take account of the altitude of the station and the rock between the station and sea level.

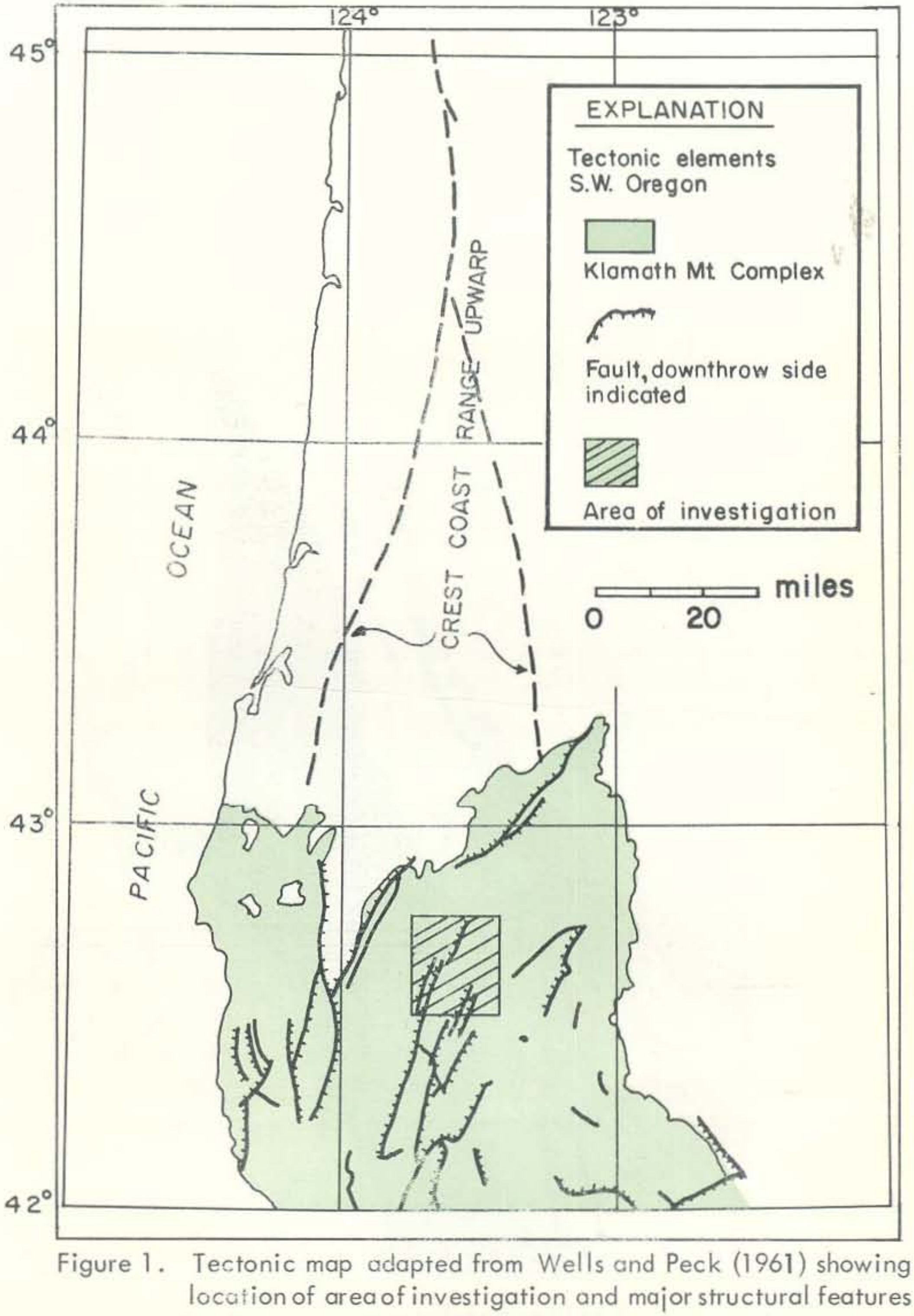


Figure 1. Tectonic map adapted from Wells and Peck (1961) showing location of area of investigation and major structural features in the pre-Tertiary of southwest Oregon.

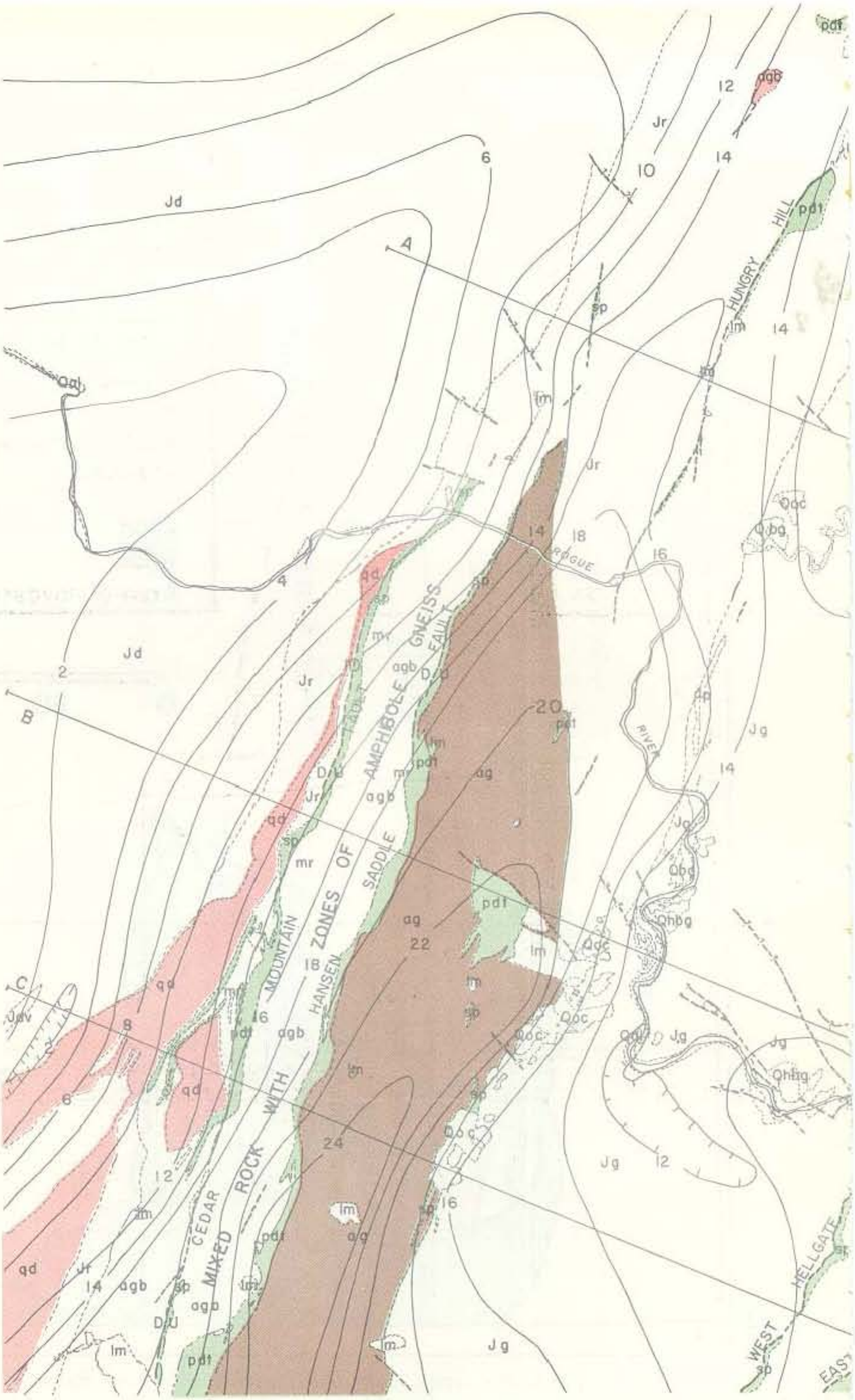
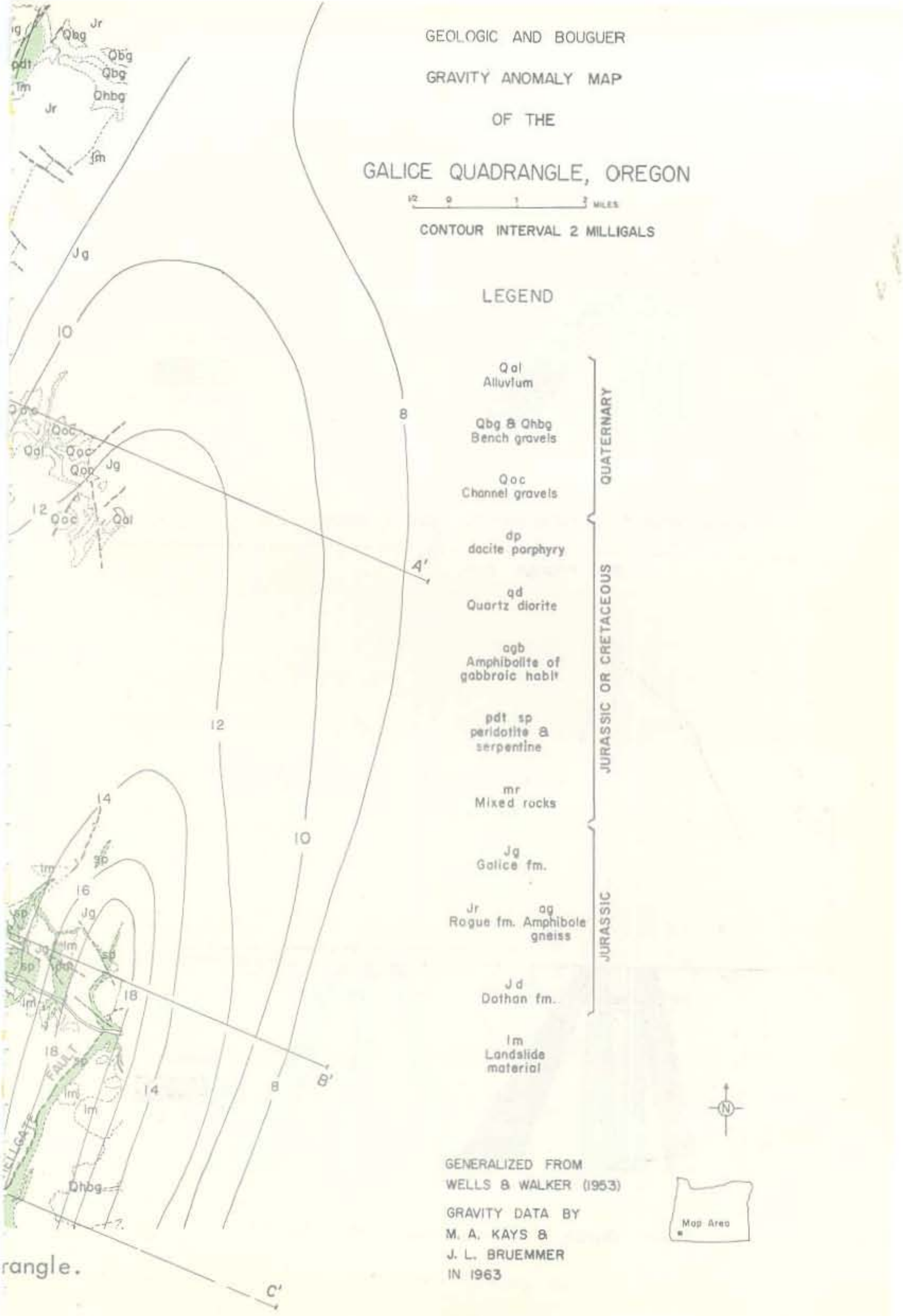


Figure 2. Combined geologic and Bouguer gravity map, Galice qu



GEOLOGIC AND BOUGUER GRAVITY ANOMALY MAP OF THE

GALICE QUADRANGLE, OREGON

1/2 0 1 2 MILES

CONTOUR INTERVAL 2 MILLIGALS

LEGEND

QUATERNARY

- Qal — Alluvium
- Qbg & Qhbg — Bench gravels
- Qoc — Channel gravels

JURASSIC OR CRETACEOUS

- dp — dacite porphyry
- qd — Quartz diorite
- agb — Amphibolite of gabbroic habit
- pdt sp — peridotite & serpentine
- mr — Mixed rocks

JURASSIC

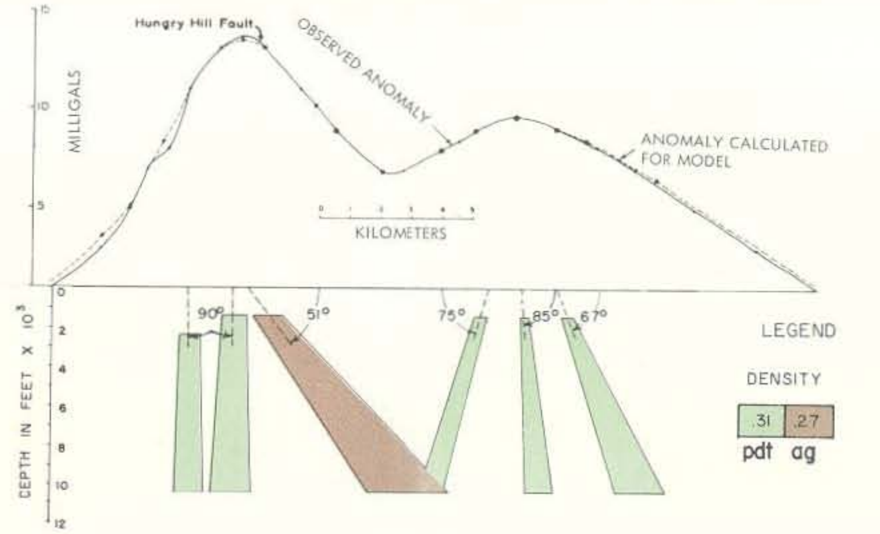
- Jg — Galice fm.
- Jr — Rogue fm.
- ag — Amphibole gneiss
- Jd — Dothan fm.

Im — Landslide material

GENERALIZED FROM WELLS & WALKER (1953)

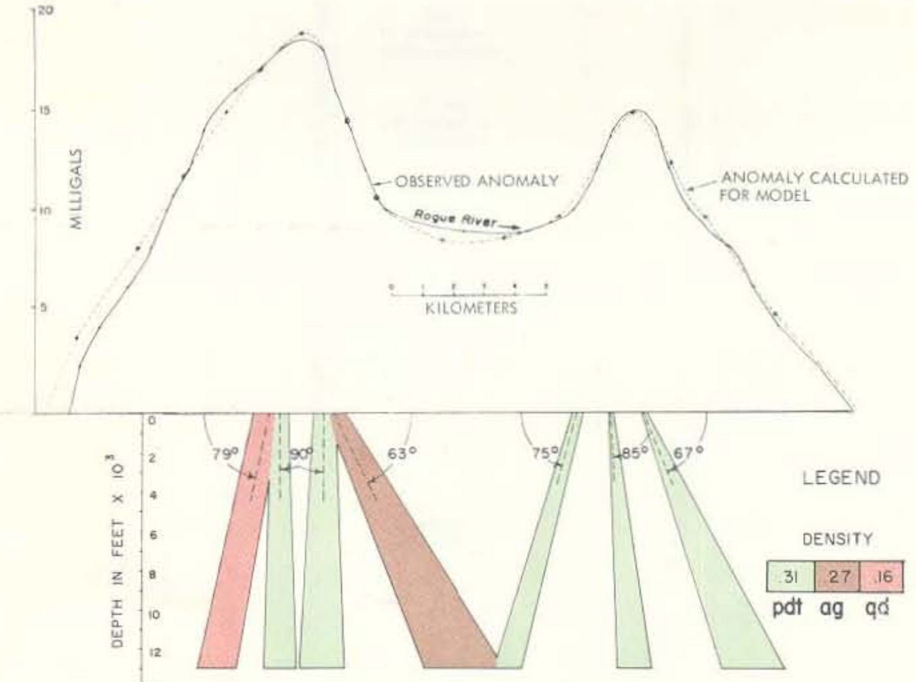
GRAVITY DATA BY M. A. KAYS & J. L. BRUEMMER IN 1963

rangle.



GRAVITY PROFILE & MATHEMATICAL DENSITY MODEL

FOR PROFILE A-A'



GRAVITY PROFILE & MATHEMATICAL DENSITY MODEL

FOR PROFILE B-B'

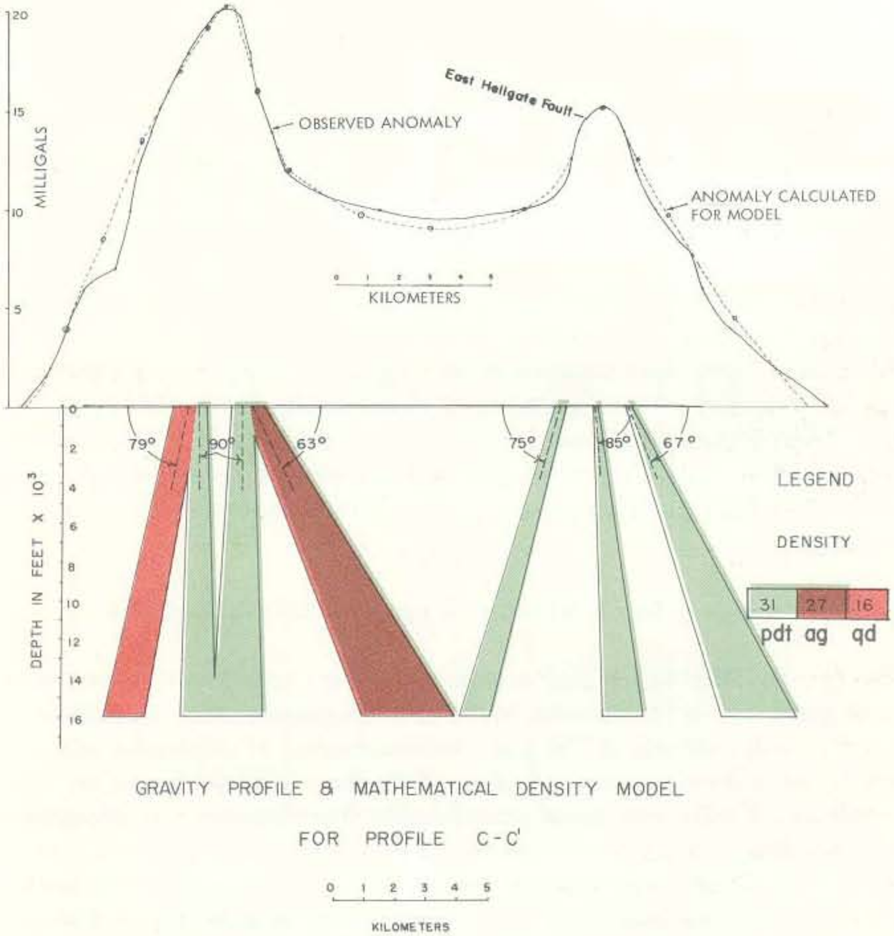


Figure 3. Observed and computed gravity profiles along AA', BB', CC', and relation to the mathematical density model. Four milligals have been subtracted from all Bouguer gravity observations in order that these profiles can be compared with the theoretical profiles.

and amphibolite gneiss, all adjacent to major faults, are associated with sharp, well-defined gravity highs. The major gravity high in the quadrangle trends northeast, paralleling the Hansen Saddle-Cedar Mountain fault zone in the south and the Hungry Hill fault in the north. This gravity high coincides specifically with the partially serpentinized peridotite-amphibolite gneiss association. The effect on the gravity distribution by adjacent less dense sedimentary rocks is noticeable in the steepness of the gravity gradient as these units are approached. A smaller but well-defined gravity high, with up to 5 mgals of closure (fig. 2) coincides with the less extensive Hellgate fault system and the attendant recrystallized Galice-serpentinized peridotite association.

All gravity data were reduced according to the Bouguer reduction procedures for a density of 2.67 gram/cc as described by Swick (1942, p. 60-68). Terrain corrections were made out to a distance of 20 kilometers from each station according to an approximate method described by Kane (1962, p. 455-462), utilizing computer facilities available at the University of Oregon.

Interpretations of the Gravity Distribution

The gravity distribution thus appears to reflect both location and magnitude of major tectonic elements in the Galice quadrangle. This observation holds only because of the peculiar occurrence of ultramafic and recrystallized rocks along major faults. From the regional viewpoint, moreover, this peculiarity may be of considerable significance, for injection of peridotite along major faults appears to be the rule rather than the exception. Thus, it may well be that gravity maps in this region essentially represent the tectonic framework. Further, several preliminary interpretations of the subsurface extent of units exposed, based upon surface geology and gravity observations, are possible at this time. However, these interpretations are viewed by the authors as only rough order of magnitude approximations which may serve as preliminary models to be tested in resolving the major structural features of southwestern Oregon.

The present interpretation of the subsurface configuration of the various rock bodies is based on the development of a geometric model which satisfies both surface geologic data and gravity distribution. Skeels (1963, personal communication) suggested that a method of successive estimations of the gravity distribution produced by a series of slabs would give the best fit, and in a recent paper (1963) gave an approximate solution for the problem of depth compensation. The model adopted here involves slabs of dense rock -- peridotite, amphibolite, or quartz diorite -- with various dips separated by bodies of lighter rocks. In order to obtain satisfactory correspondence between profiles computed from the model and observed profiles, it is necessary to allow thickening of the slabs with depth, and to use a different depth of compensation for each profile. As the latter restriction is concerned only with the magnitude of a gravity anomaly and not with its shape, it does not conflict with realistic geometric interpretation; in fact, the variation in compensation required here seems compatible with apparent lateral change in magnitude of the structural elements at the surface. Analysis of a number of postulated geometric models was carried out using Ramsey's (1940, p. 30) equation.

For profile AA' (fig. 3), a model involving slabs which extend from 1,500 to 10,500 feet produces a theoretical profile which agrees closely with the observed gravity. The Hansen Saddle-Cedar Mountain peridotite-amphibolite association and the Hellgate fault association each involve three mutually exclusive slabs of denser rock. Models with the same basic geometry also provide good fits with the observed profiles BB' and CC' (fig. 3) when depths of compensation of 13,000 and 16,000 feet respectively are adopted.

The important point is that one basic model of the subsurface geometry with only minor modifications produces close approximations of the observed gravity in three different profiles. Although gravity analysis indicated some minor modifications, this model also agrees in general with the geologic cross section of Wells and Walker (1953).

Table I. Densities of major rock types in the Galice quadrangle.

Density (gram/cc)	No. Samples	Occurrence or Rock Type
2.64	6	Dothan Formation - argillites and graywackes
2.75	2	Quartz diorite intrusives
3.01	4	Peridotite - serpentinite association
2.92	8	Hornblende gabbro and schistose rocks of the mixed rock zone
2.97	13	Amphibolite gneiss of the Rogue (?) Formation
2.90	5	Rogue Formation - partially recrystallized sedimentary and volcanic rocks
2.69	5	Galice Formation - sedimentary and volcanic rocks
2.85	6	Galice Formation - recrystallized sedimentary and volcanic rocks

Conclusions

On the basis of surface geology and gravity data, in certain cases, the amount of peridotite injected appears to be directly related to the magnitude and extent of faulting. Results of calculations based upon geometric models indicate that the faults dip steeply. Depths of compensation required indicate that they extend 2½ to 3 miles downward into the crust. The peridotite masses broaden and appear to coalesce eventually.

Certain problems are encountered in regard to petrologic models to explain the occurrence of some of the lithologic units. The amphibolite gneiss, for example, appears distinctly out of place with respect to the rocks immediately adjacent which are essentially unmetamorphosed volcanic and sedimentary rocks. The localized distribution of these metamorphic rocks seems to preclude widespread regional metamorphism. However, faults roughly coincident with the bodies of amphibolite gneiss suggest that rocks of amphibolite facies grade may be prevalent at depth, and that the present outcrops represent tectonic blocks carried up along major faults during forceful injection of peridotite.

Acknowledgments

Data reduction which included terrain corrections to distances of 20 kilometers from each station was facilitated by the 1620 IBM digital computer at the University of Oregon. The authors are indebted to B.J. Witt for providing them with his generalized computer program. Thanks are also due Dr. G. T. Benson, who kindly read the manuscript, and Dr. V.E. McMath, who offered many helpful suggestions. This study was supported in part by a Faculty Summer Research Grant from the Office of Scientific and Scholarly Research of the University of Oregon.

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(Airport Gravity Base Station Network in Oregon, continued.)

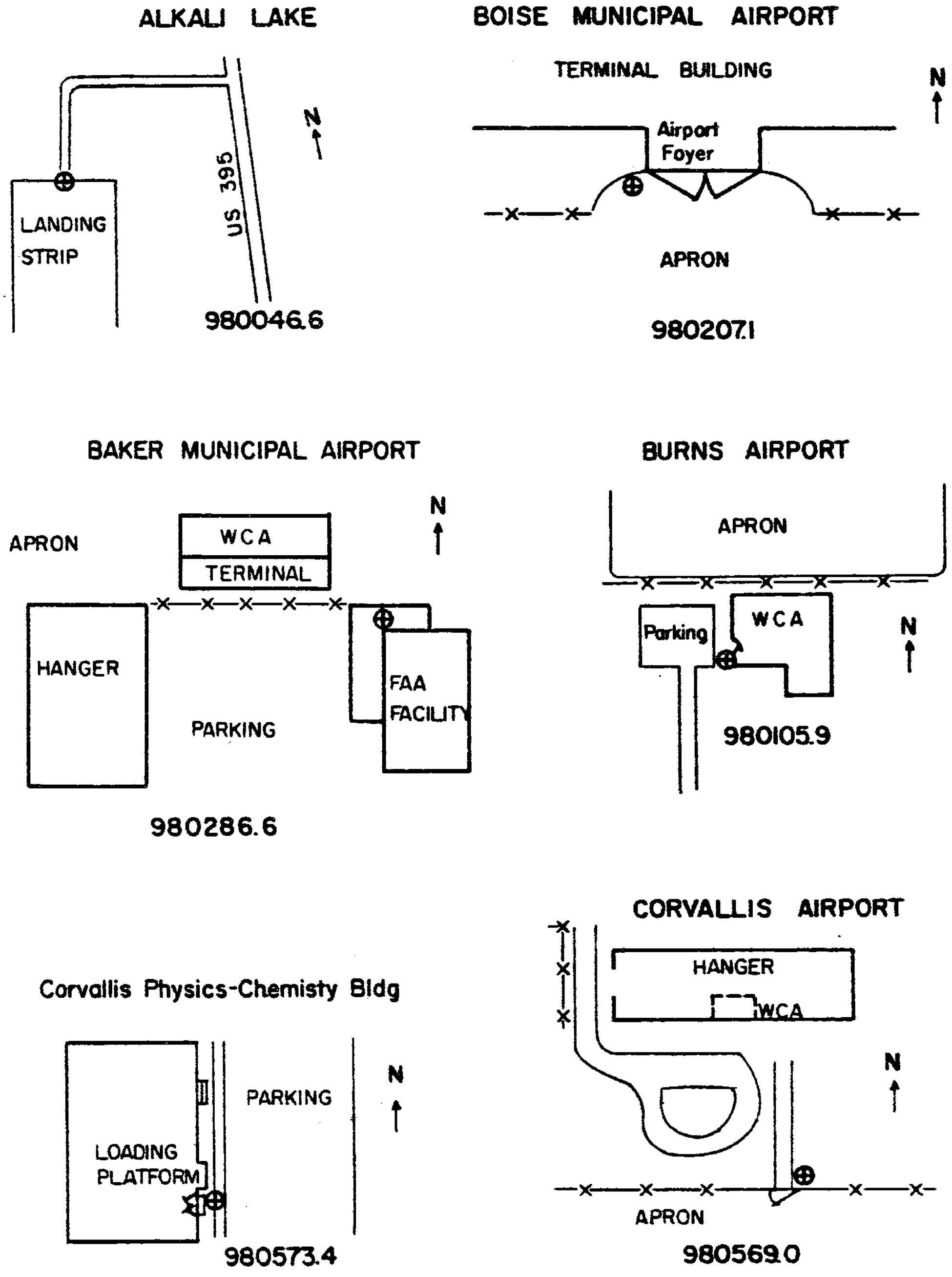
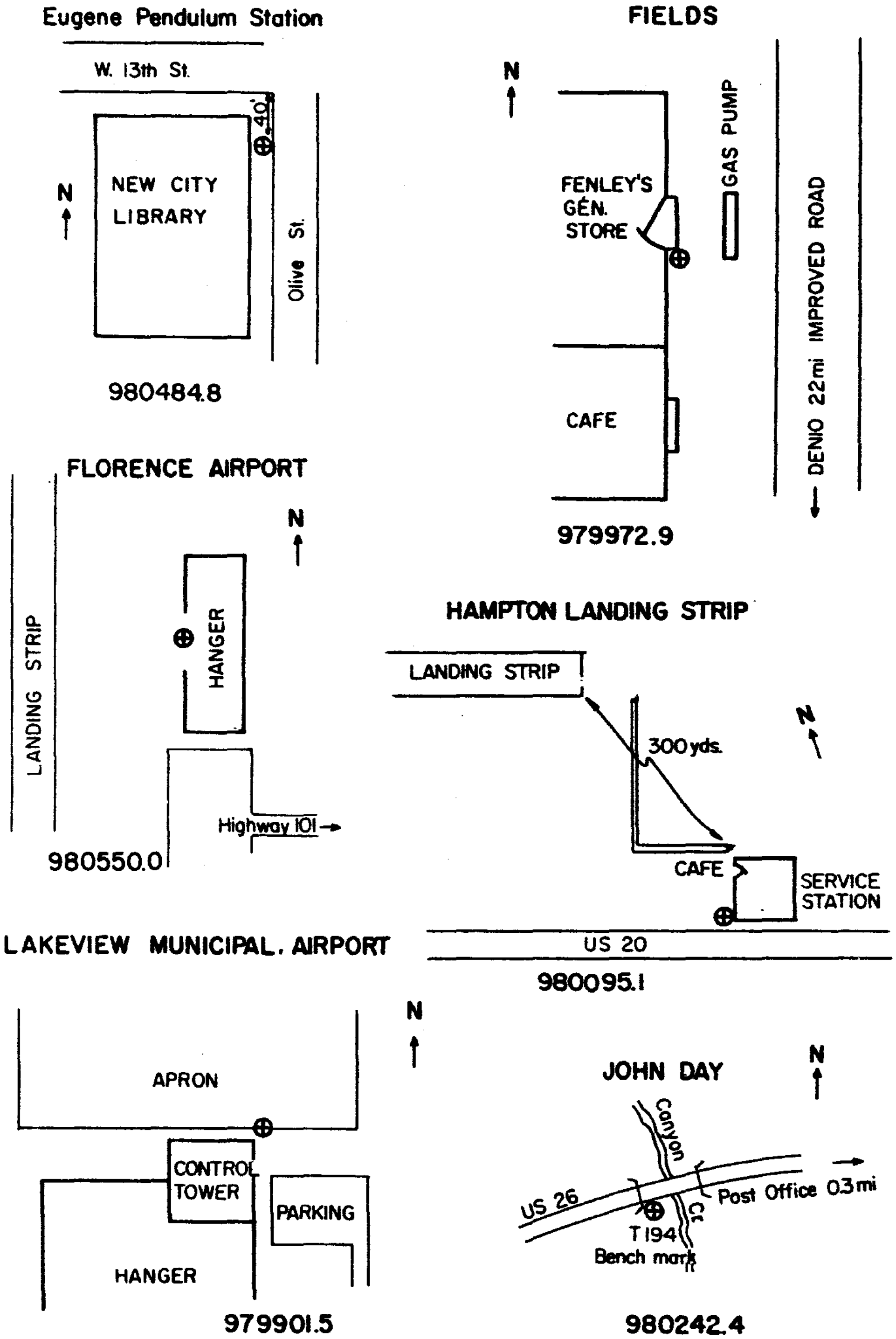
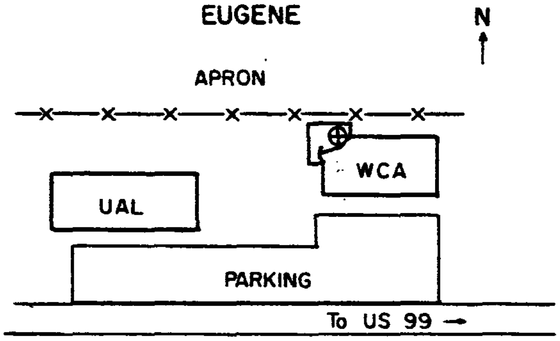


Figure 2. Plan views of gravity base stations established in Oregon. (continued on pages 54, 55, and 56)



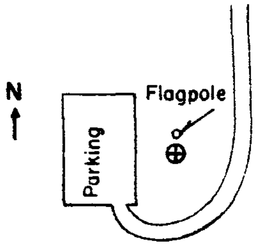
(Figure-2, continued)

MAHON SWEET AIRPORT
EUGENE



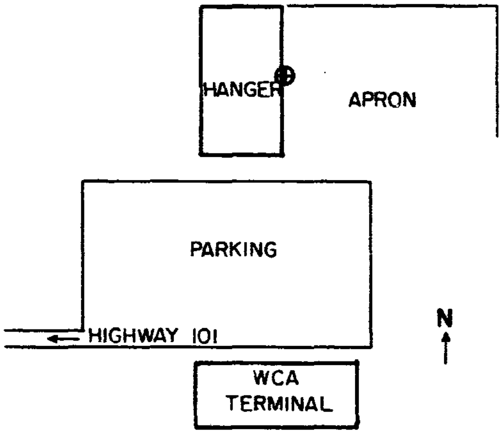
980514.6

Mary's Peak



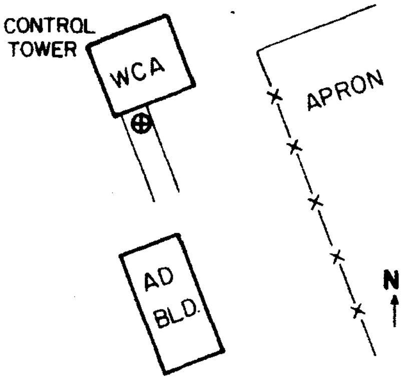
980362.6

NEWPORT MUNICIPAL AIRPORT



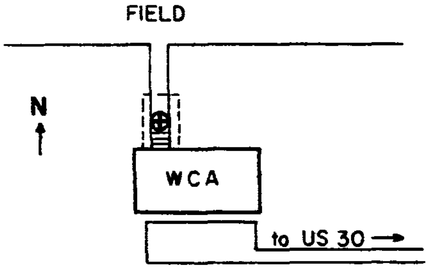
980596.2

NORTH BEND MUNICIPAL AIRPORT



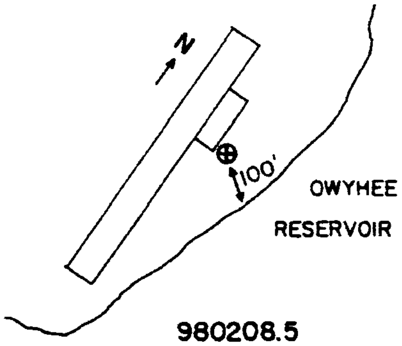
980492.2

ONTARIO AIRPORT



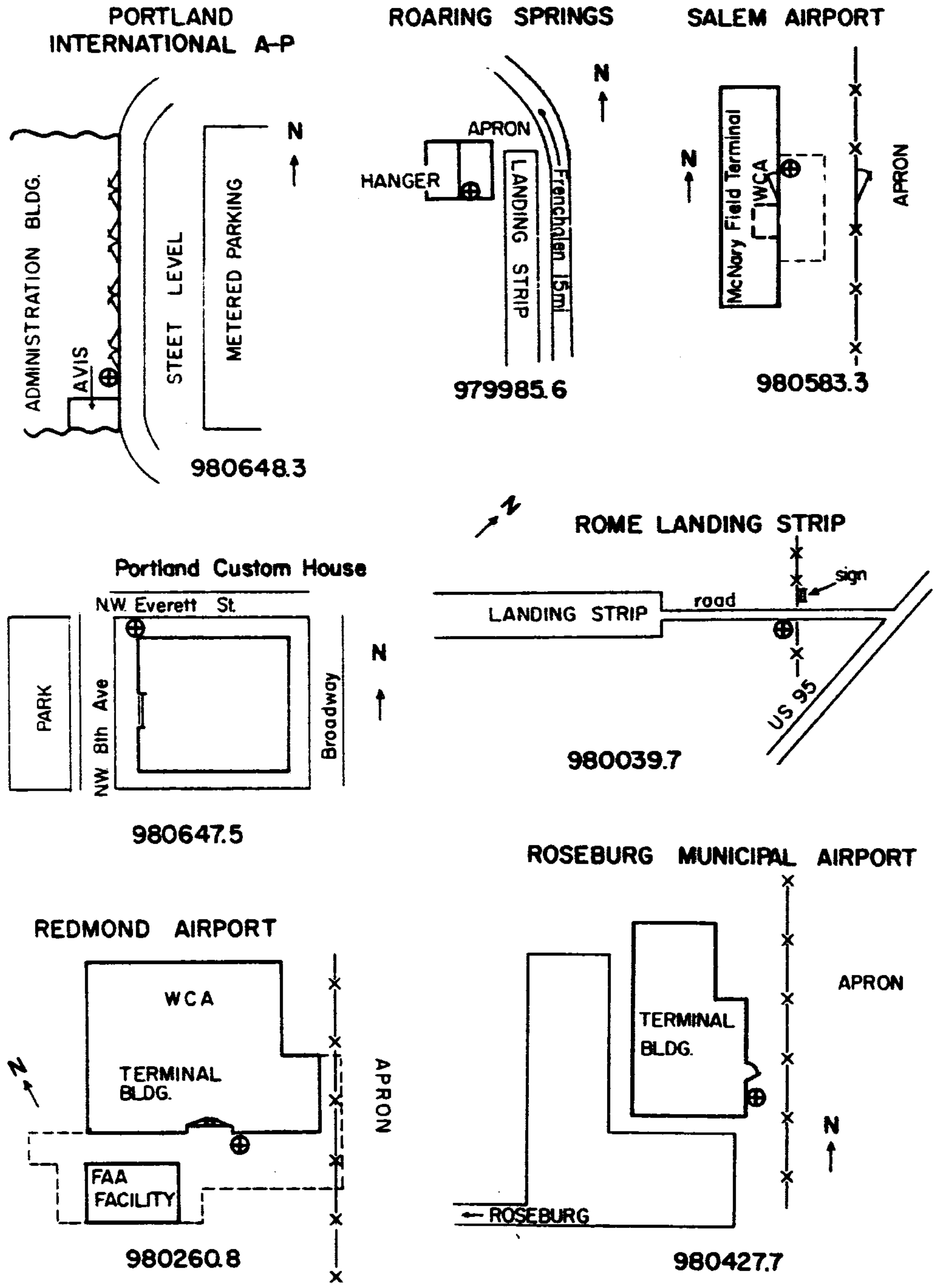
980303.5

PELICAN POINT AIRPORT



980208.5

(Figure 2, continued)



(Figure 2, concluded)

The ORE BIN
Volume 26, No. 4
April, 1964

THE OCEANS: A NEGLECTED MINING FRONTIER

By John V. Byrne
Department of Oceanography
Oregon State University, Corvallis, Oregon

Man first mined the seas more than 4,000 years ago. First he discovered that when sea water evaporated it left a thin deposit of salt. Soon he learned that he could create artificial ponds of sea water and produce salt by solar evaporation, a method still in use today. Other products were also manufactured from the sea in early times. The Phoenicians "mined" the tiny marine snail, Murex, in order to produce a bromine dye we call "Tyrian purple." Islanders in the South Pacific learned to quarry coral reefs to produce building blocks. In other areas oyster shells have long been used in the production of lime.

Although the sea supplied a few needed materials, it was ignored as a source for a number of important minerals. Only during the past century, as the known supply of commercially important minerals on land decreased, has man thought of the sea as a major origin for them. In recent years iron, tin, gold, and even diamonds have been profitably mined from the continental shelf in various parts of the world. In addition to salt, magnesium, bromine, and other elements have been extracted from sea water commercially.

Mineral deposits occurring beyond the shoreline can be separated into three groups. The first is the ocean itself. The "chemical soup" which we call sea water covers approximately 71 percent of the earth's surface; its volume is on the order of 300 million cubic miles; it contains virtually all of the elements known to man. Table 1 lists some of the important elements in sea water and their abundance.

In the second group of mineral deposits are those beneath the continental shelf. These include petroleum, gas, sulfur, and coal. Because these deposits are not related directly to the present ocean, they will not be considered in this paper.

Minerals which have been concentrated on the ocean floor, either by physical or by chemical oceanographic processes, constitute the third group. Deposits concentrated by physical oceanographic processes are the beach placers, either exposed along the margin of the seas or submerged on the continental shelf. More or less related to the beach placers but not actually formed by marine processes are those stream placers which formed during the Pleistocene Epoch when sea level was lower. These deposits were submerged during the post-glacial rise of the sea. The deposits formed by chemical oceanographic processes are termed authigenic, and include primarily glauconite, phosphorite, and manganese.

Placers

Placers of both beach and stream types exist on the continental shelf. In some parts of the world, both have been mined successfully for tin, magnetite, ilmenite, chromite, gold, and diamonds. The presence of the placers on the continental shelf is related to the lowering of sea level which took place during the last major Pleistocene glaciation (Wisconsin stage). During glacial periods water, which normally would have returned to the sea as runoff, was added to the glaciers in the form of ice. Continued evaporation of water from the sea and the failure of it to return resulted in a lowering of the sea surface. The minimum level of the sea during the Wisconsin glaciation has been estimated as about 300 to 450 feet below the present sea level. For convenience, we may assume that during the period of maximum Wisconsin glaciation the shoreline existed at about the position of the present 70-fathom* contour. Streams discharging into the ocean at that time would have formed placers in the area shoreward of the present 70-fathom line. With the rise of sea level accompanying the melting of the glaciers, these placers were submerged and may have been covered by sediments deposited under normal shallow marine conditions. Stream placers on the continental shelf are usually related to streams with known placers on land, and in general are oriented at right angles to the present shoreline and to the contours of the continental shelf.

Beach placers are best developed near the mouths of streams that carry commercially important minerals. These placers are developed as low, elongate ridges parallel to the shoreline in response to surf action and longshore currents. The oscillating motion of water in waves, which wash up on the beach and then run back to sea, tend to winnow the finer and lighter particles and leave behind the coarser and heavier grains. Because most of the minerals of economic importance in beach sands are heavier than the non-economic ones, they lag behind and become concentrated along the shore. The richest beach placers are formed where sands are reworked by both streams and waves. Submerged beach placers may occur between the present shoreline and the Wisconsin level, now at a depth of about 70 fathoms.

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* One fathom equals 6 feet.

Table 1. Abundance of some elements in solution in sea water*
(Adapted from Mero, 1963)

Element	Weight Percent (% x 10^4)	Tons of element per cubic mile of sea water	Total tonnage of element in oceans
Chlorine	18,930	89.4×10^6	29.3×10^{15}
Sodium	10,561	49.7×10^6	16.3×10^{15}
Magnesium	1,272	6.0×10^6	2.0×10^{15}
Calcium	400	1.9×10^6	0.6×10^{15}
Potassium	380	1.8×10^6	0.6×10^{15}
Bromine	65	306,000	0.1×10^{15}
Strontium	13	61,200	$20{,}100 \times 10^9$
Silicon	4.0	21,200	$6{,}950 \times 10^9$
Aluminum	0.5	2,360	770×10^9
Lithium	0.1	470	154×10^9
Phosphorus	0.1	470	154×10^9
Barium	0.05	235	77×10^9
Iron	0.02	94	31×10^9
Manganese	0.01	47	15×10^9
Copper	0.01	47	15×10^9
Zinc	0.005	24	$7{,}850 \times 10^6$
Lead	0.004	19	$6{,}230 \times 10^6$
Molybdenum	0.0005	2.4	790×10^6
Silver	0.0003	1.4	470×10^6
Vanadium	0.0003	1.4	470×10^6
Nickel	0.0001	0.47	154×10^6

*Abstracted from Sverdrup, Johnson, and Fleming, 1942, The Oceans. Prentice-Hall, New York.

Authigenic Deposits

Authigenic minerals form on the sea floor by direct chemical precipitation from sea water. Although there are a considerable number of these minerals, only three which have known economic potential will be considered: glauconite, phosphorite, and manganese (see Figure 1).

Glauconite

Glauconite is considered by most geologists to be a greenish, argillaceous mineral closely related to the micas. Essentially it is a hydrous potassium iron silicate. It has been used as a soil conditioner and as a water softener, but might be commercially important as a source of potash. Approximately 5,600 tons of this mineral was produced annually between 1957 and 1961 from a source in New Jersey (H. D. Hess, written communication, 1963).

Glauconite is extremely common on the outer continental shelf and on the upper continental slope where it appears to be forming at the present time. Although relatively little is known concerning the origin of the mineral, numerous observations have been made of its occurrence. Cloud (1955) summarizes these observations and lists the apparent physical limits of its formation. Glauconite occurs mainly in areas where detrital deposition is extremely slow, usually near the boundary between the continental shelf and the continental slope. In areas of glauconite accumulation, the sea water generally has a normal salinity and oxygen content, although micro-reducing environments may be present, for example inside the tests of foraminifera. Glauconite has been collected from the bottom in water 5 to 1,000 fathoms deep, but appears to be best developed in water 10 to 400 fathoms deep. It has been observed only in waters of moderate temperature, and generally does not form in warm water. In the tropics it has been found only at depths below 30 to 130 fathoms. The writer knows of no estimates of the amount of glauconite existing on the ocean floor, but the abundance of the mineral along the edge of the continental shelf off western North America suggests that it must be tremendous.

Phosphorite

Phosphorite has been collected from the continental shelves of Australia, Japan, Spain, South America, and the United States (Mero, 1961). This material, a potential source of phosphate fertilizer, coats rocks and forms nodules ranging from sand size to two feet in diameter. The nodules are hard, dense, brown to black objects with smooth, glazed surfaces. Most of the small nodules are pure phosphorite; larger ones may be conglomeratic, including rock fragments or smaller phosphorite nodules. Mineralogically, phosphorite consists of collophane and francolite (Mero, 1961). Chemical analyses (Table 2) indicate that the phosphorite nodules contain about 29 percent P_2O_5, slightly less than the phosphate deposits being mined in Idaho, Florida, and Tennessee.

Phosphorite forms in environments of slow deposition as at the edge of

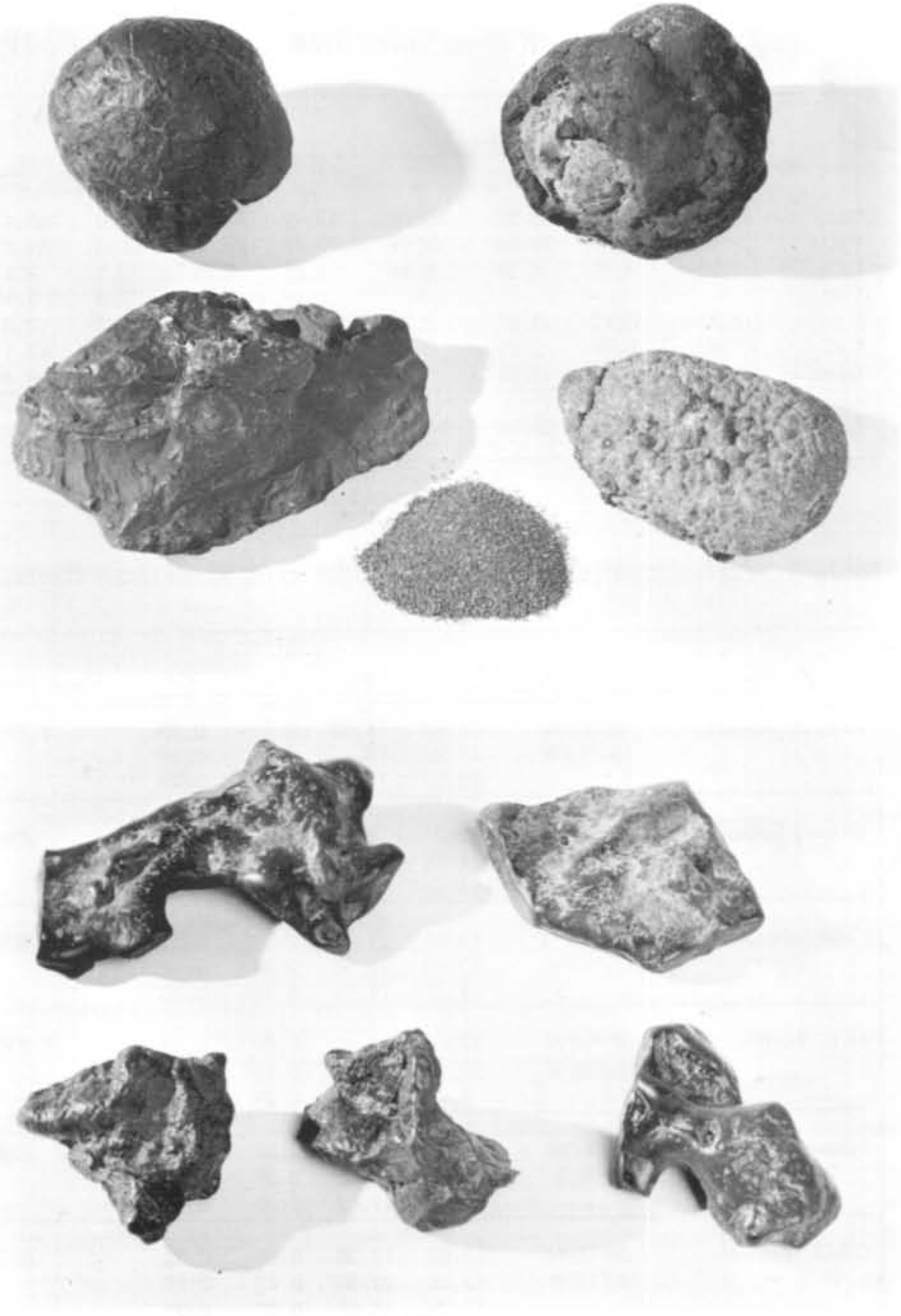


Figure 1. Marine authigenic minerals. Top: manganese nodules and and glauconite grains. Bottom: phosphorite nodules.

Table 2. Analyses of phosphorite (from Emery, 1960, p. 72).

	California Sea Floor Samples								
	69	106	127	158	162	183	Idaho	Fla.	Tenn.
CaO	47.35	45.43	45.52	46.58	37.19	47.41	48.0	36.4	45.4
P_2O_5	29.56	29.19	28.96	29.09	22.43	29.66	32.3	31.3	31.0
CO_2	3.91	4.01	4.30	4.54	4.63	4.87	3.1	2.2	2.2
SO_3	-	-	-	-	-	-	2.3	0.1	1.3
F	3.31	3.12	3.07	3.15	2.47	3.36	0.5	2.0	3.8
R_2O_3	0.43	0.30	2.03	0.70	3.93	1.40	1.2	12.7	4.6
Organic	0.10	1.90	2.25	0.44	0.35	1.50	-	6.2	3.8
Total	84.66	83.95	86.13	84.50	71.00	88.20	87.4	90.9	92.1

Table 3. Partial analyses* of some sea floor manganese (from Dietz, 1955).

Location		Fe	Mn	Ni	Co	Depth (in fathoms)
N.E. of Hawaii	27°20'N	16.47	14.30	0.20	0.20	2,790
	150°10'W	17.99	14.44	0.32	0.21	
		16.53	14.90	0.29	0.12	
Gilbert Seamount	52°47'N	15.07	18.52	0.30	0.25	800
	150°05'W	14.78	19.95	0.31	0.31	
		14.54	19.96	0.31	0.37	
Cape Johnson Guyot	17°04'N	12.86	21.40	0.60	0.61	1,000
	177°15'W	12.60	22.58	0.65	0.64	
		14.71	19.11	0.48	0.38	
N.E. Pacific	40°14'N	12.00	13.48	0.21	0.15	2,790
	155°05'W	12.23	13.34	0.16	0.12	
		9.16	10.78	0.24	0.07	
Sylvania Seamount	11°57'N	17.20	18.58	0.37	0.08	750
	164°46'E	15.64	15.22	0.39	0.32	
		14.50	17.62	0.38	0.24	
GA-3 Seamount	56°10'N	13.03	19.38	0.58	0.23	800
	145°15'W	12.86	22.53	0.42	0.19	
		13.29	18.69	0.53	0.35	

(*Analyses made on three separate pieces of the same nodule. All results given in weight percent.)

the continental shelf and the tops of submarine banks and ridges. Water depth appears to exert little, if any, control on the formation of the material; samples have been dredged from about 1,900 fathoms. Although deep occurrences of the nodules are known, the mineral is most common in water depths of 20 to 200 fathoms. Most known deposits are in regions where phosphate-rich water at moderate depth is brought to the surface as a result of upwelling. It is believed by several workers (d'Anglejan, 1964, and Wyatt, 1956) that where cool, deep waters supersaturated with tri-calcium phosphate rise to the surface, the increase of temperature and pH and decrease of pressure result in colloidal precipitation of the phosphate. Because the colloidal particles carry a charge, they are attracted to solid objects on the sea floor about which they form a nodule.

Emery (1960) estimates approximately one billion tons of phosphorite off the coast of southern California. If only 10 percent of this is economically important, it will be possible to produce half a million tons per year for 200 years. Mero (1961) believes that phosphate fertilizer from this source will compete successfully in the West Coast fertilizer market with phosphates now brought in from the continental sources to the east. Techniques for recovering the phosphorite on a commercial basis are currently being developed.

Manganese

Deep-sea manganese nodules have probably received more public attention during recent years than any of the other marine mineral deposits. These nodules, some smooth and some knobby, range in size from peas to potatoes. They are light brown to earthy black, friable, fairly soft, and range in density from about 2.1 to 3.1 grams per cubic centimeter. Internally they are usually layered, frequently around a nucleus such as a shark's tooth, a whale's earbone, a micrometerorite, or another hard object.

The nodules consist primarily of manganese and iron oxides, but contain small percentages of other important metals. The chemical composition of some Pacific Ocean nodules is given in Table 3, taken from Dietz (1955). Petrographic and X-ray studies of the nodules indicate that they are complex and might properly be considered as rocks. They have a layered structure in which layers of MnO_2 alternate with disordered layers of hydrated $Mn(OH)_2$ plus $Fe(OH)_3$.

Like the other authigenic minerals, manganese nodules occur in areas of extremely slow deposition, in this case in the abyssal depths of the oceans. The large nodules are common only at the surface of the sediments, but smaller ones may be present within the sediment. The nodules appear to be most common in areas of red clay, but are also found where organic oozes cover the deep ocean floor. Photographs of the sea floor where manganese nodules are abundant show scour and ripple marks, indicating active bottom currents in such areas.

Since the Challenger Expedition of the 1870's, when manganese nodules were first collected, geologists and chemists have pondered their origin. At the present time three theories are prevalent. Goldberg and Arrhenius (1958) suggest that the ocean is saturated with respect to manganese and iron and that the addition of these two elements by river runoff causes precipitation of hydrated oxides in colloidal form. As the colloids settle they "scavenge" cobalt, nickel, copper, molybdenum, and other metals from the sea water. The colloidal particles carry a charge, and when they reach the sea floor they are attracted to any projecting objects, for example, sharks' teeth. Bottom currents carry a new supply of water bearing the colloids to the nucleus, and the nodules are thereby built up layer by layer. The rate of accretion in this manner is of the order of 0.01 to 1.0 mm per 1,000 years.

A second theory favors biological activity as a cause of the precipitation, and is based on the discovery of bacteria on some of the nodules (Butkevich, 1928). It is generally conceded that the bacteria are on the nodules, but it has not been demonstrated convincingly that they cause precipitation of manganese and iron in the deep sea environment.

Recently, a third hypothesis has been proposed by Bonatti and Nayudu (in press). On the basis of petrographic evidence they believe many of the nodules to be the result of submarine alteration of volcanic rocks. Their evidence has prompted a reexamination of many nodules from different parts of the Pacific. It has been suggested by Arrhenius, Mero, and Korkisch (1964) that both the volcanic and the precipitation hypotheses may account for the nodule formation. Further, they suggest that the percentage of cobalt in the nodules varies according to origin and that it may be possible to distinguish the two types on the basis of the manganese-cobalt ratio; a low ratio for the volcanic type, a high ratio for the type formed by slow precipitation.

Whatever the origin of the nodules, they are certainly abundant. It has been estimated from deep-sea photographs and dredge hauls that in some parts of the Pacific there are more than 8 pounds of nodules per square foot, more than 100,000 tons per square mile. Mero (1962) suggests there may be as much as a trillion tons of nodules on the floor of the Pacific alone.

Oceanic Prospecting

Prospecting for minerals on the floor of the ocean is now possible. Considerable information is available on the conditions of occurrence for both authigenic and placer deposits, and equipment can be obtained for submarine exploration.

The hypsographic curve of Figure 2 summarizes the depth distribution of placer and authigenic deposits in the Pacific Ocean. The curve represents the percentage of Pacific Ocean bottom of different water depths. Indicated on the curve are the depth zones in which placer deposits, glauconite, phosphorite, and manganese nodules are most likely to exist. The area of the Pacific Ocean represented by each zone is also indicated. Placer deposits occur in the interval 0 to 70 fathoms, which represents an area of about 2.8 million square miles or approximately 4 percent of the total area of the Pacific Ocean. Glauconite is most likely in the depth interval 10 to 400 fathoms, which is about 7 percent of the Pacific Ocean basin or approximately 5.0 million square miles. For phosphorite the depth of occurrence is primarily 20 to 200 fathoms, representing 5 percent of the basin or 3.5 million square miles. Manganese nodules occur at depths generally greater than 200 fathoms, common to about 93 percent of the Pacific, an area of about 65 million square miles.

From this type of analysis it is possible to make a first approximation of the potential prospect areas, keeping in mind that not all of the area is suitable for accumulation of a given mineral deposit. Manganese nodules, for example, do not occur in areas of relatively rapid deposition of detrital sediment. From knowledge of the distribution of deep-sea sediment, the area of terrigenous deposition would be eliminated. Only the areas of relatively slow deposition in which the biogenous oozes and red clays are present would be considered in prospecting for the nodules. Fortunately, this type of information is available.

In prospecting for phosphorite, areas where depth of water ranges from 20 to 200 fathoms should be outlined. Particular attention would be focused on those spots where phosphate-rich water is brought to the surface by upwelling. Again, there is a considerable amount of information available on the location, period, and nature of the upwelling process (Wyatt and Kujala, 1962).

Placer deposits lie between the 70 fathom contour and the shoreline. The position of known placers on land, and the location of streams draining mineralized zones would be used to determine the favorable areas on the continental shelf for initial exploration.

General mineral prospect areas for the northeast Pacific are shown in Figure 3. The areas outlined are based primarily on the bathymetry of the region. Placer prospects are shown in the areas shallower than 70 fathoms. Glauconite and phosphorite prospects are mapped together for the interval from 70 to 400 fathoms. It is quite possible that these two authigenic minerals might occur in water less than 70 fathoms deep. However, they would

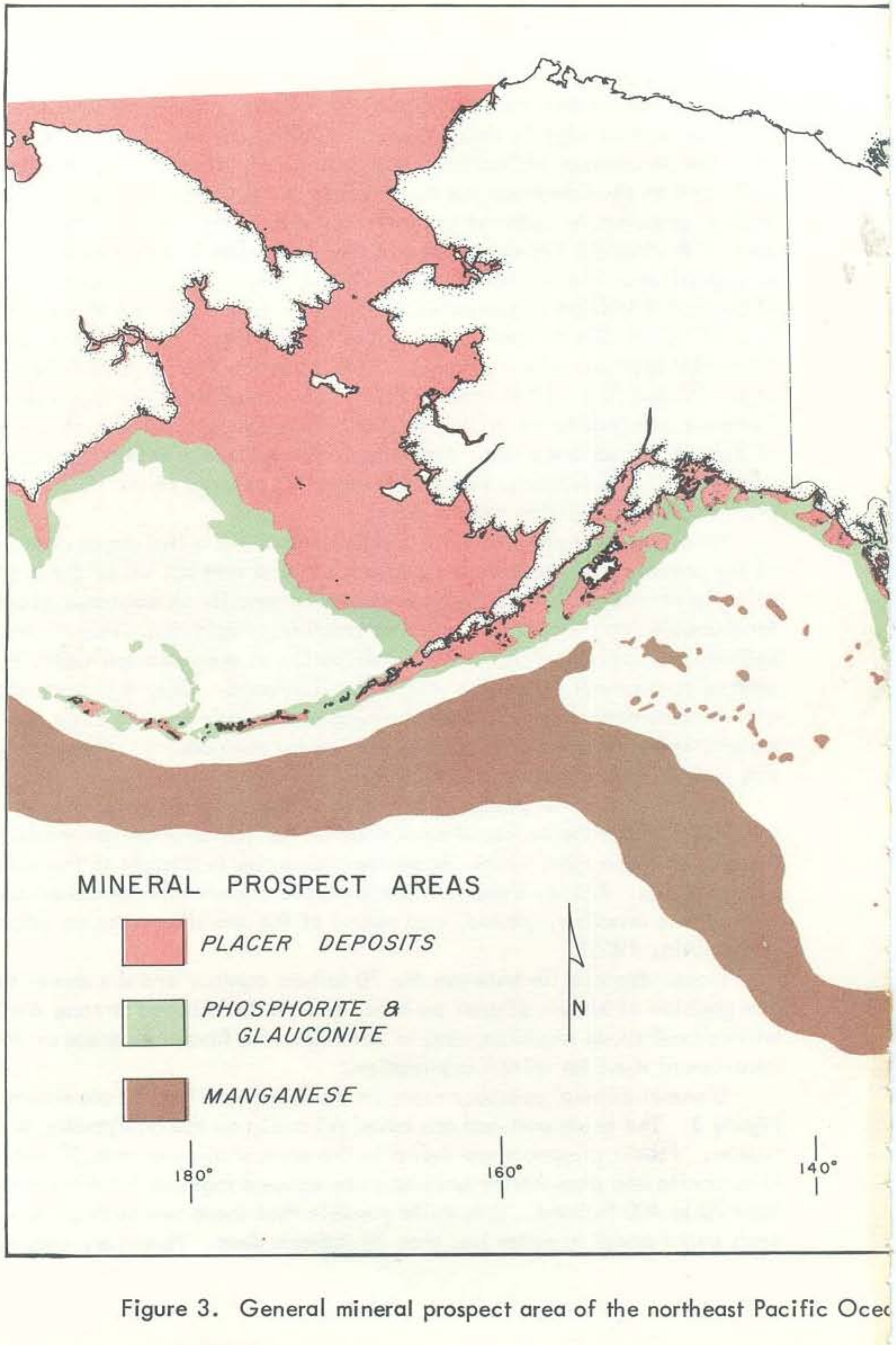


Figure 3. General mineral prospect area of the northeast Pacific Oce

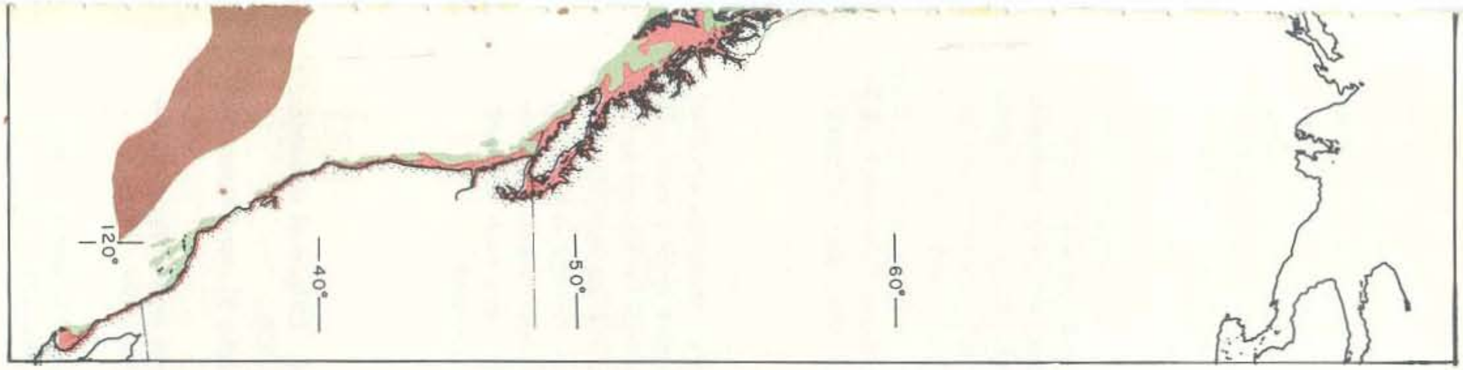
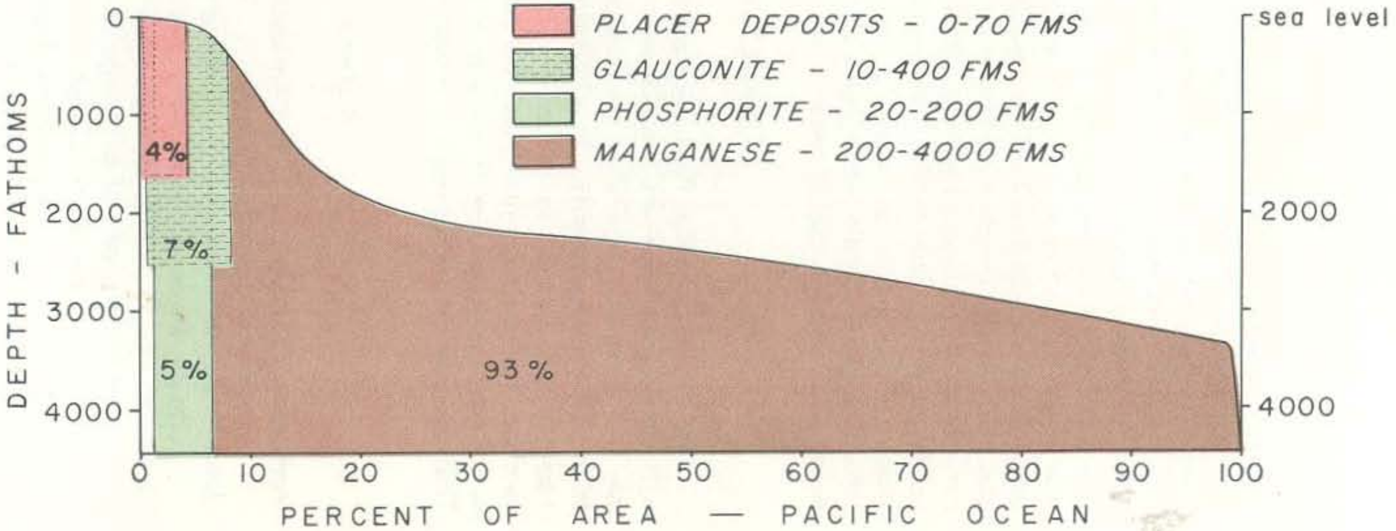


Figure 2. Hypsographic curve showing the percentage of Pacific Ocean floor on which various mineral deposits are likely to occur.



not be in the same area as the placer deposits, because the placers are detrital minerals and are concentrated in areas of detrital deposition.

The manganese nodule area, which is indicated seaward of the other prospects, does not conform strictly to bathymetry. Deep sea terrigenous sediment is known to be present over much of the floor of the Bering Sea and much of the abyssal plain area adjacent to the United States and Canada. The isolated manganese prospects off Canada and Alaska are based on known occurrences of the nodules on the summits of seamounts rising above the abyssal plains.

Geological and geophysical equipment designed for oceanographic research can be used in the prospecting for marine mineral deposits. Echo-sounders and sub-bottom profilers can delineate ancient drainage patterns, buried erosional terraces on which beach placers might occur, and Pleistocene beaches. Bottom sampler and gravity and jet coring devices can be used to obtain surface and subsurface samples of sediment and rock. A variety of dredges is available for the collection of rocks or nodules. Deep sea cameras will obtain photographs of manganese nodules from which estimates of abundance can be made. In shallow water, television is feasible.

Conclusion

It is inevitable that the known commercial mineral resources on land will be expended and new deposits must be found to take their places. The day will certainly come when the mineral prospector will be forced to look to the sea for ore deposits. In all likelihood the sea will be exploited successfully long before that day arrives. Advancing technology is bringing us closer to the time when those with initiative and imagination will turn to the sea simply because it is easier to make a profit there than on land. That day may not be far away. In fact -- it may be at hand.

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NEW EXHIBITS AT PORTLAND OFFICE

On display in the department's Portland office is a 5-foot bathymetric relief model of the continental terrace which lies off the Oregon coast. The three-dimensional model, which was built by C. J. Newhouse, illustrates graphically the bathymetric charts compiled by Dr. John V. Byrne for a series of Ore Bin articles on the continental terrace. Contours on the model are shown in fathoms and depth in progressively darker shades of blue. Outlined are the areas of federal lands offered for lease and the 3-mile limit of state-owned offshore land.

Another new display in the department's Portland office is a collection of volcanic bombs, lava, cinders, and other once-molten materials that erupted from recent volcanoes in Oregon. Most of the specimens came from Diamond Craters in central Harney County and were collected by Norman Peterson and Edward Groh, whose report on this unique volcanic area appeared in the February issue of The Ore Bin.

* * * * *

PRELIMINARY GEOCHEMICAL DATA IN OPEN FILE

The results of the analysis of 982 stream-sediment samples, collected as a part of the Department's geochemical sampling program, are available for inspection at the Department's office in Portland. Samples were analyzed by rapid wet-chemical methods for copper, zinc, and molybdenum. The information will not be published until field checks can be made to verify anomalies.

* * * * *

PLASTIC RELIEF MODEL OF STATE INSTALLED IN DEPARTMENT

A plastic relief model of Oregon has been installed in the Department's office in Portland. The model, composed of 18 separate sheets obtained from the Army Map Service, measures approximately 7 by 10 feet. Vertical exaggeration is twice the horizontal. The completed map clearly shows up many geological relationships and provides a reasonably accurate topographic base for the entire state.

* * * * *

ANTELOPE-ASHWOOD REPORT PUBLISHED BY USGS

Recently issued by the U. S. Geological Survey is Bulletin 1161-D, "Geologic Reconnaissance of the Antelope-Ashwood Area, North-Central Oregon," by Dallas L. Peck. The area described and mapped covers about 750 square miles in Jefferson, Wasco, Crook, and Wheeler Counties. Rocks exposed include partially metamorphosed pre-Tertiary rocks; Eocene Clarno Formation; late Oligocene and early Miocene John Day Formation; middle Miocene Columbia River Basalt; Pliocene The Dalles Formation; Pliocene or Pleistocene basalt; and Quaternary loess and alluvium. Special emphasis is given the John Day Formation, which consists of about 4,000 feet of tuff and rhyolitic ash and lava flows, divisible into nine mappable members. Discussed in some detail is the Priday Ranch agate deposit, which occurs at the base of a welded ash flow in the John Day Formation.

The 26-page bulletin contains photographs and a geologic map. It may be obtained from The Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. The price is 65 cents.

* * * * *

BRISTOL REAPPOINTED TO GOVERNING BOARD

Governor Hatfield has reappointed Fayette I. Bristol to the department's Governing Board for a 4-year term beginning March 16, 1964 and ending March 15, 1968. Mr. Bristol, who is President of the Bristol Silica Co., Grants Pass, Oregon, has been a member of the board since April 1961.

* * * * *

EXPLORATION CONTRACT APPROVED FOR OREGON KING

Oregon King Consolidated Mines, Inc., of Portland has contracted with the Office of Minerals Exploration for assistance to explore for silver and gold in Jefferson County, Oregon. Total cost of the work is estimated at $55,150, of which the Government participation is $27,575.

Work will consist of underground exploration by drifting, crosscutting, and long-hole drilling for silver- and gold-bearing ore bodies in shear zones cutting andesitic country rock of the Clarno Formation.

Control of the Oregon King mine near Ashwood was acquired by the applicant in 1962. In preparation for the exploration, a shaft and several levels have been rehabilitated.

* * * * *

POWER LINE AIDS MINERAL INDUSTRY

The longest tower-to-tower span of electric distribution line in Oregon is in a power-distribution facility servicing Oregon's mineral industry. The big span, which was built by the California-Pacific Utilities Co., covers a horizontal distance of 3,380 feet, or well in excess of 0.6 of a mile, according to Cal-Pacific officials. This distribution facility carries 22,000 volts across the summit of the Elkhorn range, Baker County, from the Marble Creek quarry of the Chemical Lime Co. to a newly developed quarry located at the head of Baboon Creek, also in Baker County. Intended use of the power is for the crushing plant at the new quarry.

This same distribution facility contains a second span of notably long proportions - 2,988 feet, horizontal tower-to-tower distance. Both long spans occur in the section of line located west of the Elkhorn summit.

Chemical Lime produces a variety of burned lime products at a plant located in the Baker Valley, at Wingville. Since the beginning of operations in 1957, raw limestone has been obtained from the Marble Creek quarry.

* * * * *

HELLGATE CANYON

Hellgate Canyon is a narrow, steep-walled canyon about half a mile long, where the waters of the Rogue River flow swift and deep. This scenic attraction can be enjoyed by those who drive along the Rogue through the historic mining center of Galice in southern Oregon. Vantage points along the Merlin-Galice road, high on the north edge of the canyon, provide spectacular views. The feature is 14 miles by road northwest of Grants Pass.

The Rogue has carved this canyon in hard, massive, gray-green rocks which, because of their color, are commonly called "greenstones." These rocks were originally products of volcanoes and consisted of layered dacitic tuffs, andesitic agglomerates, and lava flows. As the result of heat and pressure from deep burial and subsequent folding they have been altered (metamorphosed) almost beyond recognition. The greenstones are interbedded with sedimentary rocks of the Galice Formation of Late Jurassic age, and thus are about 150 million years old.

Prominent serpentine dikes have intruded the greenstones along two major northeast-trending faults named for Hellgate Canyon. East Hellgate fault crosses the river at the upper entrance to the canyon and is visible as a zone of highly sheared serpentine in the road cuts. West Hellgate fault is less sharply defined. It crosses $1\frac{1}{2}$ miles down the river and fans out in a broad zone of sheared serpentine near Hellgate Bridge. The serpentine within the faults is a greenish-black, altered, igneous rock with characteristic waxy luster on its sheared surfaces.

The main controlling factor in the shaping of the valley of the Rogue has been the hardness of the rock encountered by the river as it carved its way downward. Hellgate Canyon marks an abrupt change in the river gradient. Upstream from the canyon the Rogue glides with gentle gradient in a broad, alluviated valley which is underlain by easily eroded, in part decomposed, diorite. Downstream the river dashes through a steep canyon with numerous rapids in the more resistant rocks of the Galice, Rogue, and Dothan Formations. (Photograph by Oregon State Highway Dept., Travel Division)

THE RESIDUAL EXPANSIBILITY OF PUMICE

By N. S. Wagner* and L. L. Hoagland**

Pumice is a glassy, volcanic rock with a frothy texture. Its color is generally whitish or pearly gray, but sometimes tan. The texture and composition of this rock, when fresh and unweathered, make it suitable for use as a natural lightweight aggregate. Pumice aggregate has its chief application in lightweight, fire-resistant, and insulating materials in which structural strength is needed.

Perlite, another volcanic glass of similar chemical composition, is a dense rock that, when crushed and heated to certain temperatures, expands and produces a synthetic pumice. Like pumice, it is marketed for a number of lightweight aggregate purposes. Expanded perlite, however, is many times lighter in weight than pumice and consequently is more successful in extra-lightweight applications.

The purpose of this study was to determine if pumice, which is so similar chemically to expanded perlite but is heavier, has the capacity for further expansion. Laboratory experiments proved that additional cellularity could be induced in the pumice treated and that an extra-lightweight aggregate could be produced.

Laboratory Tests and Results

Expansion tests were run on pumice samples originating from sources in the Bend area, Deschutes County, where fine-quality pumice block and plaster sand aggregate has been produced continuously since 1946. Both fresh and moderately weathered pumice were tested at the outset to determine if any capacity for expansion existed and whether or not alteration had any appreciable bearing on the expansibility. The samples for this phase of the investigation originated from widely dispersed locations and were furnished by William E. Miller, Central Oregon Pumice Co., Bend, Oregon. The samples were all crushed and screened to a minus 20, plus 28 mesh. Testing was carried out in an electric muffle furnace at 1,900° F with five-second exposures per test. Results are listed on the following page.

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* Geologist, Oregon Dept. of Geology and Mineral Industries.

**Assayer-Chemist, Oregon Dept. of Geology and Mineral Industries.

Locality	Sample description	Volume increase
1.	Fresh, commercial grade pumice	100 %
2.	Same	95 %
3.	Same	105 %
4.	Moderately weathered pumice	none
5.	Same	50 %
6.	Same	30 %

These results indicate that some pumice has a capacity to develop a cellularity over and above that with which it was endowed by nature. Since this capacity is greatest in fresh, unweathered material, Locality 3 was selected as offering the material best suited for continued study. A new sample was therefore acquired from this source and its volume increase checked by a repeat test on a fraction again screened minus 20, plus 28 mesh and again exposed to 1,900°F. for five seconds. Volume increase for this check test was 110 percent, which compares favorably with the initial (105 percent) expansion result.

Using a coarser (minus 2.362 mm, plus 2.00 mm) fraction, test portions of this sample were expanded at 50° intervals from 1,700° to 1,900° F. and held in the furnace for 15-second intervals:

Degrees F.	Volume increase
1,900	90 %
1,850	100 %
1,800	110 %
1,750	95 %
1,700	75 %

Microscopic examination of the expanded products reveals that considerable fusing and collapse of the bubbles had taken place on the surface of the particles in the test made at 1,900°F. Conversely, no fusing or collapse of the surface structures is evident on the particles from the test portions expanded at temperatures of 1,800°F. or lower, despite the prolonged heating. From these observations it is apparent that maximum expansion for this particular pumice takes place in the vicinity of 1,800°F., that temperatures below 1,750°F. result in only partial expansion, and that destruction of induced cellularity is appreciable at temperatures above 1,850°F. The volume increase of 110 percent shows that it is technically possible to reduce the weight of this particular pumice by half. Pumice in aggregate form normally weighs 33 pounds per cubic foot. The artificially expanded aggregate would then weigh about 15 pounds per cubic foot -- a weight closely approaching that of expanded perlite. Expansion of perlite in a muffle furnace usually results in volume increases somewhat lower than are obtained by expansion in a commercial plant. If this holds true for pumice, an even lighter expanded product might be obtained.

Conclusions

Although a great deal more study will have to be made before the expansibility potential of pumice can be fully evaluated, the present findings suggest that such study is warranted because (1) some pumice does have a capacity to expand, and (2) the expanded product is competitive from a weight standpoint for many of the extra-lightweight aggregate applications.

Future investigation will necessarily have to include tests to determine if pumice from other localities will expand as did the Locality 3 pumice. Needed also will be studies to establish processing costs and the suitability of artificially expanded pumice as an aggregate. Should further study prove fresh pumice expansible, the economics of expansion feasible, and the expanded product physically suitable for use in the field of special-purpose, extra-lightweight aggregate applications, then the expansibility potential of this "common variety" rock could be of considerable commercial importance.

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BUFFALO MINE TO EXPAND OPERATIONS

Jim Jackson, operator of the Buffalo mine in Grant County, has been granted a Small Business Administration loan of $105,000 with which to expand operations and up-date facilities. The Buffalo has been the state's principal lode-gold producer for many years. Exploratory development during the past 3 years has demonstrated downward continuation of the vein to the 600 level and its persistence for a strike length of several hundred feet. Production during this exploratory period has been limited to the milling of development rock. In 1963 approximately 1,400 tons of such ore produced nearly 320 tons of concentrates. Jackson reports that increased silver values have been found on the 600 level.

As a result of the loan a more accelerated mining program is planned for the coming summer.

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1964 AMC MINING CONVENTION PLANS PROGRESS

Arrangements for the 1964 Metal Mining and Industrial Minerals Convention of the American Mining Congress to be held in Portland September 13 to 16 are nearing completion, J. Allen Overton, Jr. (AMC Executive Vice President), announced in Portland concluding meetings held April 7 and 8 of the convention chairmen and the program committee.

Under the direction of General Chairman Earl S. Mollard (Western States Representative of The Hanna Mining Co., Myrtle Creek, Oregon, and chairman of AMC's Western Division) the arrangements committee is developing plans for the various convention activities which include a welcoming luncheon, two evening functions, special events for the ladies, and field trips. Wesley P. Goss (President, Magma Copper Co., Superior, Arizona), program chairman, announced upon completion of his committee's meeting that the Portland convention will have one of the most outstanding programs ever presented by the AMC.

The following Pacific Northwest industry leaders are serving in important arrangement committee posts:

Ernest G. Swigert, honorary chairman, Chairman of the Board, Hyster Co., Portland, Oregon; Earl S. Mollard, general chairman, Western States Representative, The Hanna Mining Co., Myrtle Creek, Oregon; Hollis M. Dole, secretary, State Geologist, State of Oregon Department of Geology and Mineral Industries, Portland; Veryl N. Hoover, co-chairman of the welcoming committee, Vice President of Pacific Power & Light Co., Portland; Frank E. McCaslin, co-chairman of the welcoming committee, President of Oregon Portland Cement Co., Portland;

Fayette I. Bristol, co-chairman of the welcoming committee, President of Bristol Silica Co., Rogue River, Oregon; Donald R. Dawson, chairman of the publicity committee, of Dawson, Turner & Jenkins, Portland; Donald Tilson, co-chairman of the trips committee, Regional Manager, Aluminum Co. of America, Vancouver, Washington; Emmons Coleman, co-chairman of the trips committee, Manager, The Hanna Mining Co., Riddle, Oregon; James H. McClain, co-chairman of the trips committee, Assistant to General Manager, Wah Chang Corp., Albany, Oregon; Mrs. Earl S. Mollard, honorary chairman of the ladies'committee; and Mrs. Veryl N. Hoover, Mrs. Fayette I. Bristol, and Mrs. Frank E. McCaslin, co-chairmen of the ladies' committee.

Hotel reservations are being handled through the American Mining Congress Housing Bureau, operated by the Portland Convention Bureau at 1020 S. W. Front Ave., Portland, Oregon 97214. First assignment of accommodations will be made in June.

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The ORE BIN
Volume 26, No. 5
May, 1964

SEDIMENTARY ROCKS FROM THE CONTINENTAL SHELF AND SLOPE OFF THE CENTRAL COAST OF OREGON

By

Neil J. Maloney and John V. Byrne*

During the period from July 1961 to September 1963, rocks were collected from 138 different locations on the continental shelf and slope off the central coast of Oregon by the Department of Oceanography, Oregon State University. The sample locations, types of samplers, and general lithologies for all of the samples are listed in Table 1. The sample positions are plotted in Figure 1.

In Table 1 the samples are numbered consecutively according to their geographic position. The OSU Sample Number, by which the sample is filed at the Department of Oceanography, is given also. Two locations are listed for those samples collected by dragging a dredge along the bottom for some distance. The two positions indicate the start and finish of the dredge haul. Other types of samples have only one location listed. Positions are based on navigation by loran or by radar. The approximate depths from which the samples were taken can be estimated from the contours in Figure 1.

Gravity corers, grab samplers, and a variety of dredges were used to collect the rocks. The gravity corer was allowed to fall free into the bottom. The weight of the instrument (about 50 pounds) was sufficient to drive the core barrel 3 to 4 inches into soft rock. The grab sampler used was a Dietz-Lafond "snapper" type and was successful in collecting rocks lying loose on the bottom. Four types of dredges were employed: The anchor dredge and the otter trawl are primarily biological dredges; the frame or Agassiz dredge is used both by geologists and biologists; and the pipe dredge, designed for collecting rocks, is employed almost solely by geologists. In essence, all of the dredges are simply open frames to which is attached some type of collecting bag or container. As the dredge is dragged across the sea floor, it scoops up whatever it encounters.

General lithologies are listed in Table 1. The rocks are predominantly siltstones, with a few samples of sandstone and limestone. Limestone samples

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* Department of Oceanography, Oregon State University, Corvallis.

TABLE 1. Rock Samples - Oregon Continental Terrace

No.	OSU Sample No.	Latitude	Longitude	Type of Sampler[1]	Rock Type
1	6308-1	43 48.1	124 53.8	P	Silty limestone
		43 50.0	124 55.0		
2	OC-0023	43 49.8	124 46.5	OT	Calcareous siltstone with vugular aragonite
3	6306-2	43 50.1	124 55.5	P	Silty limestone
4	6306-3	43 50.3	124 53.1	P	Shaley mud
5	6301-16	43 51.0	124 25.0	F	Siltstone
6	6306-4	43 52.0	124 56.0	P	Green pellet, calcareous siltstone
7	6306-10	43 54.6	124 47.1	P	Limestone
		43 55.0	124 47.6		
8	6308-15	43 55.1	124 54.2	P	Silty limestone
9	6306-8	43 55.1	124 56.0	P	Silty limestone
10	6209-23	43 55.4	124 47.7	F	Limestone
11	6306-9	43 55.4	124 42.2	P	Limestone
12	6301-2-100	43 56.0	124 25.4	G	Siltstone
13	6301-2-96	43 56.0	124 43.0	C	Stiff, gray, silty clay
14	6301-2-95	43 56.0	124 47.2	C	Clayey siltstone
15	6301-2-93	43 56.0	124 55.4	C	Limestone pebbles
16	6301-17	43 57.7	124 40.0	F	Siltstone
		43 58.4	124 41.6		
17	6308-16	43 58.5	125 08.3	P	Silty limestone
		43 59.8	125 09.0		
18	6301-2-89	43 59.0	124 42.8	G	Calcareous siltstone pebble
19	6301-2-90	43 59.0	124 46.9	C	Friable clayey siltstone
20	6209-24	43 59.0	124 47.7	F	Silty limestone
21	6301-2-91	43 59.0	124 51.0	C	Friable clayey siltstone
22	6301-2-92	43 59.0	124 56.7	C	Diatomaceous clayey siltstone
23	6209-25	43 59.3	124 53.9	F	Diatomaceous siltstone
24	6209-21	43 59.8	124 51.6	F	Siltstone
25	6306-11	44 00.0	124 56.8	P	Diatomaceous siltstone
26	6301-2-73	44 02.0	124 47.4	C	Friable clayey siltstone
27	6301-2-72	44 02.0	124 51.5	C	Friable clayey siltstone
28	6301-2-71	44 02.0	124 55.5	C	Friable clayey siltstone
29	6209-20	44 02.1	124 51.9	F	Diatomaceous siltstone, calcareous pebble
30	6209-19	44 04.0	124 51.5	F	Calcareous fine sandstone and siltstone
31	6308-18	44 04.5	125 14.4	P	Stiff clay and shale chips
		44 04.3	125 14.2		
32	6306-15	44 04.9	125 01.0	P	Pebbles
33	6301-2-69	44 05.1	124 50.5	C	Friable clayey siltstone
34	6301-2-67	44 05.2	124 42.2	C	Limestone pebbles
35	6301-2-68	44 05.5	124 46.3	C	Friable clayey siltstone
36	6209-18	44 05.5	124 54.3	F	Silty limestone cobble, diatomaceous siltstone

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[1] Type of Sampler -- C-Corer, F-Frame Dredge, G-Grab Sampler, OT-Otter Trawl, P-Pipe Dredge, AD-Anchor Dredge.

Compiled November 1963, Department of Oceanography, Oregon State University.

TABLE 1. Rock Samples - Oregon Continental Terrace, Continued

No.	OSU Sample No.	Latitude	Longitude	Type of Sampler	Rock Type
37	6301-2-51	44 08.0	124 39.2	C	Limestone pebbles
38	6301-2-50	44 08.0	124 43.5	C	Friable clayey siltstone
39	6301-2-49	44 08.0	124 47.5	C	Friable clayey siltstone
40	6301-2-48	44 08.0	124 51.6	C	Friable clayey siltstone
41	6209-17	44 08.1	124 48.5	F	Siltstone
		44 08.1	124 48.9		
42	OC-0048	44 09.2	124 39.2	OT	Calcareous fine sandstone
		44 12.7	124 39.7		
43	6306-18	44 09.7	124 59.3	P	Clayey siltstone
		44 09.5	124 59.7		
44	6209-16	44 09.8	124 48.5	F	Clayey siltstone, calcareous siltstone
45	6209-14	44 10.5	124 48.8	F	Green pellet sandstone, calcareous siltstone, diatomaceous siltstone
		44 10.7	124 49.1		
46	6209-12	44 10.8	124 46.6	F	Siltstone, calcareous siltstone, green pellet sandstone, breccia
47	6209-13	44 10.8	124 51.4	F	Siltstone, calcareous siltstone, green pellet sandstone, breccia
48	6301-2-43	44 11.1	124 44.4	G	Clayey siltstone, limestone pebble
49	6301-2-44	44 11.1	124 48.4	G	Clayey siltstone
50	6301-2-45	44 11.1	124 52.6	C	Clayey siltstone
51	6301-2-41	44 11.3	124 35.8	G	Calcareous siltstone pebble
52	6301-2-42	44 11.3	124 40.0	G	Siltstone
53	6209-15	44 12.4	124 49.5	F	Green pellet sandstone, siltstone
		44 12.6	124 49.9		
54	6308-23	44 13.0	125 14.1	P	Stiff, gray clay
		44 13.9	125 14.1		
55	6209-11	44 14.1	124 43.5	F	Siltstone, calcareous siltstone
56	6301-2-28	44 14.2	124 35.3	G	Limestone pebble, friable siltstone
57	6301-2-27	44 14.2	124 39.5	C	Calcareous siltstone, friable sandstone
58	6301-2-26	44 14.2	124 43.6	G	Siltstone
59	6301-2-25	44 14.2	124 47.7	C	Friable clayey siltstone
60	6301-2-24	44 14.2	124 52.0	C	Friable silty clay
61	6301-2-23	44 14.2	124 56.2	G	Limestone pebble
62	6301-15	44 14.8	124 52.5	F	Sandstone
		44 15.1	124 51.2		
63	6301-14	44 14.9	124 55.0	F	Silty limestone
		44 15.0	124 54.3		
64	6301-2-17	44 17.0	124 35.5	G	Limestone pebbles
65	6301-2-18	44 17.0	124 37.9	G	Siltstone
66	6301-2-19	44 17.0	124 42.0	G	Siltstone
67	6301-2-21	44 17.0	124 50.3	G	Siltstone, gravel
68	6209-7	44 17.2	124 35.5	F	Siltstone, calcareous siltstone
69	6209-8	44 17.2	124 39.8	F	Green pellet sandstone, diatomaceous siltstone
70	6209-9	44 17.3	124 43.4	F	Diatomaceous siltstone, silty limestone boulder
71	OC-0018	44 18.1	125 13.2	OT	Mudstone, diatomite
		44 29.7	125 15.4		
72	6308-28	44 19.0	125 07.7	P	Pebbles, shale chips
		44 20.0	125 07.7		

TABLE 1. Rock Samples – Oregon Continental Terrace, Continued

No.	OSU Sample No.	Latitude	Longitude	Type of Sampler	Rock Type
73	6301-2-4	44 19.7	124 30.0	G	Gravel
74	6301-2-5	44 19.9	124 28.3	G	Limestone pebbles
75	6301-2-3	44 20.0	124 41.0	C	Friable fine sandstone
76	6209-10	44 20.0	124 41.0	F	Siltstone
77	6301-2-2	44 20.0	124 45.2	C	Clayey siltstone
78	6212-18	44 20.6	124 34.4	F	Clayey siltstone
79	OC-0022	44 21.9 44 21.0	124 43.6 124 43.6	OT	Clayey siltstone
80	OC-0002	44 22.5 44.24.0	125 13.8 125 14.2	OT	Silty limestone
81	OC-0015	44 22.7	124 38.8	OT	Silty mudstone
82	OC-0027	44 22.7	124 39.3	G	Diatomaceous siltstone
83	OC-0032	44 22.8	124 35.4	G	Siltstone, limestone, pebbles
84	OC-0024	44 23.0	124 31.0	G	Silty limestone, diatomaceous siltstone
85	OC-0012	44 23.9	124 40.1	OT	Diatomaceous siltstone
86	OC-0028	44 25.6	124 26.8	G	Siltstone
87	OC-0026	44 25.6	124 31.2	G	Siltstone
88	OC-0033	44 25.8	124 39.3	G	Siltstone
89	6209-4	44 26.3	124 50.6	F	Siltstone
90	6209-5	44 26.3 44 26.7	124 42.8 124 44.1	F	Calcareous siltstone
91	OC-0017	44 27.0 44 35.8	125 15.6 125 15.6	OT	Mudstone, clinker
92	OC-0005	44 27.6	125 14.2	OT	Wood, clinker, clayey siltstone
93	OC-0014	44 28.3	125 13.4	OT	Clinker
94	OC-0027	44 28.8	124 31.2	G	Calcareous siltstone
95	OC-0043	44 28.8	124 48.1		Siltstone
96	6212-17	44 28.9	124 39.5	F	Calcareous siltstone
97	6301-4	44 29.5 44 30.0	124 56.0 124 56.0	F	Siltstone
98	6212-8	44 30.0	124 20.5	F	Silty limestone, siltstone
99	6212-9	44 30.0	124 24.0	F	Diatomaceous siltstone
100	6212-10	44 30.0	124 25.5	F	Siltstone, calcareous siltstone with green pellets
101	6301-1	44 30.0	124 41.6	F	Silty limestone, calcareous siltstone
102	OC-0021	44 30.2	124 22.6	OT	Siltstone, calcareous siltstone
103	6301-2	44 30.2 44 30.6	124 49.3 124 49.4	F	Silty limestone, calcareous siltstone
104	OC-0016	44 31.7	124 22.8		Clayey siltstone with diatoms
105	6212-6	44 32.4	124 24.5	F	Calcareous siltstone
106	6212-16	44 32.4	124 30.0	F	Calcareous siltstone, siltstone
107	6212-7	44 32.5	124 26.4	F	Siltstone, calcareous siltstone
108	OC-0036	44 33.5	125 14.5	AD	Friable fine sandstone
109	6212-2	44 34.7	124 23.7	F	Siltstone
110	OC-0025	44 34.7	124 27.5	G	Diatomaceous siltstone
111	6212-15	44 34.8	124 31.5	F	Siltstone
112	6212-4	44 35.3	124 27.2	F	Calcareous siltstone
113	OC-0001	44 37.2	124 26.4	F	Diatomaceous siltstone
114	OC-0035	44 37.5	124 26.7	G	Calcareous siltstone, siltstone pebbles
115	OC-0047	44 37.0 44 37.8	125 01.5 125 00.6	AD	Coal, clinker

TABLE 1. Rock Samples - Oregon Continental Terrace, Continued

No.	OSU Sample No.	Latitude	Longitude	Type of Sampler	Rock Type
116	OC-0031	44 37.7	124 22.5	G	Siltstone
117	OC-0004	44 38.1	124 51.8	OT	Siltstone
118	OC-0042	44 38.1	124 51.8	AD	Clayey siltstone
119	OC-0040	44 38.3 44 38.8	125 19.3 125 19.5	AD	Silty mudstone
120	OC-0046	44 38.5	124 50.7	AD	Calcareous siltstone
121	OC-0045	44 38.6	124 20.1	AD	Friable sandstone
122	OC-0019	44 38.6	124 25.6		Diatomaceous siltstone, calcareous siltstone
123	OC-0009	44 38.6	124 25.7		Diatomaceous siltstone
124	OC-0010	44 38.6	124 26.2	F	Clayey siltstone with diatoms
125	OC-0007	44 38.8 44 39.0	124 43.5 124 44.0	F	Silty limestone
126	OC-0039	44 38.8	125 12.1	AD	Sandstone, siltstone
127	OC-0037	44 39.0	125 10.0	AD	Calcareous siltstone, clayey siltstone
128	OC-0041	44 39.0	125 11.0	AD	Clayey siltstone
129	OC-0008	44 39.1	125 00.5		Limestone
130	OC-0038	44 39.1	125 19.5	AD	Sandstone, clayey silt
131	OC-0006	44 39.6	124 52.6		Calcareous siltstone
132	OC-0020	44 39.7	124 27.0	F	Siltstone
133	OC-0003	44 39.9	124 50.3	F	Calcareous siltstone, silty limestone
134	OC-0013	44 40.0	124 56.0	F	Clinker
135	OC-0034	44 40.5	124 31.5	G	Diatomaceous siltstone
136	OC-0011	44 40.6	124 58.9	F	Coal
137	6305-3	44 41.0	125 06.0	P	Friable mudstone
138	OC-0044	44 44.8	124 32.3	F	Silty limestone

may represent calcareous concretions which have "weathered" from the less resistant siltstone or shale. The stiff gray clay (sample 54) may be shale in a stage of formation, or possibly is a submarine "weathering" product of a shale or mudstone. Several samples are believed to have been dropped from ships, and are thought not to have been in place at the time of collection, for example, the clinkers and coal of samples 93, 115, 134, 136.

In view of the current interest in the petroleum possibilities of the area off the coast of Oregon, these rock samples have been made available for examination at the Department of Oceanography on the campus of Oregon State University in Corvallis. Arrangements for such an examination may be made by contacting Dr. John V. Byrne at the Department of Oceanography.

Acknowledgements: The rocks were collected during the course of research carried out under contract with the Office of Naval Research, Contract Nonr 1286; (10) Project NR 083-102.

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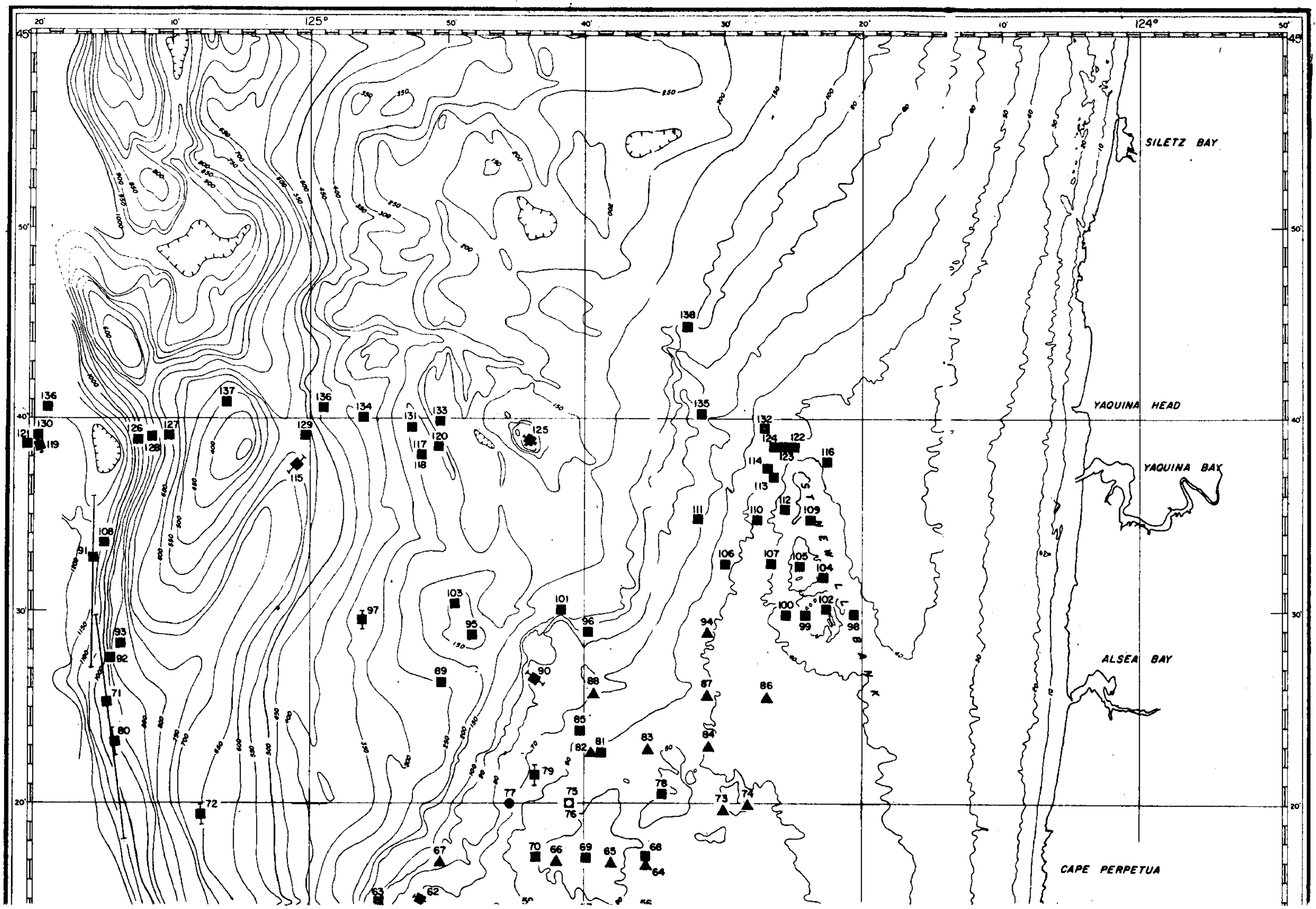
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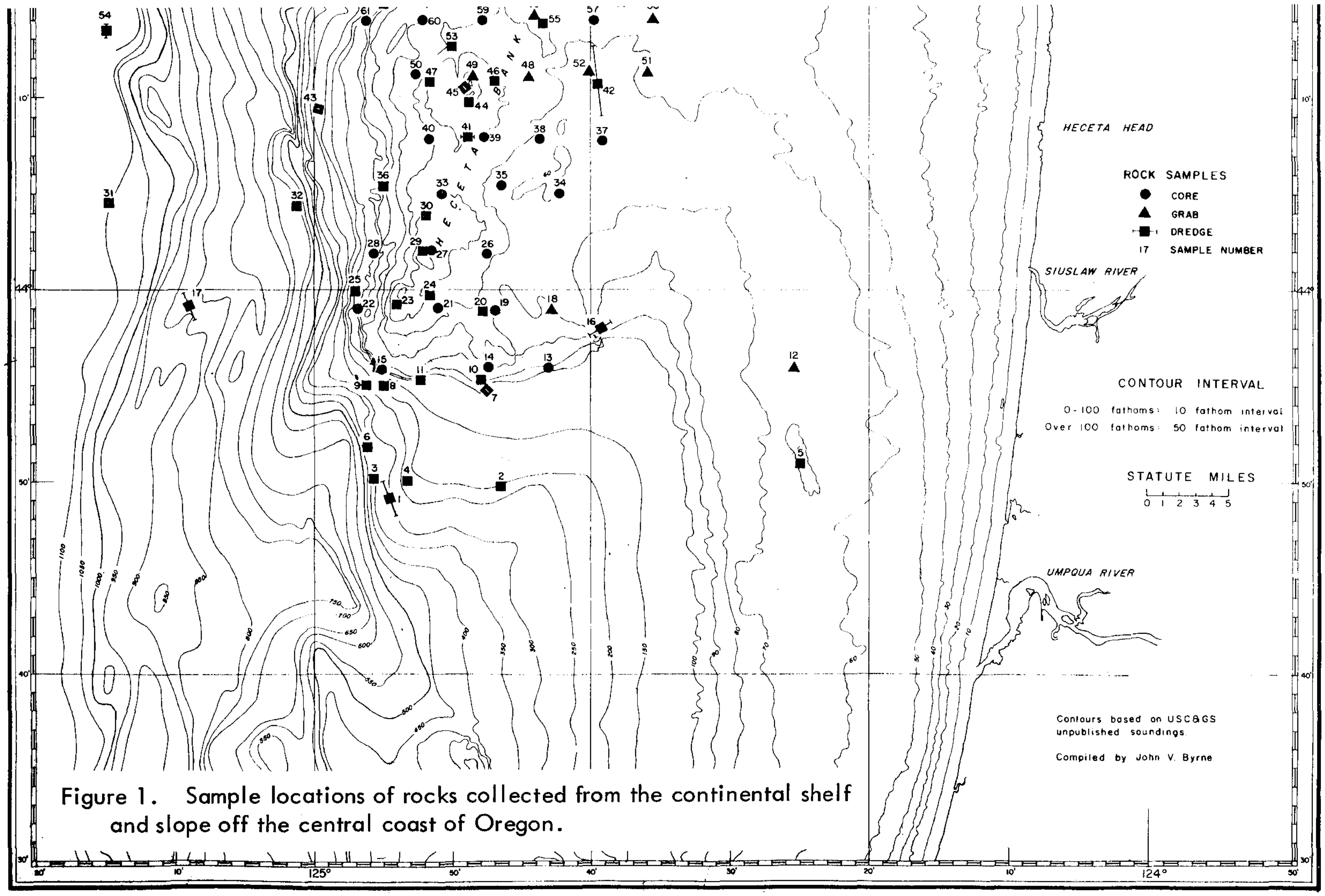

Figure 1. Sample locations of rocks collected from the continental shelf and slope off the central coast of Oregon.

COMPARISON OF THREE CURRENT WILDERNESS BILLS WITH EXISTING SITUATION

Item	Existing Situation*	Dingell Bill (H.R. 9162)	Saylor Bill (H. R. 9070)	S. 4
Length of Bill		15 pages and 5 lines	15 pages	21 pages and 3 lines
Title	1-National Forest Wilderness, Wild, Canoe and Primitive Areas. 2-National Park System. 3-National Wildlife Refuge and Game Range System.	To establish National Wilderness Preservation System, etc.	Same as H.R. 9162	Same as H.R. 9162
Purpose	1-To secure benefits of enduring resource of wilderness. 2-To conserve and enjoy scenery, natural and historical objects unimpaired. 3-To protect & manage wildlife resources.	To secure benefits of enduring resource of wilderness.	Same as H. R. 9162	Same as H. R. 9162
Definition of Wilderness	1-"Tract of land established under regulation U-1 (or U-2) in which the primitive environment has been preserved." (F.S. Manual) 2-None 3-None	Area "untrammeled by man" where man is visitor only. 5,000 acres or more undeveloped federal land retaining primeval character.	Same as H. R. 9162	Same as H. R. 9162
Extent of System in Wilderness Administration	1-N.F. wilderness-type areas - 14.7 million acres. 2-N.P. System - 22 million A. 3-N.W.R.System-25 million A.	8.6 million acres at outset. Potentially over 60 million acres with additions by Acts of Congress.	Same as H. R. 9162	14.7 million acres at outset. Potentially over 60 million acres unless vetoed by Congress.

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*Numbers used under "Exiting Situation" indicate: 1-on national forest units; 2-on national park units; 3-on national wildlife refuge and game range units.

Item	Existing Situation	Dingell Bill (H.R. 9162)	Saylor Bill (H. R. 9070)	S. 4 (Page 2)
Commercial Forest Land Included	1-4.7 million acres,32% (U.S.D.A., 2/23/61) 2-Unknown 3-Unknown	2.9 million acres on national forests at outset. Potentially 4.7 million acres in national forests and unknown amount in national parks and wildlife refuges with additions by Acts of Congress.	Same as H. R. 9162	4.7 million acres or 32% of national forest wilderness-type areas (U.S.D.A.-2/23/61). Unknown amount in national parks and wildlife refuges.
Percentage of System in West	1-94% in 11 Western States 2-About 90% 3-Same	About 90%	Same as H. R. 9162	Same as H. R. 9162
Addition or Deletion	1-By Executive order of Chief of Forest Service or Secretary of Agriculture. 2-By proclamation of President or Act of Congress. Total elimination by Act of Congress. 3-Same	By Act of Congress	By Act of Congress	By Executive Branch recommendation and failure of Congress to veto.
Review Period	1-Indefinite for primitive areas. 2-No review period for parks. 3-No review period for refuges or ranges.	10 years for primitive areas and national parks and wildlike units	Total of 5 years for primitive areas and national parks and wildlife units.	10 years for primitive areas and national park and wildlife units.
Criteria for Recommended Inclusions	1-"forest officers will analyze all public values of the land and determine the highest public value." (F.S.Manual) 2-Meet national park standards. 3-Meet national wildlife refuge and national game range standards.	Primitive areas- "Suitability for preservation as wilderness." National Park-"Roadless portions of" suitable "for preservation as wilderness." Wilderness refuge- "portions of" suitable "for preservation as wilderness."	Primitive areas-"Suitability for preservation." National Park-"5,000 or more contiguous acres" without roads suitable "for continued preservation as wilderness." Wildlife refuge-5,000 or more contiguous acres without roads or "roadless islands within" suitable "for	Primitive areas-included at the outset. Possible deletion after review of "portions not predominantly of wilderness value." National Park-"5,000 acres or more without roads" which Secretary recommends not needed "for roads, motor trails, buildings, accommodations for visitors, and

Item	Existing Situation	Dingell Bill (H. R. 9162)	Saylor Bill (H. R. 9070)	S. 4 (Page 3)
Criteria, continued			continued preservation as wilderness."	administrative installations." Wilderness Refuge-"Such portions" as Secretary "may recommend."
Status of Primitive Areas During Review Period	1-Continue to be administered by the Secretary of Agriculture as primitive areas.	"Continue to be administered by the Secretary of Agriculture as primitive areas" during 10-year review period or until Congress has acted.	"Continue to be administered by the Secretary of Agriculture as on the date of this Act until Congress has acted on or has determined otherwise."	Primitive areas included in system at outset.
Status of Primitive Areas Not Included After Review Period	1-Become unreserved national forest land.	Not clear	Remain primitive areas until Congress acts on.	When no recommendation for continued inclusion of an area in system has become effective within 14 years, area "shall cease to be a part of the wilderness system."
Roads	1-No roads permitted in national forest primitive, wilderness, wild or canoe areas except for ingress to or egress from privately owned property. 2-Roads permitted in national parks to meet minimum requirements of administration. Some 90% of system without roads and policy to keep it that way. 3-Roads permitted in wildlife refuge units to meet minimum requirements of administration. In practice, held to minimum.	"No permanent road." "No temporary road..except as necessary to meet minimum requirements for the administration of the area for the purpose of this Act...subject to existing private rights."	"No permanent road..nor any temporary road...in excess of minimum required for the administration of the area for the purposes of this Act ...subject to any existing private rights."	Same as H. R. 9070

Item	Existing Situation	Dingell Bell (H. R. 9162)	Saylor Bill (H. R. 9070)	S. 4
Motor Transportation and Mechanized Equipment	1-Not permitted in national forest wilderness-type areas. 2-Permitted only in roaded portions of national park system. No off-highway use. 3-Permitted only in roaded portions of national wildlife refuge system.	"No use of motor vehicles motorized equipment or motor boars, no landing of aircraft nor other form of mechanical transport, and no structure or installation...except as necessary to meet minimum requirements for administration."	No "use of motor vehicles motorized equipment or motor boars, or landing of aircraft, nor any other mechanical transport or delivery of persons or supplies... nor any structure or installation in excess of the minimum required, etc."	Same as H. R. 9070
Established Use of Aircraft or Motorboats	1-Permitted where established on national forest wilderness-type areas. 2-Landing of aircraft prohibited. Motorboats by permission of park superintendent. 3-Not permitted unless compatible with refuge and range objectives.	"May be permitted to continue subject to such restrictions as the Secretary...deems desirable."	Same as H. R. 9162	"Shall be permitted to continue subject to such regulations as the appropriate Secretary finds necessary."
Protection Against Fire, Insects and Diseases	1-Protection measures permitted by administrative discretion on national forest wilderness type areas. 2-Protection measures permitted when considered necessary on park units. 3-Protection measures permitted as necessary to wildlife protection and management.	"Such measures may be taken as may be necessary in the control of fire, insects and diseases, subject to such conditions as the appropriate Secretary deems desirable."	Same as H. R. 9162	"Such measures may be taken as are necessary in the control of fire, insects, and diseases, subject to such regulations as the appropriate Secretary finds necessary."

(Page 5)

Item	Existing Situation	Dingell Bill (H. R. 9162)	Saylor Bill (H. R. 9070)	S. 4
Commercial Timber Harvesting	1-None except in Boundary Waters Canoe Area under special Act of Congress. 2-None in national park units. 3-Permitted as tool in wildlife management	None except in Boundary Waters Canoe Area	None except in Boundary Waters Canoe Area	None except in Boundary Waters Canoe Area.
Grazing of Livestock	1-Regulations permit on national forest wilderness-type areas. Often excluded. 2-Generally excluded on national parks. Some grazing on monuments. 3-Permitted as tool in wildlife management.	Where established on national forest areas, "shall be permitted to continue subject to such reasonable regulations as are deemed necessary by the Secretary of Agriculture."	Same as H. R. 9162	Where established on national forest and public domain areas, "shall be permitted to continue subject to such regulations as are deemed necessary by the Secretary."
Mining and Mineral Leasing	1-Mineral leasing and mining laws continue in force on national forest wilderness-type areas. 2-Mining excluded from national parks with few exceptions. 3-Mining permitted when compatible with wildlife management.	Existing laws pertaining to mineral leasing and mining extended to December 31, 1973 on areas in system. After that date no patents shall issue "except for valid claims filed on or before December 31, 1973."	Prospecting for minerals can continue within national forest areas if "compatible with the preservation of the wilderness environment." Periodic mineral surveys by Geological Survey and Bureau of Mines on national forest areas. No provision for development and mining of minerals.	Within national forest and public domain areas included in system, "President may, within a specific area and in accordance with such regulations as he may deem desirable, authorize prospecting and mining."
Water and Power Projects	1-Permitted according to withdrawals by Federal Power Commission (private projects) or B.L.M. (Public projects). 2-Not permitted in national park units. 3-Generally not permitted	Within national forest areas in system, "President may, within a specific area and in accordance with such regulations as he may deem desirable, authorize prospecting for water resources, the	Same as H. R. 9162	Within national forest and public domain areas included in system, "President may, within a specific area and in accordance with such regulations as he may deem desirable, authorize...

Item	Existing Situation	Dingell Bill (H. R. 9162)	Saylor Bill (H. R. 9070)	S. 4 (Page 6)
Water & Power Projects, Cont.	in national wildlife refuges and game ranges.	establishment and maintenance of reservoirs, water conservation works, power projects, transmission lines, and other facilities needed in the public interest, including the road construction and maintenance essential to development and use thereof..."		establishment and maintenance of reservoirs, water-conservation works, transmission lines, and other facilities needed in the public interest including the road construction and maintenance essential to development and use thereof...."
Commercial Services	1-Permitted when compatible with wilderness administration. 2-Permitted when compatible with national park objectives. 3-Permitted when compatible with wildlife management goal.	"May be performed...to the extent necessary for activities which are proper for realizing the recreational or other wilderness purposes of the areas."	Same as H. R. 9162	Same as H. R. 9162
Hunting and Fishing	1-Permitted on national forest wilderness-type areas. 2-Fishing permitted on most park units. Hunting not permitted. 3-Hunting permitted on national game ranges, not on wildlife refuges. Fishing permitted on both.	"Secretary of Agriculture shall..permit hunting and fishing...to the extent that it is not incompatible with wilderness preservation" and without affecting jurisdiction of States.	Same as H. R. 9162	Not clear. Nothing in Act to affect jurisdiction or responsibilities of .... States with respect to wildlife and fish in the national forests."

Item	Existing Situation	Dingell Bill (H. R. 9162)	Saylor Bill (H. R. 9070)	S. 4
Surrounded Non-Federal Land	1-Can be exchanged or purchased when funds authorized. 2-Same 3-Same	Where its land is completely surrounded by lands in system, State shall be given either (1) such rights as may be necessary to assure adequate access..or(2)..lands in the same State, not exceeding the value of the surrounded land in exchange. "Where privately owned lands (or) mining claims..are wholly within a wilderness area.. Secretary of Agriculture shall, by reasonable regulations consistent with preservation of the area of wilderness, permit ingress and egress by means... customarily enjoyed." Secretary of Agriculture is authorized to acquire private land within the perimeter of any area if (1) the owner concurs or (2) if acquisition is authorized by Congress.	Same as H.R. 9162 (No provision in any of bills for lands in exchange for surrounded private lands as provided for surrounded State lands.)	For surrounded State land, same as H.R. 9162. For privately-owned land "within any portion of...system under his jurisdiction" Secretary of Interior and Agriculture subject to approval of funds by Congress, "are each authorized to acquire as part of the wilderness system." Does not confer right of condemnation or impair "customary" access rights.
Public Hearings	1-Held by Forest Service in local areas on proposals to reclassify primitive areas. 2-Held by House and Senate Interior Committees on national park legislative	Prior to submitting any recommendations to President on suitability of any area for preservation as wilderness, Secretaries of Agriculture and Interior shall give appropriate public notice and hold public hearing or hearings convenient	Same as H. R. 9162	Same as H.R. 9162 except that 10 federal agencies concerned are listed and "it shall be the responsibility of each named federal agency to submit its independent views concerning the designation of an area as 'wilderness'

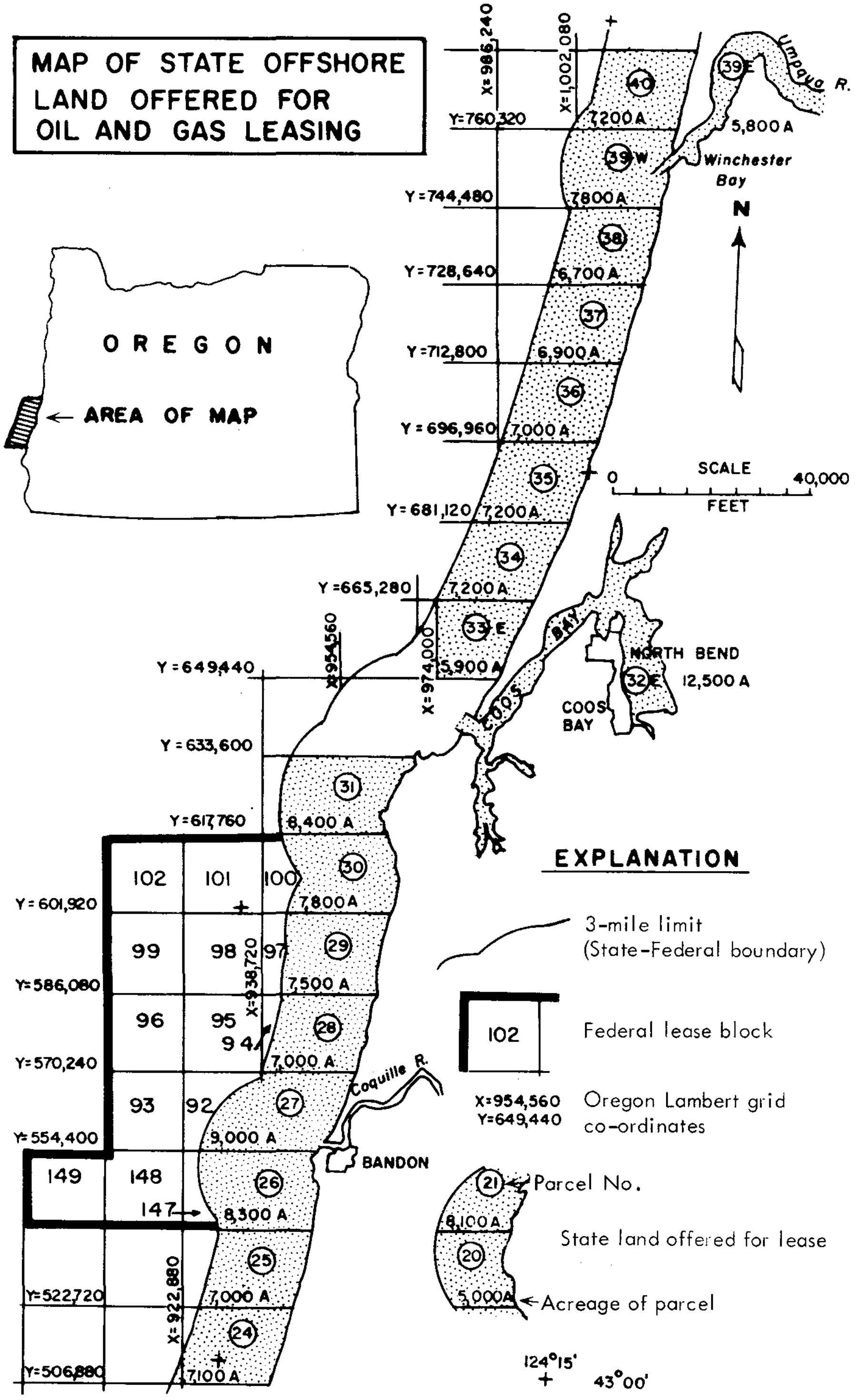
Item	Existing Situation	Dingell Bill (H. R. 9162)	Saylor Bill (H. R. 9070)	S. 4
Public Hearings, Cont.	proposals. 3-Held by House and Senate Interior Committees on national wildlife refuge legislative proposals.	to area affected and invite views on proposed action by Governor of State, governing board of each county or borough (Alaska) and federal departments and agencies concerned. Such views included with recommendations to Congress.		giving an analysis of the comparative values that may be involved as between wilderness and that type of development or uses for which the federal agency has administrative responsibility."
Land Use Commission	1-None 2-None 3-None	None provided.	None provided.	Presidential Land Use Commission established for "any State having more than 90 per centum of its total land area owned by the federal government on January 1, 1961 (Alaska). Commission "shall make recommendations to the appropriate Secretary as to how the federally owned land can best be utilized, developed, protected, and preserved." Such recommendations to accompany any recommendations to Congress.
Periodic Review	1-Periodic reviews of all resource values permitted by law in areas administered for wilderness, but not conducted in practice. 2-Same 3-Same	None provided.	None provided except for "planned, recurring" survey of mineral values by Geological Survey and Bureau of Mines. Results to be available to public and submitted to Congress.	None provided.

Compiled by:

H. R. Glascock, Jr.
Western Forestry and Conservation Association
712 U.S. National Bank Building
Portland, Oregon 97204

December 30, 1963

MAP OF STATE OFFSHORE LAND OFFERED FOR OIL AND GAS LEASING



OFFSHORE AREA SELECTED FOR LEASING

The State Land Board announced on May 24, 1964, that 16 parcels of tide and submerged land between Reedsport and Bandon, totalling 136,300 acres, would be offered for oil and gas leasing in October (see map). Bottom lands at the mouth of the Umpqua River and in Coos Bay will be open to oil and gas leasing, but no drilling will be allowed on either parcel. It will be necessary to slant-drill wells from adjacent shoreland in order to explore for oil beneath the embayments.

Oregon law requires that a public hearing be held before any offshore leases are granted so that it can be definitely determined that leasing would be in the best interest of the State. The specific date for the hearing, which will probably be some time in July, will be announced by the Land Board.

* * * * *

SEISMOGRAPH INSTALLED AT OMSI

The Oregon Museum of Science and Industry has recently completed installation of a seismograph given it by the U.S. Coast and Geodetic Survey. Installation was performed by two seismologists from Oregon State University. The delicate sensing mechanism which detects the faint tremors of the earth generated by earthquakes, storms at sea, and other vibrations, including man-made ones, is mounted on top of a 48-foot concrete column under the museum. The recording part of the machine is on display in the Industrial Wing of the building, where a visible record is traced on a revolving drum which must be changed daily.

* * * * *

NORTHEAST OREGON GROUND-WATER REPORTS PUBLISHED

Two Water-Supply Papers recently issued by the U.S. Geological Survey describe the geology and the ground-water potential of large areas in northeastern Oregon. Water-Supply Paper 1597, "Geology and ground-water resources of the upper Grande Ronde River basin, Union County," by E. R. Hampton and S. G. Brown, covers most of Union County. Water-Supply Paper 1620, "Geology and ground water of the Umatilla River basin, Oregon," by G. M. Hogenson, covers large parts of Umatilla and Morrow Counties. Geologic maps and well records are supplied with each paper. Both reports are for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., 20402. The price has not yet been announced.

* * * * *

PENDING MINING LEGISLATION

H.R. 10892 - Federal Purchase Program for Domestic Manganese - Clark, (Pa.). Committee on Interior and Insular Affairs. Would direct the Secretary of the Interior to make a survey of the domestic manganese mining industry and determine the price required to be paid to domestic producers in order to achieve maximum production of manganese from mines in the United States and thereby diminish or eliminate reliance on supplies from foreign sources.

Would also direct the Secretary to establish a program for the purchase and resale of domestic produced manganese. Purchases would be at the price or prices determined by the Secretary. Sales would be at public auction in accordance with regulations established by the Secretary.

S. 2764 - Amend Mining Laws--Validity of Claims - Cannon (Nev.) and Goldwater (Ariz.). Committee on Interior and Insular Affairs. Would provide that a "valuable mineral deposit" within the meaning of the mining laws can be proved by establishing that such deposit was marketable at the time application for patent was made. It would apply only to claims located prior to July 23, 1955, the date of enactment of Public Law 167, which removed common varieties of several minerals, including sand and gravel, from the purview of the mining laws.

S. 2765 - Amend Mining Laws--Sand and Gravel - Cannon (Nev.), Goldwater (Ariz.) and Mechem (N.M.). Committee on Interior and Insular Affairs. Would provide that deposits of sand and gravel which can be mined, processed and marketed for use as high-grade construction aggregates are locatable under the mining laws.

H.R. 8305 - Notification of Public Land Actions - Aspinall (Colo.) Leg. Bull. 64-3, p. 3. In Senate Interior Committee following House passage April 6.

Would provide that until June 30, 1968, the Secretary of the Interior may not effect a withdrawal, reservation, restriction, or change in use designation or classification involving more than 2,560 acres of public lands until after the expiration of 60 days from the date upon which detailed information concerning the proposed action is submitted to Congress. Similar notice would be required before the Secretary of Agriculture could effect any formal classification or designation of national forest lands involving 5,000 acres or more. (American Mining Congress Legislative Bull . No. 64-4, April 30, 1964)

* * * * *

ASTORIA FORMATION WORK PUBLISHED BY SURVEY

An important contribution to Oregon geology recently issued by the U. S. Geological Survey is Professional Paper 419, "Miocene marine mollusks from the Astoria Formation in Oregon," by Ellen James Moore. In this comprehensive work, Mrs. Moore has brought together all available information on the geology and paleontology of the Miocene Astoria Formation. She has restudied old fossil collections of early workers and has added new material she obtained from dredgings in Coos Bay, where Miocene rocks were not previously known. The 109-page publication has an additional 32 pages of photographs of fossils. It also includes columnar sections of the Newport area and a check list of fossils from 187 localities along the coast between the Astoria area and Coos Bay. The report may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington D. C., 20402. The price is $2.75.

Recommended as a supplement to Professional Paper 419 is the report by Betty Rae Dodds, "The relocation of geologic locales in Astoria, Oregon," which was published in the July 1963 ORE BIN after Mrs. Moore's report had gone to press.

* * * * *

BOHEMIA DISTRICT MINES TO BE DIAMOND DRILLED

Federal Resources Corp. of Salt Lake City has entered into an agreement with Lane Minerals, Inc., of Cottage Grove to explore mines and prospects located on a total of 156 patented and unpatented mining claims in the Bohemia mining district southeast of Cottage Grove in southern Lane County. The district has been a sporadic producer of gold, silver, copper, lead, and zinc since it was discovered in 1858.

Heavy snows in the hills in the Bohemia district will delay any serious work until at least June 1, when surface and underground exploration, including diamond drilling and tunneling, will get under way. Mines involved in the program are the Champion, Evening Star, Musick, and numerous other smaller mines and prospects.

Strengthening prices for silver, copper, lead, and zinc are furnishing the incentive for the exploration program by Federal Resources. The company has been a major uranium producer in the Southwest and has recently diversified into the production of other metals.

* * * * *

AMERICAN MINING CONGRESS CONVENTION

Portland, Oregon September 13 - 16, 1964

BARTER FOR CHROME ORE AND FERROCHROMIUM

The Department of Agriculture has invited U. S. firms to submit barter offers for metallurgical-grade chrome ore mined in and exported from Turkey, and high- and low-carbon ferrochromium produced in the United States from chrome ore or concentrates produced in Turkey. Deadline for submission of offers is April 6.

The project will provide for exchange of about 100,000 long dry tons of metallurgical-grade chrome ore from Turkey and about 7,500 short tons each of high- and low-carbon ferrochromium for equivalent value of Commodity Credit Corporation-owned agricultural commodities specified in the invitation for export to Finland, Yugoslavia, Poland, and Israel. Subject to prior CCC approval, commodities may be shipped to other countries under conditions also outlined in the invitation. (AMC News Bulletin No. 64-7, March 26, 1964)

* * * * *

ASH GROVE LIME & PORTLAND CEMENT CO. PLANT OPENS

The world's newest and most fully automated lime plant went into production in Portland on April 29. Ash Grove Lime & Portland Cement Co. of Kansas City, Missouri, built the $3 million plant which uses high-calcium limestone imported from Texada Island, British Columbia. One of the unusual features of the plant is the vertical axis rotary hearth, which is used instead of the normal horizontally revolving kiln. Uniform quality is obtained by automatic controls which adjust the speed of rotation, depth of the bed, and heat from the gas burners.

Burned lime has been used by man since early historical times. Today lime is utilized in metallurgical processes, water treatment, wood pulp production, leather manufacture, paint production, and numerous other applications.

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NOTICE: The List of Available Publications shown on the inside back cover of the April to June issues of The ORE BIN has been out-moded. For the current list of Short Papers, please refer to the outside back cover. Bull. 50 is out of print; Bull. 52 is available at $3.50; Bull.53, Third Supplement to the Bibliography, is $1.50; Bull. 54, Thirteenth Biennial Report, is free; and Bull. 55, Quicksilver in Oregon, $3.50.

The ORE BIN
Volume 26, No. 6
June, 1964

GEOLOGIC ADVENTURES ON THE LOWER ILLINOIS RIVER, SOUTHWESTERN OREGON

By Len Ramp*

This is the account of a 35-mile boat trip down the lower Illinois River through a rugged and primitive part of southwestern Oregon that few people have seen. The trip was made by Eugene W. Schaffer, Jr.,** and the writer in September 1963, using a 6-man rubber life boat generously loaned by Les Saffer of Selma, Oregon.

The purpose of the trip, in addition to exploring a remote area, was to observe the geology along the canyon walls of the Illinois and to obtain sand samples from tributary streams for geochemical analysis. The sampling is part of a long-range geochemical program being conducted by the Department, results of which will be reported at a later date.

Geology and Accessibility

The lower Illinois River generally flows northwesterly through a remote and mountainous region before it joins the Rogue River at Agness. This region is underlain chiefly by metamorphic rocks of Late Jurassic age, intruded by Late Jurassic to Early Cretaceous ultramafic to granitic rocks. Geologic mapping in the lower Illinois River area east of 124° longitude has been done in fair detail by Wells and others (1948) (see accompanying geologic map). The southwestern part of the area has been mapped on a reconnaissance basis by Wells and Peck (1961) and the northwestern corner by Diller (1914).

Much of the lower Illinois River is either inaccessible or very difficult to reach. From Selma, on U.S. Highway 199, a road extends downstream 18 miles to the vicinity of Oak Flat. From Agness, at the mouth of the Illinois River, a road leads upstream 3 miles to a point near Nancy Creek. A trail connecting these two points follows the river in part, but between Pine Flat and Collier Bar the trail rises over Bald Mountain, leaving a

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* Geologist, Oregon Dept. Geology & Mineral Industries, Grants Pass.
** Student, University of Oregon.

14-mile stretch of river completely isolated except by boat (see map).

Between Oak Flat and Agness the Illinois drops approximately 750 feet or an average of 22 feet per mile; however, in a 2-mile stretch southwest of South Bend Mountain the drop is 100 feet. The average rate of discharge as measured on the Illinois near Agness for the 3-year period 1961 through 1963 was 4,000 cubic feet per second, according to the Surface Water Branch of the U.S. Geological Survey.

Early Explorers

The first gold mining in southwestern Oregon was probably done at the mouth of Josephine Creek on the Illinois River in the summer of 1850. Gold was discovered there by a party of prospectors from California, some of whom were originally from Illinois, for which state the river was named (Spreen, 1939). It wasn't until 1852, when gold was discovered on Jackson Creek in Jackson County, that the gold rush into southwestern Oregon began. Gold miners then prospected all of the tributaries of the Rogue and Illinois Rivers, especially those down stream from important placers such as Sailors' Diggings at Waldo and the gravels of Josephine Creek.

These early prospectors found rich gold placers along Briggs Creek and tested each tributary that entered the lower Illinois down stream eagerly searching for "colors." Access to the area was along Indian and deer trails and creek beds. They named Yukon, Klondike, and Nome Creeks after the famous northern rivers in the hope that the same kind of gold discoveries would be made, but except for the placer gold in the headwaters of Silver Creek and a few isolated bars along the main river, such as at Clear Creek, their findings were disappointing.

The first boating venture by white men down the Illinois River was made by three prospectors in August 1857. Their boat was built of hand-hewn Port Orford cedar and was launched at the mouth of Rancherie Creek, which joins the Illinois about 5 miles above Oak Flat. The account of this expedition (published in the Grants Pass Courier April 25, 1924 and in a special edition April 2, 1960) is told by Dan L. Green, first sheriff of Josephine County, who made the trip with Captain O. T. Root and a sailor named Fisher. Green tells of their unsuccessful hunt for gold, various encounters with Indians, and the loss of supplies and equipment when their boat swamped in rapids. He mentions seeing many deer, elk, and large, black timber wolves.

Since those early days, the area has been explored intermittently and with difficulty by prospectors, geologists, and other adventurers.

Account of the 1963 Boat Trip

As nearly as can be determined from available records, ours was the eighth boat trip down the Illinois River since Captain Root's expedition 106 years ago. The low water of late summer made necessary more portages than would have been required earlier in the season, but a larger stream flow would have greatly increased the turbulence and of course the hazards. The rubber boat proved to be a most satisfactory means of transportation.

Forty-four samples of sand collected from tributary streams are now being analyzed in the Portland office for traces of copper, zinc, and molybdenum. If anomalous amounts of any of these indicator metals are found, the sample source will be investigated further.

From field notes and data plotted on quadrangle maps during the trip, together with a later study of aerial photographs, it was possible to make slight revisions in previous geologic mapping and add some new information for the area west of 124° longitude, where only reconnaissance work had been done.

A daily record of the boat trip and the geology encountered between Oak Flat and Agness follows.

First day (Tuesday,.September 10):

Norman Peterson, geologist at the Department's Grants Pass office, drove Gene Schaffer and me down the Illinois River to the end of the road at Oak Flat and arranged to meet us at Agness on Friday evening, 3½ days and 35 miles later.

We packed our bedding, food, and equipment in water-proof plastic bags and stacked them on inflated air mattresses on the floor of the rubber boat. About 2:30 o'clock in the afternoon we finally got under way in our flimsy little craft.

Geologically, we started out near the west edge of the small granodiorite stock which underlies the Oak Flat area. Soon we were looking up at a slightly older, darker, and more resistant hornblende diorite (see geologic map and cross section). These rocks stand in bold relief and in most places form very steep canyon walls. Most of the hornblende diorite (as it is mapped by Wells and others, 1948) is gneissic and in places appears to be recrystallized. The gneissic banding is variable, but generally it dips steeply and strikes northerly. The canyon walls weather to steep rugged slopes with jumbled boulders and talus at the base. Dense timber covers the south walls of the canyon, but vegetation is sparse on the north side (south slope) with the exception of lush, large-leaved water plants ("wild rhubarb") which mark locations of side streams and springs.

When taking sand samples from some of the small side streams it was necessary to climb steep canyon walls to reach their hanging valleys above flood-stage deposits of the main stream. Only the larger, heavier-flowing tributaries have kept pace with downcutting erosion of the main canyon.

During the first day we covered a little less than 3 miles, and set up our camp just before dark on a gravel bar a short distance upstream from Hayden Creek (see map). That first afternoon we had encountered an average of four difficult-to-impassable riffles per mile of river and found it necessary to make portages just below Panther Creek, at Nome Creek, and near our first night's camp site. The other riffles were shallow and by wading, lifting, pushing, and roping through swift, more hazardous stretches, we managed without unloading the boat. From the first day's progress, we realized it was going to be difficult to go the planned distance in the allotted time.

Second day (Wednesday, September 11):

About noón on the second day we arrived at Clear Creek. Here we met Mr. Noble, an elderly prospector who lives alone in a cabin on a mining claim at the mouth of the creek. He was the only person we were to see for four days.

Continuing downstream to Pine Flat, we came to a light-colored, coarse-grained granodiorite similar to that exposed at Oak Flat. The less resistant granitic rock accounts for the flat areas where gravel bars are built up on both sides of the river (see Figure 1). Pine Flat was named by Captain Root, member of the first boat expedition. In those days the flat area was covered with grass and tall pine trees. The remains of an early settlement are located on this flat. According to Josephine County records, M.D.Weaver patented the property as a homestead in 1919. He first raised pigs and later cattle. He sold the property in 1939.

Some curious otters watched us as we worked our way through the rapids above Pine Creek. For the next two days of our journey the otters kept popping up to watch us and sound their shrill whistles. We enjoyed their elusive company and amusing appearance, but we had the feeling they were just waiting for us to capsize so they could have a good laugh.

Downstream from the Pine Flat gravel bars dark green to black altered basaltic rocks of the Dotham Formation are exposed. There are also boulders of bright-red chert in a landslide block of reddish-brown brecciated basalt just below Florence Creek. Some polishing quality red jasper with green tint was also found at this location.

We covered a distance of 6 miles this second day and the going was equally as rough as on the previous afternoon, with numerous difficult rapids.

Our Wednesday night camp was on a gravel bar at the mouth of Klondike Creek. Plenty of dry, flood-deposited driftwood was available for our campfire.

Third day (Thursday, September 12):

Before starting out Thursday morning, we patched the existing holes in our boat. Then, using some poles and old boards containing nails that we found in the driftwood, we improvised a rack to hold our gear off the bottom of the boat to lessen the chances of punching more holes.

Below Klondike Creek the river has carved a rugged and beautiful canyon in massive graywacke sandstones, typical of the Dothan Formation. We drifted along magnificent stretches where deep placid pools mirrored the bold rocks, dense timber, and the sky. Between stretches of quiet water there were treacherous, thundering rapids which required that we either rope through or portage around (see Figure 2). On one occasion we unexpectedly careened off a rock and were whipped backwards over a small waterfall formed by a log. Except for shipping some water, we came through the breath-taking experience undamaged.

We covered nearly 8 miles on Thursday. From Klondike Creek we worked our way down river to the northwest for about 3 miles, then around a bend to the southwest. Here the river follows the strike of the Dothan Formation for about 4 miles; its southerly course is controlled by a less resistant horizon of interbedded siltstone and sandstone dipping steeply eastward. The interbeds of dark siltstone looked favorable for fossils, but we were unsuccessful in finding any.

Massive graywacke sandstone of the Dothan Formation crops out in the steep bluffs on both sides of the river and underlies South Bend Mountain, a high, timbered ridge paralleling the river to the west.

At the south end of South Bend Mountain the river again turns northwestward abruptly and crosses the massive Dothan sandstone, which in this area contains some lenses of highly resistant chert. Downstream from the turn we found the steep and narrow canyon so choked with large boulders that it was nearly impassable. The boulders, some as much as 30 feet in diameter, are remnants of recent landslides which brought large quantities of rock and earth into the gorge and nearby tributary streams. We had been through many tough places before this point, but so far this was the most difficult part of our strenuous trip. The footing was precarious as we crawled and slipped between, over, and around the wet boulders. After a portage of 1,000 feet we set up our camp for Thursday night at a point about 1 mile downstream from the river bend. We noted large, fresh tracks of a lone wolf cutting across the sand near our campsite. The sky was overcast and we expected rain, so we fashioned a tent by setting the boat on edge and fastening a 10-by-12 foot plastic tarpaulin to it. If our four-footed friend returned to look us over that night, we were too tired to care.

Fourth day (Friday, September 13):

Friday the 13th turned out to be the toughest day of all. We were under way by 8:30 a.m. and by 6:30 p.m. we had covered only 4 miles. The first mile took most of the day. We lost track of the number of portages that we were forced to make in this area of steep stream gradient and clusters of huge boulders.

About a mile upstream from Collier Creek we noted a definite change in the Dothan Formation. We were now traversing an area where, as mentioned earlier, only reconnaissance mapping had been done. As we progressed westward, the rocks were more highly fractured and altered to greenstone, probably representing in part altered lavas of the Dothan Formation. The rocks gradually became more impregnated with white seams of quartz, feldspar, sericite, and saussurite(?). In the vicinity of Collier Creek and Collier Bar (see Figure 3) the rock has been altered to gneiss containing many narrow seams and dikes of diorite which may represent completely recrystallized portions of the original rock or perhaps fingers of primary igneous rock injected from an underlying magma. These rocks are believed to be a northern extension of those exposed in the Big Craggies, called "Craggy gneiss" by Butler and Mitchell (1916) and classified as "gneiss and schist derived from the Dothan Formation" by Wells and Peck (1961). A more careful study of exposures along this part of the river may reveal the true relationship of this gneiss to the Dothan Formation.

Extremely weary, we set up camp at nightfall on the east bank of the river 1 mile downstream from Collier Creek, knowing that Norm Peterson was looking for us at Agness. Our food supply was getting low and we still had more than 12 miles to travel.

Fifth day (Saturday, September 14):

Fortunately, the going was easier on this day and we ran the rapids with the growing confidence of experience. In calmer stretches it was necessary to paddle steadily to overcome an increasing upstream breeze.

This final lap of the trip took us through some of the more interesting geology and past the only mineralized area seen. Two patches of red iron-oxide stain exposed on the east bank of the river 1½ miles downstream from Collier Creek mark the location of mineralization. At the first area of coloration, which is about 40 by 50 feet in size, we noted massive lenses

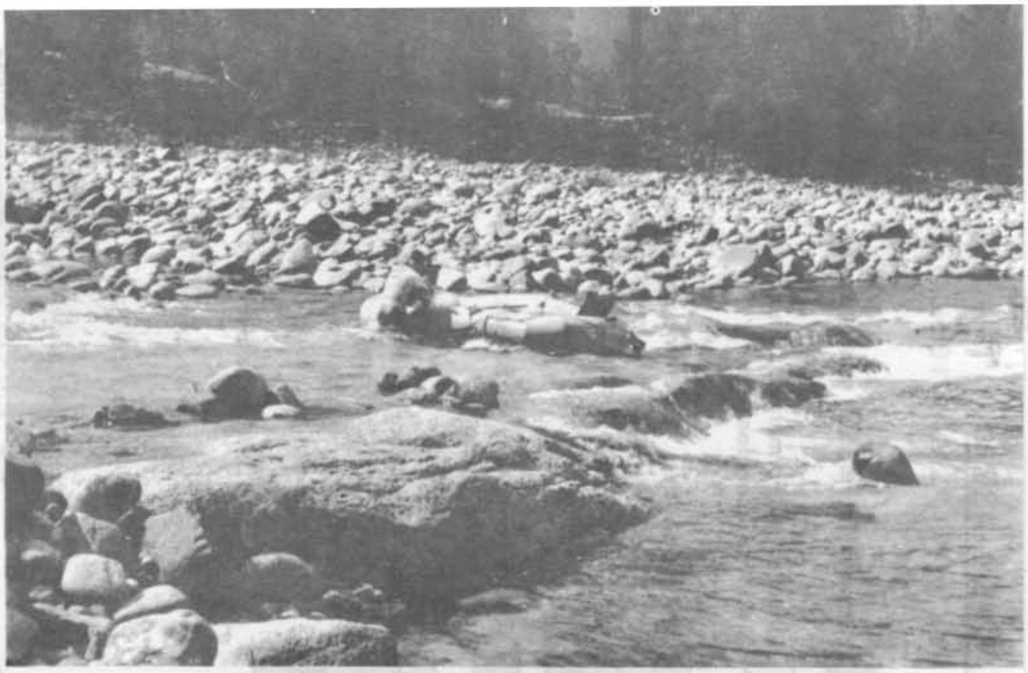
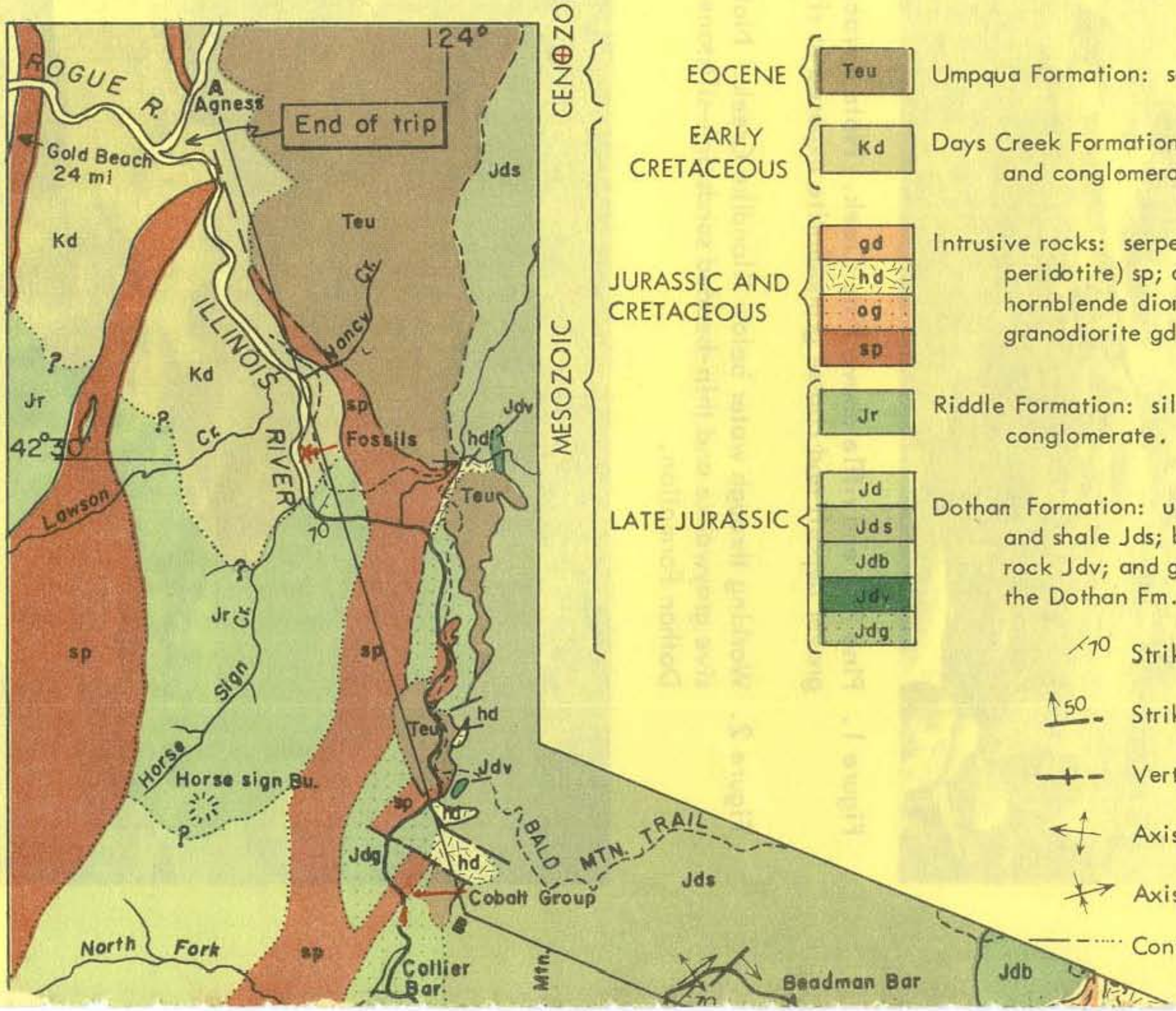


Figure 1. Pine Flat and riffle above Pine Creek. Note terrace gravel deposit and coarse granodiorite exposed in river.

Figure 2. Working through water below Klondike Creek. Note massive graywacke and thin-bedded sandstone-siltstone of Dothan Formation.

GEOLOGIC MAP — LOWER ILLINOIS RIVER AREA



EXPLANATION

CENOZOIC	EOCENE	Teu	Umpqua Formation: sandstone and conglomerate
MESOZOIC	EARLY CRETACEOUS	Kd	Days Creek Formation: sandstone, siltstone, and conglomerate
	JURASSIC AND CRETACEOUS	gd hd og sp	Intrusive rocks: serpentine (includes peridotite) sp; olivine gabbro og; hornblende diorite hd; and granodiorite gd.
		Jr	Riddle Formation: siltstone, sandstone, and conglomerate.
	LATE JURASSIC	Jd Jds Jdb Jdv Jdg	Dothan Formation: undifferentiated Jd; sandstone and shale Jds; basalt Jdb; altered volcanic rock Jdv; and gneiss (possibly altered from the Dothan Fm.) Jdg.

70 Strike and dip of beds

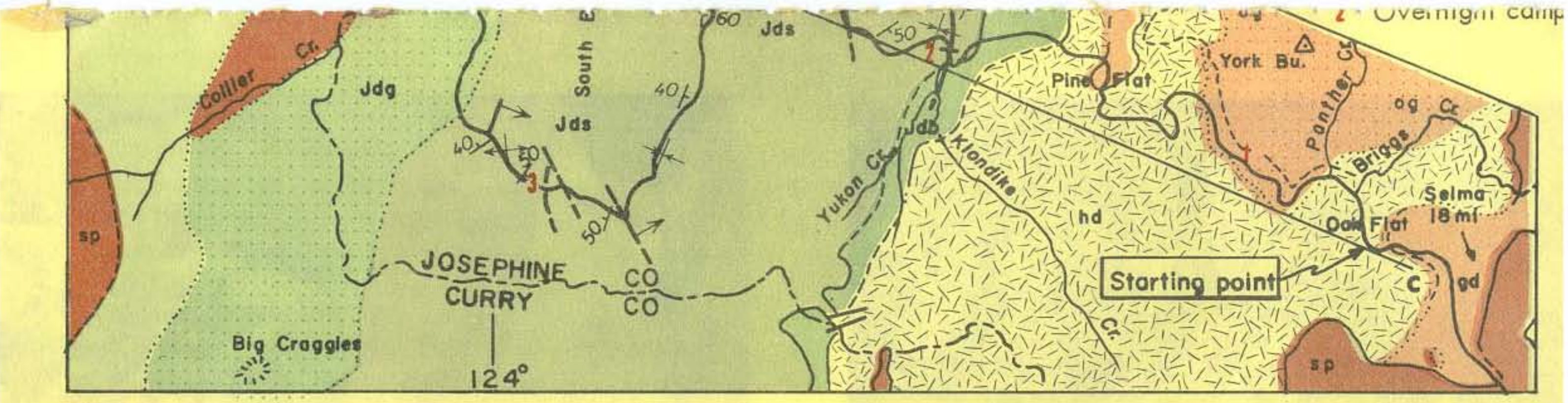
50 Strike and dip of fault

Vertical fault

Axis of anticline showing plunge

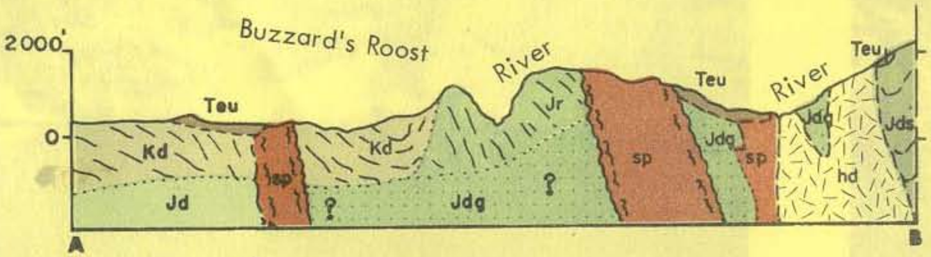
Axis of syncline showing plunge

Contact dashed where approximate; dotted where inferred.



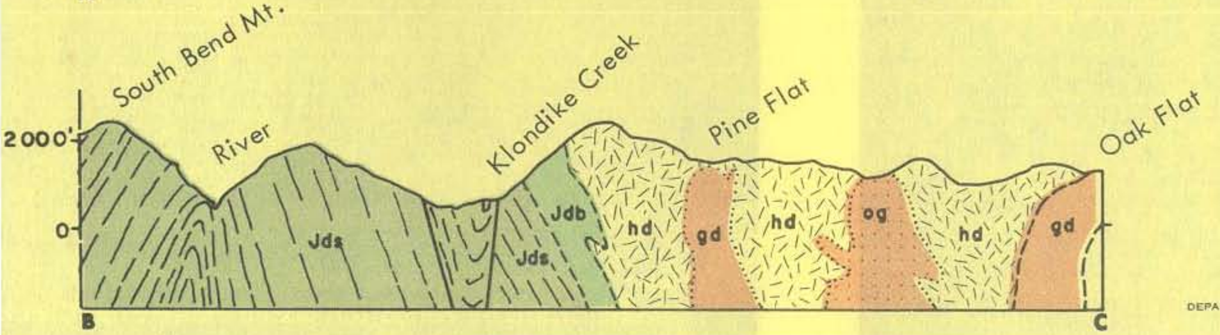
GENERALIZED GEOLOGIC SECTIONS

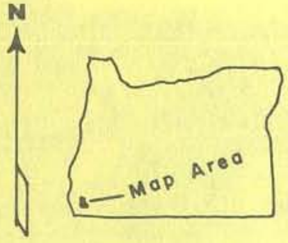
Adapted from:
Diller, 1903
Wells, Hotz, and Cater, 1949
Wells and Peck, 1961



1 2 3 4 5 miles

Vertical scale exagerated 2 ½ times





Map prepared by
STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

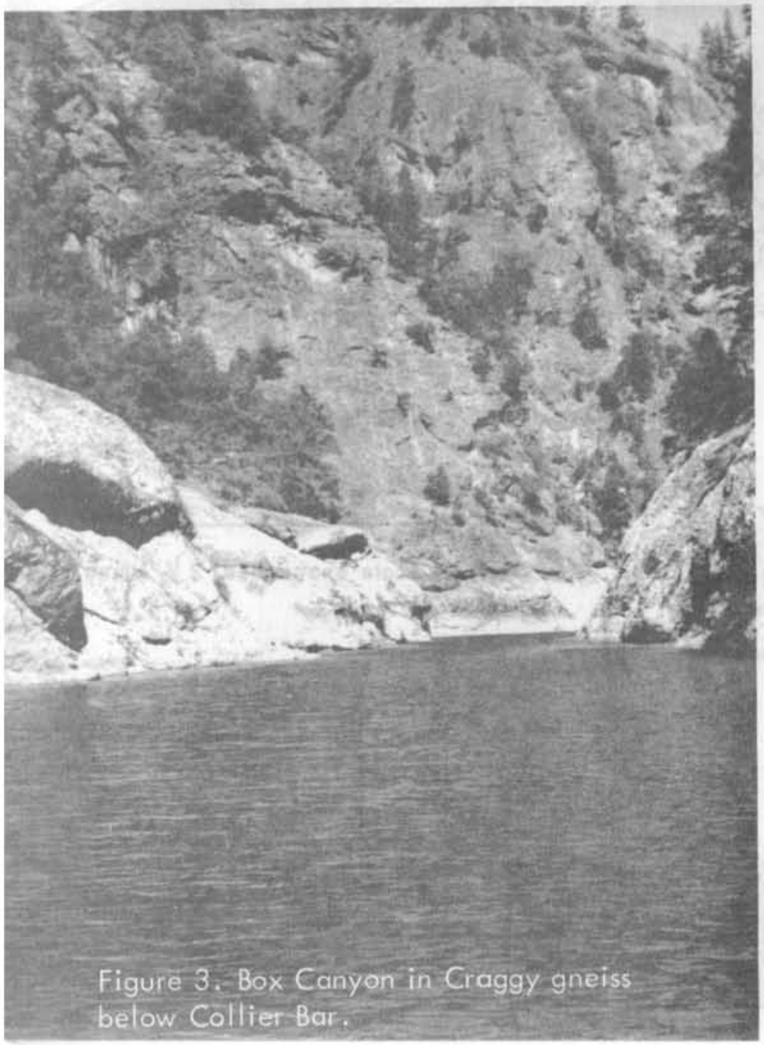


Figure 3. Box Canyon in Craggy gneiss below Collier Bar.

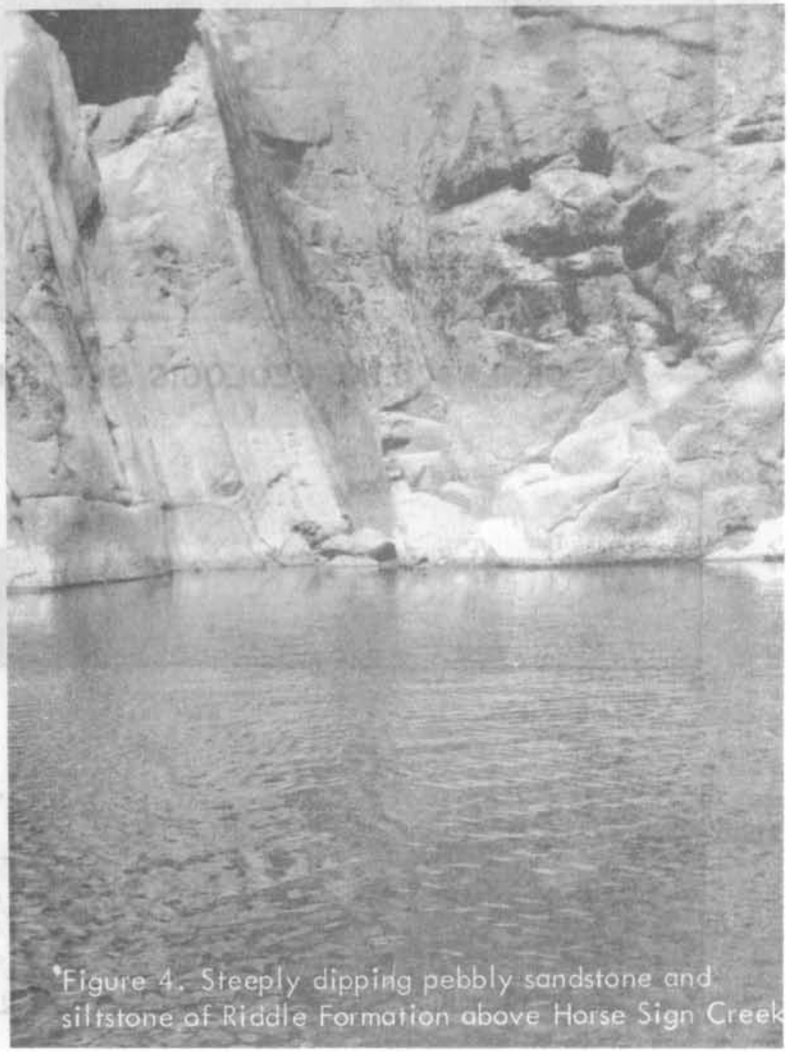


Figure 4. Steeply dipping pebbly sandstone and siltstone of Riddle Formation above Horse Sign Creek

and streaks of sulfides (largely pyrrhotite) as much as 4 feet thick, interspersed with disseminated pyrite and chalcopyrite in a siliceous matrix. A short distance downstream to the north a more extensive area of iron-oxide stain, which we did not examine, crops out in the steep bank in the form of a lens-shaped body about 50 by 175 feet in size.

The mineralization occurs in or near the contact of serpentine and gneiss and is undoubtedly part of a larger deposit described as the Cobalt Group by Parks and Swartley (1916). A sample of sulfide-bearing rock (P-20998) reportedly taken from this occurrence by a prospector in 1957, assayed 0.20 percent copper and traces of gold, nickel, and cobalt.

About 3 miles downstream from Collier Creek we came to a nearly horizontal sandy conglomerate lying unconformably on the eroded top of the gneiss and serpentine. Where viewed, the formation has a northerly strike and gentle dip west. Wells and others (1949, p. 15) map and describe similar sedimentary rocks nearby on the east side of the river in the northwestern edge of the Kerby quadrangle as belonging to the Arago group (Umpqua equivalent) of Eocene Age.

Serpentine exposed near the mouth of Indigo Creek is highly sheared and probably represents a fault zone. Between Indigo and Horse Sign Creeks we noted steeply dipping marine sedimentary beds of the Late Jurassic Riddle Formation consisting largely of sandstone, siltstone, some pebbly sandstone, and conglomerate (see Figure 4).

Near Horse Sign Creek, the approximate contact of the Riddle and Days Creek Formations, we found a few fragmentary fossil gastropod and pelecypod shells, but did not make a collection. Norm Peterson, who walked up to Horse Sign Riffle looking for us Friday evening, collected some specimens of the pelecypod *Buchia crassicollis* (Keyserling) from a point on the east side of the river about half a mile downstream from Horse Sign Creek. Imlay and others (1959) assign sedimentary rocks in southwestern Oregon containing *Buchia crassicollis* (Keyserling) to the Early Cretaceous Days Creek Formation. Wells and Peck (1961) map both the Riddle and Days Creek Formations (subdivisions of the Myrtle Group) along the Illinois River south of Agness. Both the Riddle and Days Creek Formations dip steeply and in places appear to be overturned.

Just before dark on Saturday we made one last portage over the temporary fill where the new bridge is being constructed across the mouth of the Illinois River. Tired, cold, wet, and looking like a couple of unkempt prospectors, we entered the Larry Lucas Lodge at Agness. Norm Peterson apparently had complete faith in our ability to reach our destination, for the owners of the lodge were expecting us and greeted us with warm hospitality and an abundance of good food, which, needless to say, we thoroughly enjoyed.

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* * * * *

WILDERNESS BILL PASSES HOUSE COMMITTEE

The House Interior Subcommittee on Public Lands has passed H.R. 9070 (see May ORE BIN) for a National Wilderness Preservation System.

* * * * *

AMERICAN MINING CONGRESS CONVENTION

September 13-16, 1964

PORTLAND, OREGON - "WORLD SEAPORT OF THE PACIFIC"

HATFIELD CHAIRMAN OF 1965 CONFERENCE

Governor Mark O. Hatfield (Oregon) was elected chairman of the Western Governors Conference for 1965 at the Western Governors Conference held May 3-6 in San Francisco, California. The 1965 meeting will be held in Portland June 10-12

The San Francisco meeting passed 20 resolutions, of which seven dealt directly with the mineral industry. The longest, which came out of Governor Hatfield's Committee on Natural Resources, is as follows:

1. Destruction or impairment of any natural resource value in the exploration, development or use of another resource should be avoided as much as possible or in any case be kept to an absolute minimum.

2. Development of material resource values can be compatible with enjoyment of scenic and recreational opportunities, if such development is properly planned to accomodate these and other competing uses.

3. Public land policies should guarantee, insofar as is possible, full and continuous resource use for the benefit of all the people.

4. There should be no unnecessary restrictions upon access to or use of public lands for natural resource exploration, development or use. Any restrictions should be clearly in the broad public interest. Appropriate legislation should be enacted to increase the area of public lands that may be held under federal lease for both phosphate and coal.

5. Pending completion of the public lands study, interim public lands legislation should be enacted to resolve certain critical problems such as:
    a. Pre-discovery protection under the mining laws.
    b. Congressional review of administrative agency proposals for substantive changes in public land use.

6. Legislation should be enacted to:
    a. Increase the percentage depletion allowance rate on gold from 15 percent to 23 percent.
    b. Remove the present limitation that such allowance shall not exceed 50 percent of the taxpayer's taxable income from the mining property.

Other resolutions of interest to the mining industry concerned royalties, oil shale, silver, silver dollars, safety, and sand and gravel.

Just prior to the Western Governors Conference, the Western Governors Mining Advisory Council (DeWitt Nelson, Chairman, California)met in San Francisco in order to work with the Conference.

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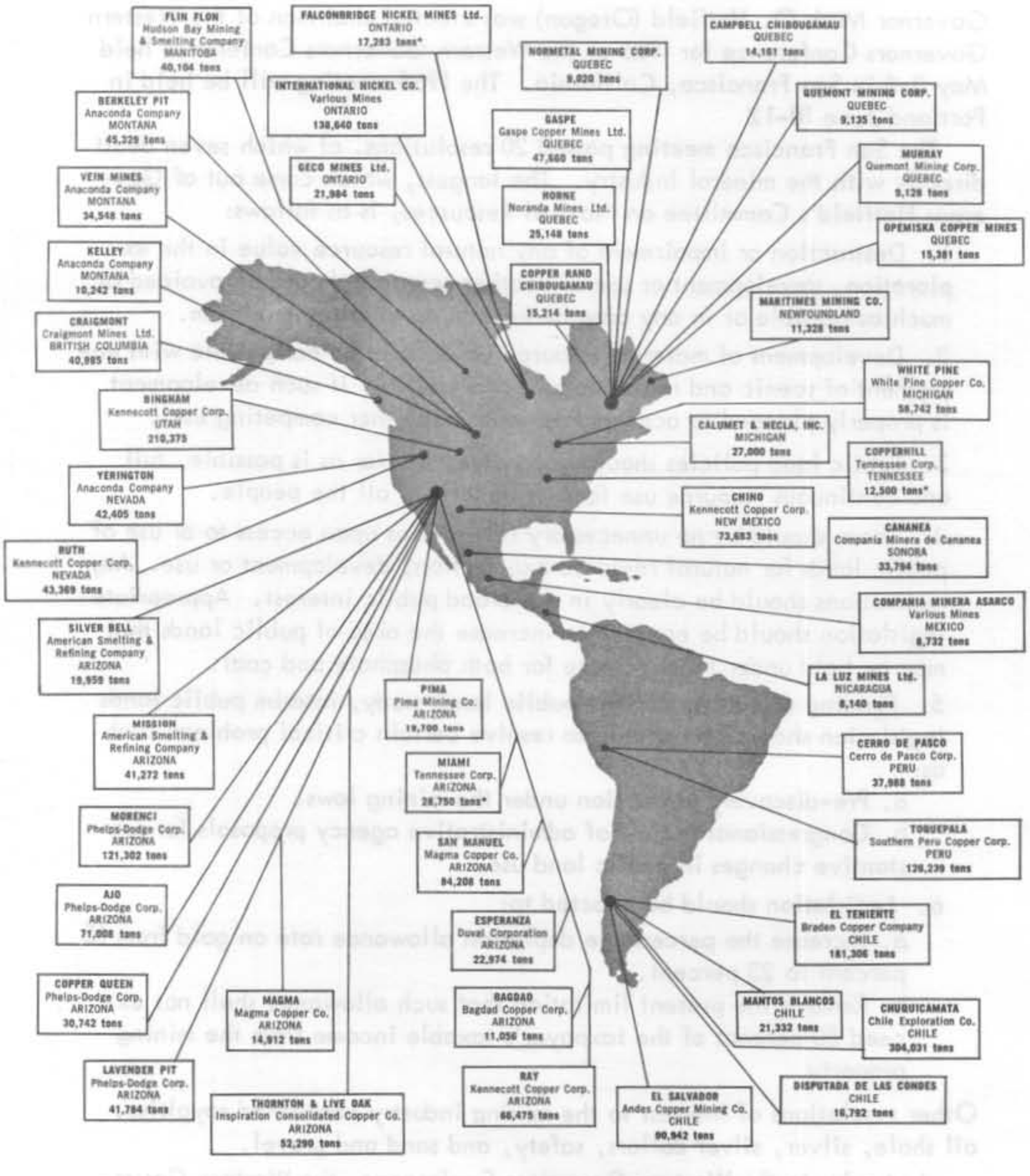
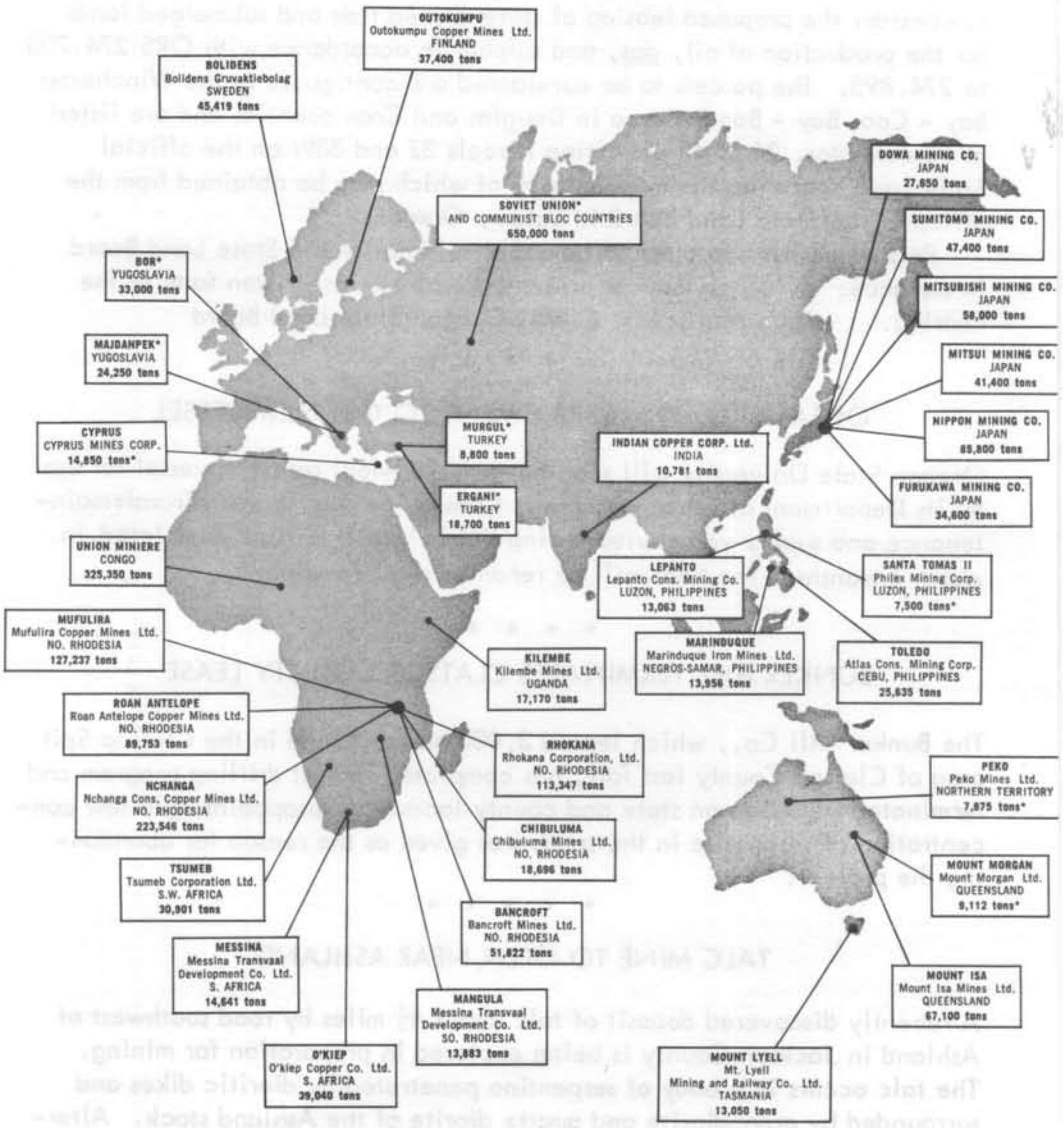
PRINCIPAL COPPER PRODUCERS



Map shows 1962 copper production of mines producing 7,500 (or more) short tons of metal in concentrates (Courtesy of American Cyanamid Co., New York).

OF THE WORLD IN 1962



NOTICE OF PUBLIC HEARING

Notice is hereby given of a public hearing to be held beginning July 28, 1964, at 10 a.m. in the Council Room of the City Hall, Coos Bay, Oregon, to consider the proposed leasing of state-owned tide and submerged lands for the production of oil, gas, and sulphur in accordance with ORS 274.705 to 274.895. The parcels to be considered are contiguous to the Winchester Bay - Coos Bay - Bandon area in Douglas and Coos counties and are listed as Parcels Nos. 24 to 40 excepting Parcels 32 and 33W on the official State Land Board leasing map, a copy of which may be obtained from the office of the State Land Board in Salem, Oregon.

Persons desiring to offer testimony should notify the State Land Board in advance. Evidence may be presented orally or in written form at the hearing. Dale Mallicoat, Clerk, Oregon State Land Board

* * * * *

OCEANOGRAPHY DEPARTMENT TO GET NEW VESSEL

Oregon State University will soon have an 180-foot research vessel for use by its Department of Oceanography. Conversion of a former aircraft maintenance and supply vessel used during World War II will be completed in about 4 months. The boat will be renamed the "Yaquina."

* * * * *

BUNKER HILL TERMINATES CLATSOP COUNTY LEASE

The Bunker Hill Co., which leased 3,000 acres of land in the Clatsop Spit area of Clatsop County last fall, has completed its test drilling program and terminated its leases on state and county lands. A disappointingly low concentration of magnetite in the sands was given as the reason for abandoning the project.

* * * * *

TALC MINE TO OPEN NEAR ASHLAND

A recently discovered deposit of talc about 4½ miles by road southwest of Ashland in Jackson County is being explored in preparation for mining. The talc occurs in a body of serpentine penetrated by dioritic dikes and surrounded by granodiorite and quartz diorite of the Ashland stock. Alteration of the serpentine along the dikes has produced the talc which in some places is 4 feet wide. The property is owned by L. A. Bratcher, Ashland, a well-known mine operator. Tom Carrithers, Santa Cruz, California, is doing the exploration work.

* * * * *

The ORE BIN
Volume 26, No. 7
July, 1964

THE PORT ORFORD METEORITE*

by

E. P. Henderson
Associate Curator in Charge of Division of Meteorites
U.S. National Museum, Smithsonian Institution, Washington, D.C.
and
Hollis M. Dole
State Geologist, Oregon Department of Geology and
Mineral Industries, Portland, Oregon

Introduction

From a confusing assemblage of notes and letters of Dr. John Evans comes a report of the existence of a large meteorite in the Port Orford area of southwestern Oregon. Dr. Evans, a geologist-explorer employed by the U. S. Government, conducted a survey of the Washington and Oregon Territories between 1851 and 1856. His final Oregon trip, made in 1856, was to Coos Bay and Port Orford on the southern Oregon coast.

Since 1859, when his discovery was made public, probably several hundred field parties have attempted to locate this meteorite. It is not surprising that none of the searches have been successful, for Dr. Evans' log of his trip makes no mention of a meteorite, and his directions in letters written after he returned to Washington, D. C., are vague and somewhat contradictory. For that matter, when Evans recalled the dimensions of the meteorite, he prefaced his remarks with this phrase: "I cannot speak with certainty." A critical analysis of the meager and conflicting data could well lead one to consider the possibility that the large mass commonly referred to as the "Port Orford meteorite" is a myth.

Several times within the past half century the phantom of this meteorite has been revived by printed articles. Hollister, 1963, wrote as follows:

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* Published with the permission of the Secretary of the Smithsonian Institution.

"The Port Orford meteorite isn't the product of a sun-struck prospector's dream and it hasn't been spirited away. The searchers keep returning because they know a pallasite[1/] is still there. Because somewhere in the western slope of southern Oregon mountains lies an eleven-ton rock from outer space worth anywhere up to $2,200,000, and that evaluation in 1937 dollars. Today, thanks to inflation, the finder might even have a couple of million left for his pocket after squaring with Uncle Sugar."

Exaggerated statements, like the above, excite the public and encourage persons to undertake trips which expose them to physical hardships and to financial expenses they cannot afford.

Many of the accounts about this meteorite were written to stimulate the reader's imagination and to develop a desire to search for it, but these reports failed to give the reader the full facts. The majority of those who have searched for this meteorite would not have recognized it even if they had walked over it

Between 1938 and 1950 Prof. J. H. Pruett got a "lot of mileage" out of some rather careless writing about the Port Orford meteorite. The press may have asked him to prepare a popular article; if so, it was logical for him to discuss an Oregon meteorite for Oregon readers. Without question, Prof. Pruett was responsible for much of the interest in this meteorite, but if he had never written about it, someone else would have done so. Pruett over-simplified the difficulties of finding the meteorite and played upon people's desires to gain fame by finding a rare object and be rewarded for the effort. There were errors in Pruett's reports which have become magnified through retelling.

La Paz (1951) noted errors, but unfortunately not enough attention has been given to his critical review of Pruett's articles. Pruett's errors were: (1) the date given for the discovery of the Port Orford meteorite; (2) the year that Dr. Evans died; (3) the weight of the specimen in the U.S. National Museum; and (4) the statement that the Smithsonian Institution had offered $1 per pound for almost any kind of meteorite.

Since we have criticized others, we must not overlook our part in what has happened. For years Henderson has felt rather strongly that the public has been misled by one-sided reports about the Port Orford meteorite. Although he has stated his views in scores of letters, these were not published. This was a mistake.

The purpose of this article is to publicize the facts as we see them and provide information for those interested in the background of this meteorite, or interested in searching for it.

Time may prove our opinions to be wrong, but possibly the best way to

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[1/] A meteorite composed essentially of the mineral olivine and metallic iron.

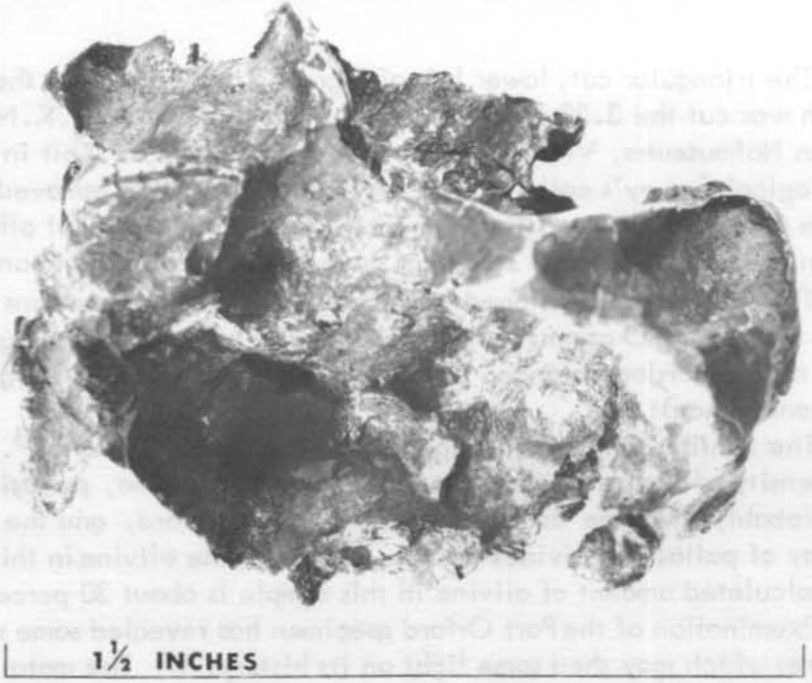

Figure 1. The Port Orford Meteorite. Photograph enlarged three times; actual size is about 1 by 1½ inches. Black fusion crust on the metal in certain depressions indicates that olivine was lost from those areas during the high-velocity flight. Unaltered olivine covered with fresh flight crust is present. This specimen shows no signs of long exposure to weathering in a humid climate. Sample is in the Smithsonian Institution, Washington, D. C.

locate the Port Orford meteorite is by searching among old documents and records for a possible notebook in which Dr. Evans may have made notations as he collected his specimens. Although that kind of search is not as much fun as walking over those wooded Oregon hills, it may be more helpful in finding the lost meteorite.

Known Specimens of the Port Orford Meteorite

Three museums have specimens labeled "Port Orford Meteorite." The largest sample weighs 24.2 grams (0.854 oz.) and is in the Smithsonian Institution (Figure 1). This one was in the collection of rocks and minerals Dr. Evans obtained in Oregon Territory in 1956 and examined by Dr. Charles T. Jackson, in Boston. After the specimen was identified as a meteorite, it remained in the Boston Natural History Society collections for about 60 years. In 1920 it was acquired by the Smithsonian Institution.

The triangular cut, lower left of Figure 1, may represent the spot from which was cut the 3.53 gram (0.125 oz.) sample now in K.K.Naturhistorischen Hofmuseums, Vienna. The 0.19 gram (0.007 oz.) bit in the India Geological Survey's collection, Calcutta, possibly was removed from one of the other four places where slivers of metal have been cut off. In addition to these cuts, some scrapings have been removed along one edge.

The specimen accessioned into the Smithsonian's collections is recorded as weighing 25 grams, but very likely the original weighing was not done on a precision balance. Today the specimen weighs 24.2 grams (less than one ounce).

The density of this specimen was found to be 6.30 gms/cm^3.[2/] Using the density of the metal phase from the Salta, Argentina, pallasite, as being probably the same as the metal in the Port Orford, and the average density of pallasitic olivines (Mason, 1963) for the olivine in this specimen, the calculated amount of olivine in this sample is about 30 percent.

Examination of the Port Orford specimen has revealed some significant features which may shed some light on its history: (1) The metal is not battered; (2) The olivine is bright and unusually free from alteration; and (3) The metal has numerous patches of fresh flight crust on it and in places these show delicate markings. These features indicate that this specimen was not removed from a large mass by a hammering operation. Also, it has not had long exposure to abrasion by running water or to weathering conditions in the soil. It is unwise to make a definite statement, but this evidence indicates that the meteorite is a comparatively recent fall, and if it is from western Oregon, where the climate is quite humid, it probably fell within the last 500 years.

Historical Account of the Port Orford Meteorite

Dr. Charles T. Jackson, a chemist in Boston, discovered the meteorite among a group of minerals which Dr. Evans collected in Oregon and brought it to the attention of the Boston Society of Natural History at its October 5, 1859, meeting. In the Proceedings of that Society (published in 1861) is the first published notice:

"... among some specimens recently received from Oregon Territory was a piece of meteorite containing crystals of olivine (and) yielding 9 percent of nickel. It was identical in appearance, and probably in composition, with the Pallas meteorite of Siberia; he though it not improbable

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[2/] Pure iron has a density of 7.86. Native iron ranges between 7.4 and 7.8 because it frequently contains lighter inclusions.

that pieces may have fallen in the same meteoric shower in both countries, as has happened in other instances though less widely separated."

In two later meetings of the Society, Jackson read from letters Evans had written him from Washington. The first Evans letter, read November 2, 1859, stated:

"... the meteorite recently found in that Territory is identical with the Pallas meteorite of Siberia."

The second, read November 16, 1859, revealed:

"... (that) the mass, about 3 feet of which was above ground, was in the mountains, about 40 miles from Port Orford, on the Pacific, and easily accessible by mules. (And that) he hoped the society, as a body or individually, would take speedy and proper measures to secure its disposition by the Government in the Smithsonian Institution."

The next significant mention of this meteorite appeared in 1860 when W. K. Haidinger, authority on meteorites in Vienna, Austria, reported to the Vienna Academy that Mr. Nathanial Holmes of St. Louis had informed him about the great meteorite Dr. John Evans found on his latest expedition to Oregon. Haidinger (1860) said it was partly embedded in the earth and was larger than the Siberian Pallas iron and gave the locality as:

"It lies in the Rogue River Mountains, not very far from Port Orford, on the Pacific, about in 42° 35' North Latitude and 123° to 124° West Longitude."

In 1861 Haidinger again reported to the Vienna Academy:

"Of the iron mass from Oregon, mentioned in the session of July 5 of last year, news of which was obtained from a letter from Mr. Nathanial Holmes, of St. Louis, I have the honor to place in the Imperial Cabinet a piece weighing 3.53 grams,[3/] which I owe to the friendly offices of Dr. Charles T. Jackson of New York City."

All our useful information about the Port Orford meteorite must be credited to Dr. Jackson's efforts to get data from Dr. Evans. After identifying this specimen, he corresponded with Evans in Washington but had no way of evaluating this information by discussing it with Evans. Evans died in May 1861, soon after the correspondence began.

Jackson, 1861, in a biographical sketch of Evans, said:

"One of the most interesting scientific discoveries made by Doctor Evans during his explorations in Oregon, was that of an enormous mass of meteoritic iron containing an abundance of chrysolite or olivine embedded in it. During the Indian war in that region, Doctor Evans ascended Bald Mountain, one of the Rogue River Range which is situated from thirty-five

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[3/] 3.53 grams = 0.125 oz.

to forty miles from Port Orford, a village and port of entry on the Pacific coast, and obtained some pieces of metallic iron, which he broke off from a mass projecting from the grass-covered soil on the slope of the mountain. He was not aware of its meteoric nature until the chemical analysis was made, but the singularity of its appearance caused him to observe very closely its situation, so that when his attention was called to the subject he readily remembered the position, form, appearance, and magnitude of the mass and manifested the most lively interest in procuring it for the Government collection in the Smithsonian Institution at Washington, a duty I doubt not he would have been commissioned to perform had his life been spared.

"By the aid of information contained in letters to me perhaps some traveler in those regions may be able to find this very interesting meteorite, and I shall, therefore, transcribe what he says of it. In reply to my inquiry, whether he felt confident he could again find this mass of meteoritic iron, he says in his letter of May 1, 1860:

"'There cannot be the least difficulty in my finding the meteorite. The western face of Bald Mountain, where it is situated, is, as its name indicates, bare of timber, a grassy slope, without projecting rocks in the immediate vicinity of the meteorite. The mountain is a prominent landmark, seen for long distance on the ocean, as it is higher than any of the surrounding mountains. It would doubtless be best and most economical to make a preliminary visit to the locality, accompanied only by the two voyagers[4/] alluded to in my last letter.'"

Apparently Evans thought about the ownership of this meteorite, for, after consulting the General Land Office and the Indian Bureau in Washington, he concluded the title was vested in the Indians, the land not yet having been ceded to the United States. Evans continues, according to Jackson, by saying:

"As to the cost of transportation of the meteorite to Port Orford, it is difficult to make an accurate estimate. It is situated in a mountainous region, thirty to thirty-five miles from the coast, and the only access to it is by mountain trails. It might be removed in pieces from one hundred to one hundred and fifty pounds in weight on pack mules; and accurate measurements made of the whole mass without great expense, say from $1,200 to $1,500. But to remove it entirely would either be impractical or involve great expense, unless indeed a river which passes the base of the mountain (Sixes River), and empties into the Pacific, should prove navigable for a raft of sufficient size for its transportation. There is water enough, but it

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[4/] Two of the Canadian Frenchmen employed by the Hudson Bay Company.

is no doubt much obstructed by fallen timber, and may have rapids, which it would be difficult to pass over with such a heavy load. In either mode of transportation my first duty would be to explore this river."

In another letter (not dated) to Jackson, Evans said:

"As to the dimensions of the meteorite I cannot speak with certainty, as no measurements were made at the time. But my recollection is that four or five feet projected from the surface of the mountain, that it was about the same number of feet in width, and perhaps three or four feet in thickness; but it is no doubt deeply buried in the earth, as the country is very mountainous, generally heavily timbered, and subject to washings from rains and melting of snow in the spring, so that in a few years these causes might cover up a large portion of it. The mass exposed was quite irregular in shape. . . ."

In another letter (not dated) Evans said:

"The locality is about forty miles from Port Orford, in the mountains which rise almost directly from the coast, only accessible by pack mules. But each mule might carry three hundred pounds weight, and if required make several trips, to secure the whole mass. It would, however, be necessary to take along suitable tools, to separate the mass, which might be desirable, be adjusted together afterwards. But I should suppose that each institution, which might furnish the funds, would desire a portion of the mass."

Jackson said that "every possible exertion was made in Congress, and with the departments at Washington, to induce the government to take measures for procuring this very valuable meteorite, and to cause it to be placed in the museum of the Smithsonian Institution, where it could readily be examined by scientific men, but Dr. Evans' death and the present unhappy state (Civil War) of the country seem to prevent the realization, for the present, of this enterprise."

Dr. Evans' log, a hand-written document stored in the Smithsonian's files, described the 1856 journey in the Port Orford region but contains no mention of a meteorite. Consequently the foregoing paragraphs give all the information that is available on location and size of the "missing" Port Orford meteorite. More recently published reports by other writers are largely recapitulations of former accounts.

Pointers to Keep in Mind While Reading Evans' Log

When reading the portion of Evans' log describing his travels near Port Orford, one should keep several possibilities in mind before forming an opinion about the reliability of the information given.

(1) In reading the existing copy of Evans' log one is impressed with the fact that nothing is said about seeing or collecting anything like a meteorite. This omission suggests that there may be a missing notebook with some comments about the rock specimens Evans collected on this trip. Such a record logically would remain with the specimens, or be turned over to the office from which Dr. Evans obtained support on his trip.

If it is assumed that Dr. Evans saw the meteorite, and failed to record it in the existing log, it does not prove he did not record the information elsewhere. If no other notebook of Dr. Evans' is ever found, then the location of the point of discovery of this meteorite may always remain in this confused state. The Evans' log is not very informative. The existing log somewhat resembles an outline Evans possibly might have been preparing to use in writing a readable story about his travels.

(2) Dr. Evans' log, together with comments in his letters to Jackson, are all we have to go on to relocate the position of the Port Orford meteorite. No one has established whether or not the handwritten log is the original copy and, as explained below, the majority of it is not in the handwriting of Dr. Evans. It could be a log transcribed by some member of the party.

The log is an unbound, hand-written document, measuring 12½ by 8 inches. Its appearance indicates that someone was transcribing a previous document and had difficulty deciphering portions of it. Surely an experienced explorer, such as Dr. Evans, would not carry unbound paper into the field to keep notes on.

To better appraise the reliability of this document the Library of Congress supplied samples of Dr. Evans' handwriting of about this same year. Four pages were obtained and used as samples of Dr. Evans' script andwere compared with 14 pages from the Evans log. Incidentally, five of the 14 pages were descriptions of his travels from Port Orford across the Rogue River Mountains.

The handwritten material was taken to the Federal Bureau of Investigation's laboratories for study. Their report states that "the majority of the handwriting of Evans' log in the Smithsonian's library was not written by the writer or writers of the specimen supplied by the Library of Congress as a sample of Dr. Evans' handwriting."

This finding does not disqualify the authenticity of the records but it evaluates them more accurately. The persons transcribing a previous record perhaps were instructed to omit the sections dealing with specimens or there may be another record book with data about Evans' collections.

(3) Dr. Evans may have taken a side trip from Port Orford prior to the journey described in the log. If the meteorite was obtained at that time, he might purposely have omitted it from the log.

(4) The meteorite, as Evans suggested, may have been covered by a landslide since it was seen.

(5) Port Orford, between 1850 and 1860, was a small seaport. The chief interest of the inhabitants was the development of the country and most folks were prospectors looking for outcrops of gold or other precious metal. Prospectors were working in the area before Evans got there. If one of them had located the meteorite, he either would have assumed it was iron ore or a precious metal, like silver. These men were keen enough to realize that iron ore in this remote place would have little value, while a silver strike would mean a fortune. Hence, the finder of such a specimen would probably think he had an outcrop worth investigating and would return to civilization to find out what he had. Such a prospector might have given someone in Port Orford a piece which later was given to Evans.

An Attempt to Follow Dr. Evans' Trek

During the summer of 1939 Henderson hiked the trails from Powers, Oregon, to within sight of Port Orford. The purpose was to determine how accurately Evans' route could be followed, using the log of his travels, and to try to find the meteorite. The log was discussed with personnel of the U.S. Forest Service, both in the field and in their regional offices, and the consensus was that the trails shown in Figure 2 are as good an interpretation as can be made of Dr. Evans' journey through this section of Oregon. Our confidence in the route was strengthened by the fact that although some simplification of old trails has taken place, generally speaking existing trails follow the old one. Prof. J. E. Allen, Department of Geology, Portland State College, Portland, Oregon, also reconstructed a map (Lange, 1958) of Evans' route basing his locations on Evans' log and referring to modern topographic maps.[5] The two trail maps agree fairly closely.

The portions of Dr. Evans' log describing the trek from Port Orford across the Rogue River Mountains is reproduced, followed by Henderson's comments, which are underscored.

Route from Port Orford across the Rogue River Mountains:

"Started Saturday, July 18, 1856. Started from Port Orford at 9 a.m. Bright and beautiful morning. Passed near Sawdust River three miles from

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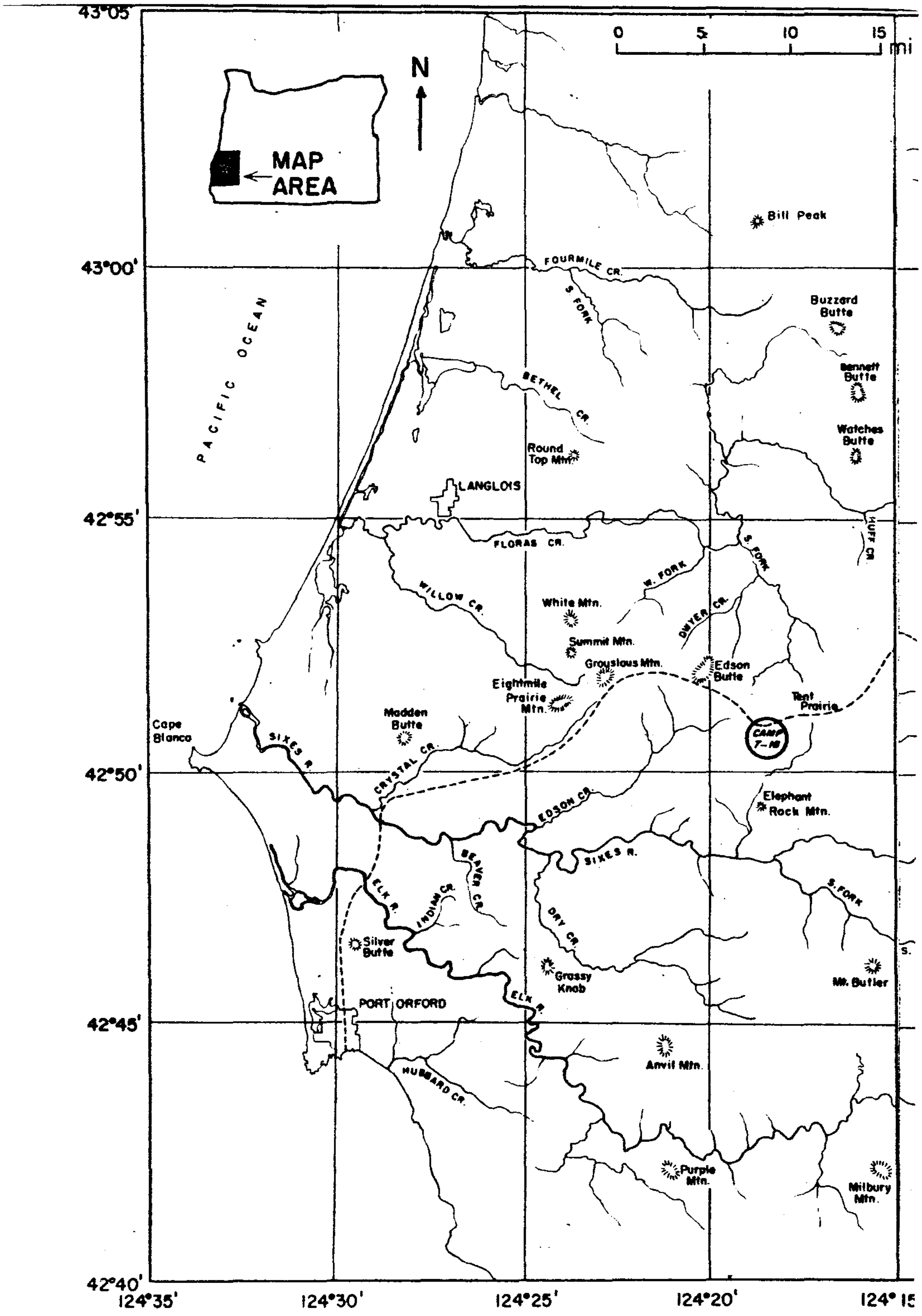
[5] These maps are the Agness, Langlois, Port Orford, and Powers 15-minute series (topographic). They are available at the U.S. Geological Survey, Denver Federal Center, Denver, Colorado, for 30 cents each.


43°05'
0
5
10
15
mi
N
MAP AREA
Bill Peak
43°00'
FOURMILE CR.
S. FORK
PACIFIC OCEAN
Buzzard Butte
Bennett Butte
BETHEL CR.
Watches Butte
Round Top Mtn.
LANGLOIS
42°55'
FLORAS CR.
HUFF CR.
W. FORK
S. FORK
WILLOW CR.
White Mtn.
DWYER CR.
Summit Mtn.
Grouslous Mtn.
Edson Butte
Eightmile Prairie Mtn.
Tent Prairie
Madden Butte
Cape Blanco
SIXES R.
CRYSTAL CR.
CAMP T-10
42°50'
Elephant Rock Mtn.
EDSON CR.
SIXES R.
S. FORK
BEAVER CR.
ELK R.
INDIAN CR.
DRY CR.
S.
Silver Butte
Grassy Knob
Mt. Butler
PORT ORFORD
ELK R.
42°45'
Anvil Mtn.
HUBBARD CR.
Purple Mtn.
Milbury Mtn.
42°40'
124°35'
124°30'
124°25'
124°20'
124°15

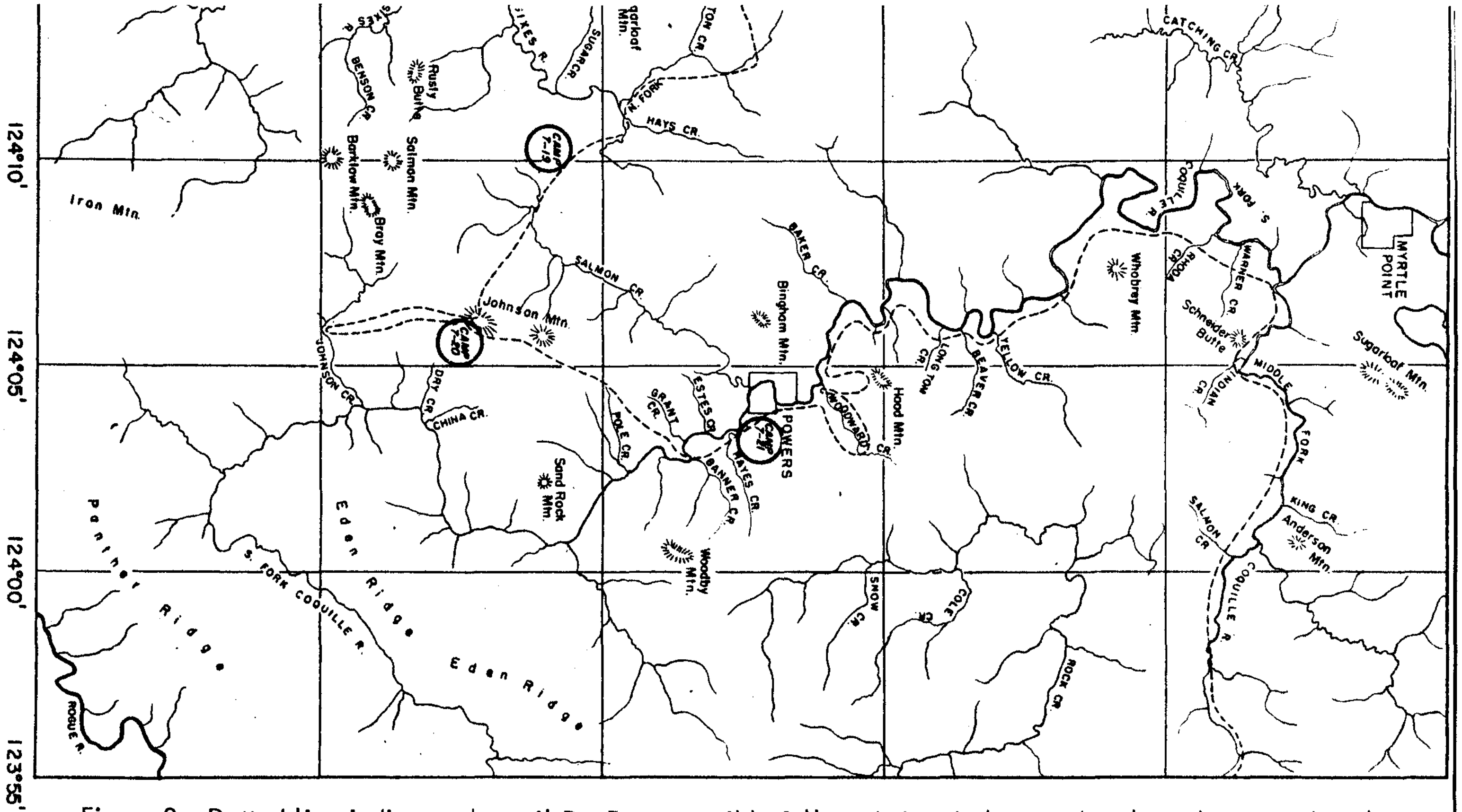


Figure 2. Dotted line indicates the trail Dr. Evans possibly followed; the circles are the places he camped on the nights of July 18, 19, and 21, 1856. This map was produced from data obtained from the Langlois and Powers, Oregon, maps of the U.S.G.S., 1954; also, from the U.S. Forest Service map of Port Orford Ranger District, Siskiyou National Forest, Oregon, September 1936, on which map Henderson traced his trail when he hiked from near Powers, Oregon, to within sight of the junction of the Sixes River and Crystal Creek.

town, through the woods four miles to Elk River. Saw small prairie, fine site for a farm. Passed through small prairies on Elk River, such prairies are occasionally found on this river as you ascend it; passed through two other small prairies. Finest white cedar trees all along the route in great numbers. Two miles further on crossed the Sixes River. Sandstone exposed along its shores. (Evans' distances do not agree with those scaled on present-day maps because he probably had no accurate way for measuring distance; also, his routes likely were more irregular than existing trails.) As we proceeded we crossed two high elevations, mountain ranges; our way has generally been along the divide between Elk River and the Ocean, running in a north west and S.E. direction. The woods are filled with a luxuriant growth of grass resembling timothy and this region would afford pasturage for thousands of stock. On a high divide fourteen miles from Port Orford saw an exposure crowning its summit, of fine grained grit or sandstone. This is the only exposure of rock in place met with on the route except before noticed. At 3 p.m. reached the summit of the highest elevation yet crossed on which is situated a large prairie of excellent grass at least eighteen inches in height. Passing along and up a still higher ridge, the light colored sandstone appeared in place. Had a magnificent view of the ocean to the N.W. and S.E. Sixes River is much larger than is laid down on the maps and Floras Creek much shorter. On our route we headed the latter whilst a fork of Sixes River overlaps it, and its valley appears on our right. (Evans seems to be advancing upstream along Crystal Creek from the Sixes and traveling in a general direction toward Eight Mile Prairie Mt.)

"The ridges on which we are traveling must be at least 1,000 to 1,200 feet above the ocean. Camped at a small spring surrounded by hills. The grass at least two feet high; along our route for the last six miles all through the tall fir, cedar and hemlock trees, the ground was covered with this luxuriant growth of grass, mingled with wild flowers. Blackberries and other berries were plenty on the slopes of the ridges. Distance traveled eighteen miles. (Surely Evans measured distances along the trails and not as a straight line from where his day's travel started. Thus his estimate of 18 miles by winding trails probably is something like 8 to 12 miles airline distance from Port Orford. After passing to the south and east of Grouslous Mountain he apparently camped on the night of July 18 near Edson Butte. Edson Butte is situated approximately 42° 52' N., 124° 20' W. and is about 12 miles airline northwest of Port Orford.)

"Sunday, July 19, 1856. Started at 7-1/2 a.m. Our route for eight miles was along ridges covered with fine grass and flowers mentioned yesterday. On the different slopes every variety of spring and fall flowers. Passed through a chain of prairies, some of them several miles in extent, which like open woodlands were covered with grass three and a half feet high - timothy and other grasses. The highest ranges run, a little west of north, and south of east, as our course is north of east we have occasionally to cross from ridge to ridge by connecting ridges of lesser elevation, sometimes to descend to the bed of small streams. Crossed a fork of the Sixes River at 11-1/2 a.m. (Within 3 hours after leaving his camp of the 18th, Evans arrived at a fork of the Sixes River. South and southeast of where I assumed he camped on the 18th, there are several small streams draining into the Sixes. If Evans referred to one of these as "a fork of the Sixes," then he pushed south from where we indicated he camped. Thus, Evans went in a different direction than the one he reported.)

"The trail follows the ridges as far as practicable and consequently our course from their direction is a winding one. Almost all the higher summits had rock in place, cropping out and crowning a considerable portion of it. Talcose slate seemed to be the prevailing rock, and the other slates seen on the shore of the ocean; also a light colored sandstone, and the compact or ashy colored rock seen on the beach. Outbursts of granite and trap or basalt were seen rising to a considerable elevation. Stopped on a prairie elevation for our horses to feed and rest. Saw marks and trails of elk all along the prairie, but not the animal itself. On almost every elevated ridge or mountain spur were seen exposures of rock just enumerated. Crossed two or three small creeks, forks of Sixes River, camped at 5 p.m. on a small creek tributary of Salmon River. (Evans camped after 8 hours on the trail and estimated his day's journey to be 21 miles. He averaged 2.5 miles per hour for the day, rather good for rough country and with some time out for observations. On this date or the next, Evans should have been about 40 miles from Port Orford, so if his 40 mile estimate is significant, this may be near the location he reported to Jackson for the meteorite. There are bald mountains near here but none is visible from Port Orford or from the sea.)

"The prairie in which we are camped is three quarters of a mile long by half mile wide, and very rich sandy loam; the grass, a kind of wild oats, is in places six to eight feet high and other grasses going to seed six or seven feet high. Timothy (wild) is very abundant in this and other prairies passed through, and is from three to five feet high; other grasses filling up the prairie and so dense as to render walking difficult is from two to two and a half feet, this is a fair example of the luxuriant growth of grasses, not only in the chain of prairies through which the trail passes, but on the ridges and intervening slopes between them. The climate is delightfully cool and bracing. The woods are filled with elk, deer and black bear, and there is no want for meat. Mr. Bray at our present camp had returned to his home but two days previous to our arrival, and had already two hanging up in his log cabin, so he said help yourselves for it is impossible for me to eat it all and half an hour any morning will get me another. Distance traveled twenty one miles. (This places Evans in the vicinity of what is now known as the Powers Ranch, approximately 42° 48' N. and 124°9' W. Mr. Bray's name is mentioned which may give another rather good reference point. Bray Mountain according to the Port Orford map of 1903 is located at 42°46'N., 124° 7'W.)

"Monday, July 20, 1856. Collected a few specimens of grass. Amongst the grasses of this and other prairies is an abundance of mountain clover. The heads are not so large as the cultivated clover; the stalk is about two to two and a half feet high. The soil in this prairie is very good and produces fine vegetables. This prairie is nearly surrounded by high mountains, but there are other similar prairies hidden by tall trees in the immediate neighborhood; in fact the whole route is through a chain of prairies, some of them several miles long, along ridges covered with fine grass in the deep woods and occasionally in passing from ridge to ridge over high mountains. Noticed today a tree called chestnut oak. It has acorns like the white oak, but the foliage was more like the chestnut. Thermometer at 6 p.m. 48°.

"Tuesday, July 21, 1856. Started at 7-1/4 a.m. passed along two prairie ridges and woodland to a high and steep mountain estimated at two thousand feet in elevation, collected specimen of the rock along the route, talcose and other slates, gritty sandstone, granite, etc. The descent from the valley occupied one hour and a half. The descent to the gold mines of Johnson and others on the fork of the Coquille R. Abbott's branch, also occupied an hour and a half. The descent is much more gradual. The creek at the mines runs through steep mountains covered with timber. Saw a new species of laurel with rare and beautiful flowers. It seems strange to see in full beauty the flowers of early spring roses, etc. scattered along your pathway at this season of the year. Passed over a high (bald) mountain so called, but while of great elevation it is covered at the summit with most luxuriant grass and flowers. Thermometer at 12 m. 69°. The creek is bordered by high steep banks (mountains) its bed filled with large boulders of granite, gneiss, talcose and other slates, showing it to be to some extent a gold bearing region. But there is little quartz either in the rocks or in boulders, and the slate and other rocks, so far as has been discovered, do not contain many signs of gold. The distance to the Great Bend is only twelve miles from this place, but we have already visited the head waters of some of its small tributaries and collected specimens on the divide between this creek and Rogue River, which indicate the geology with sufficient certainty. Returned to Bald Mountain and camped. From our last camp to Johnson's diggings we had a mountain to cross at least two thousand feet in elevation. Distance traveled twelve miles." (The description places the Evans party in the vicinity of Johnson Mountain, along Johnson Creek.

Bald Mountain is mentioned twice in this day's log, first, going, and second, returning to camp. If there is one day in this log that is critical, this is it. This day he specifically mentions collecting rock specimens - on the way to the mountain and on the Rogue River divide. The "Great Bend," unfortunately, could be the bend in the south fork of the Coquille River, Big Bend of the Rogue River near Illahe, or the bend in the Rogue River at Agness where the Illinois River joins the Rogue. The latter does appear to be a little distant.)

An Appraisal of the Record

The record of the Port Orford meteorite is sketchy, to say the least. Because so little information is known, the situation lends itself to a wide variety of interpretations and we have perhaps introduced some more. Some writers appear to have purposely capitalized on the vagueness of the record, in order to produce a mystery story. These stories appeal to editors of popular journals and to the press. The reports on this meteorite, through a bit of literary legerdemain, gloss over or make light of the incompleteness of the record. Also, they have gone too far in stressing a greatly exaggerated value for this particular meteorite. No reason was given for the claim that this specimen has greater scientific importance than other meteorites. In view of what has happened, it is important to list the basic facts about the history of the Port Orford meteorite. They are as follows:

(1) A piece of meteoritic material, called the Port Orford meteorite, was found among the specimens Dr. Evans sent back from his travels in Oregon. This is about all we know. It was not established that this particular sample was found by Dr. Evans or given to one of his party.

(2) Evans was informed about the meteorite in a letter from Dr. Jackson. Jackson, in reporting this find to the Boston Society of Natural History on October 5, 1859, said: "Among some specimens recently received from Oregon Territory was a piece of meteorite." If he knew a locality, he surely would have reported it. On November 16, 1859, he read letters from Dr. Evans, mailed from Washington, which reported the locality. This indicated Dr. Evans supplied the information but the question is, from what source did Dr. Evans get the locality information?

(3) Dr. Evans had a map of the area because, on July 18, he stated, "the Sixes River is much larger than it is laid down on the maps and Floras Creek is shorter." This shows that other records existed.

(4) The size of the meteorite is a pure guess, because Evans said in a letter to Jackson, "as to the dimensions--I cannot speak with certainty." Then he gives dimensions.

(5) Jackson, in 1861, stated in his biographical sketch of Evans,

"...when his attention was called to the subject he readily remembered the position, form, appearance, and magnitude of the mass...."

(6) The largest specimen of this meteorite is in the U.S. National Museum in Washington. There are two other smaller pieces in museums in Vienna, Austria, and Calcutta, India.

What Is the Value of a Meteorite?

This is a complicated subject that we shall attempt to answer by outlining the points the U.S. National Museum considers in estimating the values of meteorites. Before going into this, it is important to make one point clear--meteorites have no commercial value, that is, no mineral can be extracted from them and sold for more than the same mineral obtained from other sources. Meteorites are scientific specimens and are valuable only for the scientific information they contain.

The importance of meteorites is judged from two different points of view: (a) the scientific information which may be obtained from them; and (b) the prestige the meteorite adds to the collection. Generally speaking, freshly fallen meteorites are more desirable than old falls. Since the Port Orford meteorite is now a reasonably old fall, this feature would undoubtedly reduce its scientific value.

Size. The reward for the recovery of a very large or a very small meteorite can be considerably less than will be offered for the finding of one weighing between 50 and 500 pounds. Very large specimens are costly to transport from the field and since funds for the purchase of meteorites are limited, not much money may remain for the reward after the cost of recovering the specimen has been paid. For small meteorites, the reward is less because there is not enough material for a complete scientific investigation. Generally speaking, there is a relationship between weight and reward, but this relationship is not directly proportional to the weight of the meteorite.

Form. The physical shape of the meteorite plays an important role in evaluating the specimen. Meteorites that fall in a fixed position become streamlined and the fusion crust on their leading sides usually displays delicate flight markings. Such meteorites are more highly prized than those which have tumbled as they pass through the air. A body which constantly changed position during flight usually does not have an interesting shape.

Broken specimens are less desirable than one that is complete and unscarred. Although some meteorites fracture or break on impact with the ground, many of them show little or no damage. Unfortunately, those who recover meteorites frequently do more damage to them than nature did. People often perform useless tests on the meteorites and the only thing these tests do is to materially lessen the scientific importance of the specimens. Hence, the rewards offered for meteorites which man has heated, broken apart with a hammer, or contaminated with acid are less than for the undamaged specimens.

Degree of preservation. This is most important. It is impossible to estimate what condition the Port Orford will be in when or if it is found. If it has disintegrated through weathering (alteration), it has lost much of its scientific as well as exhibition value.

We know the Port Orford meteorite should be a pallasite and frequently such meteorites have a tendency to decompose. However, the present specimen of the Port Orford meteorite appears to be stable.

A reward awaits the finder of the Port Orford meteorite, or any other meteorite found on public land, but the amount of the reward for the Port Orford meteorite may very well be less than would be offered for the discovery of any other meteorite that is new and of greater scientific importance. Under no conditions will the reward approach anything like $2,200, 000, the amount which has been publicized and is partly responsible for the present enthusiasm for, and interest in, the Port Orford meteorite.

The Ownership of Meteorites

The ownership of a meteorite depends upon where it is found. The courts have held that meteorites are the property of the owner of the land on which they fall, or are found, and the Antiquities Act, Public Law 209, June 8, 1906, specified that objects considered natural treasures are government property when located on federal land. Meteorites have been classified as national treasures.

The Smithsonian Institution maintains the national collection of meteorites, thus, it claims meteorites found on public land. In the past, the Smithsonian Institution has rewarded those who have recovered meteorites on public land and turned them over to the government, and calculated the rewards on the same basis as for meteorites found on private land.

If a large meteorite is located on private land, the finder, if he is not the owner of the land, should contact the owner and arrive at some agreement as to how the reward should be shared, before a public announcement is made about the discovery of the specimen.

Acknowledgments

The authors are exceedingly grateful to Lawrence B. Isham for drafting the map showing the possible trail Dr. Evans followed in this portion of his travel, to Roy S. Clarke, Jr., of the U.S. National Museum, Washington, D.C., for numerous helpful suggestions, and to staff members of the Oregon Department of Geology and Mineral Industries for assistance in preparing the manuscript for publication.

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Hon. Peter H. Dominick, U. S. Senator from Colorado, will give the opening address, to be followed by an afternoon session which will include speeches on labor relations by Sen. Karl E. Mundt (S.D.); Rep. John Dent (Penna.); and J. Mack Swigert of Taft, Stettinius & Hollister, Cincinnati, Ohio. Other sessions will cover mine finance, exploration and geology, and safety engineering. The public lands session will have as chairman Rep. Wayne N. Aspinall (Colo.) and will be addressed by W. Howard Gray, Reno attorney and chairman of the AMC Public Lands Committee. The oil-shale luncheon will feature a talk by one of the country's foremost authorities on the current status of that industry. Rep. Al Ullman (Ore.) will be a speaker on the session on taxation for mining executives, as will G. W. Welsch of Lybrand, Ross Bros. & Montgomery of Dallas; William J. Nolan, Jr., director of taxes for American Metal Climax, Inc., New York, and Robert L. Ward of Kennecott Copper Corp., New York. Wednesday there will be a space-age metals luncheon, with an afternoon session devoted to gold, silver, and monetary policies, at which Sen. Ernest Gruening (Alaska) and Sen. Wallace F. Bennett (Utah) will speak.

The convention will offer two field trips, one by air to the Hanna Mining Co.'s nickel mine and smelter at Riddle, and the other to Albany, the space-age metals center of the West. Two special luncheons are planned for the ladies, including one at Timberline Lodge on Mt. Hood. Other convention highlights include the reception on Sunday, welcoming luncheon Monday, the Miners' "cruise" Monday evening at the Portland Coliseum with dinner and a show, and the "Speechless" banquet Wednesday with dinner, dancing, and a show.

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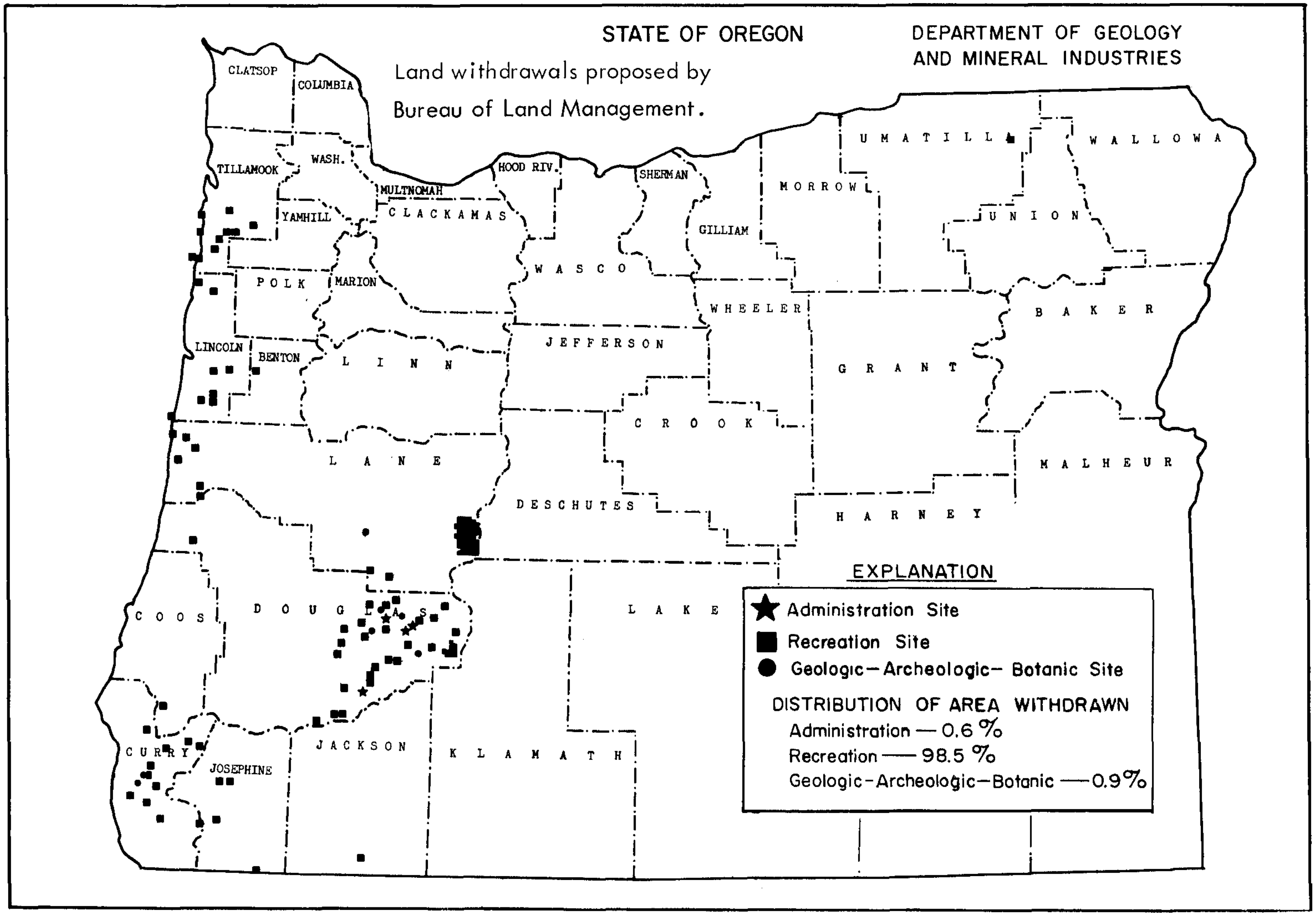
STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
Land withdrawals proposed by Bureau of Land Management.
CLATSOP
COLUMBIA
TILLAMOOK
WASH.
MULTNOMAH
HOOD RIV.
SHERMAN
UMATILLA
WALLOWA
MORROW
GILLIAM
UNION
YAMHILL
CLACKAMAS
WASCO
POLK
MARION
WHEELER
BAKER
LINCOLN
BENTON
LINN
JEFFERSON
GRANT
CROOK
LANE
MALHEUR
DESCHUTES
HARNEY
COOS
DOUGLAS
LAKE
CURRY
JOSEPHINE
JACKSON
KLAMATH
EXPLANATION
★ Administration Site
■ Recreation Site
● Geologic–Archeologic– Botanic Site
DISTRIBUTION OF AREA WITHDRAWN
Administration — 0.6 %
Recreation —— 98.5 %
Geologic-Archeologic–Botanic —— 0.9%

The ORE BIN
Volume 26, No. 8
August, 1964

MIOCENE STRATIGRAPHY OF THE YAQUINA BAY AREA, NEWPORT, OREGON [1]

By

P. D. Snavely, Jr. [2], W. W. Rau [3], and H. C. Wagner [2]

Introduction

Marine sedimentary rocks of Miocene age occur in structural basins along the Oregon coast at Astoria, Tillamook, Newport, and Coos Bay (see index map on plate 1). Inasmuch as these basins open to the west, thicker sequences of marine Miocene and younger rocks undoubtedly are present on the continental shelf. Furthermore, potential source beds and reservoir rocks for petroleum are known from surface outcrops of Miocene age in the three northern embayments. These Miocene and younger strata unquestionably will be major objectives in the aggressive petroleum exploration program now under way in offshore Oregon and Washington. Therefore, this report summarizes the lithologic characteristics and fauna of the Miocene sequence in the Yaquina Bay area of the Newport Embayment [4] in the hope that these preliminary data will prove useful in biostratigraphic interpretations of the Miocene rocks encountered in drilling on the continental shelf.

The writers wish to express their appreciation to Philip Grubaugh of the U. S. Corps of Engineers, Portland District, for his efforts in making the cores from their Yaquina Bay and Harbor exploration project available for study. We wish to thank W. O. Addicott for paleontological data on molluscan faunas and E. W. Wolfe for heavy mineral determinations. W. O. Addicott and J. G. Vedder read and criticized the report and offered valuable suggestions. Norman S. MacLeod aided measurably in the assembly of data.

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[1] Publication authorized by the Director, U.S. Geological Survey.

[2] Geologists, U.S. Geological Survey, Menlo Park, California.

[3] Geologist, Washington State Division of Mines and Geology.

[4] As used in this report, the Newport Embayment is a broad structural basin outlined by a westward-facing arcuate pattern of uppermost Eocene to Miocene rocks. Biostratigraphic studies of marine Eocene and Oligocene strata exposed in the Newport Embayment have recently been completed by the U.S. Geological Survey and reports on these units are in preparation.

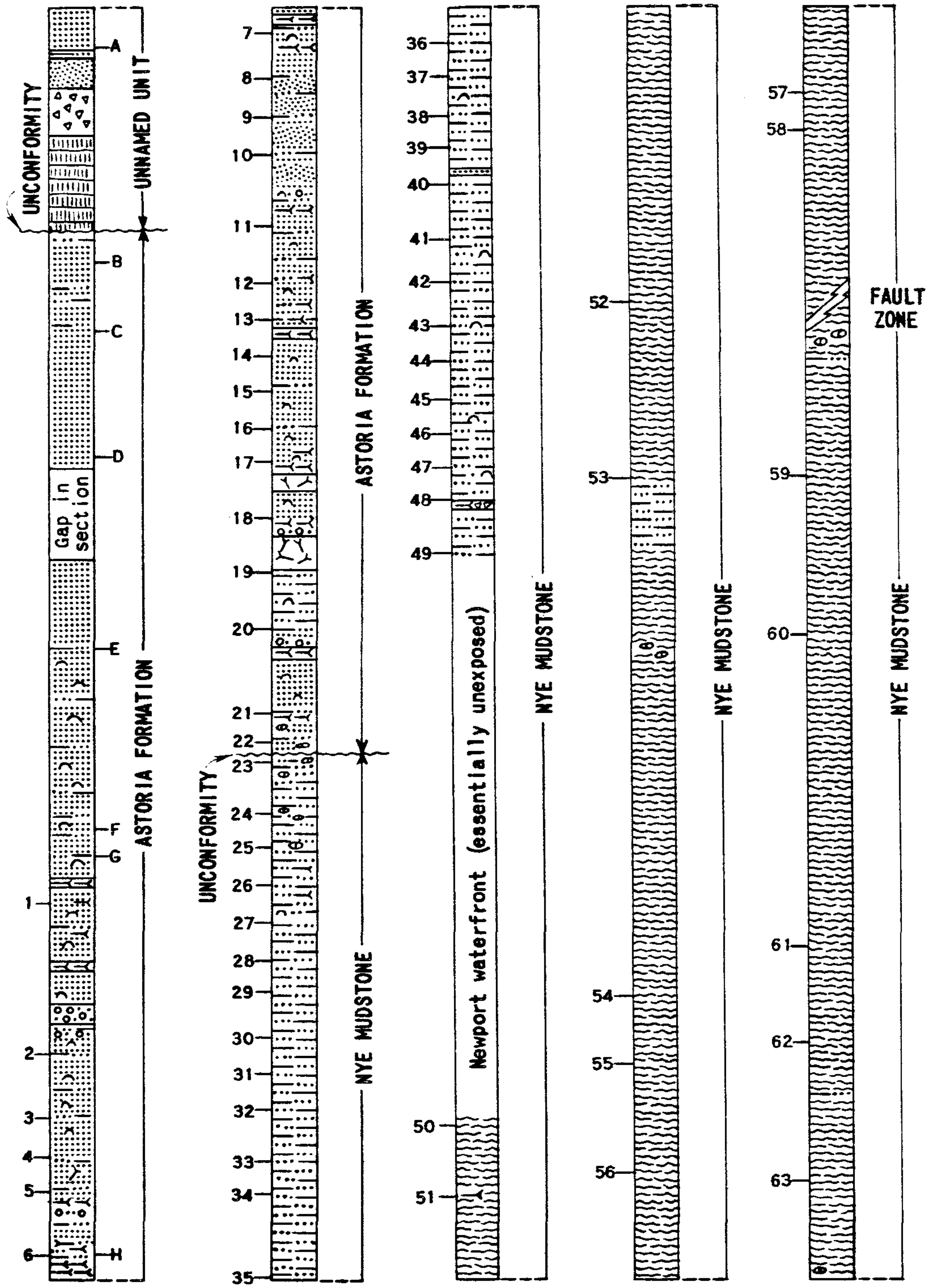

Figure 1. Generalized stratigraphy of Miocene strata at Yaquina Bay, Newport, Oregon. (Figures 1-48 indicate subsurface foraminiferal samples; 49-83 surface foraminiferal samples. Letters A-H indicate samples for which physical properties were determined.)

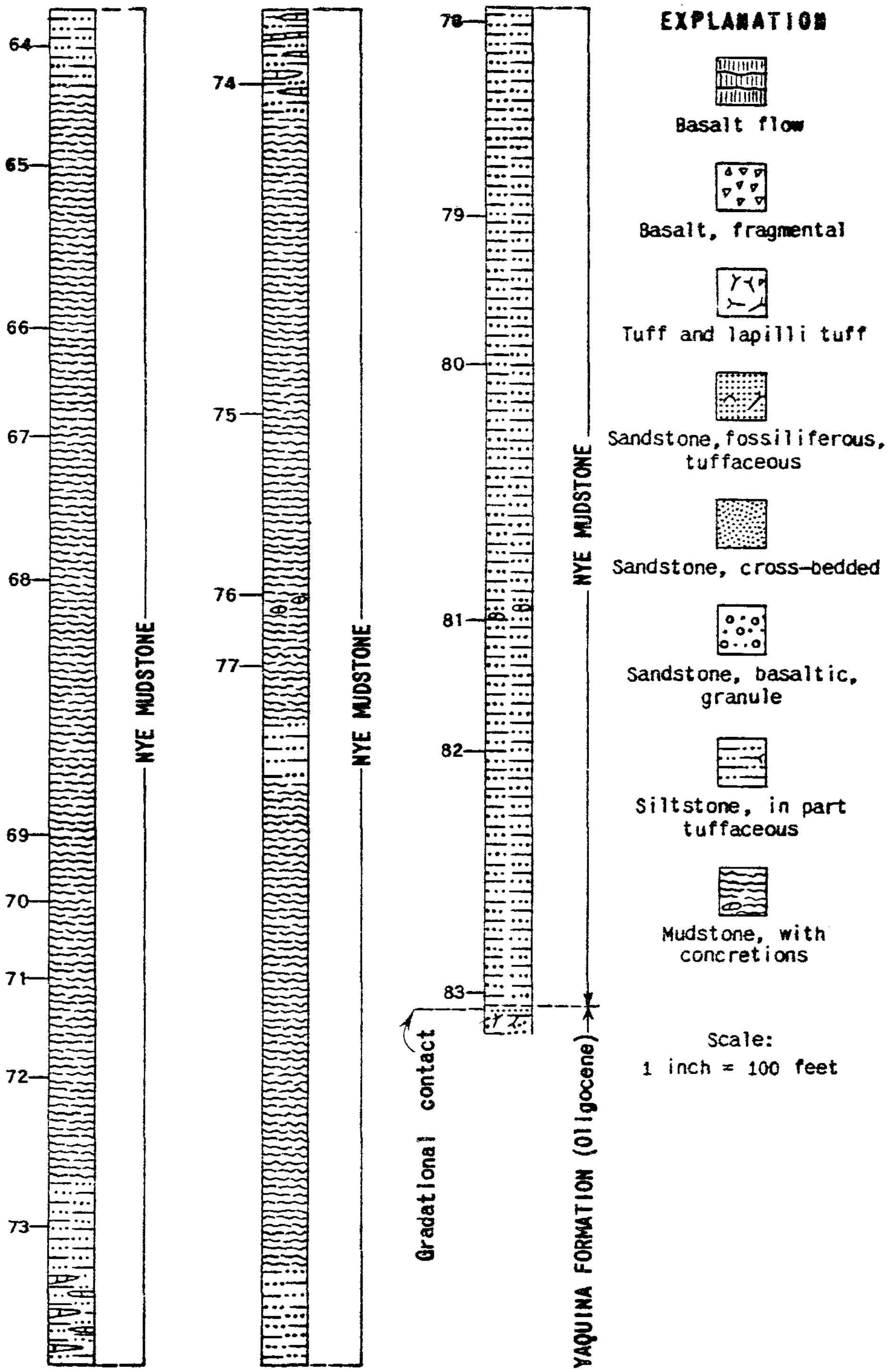

Figure 1, Continued.

Stratigraphy

In the Yaquina Bay area marine Miocene strata consist of two mappable lithologic units: an older siltstone-mudstone sequence of early Miocene age referred to the Nye Mudstone (Harrison and Eaton, 1920); Schenck, 1927; and Vokes and others, 1949) and a younger sandstone-siltstone sequence of middle Miocene age referred to the Astoria Formation (Packard and Kellogg, 1934; Schenck, 1936; Weaver, 1937; Vokes and others, 1949; and Moore, 1963). An unnamed late(?) Miocene unit, consisting of a basal basalt flow, associated waterlaid basaltic fragmental debris, and arkosic sandstone, is known in the map area (plate 1) only from cores obtained by the U.S. Corps of Engineers near the mouth of the Yaquina River. The generalized stratigraphic section of the Miocene sequence that is shown on Figure 1 was compiled from outcrop data along the north shore of Yaquina Bay and from descriptions of cores from holes drilled in the channel of the Yaquina River. The locations of the outcrop and subsurface samples from core holes referred to in this report are shown on Plate 1.

Nye Mudstone

The Nye Mudstone is best exposed in road cuts and on tidal flats along the north shore of Yaquina Bay, in highway cuts along U.S. Highway 20, and in sea cliffs 3 to 7 miles south of Newport between Henderson and Beaver Creeks. Within the city limits of Newport, late Pleistocene marine terrace deposits unconformably overlie the Nye Mudstone and limit the area of outcrop to a narrow belt along the bay. Immediately south of the bay, the Nye is largely concealed by these terrace deposits, dune sands, and bay muds. Landslides are common in areas underlain by the Nye, and several large slides occur on the north side of Yaquina Bay (plate 1).

The Nye Mudstone overlies by gradational contact sandstone beds of the late Oligocene Yaquina Formation (Harrison and Eaton, 1920; Schenck, 1927; and Vokes and others, 1949). In the map area (plate 1) the Nye consists predominantly of medium to dark olive-gray, massive, organic-rich mudstone and siltstone. A strong petroliferous odor is apparent when a fresh sample is broken. In many outcrops the unit is closely jointed; the joints are emphasized by iron-oxide staining and commonly contain a lacework of gypsum crystals. The Nye weathers to rusty brown hackly or conchoidal fragments, and most outcrops are partly covered with a scree of shaly rubble. The more deeply weathered outcrops are commonly stained with yellow jarosite.

Inasmuch as the Nye is composed of mixtures of clay, silt, and very fine sand-size particles in varying proportions, the lithologic designation differs from place to place, but commonly is mudstone or siltstone, and less commonly silty, very fine-grained sandstone. These grain-size variations are slight, and in the field much of the formation is classified as mudstone. However, in the Yaquina Bay section the Nye is predominantly sandy siltstone in its lowermost and uppermost parts. Mechanical analyses of five samples of Nye Mudstone indicate that the clay fraction ranges from 17 to 32 percent, silt from 54 to 83 percent, and very fine sand from a trace to as much as 27 percent. A sample near the base of the formation was composed of about equal proportions of sand, silt, and clay.

The Nye Mudstone commonly contains abundant brown fish scales and vertebrae,

Figure 2. Dolomitic beds and lenses in the lower part of the Nye Mudstone, north side of Yaquina Bay about half a mile east of McLean Point.

Figure 3. Unconformable contact between the dark-gray Nye Mudstone (Tn) and light-gray Astoria Formation (Ta) at Jumpoff Joe, $1\frac{1}{2}$ miles north of Yaquina Bay, Newport, Oregon. Units are overlain by late(?) Pleistocene terrace deposits (Qt).

locally abundant Foraminifera, and a meager molluscan fauna. In the uppermost part of the sequence, however, mollusks are abundant. Calcareous and dolomitic concretions, as much as 4 feet across, and lenticular beds 2 inches to more than 1 foot thick occur locally. Carbonate-cemented thin beds are common in the lower part of the sequence; large, isolated concretions generally occur in the upper part. A prominent zone of lenticular, dolomitic concretionary beds occurs about 1,200 feet above the base of the formation and is well exposed in a large cut between localities 73 and 74 (see plate 1 and figure 2). Beds of light-gray tuff and thin-bedded, fine-grained sandstone several inches thick occur in a few outcrops.

X-ray diffraction studies of the clay fraction in the Nye Mudstone show that it is composed predominantly of mixed-layered montmorillonite-illite and smaller quantities of illite and kaolinite. This composition contrasts with that of the clays in upper Eocene siltstone, where a few samples studied by X-ray techniques show a larger proportion of illite and kaolinite and lesser amounts of montmorillonite. A chemical analysis of the Nye Mudstone collected from a U.S.C.E. core hole (locality 59, plate 1) is shown in table 1, column 1.

The Nye Mudstone is about 4,400 feet thick as calculated from plane-table traverses made along the north shore of Yaquina Bay. Steep reversals in dip recorded just west of McLean Point are interpreted as being the result of faulting; however, the possibility that the landslide mapped in that area may be responsible for the anomalous dips cannot be discounted.

The outcrop thickness of the Nye Mudstone decreases rapidly northward, and about 4½ miles north of the bay in the vicinity of Moloch Creek it is less than 1,000 feet. The rapid narrowing of the outcrop belt northward is the result of onlap of the Astoria Formation onto a broad pre-Astoria structural high. Also, north of the bay the Nye Mudstone contains thick interbeds of very fine-grained sandstone, which suggests that the Nye sea became shallower in that direction. Inasmuch as the sandstone of the Yaquina Formation thickens north of the bay, it is speculated that the Nye sea shoaled northward onto a constructional high formed by a broad submarine fan or delta of Yaquina time. The molluscan fauna contained in the very fine-grained sandstone of the Nye supports the suggested shoaling of the Nye sea.

Astoria Formation

In the immediate vicinity of Newport, strata of the Astoria Formation are exposed only in a narrow belt along sea cliffs and on the wave-cut platform from the Yaquina jetty northward for 1½ miles to Jumpoff Joe. The thickest and most continuous section of the Astoria Formation exposed along this part of the Oregon coast occurs 2½ to 6 miles north of Newport on the wave-cut platform and sea cliffs between Yaquina Head and Beverly Beach where more than 500 feet of strata are exposed. The succession of stratigraphic units in the Astoria Formation is difficult to determine, as the best outcrops occur in discontinuous patches on the wave-cut platform, which is largely covered by sand most of the year. The sequence also is complicated by north-trending en echelon faults that parallel the coastline for at least 15 miles north of Newport. On the basis of a study of cores from the U.S.C.E. holes drilled near the mouth of the Yaquina River and of the distribution of key lithologic units on the wave-cut platform west of Newport, faults of this type appear to have resulted in the duplication of section as shown on plate 1. The basalt "reef" about three-quarters of a mile offshore also appears to be offset by a north-trending fault near the north border of the map.

The Astoria Formation unconformably overlies the Nye Mudstone, but the contact is poorly exposed and difficult to recognize in the sea cliff at the mouth of the Yaquina River (just south of the lighthouse). The precise location of the contact is made even more difficult in this area because thick-bedded, very fine-grained sandstone in the Astoria Formation overlies weathered massive sandy siltstone of the Nye. However, the unconformity between the two formations is sharp and well exposed in the sea cliff at Jumpoff Joe, about 1½ miles north of Yaquina Bay (fig. 3), where sandstone of the Astoria Formation rests with slight, angular discordance on typical mudstone of the Nye. This mudstone is stratigraphically lower in the Nye than the sandy siltstone exposed at the mouth of the Yaquina River.

The Astoria Formation consists of a variety of near shore marine rocks, of which olive-gray, fine- to medium-grained micaceous, arkosic sandstone and dark-gray carbonaceous siltstone are the most common. Most of the sandstone ranges from well sorted to moderately sorted despite the fact that it commonly has a dirty appearance in hand sample. A few granule- to coarse-grained basaltic sandstone beds occur in the lower and middle parts of the formation; the thickest bed, about 15 feet thick, occurs near the middle of the unit. Concretionary ledges 6 inches to 2 feet thick and individual concretions 2 to 3 feet in diameter occur locally. Ledge-forming calcareous sandstone beds are more common in the lower part of the formation.

The most distinctive stratigraphic markers in the Astoria Formation are light yellowish-gray waterlaid fine tuff beds that in places contain altered pumice fragments and carbonaceous material. The beds range in thickness from a few inches to 18 feet and, being more resistant to erosion than the adjacent sandstone and siltstone, generally form ribs in the outcrops on wave-cut platforms. The andesitic to dacitic composition of these tuffs (see table 1, col. 2) and the presence of grains of hypersthene and hornblende in some tuffs suggest that their source was from pyroclastic eruptions in an ancestral Cascade Range to the east.

Sandstone beds in the Astoria Formation range from massive to thin-bedded and generally are thicker bedded in the upper part of the sequence. Thin bedding in the sandstone is accentuated by siltstone and claystone laminae, finely macerated plant material, or concentrations of mica. The thin bedding ranges from planar to irregular, contorted, or crenulated. Commonly the original bedding has been greatly disturbed by the activity of marine organisms, which have produced a "churned" appearance. Small-scale crossbedding, ripple marks, and penecontemporaneous slump structures due to submarine sliding are common. The slump structures range from small overturned folds within beds only 1 inch thick to large infolds several feet in amplitude; the direction of overturning indicates a general westward to northwestward gliding of some beds during deposition.

Well-preserved mollusks are generally abundant throughout the lower part of the formation in both the sandstone and siltstone units and locally are concentrated in calcareous ledges or concretions. Many of the pelecypods have articulated valves indicating that they have not undergone extensive transport. Higher in the sequence mollusks occur sparingly, and no megafossils were found in the upper 250 feet of the core-hole section.

Determinations of physical properties of seven core samples of sandstone from the Astoria Formation are given in table 2. Their relative stratigraphic positions are

Table 1. Chemical compositions of Miocene rocks in the Newport Embayment, Oregon

	1	2	3	4
SiO_2	60.8	55.2	49.0	50.1
Al_2O_3	13.9	15.3	12.5	13.3
Fe_2O_3	4.0	4.3	6.4	4.5
FeO	2.0	2.0	9.3	9.3
MgO	2.2	2.4	3.8	3.8
CaO	1.0	3.5	7.2	8.1
Na_2O	2.2	3.2	2.9	3.2
K_2O	1.7	.85	.79	.75
H_2O-	5.0	6.4	1.9	1.6
H_2O+	4.7	4.8	2.4	1.1
TiO_2	.74	.84	2.8	3.0
P_2O_5	.25	.33	.68	.65
MnO	.04	.12	.22	.21
CO_2	.58	1.0	$<.05$	.06

Columns 1-3 were analyzed using methods described in U. S. Geological Survey Bull. 1144-A. Analysts: Paul Elmore, Samuel Botts, Gillison Chloe, Lowell Artis, and H. Smith, U. S. Geological Survey.

Column 4, Standard rock analysis. Analyst: Dorothy F. Powers, U.S. Geol. Surv.

1. Nye Mudstone from U.S.C.E. core hole at locality 59, plate. 1.
2. Waterlaid tuff bed between samples 17 and 18 in figure 1.
3. Basalt flow in unnamed unit; samples in westernmost core hole.
4. Waterlaid volcanic debris at Government Point, 14 miles north of Newport, Ore..

Table 2. Partial mechanical analyses, porosities, and permeabilities of sandstone samples from Miocene rocks in the Yaquina Bay area, Newport, Oregon.

(From U.S.C.E. core holes)

Size fraction[1]	Sample[2]							
(Mn)	A	B	C	D	E	F	G	H
1.0		0.2	0.3	0.1				
0.5		4.9	9.2	1.9				
0.25	Trace	57.9	61.5	42.9	0.1	0.2	0.1	0.3
0.125	0.2	22.6	19.2	33.2	12.8	10.7	26.8	5.7
0.062	33.9	5.3	3.7	9.1	45.6	55.0	42.2	36.1
0.004	63.0	9.1	6.1	12.8	36.4	30.3	28.5	53.1
<0.002	<2.9			0.0	5.1	3.8	2.4	4.8
Effective porosity (in percent)	22.1	----	----	29.2	26.6	26.0	25.6	20.4
Permeability (in milli-darcies)	21.4	----	----	1682.0	31.2	20.1	29.2	3.0

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[1] Figures given are in percent retained on the respective screen sizes and pan. Columns A and D through H were analyzed by Robert Gantnier, U. S. Geological Survey. Columns B and C were analyzed by Martin Sorenson, U. S. Geological Survey.

[2] Location of sample is shown on plate 1; stratigraphic position is shown on figure 1.

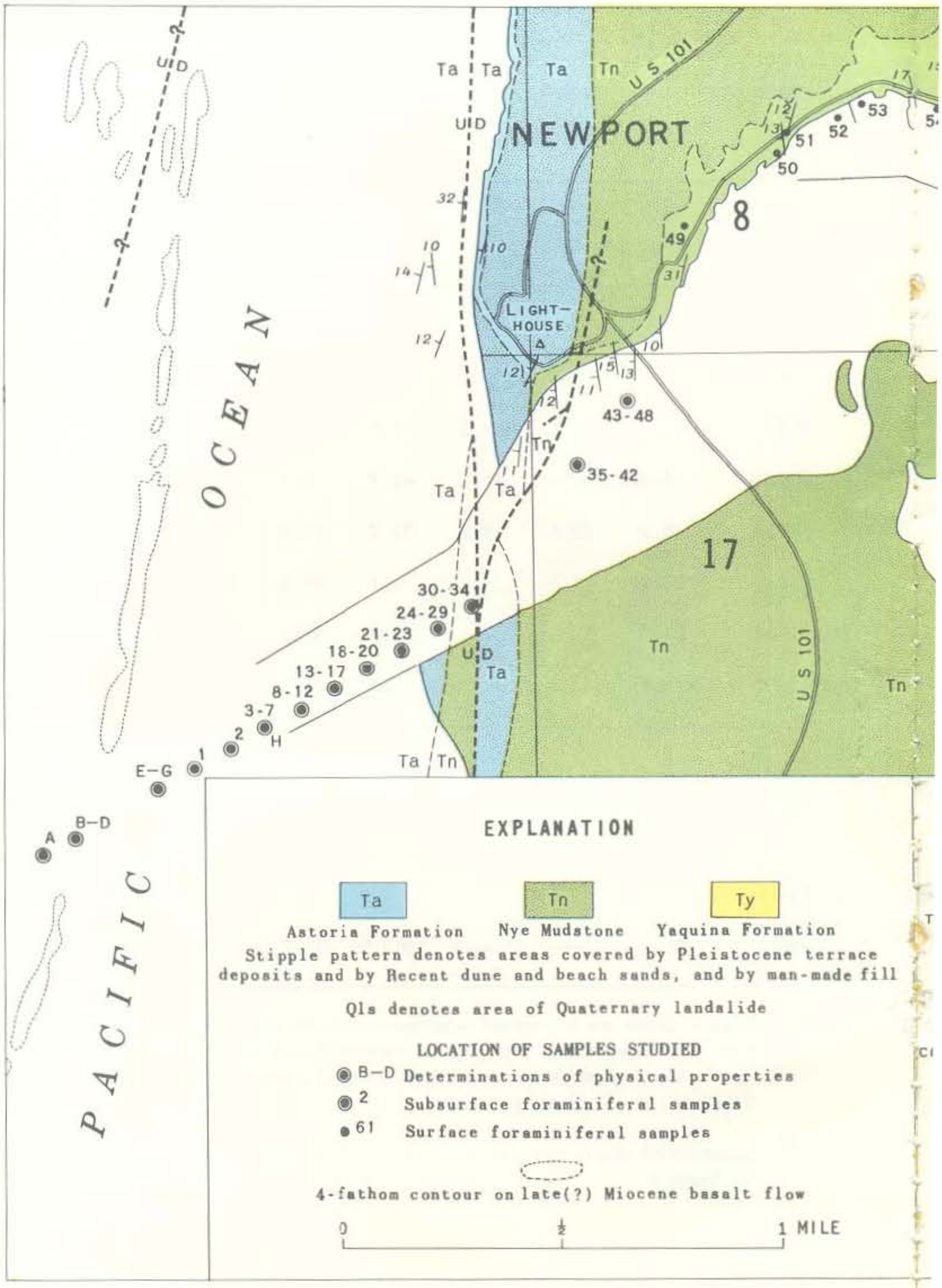
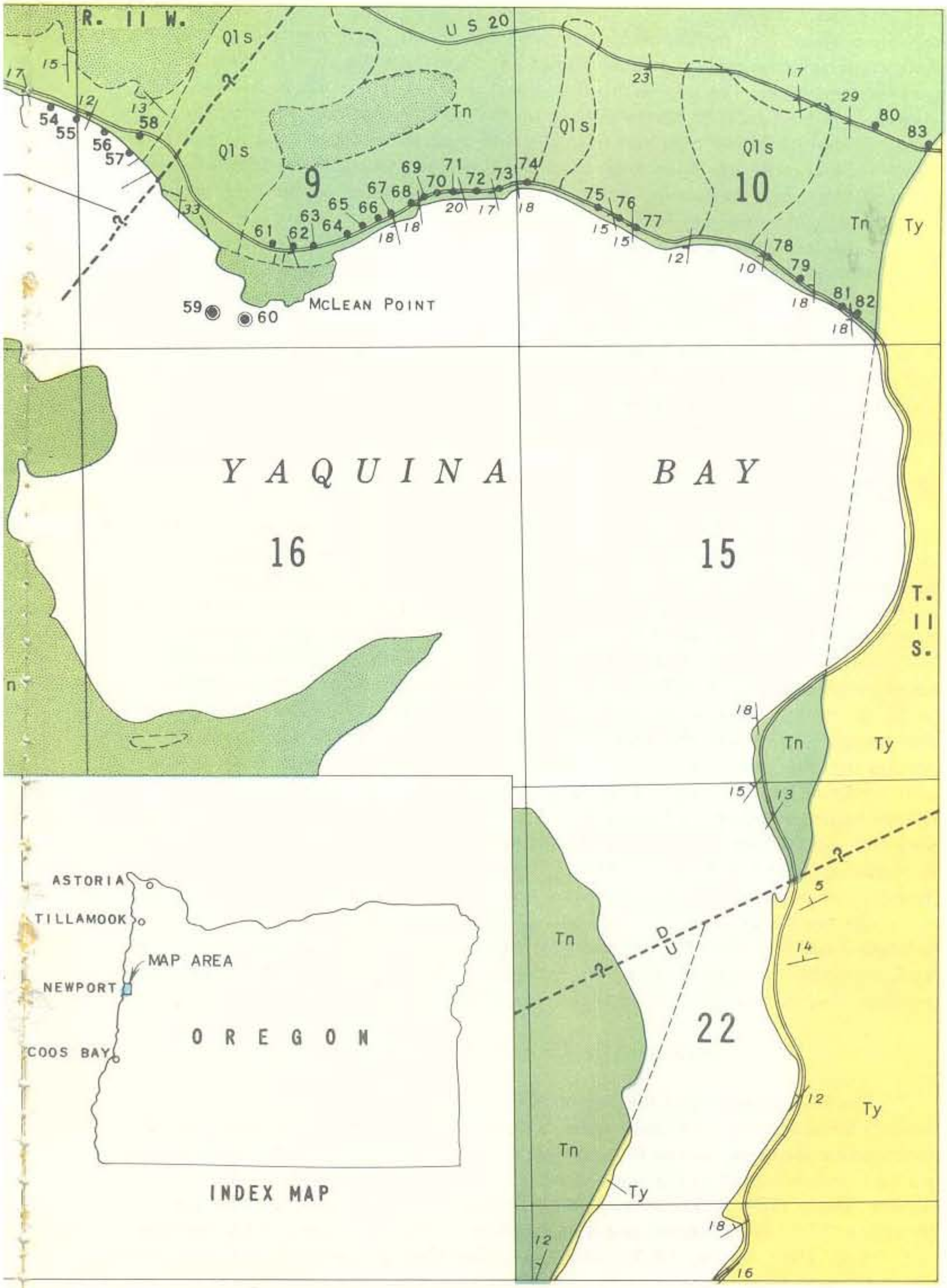


Plate 1. Geologic map of the Yaquina Bay area



ea, Newport, Oregon, showing sample locations.

shown on figure 1 by alphabetical designations B through H. Mechanical analyses indicate a range in grain size from medium-grained sandstone to silty, very fine-grained sandstone. The coarser sandstone occurs in the upper part of the formation. Porosity and permeability determinations on the medium- to fine-grained silty sandstones (B through E) indicate that even the fine-grained sandstones are potential reservoir rocks. Although these determinations have not been made on friable coarse- to medium-grained sandstones, hand-lens examination indicates that their porosities probably would be even higher.

Study of heavy mineral separations made for 25 samples of arkosic sandstone of the Astoria Formation suggests that the heavy mineral assemblage is similar throughout the unit. The mineral grains in the assemblage are predominantly subangular and consist of about 60 percent hornblende, 20 percent epidote, 8 percent garnet, 6 percent sphene, and less than 2 percent each of zircon, tourmaline, apatite, kyanite, and staurolite. Traces of red oxyhornblende(?) occur in nearly half of the samples. This heavy-mineral suite contrasts with that of the Nye Mudstone, which is characterized in general by a garnet-sphene-apatite assemblage.

Unnamed unit

In the Yaquina Bay area an unnamed unit of late(?) Miocene age unconformably overlies the Astoria Formation and consists of a basalt flow, waterlaid fragmental basaltic debris, and fine-grained sandstone. The unnamed unit is known only from the two westernmost core holes drilled about 1$\frac{1}{4}$ miles west of the mouth of the Yaquina River. The basalt flow at the base of the unit forms a north-trending "reef" indicated by the 4-fathom contour line on plate 1. This flow consists of a slightly porphyritic basalt about 60 feet thick that rests on black carbonaceous sandstone which is interpreted as an ancient soil zone. The basalt is massive and amygdaloidal throughout its thickness; the upper part is very vesicular. These data lead to the conclusion that this basalt flow was of subaerial origin and flowed out on the surface after uplift of the land and withdrawal of the sea. The flow is overlain by about 25 feet of waterlaid fragmental basaltic debris, which in turn is overlain by micaceous, very fine-grained sandstone and sandy siltstone of unknown thickness. The sandstone is irregularly bedded and crossbedded. The results of a mechanical analysis, and of porosity and permeability determinations, are given in table 2, column A.

On the basis of mineralogical similarities, as well as chemical data given in columns 3 and 4 of table 1, the basalt flow and breccia of the unnamed unit in the Yaquina cores are correlated with the volcanic rocks at Yaquina Head, Cape Foulweather, and northward as far as Government Point (14 miles north of Newport).

Age of the Miocene Sequence

The biostratigraphy of the sequence of Miocene strata exposed along Yaquina Bay has attracted many workers, because a practically uninterrupted succession of fossiliferous strata can be readily sampled here. Despite the fact that many of these workers have reported on the age and faunas of the Nye Mudstone and Astoria Formation (Dall, 1909, 1922; Howe, 1922; Schenck, 1928; Packard and Kellogg, 1934; Weaver, 1937, 1942; Warren and others, 1945; Vokes and others, 1949; Snavely and Vokes, 1949; Moore, 1963; and others), checklists of species in the order of their stratigraphic occurrence in the Miocene sequence have not been published. Table 3 presents the stratigraphic occurrence of Foraminifera in the Nye and Astoria collected systematically from both surface outcrops and from cores in U.S. Corps of Engineers test holes (localities 1-83 of plate 1). An alphabetical listing of species is given in table 4. Similar checklisting of the molluscan fauna in the Miocene sequence of the Yaquina Bay area must await further studies.[1]

Foraminiferal fauna

Although Foraminifera are abundant in both the Nye Mudstone and Astoria Formation exposed along the north side of Yaquina Bay, the number of species is limited. Individual assemblages are usually composed of two or three species that are represented by large numbers of individuals together with a few species that are poorly represented.

A two-fold subdivision of the Miocene foraminiferal sequence at Yaquina Bay has proved to be reasonably dependable in biostratigraphic work in the Newport Embayment. Fifteen species that occur in the Nye Mudstone are not found in the overlying Astoria Formation. Most significant among this group is *Uvigerinella obesa impolita* Cushman and Laiming, which occurs consistently throughout the Nye Mudstone. Additional species characteristic of the Nye, although not as consistently distributed, are *Cassidulina laevigata carinata* Cushman, *Gyroidina soldanii* d'Orbigny, and *Uvigerina auberiana* d'Orbigny.

Species confined to the overlying Astoria Formation are *Buliminella elegantissima* (d'Orbigny), *Robulus mayi* Cushman and Parker, *Valvulineria menloensis* Rau, and *Uvigerinella californica ornata* Cushman. Individual assemblages of the Astoria Formation are, therefore, differentiated from those of the Nye Mudstone primarily by the presence of one or more of these species. Inasmuch as none were found to occur either in large numbers or in many samples, it is entirely possible to encounter foraminiferal assemblages in the Astoria that do not contain any of these key species. In such cases it is not possible to differentiate Astoria assemblages from those of the Nye Mudstone.

Because of the many species found in the Nye Mudstone, but not in the Astoria Formation, Nye assemblages commonly are much more easily recognized, at least within the Newport Embayment, than assemblages of the Astoria Formation. These faunal distinctions, however, are not necessarily recognizable in the Tertiary sequence of other Pacific Coast areas. Therefore, only broad correlations with the Yaquina Bay foraminiferal sequence are justified.

The age of the lower part of the Nye Mudstone is firmly established as no older than the Saucesian Stage of Kleinpell (1938) on the basis of the present of *Nonion costiferum* (Cushman), *Bolivina advena* Cushman, *Epistominella parva* (Cushman and Laiming), and *Uvigerinella obesa impolita* Cushman and Laiming. The Saucesian Stage has been regarded as early Miocene by some workers (Kleinpell, 1934, 1938; Bandy and Kolpack, 1963); "Oligo-Miocene" by others (Weaver and others, 1944), and Oligocene and Miocene(?) by still others (Kleinpell and Weaver, 1963). In this

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[1] Biostratigraphic studies of Oligocene and Miocene molluscan faunas are currently being undertaken by W. O. Addicott of the U.S. Geological Survey.

Table 3. Checklist of Foraminifera from the Nye Mudstone and Astoria Formation, Yaquina Bay area, Newport, Oregon.

	ASTORIA FORMATION																						NYE MUDSTONE								
Species / Locs.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1. Nonionella miocenica Cushman	R	-	-	R	-	C	-	R	-	-	-	-	R	-	-	-	R	F	-	R	-	R	F	-	F	-	C	C	-	F	C
2. Buliminella subfusiformis Cushman	R	F	R	R	F	R	-	R	R	C	F	-	-	R	?	-	?	?	R	-	-	-	-	-	-	-	-	R	R	R	-
3. Buliminella elegantissima (d'Orbigny)	R	R	-	-	R	R	R	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Bulimina ovata d'Orbigny	R	F	-	-	-	R	R	F	-	-	-	-	R	-	R	-	R	R	F	-	-	-	-	-	-	-	-	-	-	-	-
5. Quinqueloculina sp.	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Nonion costiferum (Cushman)	-	F	F	F	F	-	-	R	C	C	C	C	-	F	R	R	R	F	C	C	-	F	F	F	F	C	C	F	R	C	F
7. Nonion incisum (Cushman)	-	F	?	-	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	F	R	-	-	-	C	-
8. Robulus mayi Cushman and Parker	-	R	-	-	-	-	-	-	-	-	F	?	-	-	-	-	?	-	R	R	-	-	-	-	-	-	-	-	-	-	-
9. Bolivina advena Cushman	-	F	C	C	C	F	F	R	C	F	F	F	F	R	F	-	R	C	C	F	F	C	C	C	R	F	R	F	C	-	F
10. Eponides mansfieldi oregonensis Cushman and R. E. and K.C. Stewart	-	?	-	R	F	-	-	R	F	R	F	F	R	R	R	F	-	R	F	C	-	-	R	R	R	-	F	C	-	R	F
11. Robulus spp.	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	R	F	-	-	R	-	-	R	R
12. Globigerina spp.	-	-	-	-	-	-	-	R	-	-	R	-	F	R	-	-	R	F	R	R	-	-	-	-	R	R	R	R	F	R	R
13. Valvulineria menloensis Rau	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14. Uvigerinella californica ornata Cushman	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15. Nonion incisum kernensis Kleinpell	-	-	-	-	-	-	-	-	-	-	-	F	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16. Cibicides sp.	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-
17. Epistominella parva (Cushman and Laiming)	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	R	-	R	F	-	-	-	-	-	F	-	-	-	-
18. Pseudoglandulina cf. P. inflata (Bornemann)	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19. Virgulina californiensis Cushman	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?	?	?	R	-	-	-	-	-	-	-	-	-	-	-
20. Lagena costata (Williamson)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-
21. Cassidulina laevigata carinata Cushman	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-
22. Uvigerinella obesa impolita Cushman and Laiming	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	F	F	-	C	R	-	C	F
23. Elphidium cf. E. minutum (Reuss)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	R	F	R
24. Gyroidina soldanii d'Orbigny	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25. Uvigerina auberiana d'Orbigny	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26. Plectofrondicularia californica Cushman and Stewart	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27. Bolivina marginata adelaidana Cushman and Kleinpell	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28. Nodogenerina advena Cushman and Laiming	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29. Bulimina alligata Cushman and Laiming	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30. Plectofrondicularia vaughani Cushman									-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31. Cassidulinoides sp.									-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
32. Entosolenia sp.									-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
33. Lagena substriata Williamson									-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
34. Eponides cf. E. nanus (Reuss)									-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
35. Marginulina subbullata Hantken									-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
36. Dentalina cf. D. quadrulata Cushman and Laiming									-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-

Legend

C - Common
F - Few
R - Rare
? - Questionably identified

32	-	-	-	-	R	R	-	-	-	-	R	R	-	-	-	-	-	-	-	-	R	-	F	R	F	-	-	-	-	-	-	-	-	-	-	-
33	R	F	-	-	-	R	-	-	C	-	-	R	-	-	-	-	-	-	C	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	R	R	-	-	-	R	-	-	R	R	-	R	-	-	-	-	R	-	F	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	-	C	-	R	R	R	-	-	R	R	-	R	-	-	-	-	R	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	-	C	-	R	-	C	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	-	-	-	R	-	F	-	-	-	F	R	R	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	-	F	-	R	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	-	C	-	-	-	C	-	-	R	-	-	-	-	-	-	-	R	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	-	C	-	-	-	F	-	-	-	-	-	R	-	-	-	-	R	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	-	C	-	-	-	F	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	-	C	-	-	-	R	-	-	-	-	R	R	-	-	-	-	R	-	-	-	R	C	-	R	-	-	-	-	-	-	-	-	-	-	-	-
43	-	C	-	-	-	R	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	-	C	-	-	-	R	-	-	-	-	R	-	-	-	-	-	R	-	-	-	-	C	-	-	R	-	-	-	-	-	-	-	-	-	-	-
45	-	C	-	-	-	R	-	-	-	-	R	-	-	-	-	-	F	-	-	-	-	F	-	-	-	R	-	-	-	-	-	-	-	-	-	-
46	-	C	-	-	-	R	-	-	-	-	-	R	-	-	-	-	R	-	-	-	-	C	-	R	-	F	-	-	-	-	-	-	-	-	-	-
47	-	C	-	-	-	C	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	C	-	R	R	-	-	-	-	-	-	-	-	-	-	-
48	R	C	-	R	-	F	-	-	-	-	R	-	-	-	-	-	R	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	-	C	-	F	-	F	-	-	R	-	-	F	-	-	-	-	-	-	?	-	-	?	-	-	?	-	-	-	-	-	-	-	-	-	-	-
50	-	C	-	-	-	F	-	-	C	-	R	F	-	-	-	-	R	-	-	-	-	C	-	-	F	-	-	-	-	-	-	-	-	-	-	-
51	-	C	-	R	-	F	-	-	F	F	R	C	-	-	-	-	-	R	-	-	C	C	-	-	F	R	R	R	-	-	-	-	-	-	-	-
52	-	R	-	-	-	R	-	-	-	-	R	F	-	-	-	-	-	R	-	-	C	-	R	C	C	F	R	R	C	-	-	-	-	-	-	-
53	-	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	R	-	-	-	-	-	-	-
54	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	R	-	C	-	-	-	-	-	-	-	-	-	-	-
55	-	R	-	-	-	C	-	-	R	-	R	F	-	-	-	-	-	R	-	R	C	F	F	F	C	-	-	-	F	-	-	-	-	-	-	-
56	-	R	-	-	-	C	-	-	R	-	F	F	-	-	-	-	-	R	-	R	C	F	F	F	C	R	-	F	F	R	-	-	-	-	-	-
57	-	C	-	-	-	F	-	-	F	-	-	R	-	-	-	-	-	-	R	-	F	C	-	R	-	F	-	-	R	-	-	-	-	-	-	-
58	-	-	-	-	-	C	-	-	F	-	-	F	-	-	-	-	-	F	F	R	C	-	-	C	C	F	R	F	C	-	-	-	-	-	-	-
59	-	-	-	-	-	R	-	-	-	-	R	R	-	-	-	-	-	F	F	-	F	R	-	R	C	-	-	-	R	-	-	-	-	-	-	-
60	-	-	-	-	-	R	R	-	-	-	-	-	-	-	-	-	-	R	-	-	C	C	F	R	C	F	-	-	-	-	-	-	-	-	-	-
61	-	-	-	-	-	C	-	-	-	?	R	F	-	-	-	-	-	F	C	-	C	F	F	R	C	-	F	-	F	-	-	-	-	-	-	-
62	R	C	-	C	-	C	-	-	R	-	R	F	-	-	-	-	C	-	C	-	-	C	-	-	F	-	F	-	-	-	F	-	-	-	-	-
63	-	C	-	-	-	C	-	-	-	-	-	F	-	-	-	-	C	-	F	-	-	C	-	-	R	-	-	-	-	-	-	-	-	-	-	-
64	-	C	-	?	-	C	-	-	F	-	-	F	-	-	-	-	C	-	F	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65	-	C	-	F	-	C	-	-	C	-	F	C	-	-	-	-	R	-	-	R	C	C	-	R	C	R	-	-	-	-	-	R	R	-	-	-
66	-	C	-	F	-	C	-	-	C	-	F	F	-	-	-	-	-	R	-	R	-	C	-	F	C	F	-	-	-	-	-	-	-	C	-	-
67	-	C	-	F	R	C	-	-	C	-	C	F	-	-	-	-	-	-	-	F	C	F	-	-	C	F	-	-	-	-	-	R	-	R	-	-
68	-	F	-	F	-	?	-	-	F	-	C	C	-	-	F	-	?	-	?	R	?	-	-	-	C	-	?	-	F	-	-	R	-	C	-	-
69	-	F	-	-	-	-	-	-	F	-	F	F	-	-	F	-	-	F	?	-	R	-	-	F	C	-	-	F	C	-	-	-	-	-	-	-
70	-	C	-	C	-	-	-	-	F	-	R	F	-	-	C	-	-	-	?	-	?	-	-	-	C	-	-	-	-	-	-	-	-	F	-	-
71	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-
72	-	F	-	-	-	-	-	-	C	-	R	C	-	-	C	-	-	-	?	-	-	-	-	F	C	-	-	-	R	-	-	-	-	-	-	-
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75	-	F	-	-	-	C	-	-	R	-	F	-	-	-	-	-	-	-	?	R	F	C	-	F	F	-	R	-	-	-	-	-	-	-	-	-
76	-	C	-	-	-	C	-	-	C	-	C	R	-	-	?	-	-	F	?	F	F	F	-	F	R	R	-	-	-	-	-	-	-	-	-	-
77	-	R	-	?	-	C	-	-	F	-	F	-	-	-	?	R	-	-	-	R	?	C	-	C	-	-	-	-	-	-	-	-	-	-	-	R
78	-	-	-	-	-	-	-	-	-	?	R	-	-	-	C	R	-	F	-	R	-	-	C	F	-	-	-	-	-	-	-	-	-	-	-	-
79	-	-	-	F	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	R	-	-	-	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	F	-	-	R	-	F	-	-	-	-	R	?	R	-	-	R	C	C	F	C	F	-	-	-	-	-	R	R	-	F	-
81	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	F	-	-	-	-	-	-	-	-	-	-	-	-
82	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
83	-	-	-			C	-		-	-	-	-	-	-	-	R	R	-	-	-	F	C	F	F	R	R	-	-	R	-	-	R	-	-	-	-

Table 4. Alphabetical listing of Foraminifera from the Nye Mudstone and Astoria Formation, Yaquina Bay area, Newport, Oregon.

Species

9. *Bolivina advena* Cushman
27. *Bolivina marginata adelaidana* Cushman and Kleinpell
29. *Bulimina alligata* Cushman and Laiming
4. *Bulimina ovata* d'Orbigny
3. *Buliminella elegantissima* (d'Orbigny)
2. *Buliminella subfusiformis* Cushman
21. *Cassidulina laevigata carinata* Cushman
31. *Cassidulinoides* sp.
16. *Cibicides* sp.
36. *Dentalina* cf. *D. quadrulata* Cushman and Laiming
23. *Elphidium* cf. *E. minutum* (Reuss)
32. *Entosolenia* sp.
17. *Epistominella parva* (Cushman and Laiming)
10. *Eponides mansfieldi oregonensis* Cushman and R. E. and K. C. Stewart
34. *Eponides* cf. *E. nanus* (Reuss)
12. *Globigerina* spp.
24. *Gyroidina soldanii* d'Orbigny
20. *Lagena costata* (Williamson)
33. *Lagena substriata* Williamson
35. *Marginulina subbullata* Hantken
28. *Nodogenerina advena* Cushman and Laiming
6. *Nonion costiferum* (Cushman)
7. *Nonion incisum* (Cushman)
15. *Nonion incisum kernensis* Kleinpell
1. *Nonionella miocenica* Cushman
26. *Plectofrondicularia californica* Cushman and Stewart
30. *Plectofrondicularia vaughani* Cushman
18. *Pseudoglandulina* cf. *P. inflata* (Bornemann)
5. *Quinqueloculina* sp.
8. *Robulus mayi* Cushman and Parker
11. *Robulus* spp.
25. *Uvigerina auberiana* d'Orbigny
14. *Uvigerinella californica ornata* Cushman
22. *Uvigerinella obesa impolita* Cushman and Laiming
13. *Valvulineria menloensis* Rau
19. *Virgulina californiensis* Cushman

report the Saucesian Stage is considered to be early Miocene and the Relizian Stage middle Miocene. As *Uvigerinella obesa impolita* occurs in the uppermost part of the Nye Mudstone, a Saucesian age is indicated for the entire unit.

Although the species found in the Astoria Formation in the Yaquina Bay area are known to occur in both the Relizian and Saucesian Stages, the composition of the fauna suggests a Saucesian age. Farther north, in the southern part of the Astoria Embayment, strata referred to the Astoria Formation (Wells and Peck, 1961) contain a foraminiferal assemblage diagnostic of the Relizian Stage. This fact suggests that strata assigned to the Astoria Formation in western Oregon range in age from Saucesian to Relizian and that only the lower part of the sequence (Saucesian) is present in the Yaquina Bay area.

The Yaquina Formation and the upper part of the Toledo Formation (Vokes and others, 1949), which underlie the Nye Mudstone in the Newport Embayment, contain typical Zemorrian faunas. However, several samples of tuffaceous siltstone collected in the upper part of the Toledo Formation contained the following Saucesian-like forms:

Bolivina marginata adelaidana Cushman and Kleinpell - Common
Buliminella subfusiformis Cushman - Common
Cassidulina laevigata carinata Cushman - Common
Gyroidina soldanii d'Orbigny - Few
Nonion incisum (Cushman) - Few
Pseudoglandulina cf. *P. inflata* (Bornemann) - Rare
Uvigerinella obesa impolita Cushman and Laiming - Common
Virgulina californiensis Cushman - Few

The above fauna does not contain *Nonion costiferum*, which is common in the Nye Mudstone; therefore, the absence of this species suggests a pre-Saucesian age. *Nonion costiferum* is not known to extend below the Saucesian Stage, and in the Newport Embayment it is not known below the Nye.

The occurrence of a Saucesian-like fauna without *Nonion costiferum* in the Zemorrian part of the Toledo Formation suggests that environmental conditions during that time were similar to those operative during the time of deposition of the Nye.

Cool, fairly deep water conditions (more than 2,000 feet) are suggested by the presence of *Uvigerinella obesa impolita*, *Uvigerina auberiana*, and *Gyroidina soldanii* in the lower part of the Nye Mudstone. *Nonion costiferum* tends to modify this concept, suggesting temperate conditions at depths of possibly 1,000 to 2,000 feet. Some relatively minor variations of this general environment probably took place during the deposition of the remainder of the lower part, as well as the middle part, of the Nye Mudstone. Possibly the greatest water depth was attained during the deposition of the lower middle part of the unit, where *Gyroidina soldanii*, *Cassidulina laevigata carinata*, *Uvigerina auberiana*, and *Uvigerinella obesa impolita* are present in substantial numbers. A gradual decrease in the water depth and probably an accompanying increase in water temperature took place during the deposition of the upper middle part of the Nye Mudstone. In the upper part of the Nye Mudstone, *Nonion costiferum*, *Bolivina advena*, and *Uvigerinella obesa impolita* are the persistent species and together suggest depths possibly between 500 and 1,500 feet. By Astoria time, water temperature may have been temperate, and depths possibly not more than 500 feet, for *Buliminella subfusiformis*, *Bolivina advena*, *Eponides* *mansfieldi oregonensis* and *Nonion costiferum* constitute the major part of the foraminiferal fauna.

Molluscan fauna

The rather limited molluscan assemblage contained in the Nye Mudstone has been listed by Vokes and others (1949) from collections made in the Newport Embayment. Study of these and new collections made by W. O. Addicott (written communication, May 1964) indicates that there are species in the Nye that are common also to the Astoria and Yaquina Formations; however, there seems to be a greater degree of similarity with the fauna of the Astoria. Addicott states that the Nye fauna correlates with the upper part of the Blakeley Stage or *Echinophoria apta* zone of Durham (1944). The fine-grained sandstone interbeds in the Nye contain upper Blakeley Stage index species such as *Aforia clallamensis* (Weaver), "*Apolymetis*" *twinensis* Durham, and *Macoma twinensis* Clark. However, some of the important guides, including *Liracassis apta* (Tegland), have not been found. As the upper part of the Blakeley Stage is correlated by Addicott (written communication, May 1964) with at least part of the early Miocene Vaqueros "Stage" of California, the Nye Mudstone is also considered to be of that age.

Mollusks of the Nye Mudstone suggest minimal water depths corresponding to the outer part of the sublittoral zone (low tide to 100 fathoms). Water temperatures were cool temperate in contrast to the warm-temperate environment suggested by the fauna of the overlying Astoria Formation.

Moore (1963) has recently monographed the molluscan fauna of the Astoria Formation of western Oregon and has presented evidence for correlation of that fauna with part of the Miocene of California. Of 97 Astoria species Moore lists 20 that occur in the Barker's Ranch fauna of California, which is assigned to the middle Miocene Temblor "Stage" of the informal standard section. Recent studies of the Barker's Ranch fauna by W. O. Addicott (written communication, May 1964) show an even greater number of identical species than Moore noted: 30 out of 97, or about 30 percent. According to Addicott, comparison with the fauna of the lower Miocene Vaqueros "Stage" of California reveals only 13 out of 97 species in common with the Astoria fauna.

Of particular interest to those concerned with biostratigraphic studies in the Astoria Formation in the Newport Embayment is the recognition by Addicott (written communication, May 1964) of a unique assemblage of mollusks in the upper part of the sequence exposed in the sea cliffs and on the wave-cut platform immediately north of the town of Otter Rock (locally referred to as the Marine Gardens). This high Astoria fauna is characterized by the gastropods *Nassarius arnoldi* (Anderson), *Molopophorus matthewi* Etherington, *Natica* (*Natica*) n. sp., and *Chlorostoma* aff. *C. pacificum* (Anderson and Martin). Pelecypods in these strata also occur lower in the Astoria Formation, but the most abundant mollusk in the younger beds is *Spisula albaria* (Conrad), represented by rather small individuals.

Moore (1963) concluded that the Astoria molluscan fauna is indicative of shallow- to moderate-water depths and a warm-temperate marine environment.

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NOTICE OF WELL RECORDS RELEASED

Humble Oil & Refining Co., Wicks No. 1, NE¼ sec. 11, T. 7 S., R. 1 E., Marion County. Total depth 7,797 feet. Records were released from the Department's confidential file on July 31, 1964. Available data include: core descriptions, mud log, induction electric log, and driller's log.

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METEORITE EXHIBIT OPEN TO PUBLIC

Meteorites, tektites, and impactites are on display at the Department's museum, at 1069 State Office Building, Portland. The specimens are on loan from Dr. Erwin F. Lange, Portland State College, and from the collection of the late Ben R. Bones of Grants Pass. Shown also are photographs of famous Oregon meteorites, including a fragment of the "Port Orford Meteorite" featured in the July issue of The ORE BIN.

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OREGON'S MINERAL INDUSTRY ZOOMS UPWARD

By Ralph S. Mason*

With a 19.4 percent increase in the value of minerals produced compared to 1962, Oregon mineral production rocketed to an all-time high of $62, 700,000 in 1963. As usual, industrial minerals accounted for the bulk of the state's mineral wealth, with stone and sand and gravel representing nearly 69 percent of the total. The vast increase in production value resulted primarily from the mining of increased quantities of raw materials, plus small increases in the unit values of the commodities. The low values placed on stone ($1.20 per ton) and sand and gravel ($1.22 per ton) in the U.S. Bureau of Mines canvass (see table 1) are typical of those used in computing the state total. Employment and payrolls in the state's mineral industries showed impressive gains over last year. Payrolls totalled $71,354,000 up 7.25 percent over 1962. Employment increased 3.17 percent for a total of 10,592 employees (see table 2).

Oregon's mineral industry permeates every segment of the state, and contributes importantly to the local economies of many counties. The distribution of the mineral industry by counties is shown on the accompanying map. The rapid growth of the industry in Oregon is clearly shown in table 3, which depicts the relative rank of the 19 counties which have produced more than $1 million during one or more years in the period from 1954 to 1963. During this time the yearly number of counties has doubled, from 6 in 1954 to 12 in 1963. Douglas County, largely through the efforts of Hanna Nickel Smelting at Riddle, pushed into first place for the first time in 1963. The county had been in second place for the preceding 7 years, with either Lane or Clackamas Counties in the top spot. This year for the first time Gilliam and Klamath Counties became members of the million-dollar club. Wasco and Sherman Counties, included this year, have each been members once before in the 10-year period. The 6 counties of Baker,

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

TABLE 1. Mineral Production in Oregon, 1962 - 1963 1/

Mineral		1962 Short tons (unless otherwise stated)	1962 Value (thousands)	1963 Short tons (unless otherwise stated)	1963 Value (thousands)
Clays	thousand short tons	249	$ 305	279	330
Copper (recoverable content of ores, etc.	short tons	2/	2/	17	10
Diatomite	short tons	50	2	150	3
Gold (recoverable content of ores, etc.)	troy ounces	822	29	1,809	63
Lime	thousand short tons	78	1,514	90	1,835
Mercury	76-pound flasks	2/	2/	4	1
Nickel (content of ore and concentrate)	short tons	13,110	2/	13,394	2/
Perlite	short tons	3	3/	- -	- -
Pumice and volcanic cinder	thousand short tons	2/	2/	422	664
Sand and gravel	thousand short tons	14,869	14,556	15,715	18,850
Silver (recoverable content of ores, etc.)	troy ounces	6,047	7	58,234	74
Stone	thousand short tons	18,258	20,977	19,692	24,197
Uranium ore	short tons	2,722	112	1,763	45
Value of items that cannot be disclosed: Asbestos (1962), cement, gem stones, iron ore (includes pigment material), lead, zinc, and values indicated by footnote 2/			14,956		16,621
Total			52,458		62,693

Note

1/ Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

2/ Figure withheld to avoid disclosing individual company confidential data.

3/ Less than $500.

TABLE 2. Oregon Mineral Industry Employment and Payrolls*

	1962		1963		Percent Change	
	Employment	Payrolls	Employment	Payrolls	Employment	Payrolls
1. Mining	1,263	$ 7,272,000	1,335	$ 8,667,000	+ 5.7	+19.2
2. Mineral Manufacturing	2,820	17,589,000	3,080	20,268,000	+ 9.2	+15.2
3. Primary metals	5,405	36,521,000	5,348	36,979,000	- 1.07	+ 1.25
4. Miscellaneous	352	2,190,000	407	2,316,000	+15.6	+ 5.75
	10,267	$66,535,000	10,592	$71,354,000	+ 3.17	+ 7.25

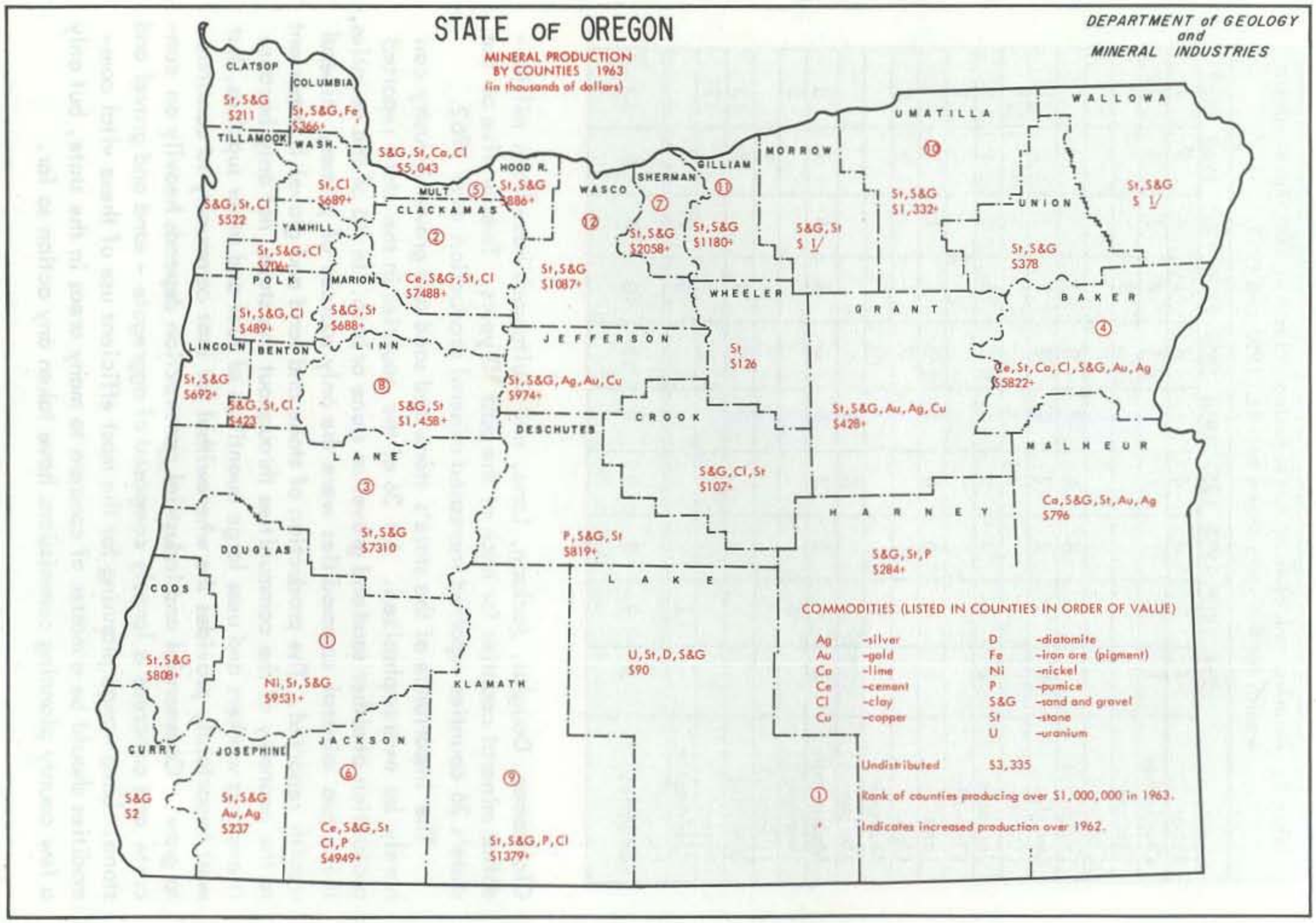
* Oregon State Employment Department figures. Percentages added.

Table 3. Relative rank of counties producing at least $1,000,000 of mineral wealth for the years shown between 1954 and 1963.

	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Baker	4	3	4	4	4	4	3	4	5	4
Clackamas	1	1	1	1	1	1	4	3	3	2
Clatsop							8			
Coos			7							
Deschutes			8	9	7	8	7			
Douglas	6	5	2	2	2	2	2	2	2	1
Gilliam										11
Jackson	2	2	3	5	5	5	6	5	4	6
Klamath										9
Lane	5	6	6	6	3	3	1	1	1	3
Linn						7			8	8
Malheur		9				10				
Marion				8	8					
Multnomah	3	4	5	3	6	6	5	6	6	5
Sherman		8								7
Tillamook									9	
Umatilla					9	9	9		7	10
Wasco				7						12
Washington		7					10	7		
No. of Counties	6	9	8	9	9	10	10	7	9	12

Clackamas, Douglas, Jackson, Lane, and Multnomah have been million-dollar mineral counties for each of the past 10 years. Twenty-five of the state's 36 counties reported increased mineral production over 1962.

The importance of the state's stone and sand and gravel industry can hardly be overemphasized. All 36 of the counties in the state reported production of either sand and gravel or stone or both. In 16 of the counties, these two mineral commodities were the only sources of primary mineral wealth reported. The production of stone and sand and gravel is important to the economy of the communities throughout the state, not only because it employs workers and uses large quantities of fuel and other supplies, but most importantly provides the wherewithal for that community to continue to grow. Commercial and industrial construction depends heavily on concrete and concrete is largely composed of aggregate - sand and gravel and stone. Long-range planning for the most efficient use of these vital commodities should be a matter of concern to many areas in the state, but only a few county planning commissions have taken any action so far.


STATE OF OREGON
MINERAL PRODUCTION BY COUNTIES 1963
(in thousands of dollars)
DEPARTMENT of GEOLOGY and MINERAL INDUSTRIES
CLATSOP
St, S&G
$211
COLUMBIA
St, S&G, Fe
$266+
TILLAMOOK
S&G, St, Cl
$522
WASH.
St, Cl
$689+
MULT
⑤
S&G, St, Ca, Cl
$5,043
YAMHILL
St, S&G, Cl
$706+
CLACKAMAS
②
Ce, S&G, St, Cl
$7488+
POLK
St, S&G, Cl
$489+
MARION
S&G, St
$688+
LINCOLN
St, S&G
$692+
BENTON
S&G, St, Cl
$423
LINN
⑧
S&G, St
$1,458+
LANE
③
St, S&G
$7310
DOUGLAS
①
Ni, St, S&G
$9531+
COOS
St, S&G
$808+
CURRY
S&G
$2
JOSEPHINE
St, S&G
Au, Ag
$237
JACKSON
⑥
Ce, S&G, St
Cl, P
$4949+
KLAMATH
⑨
St, S&G, P, Cl
$1379+
HOOD R.
St, S&G
$886+
WASCO
⑫
St, S&G
$1087+
SHERMAN
⑦
St, S&G
$2058+
GILLIAM
⑪
St, S&G
$1180+
JEFFERSON
St, S&G, Ag, Au, Cu
$974+
DESCHUTES
P, S&G, St
$819+
CROOK
S&G, Cl, St
$107+
WHEELER
St
$126
MORROW
S&G, St
$ 1/
UMATILLA
⑩
St, S&G
$1,332+
WALLOWA
St, S&G
$ 1/
UNION
St, S&G
$378
BAKER
④
Ce, St, Ca, Cl, S&G, Au, Ag
$5822+
GRANT
St, S&G, Au, Ag, Cu
$428+
HARNEY
S&G, St, P
$284+
MALHEUR
Ca, S&G, St, Au, Ag
$796
LAKE
U, St, D, S&G
$90
COMMODITIES (LISTED IN COUNTIES IN ORDER OF VALUE)
Ag -silver
Au -gold
Ca -lime
Ce -cement
Cl -clay
Cu -copper
D -diatomite
Fe -iron ore (pigment)
Ni -nickel
P -pumice
S&G -sand and gravel
St -stone
U -uranium
Undistributed $3,335
① Rank of counties producing over $1,000,000 in 1963.
+ Indicates increased production over 1962.

COMPARISON OF 1962-63 MINERAL PRODUCTION IN THE 13 WESTERN STATES

State	1962	1963*	Percent Change	Productive Rank
Alaska	$ 54,196,000	$ 67,840,000	+25.20	11
Arizona	474,131,000	481,392,000	+1.54	4
California	1,467,340,000	1,525,359,000	+3.95	1
Colorado	308,164,000	318,608,000	+3.42	6
Hawaii	14,800,000	15,300,000	+0.34	13
Idaho	82,614,000	82,787,000	+0.21	9
Montana	190,657,000	187,002,000	-1.95	7
New Mexico	675,814,000	687,825,000	+1.75	2
Nevada	83,074,000	85,441,000	+2.90	8
Oregon	52,458,000	62,693,000	+19.40	12
Utah	410,590,000	402,281,000	-2.09	5
Washington	68,478,000	71,462,000	+4.36	10
Wyoming	462,570,000	504,633,000	+9.08	3

* Some figures are preliminary estimates. Source, U.S. Bureau of Mines

Of the 13 western states, Oregon ranks 12th in value of mineral production. This is only part of the picture, however. Last year Oregon was next to the top of the list in the increase in production over 1962. Oregon showed a 19.4 percent increase, second only to the slightly higher figure of 25.2 percent turned in by Alaska.

* * * * *

CRACK-IN-THE-GROUND, LAKE COUNTY, OREGON

By

Norman V. Peterson* and Edward A. Groh**

Open cracks or fissures in the earth's surface are not uncommon; they occur fairly often as a result of earthquakes or volcanic activity, but they usually become filled with rock rubble or lava and disappear in a very short time. A large fissure that stays open for hundreds of years is, therefore, a rare feature. Such a fissure occurs in a remote part of central Oregon. It is a deep, narrow rift about 2 miles long, and it has remained open for perhaps a thousand years. For lack of any official name for it, the feature is referred to simply as "Crack-in-the-Ground."

Location and History

Crack-in-the-Ground is situated in northern Lake County in T.26 S., R. 17 E. As shown on the accompanying geologic sketch map (plate 1), it can be traced from the southwest edge of the Four Craters lava field diagonally to the southeast until it disappears in lake sediments that mark the north shoreline of prehistoric Christmas Lake.

The feature can be reached by road, but the last few miles are not suitable for cars with low road clearance. The route starts from the east side of Silver Lake on Oregon Highway 31. From this point the course leads 19 miles northeast on a paved road to Christmas Valley Lodge, then east on a graveled road 1 mile and north on a graded dirt road 4 miles. At this mileage a rough, bouldery road branches off to the left and winds northwesterly through the sagebrush. It approximately parallels the west side of the fissure for 2 miles and then skirts the western edge of Four Craters lava field (see map). This road passes within 150 yards of the northern end of Crack-in-the-Ground, where lava has flowed into the fissure and filled it.

Homesteaders in the area have known about this giant fissure for many years. Reuben Long of Fort Rock, Oregon, reports (written communication,

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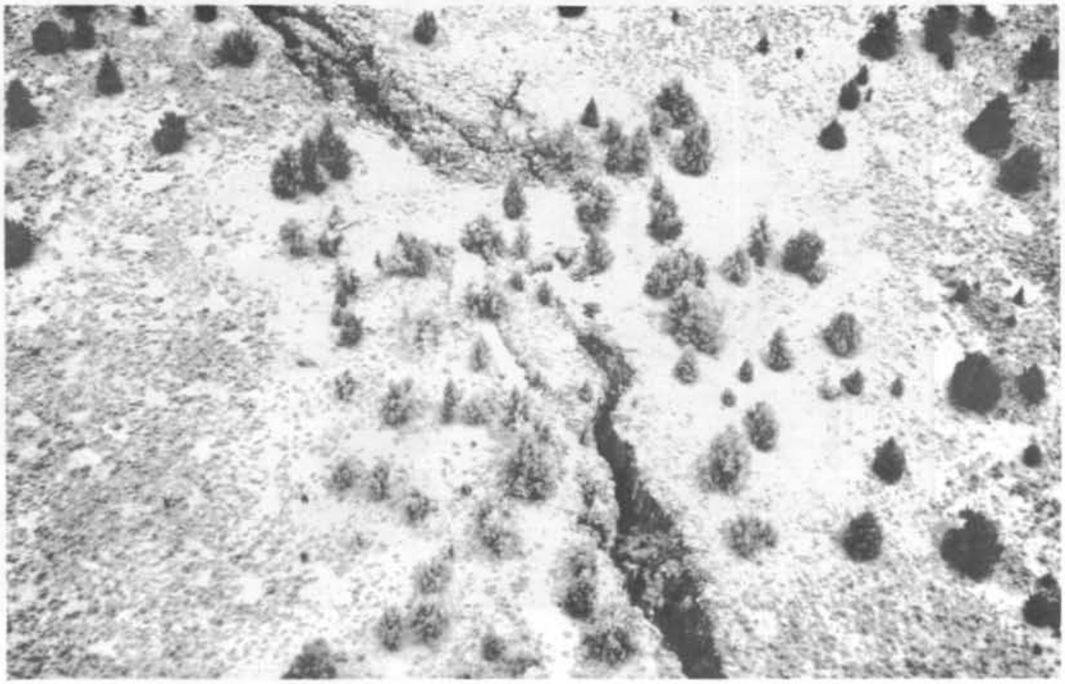
* Geologist, State of Oregon Dept. of Geology & Mineral Industries.

** Private geologist, Portland, Oregon.

Figure 1. Aerial view of Crack-in-the-Ground looking north-northwest. Four Craters lava field in the background. Road shows in upper left corner.

Figure 2. Looking down on a portion of Crack-in-the-Ground. The fissure has been filled and bridged over in the center of the picture.



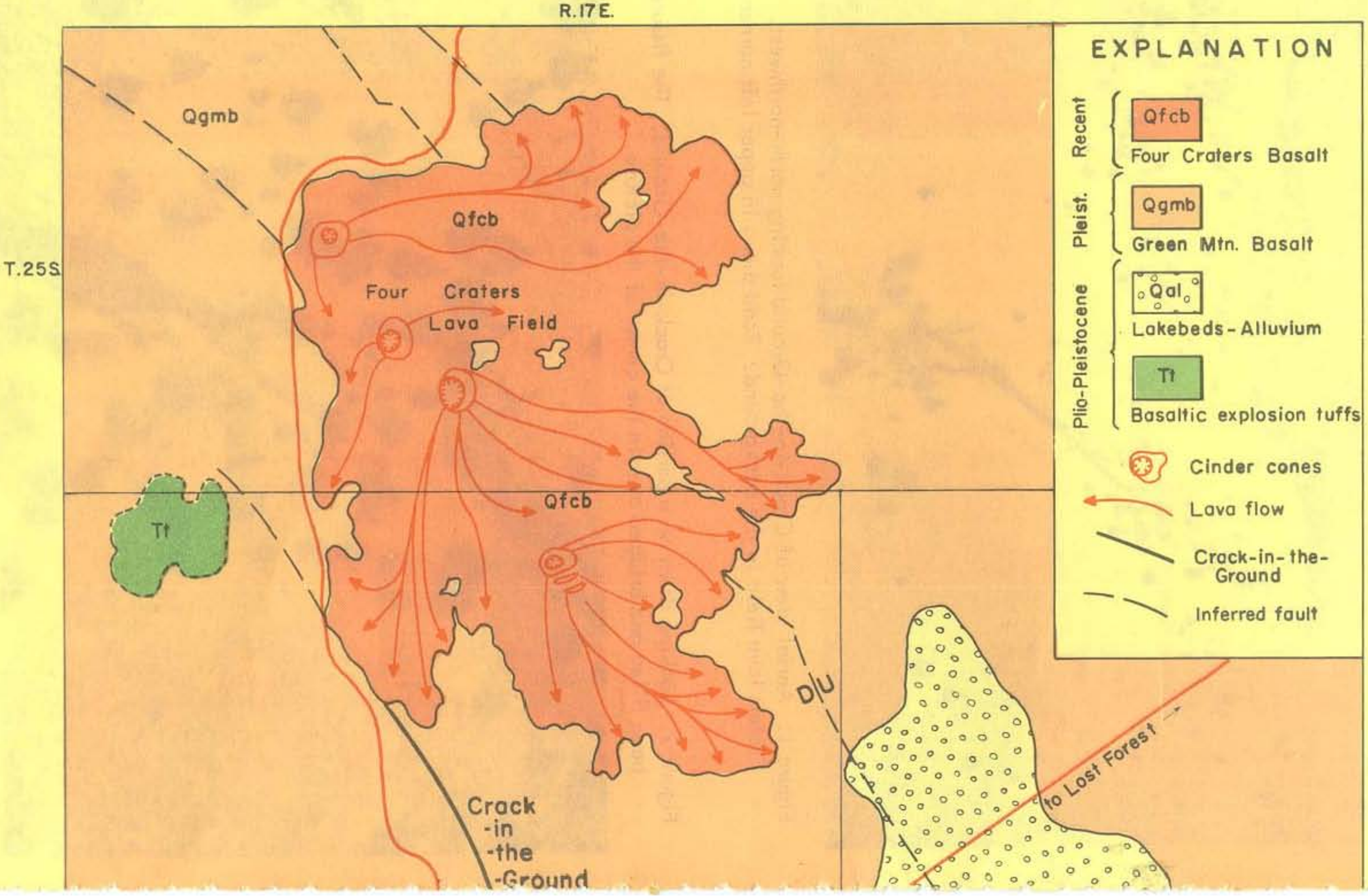
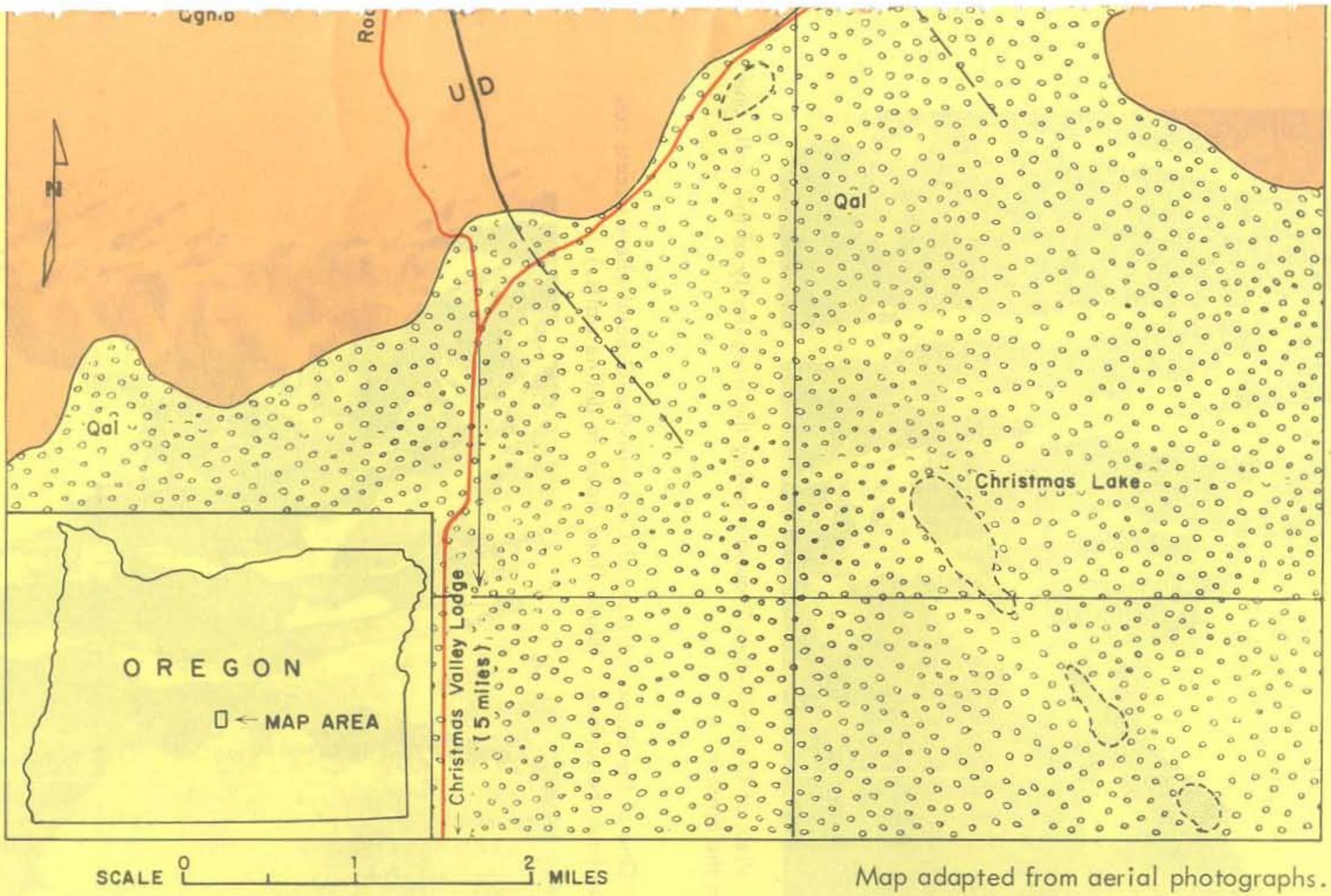


Plate 1. Geologic Sketch Map of the Crack-in-the-Ground Area.



Map adapted from aerial photographs.

Map prepared by
STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Figure 3. View of Crack-in-the-Ground showing the irregularity of the walls and fill in the bottom.

Figure 4. One of the deeper portions of Crack-in-the-Ground where access can be had from the surface. (Black lines drawn to define walls.)

1964) that when he lived at Christmas Lake as a boy he used to explore "The Crack," as it was called locally. He remembers that the homesteaders went there to hold picnics and make ice cream, using ice they found in caves in the chasm.

Description

Crack-in-the-Ground is a tension fracture in basalt. The walls are rough and irregular and show no lateral and but very slight vertical movement. The crack is open for a distance of more than 2 miles, but continues to the northwest and southeast as a trace which, although not visible on the ground, is revealed on aerial photographs. Where best developed, the fissure is from 10 to 15 feet wide at the top, narrowing downward. The depth varies, but is as much as 70 feet in some places. Figures 1 and 2 are aerial views of the crack and figures 3 and 4 are closeups.

Erosion and weathering have been at a minimum in this desert climate of northern Lake County, but over the many years that Crack-in-the-Ground has existed, some rock has sloughed off the walls and sand has blown or washed in to fill the bottom. At several places the walls have slumped, thus bridging the gap and allowing access to the deeper parts of the fissure. Winter ice is sometimes preserved during the summer in the deeper, more cavernous places where cold air is trapped.

Geologic Setting

Crack-in-the-Ground is closely related to the Four Craters lava field, one of the many isolated centers of recent volcanic activity within the high lava plains of central Oregon. Older rocks in the map area which pre-date the breach but which are broken by it include several ages of volcanic rocks and lake-bed sediments as described below.

Lake beds and alluvium

Large, shallow lakes filled the broad Fort Rock-Christmas Lake Valley beginning in late Pliocene time and continuing intermittently through the Pleistocene. During the Recent epoch, these lakes gradually shrank to small, brackish potholes and irregularly shaped saline pools. Lake beds, alluvium, and wind-blown materials of varying thicknesses mantle the floor of the basin, and wave-cut terraces around the rims represent various levels of the ancient lakes.

Explosion tuffs

The oldest volcanic rocks exposed in the area are erosional remnants of maars or tuff rings of late Pliocene to Pleistocene age. The remains of a maar just west of the Four Craters lava field is shown on plate 1. This mass of yellow-brown basaltic tuff and breccia is similar in composition and layering to Fort Rock and other remnants of maars and tuff rings, which were once numerous and widely distributed in and around the edges of the large lake basins of central Oregon (Peterson and Groh, 1963-b).

Green Mountain basalt

Surrounding the basaltic tuff remnants are younger basaltic lava flows that originated from Green Mountain, an eruptive center immediately to the northwest of the map area. The Green Mountain lavas form a low shield some 10 to 12 miles in diameter. The flows on the southern edge encroached on the pluvial lake that then filled the Fort Rock-Christmas Lake Valley and became the northern shore line. These lavas are of the pahoehoe type. Where they are exposed in the walls of Crack-in-the-Ground there are two or more flows with an overall thickness of at least 70 feet. Their surface is masked with a thin layer of soil composed mainly of fine pumice, windblown sand, and silt from lake beds in the adjacent Fort Rock-Christmas Lake Valley. Tumuli and other flow-surface features are present. Several small cinder cones near the summit of the Green Mountain shield still retain most of their initial characteristics even though they are covered by vegetation. From these observations, the Green Mountain lava is believed to be of late Pleistocene age.

Four Craters basalt

The Four Craters lava field, named in an earlier report (Peterson and Groh, 1963-a), formed from basaltic lava that flowed mainly south and east from centers along a fissure trending N. 30° W. The sluggish flows piled up a hummocky layer of black, spiny aa lava on the slightly sloping Green Mountain lava surface. Four cinder cones aligned along the fissure rise from 250 to 400 feet above the lava surface. The distance from the northernmost cone to the southernmost is roughly 2¼ miles. The southernmost cone is especially interesting, because several sectors of it were rafted off to the southeast on a slightly later lava flow. The freshness of the lava and lack of soil and vegetation on the surface indicate a Recent age for this field.

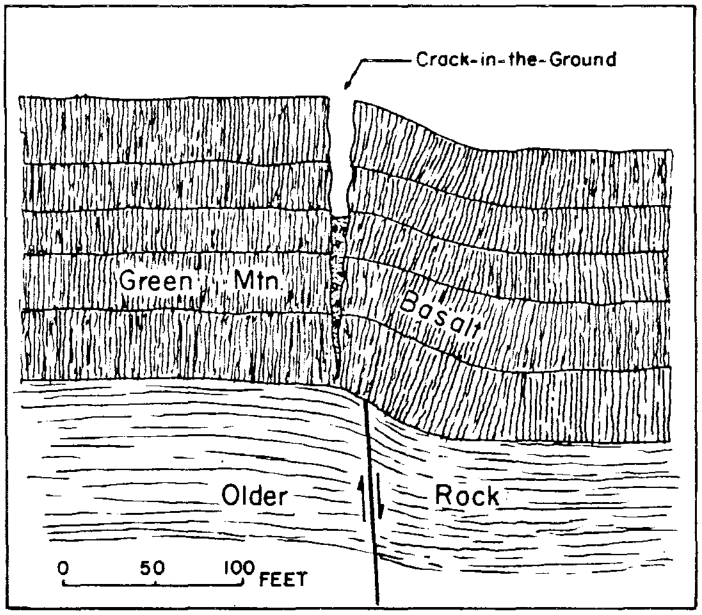


Figure 5. Generalized geologic cross section of Crack-in-the-Ground.

Origin of Crack-in-the-Ground

The eruptions from the Four Craters were accompanied by a slight sinking of the older rock surface to the southeast. This shallow, graben-like sink is about 2 miles wide and extends to the south into the old lake basin. Crack-in-the-Ground marks the western edge of this small, volcano-tectonic depression and parallels a zone of weakness concealed beneath the Pleistocene Green Mountain lava flows. The fracture is the result of rupture from simple tension along a hingeline produced by the draping of the Green Mountain flows over the edge of the upthrown side of the concealed fault zone (figure 5). The initial fracturing was probably propagated rather quickly over its length as the central block began to sink to form the shallow graben. Vertical displacement of the graben is no more than 30 feet and it diminishes to the southeast. There is the suggestion that the shallow graben continues on into the old lake basin and acts as a sump for present-day Christmas Lake and other ephemeral ponds and potholes. The sinking of the graben block and the accompanying rift on its western edge probably began with the first eruptions of the Four Craters. Crack-in-the-Ground opened before the last volcanic activity, and at its northwest end a tongue of lava piled up, tumbled into, filled, and buried the chasm for several hundred yards.

Conclusion

The eruption of the Four Craters Lava, the accompanying subsidence, and the opening of the Crack-in-the-Ground fracture probably took place no more than 1,000 years ago. Even though some filling by soil wash and windblown material has taken place, and some slumping of blocks from the walls has occurred, the crack is a relatively fresh geologic feature. This stark freshness is partly the result of subdued chemical weathering in the arid climate and a lack of any recent violent earth movements or renewed volcanic activity in the immediate area.

A system of tension fissures similar to Crack-in-the-Ground has been previously reported in the Diamond Craters by Peterson and Groh (1964), but none of these has as great a length or depth. Another fault-fissure zone that trends northwest from Newberry Volcano to Lava Butte south of Bend, Oregon, has been studied by Nichols and Stearns (1938). This fissure is associated with the recent volcanism of the area and stands open in several places.

Further investigations in the field, together with study of aerial photographs, may reveal the existence of other interesting cracks in remote parts of Oregon where volcanism and faulting have occurred.

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Peterson, N. V., and Groh, E. A., 1963-a, Recent volcanic landforms in central Oregon: The Ore Bin, vol. 25, no. 3, p. 33-45.

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* * * * *

DUNE SANDS TESTED FOR GLASS USES

A recent report by the U.S. Bureau of Mines reveals that Oregon dune sand can be used as glass sand. Tests were run on samples taken from 13 dune localities between Fort Stevens and Coos Bay. Sands between the Umpqua River and Coos Bay proved more satisfactory than those in the area between Fort Stevens and the Umpqua River where there was a higher percent of Fe_2O_3. Test results indicated that high-intensity magnetic separation followed by acid leaching would produce a product that could be used in amber and clear container-glass batches.

Report of Investigations 6484, "Beneficiation studies of the Oregon coastal dune sands for use as glass sand," is by George J. Carter, Henry M. Harris, and Karle G. Strandberg of the Bureau's Albany laboratories. It may be obtained free of charge from: Publications Distribution Section, Bureau of Mines, 4800 Forbes Avenue, Pittsburgh, Pa., 15213.

* * * * *

NEW EDITION OF OREGON GEOLOGY

"Geology of Oregon" by Ewart M. Baldwin, professor of geology at the University of Oregon, has been republished. The first edition, issued in 1959, was in great demand and was soon out of print. The new edition of 165 pages has been enlarged in order to include more text and some new photographs and charts. Added to the text are some of the new concepts on stratigraphy and offshore geology. Paper-back copies may be obtained from the University of Oregon Cooperative Bookstore, Eugene, Oregon, for \$2.65 plus 20 cents for mailing costs. A hard-back edition will be sold for \$3.95 plus 20 cents for mailing. Local bookstores are also selling the new book.

* * * * *

DRILLING RECORDS RELEASED

Records of the drilling done by Humble Oil and Refining Co. in sec. 10; T. 10 S., R. 3 W., Linn County, Oregon, were released from the confidential files by the Department on August 30, 1964. Oregon statutes require that the records be held in closed files for a 2-year period following abandonment or completion. Humble "Miller 1" was located approximately 7 miles north of Albany. Total depth reached was 4,951 feet. Reproductions of the "Miller 1" records can be obtained through the Department.

* * * * *

OFFSHORE LEASING PLANS DISCLOSED BY LAND BOARD

After considering the evidence presented at a public hearing in Coos Bay July 28, 1964, the State Land Board approved leasing of 136,300 acres of tide and submerged lands owned by the state. Being offered are submerged lands bordering the coast between Bandon and Florence and bottom of waters at the mouth of the Umpqua River and in Coos Bay (see map in February, 1964, ORE BIN). The Land Board set royalty at 12 percent and rental at $1.00 per acre for this sale. No minimum bonus bid limitation was specified. The leases will be awarded to the bidder offering the highest cash bonus. Sealed bids are to be in the hands of the State Land Board by 10:00 a.m. October 22, 1964. They will be opened at 11:00 o'clock the same morning in the Board of Control Room, State Capitol Building, Salem. The meeting will be open to the public.

Opening of bids by the State Land Board will follow a similar procedure carried out by the U.S. Bureau of Land Management in Los Angeles on October 1, 1964, at which time Federal outer continental lands bordering Oregon and Washington will be leased.

* * * * *

STATE TO LOSE MORE MINING RIGHTS

A proposed withdrawal by the Bureau of Land Management of 5,195 acres in Curry County from mineral entry has been protested by the Oregon State Department of Geology and Mineral Industries. The Bureau gives as its reason for this action "public enjoyment" of the rugged, untamed beauty of the lower Rogue River. If adopted, the 5,195 acres would be removed permanently from any possible economic benefit to the area.

Other BLM proposed withdrawals include: 320 acres in Clackamas County for seed production (in this case the BLM fears that the seeds will be "disturbed" by prospectors and miners); 360 acres in three scattered parcels in Lane, Coos, and Curry Counties "to protect material sources needed for jetty construction and surfacing BLM and private roads"; and 42 acres near Riddle to "protect gravel deposits" needed for BLM roads. The "protection" in the last two instances appears to be from some possible operation by private, tax-paying companies.

* * * * *

KENNETH O. WATKINS

Kenneth O. Watkins, well-known mining engineer of Corvallis, Oregon, died July 25, 1964. Mr. Watkins, member of AIME, was long active in mine development and production in the Bohemia Mining District.

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The ORE BIN
Volume 26, No. 10
October, 1964

AN OCCURRENCE OF VERMICULITIZED BIOTITE IN NORTHEASTERN OREGON

By

Lloyd W. Staples* and Howard C. Brooks**

The biotite in parts of the Bald Mountain batholith in northeastern Oregon has been vermiculitized, probably through the action of weathering. In the present investigation, samples from only one small area within the batholith were studied in the laboratory, but spot field tests show that biotite of other exposures of the batholith several miles distant is similarly altered. The matter was originally brought to our attention by Clinton P. Haight of Baker, Oregon, who found that when mica in the area of this study was heated it expanded like vermiculite.

The name "vermiculite" is probably derived from the Latin word *vermiculus*, which is the diminutive of *vermes*, meaning "worm." This refers to the curvy, worm-like appearance of the mica on expansion, which can be produced from the heat of a match. This simple field test, which may yield expansions of greater than 20 percent, is sometimes used to classify mica as a vermiculite. The name is also used more strictly for a mineral species which appears to be a mica but which contains a relatively large amount of water in its structure and no K_2O. The Oregon material discussed here qualifies as a vermiculite only in the first sense, as an expanding material. It is not a true vermiculite mineralogically.

Vermiculites occur in three types of rocks: (1) ultrabasic or basic, such as pyroxenites, serpentines, and dunites; (2) metamorphic, such as schists, gneisses, and marbles; and (3) granitic rocks. Most commercial deposits, as at Libby, Montana, are in ultrabasic or basic rocks and the mineral is a mixed-layer vermiculite-biotite. The type discussed in this paper is formed by alteration of mica in granitic rocks.

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* Department of Geology, University of Oregon.
** Oregon Department of Geology and Mineral Industries.

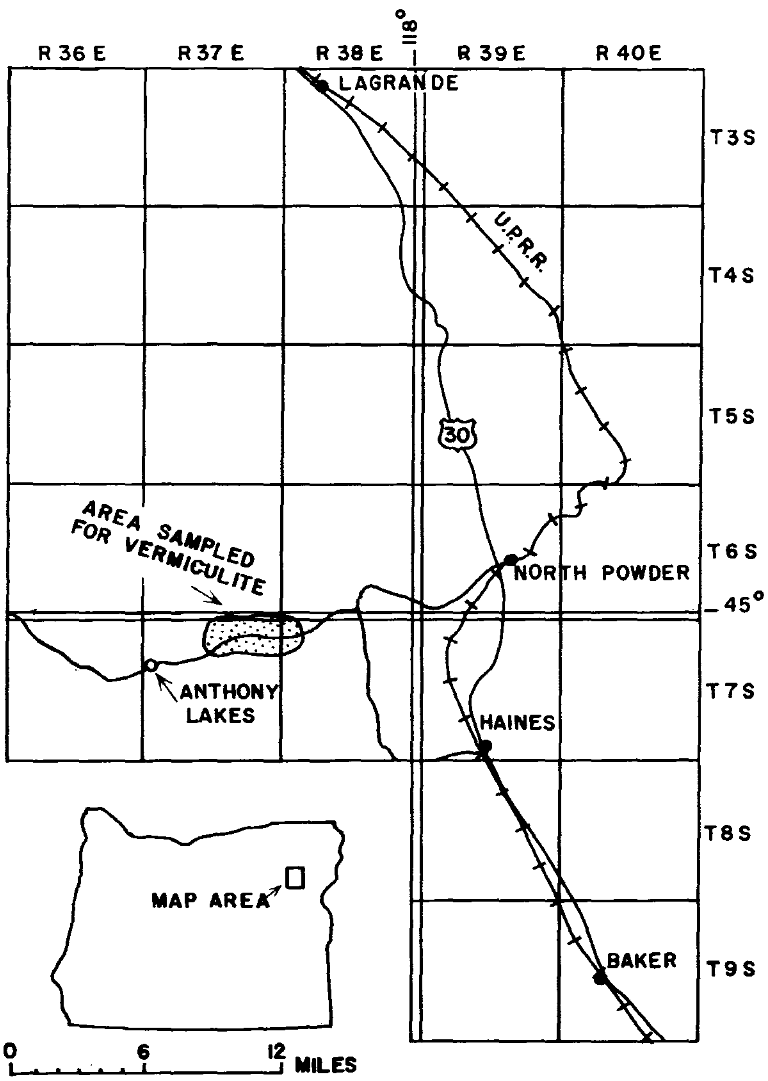

Figure 1. Sketch map showing the location of the area from which vermiculite samples were collected.

Location and Occurrence

The samples studied for this report were taken at random from an area in T. 7 S., Rs. 37 and 38 E. in Baker County (see figure 1). The area lies on the Anthony Lakes road about 10 miles west of North Powder, which is on the Union Pacific Railroad 19 miles north of Baker.

The area lies near the northeast edge of the Bald Mountain batholith, described by Taubeneck (1957). He concluded that the batholith is a composite intrusive comprising at least eight rock types representing a minimum of seven stages of intrusive activity. The rocks range from norite to quartz monzonite. Tonalite, a dioritic rock with quartz, is the most abundant and is the source of the vermiculite. Other minerals recognizable in hand specimens of the tonalite are plagioclase, quartz, hornblende, potash feldspar, and sphene. Except for variations in the mica, grain size of the tonalite usually averages 2 to 3 mm.

The crystal habit, size, and quantity of the mica grains in the tonalite vary considerably from place to place. However, there is considerable uniformity of the mica in any given locality. In parts of the area examined, the mica occurs as well-formed pseudo-hexagonal books, 2 to 6 mm in diameter, throughout zones several hundred feet wide. In such zones the mica is estimated to make up 8 to 12 percent of the rock. In other places the mica is in the form of irregular, paper-thin plates that constitute a smaller percentage of the rock. From a commercial viewpoint it is perhaps noteworthy that the tonalite containing relatively large quantities of thick euhedral grains is commonly disintegrated and crumbles easily in the hands, with the consequent freeing of a large portion of the mica grains.

Mineralogy

The mineralogy of vermiculites was not clearly understood until Gruner (1934) showed that it exists as a distinct mineral with a structural formula $(OH)_2(Mg,Fe)_3(Si,Al,Fe)_4O_{10} \cdot 4H_2O$. The structure consists of magnesium silicate sheets, like mica, interstratified with layers of water. It is the escape of this interstratified water that causes the swelling and exfoliation of the mineral on heating. Half of this water may be driven off at 110° C, and at 750° C the structure collapses to a talc structure. When biotite is altered to vermiculite, there are several intermediate stages in which a mixed-layer biotite-vermiculite structure develops, and these stages are referred to as a "hydrobiotite." During this alteration of biotite there is a loss of potassium and an oxidation of ferrous to ferric iron to neutralize the charge.

Walker (1949) studied the decomposition of biotite in soil, and he shows that there are four stages of weathering leading to true vermiculite. As weathering increases there is a decrease in refractive indices; a color change from black through golden yellow to white; a loss of iron, magnesium, and potassium; and an increase in water. He also notes that the X-ray diffraction pattern shows a change with weathering from a sharp peak at 10 Å toward 14 Å when vermiculite is produced. Using these criteria, the biotite derived from the weathering of the Bald Mountain tonalite was examined and compared. A partial chemical analysis was made by L. L. Hoagland, chemist for the Oregon Department of Geology and Mineral Industries, on two specimens of biotite from the tonalite.

The following table gives a comparison of the analyses for K_2O and H_2O of biotite, hydrobiotite, and true vermiculite.

	1	2	3	4	5
K_2O	8.34	5.76	5.16	3.66	none
H_2O^+	2.42	5.30	8.31	6.70	10.05
H_2O^-	0.48	2.95	6.21	2.38	11.42

1. Biotite. An average from biotite in 16 igneous rocks listed by Deere and others (1962, v. 3, p. 58-60).
2. Sample of biotite from Bald Mt. tonalite, analyzed by L.L. Hoagland, chemist for Oregon Department of Geology and Mineral Industries.
3. Second sample, same as No. 2.
4. Biotite in first stage of weathering listed by Walker (1949, p. 699).
5. Vermiculite (No. 3 of Gruner, 1934, p. 559).

The above table indicates that these samples of Bald Mountain biotite have lost some of their K_2O and this has been replaced by H_2O. If this process were to continue so that all of the K_2O were removed and the structure were essentially mica sheets separated by H_2O, a true vermiculite would result. The table also shows that the Bald Mountain biotite has not lost as much K_2O as Walker's first stage of weathering, but has undergone sufficient hydration to approach a vermiculite.

Walker (1949) notes that there is a consistent relationship in the change in index of refraction, color, and d-spacing of the X-ray diffraction pattern as biotite alters to vermiculite. The following table shows that in biotite, decomposed in the soil, it is possible to relate degree of alteration with decreasing index of refraction and increasing d-spacing, from 10.0 to 14.0 Å.

Order of weathering	n_y	d-basal reflection
0. Fresh black biotite	1.678	10.0 Å
1. Dark brown	1.679	9.8 - 11.0 Å
2. Glistening yellow	1.644	9.8 - 10.9 Å
3. Dull buff	1.635	9.8 - 13.7 Å
4. Dull brown	1.630	14.0 Å

In studying the Bald Mountain biotite, we could distinguish the fairly fresh material from some of the more weathered grains, but it was not possible to determine Walker's four grades from the biotite extracted from the rock. With respect to X-ray studies, the first diffraction pattern made at the University of Oregon geology laboratory was on a relatively fresh biotite and gave a basal d-spacing of 10.04 Å. A sample from another location in the tonalite area was sent to L. L. Brown, Supervisory Geologist of the Petrographic Laboratory of the U.S. Bureau of Mines at Albany, Oregon, who used a chromium target instead of copper, and reported a basal spacing of 15.0 Å. A split of his sample was run at the University of Oregon Geology Department with a copper target, and the 15.0 Å peak was confirmed for this material. This difference in spacings indicates that the Bald Mountain material also has several stages of vermiculitization, even though color is not so diagnostic as in Walker's Scotland material.

Taubeneck (1957, p. 202) notes a range in the tonalite biotites of the beta index of refraction from 1.647 to 1.653. Our material gave a range from 1.630 to 1.680, and this variation can be related to the state of vermiculitization, as indicated by the d-spacings. This is shown below:

	n_y (± 0.003)	d-basal reflection
Fresh	1.680	10.00 - 11.00
	1.677	10.04
	1.676	9.87 - 10.36
	1.670	10.47 - 10.98
	1.647	14.40
Altered	1.630	14.58

Many more samples should be studied in order to get a correlation of the d-spacing and indices of refraction of the Bald Mountain material, but the work to date indicates that a correlation is possible. It is also evident that weathering produces a mixed-layer biotite-vermiculite.

Vermiculites may swell from six to 20 times their original thickness. Two samples of the Bald Mountain material tested by Mr. Hoagland gave volume increases at 1900° F of 750 percent and 625 percent, indicating that this material swells enough to be classified as a vermiculite, but the expansion is not as great as in many other vermiculites.

Origin

There has been strong difference of opinion concerning the origin of vermiculites. The principal area of conflict is concerned with the problem of whether the mineral is formed by hydrothermal or supergene solutions. Bassett (1963) clearly presents the arguments for each of these modes of origin. Roy and Romo (1957) state that vermiculite is unquestionably the product of low-temperature weathering and no primary vermiculite can crystallize under even mild hydrothermal conditions. Bassett (1963, p. 64, and written communication, March 2, 1964) notes a granitic occurrence of vermiculite at Daggett Pass on State Route 19, Nevada, southeast of Lake Tahoe. This material has a pearly luster, swells on heating, and has been produced by weathering. He states, "...the material is probably a randomly stacked, mixed-layer vermiculite-biotite with more biotite than vermiculite. This probably is a widespread form of vermiculite that undoubtedly has been identified as biotite many times over."

In the case of the Bald Mountain batholith material, there can be little doubt that weathering and the action of ground-water solutions satisfactorily explain the change from biotite to a hydrobiotite with the expansive powers of a vermiculite.

Economic Aspects

Expanded vermiculite, an extremely light and porous product, is finding wide use as an insulating material, as lightweight aggregate for concrete and plaster, and as a soil conditioner. A large share of the vermiculite used in the Pacific Northwest comes from the Zonolite Co. operations at Libby, Montana (said to be the largest vermiculite mining operation in the world) where vermiculite makes up 30 to 90 percent of the rock mined. Much of the vermiculite occurs in large sheets and blocks which can be selectively mined. The expandable mica of the Bald Mountain tonalite comprises approximately 10 percent of the rock in which it occurs, and being a regularly distributed component of the rock cannot be selectively upgraded during mining. Although the material would have difficulty meeting present competition in the vermiculite market, it remains in reserve as a substantial low-grade vermiculite deposit.

Note: Following submission of this report for publication, the writers, assisted by Norman Wagner and Len Ramp of the Oregon Department of Geology and Mineral Industries, continued preliminary testing of exposures of Jurassic-Cretaceous granitic rocks in other parts of Oregon. It has been found that vermiculitization of the biotites is quite common and a state-wide study of this type of alteration is now in progress. Probably if geologists were to apply the match-heat test to biotites from weathered granitic outcrops elsewhere, they would frequently find that the biotite had been vermiculitized.

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MORE PUBLIC LAND TO BE WITHDRAWN FROM MINING

Oregon public land withdrawals proposed during September total more than a thousand acres. The lands involved are 296.74 acres of National Forest areas in Lane, Jackson, and Josephine Counties requested by the Forest Service for recreational purposes and 960 acres on the Powder River in Baker County requested by the Bureau of Reclamation for the development of a reservoir "to be used for irrigation, flood control, recreation, and fish and wildlife purposes." The lands in question are to be closed to any future mineral entry. Withdrawals in Oregon from January 1964 to date total 46,245 acres!

* * * * *

DRILLING RECORDS RELEASED FROM CLOSED FILES

The Department is releasing from its confidential files records covering drilling under State permits 45 and 46. Information on drilling done under permit 45 by Two States Oil & Gas Co., Inc., within Vale city limits, sec. 21, T. 18 S., R. 45 E., will be open to public inspection on October 24, 1964. Total depth was 1,185 feet.

Records describing results of drilling done under permit 46 by Reserve Oil & Gas Co. near Lebanon were released October 5, 1964. The Reserve well was drilled in sec. 7, T. 12 S., R. 1 W. Total depth was 8,603 feet.

Reproduction of drilling information released this month can be obtained through the Department.

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THRUST FAULTING IN THE ROSEBURG AREA, OREGON

By Ewart M. Baldwin*

Field evidence strongly suggests that a thrust fault trends northeastward across the Roseburg area in southwestern Oregon. The fault extends from the southwest part of the Sutherlin quadrangle to the northeast part of the Glide quadrangle, a distance of about 22 miles, but, because both ends are probably concealed, its total length may be greater (plate 1). Inasmuch as the fault passes through the Bonanza quicksilver mine and is related to the mineralization, it is referred to as the Bonanza fault. The motion of the thrust was northwestward and involved rocks of the lower member (Baldwin, 1964) of the Umpqua Formation. The intense deformation that produced the thrust occurred near the end of the early Eocene, soon after the deposition of the lower Umpqua member and before deposition of the middle Umpqua member.

General Stratigraphy of the Area

Jurassic and Cretaceous rocks occupy the southeast corner of the map area and are in fault contact with the lower and upper members of the Eocene Umpqua Formation. The Umpqua Formation consists of three units, which are described below. The Tyee Formation of middle Eocene age overlaps the Umpqua Formation at the eastern and northwestern edges of the map area. Basic igneous rocks of middle Tertiary age intrude the early Tertiary formations as sills and dikes. Quaternary alluvium masks older rocks along the Umpqua River and its tributaries. Parts of the area have been mapped in detail by graduate students at the University of Oregon (Lawrence, 1961; Patterson, 1961; Payton, 1961; and Westhusing, 1959).

Umpqua Formation

The Umpqua Formation has been divided, for convenience, into three mappable members: lower, middle, and upper. The break between the lower and middle is of such magnitude, however, that in reality there is only

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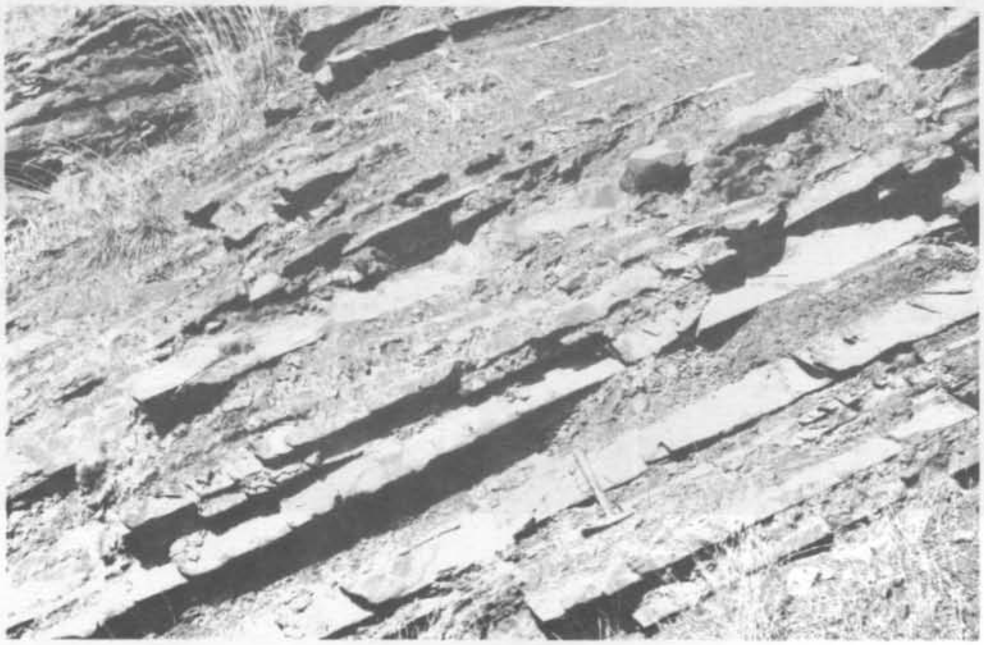
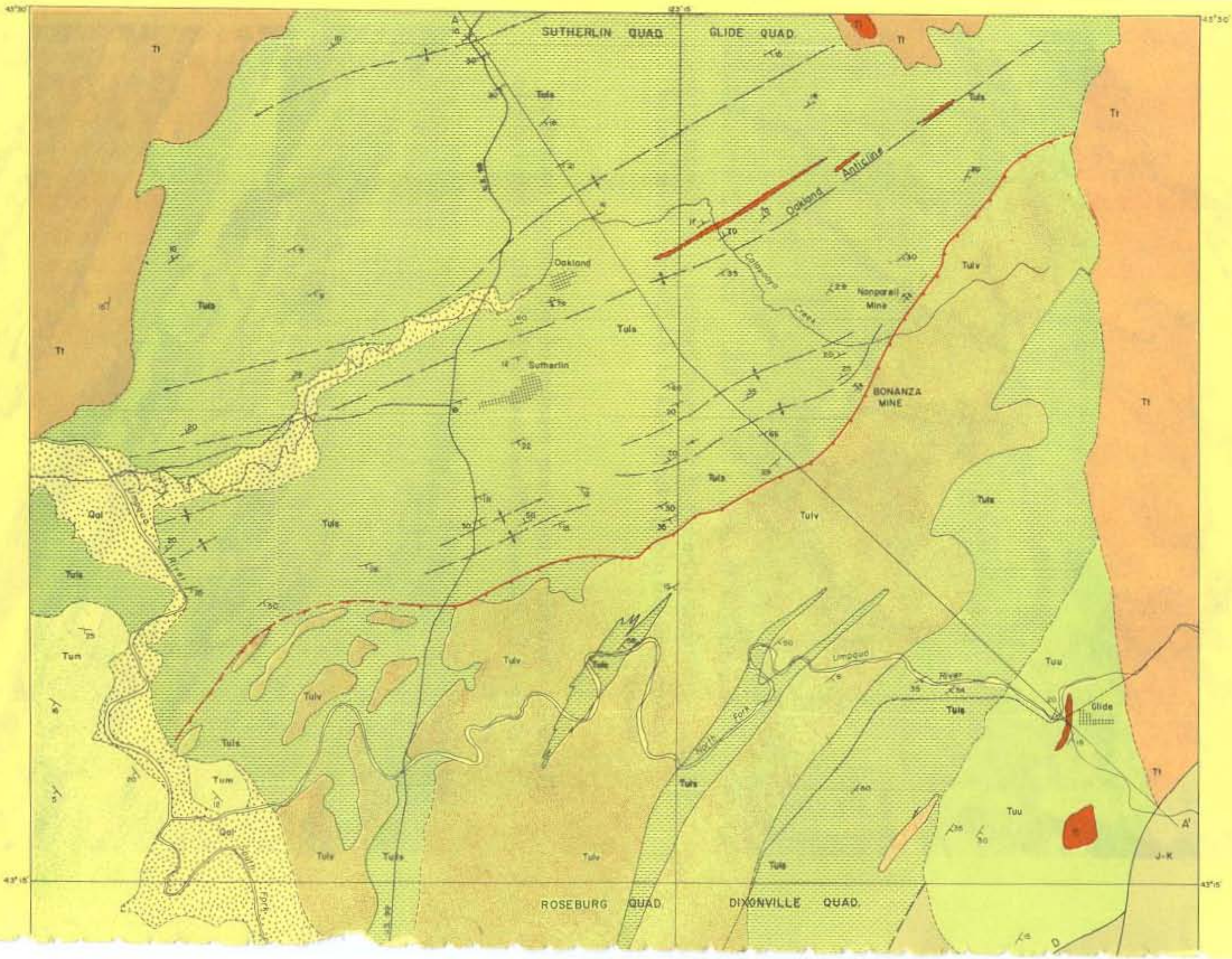
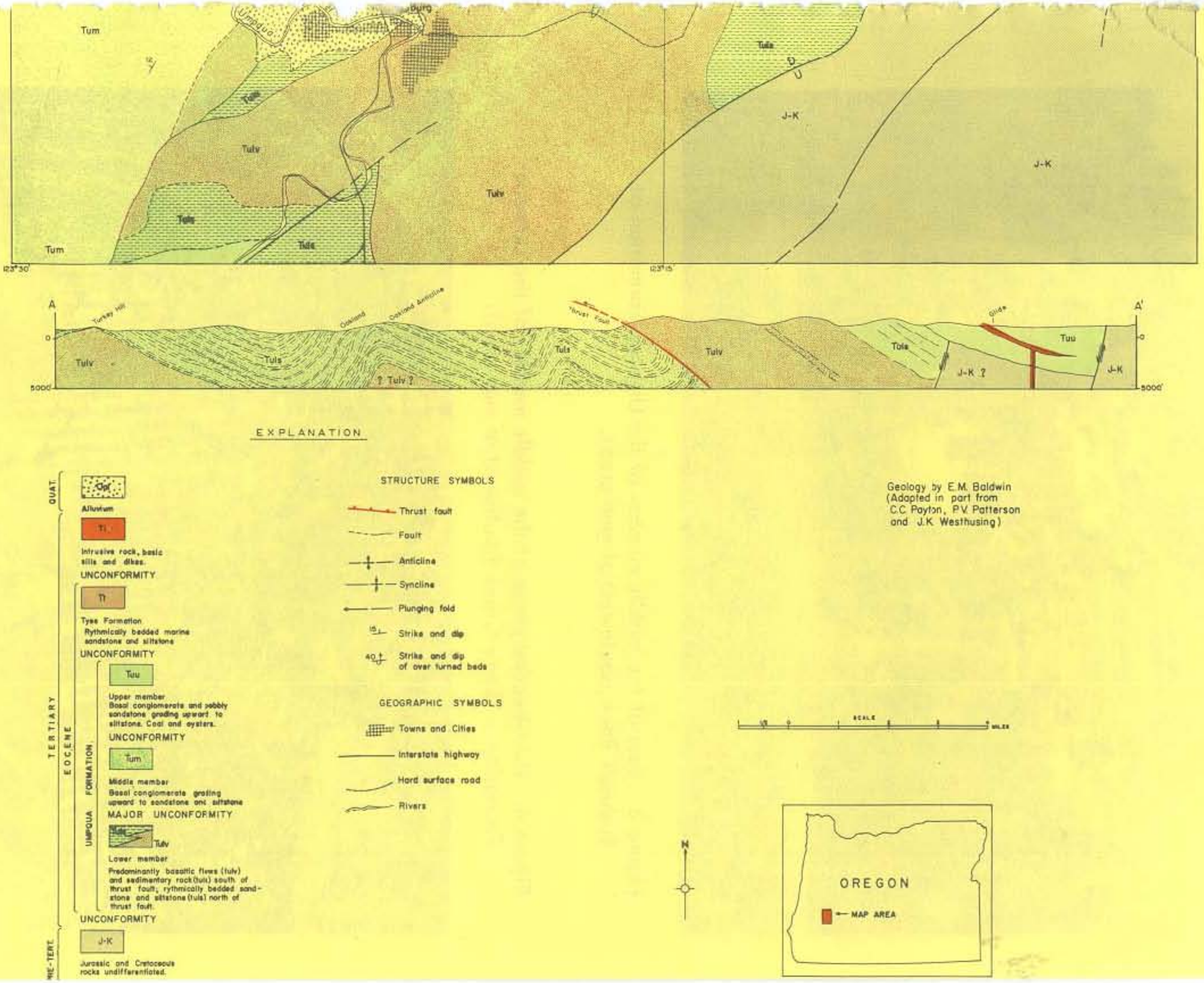
* Professor of Geology, University of Oregon, Eugene, Oregon.

Figure 1. Pillows in basalt of the lower member of the Umpqua Formation exposed along North Fork of the Umpqua River east of Wilbur.

Figure 2. Outcrop of the lower member of the Umpqua Formation along U.S. Highway 99 southwest of Sutherlin. Note rythmic bedding.




43°30'
123°15'
43°30'
SUTHERLIN QUAD
GLIDE QUAD
ROSEBURG QUAD
DIXONVILLE QUAD
43°15'
43°15'
A
A'
D
Oakland Anticline
Oakland
Sutherlin
Calapooya Creek
Nonpareil Mine
BONANZA MINE
Umpqua River
North Fork
South Fork
Glide
Tt
Tuls
Tulv
Tuu
Tum
Qal
J-K



Geology by E.M. Baldwin
(Adapted in part from
C.C. Payton, P.V. Patterson
and J.K. Westhusing)

Figure 3. Base of the middle member of the Umpqua Formation at Bushnell Rock (southwest of map area).

Figure 4. Thin-bedded phase of the middle member of the Umpqua Formation on Berry Creek (southwest of map area).

a lower and an upper Umpqua, with the upper unit divided into two parts by a relatively minor unconformity. These divisions are based upon a regional study of the Umpqua Formation in southwestern Oregon (Baldwin, 1963).

The lower member includes all of the basaltic flows of the Umpqua Formation. It consists of basalt breccia and pillow lavas (figure 1) interbedded with lesser amounts of sedimentary rock, overlain by a thick section of rhythmically bedded sandstone and siltstone (figure 2). Two of the most complete sections of the lower member are exposed along Oregon Highway 42 between Coquille and Myrtle Point (south of the map area) and along U.S. Highway 99 between Turkey Hill and the synclinal axis north of Oakland. In both sections the basalt is exposed in the center of the anticlines and is overlain by 6,000 to 8,000 feet of sedimentary rock. It is difficult to determine exactly what strata represent the base of the Umpqua, because the formation is almost everywhere faulted against pre-Tertiary rock. In most exposures, however, basalt is the oldest Eocene rock in evidence.

Both the pre-Tertiary rock and the lower member of the Umpqua Formation are overlain with marked angular unconformity by basal conglomerate of the middle member (figure 3). The unconformity represents one of the most profound breaks in the Tertiary section of western Oregon. The unconformable relationship is best exposed southwest of the map area at Bushnell Rock in the Tenmile area and in Lookingglass Valley. In both areas the basal conglomerate grades upward into sandstone and siltstone, and in places thin-bedded phases are present (figure 4). Along Tenmile Creek the beds have an average dip of 20° to 25° southeastward and range in thickness from 5,000 to 6,000 feet. It is more difficult to determine the dip in Lookingglass Valley, but the thickness of the beds appears to be as great.

The upper member of the Umpqua Formation lies unconformably upon both the lower and middle units, and in some places upon the pre-Tertiary rock. It is best exposed at Glide and southwest of the map area in Camas Valley and Flournoy Valley. The unit has a thin, basal conglomerate or pebbly sandstone grading upward into siltstone, and appears to be of shallow-water origin as shown by beds of coal and numerous oysters. The thickness in Flournoy Valley ranges between 2,500 and 3,500 feet; it is probably as much in Camas Valley and at Glide. At Glide the upper member contains a large fauna of middle Eocene age (Turner, 1938).

General Structural Features

A series of north-east trending faults displaces the Umpqua Formation and older strata southwest of Roseburg, but most of these appear to be high-angle, normal faults affecting beds as young as the upper member of the

Umpqua Formation and perhaps even the overlying Tyee Formation. The Bonanza fault, on the other hand, appears to be a thrust fault that is more closely related to the folds in the lower member of the Umpqua Formation. The lower member is steeply folded along axes commonly trending N. 45° to 75° E. and is generally parallel to the structural trends of the Mesozoic rocks. The folds plunge to the west beneath both the middle member of the Umpqua Formation and the Tyee Formation, and to the east beneath the Tyee Formation.

The absence of the middle member southeast of the fault suggests that the thrust plate was a highland area and perhaps a contributor of sediments to the middle Umpqua unit farther west.

It was not until the middle Eocene that strata of the upper member were deposited in the area east of Roseburg. The sedimentation was initiated by deposition of a thin basal conglomerate against basalt of the lower member of the Umpqua Formation. One such depositional contact can be seen about 100 yards west of the new county bridge over the North Fork of the Umpqua, a mile and a half west of Glide.

The Bonanza Fault

Origin and description

The asymmetry of the folds northwest of the trace of the Bonanza fault is considered to be proof that the direction of thrusting was from the southeast. The folds have relatively gentle dips on the southeast limb and nearly vertical dips in places on the northwest limb. The northwest limb of the Oakland anticline is noticeably steeper than the southeast limb. Along U.S. Highway 99 between Oakland and Sutherlin the steeper side to the north ranges from about 70° to dips overturned slightly to the south. Some of the steeper dips may be on subsidiary folds, but there is little doubt that the axes of the folds northwest of the Bonanza fault are tilted to the northwest.

It seems likely that the thrust which formed the Bonanza fault was initiated at the time of compression, when a fold near the active stress was overturned to the northwest. Slippage then occurred along the axial plane, bringing the basaltic rocks in the center of the anticline over the sedimentary rock that stratigraphically should overlie it. Thus the basalt on the southeast side of the Bonanza fault is correlated with basalt underlying sedimentary rock on Turkey Hill (see cross section on plate 1). On the basis of this interpretation, the lack of sedimentary rock over the basalt southeast of the fault would be due to removal by erosion.

The Bonanza fault appears to cut across the axial trends of several folds south of the Oakland anticline. Its sinuous trace suggests that it may dip less than 45°. Since thrusts are commonly arcuate in the direction of movement, it is possible that, before erosion, the upper plate of the Bonanza fault reached nearly to Sutherlin.

Relation to mineralization

The Bonanza fault appears to be the only zone of faulting in the area that has been mineralized. Distributed along it are a number of quicksilver mines and prospects, including the Bonanza and Nonpareil mines. The Bonanza mine was for many years Oregon's major quicksilver producer. The geology and mineralization at the Bonanza is described by Brown and Waters (1951) and Brooks (1963). According to their interpretation, ascending hydrothermal solutions were guided and localized by shearing and faulting in tuffaceous sandstone of the Umpqua Formation. The shear zone dips about 45° SE. parallel to the bedding, and apparently was caused by reverse movement of the rocks along bedding planes during folding. Rich pockets of ore were deposited beneath flat, gouge-filled thrust faults that transect the bedding shears.

Mineralization evidently occurred in post-Umpqua time for Hoover (1963) indicates that mineralization at the Black Butte mine, a short distance north of the map area, occurs in the Fisher Formation of late Eocene or Oligocene age. It is reasonable to assume that the two areas were mineralized at the same time.

Summary

Evidence for thrusting along the Bonanza fault lies chiefly in the age and position of the strata as determined by a regional study of the Umpqua Formation. Other evidence, such as a northwestward inclination of the folds in the area of the thrust and the shearing and reverse faulting in the Bonanza mine, support the theory that basalt in the lower member of the Umpqua Formation is thrust northwestward over lower Umpqua sedimentary rock. Thrusting came from continued compression after relatively close folding near the end of the lower Eocene. Middle and upper Umpqua strata, unconformable upon the steeply dipping lower Umpqua basalt flows and sedimentary rock, show little evidence of severe compression but instead are cut by normal faults of younger age.

Acknowledgement: This study was partially financed by a University of Oregon Faculty Research Grant.

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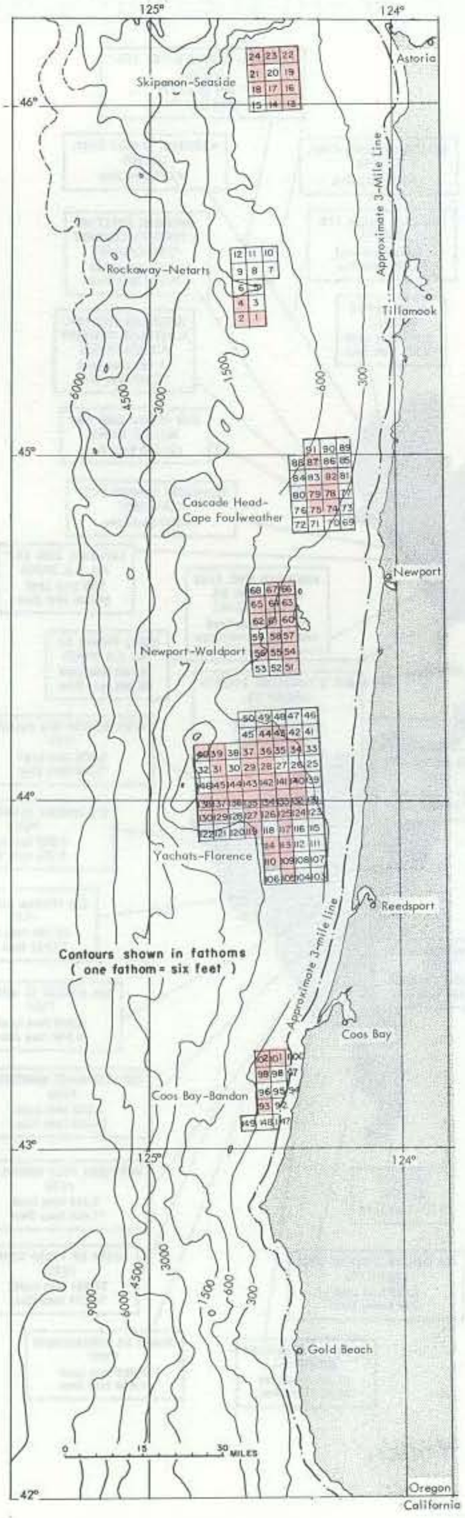
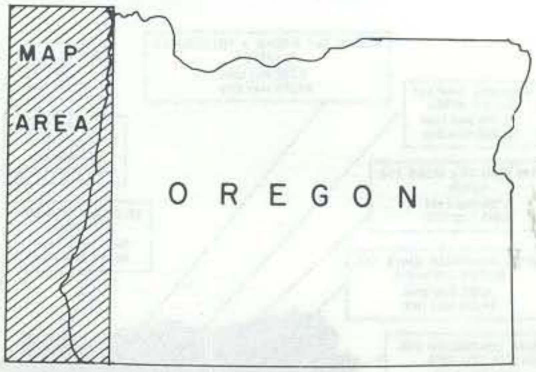
OIL COMPANIES BID ON OREGON'S OFFSHORE

The oil and gas lease sale of Federal outer continental shelf (OCS) lands off Oregon and Washington October 1 resulted in high bonus bids totalling $35,525,168.30. Offered were 196 parcels with 222 bids received on 101 parcels containing 580,689 acres. The average bonus per acre was computed to be $67.36. Of the 101 parcels leased, 74 were off Oregon and 27 off Washington. The OCS lands off Oregon brought $27,760,239.90 and those off Washington $7,764,928.40. Eleven companies participated in varying combinations, as follows: Gulf, Humble, Pan American (Standard of Indiana), Pan American-Atlantic, Pan American-Atlantic-Superior, Pan American-Superior, Richfield, Shell, Standard (of California), Standard-Union, Superior, Texaco-Mobil, Texaco-Mobil-Richfield, and Union. The single parcel (No. 136) obtained solely by Union brought the highest bid, which was $2,165,760 or $376 per acre. The lowest bid was $30,067.20 or $5.22 per acre by Pan American-Atlantic on parcel No. 127.

Map showing Federal lease blocks off the Oregon coast.



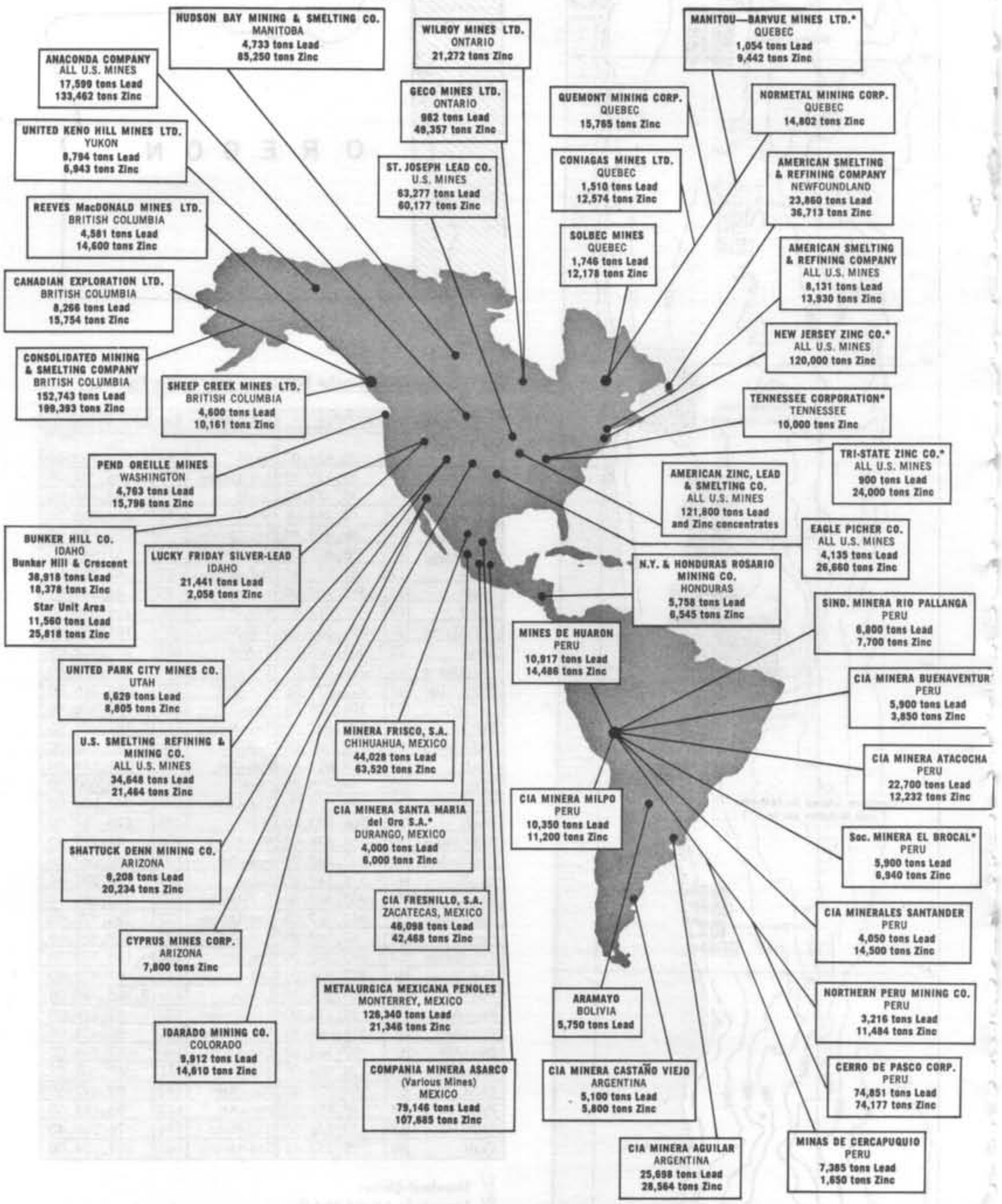


List of Successful Bidders on the Oregon Parcels

Company	Block	Price	Company	Block	Price
Shell	1	$ 35,424.00	Shell	67	$ 116,755.20
Shell	2	55,123.20	Std-Union	74	1,446.336.00
Shell	4	35,424.00	Shell	75	135,936.00
Std-Union[1]	13	43,268.00	Shell	78	652,032.00
Std-Union	14	86,468.00	Std-Union	79	1,012,124.00
Std-Union	16	58,676.00	Pan-Atl	82	57,945.60
Shell	17	87,897.60	Std-Union	87	43,250.00
Shell	18	1,598,400.00	Std-Union	93	43,246.00
Shell	19	41,817.60	S-A-P[4]	99	116,640.00
Std-Union	21	491,684.00	T-R-M	101	101,318.40
Shell	22	504,000.00	S-A-P	102	289,152.00
Std-Union	23	316,892.00	T-R-M	105	101,318.40
Std-Union	24	317,222.00	Pan-Atl	109	1,154,016.00
T-R-M[2]	28	201,308.34	Pan-Atl	110	432,806.40
Shell	29	728,087.50	Tex-Mob[5]	113	1,101,484.80
Std-Union	31	137,136.00	S-A-P	114	1,785,888.00
Shell	34	309,657.60	Pan-Atl	117	231,148.80
Shell	35	87,955.20	Shell	119	756,000.00
Pan-Atl[3]	36	173,779.20	Std-Union	124	748,888.00
Shell	37	206,553.60	Shell	125	620,064.00
Std-Union	39	58,676.00	Richfield	126	41,299.20
Std-Union	40	233,440.00	Pan-Atl	127	30,067.20
Shell	43	1,516,147.20	Shell	129	150,681.60
Shell	44	905,472.00	Std-Union	130	433,666.00
Std-Union	51	462,462.00	Std-Union	132	230,476.00
Pan-Atl	54	87,148.80	Pan-Atl	133	347,961.60
Std-Union	55	1,042,042.00	Pan-Atl	134	145,555.20
Std-Union	56	777,776.00	Std-Union	135	97,922.00
Pan-Atl	57	346,579.20	Union	136	2,165,760.00
Pan-Atl	58	58,176.00	Std-Union	137	43,278.00
Pan-Atl	60	318,067.20	Std-Union	138	86,424.00
Pan-Atl	61	87,782.40	Std-Union	140	57,774.00
Std-Union	62	173,888.00	S-A-P	141	549,504.00
Gulf	63	98,726.40	Pan-Atl	142	87,897.60
Pan-Atl	64	58,924.80	Pan-Atl	143	88,185.60
Std-Union	65	57,776.00	Richfield	144	76,260.40
Gulf	66	98,726.40	Std-Union	145	291,124.00

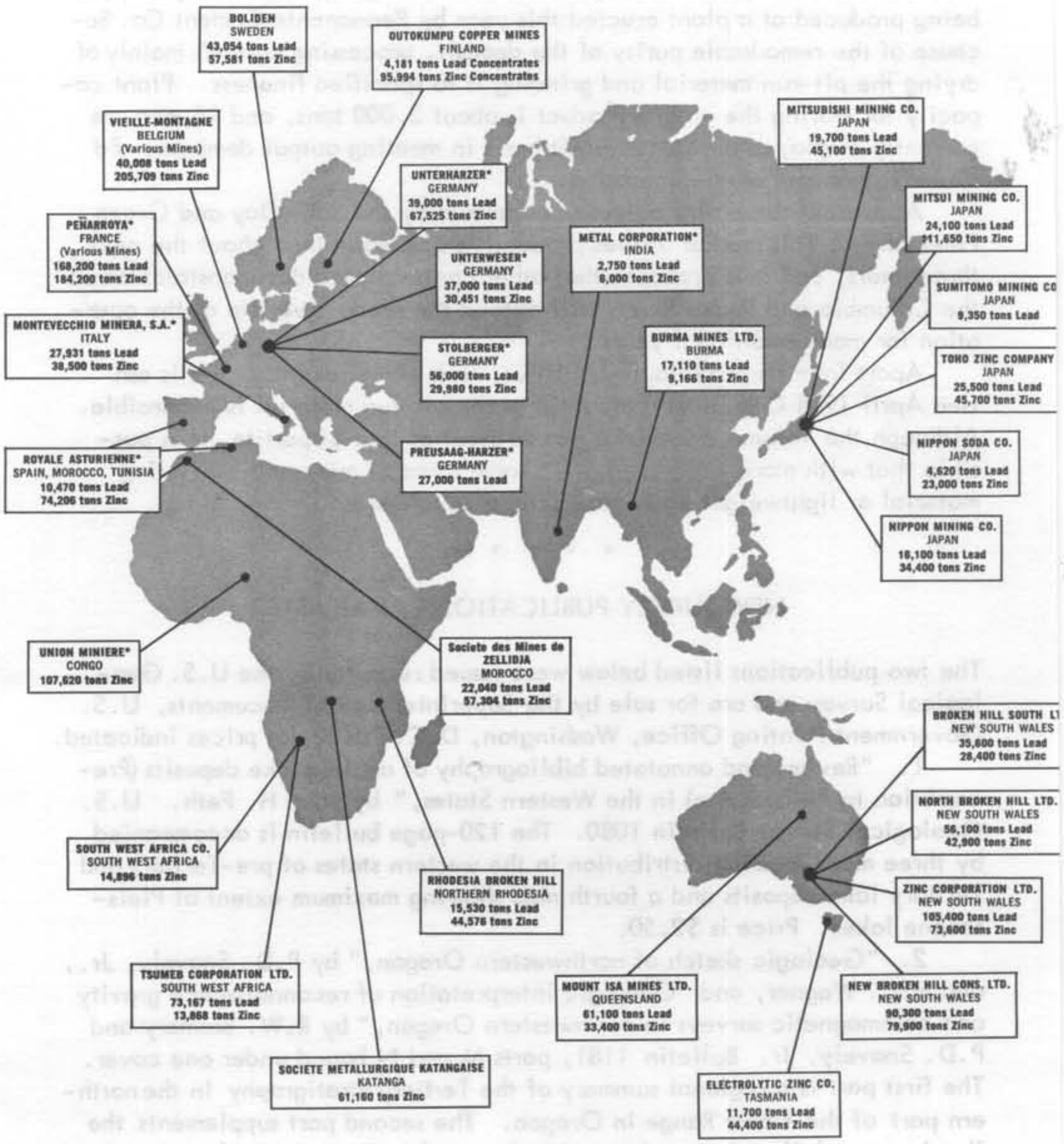
[1] Standard-Union
[2] Texaco-Richfield-Mobil
[3] Pan American-Atlantic Refining
[4] Standard-Atlantic-Pan American
[5] Texaco-Mobil

Principal Lead and Zinc Producers



(Courtesy of American Cyanamid Co., New York).

of the World in 1962



Map shows 1962 tonnage at operations producing more than 5,000 short tons of lead or zinc in concentrates

POZZOLANIC ASH PRODUCED NEAR ARLINGTON

Volcanic ash with pozzolanic qualities near Arlington, Gilliam County, is being produced at a plant erected this year by Permanente Cement Co. Because of the remarkable purity of the deposit, processing consists mainly of drying the pit-run material and grinding it to specified fineness. Plant capacity for storing the ground product is about 3,000 tons, and 15 men are currently employed on a three-shift basis in meeting output demands. Ed Coder is manager of the operation.

At present the entire output is consumed by the John Day and Green Peter dams. This market assures productive operation throughout the next three years, and it is probable that other contemplated dam construction on the Columbia and Snake Rivers will extend the productive life of the operation for many additional years.

Apart from its pozzolanic qualities, tests made recently on this ash (see April 1964 ORE BIN) indicate that the pit-run material is expansible. Although the volume increase is not as great as that of perlite, it is possible that with more experimentation some forms of marketable filtering material or lightweight aggregate can be developed.

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NEW SURVEY PUBLICATIONS AVAILABLE

The two publications listed below were issued recently by the U.S. Geological Survey and are for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, at prices indicated.

1. "Review and annotated bibliography of ancient lake deposits (Precambrian to Pleistocene) in the Western States," by John H. Feth. U.S. Geological Survey Bulletin 1080. The 120-page bulletin is accompanied by three maps showing distribution in the western states of pre-Tertiary and Tertiary lake deposits and a fourth map showing maximum extent of Pleistocene lakes. Price is $2.50.

2. "Geologic sketch of northwestern Oregon," by P.D. Snavely, Jr., and H.C. Wagner, and "Geologic interpretation of reconnaissance gravity and aeromagnetic surveys in northwestern Oregon," by R.W. Bromery and P.D. Snavely, Jr. Bulletin 1181, parts M and N bound under one cover. The first part is a regional summary of the Tertiary stratigraphy in the northern part of the Coast Range in Oregon. The second part supplements the first by correlating the geology with the results of geophysical work. Included in the 30-page dual report are a combined geologic and gravity map and two aeromagnetic profiles. Price is $1.00.

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The ORE BIN
Volume 26, No. 11
November, 1964

OIL LEASING ON THE OUTER CONTINENTAL SHELF ADJACENT TO OREGON and WASHINGTON

By V. C. Newton, Jr.* and C. J. Newhouse**

A total of $35.5 million in cash bonus offers was received October 1,1964, when officials representing the U.S. Bureau of Land Management opened the sealed envelopes which contained oil company bids for tracts of federal shelf land. The lease-sale was held at the Statler Hotel in Los Angeles and approximately 120 persons from industry attended. Representatives from the State of Oregon Land Board and Department of Geology and Mineral Industries were present to observe the procedure.

The sale proved to be highly successful. A total of $27,770,000 was bid for outer continental shelf lands bordering Oregon and $7,770,000 for shelf lands adjacent to Washington. Leases covered 425,430 acres off shore from Oregon and 155,420 acres off the Washington shore (see maps). Yearly rentals for the first lease year made the sum of receipts from the lease-sale $37 million.

Eleven major firms participated in the bidding. Several of the companies bid both jointly and separately on leases, indicating differing opinions of the geology. Pan-American Petroleum and Atlantic Refining Co., even though not engaged in extensive offshore studies until 1964, were among the most active competitors.

Leading Successful Bidders

Shell Oil Co.	$ 8,651,230
Pan American Petrol.	7,342,490
Union Oil Co.	6,905,340
Standard of Cal.	4,784,520
Atlantic Refining Co.	3,576,270
Superior	2,342,890

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* Petroleum Engineer, Oregon Dept. Geology and Mineral Ind.

** Cartographer-Geographer, Oregon Dept. Geology and Mineral Ind.

The areas of main interest are more than 10 miles from shore. The western margin of the lease block off Florence is 35 miles from land. Water depth at this distance is 500 feet. The small lease block opposite Tillamook Bay is 30 miles from shore and the water depth at this location is 1,500 feet. Shell was the only bidder on the Tillamook block.

Bidding formulas

A study of the bidding statistics reveals that companies or groups of companies used formulas for bidding. Shell Oil Co. was the most consistent in bidding a calculated value for tracts it wanted. In Washington, Shell was not a strong competitor. The company lost all the tracts for which it submitted a blanket bid of $47,400. Pan American-Atlantic Refining played a game of blanket bidding, employing the formula $30,000; $58,000; and $87,000, with high bids on desirable leases. Standard-Union countered with their philosophy of blanket bidding with a formula of $43,000; $58,000; and $86,000. They paid heavily for tracts valued highly by their scientific staffs. All these systems proved effective in obtaining leases.

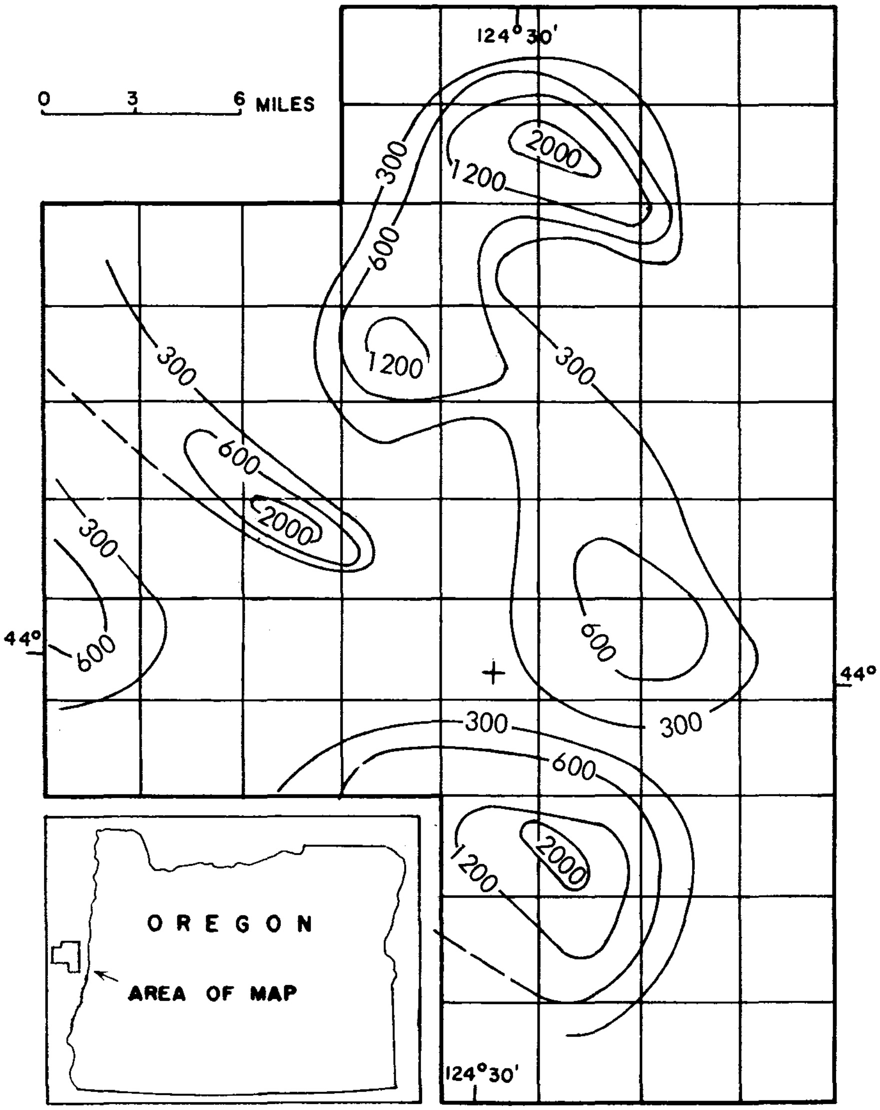
The system used by Texaco-Richfield-Mobil was generally unsuccessful. This group used a $41,300; $101,000; and $201,000 pattern. Bids on valued tracts were seldom high enough. Success of bidding by these companies averaged 15 per cent.

It is hard to visualize that bidding for tracts was done on geologic structure, because low bids won tracts next to high bids and, in some cases, tracts went unleased next to high bids. However, if a general outline is drawn around the most sought-after leases, a semblance of geologic features is suggested. Bids were apparently made on structures delineated by seismic studies (see Figure 1).

Deep test drilling planned

Deep drilling on the outer continental shelf along the Oregon coast appears to be assured in the summer of 1965. Companies must evaluate their holdings by 1969 under the 5-year term of the federal leases or relinquish them. A minimum of five or six deep test holes will be needed to determine whether or not the shelf lands are productive. Besides the time-squeeze placed on the operators by the 5-year lease term, there is pressure to avoid paying yearly rental on non-productive acreage.

Figure 1. "Isobuck" map of the Florence-Yachats lease area.



Contours based on total cash bonuses offered per parcel
(in thousands of dollars)

Two types of equipment will be used to drill in the deep-water areas leased October 1, 1964. A massive floating platform has been constructed by the Blue Water Drilling Corp. for deep-water drilling on the West Coast. It is presently being used by Shell Oil Co. to drill off shore in northern California. Large drilling ships of varied design will also be used for offshore drilling in the Northwest.

Global Marine Exploration may have one of its "Glomar" vessels available for work in Oregon and Washington. This is the same type of vessel which was used for preliminary "Mohole" drilling. Western Offshore Co. completed construction on a large drilling ship at Seattle in the spring of 1964. The ship has been contracted by Standard Oil Co. for deep-water drilling on the West Coast.

Union Oil Co. is considering moving equipment from Alaska to conduct work on its newly acquired property in Oregon and Washington. Pan American Petroleum Corp. has a new twin-hulled vessel on the drawing board. The catamaran is designed to float submerged with the main deck 40 feet above the water surface. A contract has been given Western Offshore Drilling & Exploration Co. by Mobil for construction of a new floating barge for West Coast operations.

The arrangements already being made indicate the industry plans to begin drilling tracts as soon as possible. Results of the lease-sale appear to have encouraged an active role in exploration by most of the competitors.

References

Oil and Gas Journal, 1964, Oregon-Washington sale sets stage for lots of wildcatting: Oil and Gas Jour., vol. 62, no. 41, p. 108.

Oregon Dept. Geology and Mineral Industries, 1964, Deep-water oil drilling assured in the Northwest: The Ore Bin, vol. 26, no. 2, February 1964, p. 34.

__________, 1964, Offshore area selected for leasing: The Ore Bin, vol. 26, no. 5, May 1964, p. 92.

__________, 1964, Oil companies bid on Oregon's offshore: The Ore Bin, vol. 26, no. 10, October 1964, p. 184.

Note: The U.S. Bureau of Land Management's list of bids and its official lease maps showing location of federal offshore tracts are published on pages 195 to 208 of this issue.

W. E. Grant, manager of U.S. Bureau of Land Management's West Coast OCS office, conducts recent Northwest lease-sale at the Statler Hotel in Los Angeles.

Bidding Summary

Company or Group	Number of tracts bid	Number of tracts won	Average bid per acre	Expenditures for leases	Bids offered but unsuccessful	Per Cent Success of Bidding
Standard/Union	67	29	$38.60	$9,479,156	$4,872,816	45
Shell	41	23	51.80	8,905,073	3,596,390	59
Pan Am/Atl	54	27	23.00	5,189,460	1,883,140	50
Sup/Atl/Pan Am.	11	6	76.80	3,726,180	2,081,670	50
Sup/Pan Am.	2	2	245.00	2,822,688	--	100
Tex/Rich/Mob.	19	3	25.60	403,940	2,404,440	16
Union	1	1	376.00	2,165,760	--	100
Texaco/Mobil	2	1	161.00	1,101,484	751,334	50
Pan Amer.	4	4	64.00	1,473,925	--	100
Humble	4	0	31.00	-	719,077	-
Richfield	14	2	8.30	117,560	760,546	14
Gulf	4	2	17.00	197,000	196,550	50
Standard	6	1	8.80	45,366	260,968	17

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OREGON LEASE-SALE DELAYED UNTIL DECEMBER 1964

The Land Board moved back the opening of bids for state-owned tide and submerged lands from October 22, 1964, to December 3, 1964, in response to a request by the oil industry. A difference of opinion existed among the legal advisors of the oil companies as to the necessity of specifying the rate of royalty on sulphur. The postponement will not alter the competitive position of bidding. By eliminating any objectionable condition in the bidding procedure, the Land Board felt it could enhance the competition for leases. The conditions stipulated by the Land Board for bidding include: oil and gas royalty: 12½ per cent of gross production; annual rental: $1 per acre per year; and sulphur royalty: $1 per long ton. Sulphur is often a by-product in producing oil and gas.

The tracts comprise 136,300 acres of submerged land lying along the coastline between Cape Blanco and Winchester Bay. The parcels are approximately 7,000 acres in size. Four federal tracts off shore from Bandon (see map No. 3) received bids amounting to $550,000. The tracts are just half a mile from the state 3-mile line.

OFFER TO LEASE STATE-OWNED OFFSHORE LANDS

Pursuant to Oregon Revised Statutes 274.765 and other applicable statutes and regulations, the Oregon State Land Board will receive bids for the lease of certain tracts of tide and submerged lands adjacent to Coos and Douglas Counties for the purpose of extracting oil, gas and sulphur. To be considered, bids shall be delivered by mail or in person to, and shall be received at, the Land Board office, 106 State Capitol, Salem, Oregon 97310, before 10 a.m., PST, December 3, 1964. Bids will be opened publicly at 11a.m., PST, December 3, 1964, in the Board of Control room of the State Capitol in Salem.

Tracts offered for bid are tracts numbered 24, 25, 26, 27, 28, 29, 30, 31, 32E, 33E, 34, 35, 36, 37, 38, 39, 39E, and 40 as delineated and described on the official lease map adopted by the State Land Board on January 3, 1964, as revised April 16, 1964, May 12, 1964, and September 15, 1964. This map may be inspected and copies purchased at the Land Board office. Tracts 32E and 39E are subject to drilling restrictions in that drilling in bays or estuaries is prohibited.

The annual rental for all tracts leased shall be $1.00 per acre; the royalty rate for oil and gas shall be 12 1/2 per cent; and the royalty for sulphur shall be $1.00 per long ton. The lease on each tract will be awarded to the bidder who, in addition to complying with all the conditions of bidding and applicable statutes and regulations, offers the highest cash bonus.

Each tract must be applied for separately; each such bid must be sealed in a separate envelope; each such bid must be on the form provided by the Board and accompanied by duplicate lease forms executed by the bidder; and each bid must be accompanied by a certified financial statement establishing to the satisfaction of the Board the bidder's financial ability to undertake and fulfill all obligations under the prospective lease. Included with each bid shall be a certified or cashier's check made payable to the State of Oregon in an amount sufficient to cover the first year's rental, one-fifth of the cash bonus offered, and $100 fee to cover the cost of advertisement. The State Land Board reserves the right to reject any or all bids for cause.

The form of the lease, conditions for bidding, and bid forms may be obtained from the State Land Board upon request.

/s/ Dale Mallicoat, Clerk
OREGON STATE LAND BOARD
106 State Capitol
Salem, Oregon 97310

October 23, 1964
October 30, 1964

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OREGON and WASHINGTON OFFSHORE LEASE SALE
October 1, 1964

OCS-P No.	Tract No.	Bidder	Block No.	Acreage	Total Bid	Per Acre
TILLAMOOK AREA						
065	Ore 1	Shell Oil Co.	42N 66W All	5760	$ 35,424.00	$ 6.15
066	Ore 2	Shell Oil Co.	42N 67W All	5760	55,123.20	9.57
067	Ore 4	Shell Oil Co.	43N 67W All	5760	34,424.00	6.15
068	Ore 13	Std. Cal/Union	56N 63W All	5760	43,268.00	7.51+
069	Ore 14	Std. Cal/Union	56N 64W All	5760	86,468.00	15.01+
		Shell Oil Co.			61,344.00	10.65
070	Ore 16	Std. Cal/Union	57N 63W All	5760	58,676.00	10.18+
		Shell Oil Co.			41,817.60	7.26
071	Ore 17	Shell Oil Co.	57N 64W All	5760	87,897.60	15.26
072	Ore 18	Shell Oil Co.	57N 65W All	5760	1,598,400.00	277.50
		Std. Cal/Union			981,244.00	170.35
		Texaco/Rich/Mobil			201,139.20	34.92
073	Ore 19	Shell Oil Co.	58N 63W All	5760	41,817.60	7.26
074	Ore 21	Std. Cal/Union	58N 65W All	5760	491,684.00	85.36
		Shell Oil Co.			151,257.60	26.26
075	Ore 22	Shell Oil Co.	59N 63W All	5760	504,000.00	87.50
076	Ore 23	Std. Cal/Union	59N 64W All	5760	316,892.00	55.01+
		Shell Oil Co.			61,344.00	10.65
077	Ore 24	Std. Cal/Union	59N 65W All	5760	317,222.00	55.07+
		Shell Oil Co.			61,344.00	10.65
NEWPORT AREA						
078	Ore 28	Texaco/Rich/Mob	13N 67W All	5504.74	201,308.34	36.57
		Panam/Atlantic			192,776.00	35.02
		Shell Oil Co.			143,955.75	26.15
		Std. Cal/Union			41,326.00	7.50+
079	Ore 29	Shell Oil Co.	13N 68W All	5494.56	728,087.50	132.50
		Panam/Atlantic			467,696.95	85.12
		Texaco/Rich/Mobil			75,165.60	13.68
080	Ore 31	Std. Cal/Union	13N 70W All	5473.75	137,136.00	25.05+
081	Ore 34	Shell Oil Co.	14N 65W All	5760	309,657.60	53.76
082	Ore 35	Shell Oil Co.	14N 66W All	5760	87,955.20	15.27

OREGON and WASHINGTON OFFSHORE LEASE SALE, Continued

OCS-P No.	Tract No.	Bidder	Block No.	Acreage	Total Bid	Per Acre
	NEWPORT AREA, continued					
083	Ore 36	Panam/Atlantic	14N 67W All	5760	$ 173,779.20	$ 30.17
		Shell Oil Co.			58,176.00	10.10
		Std.Cal/Union			43,336.00	7.52+
084	Ore 37	Shell Oil Co.	14N 68W All	5760	206,553.60	35.86
		Panam/Atlantic			144,115.20	25.02
085	Ore 39	Std.Cal/Union	14N 70W All	5760	58,676.00	10.18+
086	Ore 40	Std.Cal/Union	14N 71W All	5760	233,440.00	40.52
		Richfield			91,180.00	15.83
087	Ore 43	Shell Oil Co.	15N 66W All	5760	1,516,147.20	263.22
		Std.Cal/Union			587.522.00	102.00+
		Panam/Atlantic			145,843.20	25.32
		Texaco/Rich/Mobil			101,318.40	17.59
088	Ore 44	Shell Oil Co.	15N 67W All	5760	905,472.00	157.20
		Supr/Panam/Atl.			576,864.00	100.15
		Std.Cal/Union			432,432.00	75.07+
		Texaco/Rich/Mobil			351,302.40	60.99
089	Ore 51	Std.Cal/Union	19N 65W All	5760	462,462.00	80.28+
		Texaco/Rich/Mobil			101,318.40	17.59
		Panam/Atlantic			30,470.40	5.29
090	Ore 54	Panam/Atlantic	20N 65W All	5760	87,148.80	15.13
091	Ore 55	Std.Cal/Union	20N 66W All	5760	1,042,042.00	180.91+
		Panam/Atlantic			59,155.20	10.27
092	Ore 56	Std.Cal/Union	20N 67W All	5760	777,776.00	135.03+
093	Ore 57	Panam/Atlantic	21N 65W All	5760	346,579.20	60.17
		Std.Cal/Union			291,824.00	50.66+
		Gulf Oil Corp.			98,726.40	17.14
094	Ore 58	Panam/Atlantic	21N 66W All	5760	58,176.00	10.10
095	Ore 60	Panam/Atlantic	22N 65W All	5760	318,067.20	55.22
		Std.Cal/Union			116,326.00	20.19+
		Gulf Oil Corp.			98,726.40	17.14
		Shell Oil Co.			30,355.20	5.27
096	Ore 61	Panam/Atlantic	22N 66W All	5760	87,782.40	15.24
		Std.Cal/Union			86,428.00	15.00+
097	Ore 62	Std.Cal/Union	22N 67W All	5760	173,888.00	30.18
		Panam/Atlantic			30,009.60	5.21
098	Ore 63	Gulf Oil Corp.	23N 65W All	5760	98,726.40	17.14
		Panam/Atlantic			58,003.20	10.07

OREGON and WASHINGTON OFFSHORE LEASE SALE, Continued

OCS-P No.	Tract No.	Bidder	Block No.	Acreage	Total Bid	Per Acre
NEWPORT AREA, continued						
099	Ore 64	Panam/Atlantic	23N 66W All	5760	$ 58,924.80	$ 10.23
		Std.Cal/Union			57,776.00	10.03+
0100	Ore 65	Std.Cal/Union	23N 67W All	5760	57,776.00	10.03+
		Panam/Atlantic			46,598.40	8.09
0101	Ore 66	Gulf Oil Corp.	24N 65W All	5760	98,726.40	17.14
		Panam/Atlantic			59,385.60	10.31
0102	Ore 67	Shell Oil Co.	24N 66W All	5760	116,755,20	20.27
		Std.Cal/Union			43,250.00	7.50+
		Panam/Atlantic			30,873.60	5.36
0103	Ore 74	Std.Cal/Union	29N 62W All	5760	1,446,336.00	251.10
		Shell Oil Co.			1,228,147.20	213.22
		Humble Oil Co.			332,812.80	57.78
		Texaco/Rich/Mobil			201,420.80	34.97
		Panam/Atlantic			58,003.20	10.07
0104	Ore 75	Shell Oil Co.	29N 63W All	5760	135,936.00	23.60
		Std.Cal/Union			102,222.00	17.74+
		Humble Oil Co.			60,768.00	10.55
		Panam/Atlantic			58,233.60	10.11
0105	Ore 78	Shell Oil Co.	30N 62W All	5760	652,032.00	113.20
		Std.Cal/Union			291,842.00	50.66+
		Humble Oil Co.			244,512.00	42.45
		Richfield			126,316.80	21.93
		Panam/Atlantic			58,464.00	10.15
0106	Ore 79	Std.Cal/Union	30N 63W All	5760	1,012,124.00	175.71+
		Shell Oil Co.			910,080.00	158.00
		Humble Oil Co.			80,985.60	14.06
		Panam/Atlantic			58,694.40	10.19
0107	Ore 82	Panam/Atlantic	31N 62W All	5760	57,945.60	10.06
0108	Ore 87	Std.Cal/Union	32N 63W All	5760	43,250.00	7.50+
COOS BAY AREA						
0109	Ore 93	Std.Cal/Union	36N 69W All	5760	43,246.00	7.50+
0110	Ore 99	Supr/Atl/Panam	38N 69W All	5760	116,640.00	20.25
		Std.Cal/Union			43,224.00	7.50
0111	Ore 101	Texaco/Rich/Mob	39N 68W All	5760	101,318.40	17.59
0112	Ore 102	Supr/Atl/Panam	39N 69W All	5760	289,152.00	50.20
		Std.Cal/Union			230,434.00	40.00

OREGON and WASHINGTON OFFSHORE LEASE SALE, Continued

OCS-P No.	Tract No.	Bidder	Block No.	Acreage	Total Bid	Per Acre
COOS BAY AREA, continued						
0113	Ore 105	Texaco/Rich/Mob	52N 66W All	5760	$ 101,318.40	$17.59
		Panam/Atlantic			58,233.60	10.11
		Std.Cal/Union			43,276.00	7.51+
0114	Ore 109	Panam/Atlantic	53N 66W All	5760	1,154,016.00	200.35
		Texaco/Rich/Mobil			371,462.40	64.49
		Std.Cal/Union			43,264.00	7.51+
0115	Ore 110	Panam/Atlantic	53N 67W All	5760	432,806.40	75.14
		Texaco/Rich/Mobil			101,318.40	17.59
		Std.Cal/Union			43,222.00	7.50+
0116	Ore 113	Texaco/Mobil	54N 66W All	5760	1,101,484.80	191.23
		Supr/Atl/Panam			1,038,528.00	180.30
		Std.Cal/Union			201,666.00	35.01
0117	Ore 114	Supr/Atl/Panam	54N 67W All	5760	1,785,888.00	310.05
		Std.Cal/Union			86,444.00	15.00+
		Richfield			76,262.40	13.24
0118	Ore 117	Panam/Atlantic	55N 66W All	5760	$ 231,148.80	$ 40.13
		Richfield			41,299.20	7.17
0119	Ore 119	Shell Oil Co.	55N 68W All	5760	756,000.00	131.25
		Panam/Atlantic			29,030.40	5.04
0120	Ore 124	Std.Cal/Union	56N 65W All	5760	748,888.00	130.01+
0121	Ore 125	Shell Oil Co.	56N 66W All	5760	620,064.00	107.65
		Panam/Atlantic			88,473.60	15.36
		Std.Cal/Union			43,216.00	7.50+
0122	Ore 126	Richfield Oil	56N 67W All	5760	41,299.20	7.17
0123	Ore 127	Panam/Atlantic	56N 68W All	5760	30,067.20	5.22
0124	Ore 129	Shell Oil Co.	56N 70W All	5760	150,681.60	26.16
		Std.Cal/Union			57,750.00	10.02+
		Texaco/Rich/Mobil			41,299.20	7.17
		Panam/Atlantic			30,412.80	5.28
0125	Ore 130	Std.Cal/Union	56N 71W All	5760	433,666.00	75.28
		Shell Oil Co.			150,681.60	26.16
		Richfield			41,299.20	7.17
		Panam/Atlantic			29,836.80	5.18
0126	Ore 132	Std.Cal/Union	57N 65W All	5760	230,476.00	40.01
		Texaco/Rich/Mobil			126,316.80	21.93
0127	Ore 133	Panam/Atlantic	57N 66W All	5760	347,961.60	60.41
		Texaco/Rich/Mobil			126,316.80	21.93
		Std.Cal/Union			86,434.00	15.00+

OREGON and WASHINGTON OFFSHORE LEASE SALE, Continued

OCS-P No.	Tract No.	Bidder	Block No.	Acreage	Total Bid	Per Acre
COOS BAY AREA, continued						
0128	Ore 134	Panam/Atlantic	57N 67W All	5760	$ 145,555.20	$25.27
		Std. Cal/Union			86,534.00	15.02+
		Richfield			41,299.20	7.17
0129	Ore 135	Std. Cal/Union	57N 68W All	5760	97,922.00	17.00+
0130	Ore 136	Union Oil Co.	57N 69W All	5760	2,165,760.00	376.00
		Texaco/Mobil			751,334.40	130.44
		Shell Oil Co.			360,460.80	62.58
		Supr/Atl/Panam			144,868.00	25.15
0131	Ore 137	Std. Cal/Union	57N 70W All	5760	43,278.00	7.51+
0132	Ore 138	Std. Cal/Union	57N 71W All	5760	86,424.00	15.00
		Texaco/Rich/Mobil			61,113.60	10.61
		Panam/Atlantic			30,009.60	5.21
0133	Ore 140	Std. Cal/Union	58N 65W All	5760	57,774.00	10.03
		Richfield			41,299.20	7.17
0134	Ore 141	Supr/Atl/Panam	58N 66W All	5760	549,504.00	95.40
		Richfield			41,299.20	7.17
0135	Ore 142	Panam/Atlantic	58N 67W All	5760	87,897.60	15.26
0136	Ore 143	Panam/Atlantic	58N 68W All	5760	88,185.60	15.31
		Std. Cal/Union			58,784.00	10.20+
0137	Ore 144	Richfield Oil	58N 69W All	5760	76,262.40	13.24
		Std. Cal/Union			57,762.00	10.02+
		Panam/Atlantic			29,721.60	5.16
0138	Ore 145	Std. Cal/Union	58N 70W All	5760	291,124.00	50.54+
		Texaco/Rich/Mobil			251,308.80	43.63
		Panam/Atlantic			31,046.40	5.39
WASHINGTON						
CAPE FLATTERY AREA						
0139	Wash 3	Std. Oil Cal.	11N 58W All	5760	45,366.00	7.87+
0140	Wash 4	Panam/Atlantic	17N 61W All	5760	86,745.60	15.06
		Std. Cal/Union			86,468.00	15.01+
0141	Wash 5	Panam/Atlantic	17N 62W All	5760	144,864.00	25.15
		Shell Oil Co.			47,462.40	8.24

OREGON and WASHINGTON OFFSHORE LEASE SALE, Continued

OCS-P No.	Tract No.	Bidder	Block No.	Acreage	Total Bid	Per Acre
CAPE FLATTERY AREA, continued						
0142	Wash 6	Panam/Atlantic	18N 61W All	5760	34,848.00	6.05
0143	Wash 7	Shell Oil Co.	18N 62W All	5760	47,462.40	8.24
0144	Wash 10	Std. Cal/Union	20N 61W All	5760	$ 291,776.00	$50.65+
		Supr/Atl/Panam			88,128.00	15.30
0145	Wash 11	Std. Cal/Union	20N 62W All	5760	58,776.00	10.20
		Panam/Atlantic			58,060.80	10.80
0146	Wash 12	Std. Cal/Union	21N 61W All	5760	291,324.00	50.57+
		Supr/Atl/Panam			233,280.00	40.50
		Texaco/Rich/Mobil			76,262.40	13.24
0147	Wash 13	Panam/Atlantic	21N 62W All	5760	87,321.60	15.16
		Std. Cal/Union			58,222.00	10.10+
		Richfield			51,379.20	8.92
COPALIS BEACH AREA						
0148	*Wash 14	Supr/Atl/Panam	34N 58W * 34N 59W	5660	40,752.00	7.20
0149	Wash 16	Superior/Panam	34N 61W All	5760	1,036,800.00	180.00
		Richfield			126,316.80	21.93
		Std. Oil of Cal.			62,336.00	10.82+
0150	Wash 17	Shell Oil Co.	34N 62W All	5760	206,553.60	35.86
		Panam/Atlantic			144,633.60	25.11
0151	Wash 20	Superior/Panam	35N 61W All	5760	1,785,888.00	310.05
		Std. Oil of Cal.			306,124.00	53.14+
		Texaco/Rich/Mobil			176,083.20	30.57
		Shell Oil Co.			47,462.40	8.24
0152	Wash 21	Panam/Atlantic	35N 62W All	5760	58,579.20	10.17
		Shell Oil Co.			47,462.40	8.24
		Texaco/Rich/Mobil			41,299.20	7.17
0153	Wash 24	Panam/Atlantic	36N 61W All	5760	347,040.00	60.25
		Std. Oil of Cal.			46,776.00	8.12+
0154	Wash 27	Shell Oil Co.	37N 61W All	5760	58,176.00	10.10
		Richfield			41,299.20	7.17
		Panam/Atlantic			35,078.40	6.09

---

* All that portion lying seaward of a line 3 geographical miles distant from the coast line of Wash.

OREGON and WASHINGTON OFFSHORE LEASE SALE, Continued

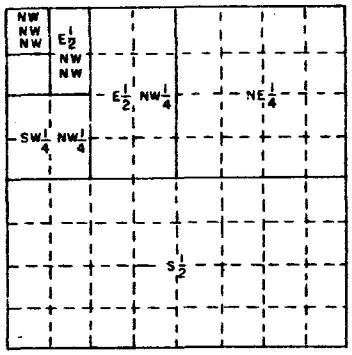
OCS-P No.	Tract No.	Bidder	Block No.	Acreage	Total Bid	Per Acre
COPALIS BEACH AREA, continued						
0155	Wash 28	Shell Oil Co.	37N 62W All	5760	50,457.60	8.76
		Panam/Atlantic			34,963.20	6.07
0156	Wash 30	Panam/Atlantic	39N 61W All	5760	145,209.60	25.21
		Std.Oil of Cal.			45,366.00	7.87
0157	Wash 31	Supr/Atl/Panam	39N 62W All	5760	894,240.00	155.25
		Shell Oil Co.			51,091.20	8.87
0158	Wash 33	Panam/Atlantic	40N 60W All	5760	$ 57,772.80	$ 10.03
0159	Wash 34	Panam/Atlantic	40N 61W All	5760	433,555.20	75.27
		Std. Oil of Cal.			61,124.00	10.61+
0160	Wash 37	Panam/Atlantic	41N 60W All	5760	29,260.80	5.08
0161	Wash 38	Panam/Atlantic	41N 61W All	5760	58,233.60	10.11
		Std.Oil of Cal.			45,366.00	7.87+
0162	Wash 43	Pan Amer. Petr.	45N 64W All	5760	865,497.60	150.26
		Std.Cal/Union			261,200.00	45.34+
		Shell Oil Co.			93,888.00	16.30
		Richfield			41,299.20	7.17
0163	Wash 44	Pan Amer.Petr.	45N 65W All	5760	145,267.20	25.22
		Std.Cal/Union			126,720.00	22.00
0164	Wash 46	Pan Amer.Petr.	46N 64W All	5760	289,497.60	50.26
		Std.Cal/Union			71,224.00	12.36+
		Shell Oil Co.			47,462.40	8.24
0165	Wash 47	Pan Amer.Petr.	46N 65W All	5760	173,664.00	30.15
		Std.Cal/Union			111,444.00	19.34+

Summary of Recent Federal Lease Sales off the West Coast

Date	State	No. Acres Offered	No. Acres Leased	Total Bonus	Average Per Acre	Total Rentals	Total Amount of All Bids Received
5/14/63	Cal.	669,777	312,976	$12,807,586	$40.93	$ 938,838	$13,989,702
10/1/64	Ore.	836,134	425,433	27,768,772	65.27	1,276,302	43,049,543
10/1/64	Wash.	253,940	155,420	7,764,928	49.96	466,260	10,530,210

Explanation for Outer Continental Lease Maps

Subdivision of blocks on
Outer Continental Shelf



Typical method of subdivision of a block, each subdivision being an aliquot part of the total based on mid-point subdivision throughout.

All blocks on the following maps are based on the Oregon (Lambert) Plane Coordinate System.

The identification of the blocks is based on the numerical sequence N(North) starting at Y origin and the numerical sequence W(West) starting at the central meridian.

Example: 36N - 74W

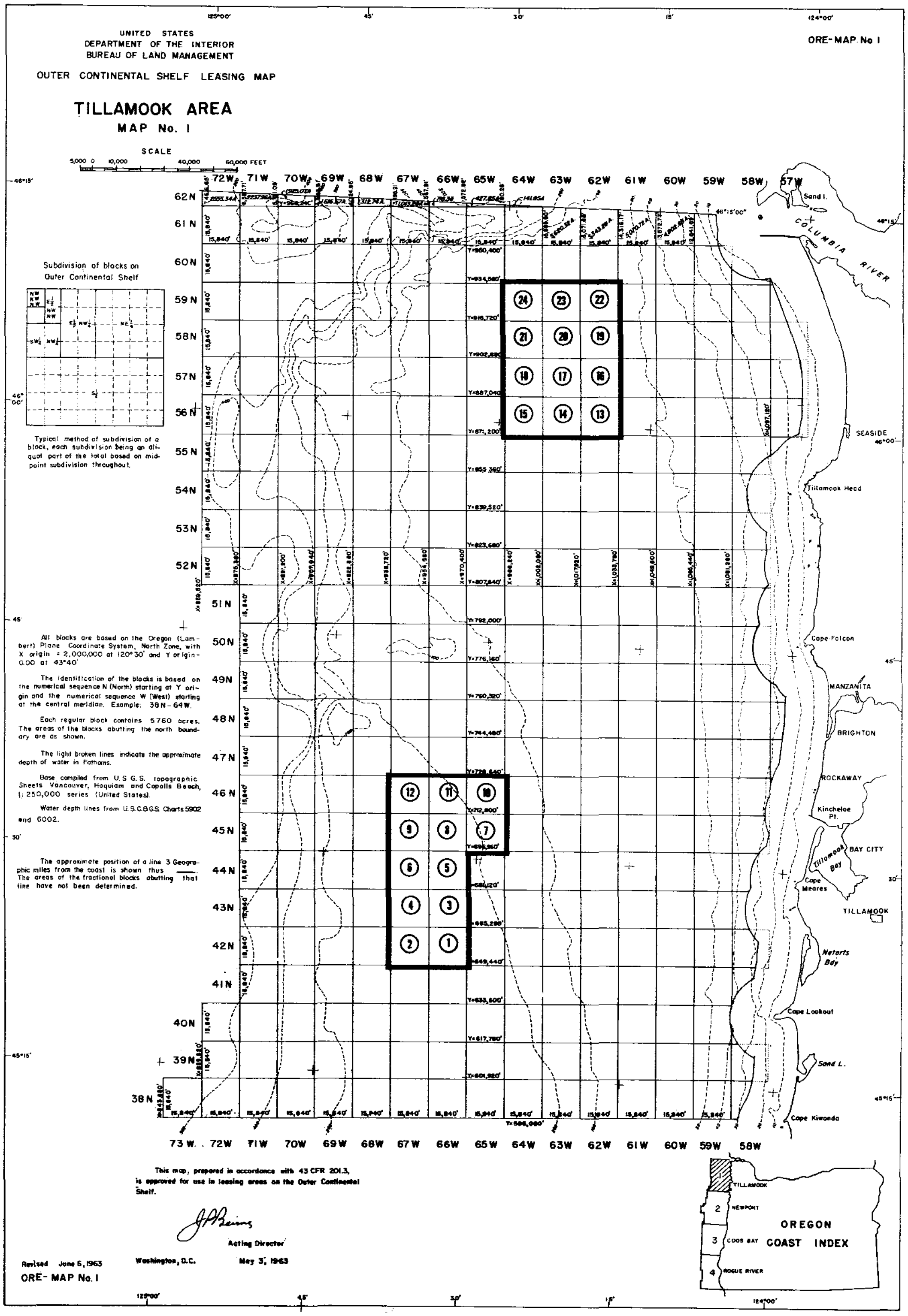
Each regular block contains 5,760 acres.

Base compiled from U.S. Geological Survey topographic sheets.

The light broken lines indicate the approximate depth of water in fathoms.

Water depth lines from U.S. Coast & Geodetic Survey Charts.

The approximate position of a line 3 geographical miles from the coast is shown thus: ——— . The areas of the fractional blocks abutting that line have not been determined.



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

OUTER CONTINENTAL SHELF LEASING MAP

TILLAMOOK AREA

MAP No. I

ORE-MAP No I

All blocks are based on the Oregon (Lambert) Plane Coordinate System, North Zone, with X origin = 2,000,000 at 120°30' and Y origin = 0.00 at 43°40'

The identification of the blocks is based on the numerical sequence N (North) starting at Y origin and the numerical sequence W (West) starting at the central meridian. Example: 38N-64W.

Each regular block contains 5760 acres. The areas of the blocks abutting the north boundary are as shown.

The light broken lines indicate the approximate depth of water in Fathoms.

Base compiled from U.S.G.S. topographic Sheets Vancouver, Hoquiam and Copalis Beach, 1:250,000 series (United States).

Water depth lines from U.S.C.&G.S. Charts 5902 and 6002.

The approximate position of a line 3 Geographic miles from the coast is shown thus ——. The areas of the fractional blocks abutting that line have not been determined.

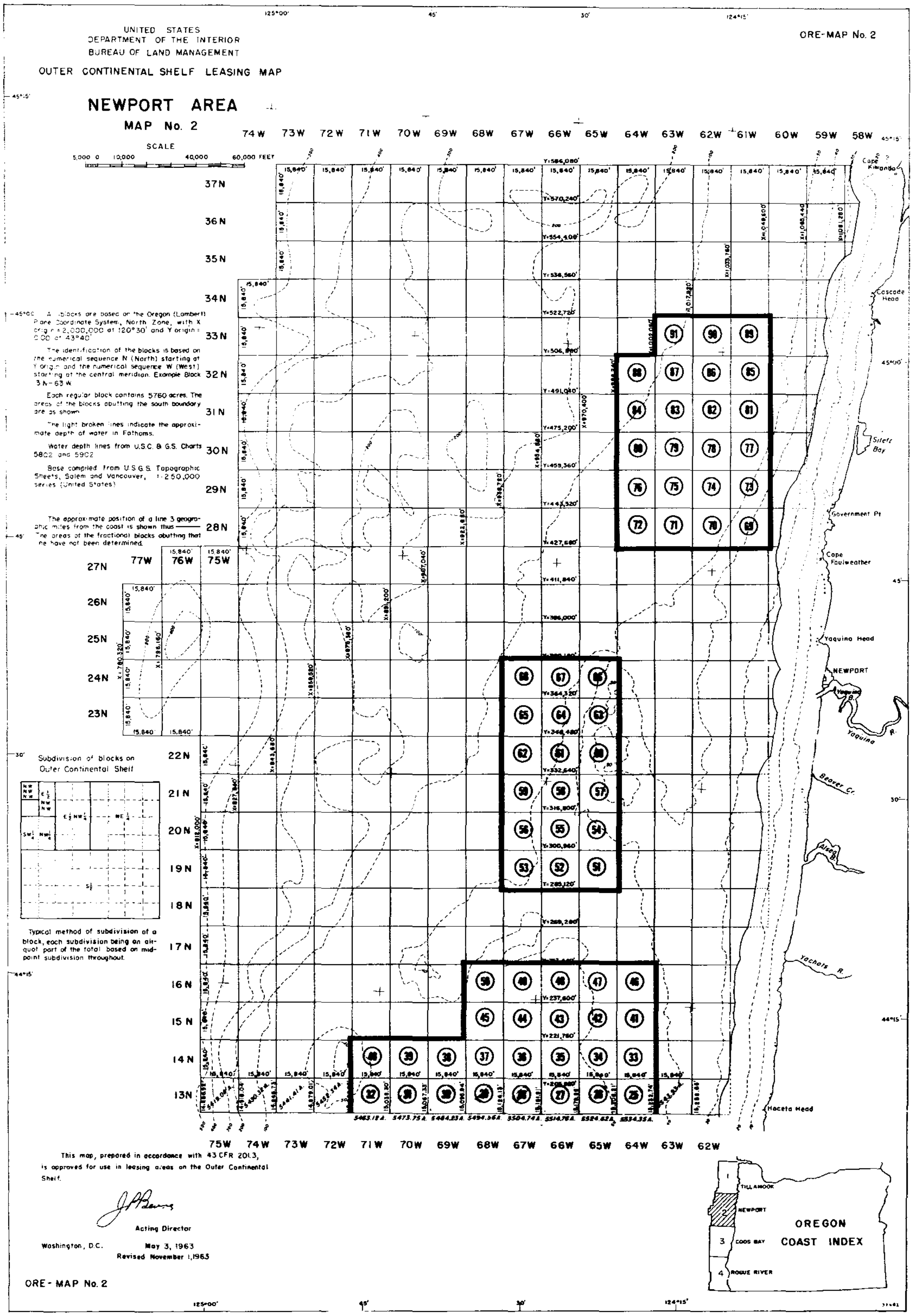
Typical method of subdivision of a block, each subdivision being an aliquot part of the total based on midpoint subdivision throughout.

This map, prepared in accordance with 43 CFR 201.3, is approved for use in leasing areas on the Outer Continental Shelf.

Acting Director

Washington, D.C. May 3, 1963

Revised June 6, 1963
ORE-MAP No. I



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

OUTER CONTINENTAL SHELF LEASING MAP

NEWPORT AREA

MAP No. 2

ORE-MAP No. 2

All blocks are based on the Oregon (Lambert) Plane Coordinate System, North Zone, with X origin = 2,000,000 at 120°30' and Y origin = 0.00 at 43°40'

The identification of the blocks is based on the numerical sequence N (North) starting at Y origin and the numerical sequence W (West) starting at the central meridian. Example Block 3 N – 63 W

Each regular block contains 5760 acres. The areas of the blocks abutting the south boundary are as shown

The light broken lines indicate the approximate depth of water in Fathoms.

Water depth lines from U.S.C. & G.S. Charts 5802 and 5902

Base compiled from U.S.G.S. Topographic Sheets, Salem and Vancouver, 1:250,000 series (United States)

The approximate position of a line 3 geographic miles from the coast is shown thus ——— The areas of the fractional blocks abutting that line have not been determined.

Subdivision of blocks on Outer Continental Shelf

Typical method of subdivision of a block, each subdivision being an aliquot part of the total based on mid-point subdivision throughout.

This map, prepared in accordance with 43 CFR 201.3, is approved for use in leasing areas on the Outer Continental Shelf.

Acting Director

Washington, D.C. May 3, 1963
Revised November 1, 1963

ORE-MAP No. 2

ORE-MAP No. 3

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

OUTER CONTINENTAL SHELF LEASING MAP

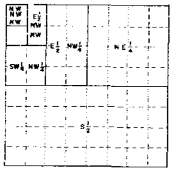
COOS BAY AREA

MAP No. 3

SCALE

5,000 0 10,000 40,000 60,000 FEET

Subdivision of blocks on Outer Continental Shelf



Typical method of subdivision of a block, each subdivision being an aliquot part of the total based on mid-point subdivision throughout

All blocks are based on the Oregon (Lambert) Plane Coordinate System, South Zone, with X origin = 2,000,000 at 120°30' and Y origin = 0.00 at 41°40'.

The identification of the blocks is based on the numerical sequence N (North) starting at Y origin and the numerical sequence W (West) starting at the central meridian. Example: 36N - 74W.

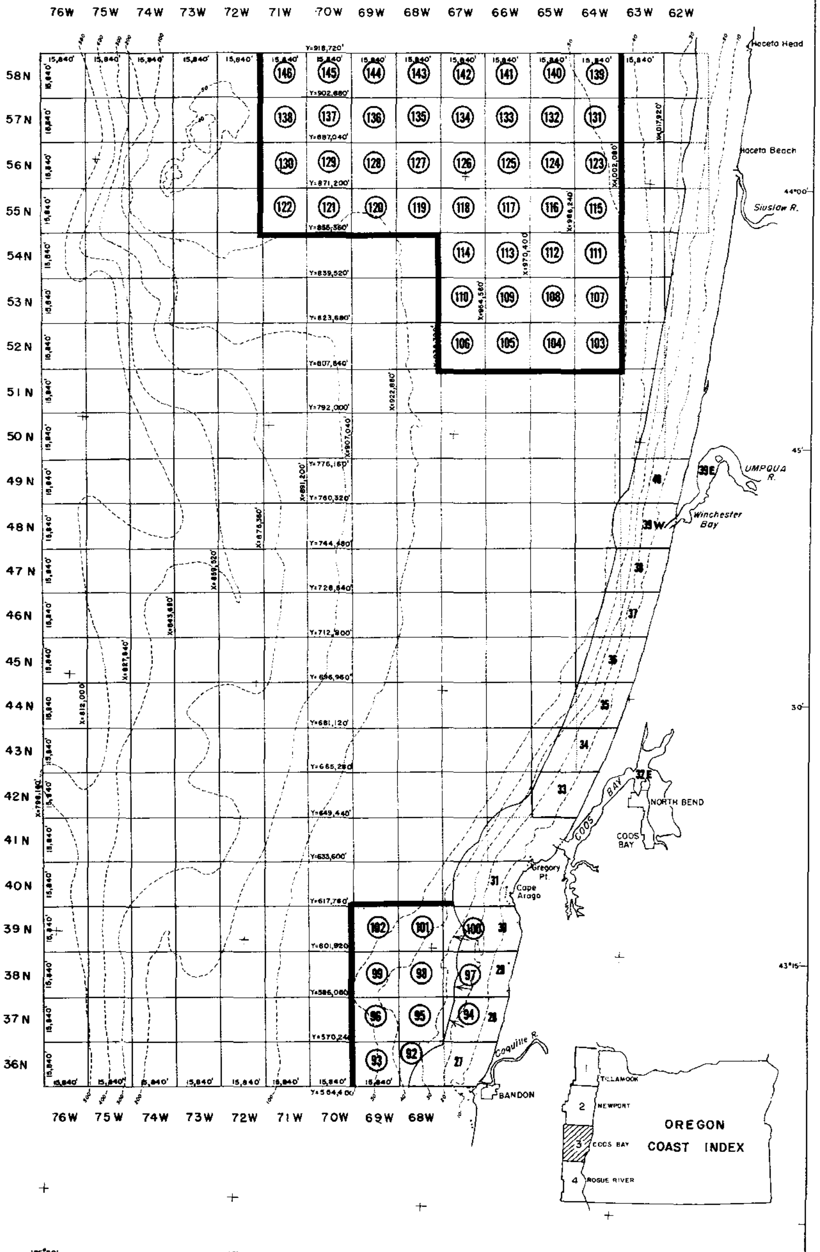
Each regular block contains 5760 acres.

Base compiled from U.S.G.S. topographic Sheets Coos Bay and Salem, 1:250,000 series. (United States)

The light broken lines indicate the approximate depth of water in Fathoms.

Water depth lines from U.S.C.&G.S. Chart 5802.

The approximate position of a line 3 Geographic miles from the coast is shown thus ——. The areas of the fractional blocks abutting that line have not been determined.



This map, prepared in accordance with 43 CFR 201.3, is approved for use in leasing areas on the Outer Continental Shelf.

JPBeiring

Acting Director

Washington, D.C. May 3, 1963

ORE-MAP No. 3

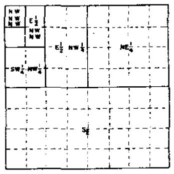
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

OUTER CONTINENTAL SHELF LEASING MAP

ROGUE RIVER AREA
MAP No. 4

SCALE
5,000 0 10,000 40,000 60,000 FEET

Subdivision of blocks on Outer Continental Shelf



Typical method of subdivision of a block, each subdivision being an aliquot part of the total based on mid-point subdivision throughout.

All blocks are based on the Oregon (Lambert) Plane Coordinate System, South Zone, with X origin = 2,000,000′ at 120°30′ and Y origin = 0.00 at 41°40′.

The identification of the blocks is based on the numerical sequence N (North) starting at Y origin and the numerical sequence W (West) starting at the central meridian. Example: 11N – 71W.

Each regular block contains 5760 acres. The areas of the blocks abutting the south boundary are as shown.

The light broken lines, indicate the approximate depth of water in Fathoms.

Base compiled from U.S.G.S. Topographic Sheet, Coos Bay, 1:250,000 series (United States).

Water depth lines from U.S.C.&G.S. Charts 5702 and 5802.

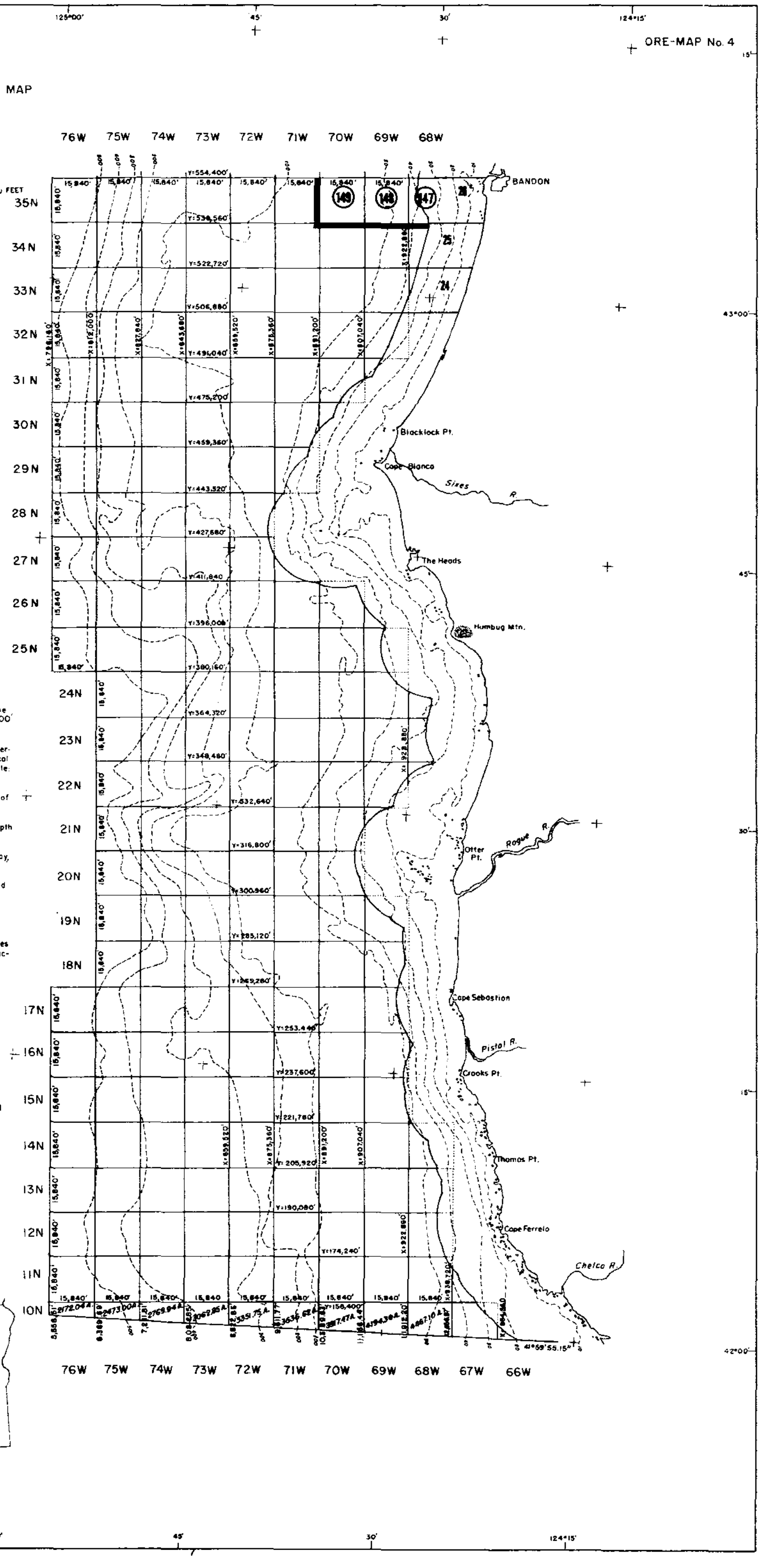
The approximate position of a line 3 geographic miles from the coast is shown thus ———. The areas of the fractional blocks abutting that line have not been determined.

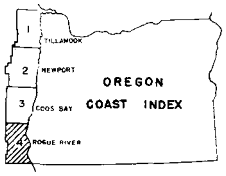
This map, prepared in accordance with 43 CFR 201.3, is approved for use in leasing areas on the Outer Continental Shelf.

J P Baines

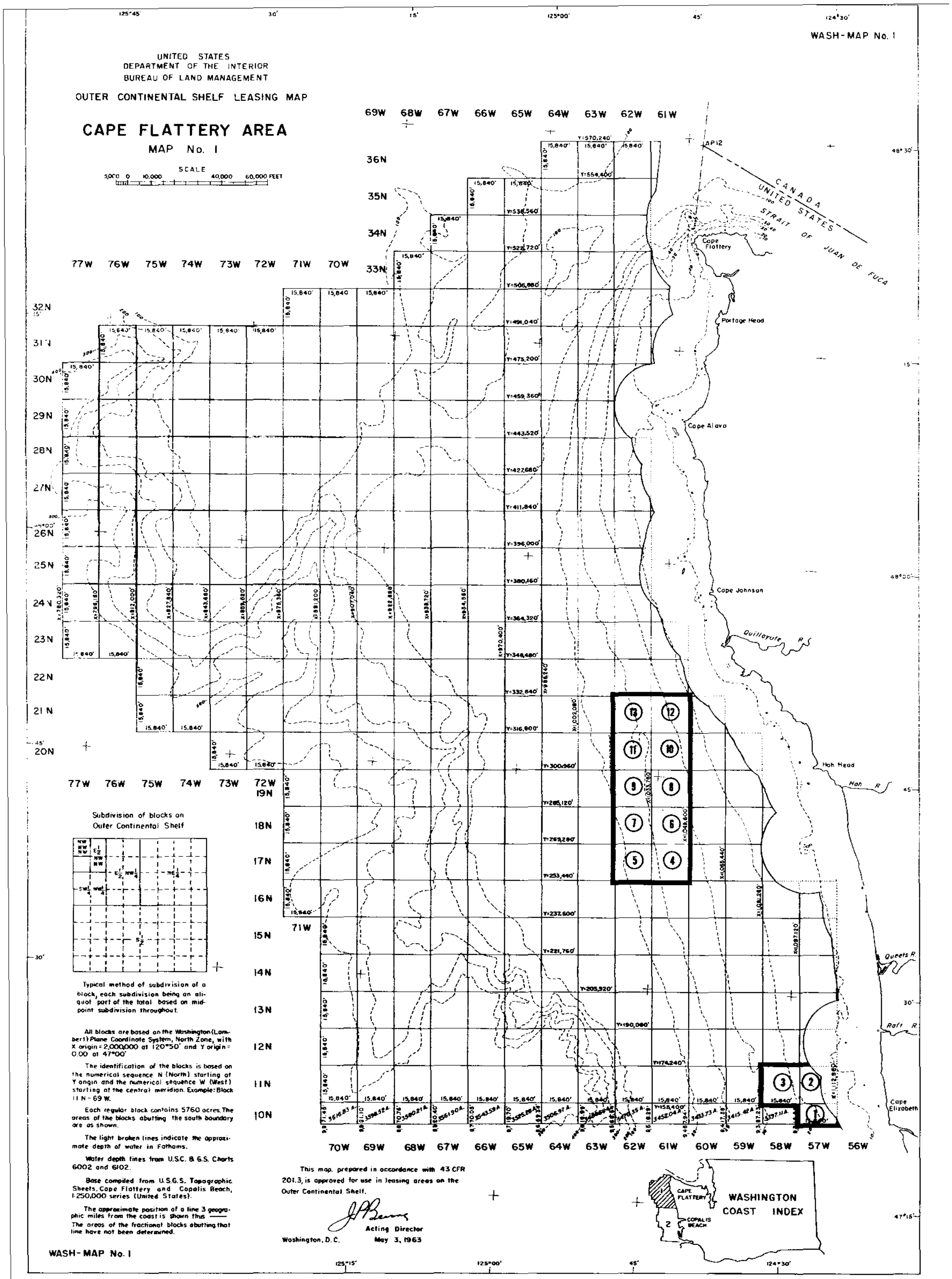
Acting Director

Washington, D.C. May 3, 1963





ORE-MAP No. 4



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

OUTER CONTINENTAL SHELF LEASING MAP

CAPE FLATTERY AREA

MAP No. 1

Subdivision of blocks on Outer Continental Shelf

Typical method of subdivision of a block, each subdivision being an aliquot part of the total based on midpoint subdivision throughout.

All blocks are based on the Washington (Lambert) Plane Coordinate System, North Zone, with X origin = 2,000,000 at 120°50' and Y origin = 0.00 at 47°00'

The identification of the blocks is based on the numerical sequence N (North) starting at Y origin and the numerical sequence W (West) starting at the central meridian. Example: Block 11 N - 69 W.

Each regular block contains 5760 acres. The areas of the blocks abutting the south boundary are as shown.

The light broken lines indicate the approximate depth of water in Fathoms.

Water depth lines from U.S.C. & G.S. Charts 6002 and 6102.

Base compiled from U.S.G.S. Topographic Sheets, Cape Flattery and Copalis Beach, 1:250,000 series (United States).

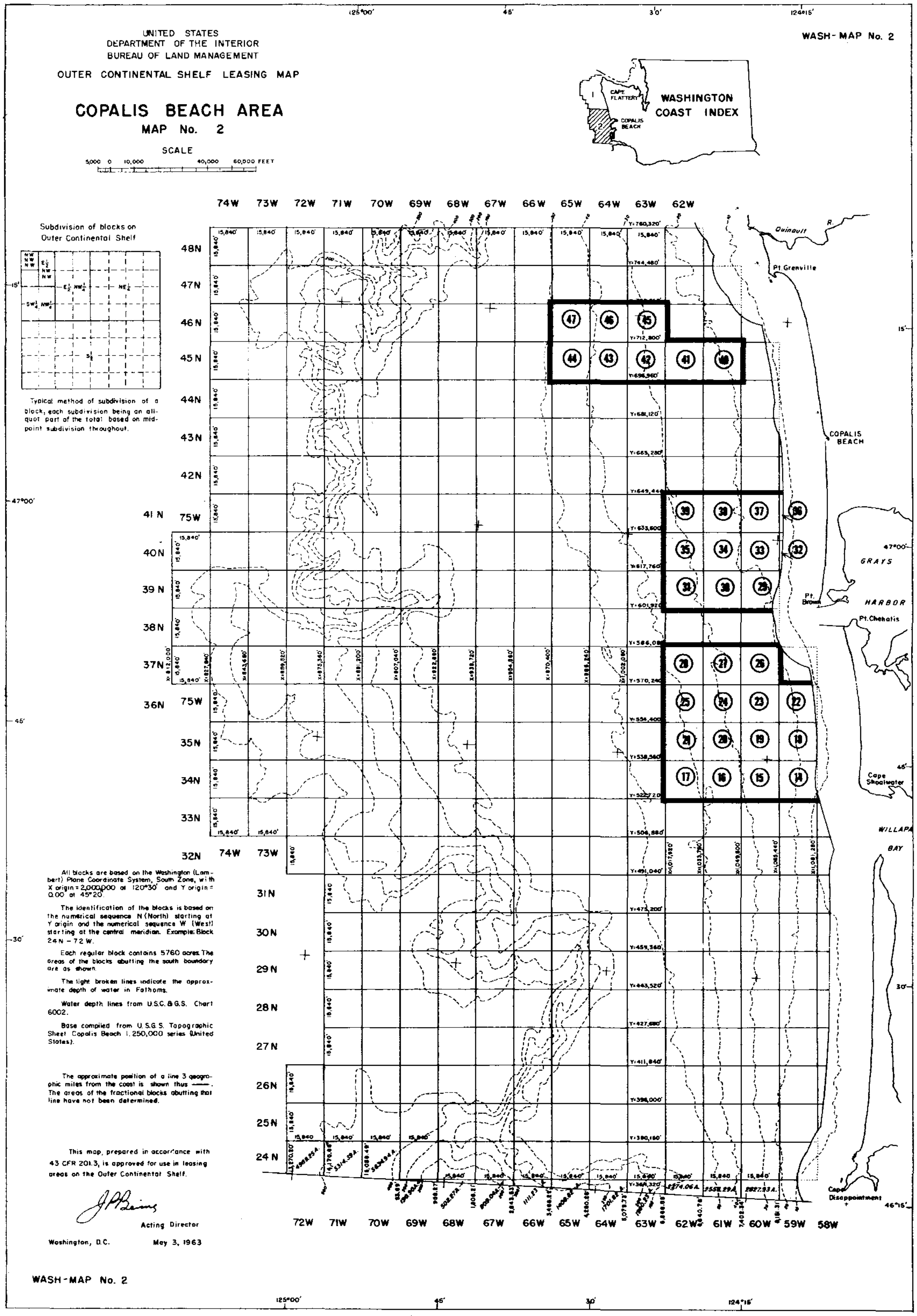
The approximate position of a line 3 geographic miles from the coast is shown thus ——— The areas of the fractional blocks abutting that line have not been determined.

WASH-MAP No. 1

This map, prepared in accordance with 43 CFR 201.3, is approved for use in leasing areas on the Outer Continental Shelf.

Acting Director

Washington, D.C. May 3, 1963


UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

OUTER CONTINENTAL SHELF LEASING MAP

COPALIS BEACH AREA

MAP No. 2

WASH-MAP No. 2

Typical method of subdivision of a block, each subdivision being an aliquot part of the total based on mid-point subdivision throughout.

All blocks are based on the Washington (Lambert) Plane Coordinate System, South Zone, with X origin = 2,000,000 at 120°30′ and Y origin = 0.00 at 45°20′.

The identification of the blocks is based on the numerical sequence N (North) starting at Y origin and the numerical sequence W (West) starting at the central meridian. Example: Block 24N – 72W.

Each regular block contains 5760 acres. The areas of the blocks abutting the south boundary are as shown.

The light broken lines indicate the approximate depth of water in Fathoms.

Water depth lines from U.S.C.&G.S. Chart 6002.

Base compiled from U.S.G.S. Topographic Sheet Copalis Beach 1:250,000 series (United States).

The approximate position of a line 3 geographic miles from the coast is shown thus ——. The areas of the fractional blocks abutting that line have not been determined.

This map, prepared in accordance with 43 CFR 201.3, is approved for use in leasing areas on the Outer Continental Shelf.

J P Beinz
Acting Director

Washington, D.C. May 3, 1963

WASH-MAP No. 2

The ORE BIN
Volume 26, No. 12
December, 1964

EARTHQUAKE GEOLOGY OF THE PORTLAND AREA, OREGON

By H. G. Schlicker*, R. J. Deacon**, and N. H. Twelker***

The Alaska Good Friday earthquake of March 27, 1964, was one of the most severe ever recorded on the North American continent. The vast damage caused by this quake emphasizes anew the importance of seismic considerations in the location and design of public buildings and other civil works.

In this report the authors point out that the Portland area has had a long history of earthquakes and can expect more; they summarize the information on the Alaska earthquake in the belief that knowledge gained from that catastrophe can be applied to earthquake resistance considerations for the Portland area; and they discuss the geologic and engineering factors that could influence the type and extent of damage in the event of a major local earthquake.

Emphasized is the need for the installation of a sufficient number of strong-motion seismographs in the Portland area to record the reaction of the various geologic units to earth movement, so that this information can be made available to those concerned with locating and designing civic structures.

Acknowledgments

The authors are very grateful to the following persons who generously contributed their time and experience by critically reading the manuscript and offering many helpful suggestions to the benefit of this paper: Mr. F. W. Libbey, mining engineer; Mr. Rowland S. Rosé, consulting structural engineer; Mr. Kurt H. Siecke, consulting engineer; and Mr. Ronald McReary, civil engineer, all residents of the Portland area.

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* Geologist, State of Oregon Department of Geology and Mineral Industries.
** Consulting Geologist, Portland, Oregon.
*** Consulting Soils Engineer, Seattle, Washington.

Introduction

History of Oregon earthquakes

Oregon has experienced many more earthquakes than is generally realized, and a good share of them have occurred in the vicinity of Portland. Since 1841, at least 160 earthquakes have been recorded in Oregon, not including those originating out of the state or at sea but felt here. Prior to 1900, only about 30 quakes had been known. Undoubtedly many more occurred but were not reported because of the scattered population, poor communications, and lack of instrumentation.

Earthquakes having intensities of VIII on the modified Mercalli scale have been reported for Oregon at Port Orford in 1873, at Portland in 1877 and in 1880, and at Milton-Freewater in 1936. Earthquakes with intensities of VII were reported at Umatilla in 1923 and at Portland in 1962; and intensity quakes of VI occurred in Portland in 1953 and at Salem in 1957. Portland alone has been the epicenter for at least 46 earthquakes ranging from II to VII in intensities. Nine of these were V and above (Berg and Baker, 1962).

Future earthquake probability

Oregon lies within the circum-Pacific belt of crustal instability along with California and Washington, both of which have recorded violent shocks in recent years. Since Oregon is a tectonically active state, consideration of the effects of earthquakes is necessary in all design and construction, particularly for schools, churches, and public buildings.

Prediction of earthquakes is a subject of great interest to many investigators; however, the difficulties to be overcome in this worthy pursuit are staggering. Such predictions may very well prove to be beyond the capability of man. Records indicate that where earthquakes have occurred in the past they will probably recur, and that the intensity of the recurrence can be much greater than that of previous quakes. The probability that an earthquake will recur increases proportionally as time elapses.

Measuring earthquakes

The earth's crust is never still. Many of its small, continual vibrations can be detected only by delicate instruments. These trivial motions, called microseisms, are caused by heavy traffic, railroad trains, wind, tide, changes in barometric pressures, storms, large explosions, and similar phenomena. Earthquake waves differ from microseisms in that they have definite beginnings and endings, and they have a definite point of origin (epicenter). They are caused primarily by movement along faults resulting from tectonic adjustments in the earth's crust or, in some cases, by vulcanism.

Earthquake waves are vibrations which travel through the earth as elastic waves. Three types of undulations originate from this source. The primary or "P" wave has a vibration parallel to the direction of propagation and is longitudinal and compressional in motion. It is the fastest wave and the one which arrives first. It travels at a velocity that equals the speed of sound through rock and varies with the density of the media. The secondary or "S" wave is a transverse one which vibrates at right angles to the direction of propagation and arrives at its destination after the "P" wave. The "L" or longest wave is a surface surge which travels along the upper surface of the disturbed rock and arrives last. These waves travel greater distances than the faster ones and tend to affect materials having larger masses. The distance from the earthquake center, or epicenter, is measured by the difference in arrival time of the "P" and "S" waves.

Several scales have been devised to describe the magnitude and intensities of earthquakes. Magnitude refers to the instrumentally measured amplitude of the recorded trace corrected for the distance from the epicenter. Magnitude,measured by seismographs, is independent of the location of the recording station. The most commonly used magnitude rating is the Richter scale. The magnitude of an earthquake is related in a general way to the amount of energy released; however, the magnitude is not a quantitative measure of energy.

Intensity refers to the observed qualitative effects of earthquake forces (that is, shaking, principally in a lateral direction). These differ from area to area, depending upon the local geology and distance from the epicenter. It is to be noted that the intensity rating is not intended to be a damage report; consequently, secondary damages such as those caused by fire, flood, or landslide should be excluded when assigning an intensity rating. Frequent reference in earthquake literature is made to the Rossi-Forel, Mercalli, and modified Mercalli scales of intensity. The modified Mercalli scale is most commonly used today (see chart on page 212).

The Alaska Good Friday Earthquake

The following paragraphs describe the reported circumstances of the great Alaska earthquake, the types of damage it caused, and the geology of the Anchorage area. This information is presented for the purpose of allowing a correlation between the Anchorage earthquake and the possible effects of a similar earthquake in or near Portland.

Instrumented data

In spite of the great amount of instrumented information gathered throughout the world during and following the Good Friday earthquake, little if any of this will be of use to engineers or geologists concerned with the effects of earthquakes on man and his works. Instrumented records, to be of use in the design of structures, must include figures on amplitude, duration, maximum acceleration, and period of vibration within the immediate area by strong-motion seismograph. Recording instruments had not been placed within the Anchorage area prior to the March 27 earthquake. Summarized briefly are the general conclusions concerning the Good Friday earthquake:

Location of epicenter: Northern Prince William Sound, near the east shore of Anakuik Island, approximately 80 miles southeast of Anchorage, Alaska.

Time of beginning of earthquake: 5:36 p.m. (local time), March 27, 1964.

Magnitude: 8.4 to 8.6 on the Richter scale.

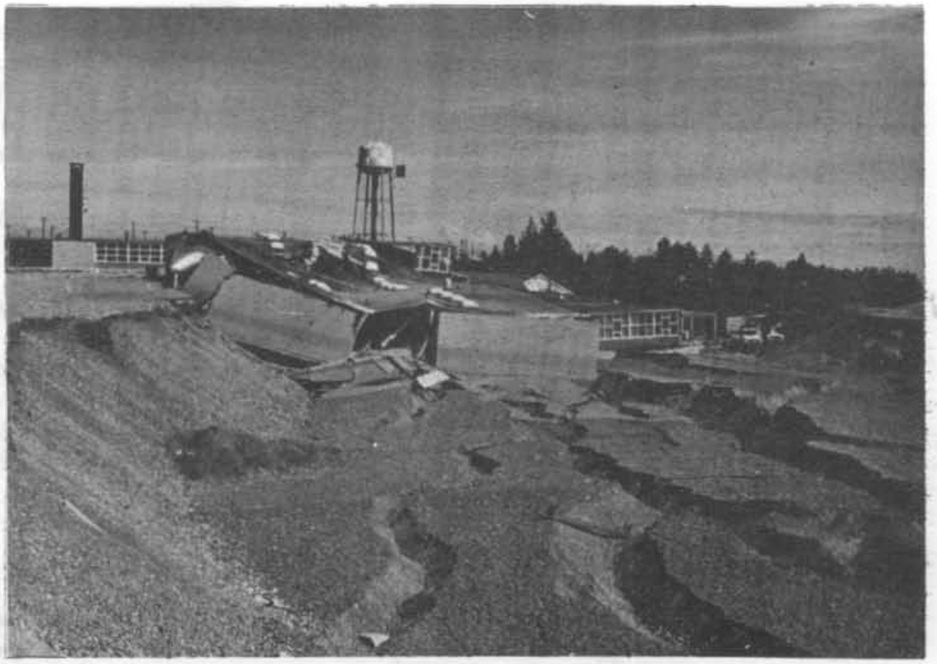
Loss of life: Approximately 114 persons dead or missing.

Property damage: Approximately $750,000,000.

THE MODIFIED MERCALLI INTENSITY SCALE OF 1931*
(Simplified for this report)

Scale degree	Effects on persons	Effects on structures	Other effects	Rossi-Forel equivalent	Equivalent shallow magnitude
I	Not felt except by few under favorable circumstances.			I	
II	Felt by few at rest.		Delicately suspended objects swing.	I-II	2.5
III	Felt noticeably indoors.		Duration estimated.	III	
IV	Felt generally indoors.		Cars rocked, windows rattled.	IV-V	3.5
V	Felt generally.	Some plaster falls.	Dishes, windows broken, pendulum clocks stop.	V-VI	
VI	Felt by all, many frightened.	Chimneys, plaster damaged.	Furniture moved, objects upset.	VI-VII	
VII	Everyone runs outdoors, felt in moving cars.	Moderate damage.		VIII	5.5
VIII	General alarm.	Very destructive and general damage to weak structures. Little damage to well-built structures.	Monuments, walls down, furniture overturned. Sand and mud ejected. Changes in well-water levels.	VIII-IX	6
IX	Panic.	Total destruction weak structures, considerable damage well-built structures.	Foundations damaged, under-ground pipes broken.	IX	
X	Panic.	Masonry and frame structures commonly destroyed. Only best buildings survive.	Ground badly cracked, rails bent. Water slopped over banks.		
XI	Panic.	Few buildings survive.	Broad fissures, fault scarps. Underground pipes out of service.	X	8.0
XII	Panic.	Total destruction.	Acceleration exceeds gravity. Waves seen in ground. Lines of sight and level distorted. objects thrown in air.		8.5

* Howell 1959



Government Hill School and adjacent gravel lot broken by landslide, Anchorage, Alaska. Photograph by Donald R. Herrick.

West Anchorage High School with once-level playground destroyed by landslide, Anchorage, Alaska. Photograph by Donald R. Herrick.

Seismic sea waves: Heavy damage in Kodiak, Seward, Valdez, and other portions of Alaska; loss of life inflicted as far away as Crescent City, California.

Duration: Not officially recorded. (The most common estimates of eyewitnesses ranged from two to four minutes. Several persons in the Anchorage area, however, timed the duration of perceptible motion and reported it to be of the order of seven minutes.)

Period of vibrations: Unknown. (Most estimates range between one and two cycles per second.)

Maximum amplitude of vibrations: Unknown.

Intensity at Anchorage: Not officially assigned. Unofficial estimates of the intensity in the Anchorage area place it at modified Mercalli VIII.

Maximum acceleration: Unknown. This information can be obtained only by means of strong-motion seismographs which must be installed and maintained in a locality on which information on earthquake motion is to be obtained. As recently as 1963, approximately 60 of the U.S. Coast and Geodetic Survey strong-motion seismographs were in use in the western United States.

Earthquake damage in Anchorage

Even a cursory examination of the Anchorage area following the earthquake of March 27 would have suggested immediately that the loss of life in Anchorage was remarkably small in comparison to the magnitude and dollar volume of the physical damage. This can be attributed in part to the fact that schools were closed, that many people had already left the downtown district where heavy damage occurred, and, in part, to simple good fortune. Similar mitigating effects attended the seismic sea-wave disasters in other parts of Alaska (Valdez, Seward, Kodiak); these waves arrived at the time of low tide. Nevertheless, the greatest loss of life was caused by seismic sea waves.

Damage inflicted in the Anchorage area by the Good Friday earthquake may be divided into two principal categories: (1) "normal" earthquake damage to structures induced by lateral forces, and (2) loss of foundation support caused by landslides set in motion by the earthquake.

Structural damage: Structural damage caused by lateral acceleration was, in general, confined to: (1) large buildings, (2) buildings which were poorly designed to resist lateral forces, and (3) buildings in which faulty construction practices or materials had been used (Steinbrugge, 1964). Many of the large, old, heavily constructed, reinforced concrete buildings survived without appreciable damage, as did a number of the one-story concrete block structures. On the other hand, several of the most recently constructed major buildings were totally demolished. Two nearly identical high-rise apartment structures suffered heavy damage to spandrel walls, and one major bearing wall in each building failed in a lower story. Nevertheless, the other main structural elements remained intact (National Board of Fire Underwriters and Pacific Fire Rating Bureau, 1964).

Building construction in the Anchorage area is governed by applicable provisions of the Uniform Building Code of the Pacific Coast Building Officials Conference. The large amount of structural damage which occurred as a result of the earthquake inevitably focuses attention on the adequacy of the building code. There is no evidence to indicate, however, that lateral acceleration caused irreparable damage where good design and construction principles were followed in accordance with the code.

Landslides: Landslides accounted for most of the major damages suffered by buildings in the Anchorage area. Four major slides and two minor ones occurred during the earthquake. The largest slide in terms of geographical area happened in the Turnagain housing district between the International Airport and downtown Anchorage. This slide involved a catastrophic flow of weak layers of the subsoil, accompanied by breaking of the upper layers into large blocks of earth. The entire mass moved as much as 500 to 600 feet in a northerly direction toward Cook Inlet. Approximately 75 houses were totally destroyed by this slide.

A large area in the apartment house district was involved in a landslide in which a single large block of the soil formation moved from 5 to 12 feet in a westerly direction toward Cook Inlet. Most of the damage done to structures in this slide occurred in a trough or graben which formed along the easterly margin of the slide block and along the pressure ridge which developed at the toe of the block. A similar slide took place in the downtown business district, where a large block of the soil formation moved approximately 17 feet in a northerly direction. A graben was formed along the south margin of this block and a pressure ridge developed at the toe of the block. Buildings located entirely on the block suffered no more damage than buildings located elsewhere at Anchorage; buildings within the graben area, however, were either severely damaged or completely destroyed.

The fourth of the major slides was in the Government Hill area. This resulted in severe damage to a new school building and destroyed a number of houses.

Geologic units in Anchorage affected by the earthquake

The City of Anchorage is built on a relatively low, flat plain of outwash sand and gravel which is underlain by a layer of soft clay and, at considerable depth, by compact glacial till (Miller and Dobrovolny, 1959). Mesozoic and Tertiary rocks underlie the Anchorage area at depths of hundreds of feet. The Mesozoic rocks rise to the east to form the Chugach Range, the highest elevation of which is 4,300 feet.

The geologic formations of greatest significance in the recent earthquake consist of: (1) the upper layer of outlying sand and gravel known as the Naptowne outwash, and (2) the underlying Bootlegger Cove Clay. The Naptowne outwash ranges from 20 to 40 feet in thickness and consists of well-graded, compact sands and gravels. This formation provides the foundation for most of the major buildings in the Anchorage area, the only exceptions being those structures which are located near the lower edges of the bluffs which border Cook Inlet.

The Bootlegger Cove Clay formation consists of three principal clay units, the uppermost of which is a fairly stiff layer ranging from 10 to 20 feet in thickness. It is underlain by a 20- to 30-foot layer of extremely soft, sensitive clay, which is in turn underlain by a stiff layer. Sand layers and lenses occur in somewhat erratic manner throughout the formation. Many of these are water bearing, although they do not provide domestic or commercial water supplies. The strength profile of the Bootlegger Cove Clay is such that shear strengths of the order of 0.5 to 1 ton per square foot occur within the upper stiff layer, decreasing to 0.3 ton per square foot in the zone of high sensitivity, and then increasing again to 0.8 to 1 ton per square foot in the lower stiff layer. The very soft, sensitive layer occurs generally between sea level and 20 feet above sea level.

The landslides which occurred in the Anchorage area developed primarily within the highly sensitive layer of clay, although it is not certain whether the primary cause of sliding was the sensitivity of the clay itself or the loss of strength of cohesionless sand or silt units under repeated shock-load applications. In any event, the slides may be considered to be the result of repeated dynamic stress application to weak, saturated materials. Complete loss of strength of both the sensitive clay and the cohesionless sand has been shown to occur in laboratory tests in which pulsating loads were applied to triaxially loaded samples. These tests were performed at the University of California in Berkeley and are reported by Shannon and Wilson (1964).

Although the Turnagain slide differed drastically in form from any of the other slides in the Anchorage area, the basic causes of all were essentially the same. The probable cause of the difference in form of the Turnagain slide is believed to be the presence of a greater thickness of the highly sensitive member of the Bootlegger Cove Clay.

Seismology of Anchorage area

Anchorage is located within a well-known earthquake region, one of many seismic belts which adjoin the Pacific Ocean. Seismic records for this area show that during the past 50 years only one earthquake of magnitude 8 or greater has occurred in Alaska. However, those of magnitude 7.0 or 7.5 have recurred nearly every five years during that time, and those of magnitude 6.0 to 6.9 are recorded at intervals of about three years (U.S. Coast and Geodetic Survey, 1964).

Earthquake damage in other Alaskan towns

In Seward the most extensive damage was caused by submarine landslides and by seismic sea waves. The Seward waterfront was completely destroyed as a result of a liquefaction slide of submerged gravels with deltaic structure. A strip of waterfront approximately 400 to 500 feet wide and nearly 7,000 feet long subsided into Resurrection Bay. Severe secondary damage was caused by fire from petroleum storage facilities.

Damage and loss of life were recorded at the Alaska Railroad terminal of Whittier; this was principally the result of seismic sea-wave inundation and fire.

Valdez, in addition to receiving severe damage from the ground motion during the earthquake, also suffered heavily from submarine landslides caused by liquefaction of submerged granular materials and was inundated by the seismic sea waves which followed the earthquake.

Geology of the Portland Area

Topography

The topography of the Portland area is controlled by the structure of the older bedrock and is modified by younger erosional and depositional features formed by the

Columbia and Willamette Rivers and smaller streams. The folded and faulted Columbia River Basalt forms the prominent northwest-trending Tualatin Mountains in the Portland area. The rather gentle slope along the west side of the mountains is controlled by the basalt dip slope, and younger lavas of Plio-Pleistocene age have tended to modify this topography. Mt. Sylvania, a relatively uneroded shield cone composed of these younger lavas, forms a prominent landmark near the south end of the Tualatin Mountains. The rather steep east flank of the Tualatin Mountains has been dissected by steep canyons of small streams flowing into the Willamette River. The silt overlying much of this basalt has been subject to landsliding due to oversteepening. In some cases the weathered basalt has been involved in landslides.

The business district and Guild Lake area on the west side of the city and the major part of northeast Portland are composed of terraced sands and gravels and interbedded silts of varied fluvio-lacustrine depositional histories and some man-made land.

Paralleling the Columbia River is a band of recent alluvium, including man-made fill. The area ranges from 1 to 2 miles in width and is low enough to be flooded annually by high waters except where it is protected by dikes. It is cut by numerous erosional scars; many are water filled. In the Willamette River channel area, made land is situated at Mocks Bottom, Guild Lake, Swan Island, and a strip several blocks wide along the east bank from the Broadway Bridge south to the Ross Island Bridge.

The Columbia River flood plain is bounded on the south by a strip of older terrace materials half a mile wide, with a slope of about 200 feet per mile. In west Portland these older terraces also slope about 200 feet per mile toward the Willamette River. In east-central Portland, these terrace deposits range from about 75 feet elevation near the Willamette River to 275 feet elevation near Mt. Tabor.

An older, gently sloping to nearly flat-lying terrace crops out in a strip about $1\frac{1}{2}$ miles wide trending southeast from the St. Johns area to S.E. 82nd Avenue, where it widens considerably and extends south to Mt. Scott.

Several prominent hills, generally round in outline with diameters ranging from half a mile to several miles, dot the terraces. These hills are resistant volcanic vents topped by either cinders or lavas and flanked by Troutdale gravels. They range from several hundred to about 1,100 feet in elevation.

Stratigraphy

Consolidated rock units cropping out in the Portland area consist of both volcanic and sedimentary rocks and include Columbia River Basalt, Boring Lava, Sandy River Mudstone, and the Troutdale Formation. Unconsolidated rock units include wide-spread lacustrine deposits, loessal clay and silt, recent alluvial material deposited by the Columbia and Willamette Rivers, and artificial fill. The distribution of these units throughout the Portland area is shown on the geologic map, page 222.

Columbia River Basalt: Columbia River Basalt of mid-Miocene age crops out in a nearly continuous band occupying most of the Tualatin Mountains (West Portland Hills). It is best exposed in road cuts and in stream and creek canyons and ravines along the east slope of the mountains facing the Willamette River. The formation consists of a variable sequence of weathered to unweathered basaltic lava flows. The total thickness of the Columbia River Basalt in the Portland area ranges from 800 to 1,000 feet as determined by deep oil tests drilled by Richfield and Texaco Oil

Companies. The basalt overlies the Oligocene marine sedimentary beds assigned to the Scappoose Formation and in turn is overlain by younger sedimentary and volcanic rocks.

The unweathered basalt flows are commonly vesicular and scoriaceous in their upper and lower parts and are dark gray and fine grained. Weathering of the basalt surface has been extensive and deep. Basalt exposures are generally light gray with variable brownish tones. The rock has been weathered locally to a depth of 170 feet (Allen, V. T., 1948, p. 61) and commonly to depths of 20 to 30 feet.

Sandy River Mudstone: Sandy River Mudstone of Pliocene age is locally present in the Portland area and is made up of claystone, siltstone, and sandstone beds. It is exposed in a small area on the west side of the Tualatin Mountains in secs. 26 and 27, T. 1 N., R. 1 W., and has been penetrated by deep-water wells in the downtown business district area in west Portland. It attains its greatest areal extent in the drainage systems of the lower Clackamas and Sandy Rivers (Trimble, 1963). It has a maximum thickness of 200 feet in the west Portland business district and is probably much thicker in the east Portland area where the Columbia River Basalt is structurally low.

Troutdale Formation: The Troutdale Formation of Pleistocene age is exposed along the flanks of local prominences. In east Portland it crops out at Rocky Butte, Kelly Butte, Mt. Tabor, and Mt. Scott. In west Portland it is exposed in a few small areas along the flanks of the Tualatin Mountains. It is extensive in the subsurface of the east Portland area and to the west in the Tualatin Valley. The formation consists of moderate- to well-indurated conglomerate and sandstone. It is believed to be more than 800 feet thick in east Portland, and in west Portland water-well logs indicate it ranges in thickness from 20 to 300 feet.

Boring Lavas: Boring Lavas of Plio-Pleistocene age locally overlie the Columbia River Basalt, the Sandy River Mudstone, and the Troutdale Formation. The distribution of the Boring Lava is controlled by the location of its eruptive vents and the topography over which the lavas flowed. These lavas are exposed in a nearly continuous belt flanking the west side of the Tualatin Mountains in the Portland area and extend from the Oregon City area northwest into Columbia County. Boring Lavas are present at Rocky Butte, Mt. Tabor, Mt. Scott, Mt. Sylvania, and generally widespread in the foothills of the Cascade Range east and south of Portland. It is likely that other parts of east Portland may be underlain by Boring Lava.

These lavas are composed mainly of flows of olivine basalt, but locally around the vents are pyroclastic rocks composed of volcanic ash, breccia, and cinders. The lavas are light gray in color and are commonly expanded in texture, containing small irregular holes. Weathering is usually much less than that of the Columbia River lavas.

Portland Hills Silt: Portland Hills Silt (loessal sandy silt) of Pleistocene age occurs as a mantle of yellowish-gray-brown, sandy, clayey silt which caps the Tualatin Mountains. It occurs mainly along the flatter areas and caps the spurs and the ridges as well. The eastern flank of the Tualatin Mountains is generally too steep for the retention of much silt, but where it is present it is relatively unstable and any overloading or oversteepening can cause slope failure. The west flank of the mountains is less steep and the silt is much thicker and more widespread. The silt generally conforms to the surface of the underlying rocks. The greatest known thickness is 55 feet but generally is less than 25 feet.

Lacustrine deposits: The Portland lowlands are covered almost entirely by Pleistocene to Recent gravel, sand, silt, and clay of lacustrine origin. These deposits lie between elevations of 50 and 350 feet, and their original surface has been dissected and terraced. Three units having significant distribution to be identified and mapped (Trimble, 1963) are a gravelly, a sandy, and a silty phase.

The gravelly deposits of this unit are exposed entirely in east Portland. In most places the gravels consist of slight to moderately compacted pebble, boulder, and cobble gravels having a sandy matrix. The gravels grade to pebbly sand near the western and northwestern limits of its distribution. Deltaic foreset bedding is common in exposures made as the result of gravel pit operations.

The sandy phase is present in an outcrop belt paralleling the Willamette River, generally extending eastward from the foot of the Tualatin Mountains. The sand is fine to very fine grained, gray to gray-brown in color, and firm to moderately dense. In north Portland it becomes medium to coarse grained and occasionally pebbly with well-developed stratification. The sand reaches a maximum thickness of about 50 feet. In west Portland it occurs between elevations of 50 to 150 feet, and much of the west-side business district is located on this unit.

The silty and clayey phase is found only in the Tualatin Valley area west of Portland and in the lowlands south of Oregon City.

Recent alluvium: Recent alluvium deposited by the Willamette and Columbia Rivers is the youngest geological unit in the Portland area. The Willamette River deposits consist mainly of uncompacted sand and silt and locally of gravel. The sand and silt deposits occur up to elevations of 50 feet. The gravels occur as prominent river bars from Ross Island upstream to the mouth of the Clackamas River.

Alluvium deposited by the Columbia River in northeast Portland is entirely fine sand and silt occurring on the flood plain up to an elevation of about 50 feet.

Artificial fill: Artificial fill areas are located in the Guild Lake area of northwest Portland, at Swan Island in the Willamette River of north Portland, and local areas along the Portland waterfront, one of the largest of which is that adjacent to the east end of the Ross Island Bridge.

Guild Lake was filled primarily by material sluiced down from the west hills Westover Terrace area. Fill material for the Swan Island and Ross Island Bridge areas was dredged from the Willamette River.

Ground water

The ground-water table is consistently near the ground surface in all of the flood plain areas adjacent to the Columbia and Willamette Rivers. In addition, many of the higher gravel terraces contain perched water tables. Many of these higher areas have a semi-perched water table which fluctuates with the seasonal rainfall. Ground water also is found at depth in confined and unconfined aquifers in the

Troutdale Formation and Columbia River Basalt.

Geologic structure

The Columbia River Basalt has been folded into a moderately gentle asymmetrical anticline with its axis roughly parallel to the northwest-trending Tualatin Mountains. The steep limb of the anticline is on its northeast flank. The eastern scarp of the Tualatin Mountains forms a nearly straight line from Oswego northwest to Scappoose Creek, where a major fault has been indicated by geologic mapping. To the southeast, the Clackamas River channel appears to have been controlled by this same fault, since this part of the Clackamas River is in direct line with the east scarp of the Tualatin Mountains. Additional evidence that the east edge of the Tualatin Mountains is faulted came from a study of the after shocks of the November 1962 earthquake (Dehlinger and others, 1963), which indicated the disturbances emanated from about 6 miles east of the escarpment in north Portland at a depth of 15 to 20 km. The trace of an east-dipping normal fault at depth would be in agreement with this location.

A second major fault has been mapped in the Chehalem Mountains east of Newberg (Hart and Newcomb, 1956). This fault is aligned with the gash through the Tualatin Mountains now occupied by Lake Oswego and may have provided the zone of weakness which allowed erosion to cut this feature. Additional prominent faults west of the Portland area are shown on the tectonic map, page 225. Release of energy from tectonic forces along these lines of weakness could greatly affect the Portland area.

The San Andreas rift zone, which passes through San Francisco and extends northwestward off the coast of Oregon, lies 270 miles west of Astoria. Seismic waves originating from this fault zone have been felt as far inland as Portland.

Reaction of Geologic Units to Earthquake Shocks

General observations

The relationship between earthquake damage and geology is obscured by imperfect observations of the effects of the interaction of myriad variables. A few simple conclusions may be stated; however, many writers on this subject are tempted to over-simplify. For example, it is generally recognized that areas of thick alluvium or unconsolidated sediments are subject to the greatest damage during a severe earthquake. Consequently, an amplification of acceleration is commonly assumed for such geologic units, as compared to accelerations which occur in competent bedrock. Without question, a tendency toward amplification of vibrations does exist in thick deposits of alluvium, particularly under shocks of light or moderate intensity; however, the use of observed damages to substantiate the amplification of vibration leads to the inclusion of extraneous information, for example, foundation failures induced by differential settlement of loose alluvial deposits and not recognized as such.

Attempts to establish a relationship between damage and geology usually lead to a distinction between "good ground" and "bad ground." The implication is that "bad ground" should be avoided by persons or agencies contemplating building construction. Unfortunately, the environment of modern urban areas does not allow the luxury of avoiding "bad ground" which, aside from a susceptibility to damage from earthquakes, may have every other conceivable advantage of location. It therefore appears that more attention should be given to the various types of damage which may befall structures on thick alluvium, and the susceptibility of the structure to each type of damage.

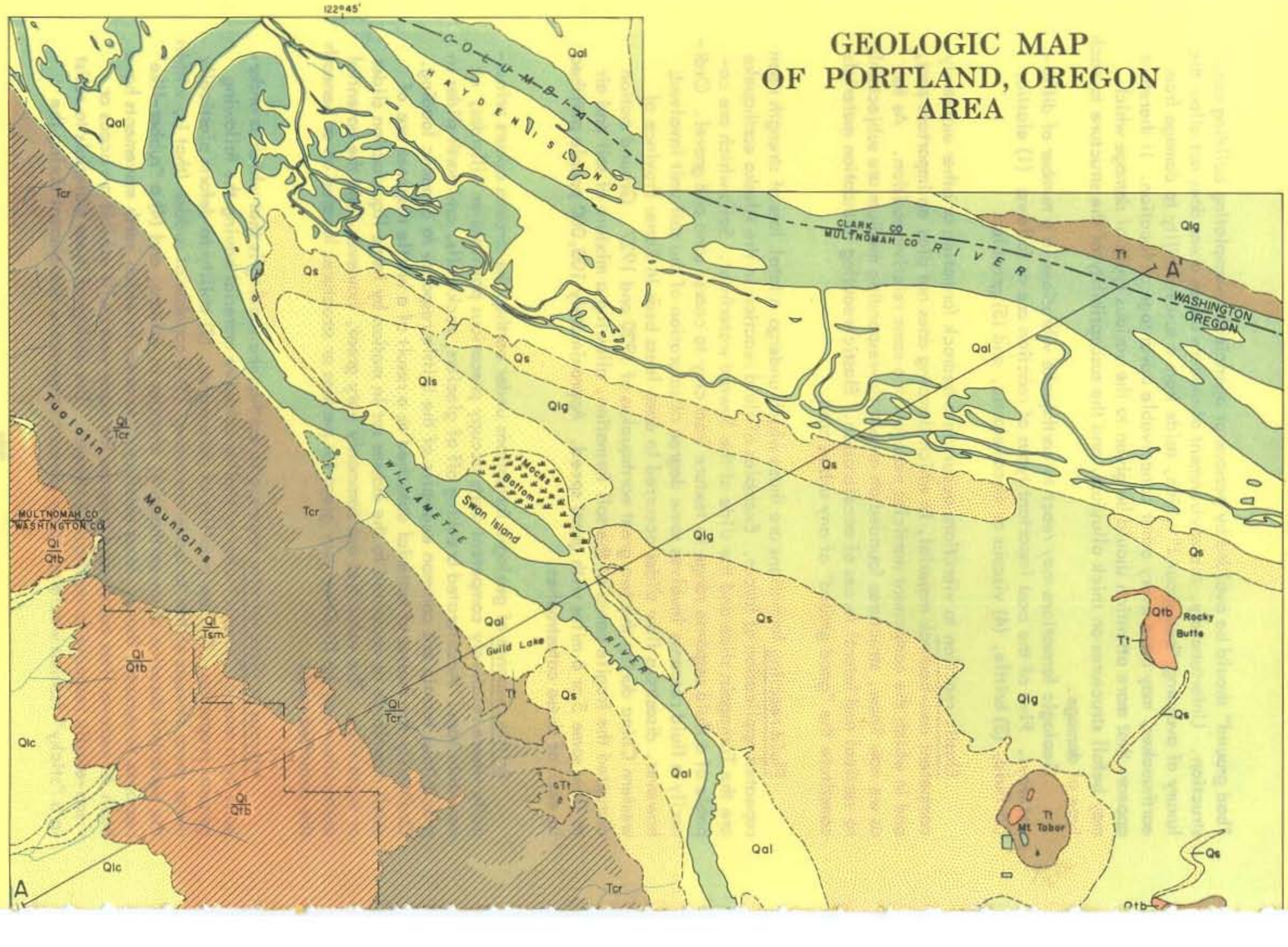
Geologic formations may react to earthquake vibrations in a number of different ways. Five of the most important types of reaction are as follows: (1) elastic, (2) fluid, (3) brittle, (4) viscous or visco-elastic, and (5) granular.

Elastic reaction to vibrations occurs in a bedrock formation or other extremely competent non-bedrock material, in which damping does not play an important part, and in which the component particles maintain the same relative position. As far as we now know, structures founded on an elastic-responding medium are subject only to vertical and lateral forces of acceleration. Elastic-reacting foundation materials constitute the "good ground" of any urban area.

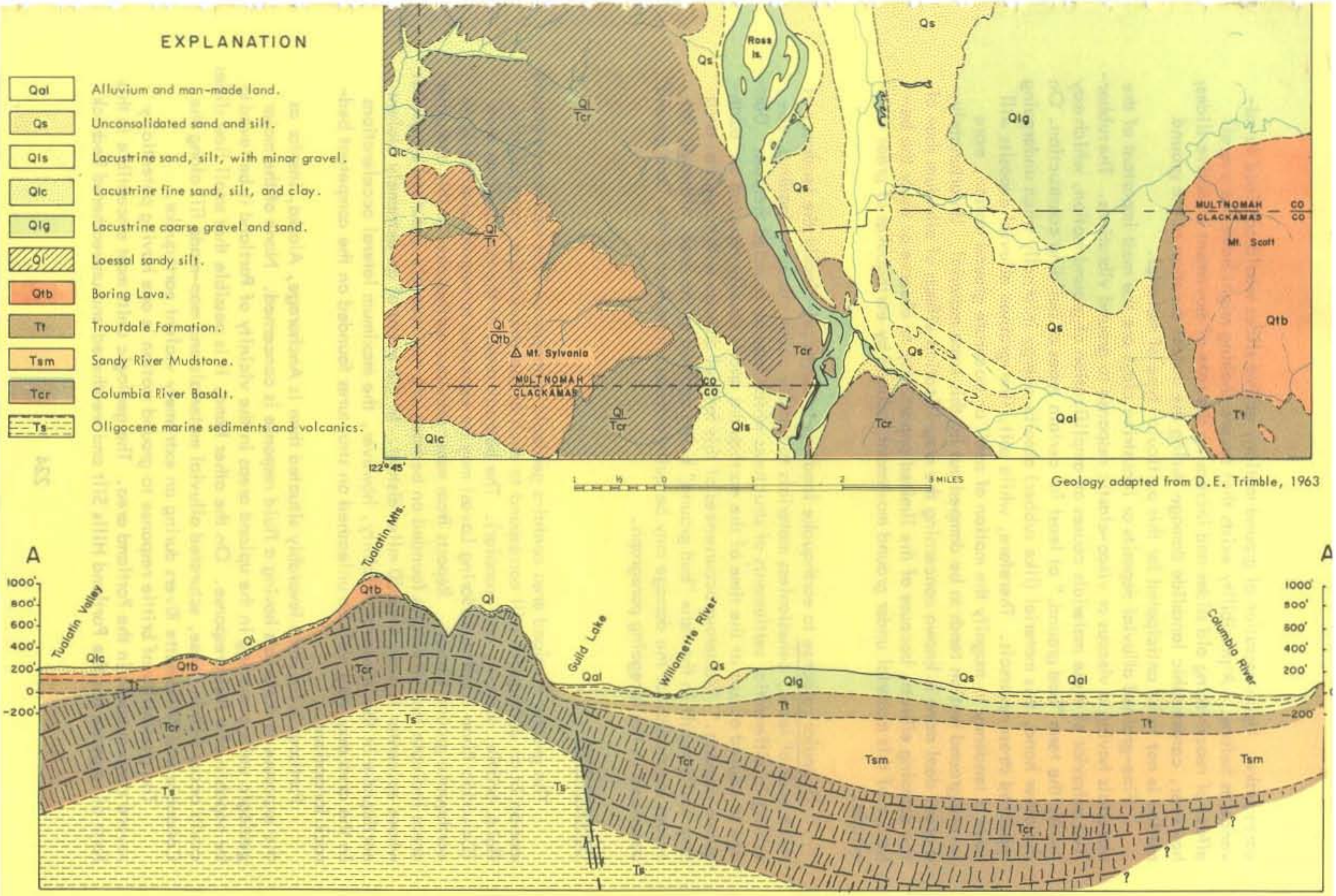
Fluid reacting formations are those which undergo a total loss of strength upon repeated application of forces. Examples of fluid reaction in the Alaska earthquake are the Turnagain slide and the slide of the Seward waterfront. Soils which are capable of a fluid response range in texture from clay to coarse sand and gravel. Ordinarily a fluid response involves some degree of saturation of the soil unit involved; however, disastrous flow slides occurred in deep loess beds in Kansu Province of western China during the two great earthquakes of 1920 and 1927. Ground motion disrupted the fragile bonds of the soil formation, allowing a mixture of soil and air to flow some 5 or 6 miles with great speed. Approximately 100,000 people perished in each of these catastrophes.

Brittle response of geologic formations under earthquake stresses occurs principally where relatively competent units occupy precarious positions on hillsides, or mountain tops. Accelerated breaking off of glaciers, rock-falls, and earth slides in precipitous terrain are common examples of the brittle response to dynamic loading. Ordinarily the masses of material detached as a result of a brittle response are of small magnitude as compared to the masses set in motion by large liquefaction slides or earth slips. The velocities are commonly very great, however, and the potential destruction may be likewise very great for persons or structures located on or beneath the detached mass.

Viscous or visco-elastic response to earthquake loading is that which is undergone by a mass of "plastic" clay or similar cohesive material having the following general properties: (1) low mobility of pore water, (2) ability to deform plastically under shear stresses of low to moderate order, (3) incapable of sudden (that is, within the period of duration of an earthquake) changes in volume, and (4) a "rubber-like" response to dynamic loads. Most existing slide areas in which earth movements have been in more-or-less continuous progress for many years will exhibit a viscous or visco-elastic response to earthquake stresses. The ability of these materials to resist in a "sticky" fashion would probably prevent large-scale detachment during the



GEOLOGIC MAP OF PORTLAND, OREGON AREA



Geology adapted from D.E. Trimble, 1963

earthquake. Upon cessation of ground motion, active slides would continue to advance as before. A possibility exists that severe shaking might have the overall effect of reactivating old slides and increasing the rate of movement of active slides; however, catastrophic landslide damage during the actual duration of the ground motion is not to be anticipated for this particular type of material.

Fine-grained alluvial deposits or lacustrine clays are the most important of the materials having a viscous or visco-elastic response to ground vibrations. The rubber-like behavior of these materials causes an amplification of ground motion, which may justify the term "bad ground," at least for certain types of building construction. On the other hand, this material (like rubber) absorbs energy internally when undergoing repeated stress reversals. Therefore, while soft, fine-grained alluvial deposits will have a tendency to magnify the motion of small or moderate ground motion, more severe ground motion tends to be damped out by this same material. Unfortunately, a great deal more is known concerning the magnification effects of alluvium than of the damping effects, because of the limited opportunity to observe or study the behavior of this material under ground movement induced by earthquakes of great magnitude.

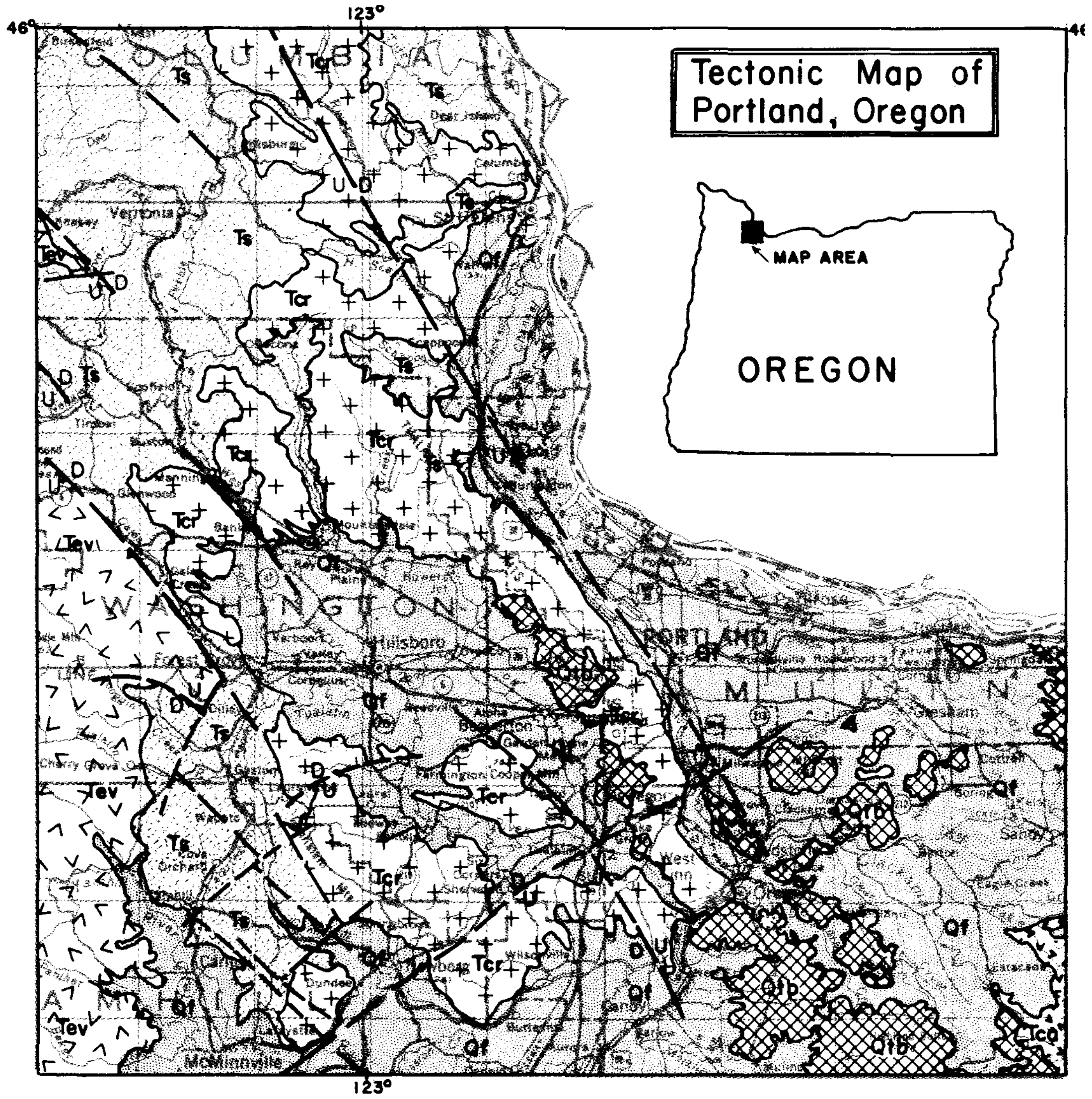
Granular response to earthquake loadings involves principally the tendency of thick beds of loose, cohesionless materials to densify under vibratory loadings, resulting in differential settlements of structures which may be founded thereon. Damage so caused occurs at the time of the earthquake and is usually reported as "earthquake damage." Numerous occurrences of this form of damage within a given area may easily result in the term "bad ground" being applied to the area, although the actual mechanism of the damage may be quite different from that of the "bad ground" described in the foregoing paragraph.

Portland area

The greater Portland area contains geologic formations whose response to ground motion in an earthquake will correspond to each of the above major types (elastic, fluid, brittle, viscous, and granular). The bedrock areas of the metropolitan area (Columbia River Basalt and Boring Lavas) may be expected to respond elastically to earthquake ground motion. Reports from many previous earthquakes in this and other areas indicate that structures founded on bedrock are not severely disturbed by quakes whose epicenter is more than 50 miles distant. In the event of an extremely violent earthquake in the immediate vicinity, however, the maximum lateral accelerations in the area may very well be unleashed on structures founded on the competent bedrock formations.

Portland is far more favorably situated than is Anchorage, Alaska, insofar as the exposure to materials having a fluid response is concerned. None of the major geologic units occurring in the upland areas in the vicinity of Portland is believed to be capable of a fluid response. On the other hand, it is possible that small flow slides could occur within loose, saturated alluvial materials and man-made fill along the Columbia and Willamette Rivers during an extremely violent earthquake.

The possibility of brittle response to ground motion is one having potentially severe consequences in the Portland area. The geologic units most susceptible to this form of response are the Portland Hills Silt and weathered and unweathered bedrock



EXPLANATION

Qf	Valley fill
Qtb	Boring Lavas
Tcq	Cascade Andesite
Tcr	Columbia River Basalt
Ts	Eocene and Oligocene marine sediments
Tev	Mid-Eocene volcanics, rocks, and sediments

0 10 20 Miles

Base map from U.S.G.S.

formations. In all instances the danger is the greatest where permanently high shear stresses are present because of steep high slopes, or in the case of bedrock, high vertical cliffs. Existing planes of weakness, such as jointing systems, interflow zones, and bedding planes, will be of great importance in individual localities.

Geologic units which will react to earthquake shocks in a viscous, visco-elastic, or granular fashion are confined primarily to the made-land and flood plain areas of the Willamette and Columbia Rivers. The possibilities of damage to structures in these areas appear to be somewhat greater than elsewhere for the following reasons: (1) differential settlement of loose granular deposits, (2) amplification of ground motion in light or moderate shocks, and (3) susceptibility to ground motion from distant earthquakes.

In the event of a nearby quake of extremely severe magnitude, the effect of ground motion of structures founded on these materials would tend to be mitigated by damping within the softer formations. In general, it is probable that the more severe the earthquake, the more serious would be damage resulting from differential settlement of structures founded on loose granular materials, regardless of what damping might take place within these materials.

Resonance

Vibrations from earthquakes at great distance tend to be of longer periods than nearby earthquakes as a result of damping out of the shorter period vibrations. Tall buildings may have natural periods of the same order as the ground vibrations induced from distant earthquakes; consequently, the phenomenon of resonance can be introduced in which the buildings are thrown into violent motion. Although the general nature of the phenomenon is easily understood, an inquiry into the exact mechanics of the process is complicated by the intricate interaction between the various components of the structure and the interaction between the structure and its foundation. Moreover, virtually no information is available concerning the type of ground vibrations and accelerations which a given building may be called upon to withstand.

Earthquake-Resistant Construction

The task of the engineering profession is not to restrict the construction of tall buildings to competent bedrock foundations, but to work toward the gathering of the necessary data and analytical tools to provide engineering solutions to the problems.

It is obvious that requirements of earthquake-resistant construction will not be the same for all types of geologic formations. Construction on an elastic-responding formation would require only consideration of pure "shaking forces," in the manner now prescribed in the building codes. This is not meant to imply, however, that only a pseudostatic lateral load is all that is needed in the design of a major structure on an elastic foundation.

Design of structures on the remaining types of formations involve problems in which mere attention to the horizontal forces may not be all that is required to effect a satisfactory degree of earthquake resistance. For example, construction on a formation having a granular response must reckon with the possibility of differential settlement and its damaging effects during an earthquake. A number of foundation treatments may be employed to this end, details of which are, of course, beyond the scope of the present paper.

Foundations on viscous or visco-elastic media offer particularly vexing design problems, inasmuch as the problems of amplification of acceleration, and resonance enter the picture. Although some authorities on seismology have taken the position that fine-grained alluvial deposits are "bad ground" for tall buildings, the fact nevertheless remains that these formations have been used and will continue to be used for this purpose where economic advantage dictates.

Somewhat more justification may be found for declaring formations (or locations) to be "bad ground" where a brittle or a fluid response is indicated. Even in these situations, however, attempts to provide constructive solutions are often warranted. For example, the serious liquefaction hazard of the Bootlegger Cove Clay at Anchorage has been found to be capable of containment, at least in certain areas, by the construction of a stabilizing (buttress) fill and possibly by several forms of in-situ stabilization. High, vertical cliffs can often be strengthened by rock bolting or by consolidation grouting to minimize or eliminate the danger of brittle response.

Since the primary purpose of earthquake provisions in building codes is to establish minimum standards for the safeguard of human life in the event of a major earthquake, extensive property damage can occur even though building codes are strictly enforced. To go beyond the "earthquake safe" provisions of the building code in order to make a structure "earthquake proof" may not be economically or physically possible. The better built structures at Anchorage apparently fulfilled the requirements for "safe" construction even though cost of repair may be uneconomical. Earthquake design reflects the present state of knowledge of the effect of earthquakes upon buildings.

The National Board of Fire Underwriters (1964) agrees that the code adopted at Anchorage is satisfactory from the standpoint of earthquake "resistance." They report, however, that performance of large structures was not as satisfactory as might have been expected. The following factors were listed as responsible for individual building failures:

1. Lack of professional plan checking by a structural engineer qualified in the field of earthquake engineering.

2. Inadequate field inspection by a governmental representative. Examples of insufficient grout around reinforcing steel in concrete block construction were cited as part of the evidence.

3. Faulty construction techniques as determined by improperly bonded joints in concrete, caused by foreign material between pours in "monolithic" construction.

4. Inadequate soils analysis. Soils and geologic information are needed to establish conditions in general areas. Major structures should have additional reports on the geology and soils.

Whether more detailed design procedures should be included in building codes if they were available is a subject on which the profession is sharply divided, some engineers holding that a code is an infringement on professional latitude and responsibility, while others maintain that codes should be strengthened and "loop-holes" plugged. For purposes of the discussion this is a moot point, in view of the current lack of information. It would appear that the information and analytical methods necessary to design earthquake-resistant structures on various types of geologic formations should first be developed and made available to the profession. It is entirely possible that as more knowledge is gained in this field the building code provisions will be revised and refined.

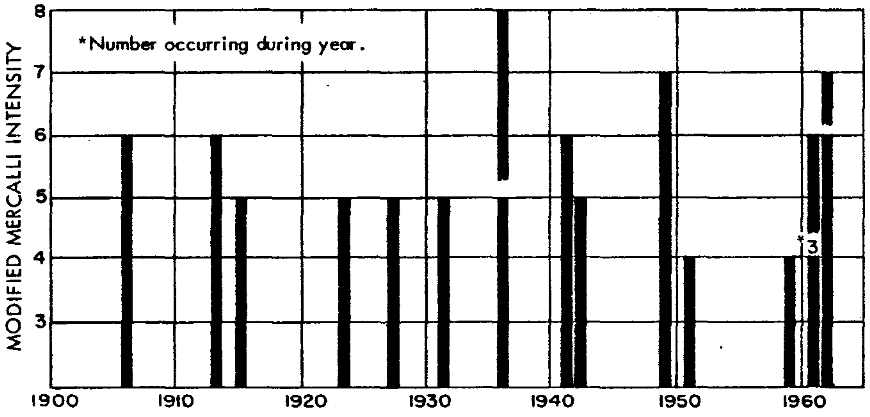
Conclusions

Although important scientific advances have been made in the field of seismology in recent years, the application of seismographs to engineering has lagged far behind. In spite of all of the studies made of the damage caused by the Alaska earthquake, no clear-cut conclusions have been reached as to whether the acceleration at Anchorage should be regarded as extremely severe, moderately severe, severe, or merely ordinary. Similarly, if a strong earthquake were to occur tomorrow in the Portland area, engineers and seismologists here would be in almost the same degree of confusion. The single strong-motion instrument in the Portland area is located in a downtown district on deep alluvium; this would be useful in correlating damages to buildings in the downtown area with recorded accelerations and ground displacements. No information would be obtained, however, for the bedrock areas, the flood plains, or for alluvium at more distant points.

This serious shortcoming can be met only by the installation of at least one strong-motion seismograph for each geologically unique ground condition. Such seismographs should be capable of recording maximum amplitude and acceleration, duration, period of vibration, and total intensity. They should require a minimum of attention other than routine inspection and maintenance.

The establishment of a system of strong-motion seismographs could best be undertaken by a joint effort of private and governmental organizations morally responsible for the safety of lives and property. Once such a system is operating, future quakes will then give information which can be applied to the design of earthquake-resistant structures for each type of geologic foundation. Since modern seismographs have now been developed for this purpose, the installation of such instruments in the Portland area should not be delayed.

EARTHQUAKES IN OREGON



Adapted from Oregon Section, A.S.C.E. Earthquake Committee, 1949.

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TSUNAMIS ON THE OREGON COAST

By Clifford E. Schatz, Herbert Curl, Jr., and Wayne V. Burt
Department of Oceanography, Oregon State University
Corvallis, Oregon

During the early hours of the morning of March 28, 1964 a tsunami struck the Oregon coast. This phenomenon, commonly called a "tidal wave," was generated by the earthquake that had shaken Alaska the evening before. The seismic waves forming the tsunami originated in the vicinity of the earthquake's epicenter and traveled in all directions to ocean shorelines where they were eventually dissipated; in some areas there was substantial loss of life and property.

Residents along the Oregon coast can be thankful that this tsunami caused relatively little loss along our shores. A tsunami of comparable magnitude struck the Hawaiian Islands in 1946 resulting in the loss of 159 lives and a $25 million property damage. Hawaii was 2,300 miles away from the epicenter in the Aleutians of that devastating earthquake, whereas our coast is only about 1,500 miles from Alaska. Oregon was fortunate this time for several reasons: the initial direction of impetus imparted to the seismic waves was away from our coast; the intervening continental shelf topography aided in refracting and dissipating the waves; and, finally, the generally high and rugged coast line of Oregon resulted in ultimate dissipation of the waves on unpopulated shorelines.

The Department of Oceanography, Oregon State University, in keeping with the national goal of oceanography to further man's knowledge of the oceans for the public's interest and welfare, dispatched survey teams up and down the Oregon coast to study the effects of this tsunami 1/. A preliminary study of the data collected by these teams very pointedly emphasizes the perhaps obvious fact that major waves will be rapidly dissipated on our rugged open coast, but that our estuaries are especially vulnerable. Since the areas surrounding the latter are generally densely populated and will become more so within the next few years, it is apparent that a study should be conducted to determine to what extent a larger tsunami may affect the estuaries and the action which can be taken to reduce loss of life and property.

Each estuary has its own peculiarities. The location of jetties and sea walls, the existence of tidal flats and sloughs, the shape and length of the channel and the depth and width of the basin enter into the effects abnormal waves can produce. For example, referring to the accompanying chart: (1) At Coos Bay, the initial wave of about 10 feet above mean high water was dissipated in its travel up the channel by the wide tidal flats and was of negligible height by the time it reached Pony Point about 7 miles up the channel. (2) At Florence, on the Siuslaw River, the initial wave was about 8 feet above mean high water at the Coast Guard Station near the entrance, but due to a fairly narrow channel the wave was apparently only slightly dissipated by the time it reached Florence in the South Slough and surrounding tidal

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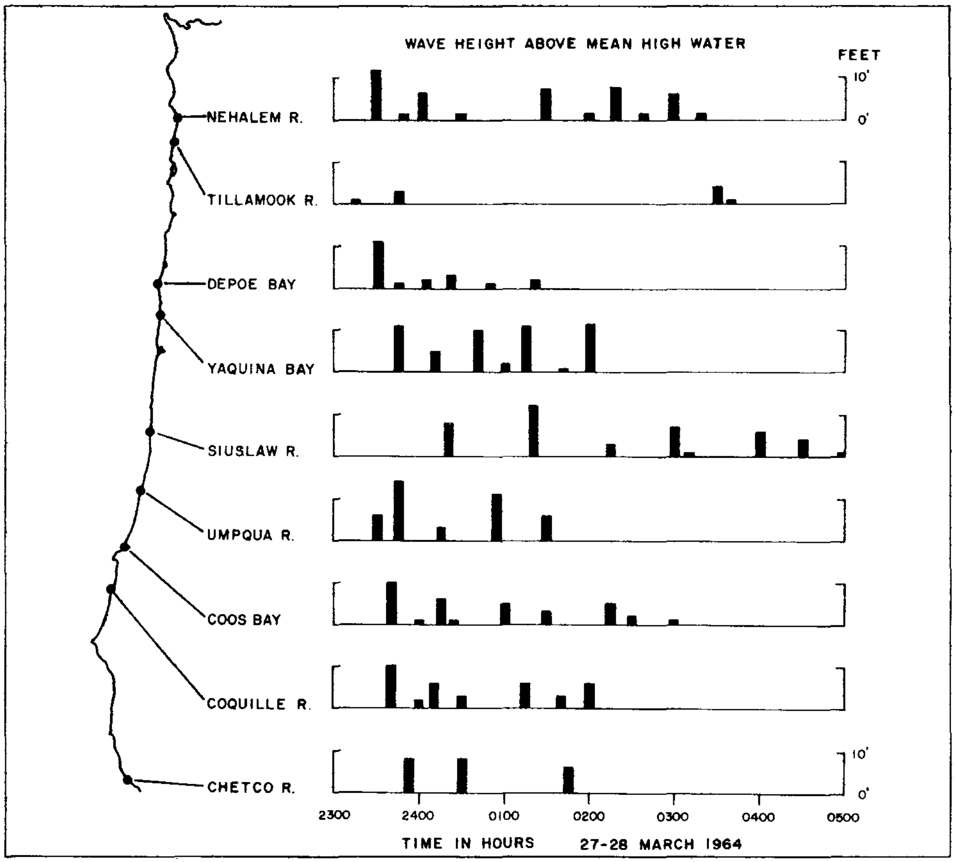
1/ Although it is not possible to acknowledge their efforts individually here, more than 20 members of the faculty and student body of the Department of Oceanography took part in this survey. Their efforts are greatly appreciated.

flats. (3) At Reedsport, about 10 miles up the Umpqua River only negligible indications existed of the 14-foot wave that was measured at the entrance. The meandering river with its wide tidal flats quickly dissipated the wave's energy. (4) In Yaquina Bay, four large waves of almost equal height were observed; whereas, in the other estuaries the subsequent waves generally decreased in magnitude following the second wave. This effect at Yaquina Bay could possibly be attributed to a seiche characteristic which is similar to the rocking motion of water from side to side in an open basin.

Since the Oregon coast is faced across the Pacific Ocean by many areas of strong earthquake activity, it is highly probable that many tsunamis have struck, and will continue to strike, our coast. It is possible that the next tsunami may be of considerably greater magnitude than this most recent one, which could increase the loss of life and property logarithmically. The Department of Oceanography at Oregon State University, therefore, proposes to initiate further studies of the major estuaries as personnel and funds permit to determine probable effects of direct seismic waves, tidal bores, and seiches of more powerful tsunamis. In line with this, survey teams made up of graduate students and staff members will be organized and briefed at the beginning of each term, and will be sent to the coast whenever reliable information predicts the approach of a tsunami. It is hoped that the results of these studies, along with those of other agencies, will prove rewarding and timely.



(Based on observations of U.S. Coast Guard personnel at the above locations.)

OREGON LEASES TWO OFFSHORE TRACTS

The State Land Board leased two of 18 submerged tracts offered at a lease-sale held in Salem December 3, 1964. Total bonuses paid amounted to $28,996. Added to this sum was $13,600 to cover rental for the first year on the two tracts.

The two leases are located along the Pacific shore three miles south of the mouth of the Umpqua River (see The Ore Bin for May, 1964, page 92). The only firms to bid on the state offshore tracts were Standard Oil Co. of California and Shell Oil Co.

Tract No.	Company	Bonus Bid	Per Acre Value
37	Shell Oil Co.	$15,663*	$2.27
37	Standard Oil Co. of California	13,662	1.98
38	Standard Oil Co. of California	13,333*	1.98
38	Shell Oil Co.	8,911	1.33

*Winning bid.

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GROUND WATER AVAILABLE IN FORT ROCK BASIN

A professional paper recently issued by the U.S. Geological Survey reveals that an ample supply of ground water exists in volcanic rocks beneath the semiarid Fort Rock Basin, where a short growing season requires irrigation for successful farming. The report, entitled "Geologic factors that control the occurrence and availability of ground water in the Fort Rock Basin, Lake County, Oregon," is by E. R. Hampton and was prepared in cooperation with the Oregon State Engineer. The 1,500 square-mile basin is underlain by Pliocene to Recent rock units consisting largely of volcanic and pyroclastic materials. Depth and areal distribution of the water-bearing rock units are influenced by a system of northward-trending broad folds and normal faults.

The 29-page report (Professional Paper 383-B) includes illustrations, well logs, and a detailed geologic map with cross sections. The publication may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. The price is $1.50.

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BRISTOL NAMED CHAIRMAN OF ADVISORY COUNCIL

Fayette I. Bristol, president of Bristol Silica Co., Rogue River, Oregon, was elected chairman of the Western Governors' Mining Advisory Council for the coming year. The council will present its recommendations to the Western Governors' Conference when that group, under the chairmanship of Governor Mark O. Hatfield, meets at Portland, Oregon, in June 1965.

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UPPER JURASSIC FOSSILS STUDIED

Recently issued by the U.S. Geological Survey is Professional Paper 483-D, "Upper Jurassic Mollusks from Eastern Oregon and Western Idaho," by R. W. Imlay. Dr. Imlay describes the Upper Jurassic formations in the three regions of northeastern Oregon and adjacent parts of Idaho where the mollusks have been found: Izee area near Burns, Oregon; Snake River Canyon near the northeast corner of Oregon; along Dennett Creek near Mineral, Idaho. The fact that more than 13,000 feet of strata were deposited in eastern Oregon during only a part of the Upper Jurassic should be of interest to geologists concerned with sedimentation and tectonics. The close affinities of the Oregon-Idaho ammonites with those of the same age in western British Columbia and Alaska increases our knowledge of the paleogeography of this part of the globe during Upper Jurassic time.

The 21-page report also includes a systematic description of the ammonite faunas. It may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. The price is 30 cents.

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WESTERN CASCADE RANGE DESCRIBED

"Geology of the central and northern parts of the Western Cascade Range in Oregon," by D. L. Peck, A. B. Griggs, H. G. Schlicker, F. G. Wells, and H. M. Dole, has been published as Professional Paper 449 by the U.S. Geological Survey in cooperation with the Oregon Department of Geology and Mineral Industries. The report describes the geology of the mountainous region lying between the High Cascades and the Willamette Valley and north of lat. 43° N. This belt of volcanic rocks consists of deformed and partially altered flows and pyroclastic rocks, the age of which ranges from late Eocene to late Miocene, as determined chiefly from fossil plants from more than 50 localities. These volcanic rocks overlie or interfinger westward with marine sedimentary rocks, and in the southwestern part of the area overlie pre-Tertiary plutonic and metamorphic rocks of the Klamath Mountains. The report is accompanied by a geologic map.

Professional Paper 449 may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. Price has not yet been announced. A limited number of copies will be for sale by the Department as soon as they are received from the Geological Survey.

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CALAPOOYA RIVER GETS NEW SPELLING

The Calapooya River, which flows generally northwestward out of the Western Cascades in Linn County and joins the Willamette River at Albany, is now to be known as <u>Calapooia</u> River. This is in accordance with the most recent (January through April, 1964) list of Decisions on Geographic Names in the United States, by the U. S. Board on Geographic Names.

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INDEX TO THE ORE BIN

Volume 26, 1964

INDEX TO THE ORE BIN, Continued

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