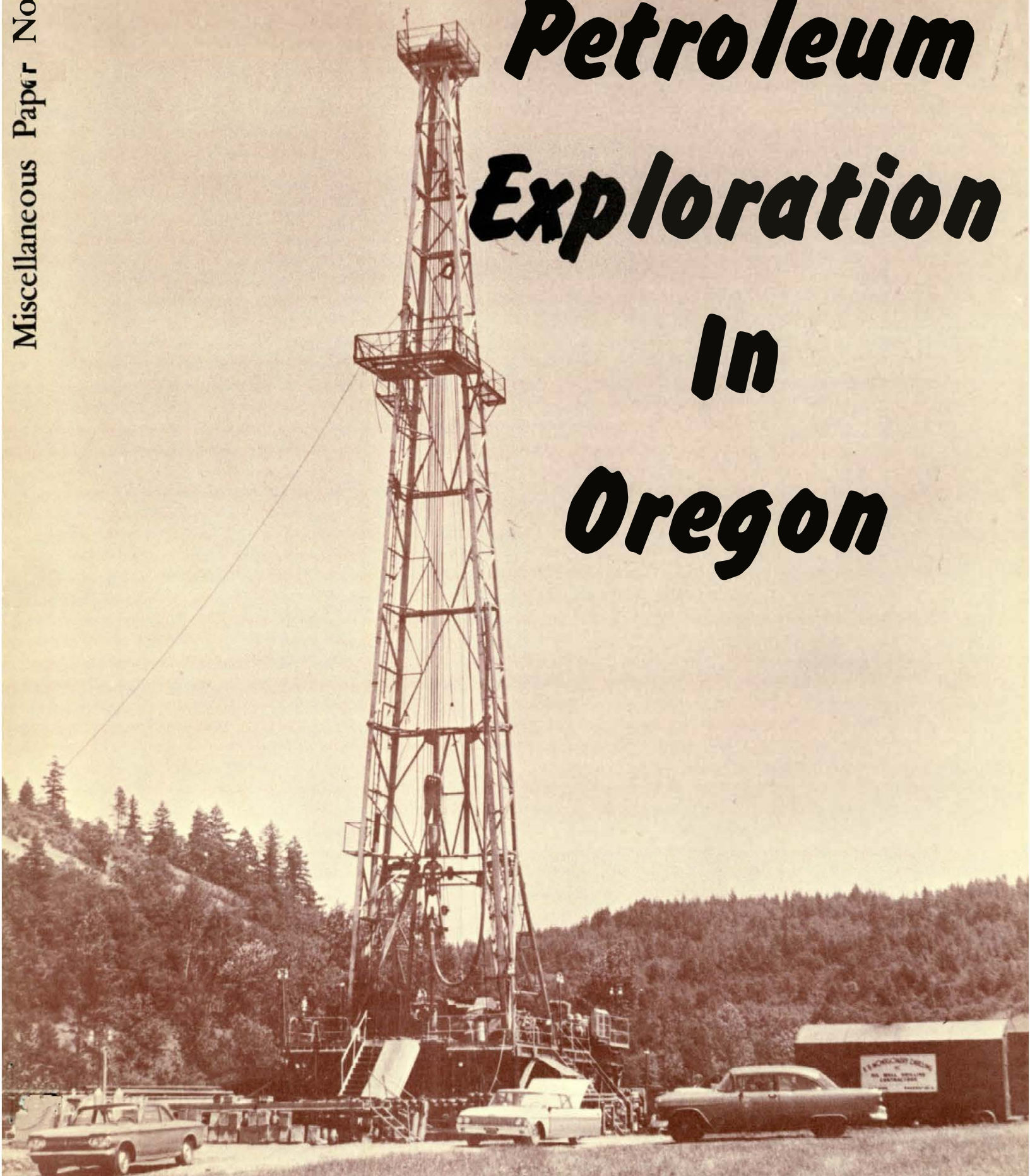


# ***Petroleum Exploration In Oregon***



STATE OF OREGON  
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

STATE OF OREGON  
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

1069 State Office Building  
Portland 1, Oregon

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MISCELLANEOUS PAPER 9

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PETROLEUM EXPLORATION IN OREGON

December 1962



Governing Board

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## FOREWORD

The articles reprinted in this paper represent current ideas on the possibility of finding commercial oil or gas deposits in Oregon. The years 1961-62 marked a point in the history of the state when oil exploration emerged as a significant effort by competent oil firms, both in onshore and offshore operations. It is hoped that the compositions included in Miscellaneous Paper 9 will provide substantial general information for those inquiring about oil and gas possibilities in Oregon, and that they will be useful in planning specific geologic studies. This publication is also meant to serve as a future reference for exploration conducted in the state during this period.

A general history of oil exploration in Oregon is given in the article by V. C. Newton, Jr., R. E. Corcoran, and R. J. Deacon reprinted from Drilling International Magazine, Dallas, Texas, April 1961. Mention is also made of porous sands found in several drillings in northwestern Oregon. The reprint of R. J. Deacon's summary of exploration in the "Circumpacific Exploration Issue" of The Oil and Gas Journal, Tulsa, Oklahoma, March 1962, gives an account of activity in various sedimentary basins of western Oregon and Washington. Regional stratigraphy and lithology are shown for basin areas on composite charts included with the text.

The article on the continental submerged lands off the central coast of Oregon by John V. Byrne is especially significant, since it is one of the first published statements on the nature of sedimentary rocks offshore. The study of oceanography along the Oregon coast is in the preliminary stages and will undoubtedly yield much data on the geology of the shelf region.

A compilation of gas analyses from test drillings and water wells in Oregon has been included as an appendix to the paper. This is the first compilation of analyses from Oregon, and it will be included with a later revised edition of Miscellaneous Paper 6, "Oil and gas exploration in Oregon." Porosity-permeability data on the Spencer Sandstone of northwestern Oregon are given in Appendix 2.

Hollis M. Dole, Director

## CONTENTS

	<u>Page</u>
Oregon, Still Without Oil, Offers Favorable Pay Areas; by V. C. Newton, Jr., R. E. Corcoran, and R. J. Deacon	1
Pacific Northwest Headed for Active Year; by R. J. Deacon	7
Geomorphology of the Continental Terrace off the Central Coast of Oregon; by John V. Byrne	17
Data on Oregon's Offshore; The ORE BIN, Vol. 23, No. 1, January 1961	24
Gas Analyses from Some Oregon Test Drillings and Water Wells; Compiled by V. C. Newton, Jr.	27
Porosity and Permeability of the Spencer Sandstone, Northwestern Oregon;	31

OREGON, STILL WITHOUT OIL,  
OFFERS FAVORABLE PAY AREAS\*

By V. C. Newton, Jr., R. E. Corcoran, and R. J. Deacon

History of Oil Exploration in Oregon

Drilling for oil began in Oregon in 1902 when A. C. Churchill and Associates drilled two shallow holes near the town of Newberg in northwestern Oregon. No shows were encountered during the drilling of these two holes so the group abandoned its venture. This has been the story many times over, as wildcatters have tried in vain to discover oil in Oregon. Since Churchill's first attempts, 160 holes have been drilled in the State but none have yielded more than a few minor shows of oil and gas.

A review of oil and gas exploration in this State does not stir any wild hope for discovering a major oil province, but with further analysis we believe a few good prospective areas can be pointed out. When one considers that only about 30 of the 160 holes drilled were located by substantial geologic data, the actual number of drillings is not significant in determining future prospects for production. Even allowing that each of the 160 holes added some information to the geologic picture, the well density would still be only one well for every 180 square miles of basin area -- not enough to even roughly outline subsurface geologic conditions. If depth drilled is given particular significance, only 29 holes have penetrated enough section to give an idea of the region's possibilities.

Until World War II, oil and gas exploration in Oregon was carried on exclusively by small groups and individual wildcatters. The Federal government encouraged oil companies to look in such areas as Oregon during the war in order to uncover new reserves in the United States. As a result Phillips Petroleum Company, The Texas Company, and Richfield Oil Corporation drilled wildcat holes in western Oregon. These drillings established the fact that there was a thick section of Tertiary marine sediments and that they contained porous sand bodies. Only minor shows of gas were found, however.

In the early 1950's another surge of interest by the major companies produced several deep drillings in the State. Considerable work was done by Standard Oil Company of California, Sinclair Oil and Gas Company, and El Paso Natural Gas Company. This time minor shows of oil were obtained and a rather interesting gas show. Following these companies, General Petroleum Corp., Sunray Mid-Continent Oil Company, Humble Oil and Refining Company, and Shell Oil Company showed interest in the region by making extensive geologic studies. Sunray, General Petroleum, and Humble culminated their studies by drilling deep tests. Other companies too have shown interest in Oregon by making studies of surface geology and by drilling test holes.

In the summer of 1960 Humble began its drilling program in southern Lake County after carrying on field investigations in the State for seven years. The first hole was abandoned after drilling

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\* An abridgment of this paper appeared in the April 1961 issue of Drilling International Magazine entitled, "Oregon without oil offers favorable pay areas." Since publication, additional information has been added to bring the material up to date as of October 1962. Permission to use the article was obtained from the Publisher, Drilling International, P.O. Box 6701, Dallas 19, Texas.

to 12,093 feet. A second hole 25 miles southeast of the first one was spudded in December 1960 and drilled to depth of 9,579 feet before it was abandoned in mid-February 1961. The structural feature tested extended for over 50 miles, from Summer Lake at the north to Goose Lake on the Oregon-California border. Humble dropped 400 thousand acres of leases held for the play several months after plugging the second hole.

The Oregon Legislature passed an offshore exploration and leasing law in 1961 when it was found that Oregon statutes did not provide for offshore investigations. Shortly after passage of the law, Shell Oil Company, Gulf Oil Corporation, Union Oil Company, and Standard Oil Company began offshore seismic studies. In 1962 six other companies joined in the offshore surveys. Standard Oil acted as operator for the seven-company group. Other members were Humble Oil and Refining Company, Pan American Petroleum Corporation, Phillips Petroleum Company, Ohio Oil Company, Superior Oil Company, and Texaco, Inc.

As a rule, major oil companies have drilled only the very large structures, taking leases on thousands of acres surrounding the play. They appear to be looking for a sizable discovery and are not concerned with finding anything smaller. After drilling one or two test holes the huge lease blocks are dropped. Being able to obtain leases at a reasonable cost is essential in this theory of prospecting.

### Significant Oil and Gas Drillings

Wells which have been drilled deeper than 4500 feet are shown on Figure 1 in order to give an idea of well-density. All but five of the holes shown were drilled using good geologic control. Geophysical surveys have been conducted throughout the State with varying degrees of success. Volcanics covering sediments in some areas and intercalated lava flows in others have made interpretation of these surveys extremely difficult. The greatest number of surveys have been made with gravity-meter and a few with magnetometer. Some seismic work has been done in Oregon, mostly in the northwestern portion of the State.

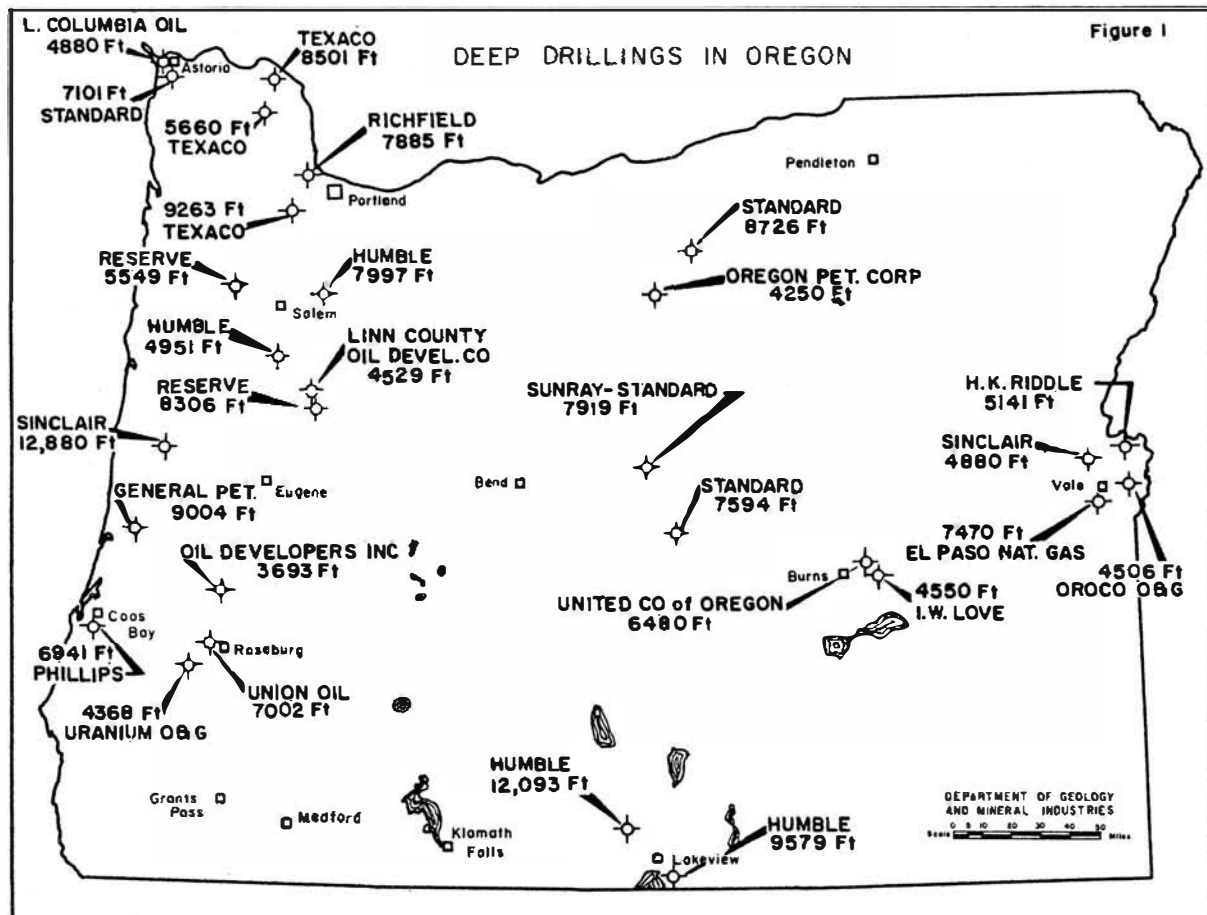
### Drilling Costs

A comparison of exploration costs in Oregon with those of other states is based mainly on drilling costs, as geophysical and geological survey expenses would be comparable with any other wildcat area in the United States. Drilling for oil and gas in Oregon costs about 20 percent more than it does in California. This is because of the expense of transporting drilling equipment long distances and of paying for additional standby time resulting from distance to oil equipment supply companies and service companies. Another important factor in drilling expenditures is the amount of volcanic rock to be penetrated. Footage cost for wells drilled below 5000 feet in Oregon ranges between \$20 and \$30 as compared to an average cost of \$16 per foot in California.

The higher drilling expenses are in part if not wholly offset by the availability of low cost land. Oregon is a public land state, having 53 percent of its area owned by the Federal government and four percent owned by the State and counties (75 percent of the land in western Oregon is privately owned). In general, private land has been leased for 10 to 50 cents per acre, and in a few speculative situations for as much as a dollar per acre.

### Oil and Gas Regulations

Regulations covering oil and gas drilling in Oregon are very comprehensive even though production has not yet been found. Oregon has been an associate member of the Interstate Oil Compact Commission since 1954. The present law was patterned after the Compact Commission's model



law and that of North Dakota and is mainly concerned with protection against contamination of groundwater and prevention of wastage of petroleum. There is no limit set on production in the law except for a reasonable limiting gas-oil ratio; however, prorationing is implied to prevent waste.

### Promising Sedimentary Areas

#### Late Tertiary non-marine basins

Most of southeast Oregon lies within the Basin and Range Province of the western United States. Three distinct late Tertiary continental basins, all of similar geologic setting, occupy portions of this area: Vale-Ontario, Harney, and Lakeview. (See map of generalized geologic provinces.)

The most promising reservoir beds appear to be in the upper Miocene to middle Pliocene continental sandstones and conglomerates. Several excellent gas shows from relatively shallow horizons in both the Vale-Ontario and the Lakeview basins indicate that a commercial field may be found yet. The proximity of the Vale-Ontario basin to the El Paso Natural Gas Company pipeline serving the Pacific Northwest region enhances its value as a potential gas field.

Beneath the Pliocene sedimentary section in this area is a thick series of Miocene and older fine-grained tuffaceous sediments and pyroclastics with intercalated lava flows. The general lack of good permeable horizons in the lower Tertiary section as well as the cost of drilling thick basalt sequences have discouraged deep drilling in these basin areas. The entire Tertiary section has

never been penetrated, and potential pre-Tertiary oil or gas horizons in this area remain untested.

#### Tertiary sedimentary basin of Western Oregon

Rock units within the western Tertiary basin include marine, brackish-water, non-marine and isolated volcanics which range in age from lower Eocene through Pliocene. These include sands, shales, tuffs, lavas and local biostromal reef development. Marine sequences include dark organic shales which indicate petroleum source environment and locally developed sandstone containing high porosity and permeability. Prospective sedimentary rock sequences cover an area of approximately 12,000 square miles in western Oregon and have an average thickness of 7500 feet. Locally sediments are in excess of 12,000 feet.

#### Columbia-Modoc plateau and Mesozoic marine areas

The Columbia-Modoc plateau and Mesozoic marine areas are discussed together because Mesozoic marine rocks are not attractive in the outcrop areas and because these rocks provide drilling objectives below the volcanic rocks of the plateau. The Columbia-Modoc plateau area of Oregon is a part of the huge lava plateau which covers not only the east part of Oregon but also parts of Washington, Idaho, Nevada, and California. Its chief interest in petroleum exploration is the existence of large structural features developed in areas where Mesozoic marine rocks also may be present.

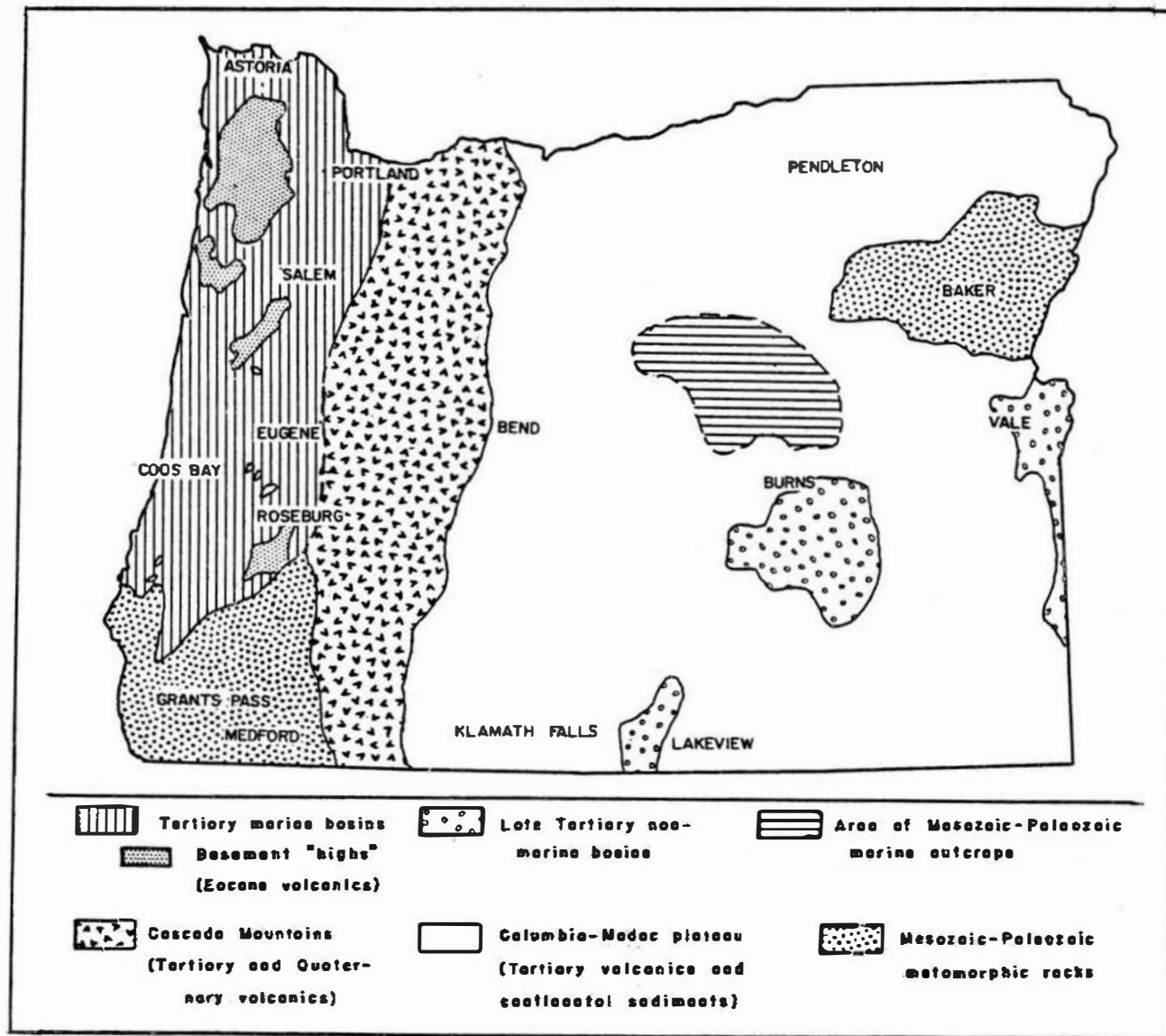
Mesozoic marine rocks range in age from Triassic through Cretaceous and are made up largely of clastics. These include sandstone, conglomerate, and limestone with locally developed reefs, particularly in the Jurassic. The aggregate thickness of the entire Mesozoic sequence is in excess of 20,000 feet.

#### Chances for Discovery of Oil and Gas in Oregon

There are good possibilities that commercial accumulations of oil and/or gas are present in one or more of Oregon's sedimentary basins. Sparse drilling has shown the presence of highly porous and permeable reservoir objectives in subsurface sections enclosed within organic shale strata. Several wells have developed minor shows of live oil and a number have developed slight staining, fluorescence, and fluorescent cuts. Favorable conditions for oil and gas accumulations, both structural and stratigraphic, are present in each of the basin areas. Certainly exploration and drilling have not yet been of sufficient quality or quantity to exclude Oregon from the ranks of potential producing areas.

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# GENERALIZED GEOLOGIC PROVINCES



OREGON, STILL WITHOUT OIL, OFFERS FAVORABLE PAY AREAS

## PACIFIC NORTHWEST HEADED FOR ACTIVE YEAR\*

By R. J. Deacon, Geological Consultant, Portland

Leasing programs, surface and seismic studies, and wildcat drilling have all quickened, as industry casts its eye on this unexplored region . . . a possible future oil province.

The Pacific Northwest states of Oregon and Washington are headed this year for one of the best exploration years in their history. Interest in Oregon and Washington oil and gas possibilities picked up sharply during the latter part of 1961, especially in Oregon, and a number of newblocks were assembled principally by major companies. Shell Oil Co.'s offshore Oregon seismic work started the ball rolling early in the year and before the year was out some five additional companies had followed suit. The offshore Oregon play quickly spread to Washington waters as activity picked up. Willamette Valley, Oregon, leasing activity was touched off in the fall with highly competitive leasing by Gulf Oil Corp. and Humble Oil & Refining Co. leading the way. More than 500,000 acres were under lease in the valley at the end of 1961.

What's the play? Reasons for the current push for Oregon and Washington production seem to be multiple. Certainly the declining production and exploration picture in California and also the high cost of California offshore exploration is a prime reason for the northward shift in interest. Other factors include the attractive marketing position of northwestern states, the availability of refineries, and the already established pipeline facilities within or close to prospective basin areas, plus the availability of large amounts of cheap acreage. Finally, the northwestern states contain a number of marine sedimentary basins representing the usual habitat of oil which have yet to give up the first commercial well. They represent a prime target for domestic reserves in an attractive marketing setting.

History: Both Oregon and Washington had their first attempt at oil and gas production in the early 1900's but significant exploratory programs with adequate financing and technical know-how didn't start until the 1940's. Since then almost all of the major companies and a number of high-grade independents have had their names on dry-hole efforts of 1 to 10 well programs.

Total exploratory wells drilled in the two-state area have amounted to some 500 wells accounting for somewhat over a million feet of exploratory footage. Less than 10 percent of the wells, however, were drilled deeper than 5,000 feet. On structure, basement tests represent a minor percentage of the 10 percent drilled deeper than 5,000 feet. Wells drilled in western Oregon and Washington Tertiary basins account for approximately 75 percent of the wells in Washington and 48 percent in Oregon.

Subcommercial oil production was established in Washington in 1957 when Sunshine Mining Co. completed 1 Medina, Grays Harbor County, for 180 bbl. of 40°-43°-gravity paraffin-base oil. Production declined rapidly to about 3 bbl. per day in less than 6 months and almost all conceivable

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\* Reprinted by permission from the March 26, 1962 issue of The Oil and Gas Journal, 211 S. Cheyenne, Tulsa 3, Oklahoma.

EXPLORATORY eyes are moving to the Pacific Northwest where hopes are high for success in oil and gas finding. Figure 1.

methods were tried to increase production. The well, however, had produced some 12,000 bbl. through 1960 and is currently shut in. Minor, shallow gas production was also established in Washington in Rattlesnake Hills gas field (abandoned in 1940) in the east-central part of the state. Oregon has had no production of oil or gas.

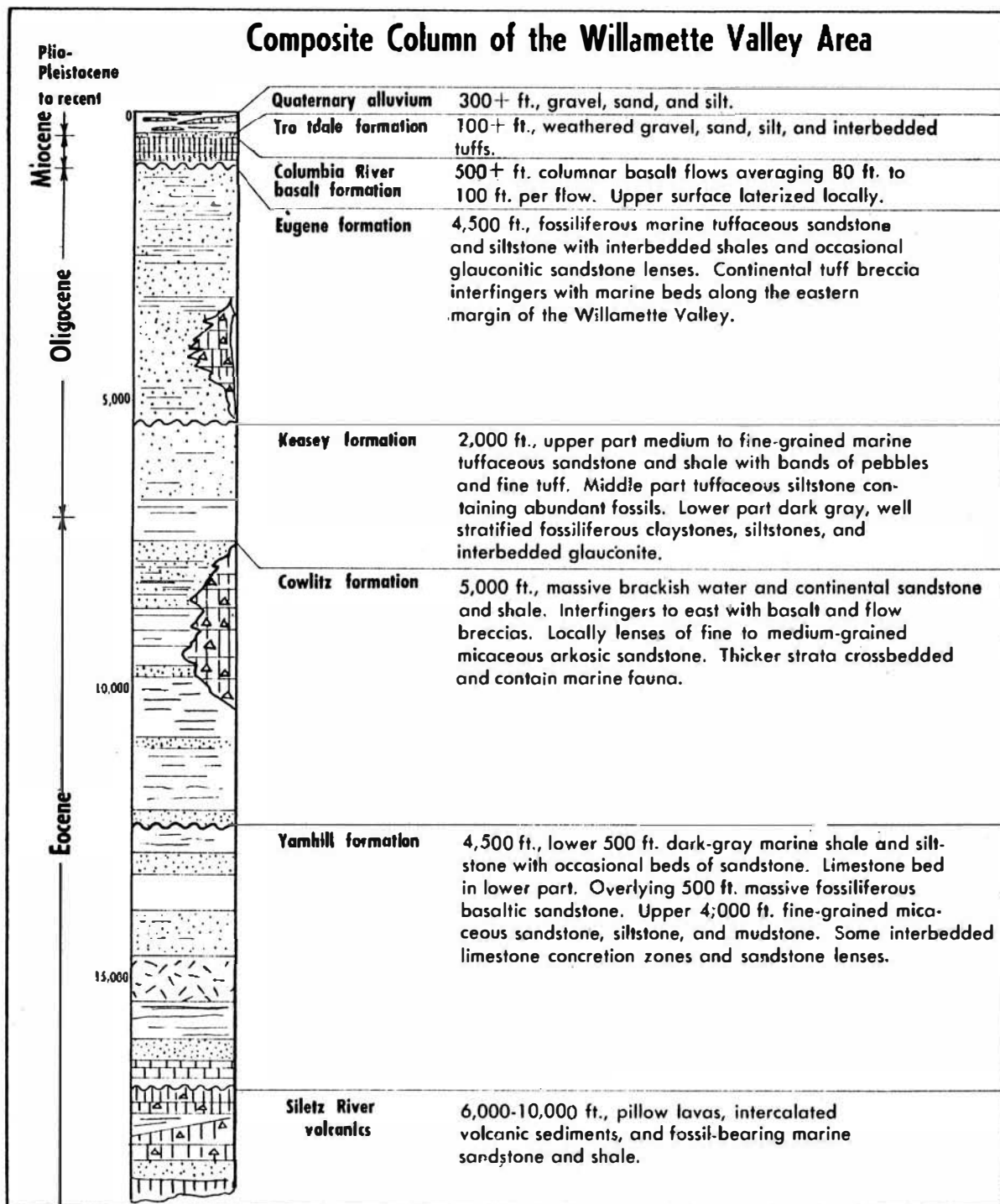
The current phase of Oregon and Washington interest is focused on possibilities within western Tertiary basins. The Oregon-Washington western Tertiary basin is subdivided into smaller basin components by tectonic elements as shown on Fig. 1. Sediments cover an area of some 26,000 miles in the two-state area and have an average thickness of 7,500 feet. A maximum thickness of 20,000 feet is present in the Clallam basin of Washington.

### Oregon Activity

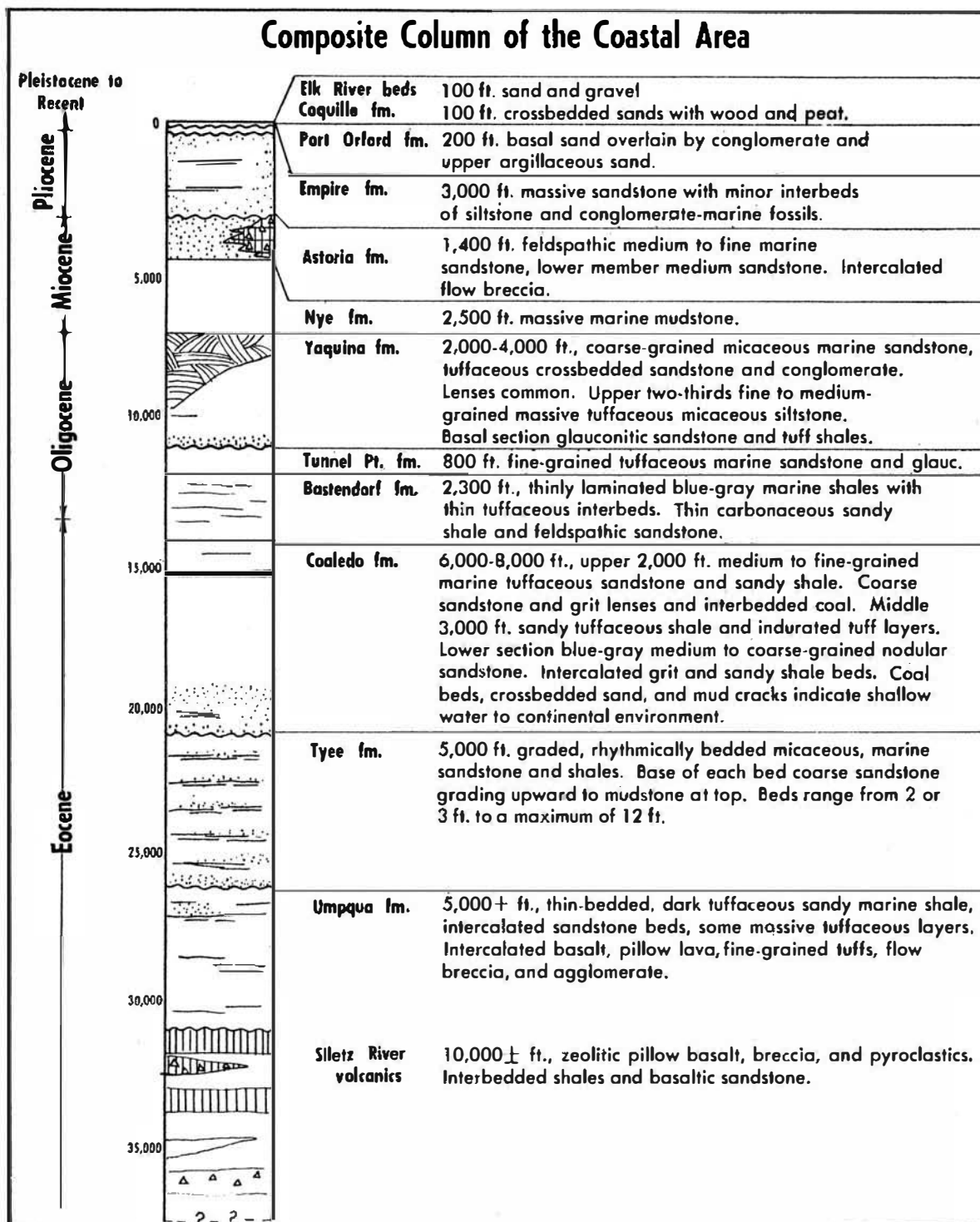
Oregon activity is concentrated in three areas, (1) the Willamette Valley and (2) the offshore coastal basin, and (3) interest has been renewed in the Middle Eocene Coast Range sediments, Willamette Valley.

The Willamette Valley is a topographic and a structural low between the Coast Range Mountains and the Cascade Mountains. The basin extends eastward into the foothills of the Coast Range where marine sediments inter-finger with and are covered with younger lava flows or clastic volcanics. The easterly extension of the basin is unknown but the approximate location of marine and nonmarine strata is indicated on Fig. 1. The western edge of the





THE WILLAMETTE VALLEY currently contains the hottest leasing play in the Pacific Northwest. Figure 2.



THE COASTAL BASIN is developed on the west flank of the Coast Range high and is believed to attain a maximum thickness of some 15,000 ft. in its offshore development. Figure 3.

basin is believed to be both structural and sedimentary.

The basin includes in excess of 10,000 feet of Upper Eocene through Oligocene marine sediments and probably several thousand feet of Middle and Lower Eocene sedimentary rocks. Fig. 2 shows composite section.

Some 33 wells have been drilled in the basin but most were shallow tests drilled without benefit of technical advice. Only four wells were drilled deeper than 5,000 feet and of those only two were drilled to basement. One well, Linn County Development Co., 1 Barr, reportedly developed a significant oil show, which has not been evaluated.

The Willamette Valley currently contains the hottest leasing play in the two-state area. W. G. Bruer, Bakersfield consultant, started things off in the middle part of the summer by leasing near Salem in the central part of the valley. Later in the fall, Gulf and Humble, coincidentally, started major leasing programs in the easterly and southeast part of the valley. Reserve Oil & Gas Co. acquired a farmout from Linn County Development Co. at about the same time and near the end of the year, Superior entered the play by filing on some 35,000 acres of federal acreage on the eastern edge of the basin. Several independents and some major companies have entered the play with protection positions. Over 500,000 acres are currently under lease and final acreage assemblage will probably amount to more than a million acres.

The play appears to be for Eocene and Oligocene edge-line conditions along the eastern margin of the basin. It is expected that Reserve will start drilling off by late spring by drilling the Linn County farmout. Drilling programs by Gulf and Humble may follow later in the summer.

Oregon offshore: Shell touched off interest in Oregon's offshore possibilities in late 1960 by filing on almost all of the state's tide and submerged lands. While the state declined to give exclusive exploration rights to Shell, it did pass legislation in the spring of 1961 which set up rules and regulations for offshore development. During the past summer, Shell, Gulf, Union, and California Standard conducted nonexplosive seismic work from Coos Bay to the mouth of the Columbia River.

The coastal basin is developed on the west flank of the Coast Range high and is believed to attain a maximum thickness of some 15,000 feet in its offshore development. Only a small portion of the basin is exposed in selective onshore embayments at Coos Bay, Newport, and Nehalem to indicate the type of section developed offshore. Upper Eocene through Pliocene marine sedimentary rocks are prime objectives. These strata locally overly middle Eocene marine sediments which may also provide objectives and increase the potential thickness of the offshore section by another 5,000-10,000 feet. The sediments include potential reservoir objectives in several horizons throughout the section, Fig. 3.

A considerable shelf area is present along most of the coast with water depths of less than 300 feet, and within the state's 3-mile limit large areas have water depths of less than 150 feet.

Previous exploration within the onshore portion of the basin has been slight. Only two wells have been drilled to greater than 5,000-foot depth, although both of these bottomed in basement. Some 18 wells have been drilled on the coast for a total footage of 44,823 feet with less than half the wells not deeper than 2,000 feet.

The coastal basin probably represents Oregon's greatest potential for oil and gas. The basin has the advantage of being located away from the extensive volcanic activity and probably is not as broken with major basement structural highs as are some of the interior basins.

Continued intensive offshore seismic work by the state companies that worked during the previous summer is expected for 1962. One or two additional companies are also expected to commence work. Should Shell or any of the companies which have developed offshore data elect to nominate offshore parcels for leases, offshore activity should pick up sharply.

Mid-Eocene Coast Range sediments: These occupy the southern one-half of the Coast Range and contain a number of large exceptionally well developed nearly north-south-trending anticlines. Some of the anticlines are 20 miles long and 6 miles wide and contain up to 3,000 feet of vertical relief. On the basis of the structure alone, this is a highly attractive area.

The structures are developed in the middle Eocene Tyee formation which consists of a widespread and monotonously uniform sequence of hard, impermeable, graywacke sandstone with thin intercalations of siltstone and carbonaceous siltstone. While the unit is considered to be marine, fossils are rare to nonexistent in most areas. The Tyee formation overlies unconformably the middle to lower Eocene Umpqua formation consisting predominantly of rhythmic thin-bedded siltstone and graywacke sandstone. Some clean quartz sandstones are locally present near the basal part of the section.

Standard Oil Co. of California, Western Operations, Inc., renewed interest in this area by commencing land assemblage during the past summer on a large symmetrical anticline developed in the Tyee formation near Reedsport in Douglas County.

Two deep important basement tests have been drilled in the middle Eocene section in recent years. Sinclair Oil & Gas Co. drilled the Northwest's deepest test in 1956 on a large Tyee structure. The well penetrated both the Tyee and Umpqua formations and bottomed in lower Eocene basement volcanics at 12,880 feet. A year later Mobil drilled a similar structure to the south and also bottomed in basement at 9,004 feet. Neither well gave up significant shows or found permeable sands. Somewhere in the area, the Tyee or Umpqua formations should contain some permeable sands. Perhaps Standard's ideas at Reedsport will lead the way.

### Washington Activity

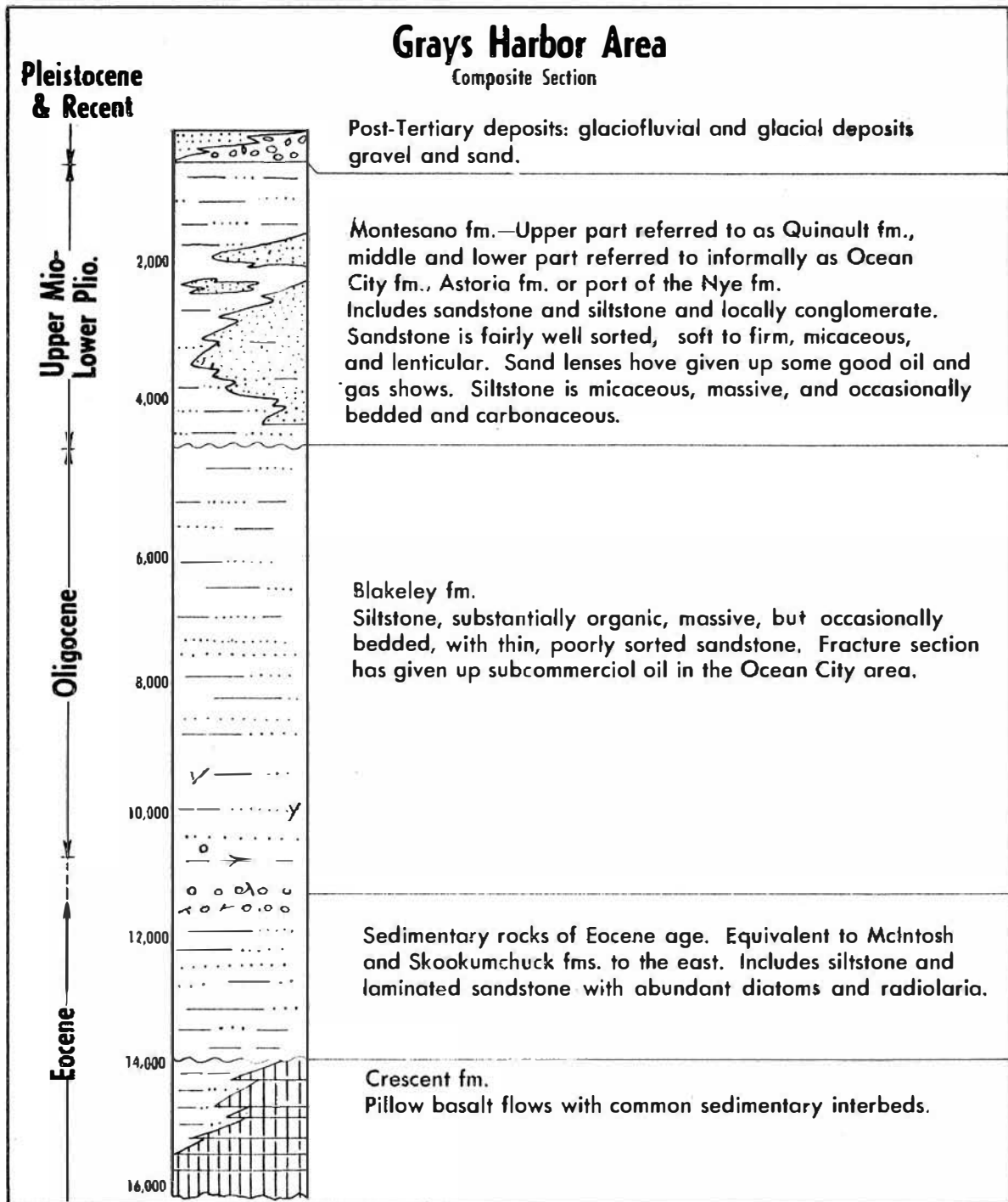
Interest in Washington in 1962 is focused on offshore Grays Harbor where Union is scheduled to drill the Northwest's first offshore well. Drilling activity should also develop before the summer is out in the Puget and Bellingham basins and possibly the Chehalis and Clallam basins.

Grays Harbor basin: The Grays Harbor basin (see Fig. 1) includes an entirely marine sedimentary section of some 14,000 feet of primarily shales and siltstone with lesser amounts of sandstone. The sediments range from upper Eocene through Pliocene. Unconformities are present at the base of the Miocene-Pliocene Montesano formation and Eocene Skookumchuck-McIntosh formation, Fig. 4.

High interest in the basin was set off in the late 1940's when Union Oil Co. first found oil and gas shows near Ocean City from tight fractured sandstone and siltstone of the Oligocene Blakeley formation. Sunshine Mining Co. set off a flurry of leasing activity in 1957 when it completed its 1 Medina for 180 bbl. per day of high-gravity oil. Activity died a natural death when production rapidly fell off. Sunshine went on another siege to get production from the area when it drilled four wells in 1960. Complex structure, tight sands, and high bottom-hole pressures have combined to create a series of problems that haven't yet been solved. Just one good permeable sand would probably put the area in the oil business.

The Grays Harbor basin has had by far the highest drilling concentration of Washington basins. Some 65 wells have been drilled in the basin but only 10 were drilled below 5,000 feet. Thirty-two were drilled from 2,000-5,000 feet and 24 were less than 2,000 feet in depth. Only a few went to basement.

Union Oil Co.'s offshore drilling programs scheduled for this summer will be watched with high interest. Union, during the past two summers, has conducted offshore gas-exploder work and undoubtedly has found better structural locations offshore. The possibility of better sand development particularly in the upper Miocene-Pliocene section may also be better offshore and some oil



GRAYS HARBOR BASIN has had by far the highest drilling concentration of Washington basins.  
Fig. 4

and gas shows have been found in onshore wells in this section.

**Puget and Chehalis basins:** These basins are considered together because both contain similar stratigraphic sections. The basins are separated by tectonic elements as shown on Fig. 1 and each includes thick upper Eocene marine and nonmarine sections in excess of 10,000 feet and local marine Oligocene beds. See Fig. 5.

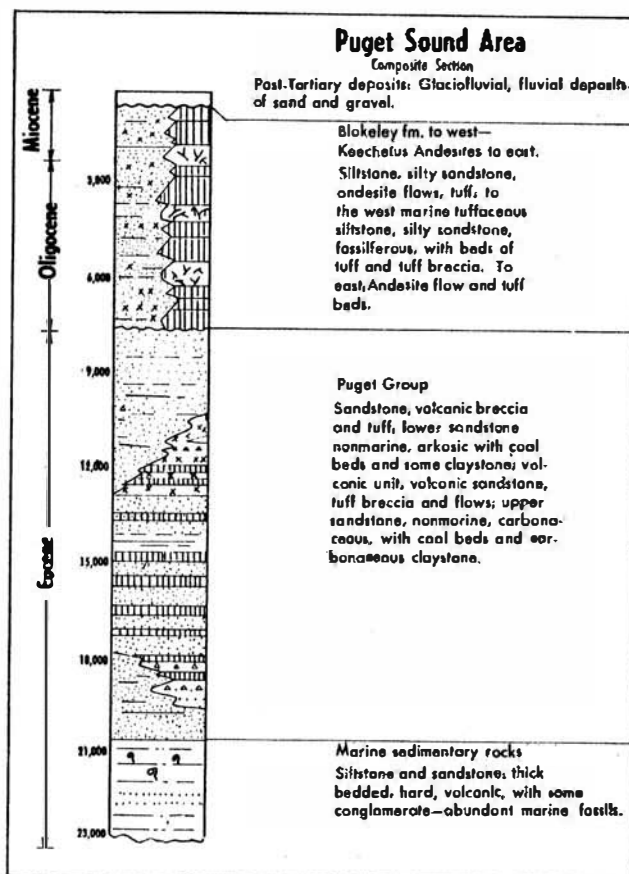
The Puget and Chehalis basin sections are very similar to Alaska's Cook Inlet basin Kenai producing section. The sections are predominately sand with siltstone and coal intercalations that interfinger westerly with marine sands and shales. Both oil and gas shows have been developed in wells drilled in the basins.

No wells have penetrated basement in the Puget basin and only one well has reached basement in the Chehalis basin. The Puget basin has had some 20 wells drilled for a total footage of 59,855 feet but only 5 have gone below 5,000 feet. Some 38 wells have been drilled in the Chehalis basin for a total footage of 123,272 feet with only 8 of the 38 wells going below 5,000 feet. Prime objectives in the McIntosh formation developed in the Chehalis basin are below 10,000 feet and no well has yet tested this section.

Large undeveloped land blocks are held in both basins. Humble Oil & Refining Co. is the major landholder with more than 100,000 acres in both basins. Substantial acreage blocks in the Chehalis basin are also held by Texaco and Shell, plus significant acreage holdings by several independents. Puget basin landholders in addition to Humble include Edward J. Carr, Los Angeles independent, with 26,000 acres, and A. E. McCroskey with approximately 15,000 acres.

The Puget basin seems definitely headed for additional development this year. Edward J. Carr is reportedly planning a deep test (10,000+ feet) within his 26,000-acre Lake Tapps block (California Standard farmout) as a followup of a 7,500-foot duster drilled in January of this year. Carr ran production pipe on the well and tested reported oil and gas shows in four zones between 5,800 and 7,000 feet. The well turned out to be a dud but not without bringing up some 67-70 major company land men to stand by during testing. The A. E. McCroskey block falls east of the Carr acreage and reportedly also is headed for drilling this summer.

Drilling potential for the Chehalis basin in 1962 will probably depend on whether or not the major landholders, Humble, Shell and Texaco, can get together on a joint deep McIntosh test.



THE PUGET and Chehalis basins are very similar to Alaska's Cook Inlet basin Kenai producing area. Fig. 5.

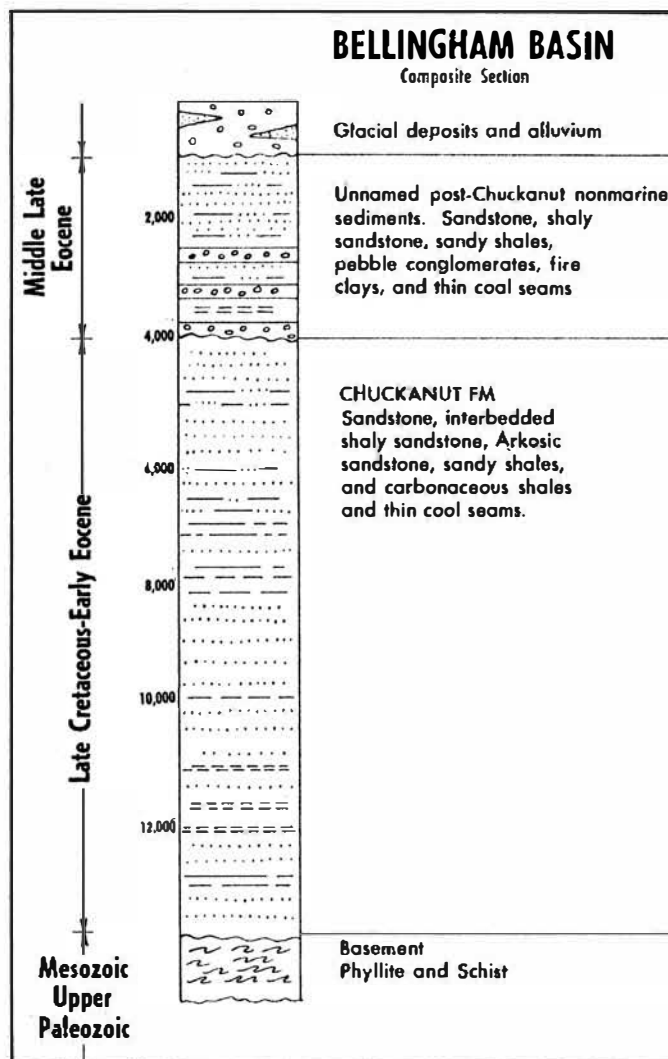
**Clallam basin:** The Clallam basin includes the thickest section of Tertiary marine sedimentary beds of any of the Oregon or Washington basins. The basin includes more than 20,000 feet or predominately marine siltstone and shale with lesser amounts of sandstone and conglomerate ranging from upper Eocene through lower Miocene. Sandstone is present at the base of the section as widespread units in the Lyre formation, as lenticular bodies in the middle part of the Twinn River formation and as massive thick-bedded units in the overlying Clallam formation. The basin has its maximum development offshore in the Straits of Juan De Fuca.

Past drilling in the basin has been sparse and has been done primarily in recent years. Only seven wells have been drilled in the basin and of these, three have gone below 5,000 feet and one was taken to basement. During the past year, Steve West, Los Angeles independent, drilled two tests near Port Angeles and in one, thin gilsonite beds were found. Texaco holds substantial acreage in the basin in addition to Independent Steve West. The Texaco acreage was assembled during the past year and may represent a drillable block for this year.

Offshore seismic work was done during the past summer and additional work is expected also to develop during the coming summer.

**Bellingham basin:** Richfield Oil Corp.-Pure Oil Co. is currently drilling the second well of a three-well program in the Canadian part of the basin. The first was located near Abbotsford and was dry and abandoned in basement at 3,141 feet. The current active well is located about 2 miles north of the international border and was drilling at  $\pm$  8,000 feet at this writing.

The Bellingham basin covers a part of northwest Whatcom County, Washington, and the Fraser River delta lowlands of British Columbia, Canada. The basin is about equally divided between Washington and British Columbia, and includes better than 12,000 feet of late Cretaceous or early Eocene nonmarine sediments and middle to late Eocene nonmarine sediments. In Washington the early Eocene or late Cretaceous sequence is called the Chuckanut formation which consists predominately of sandstone and thin sandy shales and coal seams. The Chuckanut formation may be equivalent, at least in part, to the marine Cretaceous Nanaimo formation exposed on the northeast side of Vancouver Island. Unnamed nonmarine sandstone, sandy shales, and conglomerate with thin



THE BELLINGHAM basin is about equally divided between Washington and British Columbia. Fig. 6.

coal seams of middle to late Eocene age unconformably overlie the Chuckanut formation. The basement complex of the basin consists of Mesozoic and upper Paleozoic phyllite, schist, and granite, Fig. 6.

Some 77 wells have been drilled in the Washington portion of the basin but more than two-thirds were drilled to depths less than 1,000 feet. Only two were taken below 5,000 feet and only five from 2,000 to 5,000. The British Columbia portion of the basin has had some 20 wells with 2 going below 5,000 feet. Both gas and oil shows have been reported from seeps and wells. A shallow gas field was established in Whatcom County, Washington, during the 1930's from sands within the quaternary glacial section. Flow potential on wells were reported as high as 5 M.M. c.f.d. but the field was never put on commercial production.

In addition to the Richfield-Pure current drilling program, Can-American Petroleum Co., British Columbia, has indicated plans to drill in Washington in the spring or early summer. El Paso Natural Gas Co. acquired acreage on a surface anticline in Whatcom County late last year and reportedly plans drilling during the year.

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GEOMORPHOLOGY OF THE CONTINENTAL TERRACE\*  
OFF THE CENTRAL COAST OF OREGON

By John V. Byrne, Geologist  
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## Introduction

The major submarine geomorphic features off the Oregon coast are the continental shelf, extending from low water to the first pronounced increase of slope to deeper water, and the continental slope, from the outer edge of the shelf to the decrease of slope at the edge of the abyssal plain (Figure 1). Together, these constitute the continental terrace. The terrace varies in width from more than 70 miles off Astoria to less than 40 miles <sup>1/</sup> off Cape Blanco, and extends to the 1,500- to 1,700-fathom <sup>2/</sup> depths of the southward-deepening abyssal plain. Off the Columbia River, Astoria Canyon and Astoria Cone alter the shape of the continental terrace.

Astoria Canyon, the only major submarine canyon off the Oregon coast, heads 10 miles west of the mouth of the Columbia at a depth of 70 fathoms, and extends some 60 miles to a depth of 1000 fathoms, where its identity as a canyon is lost on Astoria Cone. It is somewhat serpentine in shape, is 4 miles wide where it crosses the edge of the continental shelf, and has an axial slope of about 2° near its head and 1° beyond the edge of the shelf.

Astoria Cone is a fan-shaped feature extending from 1000 fathoms along the continental slope to the abyssal plain at 1,500 fathoms, and covering an area of more than 3,500 square miles. It slopes about 0.5°, and is undoubtedly the result of deposition from turbidity currents which discharge from Astoria Canyon.

The continental shelf along the Oregon coast differs notably from the average continental shelf. According to Shepard (1948, p. 143), shelves around the world have an average width of 42 miles, an average slope of 0°07', and an average depth at the outer edge of 72 fathoms. The shelf along Oregon is 9 to 40 miles wide, slopes 0°08' to 0°43', and has a depth at its outer edge of 80 to 100 fathoms. Thus, the Oregon continental shelf is characteristically narrower, steeper, and deeper than the average continental shelf.

The Oregon continental slope, from the edge of the shelf to the abyssal plain, is 13 to 60 miles wide and, eliminating irregularities, has an inclination of from 1°24' to 7°18', with 2° to 3° the most common. In general, the slope is narrowest and steepest where the shelf is widest. Shepard (1948, p. 187) states that the typical continental slope averages 4°17' for the first 1000 fathoms.

A bathymetric chart of the continental shelf and upper two-thirds of the continental slope (to a depth of 1000 fathoms) for the area between 43°30' N. and 45°00' N. has been prepared from

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<sup>1/</sup> Statute miles will be used throughout this report.

<sup>2/</sup> One fathom is a measure of depth equal to 6 feet.

\*Reprinted with permission of the author from The ORE BIN, Vol. 24, No. 5, May 1962.

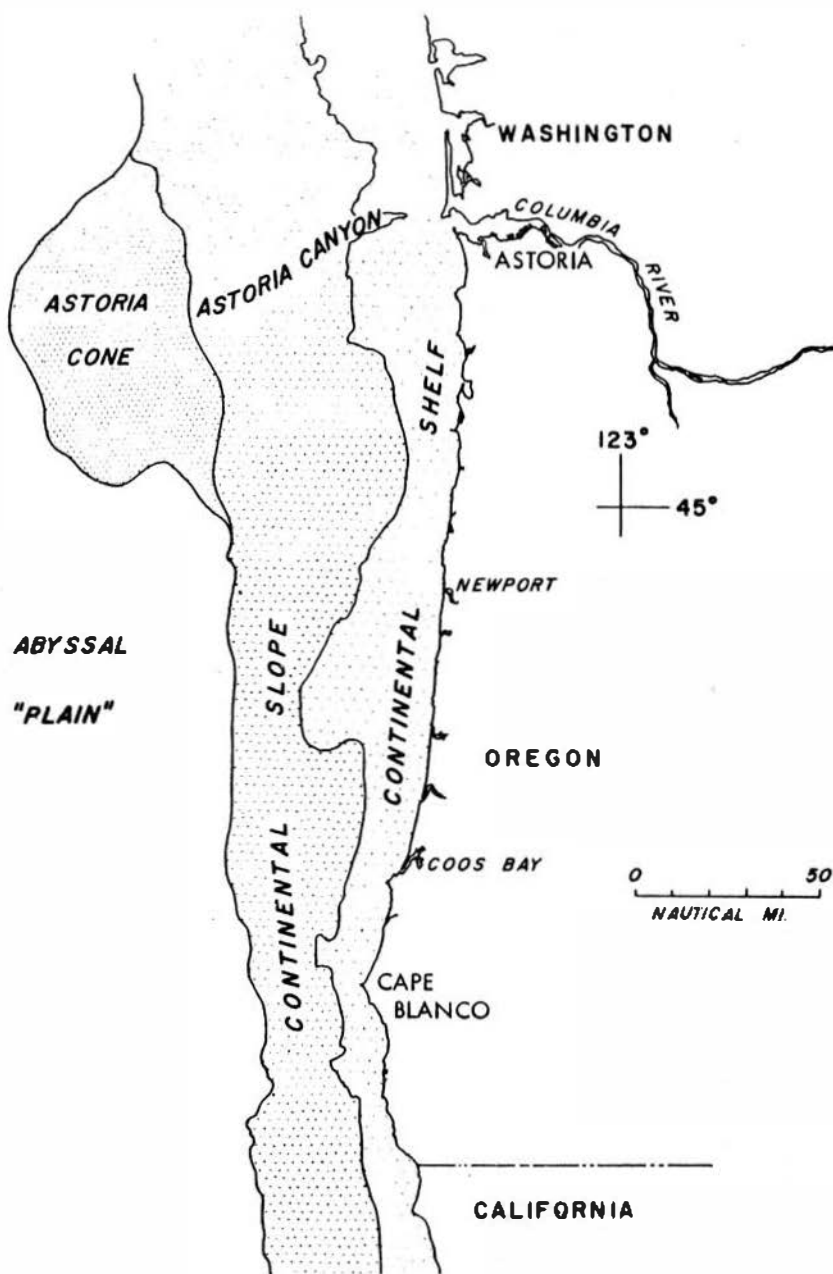


Figure 1. Index map of the submarine geomorphic features off Oregon.

unpublished soundings of the United States Coast and Geodetic Survey and Precision Depth Records obtained by the Oregon State University Research Vessel ACONA (see chart, Plate 1). The bathymetric detail represented on the chart is a function of sounding density and contour interval. On the shelf the sounding density varies from 15 to 20 soundings per square mile except in selected areas, such as Stonewall and Heceto Bonks, where there are as many as 60 per square mile; the density is much less on the continental slope, 2 to 5 soundings per square mile. In order to show geomorphic detail of the continental shelf, a 10-fathom contour interval has been used to a depth of 100 fathoms; the interval is 50 fathoms for depths greater than 100 fathoms.

### Continental Shelf

In the chart area the continental shelf widens from 16 miles at 45°00' N. to a maximum of 40 miles at 44°12.7'N. At approximately 43°55'N. the shelf narrows abruptly to about 20 miles, and then narrows gradually to 15 miles at 43°30'N. The depth of water at the edge of the shelf varies locally from 80 to 95 fathoms. The slope of the shelf averages 0°09' to 0°22', and is steepest where the shelf is narrow. The slope is generally greatest close to shore. The break in slope at the edge of the shelf is most pronounced in the central part of the area, particularly in the vicinity of Heceta Bank, and is least evident to the north and south (Figure 2).

Numerous shoals, which may be geologically related to the exceptional width of the shelf, characterize the Central Shelf Extension between 43°55'N. and 45°00'N. Of possible economic interest are the topographic highs Stonewall Bank, Heceta Bank, and the unnamed shoals lying between them.

#### Stonewall Bank

Stonewall Bank, located 17 miles southwest of Yaquina Bay, is a rise approximately 14 miles long and 9 miles wide, with 210 feet of relief, and with a crest in less than 20 fathoms of water. It consists of two high areas (delineated by the 30-fathom contour) separated by a shallow east-trending submarine valley. The bank, as outlined by the 40-fathom contour, trends N. 18° W.

Rocks have been collected from two places on the bank. At the northern end of the shoal (44°37.2'N., 124°26.4'W.) dense light-gray fossiliferous mudstone was dredged from about 46 fathoms of water. Dense gray siltstone or fine sandstone was taken from the southern part of the bank at 44°30.2'N., 124°22.6'W. The faunal content of the siltstone from the southern part of the bank was determined independently by the geologic research section of the Humble Oil & Refining Co. and by the western operating division of the Standard Oil Co. of California to be of Pliocene to Recent age. On the basis of these faunal analyses and the extreme induration of the rock, it is considered to be of Pliocene age.

Precision depth records which traverse the bank reveal an exceptional topographic symmetry. The presence of several ridges remarkably alike in shape and size on both sides of the shoal suggest that Stonewall Bank is the surface expression of a symmetrical fold, more likely on anticline than a syncline.

#### Heceta Bank

Heceta Bank, lying approximately 35 miles west of the mouth of the Siuslaw River, is a shoal area 25 miles long, 6 to 8 miles wide, and less than 60 fathoms deep. It has a total relief of 240 feet, and consists of two individual highs outlined by the 50-fathom curve. The southern part of the bank, which is 8.5 miles long and 3 miles wide, is asymmetrical (30 to 60 fathoms) with 2° to 3° slopes on the east side and slopes less than 1° on the west. The southern part of the bank, which appears to be offset from the northern part, is aligned with an escarpment to the southwest which trends N. 32° E. The alignment of the southern part of the bank with the escarpment and the lack of symmetry suggest the possible existence of a northeast-trending fault between the northern and southern portions of the bank.

The northern part of Heceta Bank is more or less equidimensional and may be structurally related to the unnamed shoal to the northeast.

Although no rocks have been dredged by the ACONA from Heceta Bank itself, the published notations "hard brown clay" (U.S.C. & G.S. Chart 5802) at two positions on the southern part of the bank (44°01.5'N., 124°52.3'W.; 44°03.0'N., 124°51.3'W.) are more than likely based on the collection of water-soaked shale or mudstone.

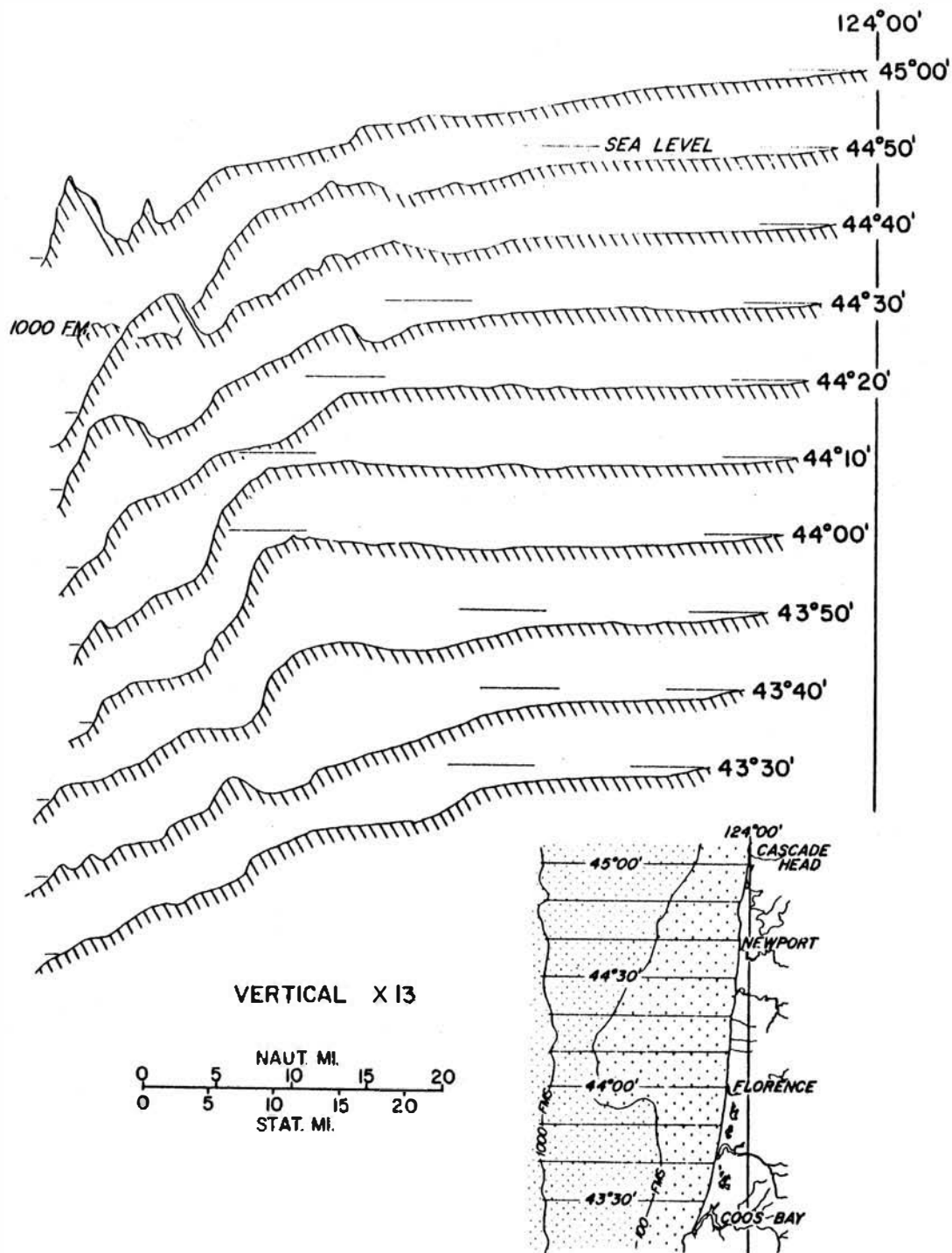


Figure 2. Profiles of the continental terrace from 43°30'N. to 45°00'N.

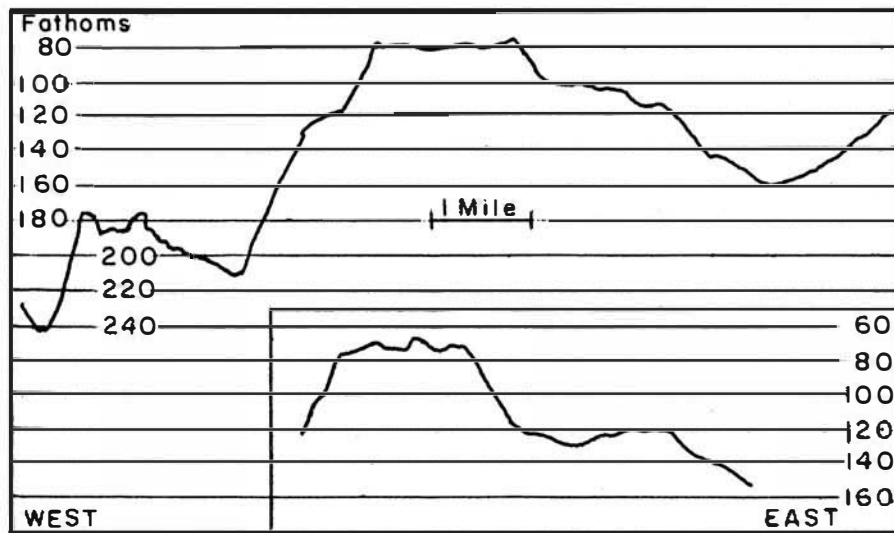


Figure 3. Precision Depth Records across the truncated seamount near the edge of the continental shelf west of Yaquina Head ( $44^{\circ}39'N.$ ,  $124^{\circ}44'W.$ )

#### Other high areas

Other high areas on the shelf of possible geologic interest are the ridge southeast of Heceta Bank ( $43^{\circ}57.5'N.$ ,  $124^{\circ}40'W.$ ) and the unnamed shoal, outlined by the 60-fathom contour, 15 miles northwest of the mouth of the Umpqua River. The ridge southeast of Heceta Bank is 8 miles long, has 120 feet of relief on the northeast side, and is oriented  $N.35^{\circ}W.$  The unnamed shoal is 4 miles long, exhibits 90 feet of relief, and is oriented  $N.18^{\circ}W.$ , the same orientation as Stonewall Bank.

No rocks have been dredged from the ridge or the unnamed shoal by the ACONA. However, grayish-brown mudstone was collected from the northwestern flank of the shoal lying between Heceta and Stonewall Banks ( $44^{\circ}21.5'N.$ ,  $124^{\circ}43.6'W.$ ). Other rocks collected from the shelf by the United States Bureau of Commercial Fisheries vessel JOHN N. COBB are described as "phosphatized siltstone or sandstone," from the low area east of the north end of Heceta Bank (about  $44^{\circ}11.0'N.$ ,  $124^{\circ}39.4'W.$ ); "light olive-gray siltstone," from water 75 to 100 fathoms deep west of the north end of Stonewall Bank (approximately  $44^{\circ}34.5'N.$ ,  $124^{\circ}32.5'W.$ ); and "olive-gray fine to medium sandstone," from the same area (approximately  $44^{\circ}36.6'N.$ ,  $124^{\circ}33.7'W.$ ) (Gerald A. Fowler, oral communication, 1961.)

#### Continental Slope

The continental slope to a depth of 1000 fathoms has an average inclination of  $1^{\circ}12'$  to  $4^{\circ}18'$  in the chart area, and is generally steepest where the shelf is widest. Locally, a maximum slope of  $40^{\circ}$  is attained along a 600-foot high escarpment south of Heceta Bank ( $43^{\circ}56.6'N.$ ,  $124^{\circ}56.0'W.$ ). The escarpment west of Heceta Bank averages  $16^{\circ}$  for 1,500 feet, but slopes as much as  $30^{\circ}$  for vertical distances of 300 feet. With the exception of the previously mentioned "fault scarp" southwest of Heceta Bank, the Heceta Bank escarpment strikes north and is undoubtedly a structural feature.

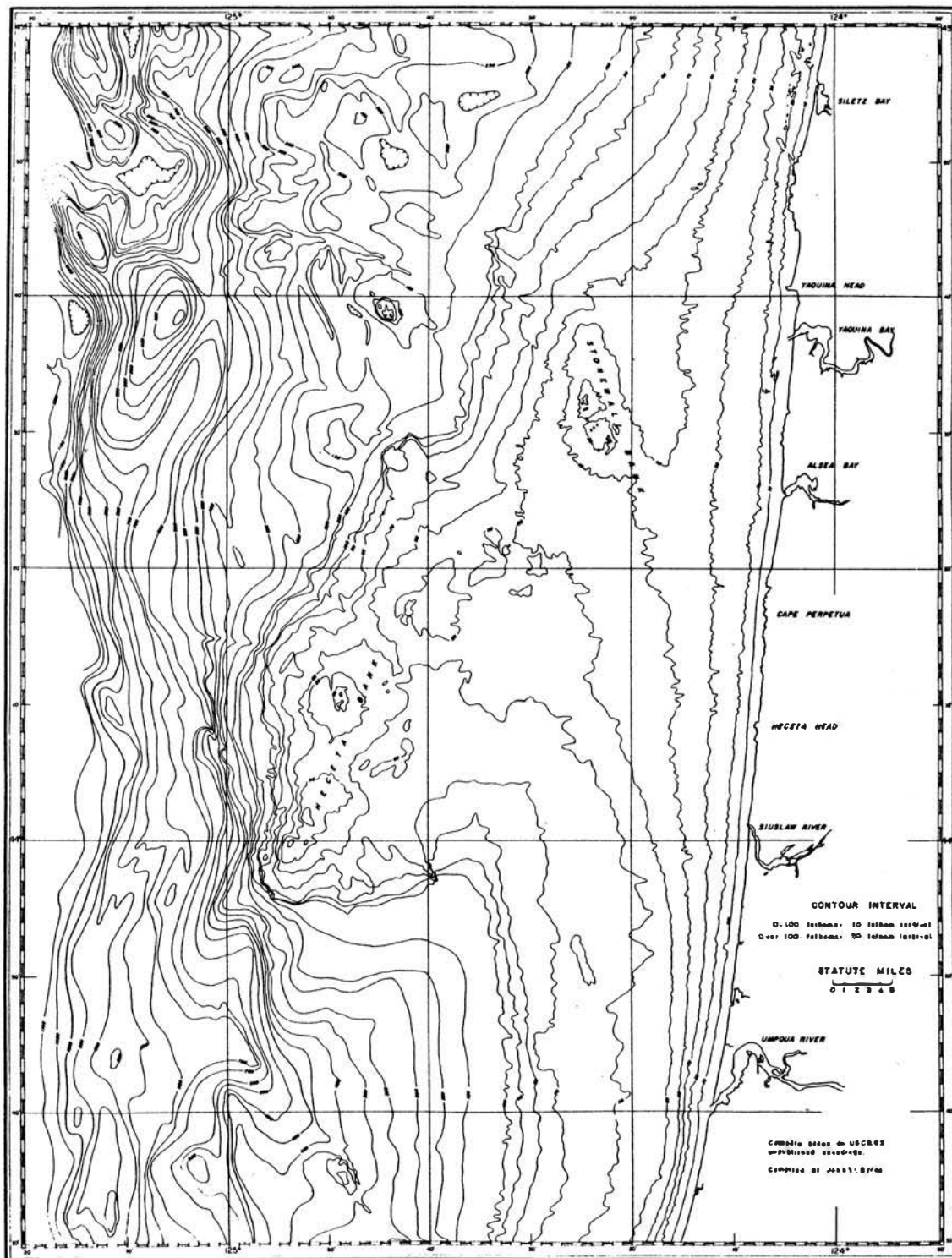


Plate I. Bathymetric chart of the continental terrace off central Oregon, 43°30'N. to 45°00'N. and offshore to 1000 fathoms.

South of Heceta Bank the continental slope is fairly gradual, and in the vicinity of  $43^{\circ}40'N$ . is characterized by a series of isolated hills. A broad trough evident below 450 fathoms opposite the Umpqua River is aligned  $N.30^{\circ}W$ . with a hill having 600 feet of relief ( $43^{\circ}35'N$ .,  $124^{\circ}48'W$ .) and with a submarine canyon northeast of the hill. This alignment may also be structurally controlled.

North of Heceta Bank the continental slope is dominated by numerous hills and small seamounts, one-half to 6 miles wide, up to 1,800 feet high on the landward side, and with side slopes as high as  $10^{\circ}$ . The maximum relief of any of the hills shown on the chart occurs on the seaward side of the seamount at  $44^{\circ}38'N$ .,  $125^{\circ}05'W$ . This hill drops a total of 5,352 feet, from 322 fathoms to 1,214 fathoms, in a distance of 8 miles. (See section  $44^{\circ}40'N$ . on Figure 2.)

The small seamount near the edge of the shelf opposite Yaquina Head is of some interest, since it is the only one which extends into water less than 100 fathoms deep (Figure 3). The flat top of this hill is clearly the result of truncation by wave action in shallow water. Such erosion most likely took place during the most recent Pleistocene lowering of sea level. The sides of this seamount are fairly symmetrical and slope about  $5^{\circ}$ . Phosphorite-coated limestone was dredged from the flat top, indicating that the seamount is nonvolcanic in origin. The symmetry of the sides and the rim along the top suggest that it is the surface expression of an anticlinal fold.

As erosion is relatively insignificant in deep water, most of the topographic features on the continental slope are primary and have been modified only by deposition. Thus, the hills on the continental slope must be of either volcanic or structural origin. To date, only sedimentary rocks have been collected from this small seamount province, indicating that the hills are structural features. Rocks taken from deep water in this area are: dense silty limestone, dredged from 235 fathoms of water at  $44^{\circ}39.6'N$ .,  $124^{\circ}52.6'W$ .; small fragments of shale, taken in 850 fathoms at  $44^{\circ}27.6'N$ .,  $125^{\circ}14.2'W$ .; and phosphorite-covered dense limestone, collected from approximately 1000 fathoms at  $44^{\circ}21.0'N$ .,  $125^{\circ}14.3'W$ .

### Conclusions

On the basis of the general geomorphology of the continental shelf and slope, on the detailed character of the bottom determined from precision depth records, and on the distribution of sedimentary rocks it is concluded that in the area of the Central Shelf Extension (1) volcanic rocks are scarce if not absent in the vicinity of the submarine banks, hills, and seamounts, (2) a reasonably thick sedimentary section is present with rocks as young as Pliocene, and (3) fault and fold structures exist on both the continental shelf and continental slope.

Acknowledgement: This study was carried out under Office of Naval Research contract NONR 1926(02).

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## DATA ON OREGON'S OFFSHORE\*

A map of Oregon's coastal and offshore lands is presented here in response to the interest shown in this subject in recent months. The generalized geology on the map has been compiled from published material and from unpublished work for the State Geologic Map. The bathymetric contours and the two cross-sections are based on the International Map of the World. The drilling information is from the department records, and only those wells considered significant are mentioned. Additional drilling records are available from the department.

Accompanying the map are references on Oregon geology and a list of nautical charts. Most of the detailed geologic maps may be purchased from the U. S. Geological Survey. Unpublished theses are on file in the department's offices and at the universities or colleges where they were submitted for advanced degrees. Charts may be obtained from the U. S. Coast and Geodetic Survey or local marine outfitting establishments.

All lands within the 3-mile limit belong to the State of Oregon. A recent opinion by the Attorney General ruled that the state has no authority to lease such lands. However, legislation which will give the State Land Board the authority to lease is being prepared for presentation at the current session of the legislature. Lands beyond the 3-mile limit belong to the federal government and are leased through the U. S. Bureau of Land Management.

As yet 600 feet (100 fathoms) is the maximum water depth in which a drilling has been made. Offshore drilling is done by one of three methods: (1) by directional drilling from the shore, (2) by means of towers or man-made islands in shallow water, or (3) by specially constructed drilling ships in deeper water. At the present time wells are being drilled off the shores of Texas, California, and Louisiana.

## NAUTICAL CHARTS ALONG OREGON COAST

<u>C &amp; GS</u> <u>Chart No.</u>	<u>Title</u>	<u>Scale</u>	<u>Price</u>
5052	San Francisco to Cape Flattery (A Sailing chart showing generalized shoreline, soundings, and topography.)	1:1,200,000	\$ 1.00
5021	Monterey Bay to Coos Bay	1:811,980	1.00
5022	Cape Blanco to Cape Flattery (Sailing charts with more detail on shoreline, soundings, and coastal topography.)	1:736,560	1.00
5702	Trinidad Head to Cape Blanco	1:196,948	1.00
5802	Cape Blanco to Yaquina Head	1:191,730	1.00
5902	Yaquina Head to Columbia River (General charts for coastwise navigation. Considerable detail on shoreline and off-shore topography.)	1:185,238	1.00

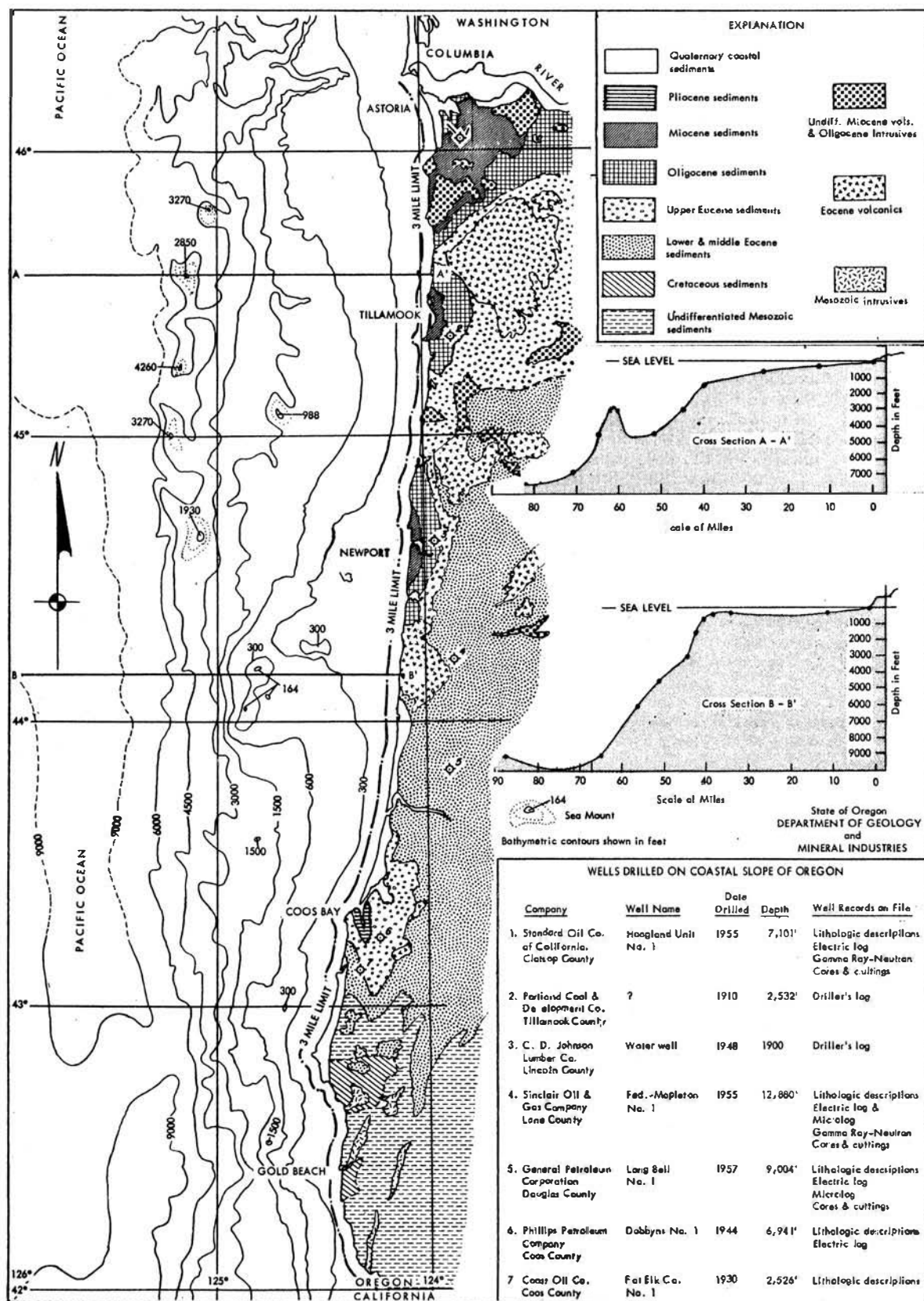
Harbor charts at various scales larger than the above are available of the following areas: Columbia River, Nehalem River, Tillamook Bay, Netarts Bay, Depoe Bay, Yaquina Bay, Siuslaw River, Umpqua River, Coos Bay, Coquille River, Port Orford to Cape Blanco, Cape Sebastian to Humbug Mountain, and Pyramid Point to Cape Sebastian.

Charts may be obtained at the following places:

Astoria: Englund Marine Supply, Foot of 15th St.  
Coos Bay: Independent Stevedore Co., Inc.  
Newport: Englund Marine Supply Co., 252 Bay Blvd.  
North Bend: Oregon Pacific Co., Inc.

Portland:  
U. S. Coast and Geodetic Survey District Office  
314 U. S. Court House, 620 S. W. Main St.  
Frank H. Parks, 213 S. W. Washington St.  
Portland Instrument Co., 334 S. W. 5th Ave.

\* Reprinted from The ORE BIN, Vol. 23, No. 1, January 1961.



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## Gas Analyses from Exploratory Drillings and Water Wells in Oregon

Well No.	O	H	CO <sub>2</sub>	Analysis by Percent Volume				Iso-Butane	Normal Butane	Gas Zone Depth	Well-Head Press.		Est. Flow Rate
				N	CH <sub>4</sub>	Ethane	Propane				Shut-in	Flow	
1			0.5	12.5	87.0					Surface			Bubbles
2			0.7	13.1	86.2					Surface			Bubbles
3	0.2	0.5	0.4	46.7	51.8					608'	?	Neg.	Weak
4	4.5(air)		Tr.		94.91	0.41	0.10	Tr.	0.05	2,236'	?	?	Small
5					98.5	1.5				1,700'	?	?	Small
6	1.2		0.4	24.7	73.7					60'			Bubbles
7	0.5		1.5	6.7	91.3					265'	?	Neg.	Bubbles
8			0.5	26.0	73.5					370'	?	Neg.	Weak
9			0.3	8.41	90.33	0.96				3,300'	15psi(?)	?	200+ MCF/D
10A	0.40			43.71	55.89					1,152'	Hydro.	510psi	Bubbles
10B	0.43		0.08	42.99	56.50					(Form. Test - Wet) 2,158	Hydro.	985psi	Bubbles
11	63.5(air)		0.2	18.4	17.5	0.3	0.1			(Form. Test - Wet) 2,230'	?	?	Bubbles
12				0.9	99.1					2,000	420psi	?	500+ MCF/D
13	0.2		0.4	10.8	88.6					508'	?	?	Small
14	0.9		0.1	11.9	87.1					700'	39psi	?	Bubbles
15*	2.0			7.8	91.0					325'	?	?	Bubbles
16	0.1			36.1	63.8					1,835'	?	?	Weak
17					99.8	0.17	0.03			1,440'	?	?	50+ MCF/D
18					67.0	6.4				300'(?)	?	?	Bubbles
19			0.15	2.0	97.85					1,000'	?	?	Small
20	0.2		3.1	28.7	64.3	4.7				2,700	(Form. test - dry)		Weak

\* Flame test - 1,204 BTU. This indicates that heavier fractions through hexane probably are present.

## SUPPLEMENTAL WELL DATA FOR GAS ANALYSIS TABLE

No.	Well Name	Location	Remarks
1	Herrick's Mineral Spring	SE $\frac{1}{4}$ sec. 23, T. 8 N., R. 7 W. Clatsop County	Grand Rapids on Nehalem River. U.S.G.S. Bull. 590, p. 108. Analysis by U. S. Bureau of Mines, Pittsburgh, Pa.
2	Seep	SW $\frac{1}{4}$ sec. 7, T. 4 N., R. 7 W. Clatsop County	From bed of Nehalem River at Lukkarila Ranch. Ref. above.
3	Texas Co. . Potter C.H. No. 1	SE $\frac{1}{4}$ sec. 8, T. 4 N., R. 3 W. Columbia County	Small show of gas. Gas analysis by Texas Co.
4	Pacific Petrol. Corp., Morrison No. 1	SE $\frac{1}{4}$ sec. 28, T. 28 S., R. 14 W., Coos County	Small flow of gas, some oil shows reported. Oregon Dept. Geology & Min. Ind. Bull. 14C, vol. 1, p. 25, 1940. Gas analysis by Smith-Emery Co., Los Angeles, Calif.
5	Lona Gray Berna No. 1	NE $\frac{1}{4}$ sec. 32, T. 19 S., R. 18 E. Crook County	Small amount of gas encountered. Analysis by Hornkohl Laboratories, Bakersfield, Calif.
6	Water well	Sec. 3, T. 28 S., R. 7 W. Douglas County	Wilson Farm well. Small amount of gas bubbles up in the water. Gas analysis by Northwest Natural Gas Co. (?). Small amount of light gravity oil reported in the water.
7	Water well	Sec. ?, T. 24 S., R. 32 $\frac{1}{2}$ E. Harney County	Water well near the store at Lawen. Analysis by Smith, Emery & Co., San Francisco, Calif.
8	Water well	9 miles southwest of Lakeview. Lake County	Well on the Carter Ranch. Ref.: Oregon Bur. Mines, Mineral Res. of Oregon, vol. 3, no. 2.
9	Tri-State Gas & Petrol. Co. Fisher No. 1	SW $\frac{1}{4}$ sec. 22, T. 40 S., R. 19 E., Lake County	Drilled in 1950-51. Hit a strong flow of gas. Analysis by El Paso Natural Gas Co.

No.	Well Name	Location	Remarks
10	Oregon Oil & Gas Co. Roberts No. 1	NE $\frac{1}{4}$ sec. 25, T. 10 S., R. 8 W. Lincoln County	Small flows of gas were obtained on two formation tests. Analysis by Northwest Natural Gas Co., Portland, Oregon
11	Linn County Oil Development Co. Barr No. 1	NW $\frac{1}{4}$ sec. 32, T. 11 S., R. 1 W. Linn County	Small flow of gas on formation test. Analysis by Northwest Natural Gas Co., Portland, Oregon
12	Ontario Coop. Gas & Oil Co.	Sec. 7, T. 18 S., R. 47 E. Malheur County	In the City of Ontario. Gas blew mud and water over the top of the derrick. Pressure was relatively high, but permeability was too low for commercial development. U.S. G.S. Bull. 431-A, p. 36.
13	Water well	Sec. 14, T. 21 S., R. 46 E. Malheur County	Frank Freel well at Adrian. Gas is collected above the water tank and used domestically. Volume is small, however. Analysis by Northwest Natural Gas Co., Portland, Oregon.
14	Water well	Sec. 24, T. 1 N., R. 27 E. Morrow County	Tony Vey Ranch. Water milky colored by gas. Pressure builds up when well is shut in, bleeds off rapidly. Analysis by Northwest Natural Gas Co., Portland, Oregon.
15	Water well	Sec. 16 (?), T. 2 N., R. 25 E., Morrow County	Wells Springs area. Gas bubbles through the water in sufficient amount to be piped 600 feet to a farmhouse for domestic use. Analysis by Washington State College, 1933.
16	R. Mitchell Bliven No. 1	NW $\frac{1}{4}$ sec. 15, T. 8 S., R. 5 W. Polk County	Very small flow encountered in fine sandy siltstone. Analysis by Northwest Natural Gas Co., Portland, Oregon
17	Sam Alexander	Sec. 14, T. 7 S., R. 5 W. Polk County	The gas blows with a loud whistle when the small valve on the casing is opened, but the pressure decreases within a few minutes to only a few psi. Analysis by a major oil company in 1958.

No.	Well Name	Location	Remarks
18	Water well	SE $\frac{1}{4}$ sec. 6, T. 7 S., R. 4 W. Polk County	Well on the Cass Riggs Farm. Supplied gas for domestic use for several years. Ref., W.D. Smith; Oregon Univ. Commonwealth Review, vol. 7, no. 4, p. 174, October 1925.
19	Portland Coal & Devel. Co.	SW $\frac{1}{4}$ sec. 10, T. 2 S., R. 9 W. Tillamook County	Reported to have burned with a 4-foot flame from the end of the casing. Ref. U.S.G.S. Bull. 590, p. 68 and p. 108.
20	Clarno Basin Oil Co. Burgess No. 2	SE $\frac{1}{4}$ sec. 34, T. 7 S., R. 19 E. Wheeler County	Gas shows encountered in several zones. Small amounts. Analysis by Lazell Chemical Laboratory, Portland, Oregon (1933).

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## Porosity-Permeability of the Spencer Sandstone\*

Sample No.	Location	Permeability (md.)	Porosity (%)
1	SE cor. sec. 20, T. 1 S., R. 4 W.	184	36
2	SE $\frac{1}{4}$ sec. 32, T. 1 S., R. 4 W.	202	32.2
3	NE $\frac{1}{4}$ sec. 16, T. 2 S., R. 4 W.	1,130	31.7
4	SE $\frac{1}{4}$ sec. 30, T. 3 S., R. 4 W.	812	41.3
5	SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 30, T. 3 S., R. 3 W.	736	41.2
6	NW $\frac{1}{4}$ sec. 24, T. 3 S., R. 4 W.	1,850	41.1
7	NE $\frac{1}{4}$ sec. 1, T. 3 S., R. 4 W.	2,200	40.7
8	NW $\frac{1}{4}$ sec. 15, T. 2 S., R. 4 W.	4,510	41.5
9	NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 32, T. 1 S., R. 4 W.	3,510	32.9

Note: Samples No. 1-4 courtesy of Gulf Oil Corp. Samples No. 5-9, obtained by H. G. Schlicker and R. J. Deacon, were tested by Oil Well Research Laboratories, Long Beach, California.

\* The Occurrence of Spencer Sandstone in the Yamhill Quadrangle, Oregon, by H. G. Schlicker, geologist, State of Oregon Department of Geology and Mineral Industries: The ORE BIN, vol. 24, no. 11, November 1962.